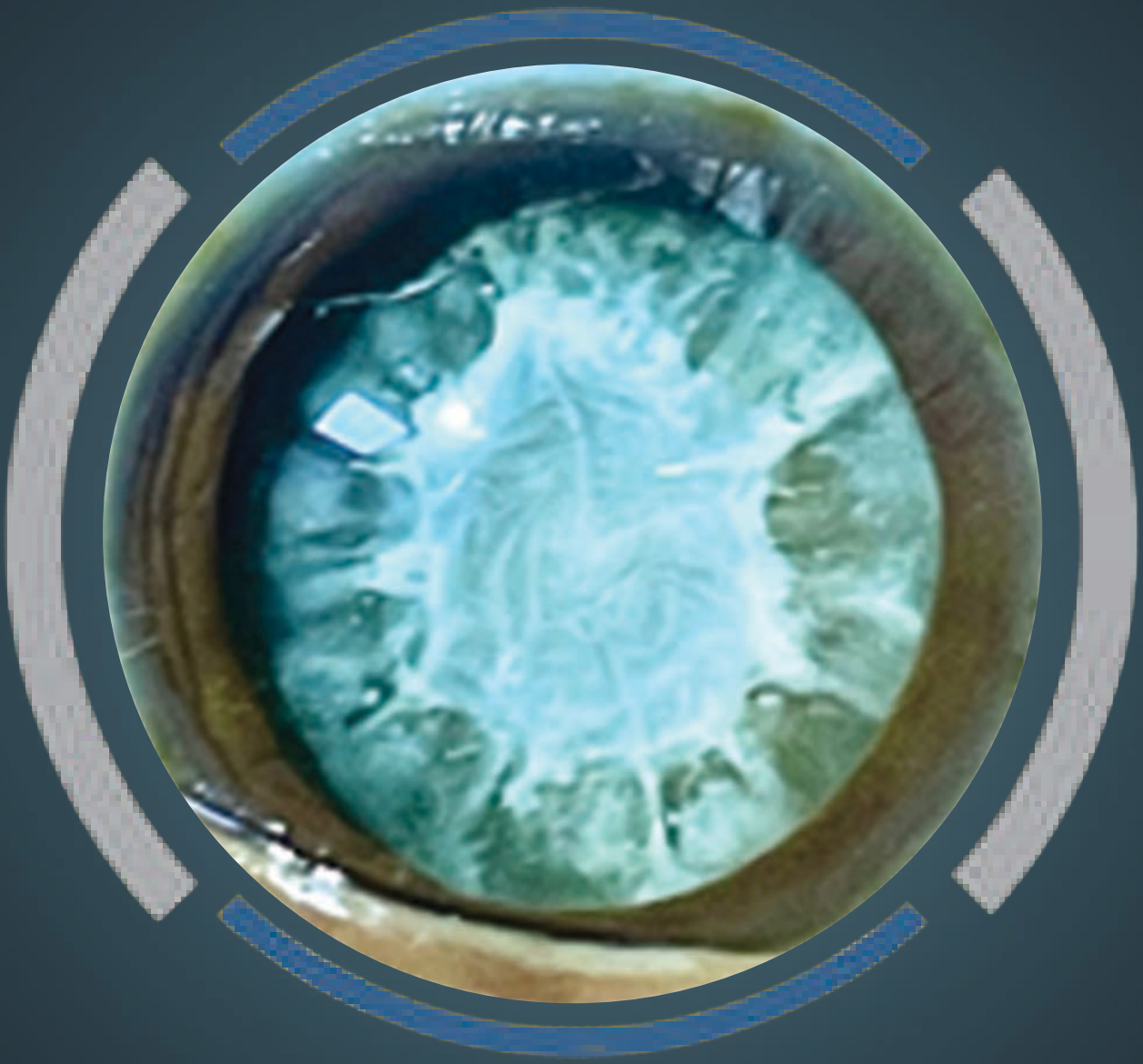
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## HIGHLIGHTS

- Towards Ergonomic Ophthalmic Practice
- Guest Editorial: Periorbital aesthetic surgery
- Can cornea be retrieved from poisoned donors? A focused narrative review
- Evolution of Sclero-Corneal Tunnel Healing in MSICS: An ASOCT based study
- Orbital Myocysticercosis: A Case Series

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# Kerala Journal of Ophthalmology

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# Healer, heal thyself! Towards ergonomic ophthalmic practice

*""Doctors often take better care of their cars than they do of themselves". Dr. Kreshner*

Work related Musculo skeletal disorders (MSD) affect ophthalmologist's world wide – Yet, most of us are blissfully unaware of the possibility that this silent epidemic may even cripple us if we do not embrace body friendly practices during work. The gravity of the problem is highlighted by the reported prevalence of MSD, among ophthalmologists that is 64% in the United Kingdom, 54% in the United States and 71% in India.[1]

A busy ophthalmic practice inherently, involves bad posturing, repeated over long periods and hence can lead to musculoskeletal morbidity. The usual symptom complex involves:

- **Back pain**: Unbalanced posture for long periods can accelerate disc degeneration – for example, I/O especially if done in sitting position.
- **Neck pain and spasm**: Due to repeated flexion/extension of the neck that is part of long hours of slit lamp/ operating microscope/computer use.
- **Pain in shoulder/arm/hand**: Due to extended periods of holding the bent arms too high, too low, or unsupported during clinical examination/surgery. Procedures like gonioscopy and slit lamp biomicroscopy are examples. Tingling in hands may develop due to repeated supporting of elbows on hard surfaces during procedures

The ideal position to avoid MSD is with the back and neck straight, knees at right angles, thighs parallel to the floor and feet flat – But the challenge is all about how to achieve this during a busy practice. That is where ergonomics becomes relevant to the ophthalmologist. Ergonomics is the process of designing or arranging workplaces, products, and systems so that they suit the professionals who use them. Let us see how ergonomic principles and designs can be incorporated in the functional space of a busy ophthalmic practitioner.

## IN THE CLINIC

- **The work space:** Keep the patient-bystander-computer triangle in mind while designing the clinic space in such a way that one can address all the three with minimal need for neck/torso twists.
- **Seating:** Stools/chairs should be height adjustable, should have a back support, which should be at the lower back, with no curves. Arm rests are not advisable as they impede smooth fore arm motion.
- Use optimum refractive correction, while at work to avoid neck and eye strain. It is ironical that many ophthalmologists hesitate to use spectacles on a regular basis.
- **While using the slit lamp**[2]: **Avoid the praying mantis position/slit lamp slouch**: While we are focused on focusing the patient's eye, most of the time, our lower back is bent, neck is extended, arms and wrists are flexed. This praying mantis position is an ergonomic disaster that can result in MSD. It can be avoided by the following:
  - Patient chair and examiner chair positions should ensure eye to eye level examination.
  - The height of the chair should be adjusted so that your back and neck are straight and your legs are not angulated over the chair.
  - Move slit lamp closer to you as needed, rather than lean forward to adjust for the patient
- **Indirect ophthalmoscopy (I/O):** While performing I/O, the neck and spine is in moderate flexion/rotation.[2,3] The following points can help reduce neck and spine strain:
  - Lighter the indirect ophthalmoscope, the better.
  - Adjusting the patient position and couch position is preferred to the examiner adopting unnaturally extreme neck and spine postures.
  - I/O with patient sitting is ergonomically ominous. So it is better to limit sitting I/O to quick screening purposes only.
- **Arm and Hand Friendly Practices**
  - Do not habitually lean elbows on hard surfaces during clinical procedures or in the office.
  - Take care to consciously bring the palms, wrists, and forearm in a straight line parallel to the floor whenever possible while sitting.
  - While using the system, adjust chair, table, monitor, key board and mouse to attain the ideal ergonomic position described earlier.

## IN THE OPERATION THEATRE (OT)

- **Seating:** Use a comfortable, hydraulic chair with low back rest and no arm rests. The backrest should be small and

positioned at the lumbar spine. This forces the surgeon to sit up straight ensuring that both the lumbar spine and the neck is poker straight. A straddle chair, which is a style of seat that forces the back into a better posture, is an increasingly popular option.

- Foot pedals may be kept on a sturdy rise of appropriate height to avoid dangling feet stretching to touch the footswitch.
- **The microscope**[4]**:** Ensure that your neck is never bent during surgery. Operating microscopes have tiltable oculars, enabling the surgeon to look forward as he works, rather than down. An angle of 20–30 degree is desirable between objective and oculars to maintain the correct posture with straight neck and spine.
- Practice an ERGO CHECK mandatorily at the beginning of each case: Adjust OT seating, table, and equipment first to ensure a straight spine, neck, knees at 90 degrees, thighs parallel to floor and foot resting flat on the floor.
- Surgical loupes which are often used especially in oculoplastic procedures can be quite heavy. Microscope is an ergonomically better option.
- **Heads up surgery**: It is a stereoscopic high-definition visualization system, which displays the surgical field of view in real-time on a 3D flat-panel display. It offers proven ergonomic benefits to the surgeon.[5]

## IN A NUT SHELL

- Avoid long hours of neck flexion and bending the back.
- Avoid slouching at the slitlamp, always move the patient closer to you, than lean forward.
- During I/O: Adjust the couch/chair/head of the patient, supple the neck of the patient – make the patient's head move as needed.
- While operating, the ocular must be moved 20°–25° toward the surgeon so that the surgeon can sit straight.
- Relax and stretch your muscles during short work breaks[6] – Do not build up muscle tension.
- Improve knowledge, attitude, and practice of ergonomics in ophthalmology. Resources like the online course encompassing the best practices in work place ergonomics offered by The American Academy of Ophthalmology task force[7] can be helpful.
- Invest in ergonomic spaces, furniture, and surgical tools because in the long run, ergonomics can prove more important than short term economic gains.

## MSD RED FLAGS AND WHAT NEXT

- Persistent muscle soreness and mobility restriction are red flags, which should not be normalized.
- Do not ignore, DO NOT SELF TREAT.
- Physiotherapists can help with stretch exercises and neck support, but exclude structural problems by an orthopedic consultation/evaluation
- Do not shy away from treatment/surgery if needed, because of the concern that it might affect your routine and practice.

## THE MSD PROBLEM: CAN OPHTHALMOLOGISTS BE PART OF THE SOLUTION?

We adjust our bodies to the design of the machine we use when, in fact, it should be the other way around.[8] Machines are meant for the people who use them. As ophthalmologists, we are the prime stake holders, who will benefit from the development of ophthalmic instruments with ergonomic designs and hence, must get involved in developing solutions. We can identify modifiable design interventions needed in ophthalmic instruments that could help reduce MSD and provide inputs to the biomedical industry to develop and market such ergonomic designs. An example of such an innovation is The Third-I Camera tool[9] with software, developed by Aurolab, which avoids the need to lean forward on the slitlamp and facilitates straight posture of the back and neck. Ophthalmic entrepreneurs could also invest in, encourage and consciously create a market for ergonomic equipment because, ultimately, it is demand for such designs that will drive supply.

## CONCLUSION

Ophthalmologists of all ages are at higher risk for work related musculoskeletal disease. Hence, knowledge, awareness and practice of ergonomics is the need of the hour for every ophthalmic practitioner to maintain musculoskeletal health. Ergonomic practices, healthy posturing, body friendly work space/equipment design, prophylactic stretch exercises and prompt medical attention can prevent chronic MSD morbidity. By providing constructive inputs to the biomedical industry, Ophthalmologists can contribute in the evolution of ergonomic instrumentation designs that can minimize this work-related health hazard.

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# Periorbital aesthetic surgery

## INTRODUCTION

The face receives maximum attention, when it comes to identity and as a sign of youth. Among the facial features, the periocular region is often a candid indicator of the age. Periorbital aesthetic concerns although global, often have certain specific ethnic considerations in each continent or country.

Ophthalmologists are often consulted for periorbital concerns, such as eyelid bags, dark circles under the eye, wrinkles around the eye, and under-eye hollows. The oculoplastic surgeon, and the astute ophthalmologist is therefore an integral part of this service provider team. There is an increasing trend to seek non-surgical cosmetic corrections for aging changes, as well as to enhance looks.[1] Moreover, many of the complications that arise out of these therapies lie in the purview of Ophthalmology.

In this chapter, we describe the relevant periorbital anatomy, and discuss the four commonest cosmetic considerations in the periorbital region, namely wrinkles, hills and valleys, hyperpigmentation, and dermatochalasis.

## FUNCTIONAL PERIORBITAL ANATOMY

To give aesthetically and functionally pleasing results, it is important to know the dynamic and functional anatomy of the periorbital region. The *eyebrow* is normally at the level of the superior orbital rim in men and above it in women. The male eyebrow is rather flat, whereas the female eyebrow arches higher laterally. The *upper eyelid crease* is a critical surgical landmark and is formed by the cutaneous expansion of the levator aponeurosis. Table 1 summarizes the differences between upper eyelid anatomy in the Asians (Oriental) and non-Asians (Caucasians). The eyelid crease is generally 7–8 mm above the lid margin in females, and slightly lower in males.[2] The *Eyelid fold* is formed by the preseptal skin and orbicularis muscle that is draped over the upper lid crease. The *Orbital septum* extends 360 degrees from the orbital rim, to fuse with the levator aponeurosis, outer tarsal borders, and canthal ligaments. In the oriental eyelid, the septum is inserted low, and has implications in cosmetic lid surgery.[3] The *Orbital* fat is contained within the orbit by the orbital septum.[4] The upper lid has two fat pads (medial and central), with the lacrimal gland occupying the lateral position. The lower eyelid has three fat pads (medial, central, and lateral). The inferior oblique muscle originates from the anterior medial orbital floor and separates the medial and central fat pad. A fascial lateral extension of the sheath of the inferior oblique inserts on the anterior lateral orbital rim and separates the central from the lateral fat pad.[5] The *lower lid crease* is not as prominent as the upper and is formed by the cutaneous insertion of fibers from lower eyelid retractors. It is usually 2 to 3 mm below the medial eyelid margin and 5 to 6 mm below the lateral eyelid margin.[5]

The junction of lower eyelid and the cheek is defined by two skin folds.[5] The *nasojugal fold* runs from the medial canthus down towards the mid-cheek, and the m*alar fold* runs from lateral canthus towards the mid cheek. The lower eyelid retractors fuse with the *orbital septum* approximately 5 mm inferior to their insertion on the tarsal plate.[6] The medial

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fat is paler and denser than the central fat pad. The lateral canthal angle is more acute than the medial canthal angle. It is normally 2 mm superior to the medial canthal position.

The concept of "negative vector" plays an important role in lower lid treatments. This assesses how far anteriorly the eyeball is placed in relation to the inferior orbital rim. In most patients, a line dropped vertically from the cornea touches the inferior orbital rim. In patients with a negative vector, the inferior orbital rim falls posterior to this line.[6] These patients may be at risk for lower lid retraction or hollowed-out appearance post blepharoplasty. Patients of African ethnicity may have genetically prominent eyes, and therefore a pre-existing negative vector. With this background let us now discuss the four commonest cosmetic considerations in the periorbital region: wrinkles, hills and valleys, hyperpigmentation, and dermatochalasis.

## PERIOCULAR WRINKLES

Dynamic periorbital wrinkles are caused by contractions of the underlying muscles. Botulinum toxin can relax the muscle underneath, thereby reducing the overlying wrinkle, to provide a younger look.[7]

### Crow's feet

Crow's feet are fine or coarse rhytids (wrinkles) originating from the lateral canthus and project outward in a fan-like distribution. They are most prominent during the "dynamic" state of smiling or squinting. With age, they may turn into static lines. Several factors accelerate the development of crow's feet, including sun exposure, smoking, lack of sub- cutaneous fat, and redundant skin.

An assessment of crow's feet should be performed at rest, while the patient is smiling. Four types of Crow's feet rhytids were identified by Kane[8] A dose of 5–15 units of Botulinum toxin type A can be injected per side, subcutaneously, about 1 cm lateral to the lateral canthus [Figure 1]. Dose can be altered based on gender, muscle function, and extent of wrinkles. Injection given above the canthal line is close to the lacrimal gland, and can induce dry eye in patients with reduced tear secretions.[9] Similarly, injection given too low to the lateral canthal line can weaken the zygomaticus major, thereby causing smile asymmetry.

**Table 1: Anatomic differences between Caucasian and Asian eyelids**

| Anatomic feature | Caucasian eyelid | Asian eyelid |
|---|---|---|
| Preseptal fat pad location | Preseptal | Preseptal and pretarsal |
| Septum–levator fusion point | Above tarsus | As low as pretarsal plane |
| Tarsal height | 9–10.5 mm | 6.5-8 mm |
| Medial lid crease origin | Medial eyelid | Medial canthus |
| Presence of crease | 100% | 50% |

### Horizontal forehead lines

The frontalis muscle is responsible for raising the eyebrows and upper eyelids. This action, over time, results in the development of horizontal forehead lines. Initially dynamic in nature, these lines can become static with age. A dose of 10–20 units of Botulinum toxin for women, and 20–30 units for men is recommended for forehead wrinkles [Figure 2].[7] The injections are placed in two rows, starting at least 2 cm above the orbital rim, to avoid brow ptosis. Side-effects include brow ptosis and blepharoptosis.

### Glabellar frown lines

The glabellar frown lines are caused by the two corrugators supercilia muscles placed horizontally, and the procerus muscle placed vertically. They collectively pull the brow medially and downward. The corrugator supercilii are two sets of horizontally oriented muscle that lie beneath the medial eyebrow, extending outward to about the mid-pupillary line. The procerus is a vertically oriented muscle that lies in between the eyebrows. The glabella is typically treated with five injection sites with a dose of 20–30 units for women, and 30–40 units for men [Figure 3].[7] Personal anecdotal experience suggests that unlike the west, the Indian patient wants only a reduction in action rather than complete akinesia. Side-effects include brow ptosis and blepharoptosis.

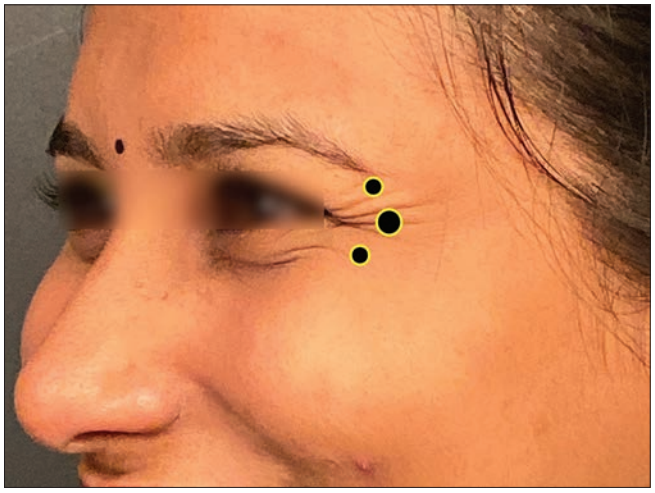


**Figure 1: Sites for Botulinum toxin injection to treat crow's feet. Usually, one injection 1 cm lateral to the lateral canthus in the subcutaneous plane is enough (5–10 units of Botulinum toxin Type A). Additional sites above or below this canthal line can be added based on the extent of the wrinkles**

### Brow contouring

Apart from wrinkles, Botulinum toxin is also used for facial contouring by altering the balance between two facial muscles. For example, the brow can be reshaped by relaxing the frontalis muscle in the midline, and relaxing the orbital part of orbicularis oculi superolateral to achieve a laterally arching eyebrow.

## PERIOCULAR HILLS AND VALLEYS

The soft tissue contour changes around the eye are best described as hollows and elevations. Hollows require fillers or fat whereas elevations may require excision where there is an apparent excess. These can be best understood as valleys (hollows) or hills (bags) and are more applicable to the lower lid aging changes.[10]

### The valleys

Starting from eyelid margin downwards the valleys include the eyelid crease hollow, tear trough, and the zygomatic hollow [Table 2].

#### *The eyelid crease hollow*

The eyelid crease hollow is formed by the cutaneous attachment of the lower eyelid retractors and represents the surface marking of the lower border of the tarsus. It is less prominent than the upper eyelid crease, and is bound superiorly by the pre-tarsal orbicularis roll, and inferiorly by the orbital fat prolapse.

#### *Tear trough or the orbital rim hollow*

The tear trough hollow is an important feature of eyelid and midface aging. It is a depression along the medial lower eyelid, just lateral to the anterior lacrimal crest and limited inferiorly by the orbital rim.[10] This region corresponds anatomically with the location of the lacrimal sac, hence the term "tear trough".

Tear trough hollow can result from several factors, including loss of subcutaneous fat, thinning of the skin over the orbital rim ligaments, and descent of the cheek. Partial bony resorption of the underlying orbital rim also contributes. While the term "tear trough" would be more appropriate for the younger age group (where it is not an aging change), in the older age group it is aptly termed as orbital rim hollow.

*The Orbital rim hollow* corresponds with the location of the orbital rim or orbitomalar ligament. Medially, it is synonymous with the "tear trough." Laterally, it follows the circular contour of the inferior orbital rim. In the mid-pupillary line, overlying the infra-orbital foramen, the orbital rim hollow widens into a triangular pit.

#### *The zygomatic hollow*

It corresponds to the location of the orbitozygomatic ligament. It lies along the origin of the levator labii superioris and zygomatic major and minor muscles. The zygomatic hollow is bound by the triangular malar fullness above and by the lateral cheek fat below.[10]

#### *Significance of the valleys*

The *eyelid crease hollow* is an important landmark of diagnostic significance. It helps differentiate the two hills that are later described in this article: orbicularis roll (which lies above it), and fat bag (which lies below it). It does not require treatment.

Amongst all the valleys, the *tear trough* (orbital rim hollow) receives the maximum attention with respect to treatment modalities. Hyaluronic acid fillers, and autologous fat transfer are the two commonly employed techniques to fill this valley [Figure 4]. Several commercial preparations of Hyaluronic acid fillers are available, along with recommendations for use.[11] For fillers as well as botulinum toxin, we now have consensus recommendations that are

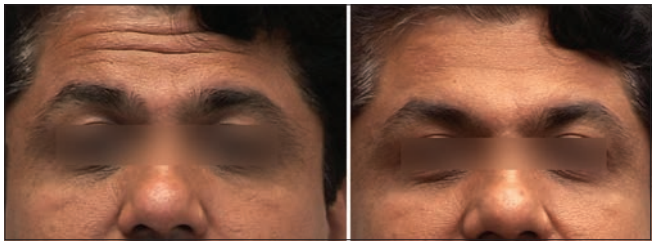


Figure 2: Pre and Post Botulinum toxin injection photographs showing reduction in dynamic horizontal forehead lines

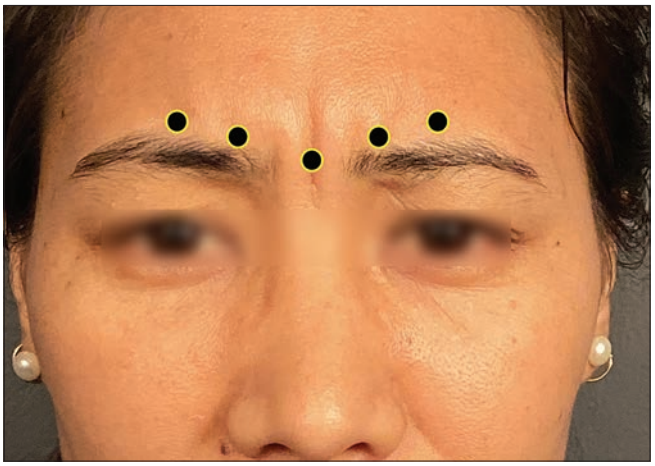


Figure 3: Botulinum toxin type A 25 units injected at five sites for the treatment of glabellar frown lines. Central point between the two eyebrows is for procerus muscle, injected superficially. Two more points on either side, for the corrugator. The lateral most point reaches mid-pupillary plane to target the tail of corrugator. Corrugator injections are placed deep, staying above and beyond the orbital rim

specific for Indian patients.[12] In majority of cases, fillers are required in the medial half (medial to the mid-pupillary line). One of the widely discussed and grave complication of filler injection is 'blindness' caused by retrograde migration of the filler particles, thereby causing central retinal artery occlusion.[13] It is important for ophthalmologists and aestheticians to be aware of this complication.

The *Zygomatic hollow* receives attention with respect to the filling of the malar volume loss. Filling the zygomatic hollow along with the tear trough restores the malar volume and thereby the malar prominence.

### *Brow deflation*

An important area of "volume loss" (can be considered as a valley) in the upper eyelid is the loss of brow fat pad. This is most apparent in the central and lateral region, and often leads to an appearance of 'pseudo-dermatochalasis' [Figure 5].

### The Hills'

Starting from eyelid margin downwards the lower eyelid hills, include the prominent orbicularis roll, orbital fat/fluid bag, and triangular malar mound [Table 3].[10]

### *Prominent orbicularis roll*

The pre-tarsal lower eyelid orbicularis roll can be excessively prominent in few, causing a cosmetic concern. It becomes more prominent when the orbicularis contracts during facial expressions such as smiling, leading to near complete closure of the palpebral aperture of the eye.

**Table 2: A simplified classification of the Hills and Valleys of the lower eyelid**

| Valleys | Hills |
|---|---|
| Tear trough (Orbital rim hollow) | Orbicularis roll |
| Eyelid Crease Hollow | Orbital fat prolapsed (Fat bag) |
| Zygomatic hollow | Fluid bag |
| | Triangular Malar Mound |

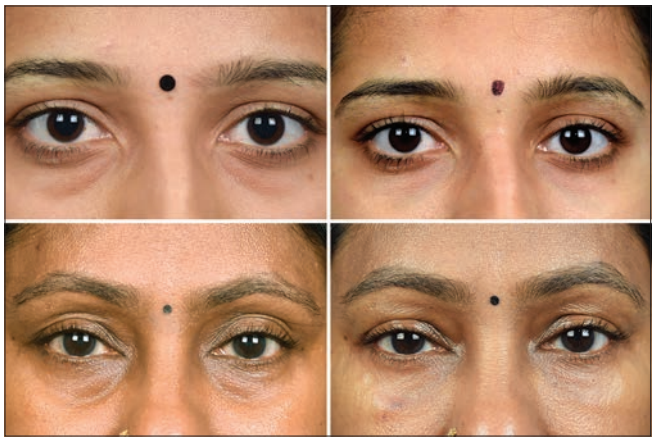


**Figure 4: Tear troughs are under-eye hollows that can make a person look old or tired. Hyaluronic acid filler was used to fill the hollow. Note the improvement in the apparent pigmentation caused by the shadowing effect**

### *Orbital fat prolapses*

This could be considered as the commonest lower lid "hill" that presents to the ophthalmologist. Orbital fat prolapse is bound superiorly by the eyelid crease hollow, and inferiorly by the orbital rim hollow.[10] The fat lies in a deeper plane, behind the orbital septum. The orbital fat seems more prominent with advancing age, and with upgazed. It appears to reduce on downgaze.

### *Fluid bag or festoons*

Fluid bag in the lower eyelid can mimic fat prolapse, and it requires experience to differentiate the two [Table 2]. Fluid bag is in the sub-cutaneous plane, is bound superiorly by the eyelid crease hollow, but need not be bound inferiorly by the orbital rim and may extend beyond it.[10] It also does not show the typical compartmentalization like fat bags and appears the same in upgazed and downgaze [Figure 6]. Fluid bags can have a bluish hue, and may be worse in morning hours, during the menstrual period, or even after a salty meal. Rarely, orbital fat and fluid may coexist.

### *The triangular malar mound*

The triangular malar mound or malar festoon is a fluid bag located inferolateral to the orbital rim.[10] It is bound above by the orbital rim hollow, and below by the zygomatic hollow [Figure 7]. Prominent triangular malar mounds often run in families and can be variable. It is often more prominent in patients with thyroid disorder due to the increased fluid retention in this region.[14] It may also have an allergic component. With loss of skin elasticity, the malar mound can become an actual festoon.

### *The significance of the hills*

For the prominent orbicularis roll, an injection of 1–2 units of Botulinum toxin type A into the pre-tarsal orbicularis in the mid-pupillary plane is the best option. *Orbital fat prolapse* requires conservative fat removal or repositioning and is the surgically most amenable "hill" in the lower



**Figure 5: Pseudo-dermatochalasis caused by mild loss of brow fat pad (a). The apparent skin fold disappears (b) after filler injection into the brow fat pad, thereby avoiding a blepharoplasty**



**Figure 6: Differentiating lower eyelid fat bags (a–c) from fluid bags (d–f). Note the compartmentalization of the fat bags (a), increase in upgaze (b), and decrease in downgaze (c). Fat bags are bound inferiorly by orbital rim hollow. In comparison, a fluid bag is not compartmentalized, has indistinct borders, does not change much with gaze and may not always be restricted by orbital rim hollow (d–f)**

**Table 3: Differentiating features between lower eyelid fat bag and fluid bag**

| Features | Fat Bag | Fluid bag |
|---|---|---|
| Variability | Constant (increases slowly over years) | Variable from day to day |
| Upper limit | Septal confluence hollow | Septal confluence hollow |
| Lower limit | Orbital rim hollow | Maya extends beyond orbital rim hollow |
| Contour | Compartmentalized into central, medial, and lateral fat pads | Single, smooth contour |
| Changes with gaze | Increases in upgazed; decreases in downgaze | Similar in all gazes |
| Anatomic location | Orbital (behind orbital septum) | Sub-cutaneous (anterior to the septum) |
| Treatment | Fat excision or repositioning | No effective treatment available |

eyelid.[15] Fluid bag and triangular malar mounds are primarily areas of fluid retention, and difficult to treat. Several non-invasive, injectable, and surgical options are available for the treatment of malar fluid bags.[16,17] When using hyaluronic acid fillers for the orbital rim hollow, patients with triangular malar mounds should be preferably avoided or injected deep, since the gel can imbibe more fluid, and look unnatural.

### *Customized approach*

The volumetric changes in the lower eyelid commonly present as a hill, a valley, or a combination of the two. It is useful to first establish an anatomic definition for the patient's symptom of "tired look." Is it the fat bag? Or is it the orbital rim hollow? Evaluating old photographs of the patient often helps understand chronological changes in the anatomy. It is always helpful to "rewind" the years by addressing the recent findings (fat or hollow), rather than give a new look to your patient.

## THE DARK CIRCLES (PERIOCULAR HYPERPIGMENTATION)

Periorbital hyper pigmentation or "dark circles," is another common cause of an aged or tired appearance. Under eye hyperpigmentation has both anatomical, internal, and environmental causes.[18] Often the cause is multi-factorial.[19,20]

Eyelid skin is the thinnest in the body and does not have fat under it. This allows fine blood vessels (capillaries) and eyelid muscle fibers to be almost "seen through," thereby giving a reddish-blue color to the skin. Compare it to the lighter color of the cheek skin, which is thicker, and has fat underneath it. Reduced sleep can lead to dilatation of these vessels, thereby increasing the "shade" of under-eye darkening.

The pigment in the skin around the eyes (Melanin), may increase due to eye allergy, a hormonal influence on pigment cells, or a reaction to a topical cream or medication. Moreover, Indian skin is overall more pigmented, making these contrasts even more striking. Lifestyle-related causes include sun exposure, inadequate sleep, overuse of alcohol and smoking.

Sometimes, the lower-eyelid contour can make it appear "darker." For example, the dark shadows will be more obvious in the presence of lower-eyelid fat bags or a hollow.

Fluid accumulation within the thin lower eyelid skin is another cause of under-eye hyperpigmentation. Systemic causes include heart, kidney and liver disease, Addison's disease, and circulatory disturbances that lead to fluid retention in the body. Post-inflammatory hyper pigmentation may also occur in patients with eczema or atopy.

The natural reasons why eyelid skin looks darker cannot be eliminated, but some remedies can be suggested. Sun



Figure 7: Pre-malar edema (asterix) with active fluid festoon (a). Chronic partially collapsed fluid festoon in patient with thyroid eye disease (b). Note the classic eye signs of thyroid eye disease

protection with the use of physical and chemical sunscreens is important in the prevention of dark circles. Good hydration thickens the eyelid skin, thereby making it less "transparent," and cold compresses help reduce the caliber of the blood vessels that are seen through the thin skin. Adequate sleep (minimum of 8 hours) would ensure that the under-eye skin looks healthy.

Next, we need to target excessive pigment in the skin. The first step is to address any obvious precipitating cause if it can be identified, for example eye allergy, or an uncorrected/changed spectacle correction. Certain under-eye creams can reduce the pigment production within the skin cells and can effectively reduce these dark areas. Hydroquinone is the best when it comes to skin lightening creams. It is recommended to use them only under the direct supervision of a dermatologist. Non-invasive methods such as the use of Intense Pulsed Light (IPL) and Q-switched lasers work by targeting the excess pigment and vascularity, reducing hyper pigmentation. However, in the Indian skin, they are of limited value, considering the risks of post-inflammatory hyper pigmentation.

Lastly, the dark circles caused by the hollows and fat bags under your eyes. These contour changes increase the dark circles by creating a shadowing effect. It requires removal of the eyelid bags, or filling of the hollow with fillers.

In summary, good hydration, treatment of any eye allergy, skin lightening creams, and effective treatment of under-eye contour changes (bags and hollows) can reduce the dark circles significantly.

## DERMATOCHALASIS AND BLEPHAROCHALASIS

Excess eyelid skin is a slow aging change. In the upper lid, it overhangs the eyelid margin. In the lower eyelid, it may appear as excessive static wrinkles. Treatment may be required both for functional as well as aesthetic reasons. Upper eyelid blepharoplasty is most commonly performed for "dermatochalasis" that represents excessive, overhanging inelastic upper eyelid skin due to aging. Blepharochalasis on the other hand represents excessive papery thin skin in the upper eyelid in young patients due to repeated episodes of edema and can also benefit by blepharoplasty. Less frequently, extensive upper eyelid xanthelasma may require a "blepharoplasty-like" excision.

### Preoperative evaluation

Preoperative patient evaluation for blepharoplasty should document medical and ocular evaluation. In addition to a complete eye examination, the evaluation of the periorbital area should consider skin quality and quantity, underlying 3-dimensional soft-tissue contours and the bony skeletal support. Ophthalmologic history should be obtained including vision, corrective lenses, allergic reactions, excess tearing, and dry eyes.

### Blepharoplasty surgery

Blepharoplasty may be performed under local or general anesthesia depending upon the surgical plan, patient preference and need for concomitant operations. A simple upper or lower eyelid blepharoplasty can be performed under local anesthesia.

*Upper eyelid blepharoplasty* universally involves removal of excess skin. Minimum 20 mm of vertical lid height should be preserved for normal eye closure. Other modifications during an upper blepharoplasty include conservative fat sculpting, reattachment of levator muscle if disinserted, lateral canthoplasty, and fixation of prolapsed lacrimal gland.

A standard upper blepharoplasty involves only skin removal, with preservation of underlying orbicularis muscle and orbital soft tissue. Skin is excised above the supra-tarsal fold. This retains most of the definition of the existing lid fold and gives an aesthetically enhancing result [Figures 8a and b] without "post-surgery appearance" or hollowed out orbit.

*Anchor (invagination) blepharoplasty*: It involves creation of upper eyelid crease by attaching the eyelid crease skin to the underlying levator aponeurosis. An anchor blepharoplasty




**Figure 8: Upper eyelid blepharoplasty. Preoperative appearance (a) and three months post-operative appearance showing a well-defined lid fold (b). Upper eyelid anchor blepharoplasty in an oriental eyelid. Preoperative appearance (c) and final post-operative appearance after 3 months showing a well-defined eyelid fold (d)**

includes minimal excision of the skin (2–3 mm), a strip of orbicularis (1–2 mm), and pretarsal fatty tissue. Anchor sutures are placed connecting the pretarsal skin to the aponeurosis. This technique is also used with some modification in the creation of eyelid fold in oriental eyelids, also popularly called as double eyelid surgery [Figures 8c and d].

Any excess orbital fat may be safely excised through an upper eyelid blepharoplasty incision, most required medially. Overall, under-correction is preferred to prevent hollowing.

*Lower eyelid blepharoplasty* can be performed in two ways: transcutaneous and transconjunctival. The transconjunctival approach leaves no external scar and reduces the chances of eyelid retraction, scleral show and postoperative ectropion than transcutaneous method.[21,22] The transcutaneous approach is preferred if there is excess skin that requires excision.[23] With the newer skin-tightening modalities available for the eyelid skin, the transconjunctival approach is most popular.[21] Transconjunctival lower lid blepharoplasty is often performed under local anesthesia. An incision is placed through the conjunctiva with a radiofrequency monopolar cautery or $CO_2$ laser. Gentle pressure on the eyeball prolapses the fat compartments, and the medial, central, and lateral fat pads are removed. The tarsoconjunctival incision heals by epithelization without any sutures. Excellent aesthetic outcome is achieved in most cases. Lateral canthopexy can be combined along with lower eyelid blepharoplasty.

## TRANSCUTANEOUS LOWER LID BLEPHAROPLASTY

Transcutaneous lower lid blepharoplasty is chosen when excess skin or orbicularis needs to be excised along with the prolapsed fat [Figure 9]. In the Caucasian patients, excess of



**Figure 9: A middle-aged patient with upper eyelid dermatochalasis, left upper eyelid ptosis, excess lower eyelid skin, and lower lid fat bags (a). The excess skin in lower eyelid warrants an anterior approach to lower eyelid fat. He underwent a transcutaneous quad-blepharoplasty with conservative fat excision, and left Müller muscle conjunctival resection for ptosis (b). Appearance on day seven postoperative (c), and 3 months postoperative (d)**

vertical skin in lower lid can be dealt with skin resurfacing techniques such as fractional laser resurfacing. In Indian skin however, laser resurfacing can lead to post-inflammatory hyper pigmentation, and hence a "skin pinch" technique to remove the skin and is ideal in such a case.

## CONCLUSION

The periocular region is the first to reveal aging changes on the face. Optimal use of botulinum toxin and fillers to enhance the periorbital and facial aesthetics is an art and science. The treatment of periocular hyperpigmentation is predominantly in the dermatologist's purview, and ophthalmologists play a limited role in treating periocular hollows to reduce the shadowing effect. Upper eyelid blepharoplasty is performed for dermatochalasis or blepharochalasis, and predominantly involves skin excision. Lower eyelid blepharoplasty is commonly performed trans-conjunctively, but can be done via anterior approach in cases of skin excess.

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### Conflicts of interest
There are no conflicts of interest.

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Review Article

# Can cornea be retrieved from poisoned donors? A focused narrative review


## ABSTRACT

Corneal opacity due to various inflammatory and infectious conditions is a leading cause of blindness globally. In India, microbial keratitis and injuries to the eye are major contributors to corneal blindness. Corneal transplant is the only therapeutic option available for these patients. Despite the pressing need for corneal transplants, the donor to recipient ratio remains low in our country. Concurrently, the World Health Organization reports around 193,000 annual deaths from unintentional poisoning, and suicide claims over 700,000 lives annually, with pesticide self poisoning accounting for about 30% of suicides. Given this context, understanding the viability of corneal retrieval from poisoned donors is crucial. This narrative review aims to analyze the demographic and clinical data of poisoned patients from whom corneas were retrieved. Additionally, the study seeks to evaluate the feasibility and outcomes of corneal salvage in these cases. PubMed, Scopus, Web of Science, Google Scholar, and ProQuest were searched using the search string: (corneal donation OR corneal retrieval OR corneal transplant OR keratoplasty) AND (poisoned donors OR envenomation). Only English language studies that included real patient data were considered for inclusion, in accordance with the SANRA guidelines. The result of this narrative review shows that corneas are typically not retrieved from poisoned donors for transplant purposes due to the concerns about toxin transfer to the recipient, despite the cornea's immune privileged status. A total of seven studies were included in the review (four case reports, one case series, two original research papers). The mean age of the donors was ≈ 41.08 years, the male: female ratio was 7.74:1, and the average success rate was 77.5%. The studies have shown successful corneal transplants from donors poisoned by substances like organophosphates, paraquat, cyanide, methanol, and snakebite venom. In conclusion, the evidence from existing studies suggests that corneas from poisoned donors can be safely utilized for transplantation without the risk of toxin transfer. Despite the systemic toxicity of various poisonous substances, corneal tissue frequently remains suitable for transplant purposes. However, further research is essential in the field of transplant toxicology to investigate the effects of different toxins on corneal tissue. Additionally, comparative studies examining the outcomes of transplants using corneas from poisoned versus non-poisoned donors are necessary to enhance our understanding of this issue.



**Keywords:** Corneal retrieval, corneal transplantation, keratoplasty, poisoned donors, transplant toxicology


## INTRODUCTION

Corneal opacity is the fifth leading cause of blindness worldwide, resulting from various inflammatory and infectious diseases that cause corneal scarring. In India, microbial keratitis and injuries to the eye are major contributors to corneal blindness.[1,2] Corneal transplants are the only treatment option, but the low donor-to-recipient ratio remains a significant challenge. Suicide ranks among


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the top causes of death worldwide, claiming over 700,000 lives annually.[3] Pesticide self-poisoning is responsible for about 20%–30% of these suicides, especially in rural agricultural areas. The World Health Organization (WHO) estimates that around 193,000 people die each year due to unintentional poisoning.[3] Some other studies indicate that annually, approximately 258,234 deaths result from pesticide self-poisoning, constituting around 30% of all suicides.[4,5]

## OBJECTIVES AND METHODOLOGY

This narrative review aims to (1) analyze the demographic profiles and clinical data of poisoned patients whose corneas were retrieved and (2) evaluate the feasibility and outcomes of corneal salvage in cases involving deceased poisoned donors. PubMed, Scopus, Web of Science, Google Scholar, and ProQuest were searched using the following string: *(corneal donation OR corneal retrieval OR corneal transplant OR keratoplasty) AND (poisoned donors OR envenomation).* The review included all types of English-language studies that contained real patient data. Studies addressing both exclusive corneal donation and corneal donation alongside other solid organ donations were included for analysis. Studies not published in English and very old articles that were not digitally archived and/or remained inaccessible were excluded. This study adhered to the Scale for the Assessment of Narrative Review Articles (SANRA) guidelines.

## RESULTS

A total of seven studies were included in the review (four case reports, one case series, two original research papers). The mean age of the donors was ≈41.08 years, the male: female ratio was 7.74:1, and the average success rate was 77.5% [Tables 1 and 2].

In the studies included in this review, it was demonstrated that corneas were retrieved from individuals poisoned by various substances, including methanol, paraquat, organophosphate compounds, snake bites, brodifacoum, secobarbital, ethyl alcohol, phenobarbital, butalbital, salicylate, cyanide, carbon monoxide, diazepam, amobarbital, and propoxyphene. Acute

**Table 1: Studies in which corneas were retrieved from poisoned donors**

| First Author | Country | Year of publication | Type of Study | No. of Donors | Age in years/Gender | Type of Poison/ Venom | No of corneas retrieved | Outcomes | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| Matitiahu Lifshitz *et al*.[6] | Israel | 2000 | Case report. | 2 | 52/M, 40/M. | Methanol | 4 corneas were retrieved, all were utilized. | Successful No rejection. | R1a- VA 20/30 R1b- VA 20/60 R2a- VA 20/30 R2b- VA 20/60 |
| Tsung – yu Tsai *et al*.[7] | Taiwan | 2011 | Case report. | 1 | 27/M | Paraquat | 2 corneas were retrieved, all were utilized. | Successful No rejection. | Visual acuities of the recipients were satisfactory. |
| P.K. Baslp *et al*.[8] | Canada | 2013 | Case series. | 9 | 50/M,36/ F,56/M, 49/M,50/ F,50/M, 27/F,25/ M,31/F, | Secobarbital, ethyl alcohol, phenobarbital, butobarbital, salicylate, cyanide, CO, diazepam, amobarbital, propoxyphene. | 14 corneas retrieved; all were transplanted | 10 grafts successful 4 grafts failed. | 10 clear grafts, the post operative vision improved in all 10 clear grafts. |
| Pragnya Rao Donthineni *et al*.[9] | India | 2019 | Original Research (Retrospective observational) | 30 | 30.4 +/-17.5 (range of 6–60) years, M:F=3.28:1 | Cobra or krait (neurotoxic) in 4 (13.3%) Vipers (hemotoxic) in 2 (6.6%) and 24 (80%) unknown envenomation. | 38 corneas were retrieved 28 were utilised. 10 were not utilised. | 21 successful 7 grafts failed. | About 75% showed clear graft, visual acuity improved. None of the corneas showed any complications or adverse events following transplantation and hence were considered safe for transplantation. |
| Swapna Sarangi *et al*.[10] | India | 2021 | Original Research (Retrospective, observational) | N/A | 38.8+/-16.5 (range of 6–60) years, M:F=285:195 | Organophosphorus compounds (OPCs) | 478 corneas were retrieved, 121 utilised. Data of remaining corneas were not available. | 23 successful grafts | 23 patients have best corrected visual acuity of 20/60. Percentage of recipients with VA 20/60 is 69.7% |

M-Male F-Female R1a- Recipient 1a, R1b- Recipient 1b, R2a-Recipient 2a, R2b- Recipient 2b. VA- Visual Acuity

**Table 2: Corneas retrieved from poisoned donors along with other solid organs**

| First Author | Country | Year of publication | Type of Study | No. of Donors | Age in years/Gender | Type of Poison/Venom | No of cornea retrieved | Outcomes | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| Bierman *et al*.[11] | United states | 1993 | Case report. | 1 | 38/M | Cyanide | 2 | Successful | The corneas remained thin and clear. |
| Ornstein DL *et al*.[12] | USA | 1999 | Case report. | 1 | 39/F | Brodifacoum | 2 | N/A | - |

M: Male, F: Female, N/A: Not available

exposure to these substances is generally not found to be toxic to cornea. The toxic effects of these substances in the context of cornea are briefly presented here for the sake of clarity.

In methanol-poisoned patients, it is metabolized to formaldehyde and formic acid, which causes histotoxic hypoxia by inhibiting the cytochrome oxidase complex of the mitochondrial respiratory chain. Formic acid is associated with retinal toxicity and metabolic acidosis. Allegedly, metabolic acidosis can disrupt the endothelial layer of the cornea. Early retrieval of corneas from deceased individuals can help prevent the detrimental effects of metabolic acidosis on cornea.

In paraquat-poisoned patients, cytotoxic effects lead to free radical formation, generating superoxide and causing cell death; paraquat is also a corrosive substance. Allegedly, direct contact with the cornea may result in epithelial damage, but systemic toxicity does not appear to affect the corneas.

In organophosphate poisoning, these compounds inhibit acetylcholinesterase, leading to an accumulation of acetylcholine and overstimulation of the nervous system. Corneal edema may occur, particularly if multiorgan dysfunction syndrome leads to hypoxia.

In envenomation due to snake bite, neurotoxic effects can occur, leading to paralysis and respiratory failure, while hemotoxic effects can cause coagulopathy and hemorrhage. Cardiotoxins, phospholipases, neurotoxins, and other venom components can disrupt the sodium–potassium ATPase pump and affect corneal health. However, for these effects to manifest, there must be pre-existing endothelial damage. The cornea typically remains unaffected by the systemic effects of envenomation. However, direct ocular exposure to venom can result in significant corneal injury or damage.

Carbon monoxide (CO) poisoning occurs when CO binds to hemoglobin with a higher affinity than oxygen, forming carboxyhemoglobin and leading to tissue hypoxia, cellular injury, and impaired mitochondrial respiration. Cyanide exerts its toxic effects by inhibiting cytochrome c oxidase in the mitochondrial respiratory chain, preventing oxygen utilization at the cellular level and resulting in histotoxic hypoxia. Barbiturates exert their effects by enhancing the activity of gamma-aminobutyric acid (GABA) at the GABA-A receptor, leading to increased inhibitory neurotransmission in the central nervous system, which can result in sedation, respiratory depression, and potential coma at high doses.

Salicylate toxicity occurs by inhibiting cyclooxygenase (COX) enzymes, disrupting prostaglandin synthesis, leading to acid–base imbalance characterized by metabolic acidosis and respiratory alkalosis. Diazepam toxicity results from gamma-aminobutyric acid (GABA) inhibitory effects at the GABA-A receptor, leading to increased neuronal inhibition and CNS depression. Ethyl alcohol toxicity arises from its competitive inhibition of glutamate at the N-methyl-D-aspartate (NMDA) receptor and its enhancement of GABAergic neurotransmission, causing CNS and respiratory depression.

The avascular nature of the cornea and its ability to derive oxygen directly from the atmosphere are two important reasons why the substances mentioned above generally do not cause significant toxic effects on the cornea.

## DISCUSSION

Corneas are not routinely preferred for transplant when retrieved from poisoned donors primarily due to the risk of transferring toxins or harmful substances to the recipient. Although the cornea is an immune-privileged site with a low risk of graft rejection, the presence of toxins could still cause complications or damage to the recipient's eye. The human cornea is made up of five layers (leaving aside the dua's layer), namely (from outer to inner), epithelium, Bowman's layer, stroma, Descemet's membrane, and the corneal endothelium. Although the effects of toxins on cornea are less discussed in clinical toxicology, eye ball is an important site of manifestation of toxicity in general (photophobia, mydriasis, miosis, depositions in avascular cornea/lens, toxins entering aqueous humor/vitreous humor). Hence, there is a good chance that several parts of the eye ball sequestrate, metabolize, or react to several toxins. Studies have also shown that vitreous humor can be used for toxicological screening when blood is unavailable.[13]

Aqueous humor is produced by the ciliary processes, which secrete the fluid into the posterior chamber of the eye. From there, it flows through the pupil into the anterior chamber. The aqueous humor then drains out of the eye through the trabecular meshwork, located at the angle where the cornea and iris meet. It collects in Schlemm's canal before being absorbed into the bloodstream. Although the cornea is avascular—except for small arcades that extend approximately 1 mm into the cornea at the limbus—toxins can still diffuse into the corneal endothelium from the aqueous humor, which is in contact with its posterior surface. The cornea relies on the diffusion of nutrients from the tear film at its surface and from the aqueous humor internally for nourishment.

The primary function of the corneal endothelium is to regulate corneal hydration by actively pumping ions, which counteracts the passive leakage of fluid into the stroma. The "pump-leak hypothesis" explains this process, whereby $Na^+$-$K^+$-ATPase (located on basolateral side facing aqueous) actively transports ions, driving water into the anterior chamber and balancing the passive leakage of aqueous humor into the stroma through intercellular junctions. Despite a decline in endothelial cell density (ECD) with age, the number of $Na^+$-$K^+$-ATPase pump sites remains relatively constant. The peak corneal endothelial cell density is reached before birth, at approximately 5000 cells/mm$^2$. ECD decreases by about 0.6% per year, and when it falls below approximately 500 cells/mm$^2$, fluid tends to accumulate in the corneal stroma, leading to swelling and loss of transparency. Other ions, such as lactate and bicarbonate (bicarbonate-dependent ATPase), along with $Na^+/H^+$ pump, are also involved in fluid transport and the maintenance of corneal hydration.

The corneal stroma, which constitutes the majority of the corneal structure, is naturally hydrophilic and tends to absorb water. However, excessive water absorption would cause corneal edema, leading to reduced transparency. The $Na^+$-$K^+$-ATPase pump regulates stromal hydration by moving sodium ions out of the endothelial cells and into the aqueous humor. This movement drives the secondary transport of water out of the stroma, preventing excess hydration and preserving corneal clarity. The corneal endothelium's barrier function is maintained by tight junctions composed of proteins such as claudins and occludins, including zonula occludens (ZO-1), as well as adherens junctions formed by cadherins and catenin. Once endothelium cells are destroyed by disease or trauma, they are lost forever. If too many endothelial cells are destroyed, corneal edema and blindness ensue, with corneal transplantation the only available therapy.[14]

Poisons that affect the cornea include methanol, which can lead to endothelial cell disruption, as well as acetone and drug-induced corneal deposits from overdoses of medications such as amiodarone, chlorpromazine, and rifabutin. Consumption of ethylene glycol may result in metabolic acidosis, leading to corneal opacity due to damage to endothelial cells. Chronic exposure to lead and mercury may also result in corneal opacity, but this is typically not a concern in the context of transplantation. Thallium poisoning can also lead to corneal edema. All heavy metals that exist as univalent cations can adversely affect the cornea to some extent by disrupting the function of the $Na^+/K^+$-ATPase pump. This disruption impairs ion transport, leading to altered stromal hydration and potentially compromising corneal clarity and function. Pesticides that can cause significant ocular toxicity include organophosphates, carbamates, herbicides, and fungicides, which can lead to opacification upon direct contact, corneal burns, and damage from exposure to the vitreous and aqueous humor. Oral consumption of organophosphates, hydrofluoric acid, and quinine can also affect the cornea.[15]

While no specific poisons are sequestered in the cornea, certain drugs such as cytarabine (a chemotherapeutic agent) can become sequestered, leading to microcyst formation. Amiodarone, used to treat cardiac arrhythmias, can cause vortex keratopathy, while chloroquine and hydroxychloroquine can cause corneal deposits. Long-term use of gold in the treatment of rheumatoid arthritis can lead to gold deposits in the cornea, and tamoxifen, used in the treatment of breast cancer, can also cause corneal deposits.[16]

Toxins that affect the $Na^+/K^+$-ATPase pump can exert toxic effects on the cornea. Some toxins, like cardiac glycosides (e.g., digoxin and ouabain), inhibit the $Na^+/K^+$-ATPase by binding to the pump. This disruption in sodium and potassium ion balance within corneal endothelial cells impairs corneal hydration and function. This results in impaired hydration, which can cause corneal edema, leading to clouding of the cornea and visual disturbances.[17]

Mercury compounds such as ethyl and methyl mercury bind to sulfhydryl groups of proteins involved in $Na^+$-$K^+$ ATPase pump, which could potentially inhibit their function, leading to cellular toxicity.[18] Lead inhibits ATPase enzyme by interfering with the binding of potassium and sodium ions, leading to dysregulation of ion transport and fluid balance in the cornea.[19] Vanadate acts as a potent inhibitor of the pump by binding to the ATP-binding site, preventing ATP hydrolysis and thus blocking the pump's ability to transport sodium and potassium.[20]

Snake venoms from families such as Elapidae (cobras, mambas) and Viperidae (vipers) contain components like cardiotoxins, phospholipases, and neurotoxins that can disrupt the sodium–potassium ATPase pump. The venom components can impair the pump's function, leading to corneal edema, and potential vision issues due to the ionic imbalance caused by the inhibition of the pump.[21]

Any toxin that causes severe dyselectrolytemia or increases levels of bicarbonate and lactate in the blood, such as carbon monoxide, cyanide, aspirin, methanol, and ethylene glycol, can be potentially hazardous to corneal clarity as they impact hydration. However, it is important to note that corneal edema can be reversible with appropriate treatment. While direct ocular exposure to these toxins tends to be more toxic, the systemic effects of many poisons are comparatively less severe, as reported in both literature and clinical practice. The Descemet's membrane is also known to be very resistant to chemical agents and toxins.

The blood-aqueous barrier, formed by the ciliary epithelium, selectively regulates the passage of substances from the blood into the aqueous humor. This barrier actively transports or excludes various toxins. Small, lipophilic molecules can more easily penetrate the barrier, while larger, hydrophilic molecules are typically restricted. Many agrochemical substances, such as organophosphorus compounds, have both lipophilic and hydrophilic properties. Since organophosphorus compounds are small and lipophilic, there is a significant risk of them crossing the blood-aqueous barrier.

The blood-retinal barrier, consisting of the retinal pigment epithelium and retinal capillary endothelium, regulates the entry of substances into the vitreous humor. This barrier is highly selective and limits the penetration of many toxins. However, if the blood-retinal barrier is disrupted due to disease or injury (could be the present toxic insult also), certain toxins can bypass it and accumulate in the vitreous humor. Once in the vitreous, these toxins can gradually diffuse into the aqueous humor and potentially become toxic to the cornea as well.[22]

Although the literature extensively describes the sequestration of certain poisons in the cornea and their effects on corneal hydration, the mechanisms underlying the elimination pathways of these substances from the cornea remain poorly understood. The role of metabolism in the cornea and the influence of transport proteins on the elimination of substances warrant further investigation, in addition to the examination of normal diffusion pathways.

It is important to recognize that most substances causing corneal toxicity exert their effects through chronic exposure. In clinical practice, however, corneas are typically procured from individuals who succumb to acute poisoning. Therefore, the mere fact of death due to poisoning should not, in itself, constitute a contraindication for corneal donation. According to the Eye Bank Association of America's (EBAA) Donor Screening Guidelines, important parameters for assessing the quality of donor corneas include several mandatory tests that must return negative or nonreactive results. These include tests for Anti-HIV-1, Anti-HIV-2, Hepatitis B Surface Antigen (HBsAg), and Anti-HCV.[23] The FDA also recommends additional testing, including an FDA-licensed screening test for anti-HIV-1 or a combination test for anti-HIV-1 and anti-HIV-2, as well as nucleic acid (NAT) tests for HIV-1 and HBV. Treponema pallidum testing for syphilis is also required.[24] The endothelial cell count of the donor cornea must be at least 2000 cells/mm$^2$. Ideally, corneas should be preserved within 8 to 10 hours of death.[25]

According to the EBAA, contraindications for corneal donation include conditions such as rabies, hepatitis B, hepatitis C, Creutzfeldt-Jakob disease, retinoblastoma, bacterial or fungal keratitis, bacterial or fungal endophthalmitis, HIV, herpes simplex virus, prion diseases, human T-cell lymphotropic virus, ocular adenocarcinoma, malignant tumors of the anterior segment, Reye syndrome, subacute sclerosing panencephalitis, progressive multifocal leukoencephalopathy, leukemias, active disseminated lymphomas, active infectious endocarditis, active septicemia, dementia, Down syndrome, congenital rubella, recipients of nonsynthetic dura mater grafts, prior refractive surgery, and neurological diseases of unknown cause.[25] It is pertinent to mention that there is no explicit bar on retrieving corneas from poisoned donors.

Law allows for only cadaveric corneal donation, and the corneas retrieved are transported in McCarey-Kaufman (MK), Cornisol, and Optisol-GS media and transplanted within 14 days. The parameters for assessing corneal viability are mentioned in Table 3.[26-28]

Preferred donor characteristics for corneal transplantation include ages between 2 and 70 years old (all the donors in the studies reviewed fall within this range). The cornea must be clear, without any edema or opacities. The indication for the recipient also plays an important role, with corneas used either as optical or therapeutic grafts. Surgical techniques such as full-thickness and lamellar keratoplasty have shown better outcomes. Postoperative care, including the use of immunosuppressants and topical steroids, is crucial to

**Table 3: Parameters for assessing corneal viability in general**

| Parameter | Normal Value/Finding | Critical Value/Finding |
|---|---|---|
| Specular Microscopy (Endothelial Cell Count) | 2,000–3,000 cells/mm$^2$ | Below 1,000 cells/mm$^2$ (unsuitable for transplant) |
| Pachymetry (Corneal Thickness) | 500–550 microns | Significant increase (indicates oedema) |
| Slit-Lamp Examination | Clear, no scarring or opacities | Presence of opacities, scarring, or ulceration |
| Vital Dye Staining (Trypan Blue, Fluorescein) | Minimal or no staining | Significant staining (indicates damaged cells) |
| Donor History and Medical Testing | No infectious diseases or systemic conditions | Positive for infectious diseases (HIV, hepatitis, etc.) |
| Storage Medium Evaluation | Proper storage, no contamination | Contamination or improper storage conditions |
| Corneal Clarity Assessment | Clear cornea | Cloudy or opaque cornea |

avoid graft rejection.[23] Common complications include graft rejection, astigmatism, and infection. The fundamental goals of corneal transplantation are to improve visual acuity and ensure graft survival.[26-28]

In the Indian context, agrochemical poisoning (such as organophosphate poisoning, paraquat, and rodenticides) and snakebite envenomation are quite common. The damage these substances cause to the cornea due to systemic toxicity is typically limited. However, direct topical exposure to these toxins can undoubtedly cause corneal toxicity, leading to symptoms such as irritation, corneal damage, or even ulceration if untreated. In severe cases of organophosphate poisoning, corneal edema may occur, particularly if multiorgan dysfunction syndrome results in hypoxia. Therefore, when considering corneas from individuals who have suffered from organophosphate poisoning or snakebite envenomation, it is essential to test corneal viability for transplantation even more rigorously than in typical cases.

Several studies reviewed in this narrative review are case reports or case series, with only two being observational studies. Importantly, none of the studies compared the outcomes of corneal transplants from poisoned donors with those from nonpoisoned donors. Both the retrospective observational studies,[9,10] while reporting successful outcomes, did not include a comparison group of nonpoisoned donors. Future studies with control groups are needed to determine if there are any differences in the outcomes of corneas transplanted from poisoned versus nonpoisoned donors.

Studies focusing on vitreous toxicology in autopsy cases of poisoning are crucial for providing stronger evidence to guide the retrieval of corneas from poisoned donors. These studies can help ensure that toxins from the donor do not compromise the recipient's corneal health or lead to post-transplant complications. Quantitative analytical chemistry data from such autopsies are particularly essential as they allow us to understand the concentration of specific toxins in blood or other body fluids that could affect corneal viability. Knowing these thresholds will enable transplant teams to make more informed decisions about which corneas are safe for transplantation. This data-driven approach is critical because it shifts decision-making from assumption-based to evidence-based, ensuring both safety and optimal outcomes in corneal transplants from poisoned donors. *In vitro* studies using human cell cultures also offer essential insights into the interactions between corneal cells and specific poisons, shedding light on the cellular and molecular mechanisms of ocular toxicity. This research is critical for developing evidence-based guidelines to ensure the safe use of corneal tissue from poisoned donors.[29] Toxin- or poison-specific parameters for the utilization of corneal tissue in transplantation are urgently needed. These can only be developed through *in vitro* studies and autopsy-based vitreous toxicology research, which provide essential insights into the effects of toxins on corneal viability. The aforementioned research is also extremely important in designing future prospective cohort studies and randomized control trials.

The current practice involves retrieving corneas from deceased donors after obtaining informed consent, followed by necessary testing. In the case of poisoned donors, corneas should be retrieved and tested for viability. If found unsuitable, they can be discarded; otherwise, they may be used for transplantation. This approach prevents the premature rejection of corneas from poisoned donors, recognizing the potential for successful transplant outcomes.

The timing of corneal retrieval from poisoned donors is an intriguing area of research. Early retrieval after death could potentially prevent the passive diffusion of toxins into the cornea. Additionally, modifying the technique of retrieval by reducing the adnexal scleral area of the corneal button may allow it to remain suitable for grafting while minimizing the scleral tissue width to reduce the toxic load on the cornea. Although it is beyond the scope of present review, it is advisable to have a robust counseling and motivation strategy to retrieve corneas as early as possible after death to increase their potential usage for transplantation.

Importantly, there are no explicit guidelines in ophthalmology that promote or prohibit the retrieval of corneas from

poisoned donors. Any toxicity affecting the cornea would be identified through the strict viability parameters established for transplantation. If all viability criteria are met, this indicates that no toxic damage to the cornea has occurred, and transplantation can proceed.

However, the issue of potential residual toxicity within the cornea and its impact on graft rejection remains a gray area that requires further investigation. Another key area of research is determining the optimal preservation timeline to minimize residual toxicity before transplantation. Additionally, improving storage media to function as detoxifying agents is an avenue worth exploring for enhancing the safety of transplants from poisoned donors.

Corneal transplants can be performed under regional anesthesia (either retrobulbar or peribulbar block) or general anesthesia, with no significant difference in outcomes between the two methods. Properly controlling intraocular pressure (IOP) is crucial to prevent intraocular prolapse and damage during the procedure. It is also essential to avoid drugs that may increase IOP or cause systemic hypotension to ensure a successful graft.

Both international and Indian guidelines emphasize the importance of careful preoperative assessment and intraoperative management to maintain graft integrity and ensure patient safety. While anesthetic considerations for corneas harvested from poisoned donors may not significantly differ from standard practices, potential interactions between residual toxins and anesthetic drugs remain a critical concern.

## Recommendations

A robust ethical framework and scientifically sound methodology should be employed for conducting future studies in the field of corneal transplant toxicology. A general outline for future studies is presented in Figure 1.

To enhance research and clinical understanding of corneal transplantation, it is essential to generate and publish more data in the public domain. A well-structured national corneal transplant database should include critical variables such as time of corneal retrieval, anonymized donor and recipient characteristics, corneal viability and suitability assessments, indications for the procedure, and transplantation outcomes. Standardized reporting of these parameters will support more robust and informed research efforts in this field. If nationwide registry data become available, age- and indication-matched retrospective observational studies comparing outcomes between poisoned and nonpoisoned corneal donors can be conducted. However, careful attention must be paid to

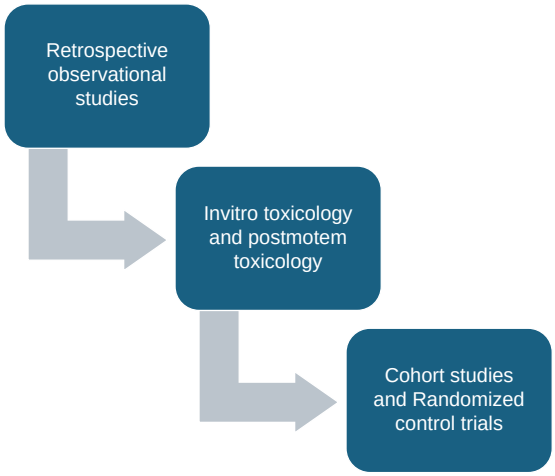



**Figure 1: Approach to research in corneal transplant toxicology**

addressing confounding variables, and appropriate statistical modeling should be applied as necessary. These studies should be carried out in large eye banks that receive corneas from various tertiary care hospitals across India.

Concurrently, *in vitro* toxicology should be considered for refining our research. Conventional petri dish or test tube methods can be replaced with *in vitro* 3D reconstructed corneal models[30] to test the effects of various common poisons on corneal tissue, allowing us to understand the doses at which toxicity occurs. Similarly, forensic pathologists in our country should initiate a project to measure vitreous levels of toxic substances in deaths due to acute poisoning and collaborate with ophthalmologists to study the effects on corneas in such cases. These *in vitro* experiments and retrospective observational studies complement each other in generating evidence regarding dose toxicity. Also, if there is a scientific rationale indicating that a specific substance would not affect the cornea, *in vitro* experiments can be conducted in those cases to generate supporting evidence.

The next level of evidence generation in this field involves conducting cohort studies or randomized controlled trials (RCTs). Cohort studies are best executed within specific subsets of poisoned and nonpoisoned donors, focusing on one type of poisoning as a distinct group. It is essential to gather robust data from *in vitro* studies before advancing to cohort studies. Additionally, data from previous transplants conducted in other countries or from earlier studies should be carefully considered to inform our research. Postmortem toxicology and *in vitro* research will establish blood and vitreous thresholds for toxic substances, beyond which corneal damage can be observed.

To confirm the utility of corneas from poisoned donors, RCTs represent the most reliable method. However, conducting

these trials raises sensitive ethical issues, particularly regarding the transplantation of corneas from poisoned donors, necessitating approval from the institutional ethics committee. Consent must be obtained from recipients, and strict inclusion criteria for donor corneas based on specific poisoning must be established. Donors with pre-existing corneal conditions that may independently affect graft survival should be excluded from the study. Random allocation of recipients should be implemented, along with stratification based on underlying health conditions. It is also vital to ensure double blinding of both the transplant surgeon and recipients regarding the donor's cause of death, with a separate allocation team managing the surgeries. Outcomes should be assessed based on 1-year graft survival rates, visual acuity, complications arising from the transplantation, endothelial cell counts, or other standard parameters used in cornea practice.

## CONCLUSION

In summary, there have been successful cases of corneal transplantation using corneas from poisoned deceased donors, though further studies are needed to strengthen the evidence in this field. The studies reviewed indicate that despite systemic toxicity from poisons or toxins, corneal tissue often remains viable and suitable for transplantation (average success rate of 77.5%). However, these studies lack a control group to compare outcomes between poisoned and non-poisoned donors. Further research is necessary to include marginal donors, such as those who have been poisoned, as a viable group for addressing corneal blindness in India.

### Limitations

Overall, there is a dearth of literature on the outcomes of corneas transplanted from poisoned donors. The sample size in each study and even when combining all the studies mentioned in this review is too small to generalize the results. The element of publication bias (where negative, inconclusive, or unfavorable outcomes are not reported in the literature) cannot be ignored in the present scenario. Therefore, large-scale multicentric studies are necessary to develop stronger evidence in this domain.

It is an established fact that numerous corneal transplants in India have been performed using tissues from poisoned donors, despite a significant number of these cases remaining unreported in the literature.

The need to inform the recipient in advance if the cornea was retrieved from a poisoned donor is currently a matter of debate. However, performing such transplants without generating proper evidence amounts to a clinical trial, which requires strict regulatory compliance. We did not examine the ethical standards of the studies reviewed.

At the same time, our search string may not have captured a few studies beyond its scope, including those that mention corneal retrieval from poisoned donors but do not provide data on transplant outcomes.

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### Conflicts of interest

There are no conflicts of interest.

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Review Article

# Students' perception of undergraduate ophthalmic teaching—A systematic review


## ABSTRACT

Ocular ailments make up about 2-3% of primary care and 20% of emergency consultations, making knowledge and understanding of Ophthalmology basics and skills an important requirement for the young doctor. Designing an Ophthalmology curriculum needs to take care of the same and opinion of all stake holders is of paramount importance, including the students. This systematic review was undertaken to assess the perception of medical students, interns and fresh medical graduates about the undergraduate training they received. The search strategy included the following keywords: 'ophthalmology' , 'undergraduate teaching' , 'students', 'interns', 'junior doctors', either singly or combined. Databases searched include Pubmed, Cochrane library, Embase and Science Direct. The search strategy was to include studies in which any survey regarding perception of medical students/ interns/ junior doctors about their undergraduate ophthalmology teaching was included. Of these, after applying the inclusion and exclusion criteria, 19 studies were included. In general, the respondents in most of the included studies felt that the ophthalmology teaching they received in their medical school , especially Ophthalmology skills, was inadequate. Novel teaching methods like team based learning, flipped classroom are preferred by students to the traditional teaching methods and incorporating these methods in the curriculum will go a long way in improving the confidence of our doctors.


**Keywords:** 'Interns', 'junior doctors' 'students', 'undergraduate teaching', 'ophthalmology'

## INTRODUCTION

Medical schools the world over are revising their curricula to accommodate the core competencies, and in this process, specialties like ophthalmology have had to deal with a shorter undergraduate teaching time span.[1] Knowledge and understanding of basic ophthalmology and ophthalmology skills remains of paramount importance as eye disorders make up a significant proportion (2–3%) of primary care consultations and about 20% of accident and emergency consultations.[2] The International Council of Ophthalmology (ICO) recommends that basic ophthalmology knowledge and ophthalmic skills should be included in the undergraduate medical curriculum.[3] The ICO also recommends 40 to 60 hours of ophthalmic teaching with suggestions of a variety of teaching methods, such as lectures, case studies, clinical placements, and integration with other specialties.[4] The ICO guidelines are considered the cornerstone in the process of developing an ophthalmology curriculum. However, there is a substantial variation in ophthalmology teaching across different medical schools, not only in terms of duration of teaching, but also in topics and clinical skills covered as well.[5] The primary care physician is often the first to evaluate eye problems and it is essential that he/she has the required skills to understand the problem and deliver primary eye care.[6] A good foundation of ophthalmology knowledge and ability to perform basic clinical skills is a prerequisite for the same. Designing a medical curriculum


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needs to keep this in mind and the limited time available along with the number of other subjects being taught requires cooperation between various specialties. The opinion of various stakeholders, including medical students, is extremely important in designing a curriculum and implementing the same. This study was undertaken to assess the perception of medical students, interns, and fresh medical graduates about the undergraduate training they received, the deficiencies they noted, and the suggestions they made regarding improving the ophthalmology curriculum.

## MATERIALS AND METHODS

### Search strategy

The search strategy included the following keywords: "ophthalmology," "undergraduate teaching," "students," "interns," "junior doctors," either singly or combined. Databases searched include PubMed, Cochrane Library, EMBASE, and Science Direct. The search strategy was to include studies in which any survey regarding the perception of medical students/interns/junior doctors about their undergraduate ophthalmology teaching was included [Figure 1].

### Inclusion and exclusion criteria

Studies were included if they fulfilled the following criteria:

1. Studies involving the participation of medical students/interns/junior doctors
2. Cross-sectional surveys and RCTs
3. Studies that included the perception of the participants regarding undergraduate ophthalmology teaching
4. Studies in which English full text could be obtained.

Studies excluded were those which had participation of medical school authorities or teachers/studies assessing knowledge exclusively, studies regarding postgraduate ophthalmology teaching and studies in which an English full text was not obtained. Although students' opinion about e-learning was included, studies regarding ophthalmology teaching during the COVID era were excluded.

## RESULTS

Using the keywords, the search strategy yielded 457 results. Of these, after applying the inclusion and exclusion criteria, 19 studies were included [Table 1]. Nine of these studies were about the perception of the participants regarding the ophthalmology teaching they received. Two studies were regarding virtual teaching methods, eight researches were about different and novel teaching methods, and one study was about the utilization of self-directed learning (SDL) by students. There were 4970 participants in all the studies included. In general, the respondents in most of the included studies felt that the ophthalmology teaching they received in their medical school, especially ophthalmology skills, was inadequate.

## DISCUSSION

There were nine studies included in this systematic review, which were regarding the perception of the participants regarding the ophthalmology teaching they received.[7-15] In most of the studies, the students commented about the lack of confidence in performing ophthalmology skills. The respondents, in most of these papers, felt that the time devoted to ophthalmology teaching was insufficient and suggested increasing the duration of the rotation to four weeks.[8,10-12] Although a study conducted in a medical college in South India had teaching hours above that of the ICO recommendations, students still felt that they were lacking in their clinical skills and knowledge of community ophthalmology.[7] Thus rather than randomly increasing the duration of the rotation, what is needed probably, is to devote more time to teaching clinical and procedural skills than what exists already in the curriculum. Students also suggested more novel methods like using virtual clinical skill teaching modalities to improve their confidence in this regard.[11] Hospital-based tutorials were preferred by students compared to lectures to improve knowledge and skills.[15] Small-group problem-based learning and hands-on skills practice are probably the best methods to improve confidence in ophthalmology knowledge and performing skills. The self-directed learning (SDL) time, which is defined as learning on one's own initiative, could be utilized by the students to bolster their theory knowledge.[16]

Two researches included in this systematic review were about the respondent's opinions regarding novel virtual methods in ophthalmology teaching.[5,17] Medical students preferred e-learning modules over classroom-based theory lectures and they felt more confident with these modules.[5] An interactive virtual ophthalmic clinic, focusing on history taking and clinical reasoning, was overwhelmingly welcomed by students and they felt that it was more useful compared to traditional teaching.[17] Utilizing virtual methods, especially outside official working hours and at the student's convenience, could help ease out the overcrowded and cramped teaching curriculum with boosting the student's confidence.

There were seven studies which focused on novel teaching strategies.[18-25] Students in the University of Pittsburgh found a four-session mini-elective with hands-on training effective and reported increased comfort with the subject.[18] However, even

**Table 1: Cross-sectional studies and RCTs of students' perception of ophthalmology undergraduate teaching**

| Sl No: | Name | Study population | No | Aim | Results | Conclusions |
|---|---|---|---|---|---|---|
| 1 | Divya K *et al.** | Third-year medical students who completed ophthalmology training | 134 | To assess the adequacy of ophthalmology teaching and to evaluate the proficiency of students in diagnosing common ophthalmic conditions and perform skills | It was noted that although teaching hours are more than ICO recommended hours, the students were deficient in their knowledge of community ophthalmology and in ophthalmic skills. | The curriculum needs to be tweaked to address gaps in knowledge of primary eye care, community ophthalmology and ophthalmic skills. |
| 2 | Abuallut I *et al.*+ | Fifth-year medical students | 322 | To assess the effectiveness of the 3-week ophthalmology curriculum in this University | Almost 43% of the respondents felt that they had adequate exposure to ophthalmology teaching requirements and felt confident in performing ocular history taking and slit lamp examination. Almost 65% of the respondents felt that the training they received was average and above. Thirty percent of students expressed their interest in having ophthalmology as a career option | There is an increased requirement for hands-on clinical training and small-group teaching. Competency-based curriculum modeled on ICO guidelines could enhance students' knowledge and skills in ophthalmology |
| 3 | Alselaimy RM *et al.*† | Interns from medical schools across Saudi Arabia | 317 | To evaluate the ophthalmology undergraduate curriculum in medical colleges in Saudi Arabia | Almost 55% of the respondents felt confident about basic ophthalmology skills. Fifty-eight percent responded that the ophthalmology teaching has an important role in deciding their future specialization. | A uniform curriculum across medical colleges based on ICO guidelines would be an ideal option. |
| 4 | Long C *et al.*‡ | Medical students of 15 Canadian medical schools | 155 students | Needs assessment for changes to ophthalmology teaching | Adequacy of ophthalmology teaching was given an average rating of 4.2 out of 10. Most students desired enhanced teaching in skills including procedural, surgical, and clinical and were also interested in virtual teaching modalities. | Less than desired ophthalmology teaching was reported by the participants and it is suggested to utilize the virtual modality for improving ophthalmology teaching. |
| 5 | Noble J§ | First-year residents who had graduated from Canadian medical schools | 386 residents | To assess the efficacy of undergraduate ophthalmology teaching | Majority (64%) of the residents felt that they had inadequate ophthalmology exposure in their undergraduate time. Only 26% of respondents felt that they had acquired sufficient ophthalmology skills | There are gaps in ophthalmology teaching, especially teaching of ophthalmology skills. |
| 6 | Onyekwe LO *et al.*‖ | Undergraduate medical students | 100 | To determine the perception of medical students toward ophthalmology | Majority of the students found ophthalmology training useful and suggested that the ophthalmology training period should be at least four weeks | It is important to design a curriculum which is of sufficient duration and can elicit subject interest and confidence in knowledge and ophthalmology skills. |
| 7 | Howie AR *et al.*¶ | Junior doctors | 348 | To evaluate junior medical officer perspectives on ophthalmology learning during medical school and perceived ophthalmology competency | Only 38.5% of the respondents felt that they had learned enough during their ophthalmology undergraduate teaching period to prepare them for their internship | The ophthalmology curriculum needs to be revisited and stress should be placed on learning skills and implementation of a problem-based learning curriculum could probably help boost students' knowledge and confidence. |
| 8 | Robles-Holmes H *et al.*** | Medical students and residents in the USA | 387 | To understand the medical student and resident physician perspective of ophthalmology education during medical school and potential strategies for improvement. | Respondents wished that they had more knowledge of basic and clinical ophthalmology before entering residency. They also wished for more clinical knowledge and skill development. | Residents felt that the exposure to ophthalmology skills and clinical knowledge is sufficient and this is an area where improvement is needed. |

*Contd...*

**Table 1: Contd...**

| Sl No: | Name | Study population | No | Aim | Results | Conclusions |
|---|---|---|---|---|---|---|
| 9 | Zhang HH *et al.*†† | Junior medical officers and medical students in Australia | 838 | To evaluate the perception of junior doctors and medical students about ophthalmology teaching in Medical Colleges | The most preferred modality of ophthalmology teaching was hospital-based tutorials; however, the most common form of teaching received was lecture based. Confidence in basic ophthalmology skills was low | The candidates reported a low level of confidence in basic ophthalmology skills training. They also felt that there was more need for clinically oriented ophthalmology teaching |
| 10 | Petrarca CA *et al.*‡‡ | Randomized controlled crossover study was done with five ophthalmology topics being taught by e-learning and the others by traditional lectures, followed by a crossover in the third year of medical school | 245 | To compare ophthalmology teaching delivered by e-learning with traditional lectures | Student satisfaction was enhanced and students felt more confident of their knowledge after the learning module. | E-learning modules are highly acceptable to ophthalmology students and may be extended to other specialties as well. |
| 11 | Succar T € | A randomized controlled trial (RCT) was conducted with medical students, who were randomly assigned into either an experimental or a control group. The experimental group was assigned to a virtual ophthalmology clinic, which is an interactive web-based teaching module stressing on history-taking skills and clinical reasoning skills. | Experimental group—93, control group—95 | To determine the impact of VOC on medical students' learning. | Eighty-eight percent of students felt that VOC was highly useful and aided ophthalmology learning. Fifty-six percent of students felt that it was more effective than traditional teaching. | VOC could prove to be a highly useful teaching resource to bolster ophthalmology undergraduate teaching |
| 12 | Mortensen P *et al.*£ | Preclinical medical students | 12 first year and 12 second year students enrolled in an elective course consisting of the basics of clinical ophthalmology | To evaluate and obtain student feedback about an elective course consisting of the basics of clinical ophthalmology | A significant number of students felt more confident about their ophthalmology knowledge and ophthalmology skills. Nearly 2/3rd of the students felt that they enjoyed the course, but they requested more hands-on practice. | The ophthalmology mini-elective course was thought to be a useful addition to the existing curriculum and the authors felt that it could be emulated in other medical colleges. |
| 13 | Lam FC *et al.*¥ | Fourth-year medical students who attended a single-day session of structured ophthalmology teaching and OSCE-based clinical teaching sessions | 211 | To assess the effectiveness of this single-day intensive ophthalmology teaching session | The students felt more confident in performing clinical skill posttraining compared to their pretraining skill levels | Intensive, structured teaching even if of limited number of days can help to improve the student's confidence, especially when teaching time is limited |
| 14 | Wu D *et al.*α | Medical students | 42 undergraduate medical students enrolled in an ophthalmology pre-internship consisting of basic theory, soft skills, and clinical practice. | To evaluate the effectiveness and student satisfaction in students attending an organized ophthalmology pre-internship | Almost 70% of the students strongly agreed that they were satisfied with this mode of teaching. The participants felt that the pre-internship improved their knowledge and also served to explore their potential | This method of teaching promoted students' enthusiasm and it is suggested to extend this process to various medical specialties |
| 15 | Horne A *et al.*β | Medical students | 30 | To assess the students' opinion about a team-based learning approach in ophthalmology | Students preferred the team-based ophthalmology teaching methodology | Team-based learning with greater student involvement is thought to be superior to the traditional classroom-based teacher-led teaching |
| 16 | Sethi S *et al.*Ω | Tutors (interns posted in ophthalmology department, who were trained and evaluated) and tutees (second-year undergraduate students) | 82 tutees | To evaluate the near peer-assisted learning of clinical ophthalmology skills by trained interns | Tutees found these sessions useful for learning ophthalmology skills | This teaching methodology could be used as an adjunct to traditional teaching and also helps to reduce the workload of medical teachers. |

*Contd...*

**Table 1: Contd...**

| Sl No: | Name | Study population | No | Aim | Results | Conclusions |
|---|---|---|---|---|---|---|
| 17 | Ding C *et al.*[∞] | Undergraduate medical students and teachers | 32 students in FC-TCLEBL class and 35 in lecture-based classroom (LBC) | To understand the benefits and challenges of the flipped classroom combined with team-, case-, lecture-, and evidence-based learning (FC-TCLEBL) for ophthalmology teaching | The students in the FC-TCLEBL felt that there was an improvement in their clinical thinking ability and independent learning ability. The LBC group reported no such improvement | Further research using a larger sample size should be undertaken to decide on the themes and hours of teaching by flipped classroom modality |
| 18 | Tsinopoulos IT *et al.*[π] | Fifth-year medical students | 673 students from the conventional curriculum and 370 students from the integrated curriculum | To evaluate the implementation of integrated teaching in an ophthalmic curriculum | Integrated teaching indicates that the complete teaching material is covered by each faculty member not considering areas of personal expertise. Students were more satisfied with the integrated curriculum compared to the conventional one. | Integrated small-group teaching of ophthalmology theory and clinical skills appears to be a preferred modality of teaching among students |
| 19 | Sahoo S.[Σ] | Fourth-year medical students having a clinical posting in ophthalmology | 51 | To assess the SDL habits of students and their perception of the same following the introduction of weekly assessment of SDL topics | Majority of the students felt that they were utilizing the SDL time slot better after the introduction of weekly assessments than that prior to it. | This again proves that assessment drives learning. The weekly assessment can help instill a healthy SDL utilization behavior and help to instill a lifelong learning habit. |


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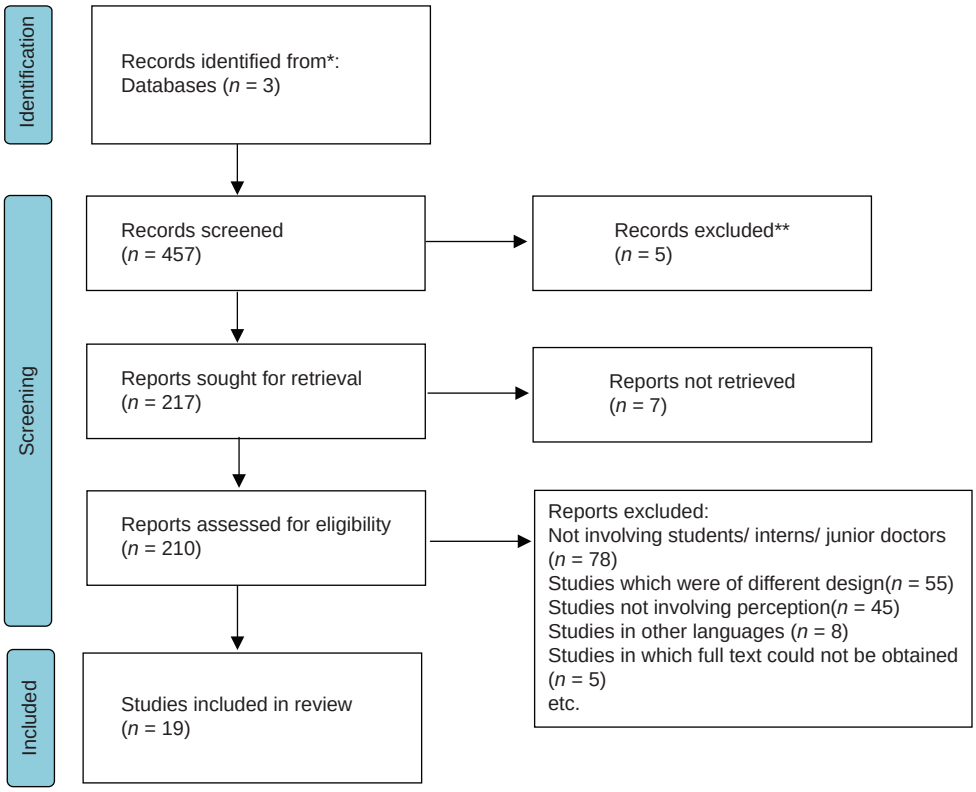



**Figure 1 Prisma flow chart.Source:Page MJ, et al. BMJ 2021;372:n71. doi: 10.1136/bmj.n71**

in this method of teaching, students wished the lectures off and preferred more physical examination and surgical practice. A single day of intensive lecture and OSCE-based workshop was conducted for fourth-year medical students and they felt more confident in performing clinical skills post-session.[19] A pre-internship conducted in a medical college in China, consisting of basic ophthalmology theory, soft skills, and clinical practice, was very well received by the participants, who reported improved knowledge and a useful avenue to explore their potential.[20] In a team case-based learning, an integrated curriculum was other methods which were well received by the participants.[21,24] Near peer-assisted learning, a method of skill training of students by trained interns posted in ophthalmology department was a novel teaching method that was very well received by the students, who found this method useful and it promoted learning in a comfortable environment.[16] This could also help reduce the burden on the overworked medical teacher without compromising on the teaching quantity and quality. Flipped classroom which consists of pre-class learning with the aid of learning resources like the Internet, followed by group learning activities in the classroom, has been gaining increasing popularity in medical education.[25] A study conducted in a University in China divided students into two groups, one having lecture-based classes and the other having flipped classroom involving team-based, case-based, lecture, and evidence-based learning.[23] Students in the flipped classroom group felt that they had improved in their independent learning and clinical reasoning ability.

Self-directed learning, described first by Knowles, is a process in which individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes.[26] SDL is considered important for lifelong learning and now forms an important part of medical education programs.[27] A study by Sahoo noted that students felt that they were utilizing the SDL time more effectively, especially if it was coupled with weekly assessments.[28]

Regarding the Indian context, two studies which focused on the students' perception of their ophthalmology teaching were obtained. Students noted that teaching of skills by interns in the ophthalmology department was useful and also fostered learning in a secure and relaxed environment.[22] Yet another research noted that students who found SDL along with weekly assessments were found to be especially useful.[28] There are very limited studies focusing on the student perception of their ophthalmology teaching from India. The CBME curriculum has been implemented in India in 2019; however, many countries have already accepted the competency-based curriculum since as early as 2009 and it is felt that this review gives an opportunity to understand the students' viewpoint and formulate changes, if necessary.

The future of our health system is in the hands of the doctors of tomorrow. A good medical training is a prerequisite for the same. The importance of a sound ophthalmology training is vital in producing a confident physician who can deal with common ophthalmic problems as well as emergencies. Although there are reviews conducted about the curriculum involving the curriculum coordinators and medical teachers, this is probably one of the few systematic reviews about student perception of their ophthalmology curriculum. More skill training is the need of the hour and this has been echoed in most of the student surveys. Majority of the students suggest a shift from classroom based to hospital-based teaching. Small-group teaching in a clinical setting is probably the best method to impart knowledge in clinical ophthalmology. Novel teaching methods, like team-based learning and flipped classroom, are preferred by students to the traditional teaching methods and incorporating these methods in the curriculum will go a long way in improving the confidence of our doctors. The utilization of SDL time is of paramount importance and coupled with skill-centered innovative teaching methods will probably be the anchor of future ophthalmology curricula and help produce confident and ready new doctors equipped to deal with ophthalmic pathologies.

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### Conflicts of interest

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# Centurion syndrome: A rare cause of epiphora in youngsters

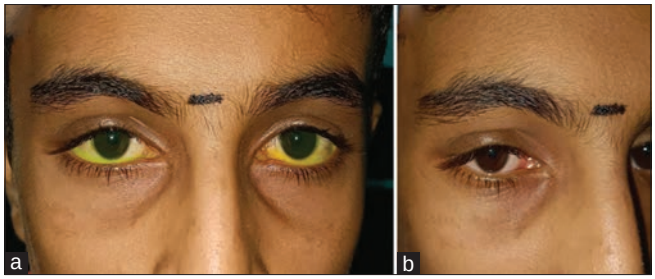



**Figure 1: (a) A case of Centurion syndrome showing positive fluorescent dye disappearance test (FDDT), prominent nasal bridge, synophrys, deep-set eyes, (b) malposition of the medial part of the lid away from the globe displacing the lacrimal puncta out of lacus lacrimalis, typical Beak sign**

A 17-year-old boy presented with a history of constant watering in both eyes for the past one year. There was no associated discharge, redness, or itching. He has been treated with topical antibiotics and antihistamines by multiple ophthalmologists, but the symptoms remain the same. On examination, there was increased tear film height in both eyes. All four punctal openings appear normal. There was no regurgitation on pressing over the sac area (ROPLAS negative). Syringing showed free flow, suggestive of patent lacrimal passage. Fluorescent dye disappearance test (FDDT) was positive in both eyes, suggestive of abnormal drainage of tears. There was a prominent nasal bridge. Lower lid was not properly apposed to globe medially in both eyes, with anterior displacement of the lacrimal puncta out of the tear lake. Hertel's exophthalmometry showed no enophthalmos. The rest of the anterior and posterior segments are normal. The clinical photographs are shown in Figure 1.

### What is the probable clinical diagnosis?

A. Dacryocystitis
B. Canaliculitis
C. Congenital Nasolacrimal Duct Obstruction
D. Centurion Syndrome

### OPTION D CENTURION SYNDROME

Centurion syndrome is a rare cause of epiphora mostly in post pubertal males, characterized by a prominent nasal bridge, synophrys, deep set eyes, and abnormal anterior insertion of medial canthal tendon along with malposition of the medial part of lid away from the globe displacing the lacrimal puncta out of lacus lacrimalis, which is usually bilateral though may be asymmetrical. It was first described by Sullivan *et al*. in 1993.[1] The term Centurion syndrome is derived from Roman soldiers (Centurions) who had a similar appearance with a prominent nasal bridge.[2] The exact etiology of this condition is still not well understood. The anterior limb of the medial canthal tendon has two lamellae. The anterior lamella is the tendon of the pretarsal part of the orbicularis oculi muscle. The posterior lamella is the musculotendinous structure of the preseptal and orbital parts of the orbicularis oculi muscle. Alam *et al*.[3] studied the magnetic resonance imaging in patients with Centurion syndrome, which revealed that the anterior limb of the MCT may not always be inserted anteriorly in cases of Centurion syndrome; it can be normal or maldeveloped. Murthy *et al*.[4] noted a sharp inferior angulation of the medial canthal tendon and termed it as "Beak sign." Various surgical procedures are described in the literature to treat this condition, including medial canthus tendon release, punctoplasty, medial conjunctivoplasty, lower lid retractor plication, posterior plication of medial canthal tendon stump, etc. Our patient underwent bilateral medial canthal tendon release. Tearing was completely resolved after surgery (Munk score pre op 5, post op 0).[5]

Diagnosis of Centurion syndrome should be kept in mind and look for medial canthal tendon abnormality while dealing with young patients complaining of bilateral constant epiphora. General ophthalmologists should be aware of this condition, as a simple surgical procedure gives a good outcome, improving the quality of life of patients with persistent epiphora.

### Financial support and sponsorship

Nil.

### Conflicts of interest

There are no conflicts of interest.

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# Quotable supreme court judgments on medical negligence

Any medical practitioner is liable in case he falls short of giving standard and due care on criminal and civil grounds. Medical negligence can also be tried under the Indian Contract Act, 1872, Indian Medical Council (Professional Conduct, Etiquette and Ethics) Regulations, 2002, the Consumer Protection Act, 2019, and various other legislations and regulations. The supreme Court, being the apex body to look after the judiciary in India, has the final say. Let us look into the instances where the Supreme Court has given its mandates while preventing medical malpractice.

## SUPREME COURT DEFINES NEGLIGENCE

Hon'ble Supreme Court in Jacob Mathew vs. State of Punjab defined medical negligence as "Negligence is the breach of duty caused by the omission to do something which a reasonable man, guided by those considerations which ordinarily regulate the conduct of human affairs would do, or doing something which a prudent and reasonable man would not do." Medical negligence is thus defined as a medical professional's conduct or omission (failure to act) that deviates from the established medical "standard of care" or that of a reasonable person, resulting in harm or injury to another person (here, the patient). In other words, medical negligence is the "failure to follow a reasonable standard of care by a healthcare professional." The type of medical service offered, the practitioner's expertise, training, and experience, and even the location where the treatment is taking place may all be taken into account when defining the acceptable level of care.

## SUPREME COURT JUDGMENTS ON WHEN A CRIMINAL PROCEEDING CAN BE MADE ON A DOCTOR

The provisions of the Indian Penal Code, 1860, are broad in nature and do not expressly deal with "medical negligence." However, certain sections can be used to establish criminal culpability. For example, section 304A of the IPC (which deals with the death of a person as a result of any rash or negligent act and carries a maximum sentence of two years in prison) is applied to both cases of accidents caused by rash and negligent motor vehicle driving and cases of medical negligence, resulting in a patient's death. Other general provisions of the IPC, such as sections 337 (causing harm) and 338 (causing grievous hurt), are also frequently invoked in medical negligence trials. Supreme Court judgments on medical negligence under criminal law in the Jacob Mathew vs. State of Punjab case.[1] There must be a gross or very high degree of negligence, resulting in a higher amount of damages incurred. Gross negligence can be described as "the severe disdain for or reckless disregard for the safety of others." The term encompasses more than just carelessness or inaction. Thus, there must be an incidence of deliberate act that has the potential to cause foreseeable harm. There must be an element of men's rea (guilty mind) or recklessness. The practitioner must have done or omitted to do something which, in the given facts and circumstances, no sensible and prudent medical professional would have done or omitted to do.

## SUPREME COURT DIRECTIVES ON MEDICAL NEGLIGENCE: KUSUM SHARMA V BATRA HOSPITAL AND MEDICAL RESEARCH CENTRE[2]

Two judges of Supreme Court panel suggested that when determining whether a medical professional is guilty of medical negligence, the following principles must be borne in mind: Negligence is the breach of a duty exercised by omission to do something which a reasonable man, guided by those considerations which ordinarily regulate the conduct of human affairs, would do, or doing something which a prudent and reasonable man would not do. The negligence to be established by the prosecution must be culpable or gross and not the negligence merely based upon an error of judgment. The medical professional is expected to bring a reasonable degree of skill and knowledge and must exercise a reasonable degree of care. A medical practitioner would be liable only where his conduct fell below that of the standards of a reasonably competent practitioner in his field. One professional doctor is clearly not negligent merely because his conclusion differs from that of another professional doctor. It would not be conducive to the efficiency of the medical profession if no doctor could administer medicine without pressure and stress. It is our bounden duty and obligation of the civil society to ensure that the medical professionals are not unnecessarily harassed or humiliated so that they can perform their professional duties without fear and apprehension. The medical professionals are entitled to get protection so long as they perform their duties with reasonable skill and competence and in the interest of the patients. The interest and welfare of the patients have to be paramount for the medical professionals.


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Essentials to Constitute Medical Negligence. There are three fundamental components of negligence: "duty," "breach," and "resulting harm." That is, to establish negligence, it must be shown that the person owed a duty of care to the plaintiff and that duty was breached, causing him/her to suffer damage as a consequence.

Essentials of Medical Negligence in Tort Law. The Supreme Court has stated that a claim for medical negligence against a doctor in tort (for civil liability) can succeed when it is proved that either: He does not possess the requisite skill which he professed to have possessed, or he did not exercise such skill with reasonable competence.

## SUPREME COURT VERDICTS ON EMERGENCY CARE[3]

Paramanand Katara vs. Union of India, 1989, was a landmark judgment where the SC held that it is obligatory for a doctor or hospital, both public or private, to provide immediate emergency medical aid to a victim of road accident.

## SUPREME COURT ON LES IPSA LOQUITOR[4]

A. H. Khodwa vs. State of Maharashtra had undergone sterilization following childbirth. The doctor, while doing the procedure, had left a mop inside the patient's abdomen. Peritonitis developed as a result, and the patient died a few days later. The doctor conducting the procedure was judged to be negligent. This amounts to res Ipsa loquitor or gross negligence.

## SUPREME COURT ON CONSENT IN MEDICAL PRACTICE[5]

Samira Kohli vs. Prabha Manchandha case SC held that unless in a lifesaving situation or unless the patient is minor, unconscious, or insane, informed consent is mandatory from the patient in all nonemergency procedures

## SUPREME COURT ON PROTECTING CONFIDENTIALITY OF A PATIENT[6]

SC protects the confidentiality of the patient to a great extent. In fact, confidentiality forms the pillar of medical ethics. As in the X vs. Hospital Z case, the doctor has the duty to keep the treatment details confidential unless there is a risk for the public or another person.

## CONCLUSION

It is estimated that every year, over 5,000,000 Indians die as a result of medical negligence. Such cases highlight the grave violation of the Right to Health as an essential aspect of the Right to Life under Article 21. On the other hand, unnecessary harassment of doctors is increasing with increase in litigations. Social media are also playing a role in this aspect, preventing the doctors from executing their duty without fear. These judges made laws that are important in the practice of the medical profession, since many of these classic judgments can be quoted in defense of any litigation.

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## Conflicts of interest

There are no conflicts of interest.

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Original Article

# Needle stick injuries in ophthalmology unit in a tertiary care center, India


## ABSTRACT

**Background:** Needle stick injuries (NSIs) and sharps injuries are prevalent among ophthalmology staff due to the nature of their work, posing significant risks of blood-borne infections. Understanding their frequency, causes, and effective management strategies is crucial. This study investigates the prevalence of NSIs and sharps injuries among ophthalmology staff at a tertiary care center, aiming to identify contributing factors and propose management strategies. **Method:** This was a retrospective review of NSIs collected from 2018 to 2022 at an ophthalmic tertiary care facility in India. All patients with NSI are treated according to the standard treatment policy. This study includes a survey of all medical staff working in the ophthalmology unit. **Result:** A total of 128 NSI were reported over 5 years is taken. Resident sustained (54; 42.5%) NSIs, nurse (41: 32.2%), physician (25; 19.6%), and other (8; 6.3%). In all maximum NSI occur in operation theater (94; 74%) followed by casualty (15; 11.8%), outpatient department (10; 7.8%), and ophthalmic ward (9; 7%). **Conclusion:** NSIs are common among the staff in operation theater during surgeries, but no seroconversions to hepatitis B, HIV, or HCV were reported in this study population, indicating the effectiveness of post-exposure protocols and vaccination. Proper disposal mechanisms for needles and sharp instruments, thorough documentation of adverse events, ongoing staff training, and prompt prophylactic treatment are especially crucial for anterior segment surgeons as essential components of the protocol for managing NSIs.



**Keywords:** Doctors, needle stick injury, nurses, ophthalmology, patients


## INTRODUCTION

A needle stick injury (NSI) is a percutaneous exposure in which the skin is harmed by a needle or other sharp object contaminated with blood or other bodily fluid as a result of accidental pricking. NSI is the second most common kind of occupational injury in the National Health Service. It is believed that 3–6 billion injections are administered each year, with 60% being hazardous. NSIs increase the risk of occupational transmission of blood diseases including HIV, hepatitis B, and hepatitis C virus.

Although there are no national monitoring systems for NSIs in India, a 2006 investigation revealed that around 63% of the 3–6 billion injections given each year are dangerous.[1] NSIs can result from various sharp instruments like blood collection needles, intravenous cannulas, hypodermic needles, suture needles, and hollow bore needles. These incidents often happen during activities such as recapping needles, moving samples, discarding needles, or improperly disposing of them in non-puncture-proof containers.[2]

In India, the prevalence and frequency of NSIs have been reported to vary between 61% and 79.5%, with a 2.3 to 4.5 yearly incidence rate per healthcare worker (HCW). The incidence density is determined to be 228.57 per 100 person-days. Furthermore, 79.5% to 90.5% of healthcare


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workers have reported experiencing at least one NSI during their careers.[3] After being exposed to a needle stick, the chance of infection varies greatly. For HBV, the infection rate can range from 1.9% to over 40%, for HCV, 2.7% to 10%, and for HIV, 0.2% to 0.44%. It is estimated that among healthcare workers, NSIs cause between 200 and 5000 HIV infections annually, 16,000 HCV infections, and roughly 66,000 HBV infections. Among healthcare workers, nurses are particularly vulnerable to accidents and risks at work when carrying out their regular responsibilities in medical facilities.[4]

Sharps injuries are risky because surgical procedures are frequently blood-heavy, involve the use of sharp instruments, and require highly coordinated interactions between surgical team members. The unique microsurgical nature of ophthalmic practice increases the danger of experiencing sharps injuries. The use of tiny tools and sutures increases the chance of instrument mishandling. Surgeons frequently work under magnification and with limited background light, increasing the risk of tool misuse outside of a confined surgical area. Medical and nursing workers may encounter similar instances when concentrating on a microscope, providing ocular injections, recapping needles, discarding needles, or performing other relevant tasks.[5]

Mansour AM highlighted these unique conditions, leading to the discovery that, in comparison to other hospital specialties, ophthalmologists face the highest risk of experiencing sharps injuries.[6]

The purpose of this study is to examine the frequency of needle stick injuries and sharps injuries (NSIs) among staff members employed in the field of ophthalmology at a tertiary care center. Additionally, the study seeks to identify the factors contributing to NSIs and explore strategies for their management.

## MATERIALS AND METHODS

This retrospective study analyses all instances of NSIs that have happened at an Indian tertiary eye care facility. The government-run hospital has an emergency room, inpatient and outpatient departments, and operating rooms in addition to providing comprehensive eye care services. Additionally, the hospital offers educational and training programs designed specifically for paramedical workers, nurses, optometrists, and postgraduate students in ophthalmology. The research follows the guidelines provided in the Helsinki Declaration. Throughout this study, the terms "needle stick injuries" and "sharp injuries" are used interchangeably.

Information on all sharps injuries occurring within 5 years was compiled by examining incident report forms and reviewing the sharps injury database at the ophthalmology units located within a tertiary care center in India. Data were collected on individual incidents. The study excludes incidents with incomplete reporting. According to hospital protocol, all sharp injury occurrences must be reported to the employee health clinic within 2 h of their incidence [Figure 1]. The information provided includes details about the injury's location, the kind of instrument involved (including the item that caused the damage), the injury's mechanism, the person who was impacted, and the post-exposure care that was applied. On a Macintosh (Redmond, WA, USA), Microsoft Excel 2008 version 12 was used for statistical analysis and computations.

## RESULTS

Over 5 years from 2018 to 2022, a total of 128 incidents of sharp injuries were reported [Table 1]. Among these reported incidents, 25 (19.6%) involved eye care physicians, 54 (42.5%) occurred among residents, and 41 (32.2%) involved nursing staff [Graph 1]. There was no evidence of seroconversion to the hepatitis B surface antigen, HIV, or HBC in any of the healthcare professionals involved. The operating theater was the location most frequently reported for injuries, representing 73.43% of incidents. Hands were the primary site of injury, accounting for 83.59% of cases. Among all injuries, 86 (67.18%) were linked to solid needles, while 32 (25%) were caused by sharp implements such as ECG electrodes, surgical blades, or scissors [refer to Table 2 and Graph 2].

## DISCUSSION

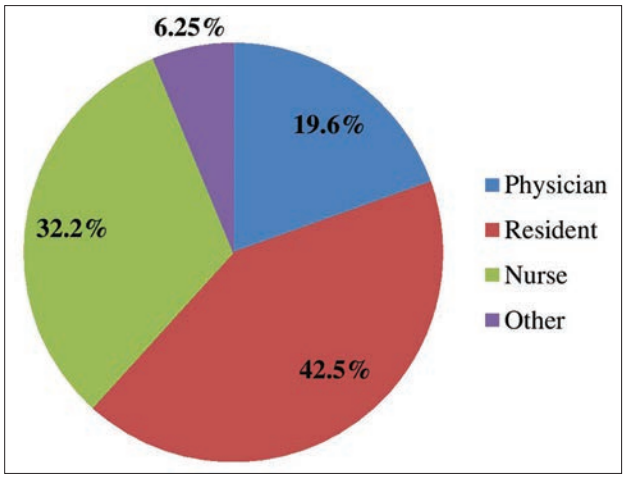
This research presents substantial findings concerning the self-reported NSIs that medical staff at a tertiary eye care facility in India reported from an ophthalmic unit. This research highlights that residents in the institute experience the highest incidence of NSIs, comprising 54 (42.18%) of the total cases. The nursing staff and doctors come next, with 41 (32.03%) and 25 (19.53%) of all NSIs accounted for by each category, respectively. Mansour AM[6] studied the rate of NSIs among employees of the Department of Ophthalmology compared to those in other departments. It revealed that ophthalmologists experienced the highest incidence of needle injuries per person among physicians. As per the investigation led by Thiyagarajan M *et al*.,[7] the nursing staff emerged as the most frequently reported group experiencing sharp/NSIs, comprising 44.6% of cases. This was followed by students at 14.5% and janitors at 13.3%. In the research carried out by Rishi E *et al*.,[8] findings revealed that ophthalmic fellows undergoing training at the institute

**Table 1: Numbers of needle stick injuries per year**

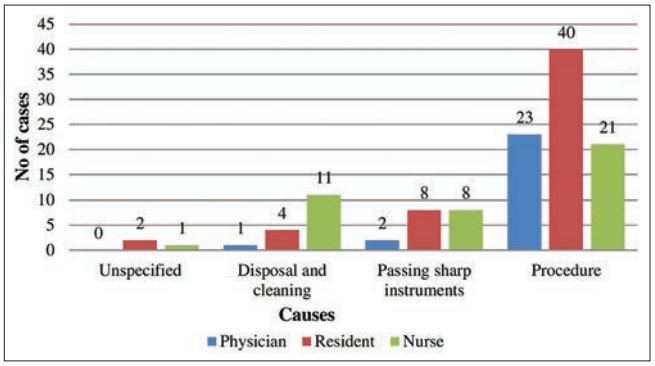
| | |
|---|---|
| Total Number of NSI Events | 128 |
| Year | |
| 2018 | 29 |
| 2019 | 27 |
| 2020 | 23 |
| 2021 | 21 |
| 2022 | 28 |

**Table 2: Distribution of sharps injuries by occupation of injured**

| Characteristic | Count | % |
|---|---|---|
| Occupation | | |
| Physician | 25 | 19.53% |
| Resident | 54 | 42.18% |
| Nurse | 41 | 32.03% |
| Other | 8 | 6.25% |
| Location | | |
| Operation theater | 94 | 73.43% |
| Emergency ward | 15 | 11.71% |
| Outpatient department | 10 | 7.81% |
| Eye Ward | 9 | 7.03% |
| Prick site | | |
| Hand | 107 | 83.59% |
| Foot | 13 | 10.15% |
| Unspecified | 8 | 6.25% |
| Type of prick | | |
| Solid needle | 86 | 67.18% |
| Sharp instruments (e.g., scissors and surgical blades | 32 | 25% |
| Hollow bore needle | 10 | 7.81% |




Graph 1: Percentage of sharp injuries by occupation




Graph 2: Causes of needle stick injury

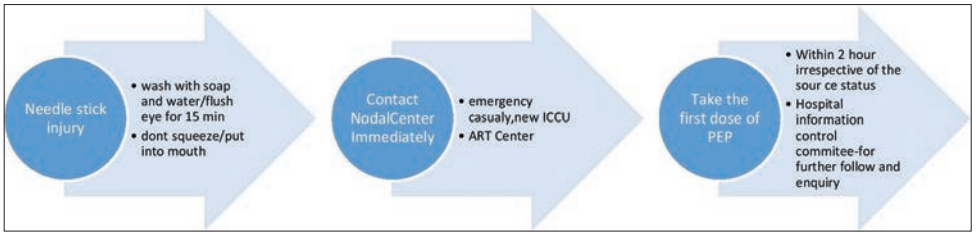



Figure 1: Flowchart describing the hospital protocol following needle stick injuries

experienced the highest incidence of Researchers Rishi E *et al*.,[8] found that the greatest rate of needle pricks occurred among ophthalmology fellows receiving training at the institute ($n$ = 33; 24%), nursing personnel ($n$ = 32; 23%), and consultants ($n$ = 30; 21%). According to Ghauri AJ *et al*.'s[9] study, doctors made up 39.7% ($n$ = 27) of NSIs, nurses made up 54.4% ($n$ = 37), and allied healthcare workers made up 5.9% ($n$ = 4). Similarly, Jayanth ST *et al*.[10] investigated needle prick injuries at a tertiary care hospital and showed that 28% of the NSIs seen were caused by nursing staff, while 9% were caused by interns or trainees. Abdulrahman Alfarhan *et al*.[5] led a study where physicians experienced 46.8% ($n$ = 94) of the injuries, while nurses and ophthalmic technicians accounted for 40.8% ($n$ = 82) and 7% (14); of the injuries, respectively.

Most incidences of NSI reported are from operation theater 94 (73.43%) followed by the emergency ward (11.71%) and outpatient department (7.81%). The inpatient wards had the highest rate of sharps injuries (36%) compared to the results published by HPA, which showed that the operating room is the second most common location for injuries caused by sharp objects (17%) among all healthcare settings in England.[11] In our study, NSIs occur during surgical procedure 69 (53.90%) followed by passing sharp instruments 6 (4.68%). The study conducted by Alsabaani A. *et al*.[12] revealed that 42.9% of NSIs happened in the patient's room, while 52.7% of injuries happened when using sharp objects. Hand 107 (83.59%) is the typical prick location. The distribution of injuries from sharp objects can be explained by the overall high surgical volume in ophthalmology combined with a

relatively light inpatient caseload. In the United Kingdom, 2,615,809 ophthalmic surgical procedures were performed between 2004 and 2010. Of all the treatments performed in hospitals, the greatest number—2,349,284—were categorized as daycare procedures. Additionally, out of all the major surgical specialties, ophthalmology consistently showed the lowest average length of stay—just 1.3 days.[13]

During the entire 5-year duration, no cases of seroconversion were noted among the medical personnel who had been exposed to NSIs. The seroconversion rates for HBsAg, HCV, and HIV are estimated by the Centers for Disease Control and Prevention to be approximately 22%–31%, 0.5%, and 0.3%, respectively.[14]

After occupational exposure, there were 296 reported cases of HIV seroconversion worldwide, including 56 confirmed cases and 138 cases may have been acquired through work. Two cases of possibly occupationally acquired HIV infection have been reported from Chandigarh in India.[10]

Some injuries are unavoidable even after great attempts to lower the frequency of NSIs through instruction and training. Hence, it is imperative to have current guidelines and well-defined policies in place. All ophthalmic settings must adhere to standard policies regarding occupational exposure to bodily fluids, including blood [Figure 1]. These policies outline that in the event of exposure, employees must adhere to a standardized procedure, which includes promptly washing the wound with soap and water the right way and immediately notifying the nodal officer, either immediately or within a maximum of 2 h. In the event of exposure to a mucous membrane, it is crucial to thoroughly flush the area with water. Moreover, as per the protocol, the exposed employee is required to report to the Hospital Information Control Committee for additional follow-up and inquiry. Subsequently, hepatitis B, HIV, and hepatitis C testing will then be performed on the original patient. This procedure complies with both the Occupational Safety and Health Standards and the recommendations provided by the Centers for Disease Control and Prevention (CDC).[14] Thomas WJ and Murray JR reported instances of inadequate adherence to the sharps injury policy. Their findings revealed that Just 9% of surgeons in NHS hospital settings correctly implemented the sharps injury policy following an occurrence, according to their research. Additionally, 21% of surgeons chose to ignore the injury and continued operating, disregarding the policy.[15] For the sake of everyone's safety, including their own, healthcare personnel should be educated on the possible risks of these kinds of injuries. Additionally, general guidelines for the safe handling and disposal of sharps should be taught to healthcare personnel. In addition, tools and methods that reduce the need for sharp objects should be promoted and thoroughly demonstrated for their safety and efficacy.[9] Numerous studies have indicated that educational programs result in a decrease in the incidence of sharp injuries.[16-18]

## CONCLUSION

While NSIs are common among operation room staff, no seroconversions to hepatitis B, HIV, or HCV were reported in this study population. This indicates the effectiveness of post-exposure protocols and vaccination. Proper disposal mechanisms for needles and sharp instruments, thorough documentation of adverse events, ongoing staff training, and prompt prophylactic treatment are especially crucial for anterior segment surgeons as essential components of the protocol for managing NSIs.

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### Conflicts of interest

There are no conflicts of interest.

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Original Article

# Comparison of intracameral mydriatic-anesthetic combination injection v/s topical mydriatics in pupillary dilation in MSICS and to assess the receptor downregulation mechanism in same eyes dilated on consecutive days


## ABSTRACT

**Aims:** To assess the efficacy of intracameral mydriatic-anesthetic combination injection in eyes with successive pupillary dilation. To compare the pupillary dilation in intracameral combination injections (in the operating eye) compared to topical mydriatics (in the non-operating eye). To assess the receptor downregulation effect when the same eyes are dilated on two consecutive days. **Methods:** This comparative cross-sectional study included 50 subjects posted for small incision cataract surgery. Both eyes were dilated with topical mydriatics on the pre-operative day, and pupillary diameter (PD) was noted. On the next day, the operating eye was dilated with an intracameral combination injection, and the non-operating eye was dilated with topical mydriatics, and the PD of both was compared. **Results:** The average PD in the operating eye dilated with topical mydriatics was 7.940 ± 0.7117 mm on pre-operative evaluation and 7.310 ± 1.0197 mm following 30 s of intracameral combination injection on a successive day. There was no statistically significant difference in PD between the operating eye dilated with intracameral combination injection and the non-operating eye dilated with topical mydriatics on the operative day. However, there was a significant difference in PD in the operating eye dilated with topical mydriatics on pre-operative day and with intracameral combination injection on the operative day. **Conclusions:** Intracameral combination injection of tropicamide 0.02%, phenylephrine 0.32%, and lidocaine 1% are equally efficacious as topical mydriatics in pupillary dilation. The reduction in PD on the operative day when compared to that of the pre-operative day may be due to the receptor downregulation mechanism.



**Keywords:** Intracameral combination injection, pupillary diameter, receptor downregulation


## INTRODUCTION

Manual small incision cataract surgery is known for its universal applicability and cost-effectiveness. Adequate anesthesia and pupillary dilation are of paramount importance for successful cataract surgery. Topical mydriatics demands repeated instillation, prolonged patient preparation time, poorer bioavailability, and induces corneal epithelial and conjunctival toxicity attributable to the preservatives it harbors.[1,2]

Intracameral mydriatics are preservative-free, reduce ocular surface damage, help in faster recovery of surface integrity, and require negligible patient preparation time.[1]

Ample studies have been conducted on the role of intracameral mydriatics in phacoemulsification. Hence, this


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study aims to compare the role and efficacy of intracameral mydriatics and topical mydriatics in successive pupillary dilation in manual small incision cataract surgery (MSICS) and also to study the receptor downregulation mechanism in successive pupillary dilation.

## SUBJECTS AND METHODS

Intracameral mydriatic-anesthetic combination injection (IMAC) – commercially available as Phenocaine Plus injection (Entod Pharmaceuticals, Mumbai) – with a composition of tropicamide 0.02% + phenylephrine 0.31% + lidocaine 1% was used for the study. A single, experienced surgeon at our institute performed all surgeries.

This comparative, cross-sectional interventional study was performed in a tertiary eye care center in South India after approval by the institutional ethical committee and as per the Declaration of Helsinki. A total of 50 patients of both sexes with age-related cataracts were posted for MSICS.

Inclusion criteria: age >40 years, all types of cataracts, gender (both male and female), pupillary dilatation > or equal to six mm on pre-operative evaluation.

Exclusion criteria: pre-existing ocular diseases like uveitis, glaucoma, pseudoexfoliation syndrome, pseudophakia of non-operating eye, prior ocular surgery in either eye, traumatic cataract, corneal degeneration, dystrophies, pupillary dilatation <6 mm (on preoperative evaluation), H/o drug use (alpha-blockers non-steroidal anti-inflammatory drugs, prostaglandin, miotics, and prostate disease), and patients who are not ready to participate in the study.

Topical mydriatics commercially available as Tropicacyl Plus (tropicamide 0.8% + phenylephrine HCL 5%; Sunways India Pvt. Ltd.) was used for pre-operative evaluation; one drop was instilled thrice in both eyes every 15 min, and pupillary diameter (PD) was noted after 45 min on slit lamp examination. In this way, pre-operative evaluation was conducted on camp patients, and those patients who fit the inclusion criteria were noted, taken up for the study, and operated on the next day.

On the day of surgery, the non-operating eye was dilated with topical mydriatics; one drop was instilled thrice every 15 min and PD was noted after 45 min. A peribulbar block was given to the operating eye with 2% lignocaine and 0.5% bupivacaine. Standard steps of MSICS were then performed, and IMAC was injected after side port entry. The PD was measured at three different steps of surgery using a Castroviejo surgical caliper under an operating microscope: immediately after 30 s of intracameral injection, after cataractous lens removal, and at the end of surgery.

The PD of the fellow eye dilated with topical mydriatics was also measured using a Castroviejo surgical caliper under the operating microscope at the end of the surgery.

If the pupil dilation was insufficient intraoperatively, the surgeon decided to re-inject the intracameral mydriatic solution.

### Statistical analysis

Statistical Package for Social Sciences (SPSS) version 20 (IBM SPSS statistics [IBM Corp. released 2011]) was used to perform the statistical analysis. Data were entered in the Excel spreadsheet. Descriptive statistics of the explanatory and outcome variables were calculated by mean, standard deviation (SD) for quantitative variables, frequency, and proportions for qualitative variables. Inferential statistics such as the paired sample *t*-test were applied to compare the statistical differences between quantitative variables. The level of significance is set at 5%. A $P$ value $< 0.05$ was considered statistically significant. Data are presented in the form of tables, figures, graphs, and diagrams wherever necessary.

## RESULTS

Out of 50 patients, 28 (56%) were female and 22 (44%) were male. The mean age group of the patients taken up for the study was 58.58 ± 5.946 years (mean ± SD), ranging between 50 and 74.

Moreover, 39 out of 50 patients had no comorbidities (78%), while the remaining 11 patients had comorbidities.

In eyes dilated with IMAC on the day of surgery, the pupillary size increased to an average of 7.310 ± 1.0197 mm 30 s following injection, following which there was a gradual decline in pupillary size to 6.480 ± 1.1822 mm following cataractous lens removal and to 5.790 ± 1.1207 mm at the end of surgery [Table 1]. However, 98% of cases had adequate pupillary dilation throughout the procedure, and only 2% of the cases required re-injection. Thus, intracameral combination injection helped in a hassle-free and complication-free surgery.

When we compared the pupillary size of the operating eye and the non-operating eye on the previous day of surgery, it was noted that on the previous day of surgery during pre-operative evaluation, the average PD of the operating

eye was 7.940 ± 0.7117 mm and that of the non-operating eye was 7.950 ± 0.7161 mm, both of which were dilated with topical mydriatics; the mean difference between them was 0.01 mm, thus showing no statistical difference [Table 2].

Similarly, on the operating day, the average PD 30 s after injection in the operating eye was 7.310 ± 1.0197 mm, and the average PD of the non-operating eye dilated with topical mydriatics was 7.430 ± 0.9637 mm, the difference in which was 0.12 mm, which when compared also showed no statistical difference [Table 3].

It was noted that PD in the operating eye on pre-operative evaluation when dilated with topical mydriatics was 7.940 ± 0.7117 mm and when dilated with IMAC on operating day was 7.310 ± 1.0197 mm following 30 s of combination injection (IMAC) [Table 4]. Thus, the mean difference in pupillary size was 0.63 ± 0.308 mm, which was statistically significant.

In the non-operating eye, dilated with topical mydriatics, the PD on pre-operative evaluation was 7.950 ± 0.7161 mm, while on the operating day, it was 7.430 ± 0.9637 mm. Thus, the mean difference was 0.52 ± 0.247 mm, which was statistically significant [Table 5].

This difference in PD on successive dilation in the above two results could be accounted for by the receptor downregulation mechanism.

## DISCUSSION

Tropicamide is a parasympathetic antagonist that acts on the pupillary sphincter muscle, causing its relaxation and thus bringing about pupillary dilation.[3] It also inhibits parasympathetic drive, allowing sympathetic action to predominate like other anticholinergics.[4]

Phenylephrine HCL acts on alpha-adrenergic receptors of the iris dilator muscle, hence stimulating and dilating it.[5]

Lincoff *et al.*[6] have shown that lignocaine dilates the pupil by blocking the parasympathetic tone of the sphincter pupillae.

Suan *et al.*[7] conducted a study on intracameral mydriatics compared to topical mydriatics in pupil dilation for phacoemulsification cataract surgery. This study comprised 112 patients, with 56 patients in each group, of whom 48 were male (42%) and 64 were female (57.14%).[7] Also, in a study conducted by Labetoulle *et al.* on the evaluation of the efficacy and safety of a standardized intracameral combination of mydriatics and anesthetics for cataract surgery in 591 patients, out of which 254 (42.9%) were men and 337 (57%) were women.[8] Similarly, in our study, out of 50 patients, 28 (56%) were female and 22 (44%) were male.

The mean age group of the patients taken up for our study was 58.58 ± 5.946 years (mean ± SD).

Similarly, the mean age group was between 62.93 ± 5.83 years (mean ± SD) in a study conducted by Suan *et al.*[7] and 69.1 ± 9.5 years in a study conducted by Labettoule *et al.*[9]

In our study, we noted a rise in PD in the operating eye from a baseline value of 3.030 ± 0.9114 mm to 7.940 ± 0.7117 mm with topical mydriatics on pre-operative evaluation, and to 7.310 ± 1.0197 mm following 30 s of intracameral combination injection, which descended to 5.790 ± 1.1207 mm by the end of surgery.

Also on the day of surgery, when we compared the pupillary size of the operating eye dilated with IMAC (7.310 ± 1.0197 mm) and the non-operating eye dilated with topical eye drops (7.430 ± 0.9637), it was noted that the pupillary size

**Table 1: Pupillary size (in mm) in different steps of cataract surgery with intracameral combination injection**

| | *n* | Minimum | Maximum | Mean | SD |
|---|---|---|---|---|---|
| 30 s after inj. | 50 | 5.0 | 9.0 | 7.310 | 1.0197 |
| Cataractous lens removal | 50 | 4.0 | 9.0 | 6.480 | 1.1822 |
| End of surgery | 50 | 3.0 | 8.0 | 5.790 | 1.1207 |

**Table 2: PD (in mm) in eyes dilated with topical mydriatics on the previous day (pre-operative evaluation)**

| | *n* | Minimum (mm) | Maximum (mm) | Mean | SD | Mean diff | *P* |
|---|---|---|---|---|---|---|---|
| Operating eye | 50 | 7.0 | 9.0 | 7.940 | 0.7117 | −0.01 | 0.84 |
| Non-operating eye | 50 | 7.0 | 9.0 | 7.950 | 0.7161 | | |

**Table 3: Pupillary size (in mm) on the day of surgery**

| | *n* | Minimum | Maximum | Mean | SD | Mean diff | *P* |
|---|---|---|---|---|---|---|---|
| 30 s after injection in the operating eye | 50 | 5.0 | 9.0 | 7.310 | 1.0197 | −0.12 | 0.379 |
| PD in non-operating eye dilated with topical mydriatics | 50 | 5.0 | 10.0 | 7.430 | 0.9637 | | |

**Table 4: Pupillary size (in mm) of the operating eye (after dilatation) on successive days**

| | *n* | Minimum | Maximum | Mean | SD | Mean diff | *P* |
|---|---|---|---|---|---|---|---|
| On pre-op evaluation with topical mydriatics | 50 | 7.0 | 9.0 | 7.940 | 0.7117 | 0.63 | 0.001* |
| 30 s after inj. on operating day | 50 | 5.0 | 9.0 | 7.310 | 1.0197 | | |

*Significant

**Table 5: PD (in mm) in the non-operating eye dilated with topical mydriatics on successive days**

| | *n* | Minimum | Maximum | Mean | SD | Mean diff | *P* |
|---|---|---|---|---|---|---|---|
| On previous day of surgery | 50 | 7.0 | 9.0 | 7.950 | 0.7161 | 0.52 | 0.001* |
| On the day of surgery | 50 | 5.0 | 10.0 | 7.430 | 0.9637 | | |

*Significant

in the topical group was slightly larger (0.12 mm) compared to the IMAC group, but it was statistically insignificant.

Similarly, on the pre-operative day, the pupillary size of the operating eye and non-operating eye dilated with topical eye drops was 7.940 ± 0.7117 mm and 7.950 ± 0.7161 mm, respectively. The difference in pupillary size in both eyes was negligible (0.01 mm) and thus insignificant.

When we compared the pupillary size in the non-operating eye dilated with topical mydriatics during evaluation on the pre-operative day (7.950 ± 0.7161 mm) and on the day of surgery (7.430 ± 0.9637 mm) on successive days, there was a difference of 0.52 mm, which was statistically significant, with which we analyzed the receptor downregulation mechanism.

Similarly, when we compared pupillary size in the operating eye dilated with topical mydriatic during pre-operative evaluation (7.940 ± 0.7117 mm) and on the day of surgery with IMAC (7.310 ± 1.10197 mm) on successive days, there was a difference of 0.63 mm, which was statistically significant, thus we were successful in analyzing the receptor downregulation mechanism in both groups dilated on successive days.

In a study, conducted by McCormack *et al*.[10] the difference in PD in eyes dilated with topical mydriatics on two consecutive days showed a reduction in PD of 0.15 mm on the second day; though the reduction in PD was less, it was statistically significant and thus similar to our study. The lesser reduction in PD in their study could be because the age group of the patients included in their study was between 21 and 67 years, with the average age being <50 years.[10]

In our study, on the operative day, the mean pupil size in the topical group (non-operating eye) was 7.430 ± 0.9637 mm, and the mean PD in the intracameral group before capsulorhexis was 7.310 ± 1.0197 mm. The mean PD in the topical group was slightly higher (+0.12 mm) compared to that of the intracameral group, but was not statistically significant. Contrary to our study, Suan *et al.*[7] studied that the mean pupil size before capsulorhexis in the topical group (7.23 ± 1.08 mm) was significantly higher compared to that of the intracameral group (6.40 ± 0.80 mm) ($P = 0.01$). The intracameral injectable used in the study conducted by Suan *et al.*[7] was a preservative-free mixture of lidocaine 1.0% and phenylephrine 1.5%, while in our study, the intracameral injectable used was tropicamide 0.02%, phenylephrine 0.32%, and lidocaine 1% thus, the difference in the constitution of the injectable would have led to the contrary between the two studies.

In our study, the mean PD was 7.310 mm following 30 s of IMAC injection, which reduced to 5.790 mm at the end of surgery. Similarly, Suresha *et al.*[11] studied that the average PD 30 s following intracameral mydriatic solution (lignocaine 1% and epinephrine 0.1%) was 7.35 ± 1.2 mm, and by the end of the surgery, it was 5.53 ± 1.171 mm.

However, the mean pupillary dilation in the intracameral group was 6.3 mm at the beginning of surgery and 6.1 mm at the end of surgery in a study conducted by Morgado *et al.*[12] This difference when compared to our study could be because the intracameral mydriatic they used only contained 1% lidocaine and 2.5% phenylephrine and the reduction in PD from the start to the end of the procedure was very minimal, likely because the surgical method adopted in their study was phacoemulsification.

In our study, 98% of the patients underwent successful cataract surgery without the aid of IMAC reinjection, while only 2% of the patients needed re-injection before nucleus prolapse. Similarly, Labetoulle *et al.* studied that 96% of patients did not require re-injection during the surgery. Thus, IMAC can be used as an effective and safe alternative to topical mydriatics.[9,12]

Chiambaretta *et al.*[13] studied that the mean change in PD from start to end of surgery in the intracameral combination group was −1.67 ± 0.98 mm, while in our study the difference

was −1.52 ± 0.10 mm, yet both studies were successful in maintaining effective mydriasis, thus allowing us to perform crucial steps like intraocular lens implantation and cortical wash with ease.[13]

Receptor downregulation is characterized by a reduction in the total number of receptors in the cell due to endocytosis, followed by subsequent degradation of the receptors caused by long-term exposure to agonists.

In our study, the mean PD in the operating eye on preoperative evaluation with topical mydriatics and with the IMAC group on the operating day was 7.940 ± 0.7117 mm and 7.310 ± 1.0197 mm, respectively. Also, the mean PD in the non-operating eye dilated with topical mydriatics on the pre-operative day and the operative day was 7.950 ± 0.7161 mm and 7.430 ± 0.9637 mm. The mean difference in PD in eyes dilated with topical tropicamide on the pre-operative day and IMAC on the operative day was 0.4 mm, and the mean difference in PD in eyes dilated with topical tropicamide on the pre-operative day and operative day was 0.5 mm. This difference in PD in both groups was statistically significant, probably owing to the receptor downregulation mechanism.

Similarly, McCormack *et al.*[10] conducted a study to determine the effect of serial doses of two commonly used mydriatic agents on two consecutive days in 28 subjects, in which eyes dilated with topical tropicamide on two consecutive days showed 0.15 mm less PD on the second day and concluded that pupils should probably not be dilated on the day before surgery to achieve full dilatation.[10]

Also, Power *et al.*[14] conducted a study in 40 eyes in patients aged between 55 and 86 years, with a mean age of 65.5 years. He concluded that the eyes dilated with topical cyclopentolate 1% on two consecutive days dilated 0.73 mm less than those eyes dilated with topical tropicamide 1%. It was stated that the initial dose of mydriatics altered the acetylcholine receptors on the iris, henceforth preventing a complete response to the second dose. It was also stated that the greater toxic effect of cyclopentolate 1% could have led to a greater reduction in pupillary size compared to that of tropicamide.[14]

Haddad *et al.*[15] conducted a study in 32 subjects over 21 years of age in which eyes were dilated on two consecutive days with 10% phenylephrine and were found to dilate 0.3–0.4 mm less on the second day compared to the first day in patients of >50 years of age which was similar to our study.

## CONCLUSION

- IMAC injection is an effective method of pupillary dilation in MSICS.
- IMAC injection can be adopted as a better alternative as it is equally efficacious as topical mydriatics in attaining successful, sustained pupillary dilation in MSICS.
- It can affect pupillary dilation when dilated for consecutive days due to receptor downregulation, which can affect surgery in some cases, though negligible in the majority.

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### Conflicts of interest
There are no conflicts of interest.

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Original Article

# Accuracy of a free, open source, machine learning model, made using teachable machine in detecting retinitis pigmentosa on fundus images


## ABSTRACT

**Background and Aims:** Assessing the accuracy and the discrimination ability of a free web-based machine learning model to identify the presence of retinitis pigmentosa. **Settings and Design:** For the study, 373 ultrawide-field autofluorescence images (150, retinitis pigmentosa; 223, normal) were obtained from the patients. The machine learning tool used is called teachable machine that uses TensorFlow.js, a library for machine learning in JavaScript, to train and run the models in the browser of the user itself. **Materials and Methods:** Two separate deep learning models were created with both models using 85:15 as the ratio of training vs testing images. The images in both models were randomly selected in one case by the teachable machine neural network itself, and in the other, it was manually selected. **Results:** The accuracy of the first model was found to be 98.25%. The sensitivity of the model was found to be 95.65%, and the specificity was found to be 100%. The accuracy of the second model was found to be 94.74%. The sensitivity and specificity of the model were found to be 91.30% and 97.06%. **Discussion:** The study found to show that the machine learning model could distinguish between the retinitis pigmentosa eyes and normal, healthy eyes with a high specificity and sensitivity.



**Keywords:** AI model, machine learning, retinitis pigmentosa, teachable machine


## INTRODUCTION

Retinitis pigmentosa (RP) is a group of genetic eye disorders characterized by the progressive degeneration of photoreceptor cells in the retina, leading to vision loss. It typically begins with night blindness and gradually narrows the visual field, often resulting in tunnel vision [Figure 1].[1]

In these modern times, artificial intelligence (AI) has become a prominent tool that is being widely used in numerous industries.[2] Considering the various applications of AI in healthcare like diagnostic software's, patient engagement software's, AI assisted therapeutic recommendations, AI-performed surgeries etc., an open source ai for creating machine learning models is game-changing.[3]

The application of AI in ophthalmology mainly concentrates on the diseases with a high incidence, such as diabetic retinopathy, age-related macular degeneration, glaucoma, retinopathy of prematurity, age-related or congenital cataract, and few with retinal vein occlusion.[4]

Teachable Machine which is a free to use, open source, web-based computer program created by Google Creative LabTeachable Machine helps in creating machine learning models of various types. Learning rate and the batch size can be adjusted while making a model in this software.[5] Tensor flow.js is an amateur friendly software, great for beginners.[6]


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A diagnostic software for various diseases like the one made in this study for retinitis pigmentosa can be used in effective diagnosis of a disease even when a clinician is unavailable or when there is a limitation of time.[7]

## MATERIALS AND METHODS

### Study design

This study is a retrospective study. The study period of this study was roughly 90 days. The sample size was determined according to the number of registered retinitis pigmentosa cases in clinical database of the Opthalmology Department of Tsukazaki hospital. Out of these, in this study, fundus images with only typical retinits pigmentosa were included. Retinitis pigmentosa cases with complications like previous retinal procedure like photocoagulation, vitreous hemorrhage, cataract, and cases with other coexisting fundal disease were excluded. The number of normal cases that were selected was according to the clinical database at the same hospital that were seen and checked again for retinitis pigmentosa by an ophthalmologist.

### Study setting

373 ultra-wide field pseudocolor images were used to train and test the machine learning model. The images used for this study were obtained from the open database provided in the study by Masumoto *et al*.[5] The Optos® camera (Optos Plc, Dunfermline, Scotland) was used to capture the fundus images since it can acquire wide-angle photographs of the fundus. Each image is of size 11.43 MB and resolution of 3900 × 3072. Informed consent was taken from the patients at the time of obtaining the images. To diagnose the images as normal and retinitis pigmentosa, fluorescein angiography, full-field electroretinograms (ERGs), and clinical history were used by the ophthalmologists conducting the study. The diagnosis of the condition of the patients also included multiple consultations with ophthalmologists to confirm the existence of retinitis pigmentosa. In total, 150 images of patients with retinitis pigmentosa and 223 images of patients with normal eyes were used. Of this, 15% of each category was used to test the system and the remaining 85% was used to train the machine learning system.

The images were divided into two categories: 150 retinitis pigmentosa, ultrawide-field images and 223 normal ultrawide-field images uploaded onto the website. The software itself selects 15% of images from both categories at random to use to test the system and the remaining 85% to train the system. The machine learning model is never exposed to the test images until the model has been completely trained. The epochs of the system were set to 5000 to increase the accuracy of the model. The number of epochs refers to the number of times an image in the data set is fed through the training model. The batch size for the images was set to 16. The batch size refers to the number of samples that are used in one iteration of training [Figure 2].[8] The model was then trained; it took the model 3 hours and 43 minutes to get trained [Figure 3]. To test the accuracy of our created model and the accuracy of the its results, a second machine learning model was created on the same platform; this time, the test images were selected at random and not uploaded onto the system [Figure 4]. The 127 retinitis pigmentosa, ultrawide-field images, and 189 normal ultrawide-field images were uploaded onto the website. The model was set to 5000 epochs, learning rate was set to 0.001, and the batch size used was 16. The model took 3 hours and 14 minutes to train. The remaining images selected at random were then individually uploaded, and the accuracy of the system to detect retinitis pigmentosa was seen. The raw code data of both models have been attached below.

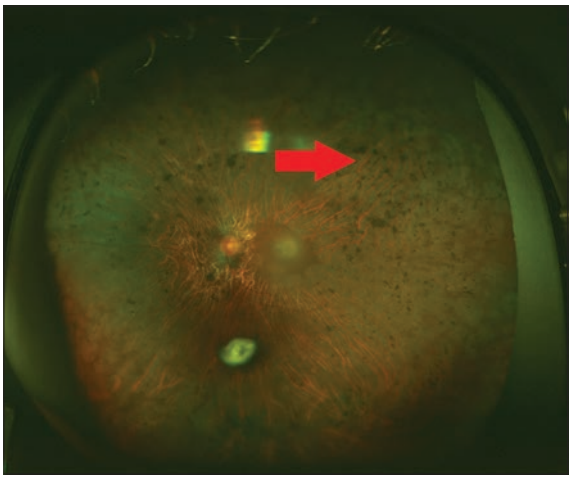


Figure 1: Retinitis pigmentosa (the red arrow in the figure points to the characteristic bone spicule pigmentation that is seen in the fundus of these patients)

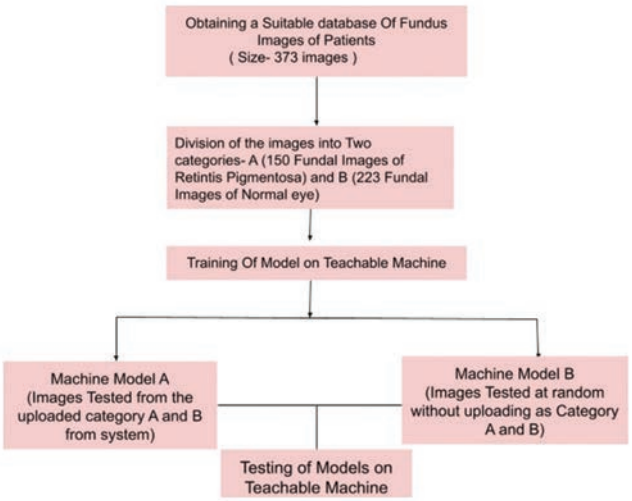



Figure 2: Flowchart

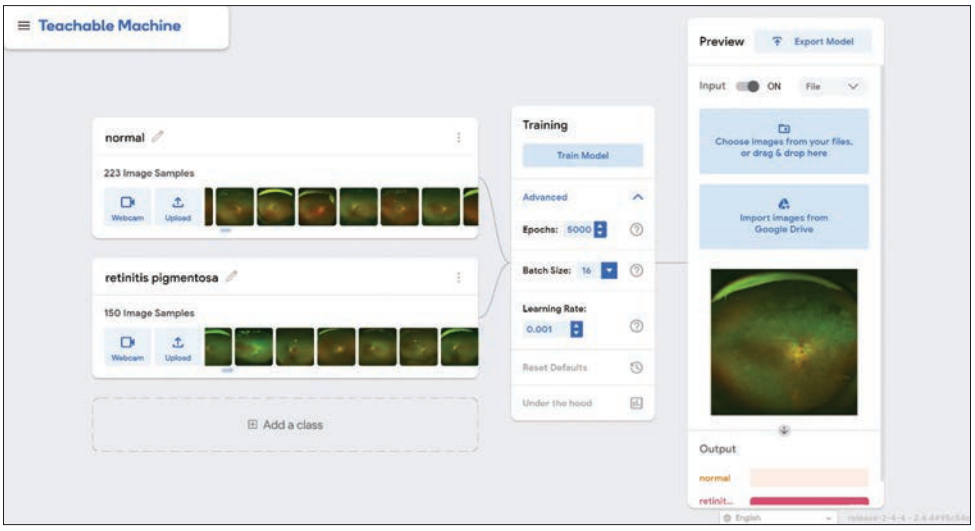



**Figure 3: Model 1**

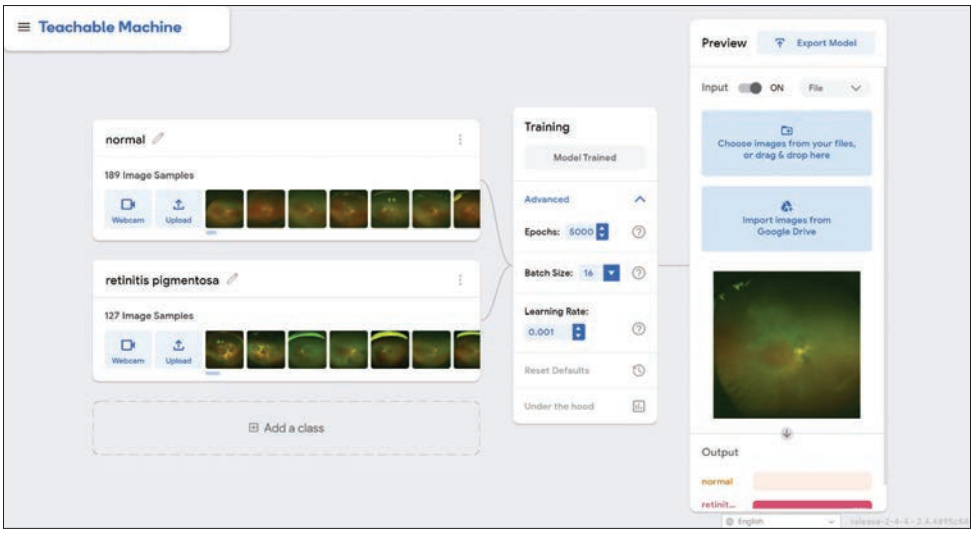



**Figure 4: Model 2**

## RESULTS

The background of the patients is described in Table 1.[7] There were no significant differences between the normal and retinitis pigmentosa groups when comparing age, sex, and ratio between the left and right eyes.

The accuracy of the first model where all 373 images were uploaded was found to be 98.25%. The sensitivity of the model was found to be 95.65%, and the specificity was found to be 100%. The precision of the model was found to be 100%. The model predicted 1 retinitis pigmentosa image out of 23 as normal, all 34 normal images were detected as normal.

The accuracy of the second model, where 15% of the images were randomly selected and used to test the machine learning model was found to be 94.74%. The sensitivity and specificity of the model were found to be 91.30% and 97.06%. The precision of the model was found to be 95.45%. The model predicted 2 retinitis pigmentosa images out of 23 as normal. The model predicted 1 normal image out of 34 as retinitis pigmentosa.

**Table 1: Background characteristics of study participants**

| | Normal | RP | P-value |
|---|---|---|---|
| *n* | 223 | 150 | |
| Age | 64.0±14.0 (11–78) | 61.1±15.1 (19–87) | *P*=0.06 (Student's *t*-test) |
| Sex, female | 123 (55.2%) | 74 (49.3%) | *P*=0.29 (Fisher's exact test) |
| Eye, left | 119 (53.4%) | 70 (46.7%) | *P*=0.21 (Fisher's exact test) |

Notes: There are no significant differences in age, female ratio, and left ratio between normal images and retinitis pigmentosa images. Age (years) is reported as the mean±standard deviation with (range). Sex, eye are shown as number with (%). RP, Retinitis Pigmentosa

## DISCUSSION

Both the machine learning models were found to have high sensitivity and specificity (95.65%, 100%, and 91.30%, 97.06%) There was very minimal difference between the sensitivity and specificity between the two models as well. The similarity in values between the two models can be attributed to both models being created on the same deep learning software (tensor flow.js). A major benefit of machine learning is that the images used in the study (ultrawide-field pseudocolor images) can be obtained without an ophthalmologist present which makes using a machine learning algorithm a viable solution to screen people in an area for RP.

Despite the machine learning model being created in a completely free to use, web-based software, the accuracy obtained for is similar to other models created. The model created by Ta-Ching Chen *et al*. was found to have an accuracy of 96% in detecting the disease with a sensitivity of 95.71%.[9] The model created by A. Miere was found to have an overall accuracy of 95% in detecting inherited diseases such as RP, Best disease, and Stargardt disease.[10]

Since teachable machine is a free to use software, one of the major benefits of the study is that the deep learning model has been made completely free of charge. It can also be made by anyone, and physicians all over the world can help contribute to the improvement of the algorithm by increasing the image data base that the AI has been exposed to. With increasing the number of images in the normal and RP groups, the accuracy of the system can be improved even further. Apart from cost, the speed at which an image can be screened for RP also decreases significantly. The machine learning model, if run on a fast computer can go through thousands of images in seconds at near to no cost in diagnosing the disease. Another major benefit of using AI is that these models are dynamic and keep improving further and further, the more the model is exposed to, the more they improve, and this makes them achieve a higher accuracy as they are used more extensively.

The limitation of the study is that the software in our study was trained using only two types of images, normal and RP. In the real world, people have multiple diseases along with RP, people can also have multiple different types of retinal changes, and these would not be accurately diagnosed by the machine learning model. Another limitation of the study is the sample size used. The AI model has been exposed to a small number of images and increasing this sample size can help further increasing the accuracy, sensitivity, and specificity of the system. Another limitation in the study is that the software used does not provide heatmaps of the images. Heatmaps of the images help us know how the various images are being studied by the machine learning algorithm helping us tweak the model and refine it further. This limitation can be overcome if the AI used to diagnose the disease is coded instead of using teachable machine.

### Supplementary material

Artificial intelligence model 1 link- https://teachablemachine.withgoogle.com/models/2CzhCbqQq/.

Artificial intelligence model 2 link- https://teachablemachine.withgoogle.com/models/gXG_I9I84/.

### Acknowledgement

I would like to express my deepest gratitude to the authors of the study titled 'Accuracy of a deep convolutional neural network in detection of retinitis pigmentosa on ultrawide-field images' by Masumoto *et al*. for providing their database of fundus images for free use under the creative commons license which allows us to use these images for non-commercial purposes. We have attempted to contact the authors of the study as well on various platforms to express our gratitude.

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Nil.

### Conflicts of interest

There are no conflicts of interest.

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Original Article

# Profile of patients undergoing cataract surgery at a district mobile ophthalmic unit in South India: A retrospective analysis of demographics, clinical profile, and comorbidities


## ABSTRACT

**Purpose:** This study aims to explore the demographic and clinical profile of cataract patients screened and operated on at a District Mobile Ophthalmic Unit (DMOU) in Kerala. **Methods:** This retrospective study analyzed data from 500 patients who underwent cataract surgery at a DMOU in Kerala between October 2022 and May 2024. Data collected included demographics, preoperative visual parameters, severity of visual impairment, and details on medical comorbidities. Statistical analysis was performed using Microsoft Excel and SPSS Version 24 with Chi-Square tests and Cramer's V calculations to identify associations between the severity of vision loss and demographic and clinical variables. **Results:** The study found that among 500 patients who underwent cataract surgery, 59% were female, with a mean age of 66.7 years, and 72.6% had significant visual impairment (BCVA less than 6/60) before surgery. Cortical cataracts were most common (75.8%), with immature senile cataracts and mature senile cataracts being the most prevalent stages. The study also found significant associations between cataract type and visual impairment, with cortical cataracts causing more visual impairment than nuclear cataracts. Additionally, 74% of patients had at least one medical comorbidity, with systemic hypertension being the most common. No significant associations were found between gender, age, medical comorbidities, and severity of visual impairment. **Conclusions:** Our study revealed that a large number of patients with severe visual impairment due to cataracts are still there in the community and can be potential beneficiaries of cataract surgery at DMOUs. We found that cortical cataracts are more common among patients, and most have multiple medical comorbidities. Research is needed to identify barriers to care-seeking and optimize outreach programs.



**Keywords:** Cataract, blindness, District Mobile Ophthalmic Units, DMOUs, NPCB


## INTRODUCTION

Cataract is the leading cause of preventable blindness in people 50 years and older. In 2020, 15.2 million people (45.5% of all causes of blindness) above 50 years had blindness due to cataracts alone, causing a significant burden.[1] Cataract-related blindness exhibits a significant global health disparity, with a disproportionately higher prevalence observed in developing countries compared to developed countries, primarily due to inequities in healthcare access and eye care services.[1] The worldwide burden of cataract-induced blindness is experiencing a steady annual growth of 1–2 million new cases, highlighting the urgency for enhanced prevention and treatment strategies to mitigate


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this trend.[2] In India, blindness due to cataracts still stands as the top reason for blindness, accounting for 81% of severe visual impairment, with an estimated 3.8 million individuals affected every year. Poor eye health costs India's economy around 0.47% to 0.70% of GDP annually, thus substantially limiting the country's growth aspirations.[3] World Health Organization (WHO) had envisioned the "Vision 2020" initiative to eliminate the avoidable causes of blindness by 2020. The WHO aims to provide people "with the right to sight" by facilitating the development and implementation of sustainable national eye care programs.[4]

India implemented the National Programme for the Control of Blindness (NPCB) in 1976, primarily focusing on identifying and treating cataract-related blindness. Key services rendered under the NPCB included community-based ophthalmology screening camps in rural areas and subsequent surgical interventions for diagnosed patients, aiming to bridge the gap in eye care services for marginalized populations.[5] Mobile eye services (MESs) were implemented in India for the first time to facilitate services to remote and economically disadvantaged regions.[6] To enhance these services, the 12th Five-Year Plan introduced a phased implementation of District Mobile Ophthalmic Units (DMOUs) in district hospitals and aimed to widen the services gradually.[7] Priority was given to remote or mountainous areas, including the North-Eastern States and economically disadvantaged regions, to broaden the scope of outreach eye care services.[7]

The MES helps to bring comprehensive ophthalmological screening and treatment to the most needed populations in socially and economically weak areas. A review of MES services found that the services benefitted more than two million people and more than 180000 surgeries for cataracts and glaucoma.[6] An MES service in rural India has screened more than 50000 patients over 1.5 years and found refractive errors and cataracts as the most common cause of blindness.[8] Research has shown promising results for Mobile Eye Surgical Units (MESUs) as a viable strategy for decentralizing cataract surgery services. Pilot models have consistently reported positive visual outcomes, highlighting the potential of MESUs to increase the accessibility and affordability of cataract surgery at the community level.[9] However, some studies have reported a less favorable visual outcome and more complications for patients who underwent surgery in MESU than in a hospital.[10] In the NPCB program, the DMOUs are designed to provide multiple services such as cataract screening, school eye screening, diabetic retinopathy screening, onsite correction of refractive errors, and transportation of patients to DHs for evaluation and additional services such as surgery.[5] Studies from the West have shown that different demographic and clinical factors can influence the utilization of the services at an MES unit.[11] However, studies on DMOUs in India are still lacking.

There is a paucity of research about the profile of patients using the services from DMOUs and their visual outcomes. The current study explores the demographic and clinical profile of cataract patients screened and underwent cataract surgery at a DMOU in Kerala.

## METHODS

A Retrospective study was conducted at the Department of Ophthalmology, General Hospital Alappuzha, Kerala, the nodal center for the Multipurpose District Mobile Ophthalmic Units (MDMOU). This study was approved by the ethics committee review board at State Health Systems Resource Centre Kerala, and departmental permission was granted to the district medical officer, Alappuzha (B1/4942/2024). Five Hundred patients from MDMOU eye camps for 19 months, from October 2022 to May 2024, who were admitted at the DH for cataract surgery are included in the current study. Patients with complicated, traumatic, congenital, and developmental cataracts were excluded from the study. A sample size of 200 is enough for retrospective studies to detect outcomes in an intervention given to 5% of the population with a precision of ± 0.03.[12] We adhered to established guidelines for retrospective studies to maintain methodological quality and rigor.[13]

### The working of the MDMOU

Accredited social health activist (ASHA) workers will visit households to identify individuals with reduced vision through a finger-counting method and compile a list of those needing evaluation at the eye camps.[14] At the camp, the patient's visual acuity was assessed using the Snellen and E-charts, an eye examination was performed using a loop and torchlight, and the intraocular pressure was measured with a Schiotz tonometer. The field ophthalmologist performed an indirect ophthalmoscopy, and patients were then considered for cataract surgery with their consent. Before surgery, all patients underwent free tests at government hospitals, including blood tests (e.g., blood sugar, viral markers, complete blood count), ECGs, urine analysis, kidney function tests, and bleeding and clotting time tests. A physician reviewed the results and issued a fitness for surgery, after which patients began using antibiotic eye drops in both eyes as advised by the optometrist, ensuring they were fully prepared for cataract surgery. Patients were transported to General Hospital Alappuzha on Thursdays, where they underwent a detailed slit lamp evaluation to detect any additional eye issues. Their cataracts were graded using the lens opacities classification system-3 (LOCS-3), and the

necessary lens power was determined through keratometry and A-scan biometry. Small Incision Cataract Surgery (SICS) occurred on Fridays, followed by Saturday discharge and returning to their homes. Patients returned for follow-up visits one week and seven weeks post-surgery, ensuring proper recovery and care.

### Data collection and statistical analysis

The principal investigator collected demographic details and preoperative visual parameters such as preoperative vision, cataract type, intraocular pressure (IOP), corneal measurements, surgical method, and intraocular lens (IOL). The visual impairment was classified based on the WHO criteria into five stages. We summarized categorical data using percentages and numerical data using mean and standard deviations. Any relationship between the severity of visual impairment and demographic and clinical variables was tested using the Chi-Square test for association. The significance level was set at a *P*-value of less than 0.05, and the strength of the significant relationship was expressed with Cramer's V. The data was analyzed using Microsoft Excel and Statistical Package for Social Sciences (SPSS) version 24.

## RESULTS

Five hundred eyes from 500 patients underwent cataract surgery during the study period. The demographic and clinical profiles of the patients are given in Table 1. Most patients were female (59%), with a mean age of 66.7 ± 7.57 years, and 77% were between 61 and 80 years. The mean intraocular pressure (IOP) before surgery was 14.9 ± 3.05 mmHg. The best-corrected visual acuity (BCVA) was less than 6/60 for 72.6% of the patients before surgery, thus showing a significant visual burden. The distribution of patients according to the WHO and NPCB criteria is described in Table 2. 61.6% of the patients belonged to the NPCB category of manifest blindness and WHO category 4 blindness.

Figure 1 represents the patients' cortical and nuclear cataracts, with the most common cortical cataract stages being immature senile cataract (IMSC) and mature senile cataract (MSC), constituting 52.4% and 23.4%, respectively. Nuclear cataracts were present in 120 patients (24%), and the most common stages were NS2 and NS4. Among the patients, 370 (74%) had at least one medical comorbidity, with the different medical comorbidities shown in Figure 2. Systemic hypertension was the most common medical comorbidity, affecting 57% of patients, followed by diabetes mellitus (31.2%) and other comorbidities, including Chronic Obstructive Pulmonary Disease (COPD) and cardiac illnesses, present in 13.2% and 8.8% of patients, respectively.

**Table 1: Demographic and clinical profile of the patients who underwent cataract surgery**

| Variables | Categories | Number (*n*) | Percentage (%) |
|---|---|---|---|
| Gender | Males | 205 | 41% |
| | Females | 295 | 59% |
| Age | <50 Years | 9 | 1.8% |
| | 51-60 Years | 91 | 18.2% |
| | 61-70 Years | 259 | 51.8% |
| | 71-80 Years | 126 | 25.2% |
| | >81 Years | 15 | 3.0% |
| Eyes operated | Right Eye | 257 | 51.4% |
| | Left Eye | 243 | 48.6% |
| **Variable** | **Mean** | **Standard Deviation** | **Range** |
| Age | 66.7 Years | 7.57 | 41-89 years |
| Intraocular Pressure | 14.9 | 3.05 | 5.10-22.4 |
| IOL Power | 21.2 | 1.78 | 14-27 |

IOL - Intraocular lens

**Table 2: The severity of patients' visual impairment based on WHO and NPCB Criteria**

| NPCB Criteria | WHO Criteria | BCVA | Number (*n*) | Percentage (%) |
|---|---|---|---|---|
| | | 6/12-6/18 | 7 | 1.4% |
| Low Vision | Category 1 | <6/18-6/60 | 130 | 26.0% |
| Economic Blindness | Category 2 | <6/60-3/60 | 30 | 6.0% |
| Social Blindness | Category 3 | <3/60-1/60 | 25 | 5.0% |
| Manifest Blindness | Category 4 | <1/60 - PL | 308 | 61.6% |
| Absolute Blindness | Category 5 | NO PL | 0 | 0 |

NPCB - National Program for Control of Blindness, WHO - World Health Organization, BCVA - Best-corrected visual acuity, PL - Perception of Light

We used a Chi-Square test to examine the relationship between visual impairment severity and demographic/clinical variables [Table 3]. A significant association was found between cataract type and visual impairment ($X^2$ (4, N = 500) =171, $P < 0.001$, V = 0.585), with cortical cataracts causing more visual impairment than nuclear cataracts (very strong association).[15] A significant, very strong association also existed between cortical cataract stages and visual impairment, with IMSC and MSC stages linked to more severe visual impairment ($X^2$ (16, N = 500) =236, $P < 0.001$, V = 0.343). For nuclear cataracts, NS2, NS3, and NS4 stages were more associated with category 1 blindness ($X^2$ (16, N = 120) =77, $P < 0.001$, V = 0.40, very strong association). No significant associations were found between gender, age, medical comorbidities, and severity of visual impairment.

## DISCUSSION

Despite initiatives such as the NPCB and the establishment of DMOU, there is a huge gap in service utilization and program implementation. An independent evaluation report of NPCB from 2010 to 2022 found that COVID-19

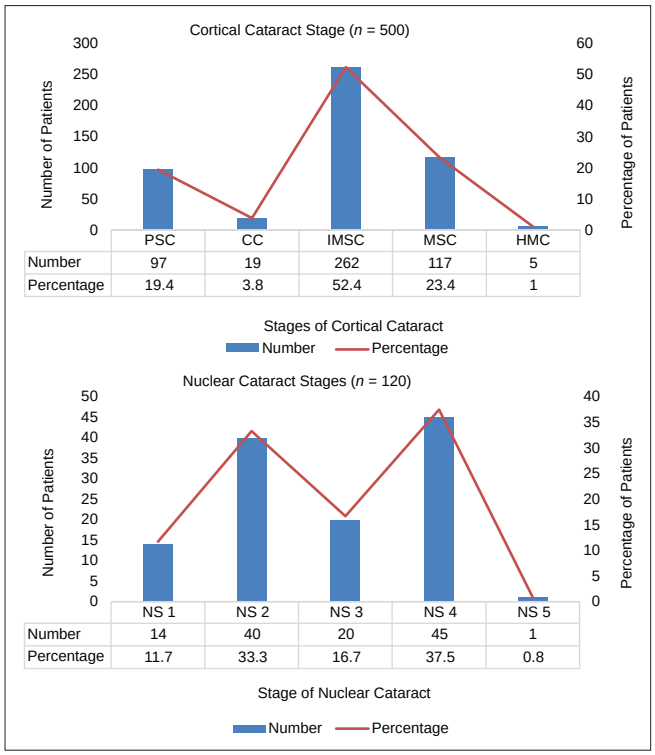



**Figure 1: The distribution of different grades of cortical and nuclear cataracts among patients. (PSC-Posterior capsular cataract, CC-Cortical cataract, IMSC-Immature senile cataract, MSC-Mature senile cataract, HMC-Hypermature cataract, NS-Nuclear stage)**

significantly impacted the NPCB interventions, leading to a 50% reduction in the number of cataract surgeries in 2021.[16] The projected number of cataract surgeries from 2022 to 2025 is around 270 lakhs. Retrospective studies help evaluate program implementation and service utilization, identify the strengths and weaknesses, and provide data for planning future changes.[17] Our study focuses on the profile of patients undergoing cataract surgery under a DMOU in south India established under the NPCB program. The findings can help identify the specific needs and factors influencing the population's service utilization.

Most patients who underwent cataract surgery at the DMOU were women. Previous reviews have found gender differences in blindness in India, with women having 69% higher odds of being cataract blind.[18] They also found that 33% of blindness in women is due to cataracts, and they had lesser odds of getting cataract surgery. An Indian study found that women underwent cataract surgery through mobile camps rather than in a hospital, as they might be reluctant to go to a hospital due to family obligations.[10] Our findings also confirm that women use DMOU services more than men, as it increases women's access to services. Other studies found that men use the camp services more than women, with 58.2% of the service users being men.[19] More than 3/4$^{th}$ of the patients in our study were older than 60, reflecting the

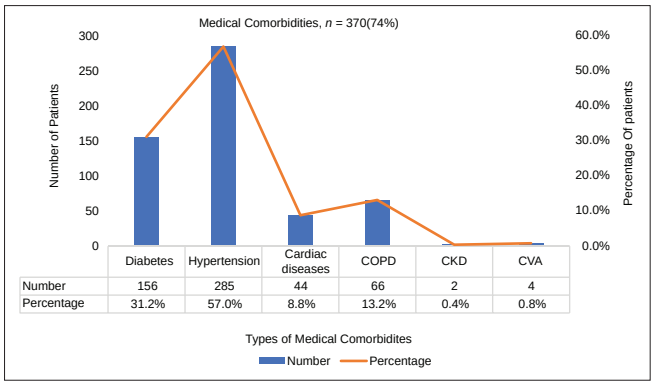



**Figure 2: Distribution of different medical comorbidities among patients. (COPD-Chronic obstructive pulmonary disease, CKD-Chronic kidney disease, CVA-Cerebrovascular accidents)**

relationship between aging and cataracts. Previous studies have demonstrated this relationship and found that age is the most important risk factor for cataracts.[20] Similar age distributions were seen in other Indian studies on camp patients undergoing surgery at base hospitals.[19,21] Compared to our data, a seven-year retrospective study from a tertiary-level specialty hospital showed a lower mean age for the patients (60 years) undergoing surgery, probably reflecting the need for outreach and mobile eye services.[22]

Most of the patients who sought DMOU care had severe visual impairment, with more than 65% belonging to WHO category 3 or above. The corresponding NPCB levels were either social or manifest blindness, thus indicating the severity of visual impairment among patients because of cataracts. About 98.6% of the patients met the preoperative vision criteria for surgical cataract treatment. Seven patients (1.4%) had mild vision loss with BCVA between 6/12 and 6/18, with posterior subcapsular cataracts presented with severe glare. These findings also reflect that a large group of patients with significant visual impairment are still there in the community, and they are the main services utilizers of the DMOU. Most hospital-based and camp-based studies from India reported a similar preoperative visual impairment, with a majority having the BCVA at WHO category 2 or above.[19,22,23] However, another study found that patients undergoing surgery have more visual impairment at baseline than at a hospital.[10]

Our study's distribution of cataract type was similar to a previous study, with almost everyone having cortical cataracts.[19,21] Interestingly, these findings contradict large community-level epidemiological studies that found an increased prevalence of nuclear cataracts and PSC compared to cortical cataracts.[24,25] A recent systematic review reported a difference in the prevalence of cataract types, with the USA and some African countries reporting more cortical cataracts and countries like India and Australia having a

**Table 3: Relationship between demographic/clinical variables and the severity of vision loss**

| WHO Categories | | Mild Vision Loss (%) | Category 1 (%) | Category 2 (%) | Category 3 (%) | Category 4 (%) | df | $\chi^2$ | *P* and Cramer's V |
|---|---|---|---|---|---|---|---|---|---|
| Gender | Male | 3 (42.9) | 56 (43.1) | 14 (46.7) | 7 (28) | 125 (40.6) | 4 | 2.41 | 0.661 |
| | Female | 4 (57.1) | 74 (56.9) | 16 (53.3) | 18 (72) | 183 (59.4) | | | |
| Age | <50 | 0 (0) | 2 (1.5) | 0 (0) | 1 (4) | 6 (1.9) | 16 | 10.6 | 0.834 |
| | 51-60 | 1 (14.3) | 19 (14.6) | 8 (26.7) | 2 (8) | 61 (19.8) | | | |
| | 61-70 | 3 (42.9) | 68 (52.3) | 16 (53.3) | 17 (68) | 155 (50.3) | | | |
| | 71-80 | 3 (42.9) | 36 (27.7) | 5 (16.7) | 5 (20) | 77 (25) | | | |
| | 81+ | 0 (0) | 5 (3.8) | 1 (3.3) | 0 (0) | 9 (2.9) | | | |
| Cataract Type | Cortical | 1 (14.3) | 49 (37.7) | 22 (73.3) | 20 (80) | 288 (93.5) | 4 | 171 | <.001 V=0.585 |
| | Nuclear | 6 (85.7) | 81 (62.3) | 8 (26.7) | 5 (20) | 20 (6.5) | | | |
| Stage of Cortical Cataract | CC | 0 (0) | 10 (7.7) | 1 (3.3) | 2 (8) | 16 (1.9) | 16 | 236 | <.001 V=0.343 |
| | HMC | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 5 (1.6) | | | |
| | IMSC | 0 (0) | 48 (36.9) | 21 (70) | 17 (68) | 176 (57.1) | | | |
| | MSC | 0 (0) | 1 (0.8) | 1 (3.3) | 3 (12) | 112 (36.4) | | | |
| | PSC | 7 (100) | 71 (54.6) | 7 (23.4) | 3 (12) | 9 (2.9) | | | |
| Nucelar Cataract Stage | NS1 | 6 (100) | 8 (9.9) | 0 (0) | 0 (0) | 0 (0) | 16 | 77 | <.001 V=0.40 |
| | NS2 | 0 (0) | 37 (45.7) | 0 (0) | 0 (0) | 3 (15) | | | |
| | NS3 | 0 (0) | 8 (9.9) | 3 (37.5) | 2 (40) | 7 (35) | | | |
| | NS4 | 0 (0) | 28 (34.6) | 5 (62.5) | 3 (60) | 9 (45) | | | |
| | NS5 | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 1 (5) | | | |
| Comorbidities | Present | 6 (85.7) | 95 (73.1) | 19 (63.3) | 22 (88) | 228 (74) | 4 | 4.88 | 0.300 |
| | Absent | 1 (14.3) | 35 (26.9) | 11 (36.7) | 3 (12) | 80 (26) | | | |

higher prevalence of nuclear cataracts.[20] Factors such as geographical location, the extent of ultraviolet light exposure, and socioeconomic status can influence the prevalence of different cataracts.[20] Previous studies have shown that the risk of developing different types of cataracts increases as age increases.[20] In our sample, 74% of patients had at least one medical comorbidity, with hypertension being the most common comorbidity, followed by diabetes. The prevalence of medical comorbidities was higher in our DMOU patients compared to hospital-based studies, which found diabetes and hypertension among 30% of their patients.[26] Larger epidemiological studies have found an increased prevalence of hypertension among patients undergoing cataract surgery in India, which is in line with the findings of our study.[25] Medical comorbidities such as hypertension and diabetes increase the odds of cataract development and also influence treatment outcomes and complications following surgery.[25] COPD patients with chronic steroid inhalators may be another contributing factor for cataract development.[27]

We found a significant relationship between the preoperative visual impairment and the type of cataract, with IMSC and MSC cortical cataracts causing more severe visual impairment than nuclear cataracts. Studies have shown that the BCVA decreases with an increase in the severity of cataracts, which may explain the findings of our study.[28] The age-related progression of both cortical and nuclear cataracts could explain the more severe visual impairment among our patients.[29] Even though previous studies had reported relationships between the severity of cataract-related vision loss and age, gender, and medical comorbidities, our study could not find a significant association between these factors and the severity of visual impairment.[25,30]

A sample size of 500 is large enough to understand the general trends in a retrospective study. The data was collected by a single team trained in ophthalmologic evaluation, and a trained ophthalmologist recorded all the data. Our current study has several limitations. First of all, the study's retrospective nature makes it difficult to draw major conclusions. The data is from a single center; hence, the findings can be influenced by geographical factors such as UV light exposure, making them less generalizable. We have not collected information about the level of control of comorbidities such as hypertension and diabetes and also about the medications patients take. These factors can also influence the severity of the cataract.

## CONCLUSION

In conclusion, our study reveals that women over 60 with severe visual impairment are the primary beneficiaries of cataract surgery at DMOUs in south India. Cortical cataracts are the most common type, and their severity correlates with preoperative visual impairment. Notably, DMOUs effectively reach patients with severe visual impairments who still abound in the community. To enhance the effectiveness of DMOU outreach programs, further research must investigate

and address the obstacles and challenges patients encounter when seeking care.

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## Conflicts of interest

There are no conflicts of interest.

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Original Article

# Visual and keratometry outcomes of combined corneal collagen cross-linking and intrastromal corneal ring segment surgery in keratoconus patients


## ABSTRACT

**Context:** To see the outcomes of combined corneal collagen cross-linking (C3R) and intrastromal corneal ring segment surgery (ICRS) in keratoconus patients in the Indian population. **Aim:** The long-term 12-month overall and specific corneal topographic and visual acuity changes among patients who underwent C3R with ICRS due to progressive keratoconus. **Settings and Design:** The medical records of consecutive progressive keratoconus patients who underwent C3R with ICRS procedure. Retrospective, hospital-based, single-arm cohort study. **Methods and Material:** The study included 72 eyes of 53 patients, with a mean age of 28.26 ± 6.76 years old. Keratoconus was diagnosed based on clinical features and tomographic findings. The progression of the disease depends upon the change in keratometry values over 6 months to 1 year. Patients with a history of previous corneal scarring, procedures, and trauma were excluded. **Results:** Among our population were 72 eyes of 53 patients (39 males and 14 females) with a mean age of 28.26 ± 6.67 (ranges from 17 to 48) years old. The statistical analysis was performed using SPSS software version 19.0. In addition, the Wilcoxon signed rank nonparametric test was used to compute the mean values of the outcome of the parameters. The mean values of maximum keratometry (Kmax) and mean keratometry (Km) significantly decreased from preoperative to postoperative 1-month follow-up visit ($P = 0.003$ and $P = 0.015$). They then stabilized from 3 months to 6 months. The best corrected visual acuity significantly improved up to 1 year of follow-up visits. **Conclusions:** The visual acuity and topographical results revealed that the C3R with ICRS procedure is safe and effective in stabilizing corneal topography and visual acuity parameters up to a long-term 12-month follow-up in patients with progressive keratoconus.



**Keywords:** Corneal collagen cross-linking and intrastromal corneal ring segment surgery, corneal topography, keratoconus, refractive error, surgical procedure


## INTRODUCTION

Keratoconus is a noninflammatory progressive ectasia of the cornea. The disease is often bilateral but can be present unilaterally.[1] Progression of keratoconus can lead to severe cornea thinning, irregular astigmatism, corneal scarring, and acute corneal hydrops, thus decreasing visual acuity and quality of vision.[2] Keratoconus was treated with nonsurgical and surgical approaches depending on the severity and progression of the disease.[3] To understand the combined surgical treatment procedure is most useful for progressive keratoconus. In India, no study is available on outcome measures after combining two surgical techniques for progressive keratoconus, such as corneal collagen


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cross-linking (C3R) and intrastromal corneal ring segment implant(ICRS).

## BACKGROUND OF THE STUDY

The combined ICRS implantation and C3R procedure was safely performed simultaneously on the same day or staged in two separate sessions; however, the simultaneous approach may be more effective, especially in improving the corneal shape.[4] If not addressed timely, a progressive form of keratoconus can lead to a severe economic impact on the patient.[5] The conventional cross-linking C3R procedure demonstrated in previous studies to halt the progression of progressive keratoconus. In this technique, 3 mW/cm$^2$ irradiated with 370 nm ultraviolet A light with a total dose of 5.4 J/cm$^2$ adapted to the cornea after 30 min of installation of riboflavin was used. The chemical reaction between UV-A and riboflavin helps increase the rigidity and stiffness of the cornea.[6] Meanwhile, the Accelerated C3R procedure (30 mW/cm2 for 3 minutes with a total dose of 5.4 J/cm$^2$) proved safe and effective for halting the progression of corneal ectasia. This procedure reduces the exposure time by maintaining the amount of UV-A treatment dose.[7,8]

### Methods

This is a retrospective, hospital-based, single-arm cohort study. Detailed evaluation of medical records of consecutive patients with keratoconus who underwent combined C3R with ICRS between January 2007 and January 2024 was done. The Institutional Ethics Committee approved the study (ITMIHSCON/08.1123/1673). All patients underwent a complete ocular examination, including slit-lamp examination, manifest refraction for corrected distance visual acuity (CDVA), dilated fundus examination, and corneal tomography using Wave Light® OculyzerTM (WaveLight AG, Erlangen, Germany). The following are the inclusion and exclusion criteria:

### Inclusion criteria

Advanced keratoconus patients underwent combined C3R with ICRS surgical procedure.

### Exclusion criteria

Patients diagnosed with other forms of corneal ectasia and who had previously undergone C3R or repeated C3R procedures, corneal scar/pterygium, history of other ocular surgical interventions, unavailability of tomography images, and patients with no follow-up visits after surgery.

Preoperatively and after combining the procedure of C3R with ICRS at 1, 3, 6, and 12 months after visual acuity evaluated with Snellen's chart and later converted to the Logarithm of the Minimum Angle of Resolution (Log MAR) for analysis. Patients using contact lenses were asked to discontinue contact lens use 3 weeks before every visit. The corneal tomographic measurements from scheimpflug imaging using WaveLight® OculyzerTM (WaveLight AG, Erlangen, Germany) were obtained at 1, 3, 6, and 12 months. The uncorrected visual acuity (UCVA), best corrected visual acuity (BCVA), mean keratometry (Km), maximum keratometry (Kmax), central corneal thickness (CCT), and topographic astigmatism were noted at every visit.

### Surgical procedure

The ICRS followed by C3R surgery was performed under topical anesthesia. A lid speculum was placed. The bag was created in the cornea using a femtosecond laser for 80% corneal thickness. A 1.4 mm incision was made on the steepest topographic axis with an entry cut thickness of 1 mm. The center of the pupil was marked, and the corneal thickness at the area of ICRS implantation was measured using ultrasound pachymetry. The centration was achieved manually, and ICRS was implanted with forceps and placed at the final position. A few patients underwent a single-ring or double-ring implant depending upon the severity of keratoconus. The C3R procedure was performed immediately after the ICRS procedure. The C3R procedure consisted of a 30-minute application of UVA light (3.0 mW/cm2 at 370 nm) to the central 7.0 mm of the cornea combined with topical application of riboflavin solution (0.1% riboflavin-5-phosphate and dextran) every 3 minutes, like the technique described by Wollensak *et al*. 1, except that the corneal epithelium was not removed before treatment. The epithelium was not removed as experience showed an ICRS epithelium leads to less patient discomfort after the procedure. Our experience with C3R and ICRS epithelium has shown equal effectiveness and safety as the procedure performed with epithelial removal. To compensate, the eye was presoaked with riboflavin for 5 minutes before UVA light was applied; riboflavin penetration of the stroma was confirmed at the slit lamp. An eyelid speculum was used to expose the eye. Standard examinations, including corneal topography and manifest refraction, were conducted preoperatively and postoperatively. At the end of the C3R procedure, we noted at slit lamp examination that the fluorescence-riboflavin solution penetrated to 50% corneal depth.[9] The ocular surface was rinsed with 20 ml of balanced saline solution at the end of UV irradiation. A soft bandage contact lens (BCL) was placed (ACUVUE OASYS, Johnson and Johnson Pvt. Ltd., India), and moxifloxacin 0.5% eye drop was installed at the end of the procedure. Postoperative patients were prescribed moxifloxacin 0.5% and nepafenac (0.1%) eye drops four times a day until removal of BCL and

carboxymethylcellulose (5 mg/ml) eye drops four times a day for 1 month. Once the BCL was removed, patients were started on loteprednol etabonate (0.5%) eye drops four times a day, followed by weekly tapering over 1 month.

### Statistical analysis

This study presented visual acuity and topographic outcome parameters as mean ± SD—the statistical analysis was performed using Statistical Package of Social Science SPSS software version 19.0. In addition, Wilcoxon signed-rank tests compute the mean values of outcome parameters of C3R with ICRS. Finally, we compared all outcome parameters at postoperative follow-up visits with baseline and between the follow-up visits—a P-value of 0.05 as the level of statistical significance.

## RESULTS

### Population characteristics

This study includes the 72 eyes of 53 patients. A final analysis was performed on 72 eyes (38 right eyes and 34 left eyes) of 53 patients with a mean age of 28.26 ± 6.76 years. In this study, patients were divided into different age groups, with a total number of 6 (8.33%) eyes from the six patients in age group 1 (less than 20 years old) and 43 (59.72%) eyes of 31 patients in age group 2 (21 to 30 years old). 20 (27.77%) eyes of 14 patients were in age group 3 (31 to 40). 3 (4.16%) eyes of two patients were in age group 4 (more than 40 years old).

Furthermore, patients were graded according to the preoperative severity of mean keratometry. The total number of eyes was 34 (47.22%) of 29 patients in grade 1 (Km ≤ 48D), 18 (25%) eyes of 16 patients in grade 2 (Km of 48D to ≤ 53D), 4 (5.55%) eyes of 4 patients in grade 3 (Km 53D to < 55D), and 16 (22.22%) eyes of 14 patients in grade 4 (Km ≥ 55D).

In this study, all the visual and topographical outcomes were evaluated postoperatively and at 1 month, 3 months, 6 months, and 12 months, compared with the baseline [Table 1]. The keratoconus was graded according to the mean keratometry value. In patients with a preoperative severity of Km grade 1 (Km ≤ 48D), BCVA significantly improved from 1 to 12 months, from 0.27 ± 0.19 Log MAR to 0.11 ± 0.11 Log MAR ($P = 0.043$) [Figure 1]. In grade 2, it significantly improved in 3 months ($P = 0.034$) compared to baseline [Table 2].

Furthermore, in age group 2 (21 to 30 years), BCVA improved significantly in the 12 months from 0.48 ± 0.25 Log MAR to 0.18 ± 0.18 Log MAR ($P = 0.05$) [Table 3].

The mean value of the spherical equivalent (SE) significantly decreased in 3 months postoperatively from -5.17 ± 5.20D to -2.22 ± 2.72D ($P = 0.01$). It stabilized from 6 months to 1 year ($P < 0.041$) compared to baseline [Figure 2]. In patients with a preoperative severity of Km grade 1 (Km ≤ 48D), SE significantly decreased from 1 to 12 months, from -3.03 ± 2.60D to -1.21 ± 1.92D ($P = 0.025$) [Table 2]. Furthermore, in both age group 2 (21 to 30 years old) and age group 3 (31 to 40 years old), the mean value of SE decreased from preoperative to 12-month follow-up visits [Table 3].

The mean value of the topographical cylinder decreased in 1 month from 4.26 ± 2.36D to 3.81 ± 2.83D. It then increased between 3 and 6 months but decreased in 1 year compared to baseline ($P = 0.289$), though this difference was not statistically significant [Figure 3]. In patients with preoperative severity of Km grades 1, 2, and 3, the topographical cylinder increased from 1 month to 6 months. However, this increase was not statistically significant [Table 2]. Furthermore, in age groups 2 and 3, the topographical cylinder decreased during the first month compared to baseline and then increased again to 6 months [Table 3].

The mean value of mean keratometry significantly decreased by 1 month postoperatively from 50.49 ± 5.65D to 48.10 ± 7.34D ($P = 0.015$). It stabilized up to 3 months and then decreased from 6 months to 1 year ($P < 0.001$) compared to baseline [Figure 4].

**Table 1: Change in Visual and topographical parameters at preoperative and postoperative treatment**

| Visits | Visual and Topographical outcomes | | | | | |
|---|---|---|---|---|---|---|
| | BCVA Mean±SD (*P*) | SE Mean±SD (*P*) | Topo cyl Mean±SD (*P*) | Kmean Mean±SD (*P*) | Kmax Mean±SD (*P*) | CCT Mean±SD (*P*) |
| Pre | 0.35±0.24 | -5.17±5.20 | 4.26±2.36 | 50.49±5.65 | 60.73±9.13 | 457.44±48.88 |
| 1 month | 0.23±0.13 (0.598) | -3.21±2.35 (0.278) | 3.81±2.83 (0.761) | 48.10±7.34 (0.015) | 56.47±6.15 (0.003) | 457.64±37.00 (0.55) |
| 3 months | 0.23±0.21 (0.011) | -2.22±2.72 (0.01) | 4.13±2.68 (0.297) | 48.48±5.31(<0.001) | 58.63±9.02 (0.007) | 446.35±46.11 (0.75) |
| 6 months | 0.21±0.16 (0.035) | -2.18±2.79 (0.813) | 4.09±3.04 (0.863) | 46.75±5.37 (0.006) | 55.79±9.10 (0.005) | 455.83±55.32 (0.206) |
| 12 months | 0.16±0.15(<0.001) | -2.23±3.54 (0.041) | 3.63±2.07 (0.289) | 45.16±3.76(<0.001) | 53.41±6.09(<0.001) | 465.50±36.95 (0.027) |
| Total | 0.26±0.21 | -3.50±4.14 | 4.05±2.57 | 48.40±5.84 | 57.91±8.66 | 455.49±46.02 |

*BCVA=Best corrected visual acuity, *SE=Spherical Equivalent, *Topo cyl=Topographical cylinder, *Kmean=Mean Keratometry, *Kmax=Maximum Keratometry, *CCT=Center Corneal Thickness

**Table 2: Change in visual and topographical parameters at preoperative and post-operative treatment in different grades of keratoconus**

| Keratoconus grades | Visits | BCVA Mean±SD (*P*) | SE Mean±SD (*P*) | Topo cyl Mean±SD (*P*) | Kmean Mean±SD (*P*) | Kmax Mean±SD (*P*) | CCT Mean±SD (*P*) |
|---|---|---|---|---|---|---|---|
| Grade 1 | Pre | 0.27±0.19 | -3.03±2.60 | 3.97±1.92 | 45.88±1.89 | 54.39±3.77 | 487.76±31.03 |
| | 1 Month | 0.20±0.14 (0.221) | -2.10±1.27 (0.715) | 4.13±3.12 (0.22) | 44.29±2.41 (0.004) | 52.28±2.50 (0.013) | 474.37±24.40 (0.396) |
| | 3 Months | 0.18±0.18 (0.157) | -2.16±2.90 (0.116) | 3.64±2.35 (0.245) | 44.82±2.17 (0.027) | 52.45±3.29 (0.036) | 473.36±28.52 (0.082) |
| | 6 Months | 0.13±0.09 (0.092) | -2.22±3.12 (0.799) | 3.13±2.25 (0.422) | 43.98±2.70 (0.005) | 51.02±2.84 (0.002) | 482.50±36.11 (0.778) |
| | 12 Months | 0.11±0.11 (0.043) | -1.21±1.92 (0.025) | 3.53±2.03 (0.457) | 43.68±2.42 (0.002) | 50.89±3.46 (0.005) | 476.75±32.28 (0.503) |
| Grade 2 | Pre | 0.48±0.25 | -6.27±4.22 | 4.62±2.56 | 50.71±1.34 | 60.04±6.07 | 441.11±51.35 |
| | 1 Month | 0.21±0.06 (0.066) | -2.17±1.15 (0.157) | 3.59±2.78 (0.386) | 49.91±1.54 (0.214) | 60.92±3.00 (0.859) | 448.30±33.77 (0.799) |
| | 3 Months | 0.22±0.17 (0.034) | -2.11±3.02 (0.197) | 3.69±2.17 (0.367) | 50.66±1.70 (0.656) | 61.48±3.60 (0.959) | 420.17±34.03 (0.019) |
| | 6 Months | 0.38±0.17 (0.317) | -2.00±0.35 | 4.90±2.94 (0.225) | 49.54±2.00 (0.225) | 60.06±4.71 (0.715) | 399.20±26.84 (0.043) |
| | 12 Months | 0.30±0.16 (0.102) | -6.06±5.77 (1) | 4.03±2.40 (0.917) | 51.08±1.52 (0.6) | 63.48±2.75 (0.075) | 420.50±9.29 (0.028) |
| Grade 3 | Pre | 0.38±0.36 | -2.625 | 3.30±0.50 | 53.85±0.58 | 64.68±3.42 | 460.00±22.29 |
| | 1 Month | 0.3 | -5.5 | 3.00±0.28 (0.655) | 54.60±0.42 (0.18) | 67.75±0.21 (0.655) | 397.00±57.98 (0.18) |
| | 3 Months | 0.3 | -1 | 4.71±1.81 (0.273) | 54.24±0.66 (0.197) | 71.60±4.01 (0.068) | 410.14±34.43 (0.068) |
| | 6 Months | 0.36±0.32 (0.18) | - | 4.3 | 53.6 | 66.7 | 396 |
| | 12 Months | 0.301 | - | - | - | - | - |
| Grade 4 | Pre | 0.34±0.24 | -9.69±8.54 | 4.73±3.15 | 59.20±2.99 | 74.00±5.96 | 410.75±37.06 |
| | 1 Month | - | - | 2.70±2.40 (0.157) | 68.75±18.74 (0.655) | 62.65±12.52 (0.655) | 406.00±24.04 (0.18) |
| | 3 Months | 0.45±0.27 (0.655) | -3.42±3.17 | 7.58±4.53 (0.08) | 59.40±3.98 (0.5) | 74.46±6.76 (0.345) | 381.60±51.82 (0.225) |
| | 6 Months | - | - | 9.03±4.05 (0.109) | 58.27±2.86 (0.285) | 76.83±6.44 (0.593) | 392.33±77.80 (1) |

*BCVA=Best corrected visual acuity, *SE=Spherical Equivalent, *Topo cyl=Topographical cylinder, *Kmean=Mean Keratometry, *Kmax=Maximum Keratometry, *CCT=Center Corneal Thickness. Keratoconus grades according to the preoperative value of mean keratometry grade 1 (Km ≤48D), grade 2 (Km of 48D to≤53D), grade 3 (Km 53D <55D), and grade 4 (Km ≥55D)

**Table 3: Change in visual and topographical parameters at preoperative and postoperative treatment in different age groups**

| Age group | Visits | BCVA Mean±SD (*P*) | SE Mean±SD (*P*) | Topo cyl Mean±SD (*P*) | Kmean Mean±SD (*P*) | Kmax Mean±SD (*P*) | CCT Mean±SD (*P*) |
|---|---|---|---|---|---|---|---|
| Group 1 | Pre | 0.40±0.56 | -2.83±1.45 | 4.50±3.43 | 51.75±7.65 | 62.33±12.25 | 459.50±52.91 |
| | 1 Month | 0.176 | -0.5 | 7 | 46.3 | 56.8 | 436 |
| | 3 Months | 0.32±0.20 (0.655) | -0.38±1.05 (0.144) | 6.10±4.74 (0.248) | 48.03±6.86 (0.028) | 59.32±15.86 (0.172) | 466.50±60.28 (0.588) |
| | 6 Months | | | 9.47±3.42 (0.109) | 53.97±5.33 (1) | 71.60±11.96 (0.285) | 428.67±50.64 (0.18) |
| | 12 Months | 0.15±0.21 | 0.13±1.94 | 4.15±2.19 (0.18) | 45.50±3.54 (0.655) | 53.05±7.71 (0.655) | 487.00±50.91 |
| Group 2 | Pre | 0.32±0.18 | -4.65±5.90 | 3.95±2.39 | 51.56±5.71 | 62.21±9.63 | 451.19±47.86 |
| | 1 Month | 0.19±0.14 | -3.63±1.65 (0.18) | 3.69±2.90 (0.528) | 50.04±9.01 (0.13) | 57.88±6.60 (0.007) | 449.78±42.28 (0.845) |
| | 3 Months | 0.22±0.23 (0.032) | -2.14±2.25 (0.077) | 4.08±2.23 (0.851) | 49.31±5.47 (0.005) | 60.18±8.46 (0.11) | 435.11±46.00 (0.038) |
| | 6 Months | 0.16±0.12 (0.059) | -0.38±2.32 (0.655) | 3.73±2.59 (0.198) | 46.60±5.31 (0.026) | 54.34±8.27 (0.005) | 455.50±70.68 (0.754) |
| | 12 Months | 0.18±0.18 (0.05) | -3.45±4.56 (0.285) | 3.60±2.40 (0.509) | 45.23±3.36 (0.004) | 53.14±5.97 (0.006) | 467.14±39.98 (0.152) |
| Group 3 | Pre | 0.46±0.29 | -8.23±3.51 | 4.78±2.01 | 48.72±4.27 | 58.44±6.50 | 465.20±52.22 |
| | 1 Month | 0.25±0.14 (0.063) | -3.51±2.76 (0.091) | 3.83±2.73 (0.374) | 46.40±3.79 (0.033) | 55.96±5.39 (0.091) | 467.27±30.61 (0.689) |
| | 3 Months | 0.25±0.19 (0.357) | -3.18±3.69 (0.172) | 3.79±2.45 (0.14) | 46.82±4.43 (0.279) | 55.64±6.30 (0.124) | 461.14±35.64 (0.397) |
| | 6 Months | 0.25±0.19 (0.285) | -3.16±2.85 (0.144) | 3.61±2.09 (0.26) | 45.57±4.53 (0.767) | 54.62±5.52 (0.407) | 463.89±38.93 (0.407) |
| | 12 Months | 0.14±0.08 (0.18) | -1.28±0.26 (0.109) | 3.70±2.09 (0.241) | 45.65±4.93 (0.475) | 55.21±7.11 (0.646) | 461.60±38.79 (0.139) |
| Group 4 | Pre | 0.06±0.10 | -1.92±0.29 | 4.90±2.19 | 44.37±3.54 | 51.67±1.93 | 491.33±25.54 |
| | 1 Month | | -2.19±0.80 (0.655) | 3.40±3.73 (0.285) | 43.30±3.55 (0.109) | 49.73±1.80 (0.109) | 476.67±13.32 (0.109) |
| | 3 Months | 0.09±0.12 (0.317) | | 1.40±1.70 (0.18) | 46.95±0.07 (0.18) | 50.45±2.19 (0.18) | 479.00±19.80 (0.317) |
| | 6 Months | 0.176091259 | -0.75 | 1.80±1.90 (0.109) | 43.77±3.53 (0.18) | 50.27±2.93 (0.285) | 460.33±17.79 (0.109) |
| | 12 Months | 0.09±0.12 | -1.00±0.50 (0.18) | 3.28±1.24 (0.109) | 43.53±2.42 (0.285) | 50.03±2.51 (0.285) | 458.75±21.45 (0.109) |

*BCVA=Best corrected visual acuity, *SE=Spherical Equivalent, *Topo cyl=Topographical cylinder, *Kmean=Mean Keratometry, *Kmax=Maximum Keratometry, *CCT=Center Corneal Thickness. Patients categorized by using different age groups, age group 1 (less than 20 years old), age group 2 (21-30 years old), age group 3 (31-40 years old), and age group 4 (more than 40 years old)

In patients with a preoperative severity of Km grade 1 (Km ≤48D), Km decreased significantly from 1 to 12 months, from 45.88 ± 1.89D to 43.68 ± 2.42D ($P$ = 0.002). Furthermore, in age group 2, the Km value decreased from 1 month to 12 months, from 51.56 ± 5.71D to 45.23 ± 3.36D ($P$ = 0.004) [Table 3].

The mean value of maximum keratometry significantly decreased 1 month postoperatively from 60.73 ± 9.13D to 56.47 ± 6.15D ($P = 0.003$). It stabilized up to 6 months and then significantly decreased to 1 year ($P < 0.001$) compared to baseline [Figure 5].

In patients with a preoperative severity of Km grade 1 (Km ≤ 48D), Kmax decreased significantly from 1 to 12 months, from 54.39 ± 3.77D to 50.89 ± 3.46D ($P = 0.005$) [Table 2].

Furthermore, in age group 2, the mean Kmax value decreased from 3 to 12 months, from 60.18 ± 8.46D to 53.14 ± 5.97D ($P = 0.006$) [Table 3].

The mean value of central corneal thickness decreased at 3 months postoperatively compared to the baseline value, from 457.44 ± 48.88 µm to 446.35 ± 46.11 µm. It then returned to the baseline value at 6 months and significantly increased at 1 year ($P = 0.027$) compared to the baseline [Figure 6].

In patients with a preoperative severity of Km grade 2 (Km of 48D to ≤ 53D), CCT decreased significantly from 1 to 6 months, from 448.30 ± 33.77 µm to 399.20 ± 26.84 µm ($P = 0.043$).

Furthermore, in age group 2, the mean value of CCT significantly decreased from 1 to 3 months, from 449.78 ± 42.28 µm to 435.11 ± 46.00 µm ($P = 0.038$) [Table 3].

## DISCUSSION

This study highlighted the long-term effectiveness and safety of the combined C3R with ICRS treatment procedure for

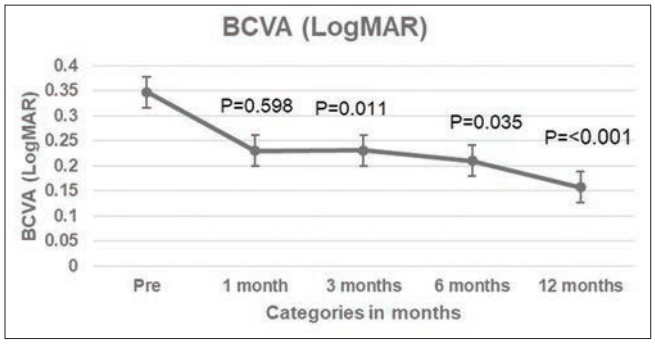



Figure 1: Long-term outcome of best corrected visual acuity

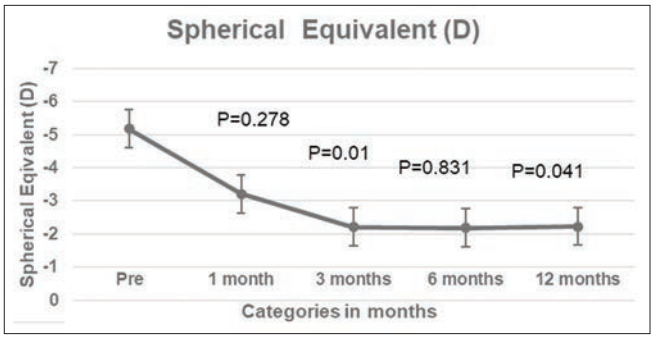



Figure 2: Long-term outcome of spherical equivalent

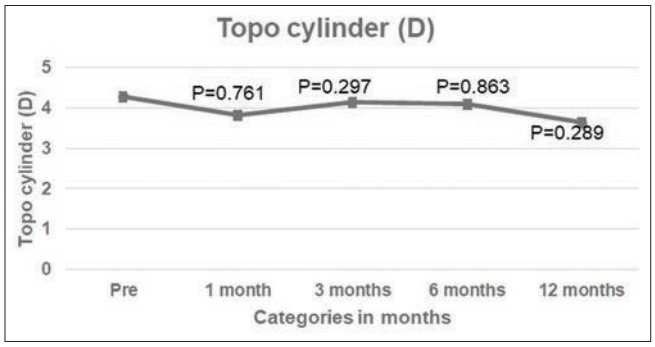



Figure 3: Long-term outcome of topographical cylinder

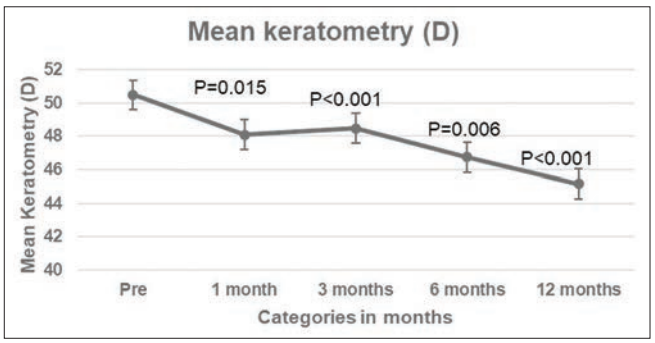



Figure 4: Long-term outcome of mean keratometry

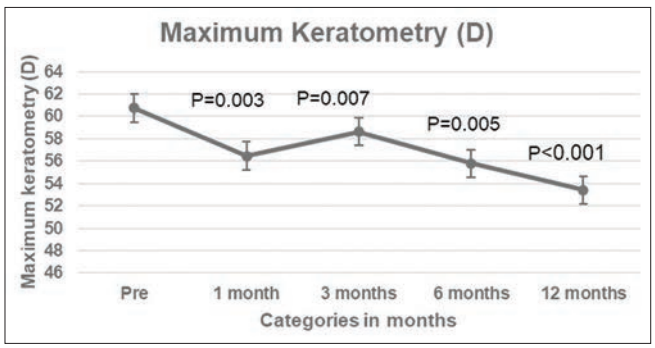



Figure 5: Long-term outcome of maximum keratometry

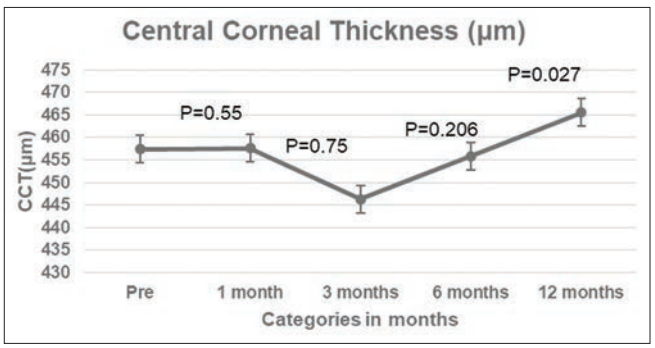



Figure 6: Long-term outcome of central corneal thickness

patients with progressive keratoconus. We also explored the postoperative topographical and visual outcomes after 1 year of the C3R with ICRS procedure. A previous study investigated Accelerated C3R (9 mW/cm$^2$) with UV-A radiation as an effective and safe treatment for halting the progression of keratoconus and stabilizing the visual acuity over 24 months.[10,11] The earlier studies proved that using riboflavin, along with UV light (3.0 mW/cm$^2$ for 30 min with a total dose of 5.4 J/cm$^2$) C3R procedure done according to Wollensak *et al*.[7] (UV-A), helps in halting the progression of keratoconus up to 1 year after the C3R procedure. In addition, the BCVA, SE, anterior and posterior corneal curvature, and elevation showed stable results after 1 year. No significant effects noticed on lens density and foveal thickness after the UV-A exposure.[11] A previous study evaluated 25 eyes of 21 patients with keratoconus. Two treatment groups were compared preoperatively and postoperatively at the last visit: ICRS only and with C3R. In the latter group, the ICRS with C3R group significantly reduced cylinders more than the ICRS-only group ($P < 0.05$). In addition, steep and average keratometry reduced in the ICRS with the C3R group ($P < 0.05$).[9] In our study, the mean value of steep keratometry and average keratometry reduces by up to 1 year after the ICRS with C3R combined surgical procedure.

Furthermore, another study evaluated 30 keratoconus patients treated with ICRS. Visual acuity, refraction, indices of corneal irregularity, and higher-order aberration were evaluated preoperatively and at 2 months, 1 year, 3 years, and 5 years postoperatively. UDVA and spherical and spherical equivalent improved ($P < 0.05$) for 3 years. On the other hand, CDVA improved for 5 years ($P < 0.05$). Topographic keratometry flattened, and corneal irregularity indices improved over 5 years (all $P < 0.05$). Coma RMS improved continuously for 5 years. ICRS has advantages in improving CDVA with topographic stabilization and decreasing coma in keratoconus for 5 years.[12] In our study, the BCVA improved significantly after 1 year of postsurgical treatment. Another study has shown better or equal results after management with one versus two ICRS in the management of keratoconus, as shown by an improvement in astigmatism, K values, and vision.[13,14]

In our study, the topographical cylinder and keratometry values decreased to 6 months. Another study resulted in the three eyes of three patients with one or both ICRS explanted after paired ICRS implantation combined with same-day C3R. There were no complications.[15.16]

The topographic corneal parameters and BCVA improved significantly in the patients with corneal keratoconus after C3R with ICRS surgery.[17,18] These results revealed that the combined C3R with ICRS procedure is safe and effective in stabilizing the corneal topography and visual acuity parameters up to long-term 12-month follow-up in patients with progressive keratoconus. The long-term effect of combining surgery of C3R with ICRS on the progression of keratoconus is currently unknown. But these combined techniques are in practice this time. Long-term follow-up is required to find out the effects of the combined technique.

## CONCLUSION

The visual acuity and topographical results revealed that the C3R with ICRS procedure is safe and effective in stabilizing corneal topography and visual acuity parameters up to a long-term 12-month follow-up in patients with progressive keratoconus. The simultaneous surgical procedure is safe and effective, especially in improving the corneal shape.

### Limitation

This study focused on combining the C3R with ICRS surgical procedure for patients with progressive keratoconus and involved a small sample size. Other surgical procedures for progressive keratoconus need to be evaluated in future.

### Key message

Keratoconus is the progressive thinning of the corneal disorder. Usually, keratoconus occurs due to genetic causes, but the exact cause is still unknown. There are distinct options available for the management of the cornea. In this study, we specify outcomes. Combining C3R with ICRS is the surgical treatment.

### List of abbreviation:

| | |
|---|---|
| C3R | Corneal Collagen Cross linking |
| ICRS | Intrastromal Corneal Ring Segment |
| UV | Ultraviolet |
| CDVA | Corrected distance visual acuity |
| Log MAR | Logarithm of the Minimum Angle of Resolution |
| UCVA | Uncorrected visual acuity |
| BCVA | Best corrected visual acuity |
| Km | Mean Keratometry |
| Kmax | Maximum Keratometry |
| CCT | Central corneal Thickness |
| BCL | bandage contact lens |
| SPSS | Statistical Package of Social Science |
| SE | Spherical Equivalent |

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### Conflicts of interest

There are no conflicts of interest.

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Original Article

# Prevalence of dry eye disease among Indian pilots: The role of noninvasive diagnostics


## ABSTRACT

**Purpose:** This study aimed to determine the prevalence of dry eye disease (DED) among Indian commercial pilots and examine its association with prolonged flight hours. Emphasis was placed on the use of the noninvasive average break-up time (NIAvg-BUT) test for diagnosing DED, as opposed to the Schirmer test, highlighting the importance of objective diagnostic methods for this population. **Methods:** This was a prospective observational cohort study conducted between August and October 2023 at a boarding center designated for medical examinations of civil pilots. A total of 100 civil pilots who underwent routine periodical medical examinations were included. The participants were screened for systemic diseases, ocular allergies, and the use of topical medications. They completed the Ocular Surface Disease Index (OSDI) questionnaire and underwent detailed ophthalmological examinations. The NIAvg-BUT was measured via the Sirius™ corneal topography device. A cutoff value of NIAvg-BUT < 10 seconds was used for diagnosing DED. **Results:** The incidence of DED among the pilots was 34%. The study revealed a statistically significant association between higher total flying hours and the presence of DED. Pilots with more flying hours had an increased risk of developing DED. **Conclusion:** This study revealed a high incidence of DED among Indian commercial pilots, which was correlated with prolonged flight hours. This shows the need for objective diagnostic tests, such as the NIAvg-BUT over other invasive tests. Further research is necessary to explore the impact of DED on the functional performance of pilots and the comfort of flight staff and passengers.



**Keywords:** Civil aviation, dry eye disease, pilots, tear breakup time


## INTRODUCTION

The reported prevalence of dry eye disease (DED) ranges from 5% to 50%, reflecting the variability in definitions and methodologies across different studies performed in different parts of the world.[1-3] According to the Tear Film and Ocular Surface Society (TFOS) Dry Eye Workshop (DEWS) II, "dry eye is a multifactorial disease of the ocular surface characterized by a loss of homeostasis of the tear film, and accompanied by ocular symptoms, in which tear film instability and hyperosmolarity, ocular surface inflammation and damage, and neurosensory abnormalities play etiological roles."[4] Current prevalence estimates likely reveal only a portion of the issue, as many individuals with mild or asymptomatic DED do not seek medical care. Optimal visual acuity and ocular health are vital for airplane pilots, who work in environments with controlled indoor conditions. Aircraft cabins typically have low humidity levels (5%–25%), temperatures between 21.8°C and 25.8°C, reduced atmospheric pressure (810 to 750 millibars), and high air exchange rates.[5-7] Since dry eyes are a cause of ocular morbidity and pilots are exposed to controlled cabin conditions, the estimation of dry eyes is


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important for timely detection and management.[8] At present, to the best of our knowledge, there are no published studies from the Indian subcontinent that determine the prevalence of dry eyes in pilots. This study aimed to determine the incidence of dry eye in Indian commercial pilots.

## METHOD

This was a prospective observational cohort study conducted between July and August 2023 at one of the boarding centers designated for medical examination of civil pilots. A standard consent form was obtained from all participants, and the study adhered to the Declaration of Helsinki. Civil pilots who visited the institution as per their routine periodical medical examination during the study period were included in the study. Pilots with systemic diseases, long-standing diseases, or ocular allergies and those taking any topical medications were excluded. The details of the participants, which included their name, age, sex, total number of flying hours, number of continuous flights > 3 hours, and smoking, were recorded. Study participants were requested to complete the OSDI (Ocular Surface Disease Index) questionnaire during the same visit. The patients were examined by a single experienced ophthalmologist. All participants underwent detailed ophthalmological examination [uncorrected visual acuity (UCVA), best-corrected visual acuity (BCVA), intraocular pressure recordings, slit lamp examination for the anterior segment, and undilated posterior segment examination with a + 90 D lens]. The noninvasive tear breakup time (NI BUT) was measured via a Sirius™ corneal topography device (Costruzione Strumenti Oftalmici; CSO, S.r.l., Italy) under dim light after examination of the anterior segment. The images of both eyes of each participant were captured after several blinks by an experienced technician who was unaware of the nature of the study design. All scans were performed in the same room with stable humidity of 35–45% and temperature 22–25 degrees between 9 am and 2 pm to avoid diurnal variations. The candidates were seated with their chin on a chinrest and forehead against the forehead strap and asked to fixate straight ahead on the rings (centering phase). The joystick button was pressed to start the measuring film. The study participants were requested to blink twice, after which the system automatically started taking measurements. The participants were asked to keep the examining eye open continuously for 17 seconds. Each successful measurement was acquired. Noninvasive first tear film break-up time (NIF-BUT) and average noninvasive tear film break-up time (NIAvg-BUT) values were noted. A cutoff value for NIAvg-BUT < 10 sec was taken into consideration for analysis [Figure 1]. The Chi-square test was used for the categorical variable and, the Mann–Whitney test was used for quantitative variables.

## RESULTS

Table 1 summarizes the baseline characteristics of the study participants. The study included a total of 100 participants, with a mean age of 45.74 ± 13.3 years. The age distribution revealed that 35% of the participants were between 18 and 40 years, 46% were between 41 and 60 years, and 19% were above 60 years. The majority of the study population was male, accounting for 91% of the participants, whereas only 9% were female. Among the notable lifestyle factors, 21% of the participants had a smoking history. The mean total flying hours of the participants were 6203.66 ± 5996.84 hours, and 40% of the participants had more than 3 hours of flying per day per flight with average of 28–35 hours of total flying per week. The study also collected data on screen time usage. The majority of the participants (45%) spent 1–4 hours per day in front of screens, 41% had less than 1 hour of screen time, 11% had 4–6 hours, and 3% had more than 6 hours of screen time per day [Table 2].

The mean TBUT score for the right eye was 12.68 ± 4.1 seconds, whereas for the left eye, it was 13.28 ± 4.03 seconds. This finding indicates that, on average, tear film stability was relatively similar between the two eyes. The prevalence of dry eye disease was 34% [Table 3].

The data revealed that 20.6% of the participants with dry eye were in the 18–40 years age group, 52.9% were in the 41–60 years age group, and 26.5% were older than 60 years [Table 2]. In the group without dry eye, the

**Table 1: Baseline characteristics of the study participants (*n* = 100)**

| Parameters | Frequency | Percent |
|---|---|---|
| Age (Mean±SD) | 45.74±13.3 years | |
| 18-40 years | 35 | 35.0 |
| 41-60 years | 46 | 46.0 |
| > 60 years | 19 | 19.0 |
| Gender | | |
| Female | 9 | 9.0 |
| Male | 91 | 91.0 |
| Smoking history | 21 | 21.0 |
| Treatment history | 9 | 9.0 |
| Total Flying hours (Mean±SD) | 6203.66±5996.84 hours | |
| Flying hours >3 hours | 40 | 40.0 |
| Screen time | | |
| < 1 hours | 41 | 41.0 |
| 1-4 hours | 45 | 45.0 |
| 4-6 hours | 11 | 11.0 |
| >6 hours | 3 | 3.0 |

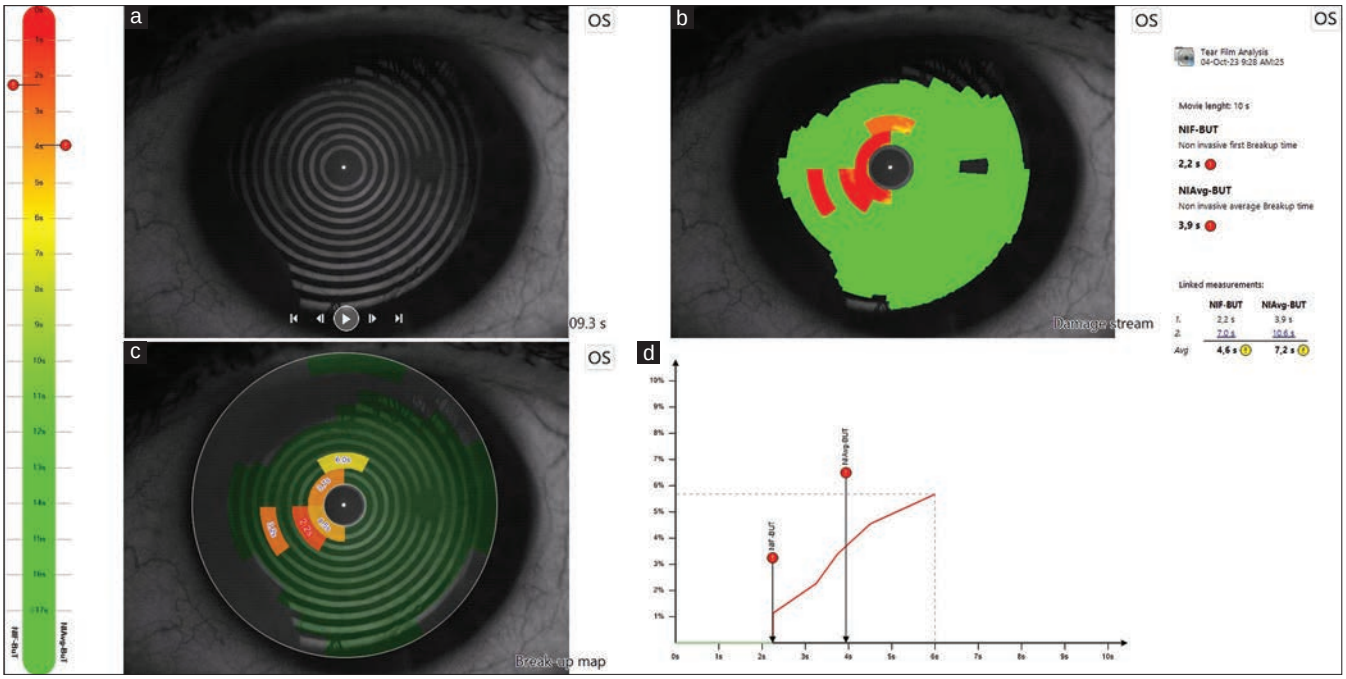



**Figure 1: Noninvasive tear break-up time (NIBUTs) image results for the left eye of a participant in our study are displayed as a real-time videokeratoscopy recording: a) dynamic map shows the tear break-up flow, b) damage stream map showing real-time breakpoints, c) break up map represents the numerical break-up times for different areas of the cornea, and d) graphical representation of the first and average NIBUTs**

**Table 2: Association of dry eye disease with various factors**

| Variable | Dry eye | | | | *P* |
|---|---|---|---|---|---|
| | Present | | Absent | | |
| | *n* | % | *n* | % | |
| Age | | | | | |
| 18-40 years | 7 | 20.6 | 28 | 42.4 | 0.078 |
| 41-60 years | 18 | 52.9 | 28 | 42.4 | |
| > 60 years | 9 | 26.5 | 10 | 15.2 | |
| Gender | | | | | |
| Female | 2 | 5.9 | 7 | 10.6 | 0.434 |
| Male | 32 | 94.1 | 59 | 89.4 | |
| Flying hours >3 hours | 13 | 38.2 | 27 | 40.9 | 0.796 |
| Smoking history | 8 | 23.5 | 13 | 19.7 | 0.656 |
| Treatment history | 4 | 11.8 | 5 | 7.6 | 0.488 |
| Screen time | | | | | |
| <1 hours | 15 | 44.1 | 26 | 39.4 | 0.327 |
| 1-4 hours | 17 | 50.0 | 28 | 42.4 | |
| 4-6 hours | 1 | 2.9 | 10 | 15.2 | |
| >6 hours | 1 | 2.9 | 2 | 3.0 | |
| Total flying hours | 8909.4±6912.0 | | 4809.8±4971.4 | | 0.001 |

**Table 3: Distribution of TBUT scores and the prevalence of dry eye disease**

| TBUT | Frequency | Percent |
|---|---|---|
| Right eye (Mean±SD) | 12.68±4.1 | |
| Left eye (Mean±SD) | 13.28±4.03 | |
| Prevalence of dry eye | 34 | 34.0 |

distribution was 42.4% for both the 18–40 years and 41–60 years age groups and 15.2% for those above 60 years. The difference in age distribution between the dry eye and non–dry eye groups was not statistically significant ($P = 0.078$).

In terms of sex, 94.1% of the participants with dry eye were male, whereas 89.4% of the participants in the non–dry eye group were male. This difference was not statistically significant ($P = 0.434$).

These confounding factors were further analyzed, and a univariate analysis was done between NIAvg-BUT and participants with more than 3 hours of screen time. However, the results were not statistically significant, and the analysis did not affect the final outcome of the study. Other factors examined included flying hours, smoking history, and treatment history. None of these variables were significantly associated with the presence of dry eye disease [Table 2].

However, the table indicates a statistically significant difference ($P = 0.001$) in the mean total number of hours spent flying between the dry eye group (8909.4 ± 6912.0 hours) and the non–dry eye group (4809.8 ± 4971.4 hours). These findings suggest that more total flying hours may be associated with an increased risk of developing dry eye disease.

## DISCUSSION

Dry eye disease (DED) is a complex, multifactorial condition that has significantly increased with the widespread use of

digital devices. This condition affects millions of people globally, and current reports likely only address the surface of the problem. Previous studies have shown that factors such as age, sex, residence, socioeconomic status, occupation, and the environment play crucial roles in the development of DED.[9] The DED study by Titiyal JS *et al*.[3] revealed a notable prevalence rate of 32% for DED in an urban area of North India. Given the chronic nature of DED, several factors influence its prevalence, and the appearance of new DED cases will continuously increase the number of cases, thus increasing the overall prevalence. Since DED is a long-term condition, individuals diagnosed with it typically remain affected for a prolonged period, contributing to the prevalence rate over time. Factors such as aging (as older people are more susceptible to DED), migration, and environmental changes can also affect prevalence rates. Commercial pilots are exposed to a controlled cockpit environment with varying levels of humidity and temperature. The ocular surface is continuously exposed to both outdoor and indoor environments, and adverse conditions can compromise the lacrimal functional unit (LFU). Factors such as high temperatures, low humidity,[10,11] air flow, and high altitudes (low atmospheric pressure) can all contribute to this impairment.[12,13] The diagnosis of DED involves evaluating subjective symptoms via the OSDI questionnaire and performing several dry eye tests. These tests include tear film break-up time (TFBUT), ocular surface staining, tear secretion volume measurement with Schirmer's test, and tear osmolarity determination.[14] There is no single definitive diagnostic method for diagnosing dry eye, so a combination of all available tests for an accurate diagnosis is advised. Similarly, there is no definitive method for diagnosing tear film stability. Generally, tests for tear film stability should be noninvasive, noncontact, documentable, and objective, with high sensitivity, specificity, repeatability, and reproducibility.[15] To achieve this goal, the Sirius (CSO, Florence, Italy) machine is one such device. A Scheimpflug camera with a Placido disc corneal topographer was used to analyze the corneal surface abnormalities better.[16,17] The cutoff value of the NIAvg-BUT is 10 s for diagnosing dry eyes.[18] Despite DED being a major cause of ocular morbidity, studies on such prevalent conditions are lacking in pilots. There have been no studies on the incidence of dry eyes in pilots from India.

In this study, approximately 34% of the pilots were determined to have DED on the basis of the NIAvg-BUT criterion of < 10 sec. The prevalence of dry eye in this subset of the population is greater than that reported in earlier studies performed in northern India.[3] We also have taken values of NIAvg-BUT values, which are more reliable, noncontact, and easily documentable compared with the Shirmer test.[19] In addition, the study revealed a statistically significant correlation between the incidence of dry eyes and number of flying hours as the incidence of dry eyes increased with increasing total number of flying hours.

In contrast to the fact that approximately one-third of the pilots were determined to have dry eyes, neither was found to have a significant OSDI score consistent with the diagnosis of dry eyes. The possible reason for this is the apprehension among them for either they would be made unfit for flying or would be asked for a frequent periodical review. This also signifies and highlights the importance of objective tests during evaluation and not relying on subjective tests or questionnaires in such scenarios.

To the best of the authors' knowledge, only one study worldwide has investigated dry eye symptoms in commercial pilots.[20]

## CONCLUSION

The study reported a 34% prevalence of DED among Indian pilots, which is associated with prolonged flight hours. Instead of the Schirmer test, this study used the noninvasive average break-up time (NIAvg-BUT) to diagnose DED in this population, highlighting the significance of objective testing methods for detecting this serious ocular condition in pilots. The data also indicate that pilots often experience dry eye symptoms during flights. Further research is necessary to determine whether DED leads to functional impairments in pilots or other flight personnel or causes significant discomfort for passengers.

### Ethical approval

Institutional ethics committee clearance was taken, dated 02 Sep 2022.

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Nil.

### Conflicts of interest

There are no conflicts of interest.

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Original Article

# Self-reported knowledge of refractive errors: A survey of a cohort of Nigerian doctors


## ABSTRACT

**Aim of the study:** To determine the knowledge and awareness of physicians about refractive errors and corrections. **Background:** Refractive errors are one of the common causes of visual impairment and blindness but the only one with the cheapest and noninvasive form of treatment. Refractive errors affect people of all ages, sex, race, and professions including those in the practice of medicine. Physicians who have knowledge of refractive errors and especially of their own will be better advocates to counsel, educate, and advice their patients of the possible causes of their poor vision and the available treatment modalities, especially refractive errors where there are no eyecare personnel, and thus will be able to institute appropriate referral. **Methodology:** A cross-sectional purposive sampling and descriptive study was conducted among doctors in Ogun State using a structured self-administered questionnaire. Participants were recruited from various hospitals (public and private) and gatherings of doctors. Those who consented were those whose responses were analyzed using SPSS version 21. **Results:** A total of 477 doctors participated in the survey with two thirds being males. Ninety-eight point five percent could recall the different types of refractive errors; 77.1% doctors reported they had refractive errors, out of which 71.5% of them reported they wear corrective lenses. Of the respondents, 20.6% of the physicians were able to match myopia as a distance error, while 12.2% correctly matched myopia with concave lenses. Among the corrective lenses wearing consultants, 11% of them reported a combination of errors, while 31.5% wear a "combination of lenses", 32 physicians who have been corrective lens-wearers for more than 20 years reported myopia, and only 15 wear "concave lenses". **Conclusion:** Refractive error seems common among the physicians; their knowledge about this eye disorder and its corrections is very poor even among corrective lens-wearers regardless of the cader of the physician or the duration of spectacle wear.


**Keywords:** Nigerian physicians, refractive errors, self-reported knowledge

## INTRODUCTION

Refractive errors indicate the inability to focus images sharply on the retina, thus causing blurring of vision in an otherwise normal eye due to failure of the eye refractive system. Refractive errors are important causes of visual impairment and blindness. An estimated 670 million people worldwide are considered visually impaired because they do not have access to corrective treatment.[1] It affects people of all ages, sexes, races, and professions. The main types of refractive errors are myopia, hypermetropia, astigmatism, and presbyopia; they present with blurring of vision for far, near, or both.[2]

The most acceptable and affordable form of treatment of refractive errors is correction glasses – this is cheap and noninvasive. The other modalities of treatment


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include contact lenses, light amplification by stimulated emission of radiation (LASER) such as Laser-assisted *in situ* keratomileusis (LASIK), and other forms of kerato-refractive surgeries like photorefractive keratectomy and radial keratotomy and intraocular surgeries such as implantable intraocular contact lenses and clear lens extraction (in very high myopia).[3] Corrective lenses used are concave lenses for myopia, convex lenses for hypermetropia and presbyopia, cylindrical lenses for astigmatism, and a combination of lenses for a combination of errors.

Physicians need good vision in their practice to avoid the risk of medical errors caused by poor vision. It is particularly desirable among surgeons and others who are involved in invasive and intervention procedures. Many physicians were noted to wear corrective lenses (almost like a trademark) for several periods; some have adjustments in prescriptions as ageing sets in due to presbyopia just like the other population of adults in Nigeria.[4]

There are no visible data on the magnitude/prevalence, level of awareness, and preferred options of correction of refractive errors among physicians in the literature. A study conducted in Nigeria in the year 2014 revealed that the prevalence of refractive errors is about 80% among medical students (prospective physicians).[5] Another study conducted in Saudi Arabia on the awareness of refractive error and correction among medical students reported that myopia is the most prevalent type of refractive error, and spectacle correction is the most preferred option of treatment.[6] The use of other modalities of correction of refractive errors like LASER gave satisfactory outcomes in a study done in Ohio, USA,[7] but this is not readily available in Nigeria.

As health care providers, physicians who had exposure in ophthalmology in their undergraduate medical training are expected to be able to display relatively good knowledge about refractive error and their corrections to educate and advice their clients of the possible causes of their poor vision and the available modalities of treatment. It is also expected that physicians, especially the several years spectacles wearers who have been in practice for many years and have had to change their spectacle a couple of times, should be able to have relatively better knowledge and understanding of refractive error to be able to recall accurately their types of refractive error, and corrective lenses including the power that they wear better than the general population.

The aim of the study was to determine the level of knowledge and awareness about refractive error in a cohort of doctors of different cadres with variable years of experience in medical practice as well as to evaluate the possible reasons why physicians who had refractive errors did not want to wear corrective lenses.

## METHODOLOGY

This is a cross-sectional, purposive sampling and descriptive study conducted over a period of 1 year. Physicians/doctors practicing in Ogun State, Nigeria, irrespective of cader or duration of practice were the participants in the study. Those with postgraduate training in ophthalmology were excluded. Physicians in this study are doctors of all caders from house officers to consultants.

The study settings were all hospitals in Ogun state: private and public, gatherings of doctors in conferences, and medical workshops, seminars, and Continuing Medical Education (CME) programs. Efforts were made to prevent duplicate enrolment by providing spaces on the questionnaires for both Medical and Dental Council of Nigeria (MDCN) registration number and names of participants because of those who would not be able to recall their MDCN registration number. We appreciate that name is a peculiar identifier, and it would be guarded.

Ethics approval to conduct the study was obtained from the Olabisi Onabanjo University Teaching Hospital, Health Research Ethics Committee (OOUTH/HREC/148/2017). A written informed consent form was signed by each respondent prior to enrolment into the study.

A purpose-designed structured self-administered questionnaire was the study instrument. The questionnaire had three sections: Sections A and B were completed by all the respondents, while section C was completed only by physicians with "refractive errors who wear corrective lenses". Section A of the questionnaire obtained information on personal, sociodemographic, and clinical characteristics of the participants. Section B sought information on awareness and knowledge of the different types of refractive errors and their corrections (corrective measures) and possible reasons why physicians who had refractive errors were not wearing any form of correction.

Section C addressed the (corrective-lenses wearing) physicians self-reported refractive error types and the type and power of corrective lenses they wear. The duration of correction of refractive error, frequency of changing lenses, the cader of eye care worker providing evaluation, and the setting where the corrective lenses were prescribed/obtained were also assessed.

The questionnaire was subjected to validity and reliability evaluation by pretesting it among some physicians in Lagos – a state close to the state where the study was conducted, and their responses were not included in the analysis. The questionnaires were distributed by research assistants and retrieved immediately after completion by the respondents. The completed questionnaires were sorted and collated for analysis. Demographic characteristics, visual acuity as reported by the participants, general knowledge on refractive error, and their personal experiences on corrective lenses were analyzed by descriptive statistics and simple percentages using SPSS version 21.

**Physicians and doctors are used interchangeably**.

## RESULTS

There were 1100 doctors registered and practicing in Ogun state at the time of the study (Nigerian Medical Association Ogun State branch secretariat), out of which 43.4% (477/1100) participated in the study; there were 147 females (147/477 = 30.8%), 4 (0.8%) did not respond, and 103 (21.6%) respondents were aged between 21 and 30 years with overall 366 (366/477 = 76.7%) aged 50 years and below, but 4 (0.8%) did not respond, 158 (158/477 = 33.1%) of the participants were practicing in urban areas, but 210 (44.1%) did not respond to their location, and 317 (317/477 = 66.5%) were working in tertiary institutions. One hundred and ninety-two (192/477 = 40.3%) physicians have been practicing medicine for 10 years and less, while 158/477 (33.1%) have been in practice for more than 20 years. Doctors of consultant cader were the most prevalent participants (128/477 = 26.8%), followed by resident doctors, 105/477 (22.0%). Four hundred and sixty-one, 461/477 (96.7%), physicians had undergraduates training in Ophthalmology, while 41/477 (8.6%) had worked in an eye clinic prior to the study. The majority of the physicians, 336/477 (70.4%), checked their vision in the last 5 years before the study, while, from their self-reported vision check, 109 had normal vision. Table 1 depicts the sociodemographic and clinical characteristics of the participating respondents.

Four hundred and seventy physicians, 470/477 (98.5%), could recall the different types of refractive errors. Three hundred and sixty-eight, 368/477 (77.2%), physicians reported they had refractive errors, but 263 (263/368 = 71.5%) "wear correction" – this formed 263/477 (55.1%) of the study participants, while 214 (214/477 = 44.9%) were not wearing correction. Of those not wearing correction, 105 (105/477 = 22.0%) reported they had refractive error but were not interested in correction and had no idea of the types of refractive errors they had.

**Table 1: Sociodemographic and clinical characteristics of the respondents (*n*=477)**

| Variable | Frequency (%) |
|---|---|
| Age range in years | |
| 21-30 | 103 (21.6) |
| 31-40 | 129 (27) |
| 41-50 | 134 (28.1) |
| 51-60 | 73 (15.2) |
| >60 | 34 (7.1) |
| No response | 4 (0.8) |
| Sex | |
| Male | 326 (68.4) |
| Female | 147 (30.8) |
| No response | 4 (0.8) |
| Location of practice | |
| Urban | 158 (33.1) |
| Suburban | 105 (22.0) |
| Rural | 4 (0.8) |
| No response | 210 (44.1) |
| Level of health institution where the physicians are practicing | |
| Primary | 29 (6.1) |
| Secondary | 43 (9.0) |
| Tertiary | 317 (66.5) |
| Private | 74 (15.5) |
| *Others | 14 (2.9) |
| Duration of practice of physicians in years | |
| 0-5 | 123 (25.8) |
| 6-10 | 69 (14.5) |
| 11-20 | 122 (25.6) |
| 21-30 | 73 (15.3) |
| >30 | 85 (17.8) |
| No response | 5 (1.0) |
| Professional cadre | |
| Consultant | 128 (26.8) |
| Medical officers | 94 (19.7) |
| Resident doctors | 105 (22.0) |
| General practitioners | 65 (13.6) |
| House officers | 58 (12.2) |
| *Others | 27 (5.7) |
| **Reported visual status and knowledge of physicians** | |
| Last time in years when visual acuity was checked | |
| 0-5 | 336 (70.4) |
| 6-10 | 56 (11.7) |
| 11-15 | 29 (6.1) |
| Never checked | 7 (1.5) |
| Cannot remember | 49 (10.3) |
| Reported visual status classification and knowledge of RE by physicians | |
| Normal vision | 109 (22.9) |
| Physicians with RE | 368 (77.1) |
| Those with RE corrected | 263 (55.1) |
| Those with RE not corrected (not wearing spectacles) | 105 (22.0) |
| Physicians who could recall the different types of RE | 470 (98.5) |

*Others – Physicians who work in the ministry and those who practice in health clinics attached to educational institutions

When testing the physicians' knowledge on the different refractive errors and correction, 98/477 (20.6%) were able to

match correctly that myopia was an error for distance, but only 58/477 (12.2%) matched myopia correctly with concave lens. Table 2 shows the details of responses of physicians about RE and corrections.

Of the 263 physicians using correction lenses, only 3/263 (1.1%) reported wearing contact lenses, while 260/263 (98.9%) "wear correction glasses". None used LASER or surgery. Table 3 shows the details of the responses of the corrective lenses' wearer about their own types of refractive errors (whether distance or near, the names of the error, and types of lenses they were wearing). One hundred and fifty-eight, 158/263 (60.1%), of the corrective lens wearers were able to classify their refractive error, but only 99 (99/263 = 37.6%) were correct. Among the 263 who reported wearing correction, 135 (135/263 = 51.3%) were able to identify with their adjudged corrective lens type, while the remaining 128 (128/263 = 48.7%) could not recall the type of lenses they were wearing. Of those who were able to identify with a lens type, 67 (67/135 = 49.6%) of them were correct.

None of the correction wearers reported whether their lenses were spherical or cylindrical, 70 (70/263 = 26.6%) remembered to add sign before their lens powers, but only 23 (23/263 = 8.7%) were correct when we analyze their reported refractive error type and their correction lenses type.

Respondents who reported knowing their refractive errors and correction were stratified according to cader. Out of the 263 correction-wearing physicians, 71/263 (27.3%) were consultants. Of the 71 consultants, 62 could classify themselves into the different refractive errors they had, but only 49 (49/71 = 69%) could mention the types of lenses they were wearing, even though their responses were inconsistent. The responses of resident doctors, medical officers, and others are shown in Table 4. The duration of practice of medicine as a physician and the duration of corrective lens use which were supposed to be advantages to their level of knowledge were also analyzed. Of the 38 physicians who have been wearing correction for between 11 and 20 years, four

**Table 2: Responses of Physicians about Refractive Error and Correction**

| Types of refractive error *n*=477 | Distance error | Near error | Error for both far and near |
|---|---|---|---|
| Myopia | 98 (20.6) | 27 (5.7) | 18 (3.8) |
| Hypermetropia | 16 (3.4) | 14 (2.9) | 5 (1.1) |
| Astigmatism | 9 (1.9) | 14 (2.9) | 9 (1.9) |
| Presbyopia | 3 (0.6) | 17 (3.6) | 11 (2.3) |
| Combination of errors | 5 (1.1) | 1 (0.2) | 13 (2.7) |

RE and perceived type of corrective lenses

| Types of refractive errors | Types of corrective lenses | | | |
|---|---|---|---|---|
| | Concave | Convex | Cylinder | Combination of lenses |
| Myopia | 58 (12.2) | 18 (3.8) | 4 (0.8) | 35 (7.3) |
| Hypermetropia | 7 (1.5) | 12 (2.5) | 0 | 7 (1.5) |
| Astigmatism | 3 (0.6) | 2 (0.4) | 9 (1.9) | 17 (3.6) |
| Presbyopia | 2 (0.4) | 10 (2.1) | 1 (0.2) | 11 (2.3) |
| Combination of errors | 3 (0.6) | 1 (0.2) | 8 (1.7) | 18 (3.8) |

*Combination of error – the different types of possible refractive error that can coexisting in one physician ie i. myopia + astigmatism, ii. hypermetropia + astigmatism, iii. Myopia + Presbyopia, iv. Hypermetropia + presbyopia, v. i + presbyopia, vi. ii + presbyopia etc. Combination of lenses – physician wearing more than one type of lenses ie Concave + Cylinder, ii. Convex +cylinder, iii. Concave + convex, iv. Concave + cylinder + convex

**Table 3: Responses of Spectacle-wearing Physicians about Refractive Error and Correction**

| Types of refractive error *n*=263 | Distance error | Near error | Error for both far and near |
|---|---|---|---|
| Myopia | 61 (23.2) | 17 (6.5) | 11 (4.2) |
| Hypermetropia | 10 (3.8) | 9 (3.4) | 2 (0.8) |
| Astigmatism | 6 (2.3) | 7 (2.7) | 5 (1.9) |
| Presbyopia | 1 (0.4) | 11 (4.2) | 7 (2.7) |
| Combination of errors | 3 (1.1) | 0 (0) | 8 (3.0) |

RE and perceived type of corrective lenses

| Types of refractive errors | Types of corrective lenses | | | |
|---|---|---|---|---|
| | Concave | Convex | Cylinder | Combination of lenses |
| Myopia | 43 (16.3) | 10 (3.8) | 1 (0.4) | 20 (7.6) |
| Hypermetropia | 4 (1.5) | 7 (2.7) | 0 | 4 (1.5) |
| Astigmatism | 1 (0.6) | 1 (0.4) | 6 (2.3) | 11 (4.2) |
| Presbyopia | 1 (0.4) | 3 (1.1) | 1 (0.4) | 7 (2.7) |
| Combination of errors | 1 (0.4) | 0 (0) | 6 (2.3) | 8 (3.0) |

**Table 4: Effect of category of physicians, duration of medical practice and duration of spectacle use on the knowledge of refractive error and correction of spectacle-wearing physician (*n*=263)**

| Variable | Types of refractive errors | | | | | Types of correction lenses | | | |
|---|---|---|---|---|---|---|---|---|---|
| | M | H | A | P | Ce | Cc | Cv | Cy | Cl |
| Category of physicians | | | | | | | | | |
| Consultants (71) | 23 | 7 | 12 | 12 | 8 | 7 | 12 | 7 | 23 |
| Residents (58) | 22 | 5 | 4 | 6 | 1 | 12 | 4 | 3 | 10 |
| Medical Officer (52) | 23 | 4 | 2 | 3 | 2 | 16 | 2 | - | 8 |
| General Practitioner (36) | 16 | 6 | 3 | 3 | 3 | 9 | 3 | 1 | 7 |
| House Officer (32) | 7 | 2 | - | - | - | 4 | 1 | - | 3 |
| Others (2) | 2 | - | - | - | - | - | - | - | 1 |
| No response (12) | 3 | - | 2 | - | 2 | 1 | - | - | 3 |
| Total | 96 | 24 | 23 | 24 | 16 | 49 | 22 | 11 | 55 |
| Duration of glasses use in years | | | | | | | | | |
| 0-5 years | 21 | 11 | 3 | 13 | 1 | 12 | 6 | 3 | 15 |
| 6-10 years | 23 | 3 | 6 | 4 | 5 | 10 | 6 | 2 | 15 |
| 11-20 years | 20 | 5 | 6 | 3 | 4 | 12 | 5 | 3 | 10 |
| 21-30 years | 12 | 2 | 4 | 1 | 5 | 8 | 2 | 2 | 8 |
| 31 years & > | 13 | - | 3 | 1 | - | 5 | 2 | 1 | 3 |
| No response | 7 | 3 | 1 | 2 | 1 | 2 | 1 | - | 4 |
| Total | 96 | 24 | 23 | 24 | 16 | 49 | 22 | 11 | 55 |
| Duration of practice of Medicine in years | | | | | | | | | |
| 0-5 years | 25 | 3 | 1 | 1 | 1 | 18 | 1 | 1 | 8 |
| 6-10 years | 14 | 4 | 3 | 1 | 1 | 8 | 1 | 2 | 5 |
| 11-20 years | 24 | 8 | 7 | 10 | 4 | 8 | 9 | 4 | 16 |
| 21-30 years | 16 | 7 | 1 | 6 | 6 | 6 | 6 | 2 | 11 |
| 31 years & > | 16 | 2 | 11 | 5 | 4 | 9 | 5 | 2 | 15 |
| No response | 1 | - | - | 1 | - | - | - | - | - |
| Total | 96 | 24 | 23 | 24 | 16 | 49 | 22 | 11 | 55 |

**Table 5: Reasons why physicians with acclaimed refractive error were not wearing corrective lenses (*n*=105)**

| Reasons for not wearing spectacles | Number of physicians (%) |
|---|---|
| Just did not want to wear spectacles | 20 (19.0) |
| Able to cope with daily activity | 62 (59.0) |
| Vision will improve with time | 3 (2.9) |
| RE did not get worse | 7 (6.7) |
| Spectacle is heavy | 4 (3.8) |
| Spectacle is foreign object | 16 (15.2) |
| Spectacle makes eye sunken | 4 (3.8) |
| Spectacle is not beautiful | 12 (11.4) |

*RE - Refractive Error

of them reported a combination of refractive errors, but ten reported wearing combinations of lenses. Of the 31 physicians practicing medicine for 5 years, 18 out of the 25 (18/25 = 72%) who reported myopia wear "concave lenses", but of the 53 who have been in practice for 11–20 years, only 8 out of the 24 (8/24 = 33.3%) who reported myopia wear "concave lenses". The longer the duration of practice and the use of spectacles, the more the likelihood of incorrectness of their responses. Details are as displayed in Table 4.

Forty-three doctors (43/477 = 9.0%) had worked in an eye clinic before but were not resident ophthalmologists at the time of the study. Thirteen of the 14 (13/14 = 92.9) who reported having refractive error among them were able to classify their refractive errors into myopia 9 persons, hypermetropia 1, astigmatism 2, and 1 with a combination of errors which are all distance errors, but only 8/13 (61.5%) reported that they wear distance correction.

Among the 105 who reported having refractive errors but were noncorrection lens wearers, 20/105 (19%) of them did not want to wear correction for no reason, 4 (3.8%) perceived spectacles as heavy, and 62/105 (59.0%) believed they were able to cope with daily activity without correction. Respondents were allowed to choose more than one response. Table 5 shows the details of the reasons given by correction lenses defaulting physicians.

When the frequency of change of glasses and where they got their prescription and correction glasses from were analyzed, 37/263 (14.1%) doctors changed their glass prescription yearly, 70/263 (26.6%) changed theirs every 2 years, 28/263 (10.7%) every 3 years, and 27/263 (10.3%) have never changed theirs. One hundred and fifty-one, 151/263 (57.4%), got the prescription for correction glasses from the ophthalmologist, 29/263 (11.0%) from

**Table 6: Effect of gender on the ability to recall the correct match of the type of RE and correction in corrective lenses wearing physicians**

| Gender | Type of RE | Type of corrective lenses | Correctness ratio and % |
|---|---|---|---|
| | **Myopia** | **Concave** | |
| Male | 65 | 33 | 33/65 (50.8%) |
| Female | 31 | 14 | 14/31 (45.2%) |
| Total | 96 | 47 | 47/96 (49%) |
| | **Hypermetropia** | **Convex** | |
| Male | 19 | 6 | 6/19 (31.6%) |
| Female | 5 | 1 | 1/5 (20%) |
| Total | 24 | 7 | 7/24 (29.2%) |
| | **Astigmatism** | **Cylinder** | |
| Male | 17 | 5 | 5/17 (29.4%) |
| Female | 6 | 1 | 1/6 (16.7%) |
| Total | 23 | 6 | 6/23 (26.1%) |
| | **Presbyopia** | **Convex** | |
| Male | 15 | 3 | 3/15 (20%) |
| Female | 9 | 1 | 1/9 (11.1) |
| Total | 24 | 4 | 4/24 (16.7%) |
| | **Combination of errors** | **Combination of lenses** | |
| Male | 9 | 3 | 3/9 (33.3%) |
| Female | 7 | 1 | 1/7 (14.3%) |
| Total | 16 | 4 | 4/16 (25%) |

the optometrist, and 8/263 (3.0%) from the optician, while 75/263 (28.5%) did not respond to this. One hundred and four, 104/263 (39.5%), correction-lens-wearing physicians obtained their glasses/spectacles from the ophthalmologists, 51/263 (19.4%) from optometrists, 20/263 (7.6%) from opticians, 12/263 (4.6%) from the market, and 76/263 (28.9%) did not respond.

When the effect of gender was considered on the ability of the physician to be able to recall correctly the type of refractive errors and correction of their own, 33 out of 65 who claimed myopia were correct about wearing concave lenses. Table 6 shows the details of the findings on this.

A good number of physicians did not complete their questionnaire, and that is responsible for the no responses recorded as shown in the tables.

## DISCUSSION

Fifty-five percent of the study population claimed they wear corrective lenses; this means that refractive error is common among the physicians. This is not surprising because from observation, many doctors tend to wear spectacles like a trademark for correction of refractive errors for far, near, or both. Unfortunately, no visible data are available for comparison.

Ninety-eight percent of the physicians recalled the names of the different types of refractive errors that exist. This shows that their undergraduate exposure in ophthalmology yielded positive results, but about 33% could classify correctly the different types of refractive errors into distance, near, or a combination of errors, while 45% were correct about the lenses used for correction of the different types of refractive errors. Unfortunately, there was disparity between those who were able to classify and those who knew the appropriate lenses for correction. This showed that a lot of guess work must have been put into play, indicating a big gap in the knowledge and understanding of physicians about refractive errors and corrections. This may have a negative effect on patients' care as physicians are likely to miss the diagnosis of refractive error-induced visual impairment and blindness and thus interfere with their judgement by not giving appropriate counselling and referral to patients to consult the eye care worker for treatment. This lack of sufficient understanding of the topic may be responsible for most of the inappropriate and no responses generated in the study, which might result in a large population of uncorrected refractive errors among physicians and the general population and thus increase the burden of visual impairment and blindness secondary to uncorrected refractive error. Similar experience was reported by Brandenburg *et al.*[8] in a survey and audit of the relationship between research culture and research activity among doctors where about 43% of participating doctors incompletely answered the questions of the research. This may be related to poor knowledge of the subjects of that research since confidence comes with knowledge or inability to recall what they knew, especially if these are not cases they often or regularly see in their practice. However, this will not invalidate the findings in the study as it highlights the need to further boost the knowledge of physicians about refractive errors.

Myopia, hypermetropia, astigmatism, and most of the combination of errors are errors for distance. Twenty percent of the physicians were correct about myopia as distance error, but 3.4% and 1.9% were correct about hypermetropia and astigmatism, respectively. Presbyopia is an error for near, but 3.6% were correct. Even though 98% of the physicians were able to recall the names of the different types of refractive errors, only 2.7% classifying a combination of errors correctly showed a big gap in their knowledge about the meaning of the names they recalled.

Concave lenses are the appropriate lenses for correction of myopia; only 12% of the physicians were correct. Unfortunately, less than 3% were correct about the lenses used for the correction of hypermetropia and astigmatism

respectively. Only 2% knew that convex lenses were used to correct presbyopia. Despite the exposure in ophthalmology at the undergraduate level, physicians generally demonstrated poor knowledge of the subject of this study. This may be because of the very short duration of their posting in undergraduate (since ophthalmology is not a core subject in medical undergraduate curriculum) and they also do not encounter many patients with refractive errors to be able to remind them of what they have learnt in school. Some others may see ophthalmology as a specialty which should be managed only by those who have further training and additional skills to do so.

The scenario is just a little different among correction-lens wearers who are expected to know the treatment of their eye disorder. The study revealed that physicians generally have a poor understanding of refractive error and correction even of their own. Consultants who are the highest cader of doctors in terms of knowledge and skills did not demonstrate a better understanding of the subject of this study than the rest of the physicians.

The male predominance stemmed from the fact that there are generally more male doctors than female in Nigeria;[9] thus, more males participated, and similar sex distribution among doctors generally has been reported.[10] Some other studies also documented that more males usually participate in research, which may be due to their larger number.[9-12] More males were likely to be better than females in their report of correctly matching the corrective lenses they wear with their refractive errors, but the difference in the knowledge is not impressive, and it is likely to be due to the dominance of male participants in the study population.

There were many participants who worked in the tertiary facilities where training and research abound; this is probably because of their better understanding of the importance of research and their readiness to hunt for more information and source for more educational resources to update their knowledge in recent advances in medical specialties than the other categories of physicians. Subsequent study designs may adopt the proportionate sampling method. Doctors of the consultant cader formed a quarter of the study population. The outcome of the study depicts generally poor understanding of refractive errors across all the caders of doctors; unfortunately, there are no visible data to cite for comparison with this research.

About 60% of the physicians have been in practice for greater than 10 years before the study; this can be either an advantage or a disadvantage. It may mean that the long years of practice of medicine as physicians enhanced their experience, thus improving their knowledge of refractive errors. On the other hand, it may also be interpreted as the older you are in the profession, the more likely the physician forgets some of the things he had learnt in school especially cases they do not manage regularly.

Two weeks ophthalmology training is a mandatory aspect of undergraduate curriculum; about 95% of the doctors consented to having undergone this important rotation of their curriculum. This is expected to positively impact on their knowledge, understanding, and a bit of competence in ophthalmology specialty, especially about refractive error. They are expected to be able to assess, manage, and offer advice where necessary about common/simple eye conditions like refractive errors of themselves and patients. The training was also supposed to prepare and inspire those who would want to specialize in ophthalmology in future. Unfortunately, the study did not align with the expectations of this aspect of the curriculum because the duration of training is so short that it did not translate to better knowledge of many of the physicians who probably conformed during the posting only to pass the end of posting assessment.

About 70% of the doctors reported they checked their vision within the past 5 years before the study. This is quite impressive, and it may be because the majority of the doctors were younger than 50 years of age and this is the period when many doctors secure jobs either as house officers, medical officers, resident doctors, or newly appointed consultants in hospitals where most establishments made vision check a mandatory part of pre-employment medical test.

About 24% of the doctors who wear correction were consultants; one-third of them reported they used their glasses for near correction, whereas only 4.6% self-reported presbyopia. This is inconsistency, even among specialists because their knowledge on refractive errors and treatment is limited.

Thirty four percent of the doctors who were correction glass wearers reported they had myopia, out of which about half of them said they wear concave lenses. Even among the 23 consultants who claimed myopia, only seven wear "concave lenses". Nineteen consultants claimed hypermetropia and presbyopia, of which 12 of them wear "convex lenses". Being consultants did not positively influence the knowledge and understanding of the specialty and of their own refractive error and correction. In view of the background observation of low knowledge, being consultants confers no additional advantage in terms of knowledge of ophthalmological disorders.

Generally, 15% of the doctors self-reported hypermetropia and presbyopia, but about 30%, which is 100% more than the expected wear corrections for near as well as both far and near, unfortunately only 8%, which is about 50% wear "convex lenses". Therefore, there was no consistency in the responses of the doctors due to their poor knowledge about their own refractive errors and correction.

One would have thought that physicians who have been in practice for long would have relatively better knowledge of all the aspects of medicine than those who are young in the profession and those who have been wearing spectacles would also be better knowledgeable about refractive error and correction than others who do not wear correction, but unfortunately, the long duration of use of spectacles and the long duration of practice of medicine as physicians made no positive impact on their level of knowledge of types of refractive errors and corrections even of their own. In fact, the younger you are in the profession, the more likely you can recall relatively correctly the type of refractive errors and correction you have. The reasons for this are beyond the scope of this research, but it can be rationalized that this deficiency in knowledge may be due to the physicians not seeing these cases regularly in their practice and thus did not have the drive and the need to aggressively update themselves on this common eye condition. Refractive error is a common ocular condition that presents even to a primary care physician; it thus behoves all physicians to keep abreast with its clinical presentations to be able to counsel their patients and thus refer appropriately. The experience is the same even among doctors who have worked in an eye clinic prior to their participation in the study.

The study was conducted in one of the states of the country, and the findings here may not be extrapolated to other states which might give a different result. Because studies of this nature are extremely rare, a large-scale, multicenter study across the various geopolitical zones of the country may be required to address possible location-related confounders.

There were many more participants from the tertiary institutions. The questionnaires were distributed at various places including tertiary facilities, secondary facilities, primary facilities, conferences, workshops, and meeting in the state organized by the umbrella body of the doctors' association where all doctors regardless of affiliates were supposed to attend. Those who consented to the study and completed the questionnaire were analyzed. It is possible that the academic nature of the various fora where the bulk of the questionnaires were administered tilted the responses in favor of tertiary facility practitioners. It is likely that there might have been a different result if many more physicians were reached, outside academic activities.

Three doctors were "contact lenses (CL) wearers", while none had kerato-refractive surgery out of those who had correction for RE. Over 140 million people wear contact lenses in the world,[13] but acceptance is generally low in Nigeria, which is evident by a study done in Abuja, Nigeria (the country's capital), on only 321 wearers of contact lenses in a country with over 200 million population – the study did not consider occupation among the participants, so it is difficult to determine how many were physicians.[14] Another study conducted in Saudi Arabia among medical students who were prospective doctors revealed that 40% of the study population were CL wearers.[15] There are no other visible data to compare our study. It can therefore be interpreted that the use of contact lenses is not popular among doctors in Nigeria.

Twenty-two percent of the study population who refused to wear corrections for their refractive error just did not want to and some for the reasons, which included that spectacles are heavy and they are foreign objects and make eyes sunken and not beautiful. All these reasons were least expected from medical doctors who are supposed to counsel the general populace on eye health. That means that many doctors themselves require health education about use of eyeglasses (which is the cheapest and noninvasive form of correction of refractive error) and other forms of corrections of refractive error. Compliance with its use will reduce the risk of medical errors among physicians and reduce burden of avoidable visual impairment and blindness among service providers themselves and subsequently the public. Public enlightenment and health education are therefore needed to change the perception of doctors of the misconstrued opinion about use of eyeglasses and other available forms of refractive error corrections.

Limitations of the study: During the research, some limitations were identified, which were: The self-reported nature of the survey made prevalence determination of the refractive errors among physicians impossible since it depended on the information provided by the participants which might not have been recalled accurately. Physicians have limited knowledge of refractive errors and corrections, but unfortunately, the reasons for this could not be determined because it is beyond the scope of the study; further studies will be required to determine why physicians lack knowledge about this common ocular disorder that they encounter in their practice and of which they are also patients.

Many respondents did not know the type of refractive errors with the lens type for correction even of their own. The gap in knowledge of the participants was responsible for most of the no responses in the study which would have made the discussion robust if questions were fully responded to.

There is a need for regular evaluation of the knowledge and update of physicians about clinical and ocular conditions which they encounter in their practice and of which they are also patients. The result of this research revealed a gap in the knowledge of physicians about refractive errors, and this makes the need for regular training important. This can be achieved with the Continuing Professional Development programs in form of continuing medical education which serves as the main source of knowledge update for doctors in Ogun state and provides remedial measures for delivering appropriate care for their patients as well.

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## Conflicts of interest

There are no conflicts of interest.

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Original Article

# Evolution of sclero-corneal tunnel healing in manual small incision cataract surgery: An anterior segment optical coherence tomography-based study


## ABSTRACT

**Purpose:** To evaluate the architecture and healing of the sclera-corneal tunnel in manual small incision cataract surgery (MSICS) using anterior segment optical coherence tomography (AS-OCT) over one month. The study also aimed to correlate incision features with best-corrected visual acuity (BCVA) at one month. **Methods:** This prospective observational study was conducted over 18 months, involving 67 patients who underwent uneventful MSICS. AS-OCT was used to evaluate wound features such as epithelial cysts, endothelial misalignment, endothelial gaping, stromal coaptation loss, Descemet's membrane detachment (DMD), and maximum corneal thickness at the internal edge of the tunnel at postoperative day 1, week 1, and month 1. **Results:** Increased corneal thickness was observed in all patients at the internal edge of the tunnel postoperatively. Patients with DMD and endothelial gaping had significantly higher corneal thickness ($P < 0.05$). Endothelial misalignment was the most common imperfection observed throughout the follow-up period. Wound imperfections did not significantly impact structural integrity or BCVA but require further investigation regarding their effect on surgically induced astigmatism. **Conclusion:** AS-OCT is a valuable tool for noninvasive assessment of sclero-corneal wound healing post MSICS. Although imperfections like endothelial misalignment and gaping are common, they do not necessarily affect visual outcomes.



**Keywords:** Anterior segment optical coherence tomography, corneal thickness, manual small incision cataract surgery, sclero-corneal tunnel, wound healing


## INTRODUCTION

Manual small incision cataract surgery (MSICS) has emerged as a widely accepted technique for cataract extraction, particularly in resource-limited settings.[1] While phacoemulsification remains the gold standard in developed countries, MSICS provides comparable visual outcomes with the added advantage of cost-effectiveness and a shorter learning curve.[2] Despite these benefits, the integrity of the sclera-corneal tunnel created during MSICS is crucial for preventing postoperative complications such as wound leakage, iris prolapse, and endophthalmitis.[3]

The sclero-corneal tunnel acts as a self-sealing valve, and its structural integrity is essential for maintaining a stable anterior chamber and promoting optimal visual recovery.[4] Anterior segment optical coherence tomography (AS-OCT) has become a valuable imaging tool for evaluating anterior segment structures, providing high-resolution, cross-sectional images of the cornea, sclera, and anterior chamber. It allows for detailed visualization of wound architecture, helping clinicians assess the healing process in the immediate postoperative period.[5]


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Previous studies have predominantly focused on clear corneal incisions made during phacoemulsification. However, there is limited literature describing the healing characteristics of the sclera-corneal tunnel following MSICS. A better understanding of wound dynamics in MSICS, as visualized by AS-OCT, can lead to optimized surgical techniques and improved postoperative management.[6]

This study aims to describe the architecture of the sclera-corneal tunnel using AS-OCT and to assess the evolution of wound healing over one month following MSICS. Additionally, the study aims to correlate these findings with the final best-corrected visual acuity (BCVA) and to explore any potential impact of incision characteristics on surgically induced astigmatism (SIA).

## METHODOLOGY

### Study design and setting

This prospective observational study was conducted at the Department of Ophthalmology, Amala Institute of Medical Sciences, Thrissur, Kerala, over 18 months from February 2014 to August 2015. The study was approved by the Institutional Ethics Committee (approval number: AIMSIEC/III/2014 Dt. 31.01.2014).

### Participants

#### *Inclusion criteria*

- Adult patients aged 18 years and above
- Patients undergoing uneventful MSICS with a sclera-corneal tunnel
- Clear corneal optics without pre-existing ocular pathologies.

#### *Exclusion criteria*

- Pre-existing sclera-corneal pathologies such as keratoconus or dystrophies
- Patients requiring an incision size greater than 6 mm due to mature cataracts
- History of ocular trauma, previous ocular surgery, or refractive procedures
- Long-term use of topical ocular medications.

### Sample size

The sample size was calculated using the formula:

$$n = 4pq/d^2$$

where $P$ is the estimated prevalence of wound healing abnormalities, $q$ is $1 - P$, and $d$ is the allowable error. A prevalence of 67% was used, with a 20% error margin, resulting in a calculated sample size of 66.7, rounded to 67 patients. A prevalence of 67% was selected to ensure that the study had sufficient patients to detect meaningful differences or patterns in wound healing. Additionally, a 20% error margin was incorporated to account for potential fluctuations in the actual prevalence. This margin provides flexibility in the sample size, ensuring the results remain reliable even if the actual prevalence differs slightly from the estimate. Consequently, the sample size was calculated to be approximately 67 patients, which was deemed adequate to represent the population and yield significant findings.

### Surgical technique

All procedures were performed by a single experienced surgeon under peribulbar anesthesia, using a combination of 2% lignocaine with adrenaline and 0.5% bupivacaine. Pupillary dilation was achieved using tropicamide 1% and phenylephrine 2.5% eye drops. A superior temporal conjunctival peritomy was made, followed by mild cautery for hemostasis. A 6 mm frown-shaped partial-thickness scleral incision was created 2 mm posterior to the limbus using a No. 15 blade.

A crescent knife was then used to dissect a tri-planar sclera-corneal tunnel extending 1 to 1.5 mm into a clear cornea. The anterior chamber was entered using a 3.2 mm keratome. A continuous curvilinear capsulorhexis was created after staining the anterior capsule with trypan blue dye. Hydrodissection was performed, and the nucleus was prolapsed into the anterior chamber and removed using viscoexpression or an irrigating vectis. The residual cortex was aspirated using a Simcoe cannula. An injector system implanted a foldable acrylic posterior chamber intraocular lens into the capsular bag. Wound integrity was verified, and stromal hydration was done with a balanced salt solution to ensure water tightness. No sutures were applied unless there was evidence of leakage. Postoperative treatment included topical antibiotic–steroid combination drops tapered over four weeks.

### AS-OCT imaging

AS-OCT imaging was performed using the Cirrus™ HD-OCT (Carl Zeiss) adapted for anterior segment imaging. All patients underwent AS-OCT scans at three follow-up visits: postoperative day 1, week 1, and month 1. The five-line raster scan was centered on the sclera-corneal tunnel at a 90° angle. The following parameters were analyzed:

1. Epithelial cysts
2. Endothelial misalignment
3. Endothelial gaping
4. Loss of stromal coaptation
5. Descemet's membrane detachment (DMD)
6. Maximum corneal thickness at the internal edge of the tunnel.

### Follow-up protocol

Patients were followed up at three key postoperative time points: day 1, week 1, and one month. Each visit included a complete ophthalmic examination, including slit-lamp evaluation, BCVA, intraocular pressure measurement, and AS-OCT imaging. Postoperative keratometry was performed at the one-month follow-up visit to assess astigmatism.

### Preoperative and postoperative astigmatism evaluation

Preoperative corneal astigmatism was measured one day before surgery using an automated keratorefractometer to establish the baseline astigmatism in the patient's eye. The values for astigmatism (K1 and K2) were recorded, and the total astigmatism was calculated. To maintain consistency, postoperative corneal astigmatism was measured one month after surgery using the same keratorefractometer. The same procedure was followed, recording K1, K2, and total astigmatism. SIA was then determined by comparing the preoperative and postoperative measurements through vector analysis.

### Data collection and analysis

Data were recorded in a structured format, including patient demographics, preoperative and postoperative clinical data, and AS-OCT findings. Statistical analysis was performed using SPSS version 23. Descriptive statistics were used for baseline characteristics. Continuous variables were analyzed using paired *t*-tests and analysis of variance for repeated measures. Categorical variables were analyzed using chi-square tests. Multivariate analysis was conducted to identify predictors of wound complications. A $P$ value of $<0.05$ was considered statistically significant.

## RESULTS

### Demographic and clinical characteristics

The demographic and clinical characteristics of the study population are summarized in Table 1. The mean age was 67.14 ± 6.75 years, with a male predominance (38.8%).

### Incidence of wound imperfections

Wound imperfections, such as endothelial gaping and DMD, were common in the immediate postoperative period. Table 2 shows the incidence of these imperfections at each follow-up visit.

### Corneal thickness changes

Corneal thickness increased significantly at the internal edge of the sclera-corneal tunnel immediately postoperatively. Table 3 shows the changes in corneal thickness over time.

### Correlation with visual acuity

There was no significant correlation between the presence of wound imperfections and BCVA at one month. Patients with DMD and endothelial gaping had higher corneal thickness, but this did not correlate with reduced BCVA [Table 4].

### Factors associated with DMD

Lower preoperative intraocular pressure (IOP) is associated with the development of DMD, as indicated by the statistically significant difference in IOP between the DMD and non-DMD groups. Reduced IOP leads to decreased corneal rigidity, making Descemet's membrane more prone to detachment during surgical manipulation. Additionally, lower IOP affects anterior chamber stability, increasing the likelihood of postoperative barotrauma and improper adhesion of Descemet's membrane. These findings confirm that lower preoperative IOP is a significant risk factor for DMD [Table 5].

**Table 1: Demographic and clinical characteristics**

| Parameter | Value |
|---|---|
| Male | 26 (38.8%) |
| Female | 41 (61.2%) |
| Mean age±SD | 67.14±6.75 |
| Right eye | 37 (55.2%) |
| Left eye | 30 (44.8%) |
| Diabetes mellitus | 25 (37.3%) |
| Mean FBS±SD | 105.7±13.9 |

**Table 2: Incidence of wound imperfections**

| Imperfection | Day 1 (%) | Week 1 (%) | Month 1 (%) |
|---|---|---|---|
| Epithelial cysts | 17.91 | 7.46 | 5.97 |
| Endothelial misalignment | 56.71 | 61.19 | 65.67 |
| Endothelial gaping | 50.74 | 40.29 | 17.91 |
| Loss of coaptation | 2.98 | 1.41 | 0.00 |
| DMD | 20.89 | 10.44 | 0.00 |

**Table 3: Corneal thickness changes over time**

| Time | Roof (Mean±SD) | Floor (Mean±SD) |
|---|---|---|
| Pre-op | 612.32±28.86 | 612.32±28.86 |
| Day 1 | 933.50±94.23 | 892.82±98.14 |
| Week 1 | 831.65±90.37 | 792.21±81.65 |
| Month 1 | 702.83±53.04 | 672.17±53.73 |

**Table 4: Visual acuity and wound imperfections**

| Imperfection | BCVA at 1 Month (Mean±SD) | *P* |
|---|---|---|
| Endothelial misalignment | 0.85±0.23 | 0.054 |
| Endothelial gaping | 0.90±0.22 | 0.383 |
| Epithelial cysts | 0.87±0.24 | 0.632 |
| DMD | 0.93±0.19 | 0.451 |

**Table 5: Preoperative IOP and DMD**

| Parameter | DMD Group (Mean±SD) | No DMD Group (Mean±SD) | *P* |
|---|---|---|---|
| Pre-op IOP (mmHg) | 12.2±2.1 | 14.8±3.5 | 0.041 |

### Impact of endothelial gaping on corneal edema

Patients with endothelial gaping had significantly higher corneal edema at all follow-up visits. Table 6 shows the comparison of corneal thickness in patients with and without gaping.

### Postoperative inflammation

On post-op Day 1, AS-OCT detected refractile particles in the anterior chamber in 6.72% of patients, while slit-lamp examination identified inflammatory cells in 2.98% of patients. The total incidence of postoperative inflammation was 9.7%. Table 7 summarizes these findings.

### Association between corneal thickness and BCVA

Patients with increased corneal thickness showed a trend toward lower BCVA at one month, though not statistically significant. Table 8 presents the correlation between corneal thickness and BCVA.

### Impact of incision length on wound healing

Patients with larger incision sizes showed a higher incidence of wound imperfections, particularly DMD and endothelial gaping. Table 9 shows the relation between incision length and wound complications.

### Comparison of preoperative and postoperative parameters

Table 10 compares key preoperative and postoperative clinical parameters, highlighting the changes in corneal thickness, IOP, and visual acuity over time.

### Outcomes of astigmatism

Table 11 presents the outcomes of astigmatism. The corneal astigmatism (K1) and K2 values increased slightly after surgery, with no statistically significant change ($P = 0.075$ for K1 and $P = 0.080$ for K2). The total astigmatism also showed a slight increase, with a $P$ value of 0.065, indicating no significant change. Overall, SIA did not significantly affect corneal curvature post-surgery.

### Surgical-induced astigmatism and wound imperfection

Table 12 presents the relationship between SIA and wound imperfection. SIA was significantly associated with endothelial gaping ($P = 0.021$), indicating a correlation between wound imperfections and astigmatism. However, there was no significant association between SIA and endothelial misalignment ($P = 0.235$) or DMD ($P = 0.50$).

**Table 6: Corneal thickness in patients with and without endothelial gaping**

| Time | Gaping (Mean±SD) | No Gaping (Mean±SD) | *P* |
|---|---|---|---|
| Day 1 | 974.06±105.13 | 890.41±55.94 | 0.0001 |
| Week 1 | 885.30±85.21 | 794.51±74.44 | 0.0001 |
| Month 1 | 778.58±29.61 | 686.01±41.04 | 0.0001 |

**Table 7: Postoperative inflammation**

| Parameter | Day 1 (%) | Week 1 (%) | Month 1 (%) |
|---|---|---|---|
| Anterior chamber debris | 8.95 | 1.49 | 0.00 |
| Cells detected by OCT | 6.72 | 0.00 | 0.00 |
| Cells detected by slit-lamp | 2.98 | 0.00 | 0.00 |

**Table 8: Correlation between corneal thickness and BCVA**

| Parameter | *r* | *P* |
|---|---|---|
| Day 1 Thickness vs. BCVA | −0.321 | 0.062 |
| Week 1 Thickness vs. BCVA | −0.287 | 0.083 |
| Month 1 Thickness vs. BCVA | −0.251 | 0.126 |

**Table 9: Incision length and wound complications**

| Incision length (mm) | Imperfections (%) | Mean corneal thickness (μm) | *P* |
|---|---|---|---|
| ≤5.5 | 30.4 | 620.32±52.41 | 0.043 |
| >5.5 | 60.7 | 732.89±71.23 | 0.031 |

## DISCUSSION

This study provides valuable insights into the architecture and healing dynamics of sclera-corneal tunnels following MSICS. AS-OCT proved to be an effective tool for noninvasive evaluation of wound integrity, detecting subtle complications that might otherwise be missed during clinical examination.[7]

The high prevalence of endothelial misalignment and gaping in the immediate postoperative period suggests a need for meticulous surgical technique and postoperative management. The reduction in these imperfections over time indicates that they may represent temporary disruptions rather than permanent damage to the wound architecture.[8]

Interestingly, while corneal thickness was significantly increased in the immediate postoperative period, it did not correlate with long-term visual outcomes. This suggests that the transient edema observed may not have a lasting impact on visual acuity, although its influence on SIA remains to be explored.[9]

The association between lower preoperative IOP and the occurrence of DMD highlights the importance of preoperative IOP management in reducing the risk of postoperative complications. The lack of a significant correlation between wound imperfections and BCVA further supports the notion that these imperfections may not be clinically significant in terms of visual outcomes.[10]

The findings of this study are consistent with existing literature, which suggests that while imperfections in the

**Table 10: Comparison of preoperative and postoperative parameters**

| Parameter | Pre-op (Mean±SD) | Post-op day 1 (Mean±SD) | Post-op week 1 (Mean±SD) | Post-op month 1 (Mean±SD) |
|---|---|---|---|---|
| Corneal thickness (μm) | 612.32±28.86 | 933.50±94.23 | 831.65±90.37 | 702.83±53.04 |
| IOP (mmHg) | 13.3±2.4 | 18.7±3.8 | 15.2±3.1 | 13.9±2.7 |
| BCVA | 0.5±0.3 | 0.7±0.4 | 0.8±0.3 | 0.9±0.2 |

**Table 11: Comparison of corneal astigmatism and surgically induced astigmatism (SIA) preoperative and postoperative measurements**

| Parameters | Preoperative (Mean±SD) | Postoperative (Mean±SD) | SIA (Mean±SD) | *P* |
|---|---|---|---|---|
| Corneal astigmatism (K1) | 1.52±0.40 | 1.61±0.45 | 0.09±0.33 | 0.075 |
| Corneal astigmatism (K2) | 2.09±0.60 | 2.23±0.63 | 0.14±0.33 | 0.080 |
| Total astigmatism | 3.61±1.02 | 3.84±1.05 | 0.23±0.48 | 0.065 |

**Table 12: Relationship between surgically induced astigmatism (SIA) and wound imperfections**

| Parameters | SIA (Mean±SD) | *P* |
|---|---|---|
| SIA and endothelial gaping | 0.33±0.40 | 0.021 |
| SIA and endothelial misalignment | 0.14±0.38 | 0.235 |
| SIA and DMD | 0.05±0.33 | 0.50 |

sclera-corneal tunnel are common, they do not necessarily lead to poor visual outcomes. However, the potential impact of these imperfections on other aspects of postoperative recovery, such as patient comfort and refractive stability, warrants further investigation.

This study has several limitations that may affect the generalizability and depth of its findings. Firstly, the results are based on the outcomes of a single surgeon in a specific setting, limiting the ability to generalize the findings to different surgical practices or healthcare environments. Additionally, factors such as surgeon experience, patient comorbidities, or variations in incision techniques were not explored, which could have influenced the outcomes, including wound healing and SIA. Furthermore, the study focuses only on short-term postoperative healing without assessing long-term refractive stability or patient satisfaction. The absence of long-term follow-up data limits the ability to determine the sustained impact of surgical techniques and wound healing characteristics on visual outcomes and quality of life. Future studies addressing these factors and including long-term outcomes will provide a more comprehensive understanding of MSICS and its clinical implications.

## CONCLUSION

AS-OCT is a valuable tool for evaluating sclera-corneal wound healing following MSICS. Despite various wound imperfections, such as endothelial gaping and DMD, these did not significantly impact final visual outcomes. The study found that SIA was significantly associated with endothelial gaping, not endothelial misalignment or DMD. Additionally, larger incision sizes (>5.5 mm) were associated with increased corneal thickness and a higher incidence of wound imperfections, suggesting that incision length may influence wound healing and astigmatism. Future studies should focus on the long-term impact of incision size, wound imperfections, and SIA on refractive outcomes and patient satisfaction.

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## Conflicts of interest

The authors declare no conflicts of interest.

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# A musical journey that lighted up lives: Charles Kelman and his revolutionary phacoemulsification surgery



Figure 1: Dr. Charles Kelman (seated) and laboratory assistant Cheryl Jalbert (right) testing phacoemulsification methods on laboratory animals at the Manhattan Eye, Ear, and Throat Hospital, prelude to the first phacoemulsification in 1967. Source: https://www.eyeworld.org/

In today's world, the term "phacoemulsification" is used ubiquitously in professional lexicon as well as in the public medical jargon. This edition brings out the fascinating story of a miracle man and his unique invention, which went on to become the standard of care and one of the most refined and successful surgical procedures done worldwide. Yes! we are referring to the one and only Charles Kelman, the superstar ophthalmologist, an original thinker, and a versatile personality, whose invention of phacoemulsification surgery [Figures 1 and 2] made a paradigm shift in the field of cataract surgery and still continues to be polished and perfected by thousands of surgeons across the globe.

Charles David Kelman [Figure 3] was born to Eva and David Kelman on May 23, 1930, in Brooklyn, New York. His father was a Jewish immigrant from Greece and was an amateur inventor, who made a great impression on young Charles' life. Charles Kelman graduated from Tufts University with a B.S. degree in just two years in 1950 and then studied Medicine at the University of Geneva, obtaining his M.D. degree in Ophthalmology in 1956. Following this, he did an internship at Kings County Hospital and a residency at Wills Eye Hospital in Philadelphia.[1]



Figure 2: Dr. Charles Kelman holding one of his phacoemulsification handpieces. Source: Foundations of Ophthalmology. Springer, Cham. https://doi.org/10.1007/978-3-319-59641-9_16

Young Kelman always wanted to be a musician and an entertainer. He started playing harmonica at the age of four, later became skilled in saxophone and clarinet, and used to performed for children's radio show from a very young age. He also played in the high school band and dreamed of stardom in music. The story goes that once after playing a song by Jimmy Dorsey on his saxophone for his father at the basement of their

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house, his father asked him if had played as well as Dorsey. When Kelman admitted that he did not play as well as Dorsey, his father said, "You will be a doctor!" These rather casual words marked a new phase in Kelman's career and were destined to make a huge impact in the field of cataract surgery later.[1]

Kelman's story was that of an adventurer with out-of-the-box ideas, unbridled passion, and determination to pursue what he believed, to the very culmination. After starting his Ophthalmology practice in 1960, he developed cryoprobes for cataract removal inspired by the works of a neurologist who used cryoprobes for the removal of brain tissue in Parkinson's disease. He was deeply upset when the neurologist took over his work without giving the needed credits. In 1963, he invented cryopexy to treat retinal detachment and received a grant of USD 2,99,000 from the John A Hartford foundation for "developing a method of removal of cataract as an out-patient procedure," as written by Kelman as the closing lines of his grant proposal.[2]

Those were the days in which cataracts were removed through large extra capsular incisions, with a long postoperative hospitalization period. He had no clue in the beginning how this could be achieved; nevertheless, he won the grant and spent three years experimenting with various instruments, techniques, and animal studies. However, could not find a suitable method that could achieve this audacious dream. He had tried with more than a dozen instruments. Although each device would engage the cataractous lenses, it could not remove the tissue from the eye and would damage the delicate ocular tissues extensively.

Disheartened at his repeated failures and dwindling funds, Kelman had neglected himself due to the obsessively consuming nature of his work. One day he found that his hair had grown long and his teeth needed cleaning. He went for a haircut first, a shoe shine next, and then for a dentist appointment for cleaning his teeth. Lying on his dentist's chair, he saw his dentist Larry Kuhn was using a probe using ultrasound energy to remove the plaques on his teeth. This new instrument was the Cavitron dental cleaner, which vibrated at ultrasonic frequencies. This was a "Eureka" moment for Charlie and he rushed out of the dentist's office shouting, "I've got it!" He returned with a newly extracted cataract and requested the dentist to allow him use the ultrasonic probe on it. To his astonishment, he realized that unlike many other methods he experimented with, the ultrasound probe was able to penetrate into the lens tissue and owing to its rapid oscillation, could make lines on the cataract without it jumping out from his hand. Kelman went on to work with Cavitron to create the first phacoemulsification machine.[2]

In 1967, following a long line of animal experiments, Charles Kelman was ready to try his new machine in the blind eye of a patient with advanced glaucoma, who had willingly agreed to undergo the operation for the benefit of medical research. The surgery was performed behind closed doors in great secrecy and was done in the presence of his long term a research assistant, Cheryl Jalbert. The procedure took more than four hours, and the time for phacoemulsification alone was seventy minutes. Owing to the heaviness of the phacoemulsification handpiece and the frequent collapse of the anterior chamber and cornea due to the poor understanding of fluidics, Kelman was seen fatigued and distressed during the surgery.[3]

In the next two years, he modified the machine further and tried it in three more eyes with relatively better success. He along with his coinventor, Anton Banko from Cavitron, patented the ideas in 1967 and entered into a contractual arrangement with Cavitron. By the 1970s, he had started training surgeons on his technique of phacoemulsification. Initially, he was opposed to the idea of publishing his invention in peer-reviewed journals, and the technique became popular among ophthalmic surgeons by the way of word of mouth alone.

It is curious to note that this breakthrough revolution in the field of medicine did not initially come out through academia, but through the denizens of private practice. Charlie had quite a fan following among the private practitioners who were enthusiastic to take it forward. When he later published his results in the American Journal of Ophthalmology in 1967, there was vehement opposition in the academic circles. The prominent academics branded the procedure as "experimental," "malpractice," and there was severe backlash and harsh criticism for almost 5 years. As a result, the medical



**Figure 3: Charles D Kelman, MD (May 23, 1930–June 1, 2004). Photograph taken by Martha Swope. Courtesy of the estate of Charles Kelman**




**Figure 4: Dr. Charles Kelman with one of the early phaco units during a 25th anniversary celebration hosted by ASCRS in 1999. Source: https://www.eyeworld.org**

insurance companies withdrew reimbursement benefits for his surgery. In the Welsch Cataract Symposium in 1973, there was an organized effort to discredit him and opposing surgeons and patients lined up to convey their bad experiences with the surgery by Kelman's technique. However, in the private practice front, the procedure was gaining momentum and many surgeries were done by enthusiastic surgeons. Such was the extent of criticism he faced for his revolutionary idea, but the persistence, passion, and self-confidence with which he faced these challenges found a way amid these "perils of innovation" and was to open uncharted territories in the history of cataract surgery [Figure 4].

Faced with vehement opposition, Kelman, with his ingenuity and "showmanship" decided to take things out to the public and made his appearance in Johnny Carlson show, a popular talk show of the times and in a never before fashion, the American public viewed the details of a purely scientific invention in the television of their bedrooms. This unconventional approach by a surgeon who knew the merit of his invention, won public imagination, and many more patients began to flow to his office for undergoing phacoemulsification surgery. He managed them surgically as well as publicized celebrity testimonials and endorsements to gather momentum to his practice. In the initial days, he had to extend his incisions after lens removal so as to introduce the rigid intraocular lens. The invention of foldable silicon intraocular lenses by Thomas R. Mazzocco enabled the introduction of intraocular lenses through smaller incisions and sealed the deal for Kelman.

Kelman also designed phakic and aphakic lens implants, such as Kelman Multiflex and Omnifit, and also worked on using magnetic techniques to extract cataract and for the removal of arterial plaques and growths from the bladder, prostate, and digestive tract. The popularity of phacoemulsification using a small incision triggered an innovative approach in other specialities and led to the development of microscopic surgeries, and Kelman can be rightly called as the "grandfather of all microscopic surgeries."

In his lifetime, Kelman obtained patents for over 100 inventions, initiated industrial medical technology by working in collaboration with industries, wrote and published books and articles, and taught at New York Medical College. He also won notable recognition as a musician, continued his appearances in the television, developed a musical comedy routine to perform in Atlantic City and Las Vegas alongside popular musicians, co-produced Broadway musicals, recorded music albums, and learnt to fly a helicopter. His autobiography titled "Through My Eyes" was published by Crown Publishing in 1985.

Kelman received many notable awards and recognitions: the Binkhorst Medal and the First Innovators Award in Ophthalmology (both from the American Society of Cataract and Refractive Surgery), and the Ridley Medal in 1990 by the International Congress of Ophthalmology, Outstanding Achievement Award for his excellence in cataract surgery from the American Society of Contemporary Ophthalmology, "Inventor of the Year Award" in 1992 and the Prestigious National Medal of Technology award. He was named "Ophthalmologist of the Century" at the International Congress on Cataract and Refractive Surgery in Montreal, Canada, and was honored with the Laureate Recognition award at the 107th Annual Meeting of the AAO in 2003.[4]

He died of lung cancer on June 1, 2004, at the age of 74, leaving a legacy that every ophthalmologist can be proud of and has proved to be a saving grace for millions of patients in their fight for light.

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### Conflicts of interest
There are no conflicts of interest.

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Case Report

# Bilateral central retinal artery occlusion with optic neuropathy, cerebral stroke, and mucormycosis in post-COVID patient – A rare presentation


## ABSTRACT

Nowadays, COVID-19 is a worldwide pandemic disease. The clinical features of this disease are not fully understood, especially the interaction of COVID-19 and preexisting comorbidities and how these together further impair the immune system. COVID-19 has been associated with inflammatory-induced homeostasis changes leading to severe coagulopathy with multi-organ involvement. The burden of thromboembolic complications in COVID-19 patients is currently unknown. The pathogenesis of retinal artery occlusions is a multifactorial process where inflammation and hypercoagulation state are established risk factors. The severity of the disease is currently managed with systemic glucocorticoids, and hence the chances of opportunistic fungal infections are more. It is likely that COVID-19 patients could be at risk of developing retinal vascular occlusions. Focused ophthalmological surveillance is advisable to prevent and manage this possible cause of severe vision loss. Here, we report a unique case of bilateral central retinal artery occlusion (CRAO) with optic neuropathy, cerebral stroke, and mucormycosis of the para-nasal sinus in a 52 years old male diabetic patient with a previous history of severe COVID-19 disease.



**Keywords:** Central retinal artery occlusion, COVID-19, mucormycosis, SARS-CoV-2, thrombosis, sepsis


## INTRODUCTION

Coronavirus disease is an infectious disease that affects different people in different ways.[1] Most infected people will develop mild to moderate illness and recover without hospitalization.[1] The severe coronavirus disease is currently managed with systemic glucocorticoids; hence, opportunistic fungal infections are more common in such patients.[2] Coronavirus has been noted to be associated with neurological symptoms, and hypercoagulability associated with COVID-19 has been described as a "sepsis-induced coagulopathy," which may predispose to a spectrum of thromboembolic events.[3] Older people and those with underlying medical problems like cardiovascular disease, diabetes, chronic respiratory disease, and cancer are more likely to develop serious illness.[4] The pathogenesis of retinal artery occlusions (RAO) is a multifactorial process where inflammatory and hypercoagulation states are established risk factors.[4] We report a case of a patient developing a bilateral CRAO with optic neuropathy, cerebral stroke, and mucormycosis of the para nasal sinus after a severe COVID infection.

## CASE REPORT

A 52-year-old male, post-COVID diabetic patient presented to the emergency with complaints of fever and altered sensorium. He was COVID positive on May 3, 2021, and was


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admitted to a civil hospital for fever and swelling of the left eye for 1 week. He became COVID-negative on May 12, 2021. Thereafter, he developed an altered sensorium for which he was referred to our hospital. At the time of presentation, sugar was 300 mg/dl, temperature 99.7, pulse 128/min, blood pressure 124/89 mmHg, and SPO2 97%.

On examination, the patient was found in a state of altered sensorium and had bilateral total ophthalmoplegia with proptosis left more than the right [Figure 1]. There were few hemorrhagic spots over the eyelid and puffiness over the maxillary area, left more than the right [Figure 1]. The pupil was mid-dilated and not reacting to light. Both the cornea was lusterless. Conjunctival vessels were prominent [Figure 1]. On fundus examination, there was a poor fundal glow [Figure 1]. The bilateral optic nerve was found pale along with bilateral central retinal artery occlusion [CRAO-cherry red spot] [Figure 1]. Ophthalmological examination was performed at the bedside, and the fundus photograph was taken with my DIY [do it yourself] innovative low-cost smartphone fundus camera [Figure 1]. The immediate digital ocular message was started and put on i.v manitol 100 ml stat and Inj LMWH-0.4 mg [low molecular weight heparin] SC twice/day. In addition to eye drop dorzolamide, 1 drop three times a day tab ecosprin (75 mg) was added 1 tab at bedtime.

A cardiac evaluation was done and had no pathology. A provisional diagnosis of bilateral orbital apex syndrome with bilateral CRAO was made and had done an ENT [ear, nose, and throat] evaluation. The endoscopic evaluation revealed congested nasal mucosa. Both the nasal cavities were found full of dried blood and secretions. A clinical suspicion of fungal sinusitis was made, and a nasal swab [Figure 2] was sent for microscopic examination and culture. Inj vancomycin (1g) and inj voriconazole (200 mg) was started twice a day. The culture report was mucormycosis positive [right-angled branching aseptate hyphae suggestive of mucormycosis] [Figure 2]. On gram stain, there were gram-positive cocci [Figure 2]. Blood culture had a positive report for streptococci [Figure 2]. MRI brain, orbit, and para-nasal sinus showed evidence of contiguous mucosal thickening in the left ethmoid air cells with T2/FLAIR hyperintensity in the left frontal lobe. Soft tissue enhancement was in the left frontal sinus and extraocular muscles, suggestive of mucormycosis. Multiple infracts in the brain and peri-vasculitis of the internal carotid artery [Figure 3]. Chest radiography was suggestive of viral pneumonia [bilateral reticular interstitial opacities] [Figure 4]. After a period of 7 days, we lost the patient.




Figure 1: Patient's clinical presentation of orbital apex syndrome and central retinal artery occlusion

## DISCUSSION

The COVID-19 disease has been described to induce inflammatory-induced homeostasis changes that predispose to thrombotic disease in both venous and arterial circulation.[1] The risk of thromboembolic events in COVID-19 patients is currently under investigation, with preliminary results showing significantly prolonged prothrombin time, high D-dimer levels and increased concentrations of proinflammatory cytokines and biomarkers of inflammation in patients with more severe disease, indicating the likelihood of disseminated intravascular coagulation or thrombotic microangiopathy.[2] The disease pattern of COVID-19 can range from mild to life-threatening pneumonia with associated bacterial and fungal infections.[2] Due to the associated comorbidities like diabetes mellitus, chronic obstructive pulmonary disease, and

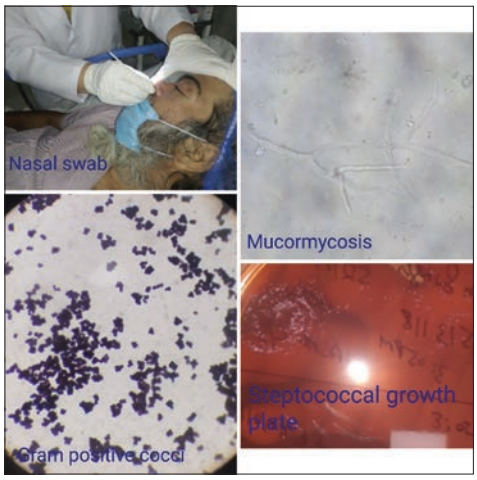



Figure 2: Nasal swab KOH mounting showing mucormycosis positive [right angled branching aseptate hypae] along with blood culture positive for streptococci

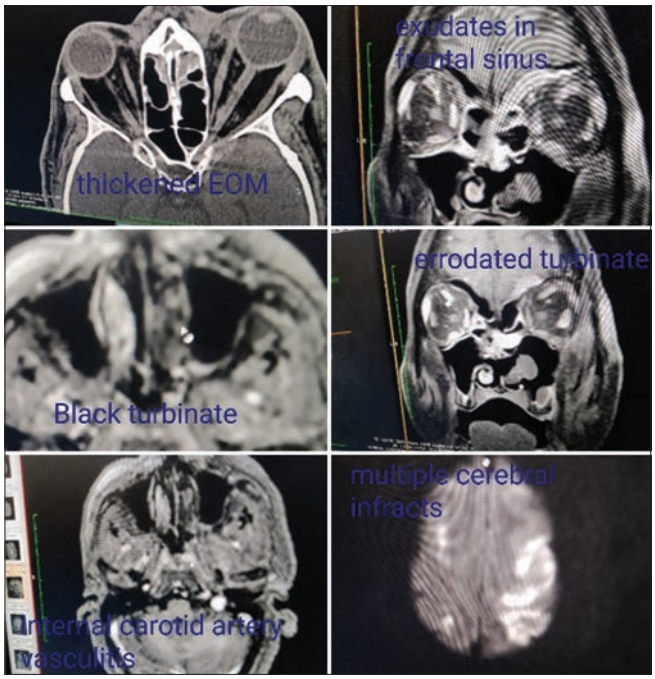



**Figure 3: MRI brain, orbit, and para nasal sinus showed evidence of contiguous mucosal thickening in the left ethmoid air cells along with soft tissue enhancement in the left frontal sinus with the destruction of turbinates suggestive of mucormycosis**

immune-compromised conditions like corticosteroid therapy, ventilation, and intensive care unit stay, these patients are prone to develop severe opportunistic infections.[2,3] A severe form of this disease is currently managed with systemic glucocorticoids, and the chance of opportunistic fungal infections is of concern in such patients. While COVID-19-associated pulmonary aspergillosis is increasingly recognized, mucormycosis is rare among COVID patients.[2] Mucormycosis is a rare but dangerous fungal infection. This aggressive infection affects the nose, eyes, brain, and lungs. Steroids reduce immunity, and it is thought that this drop in immunity could be triggering these cases of mucormycosis.[1,2]

Central retinal artery occlusion (CRAO) is an ophthalmic emergency and is akin to a myocardial infarction to the cardiologist and a cerebral stroke to the neurologist.[3] Hypercoagulability has emerged as a major cause of morbidity and mortality in patients with COVID-19.[4] There have been numerous documented cases of deep venous thrombosis, pulmonary emboli, and large-vessel ischemic strokes as a result of COVID-19 hypercoagulability. This is suspected to be due to a hyperinflammatory response caused by the SARS-CoV-2 virus.[5] Elevated inflammatory markers including IL-6, CRP, ferritin, fibrinogen, and the D-Dimer were all observed in this patient contributing to an overall prothrombotic and hypercoagulable state.[6] CRAO is a blinding ocular emergency presented with acute visual

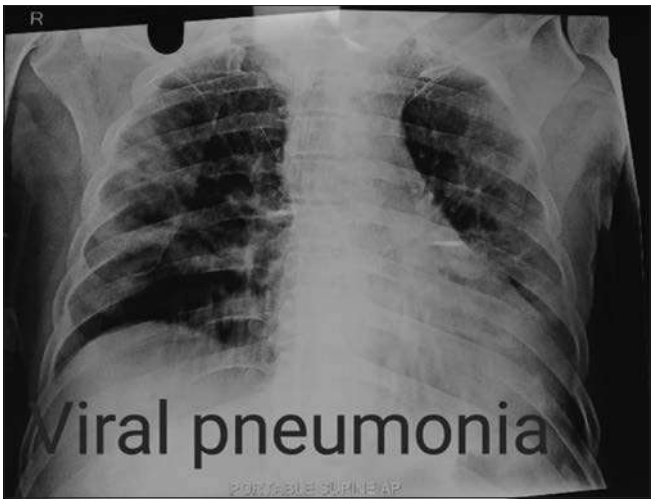



**Figure 4: Chest X-ray revealed bilateral reticular interstitial opacities consistent with viral pneumonia**

loss.[7,8] The pathogenesis of RAO is a multifactorial process where inflammation and hypercoagulation state are established risk factors.[8] Even though most cases are affected by venous thromboembolism, there are increasing reports of COVID-19-induced arterial thromboembolic complications like myocardial infarction and cerebral stroke.[9] We report a case of a patient that developed a bilateral CRAO after a severe COVID-19 disease which is different from earlier cases, where there was a unilateral presentation. CRAO is obstructions of retinal blood flow that result in severe vision loss.[10] They are divided into arteritic CRAO, mainly due to giant cells arteritis, and nonarteritic CRAO, where platelet fibrin thrombi or emboli as a result of atherosclerotic disease is responsible for over two-thirds of all CRAO cases. However, inflammatory and pro-coagulant states could also lead to the development of retinal vascular occlusions.[10] To our knowledge, there are only two reports (Acharya *et al.*, 2020)[11] of patients who developed a retinal arterial occlusion in association with COVID-19 disease.[11] In our case, it was bilateral CRAO which was different from earlier cases, and had simultaneous cerebral stroke and mucormycosis. The uniqueness of our case was bilateral CRAO and the fundus photo capturerization, using innovative DIY [Do It Yourself] fundus camera.

## Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published, and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

## Financial support and sponsorship

Nil.

## Conflicts of interest

There are no conflicts of interest.

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Case Report

# Superior rectus muscle ocular cysticercosis presenting as subconjunctival cyst


## ABSTRACT

A 32-year-old female presented with swelling in the left eye and a foreign body sensation growing insidiously for 1 month. On examination, a subconjunctival mobile cystic swelling with defined but irregular margins was noted under the superior bulbar conjunctiva in the left eye. CT scan revealed a well-defined hypodense lesion in the left superior conjunctiva with no intraocular or orbital extension and no neural involvement. Intraoperatively, the cyst was found to be arising from the superior rectus tendon. On excision biopsy, the diagnosis of cysticercosis was made. The patient was started on oral albendazole and steroids and is doing fine without any recurrence after 3 months of cyst excision.



**Keywords:** Myocysticercosis, ocular cysticercosis, superior rectus cysticercosis


## INTRODUCTION

Cysticercosis is a preventable cause of blindness endemic in India. It is a parasitic infestation caused by Cysticercus cellulose, which is the larval form of *Taenia solium*. Predisposing factors include poor hygiene and sanitary conditions, consuming contaminated raw vegetables, and drinking water. Ocular cysticercosis can be intraocular cysts in the vitreous or retinaand extraocular, which includes intraorbital or adnexal cysts. As per a study reported by Kruger-Leite, *et al*.[1] 35% of the cysts were found in the subretinal space, 22% in the vitreous, 22% in the subconjunctival space, 5% in the anterior segment, and only 1% in the orbit. However, a more recent study by Maurya, *et al*.[2] done in the Indian subcontinent reported 41.67% to be orbital cysts, 36.11% subconjunctival, 11.11% intraocular, and 11.11% as adnexal cysts. The most common clinical presentations reported in this study were subconjunctival masses and proptosis.

Clinical suspicion, computed tomography, and ultrasound imaging aid early diagnosis of cysticercosis. Treatment modality depends on the location of the cyst. In general, treatment is mostly conservative in the form of oral albendazole and steroids. Surgical excision is needed in some cases where cysts are subconjunctival or adnexal, and the excision poses no threat to the underlying tissue.

## CASE HISTORY

A 32-year-old female presented to our outpatient department with swelling in the left eye. The swelling was first noted 30 days before the day of presentation and gradually increased in size. There was no associated ocular pain, redness, or discharge from the eye; however, the patient was experiencing troublesome foreign body sensation. The patient was a resident of the Western coastal area of India, and her diet mainly included raw or cooked vegetables.

On examination, a subconjunctival cystic swelling, 1.2cm × 1cm in size, was noted under the superior bulbar conjunctiva of


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the left eye [Figure 1]. The swelling was nontender, fluctuant, mobile over the underlying structures, and characterized by well-defined but irregular margins. The posterior extent of the cyst could not be appreciated on double eversion of the upper eyelid. Ocular movements were painless without any restriction. Developmental cataract was noted in both eyes with a visual acuity of 0.3 (using a LogMAR chart). The rest of the anterior segment in both eyes was unremarkable. The posterior segment was normal on indirect ophthalmoscopy, and all angles were open on gonioscopy. Intraocular pressure was within normal range. Regional lymph nodes were not enlarged. All routine blood investigations were within normal limits. A well-defined hypodense lesion was noted in the left superior conjunctiva with no intraocular or orbital extension on the CT scan. The posterior extent was reported to be near the superior fornix. No neural involvement was seen on the CT scan.

Making a provisional diagnosis of inclusion cyst or subconjunctival cysticercosis, excision was planned. On table, the cyst was found to be arising from the superior rectus muscle tendon [Figure 2]. Since the cyst wall was adherent only to the superficial muscle fibers, excision was continued where some of the superficial fibers had to be dissected, taking utmost care to preserve the remaining muscle fibers.

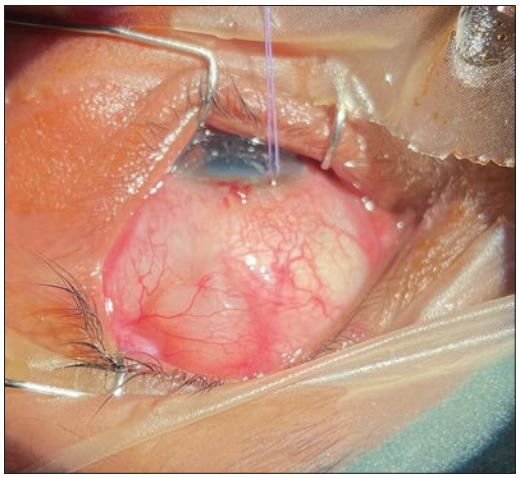


Figure 1: Subconjunctival cystic swelling, 1.2 cm × 1 cm in size under the superior bulbar conjunctiva of the left eye

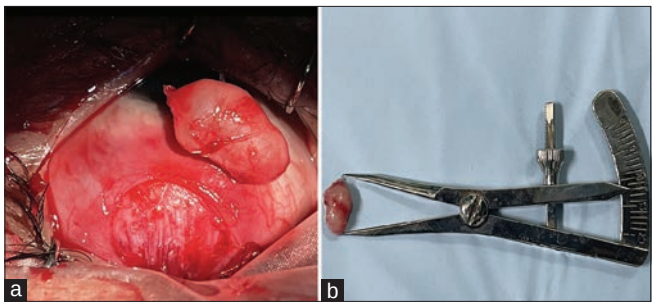



Figure 3: (a), (b) Excised cyst in toto

Cyst was excised in toto and subjected to histopathological examination [Figures 3a and 3b and 4].

Postoperatively, ocular movements were in full range without any restriction. Mild pain was present on elevation, which resolved over the next few days. The patient was started on topical antibiotics and steroids.

On histopathology, the diagnosis of cysticercosis was made [Figure 5a and 5b]. The patient was then started on oral albendazole (15 mg/kg/day) and oral prednisolone (1 mg/kg/day) for 4 weeks. After 4 weeks, oral albendazole was stopped and oral prednisolone was slowly tapered over the next month. After 3 months of follow-up, no recurrence was observed.

## DISCUSSION

Cysticercosis is caused by the seeding of larval form of *T. solium* in various body tissues following hematogenous spread. In general, *T. solium* larvae commonly infect the nervous system and ocular tissues. In Western countries,

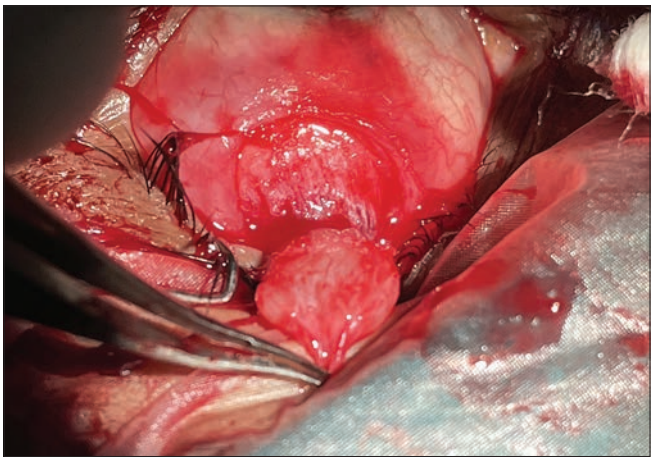


Figure 2: Cyst wall adherent to the superior rectus muscle tendon



Figure 4: Inferior surface of the cyst with adherent superficial muscle fibers

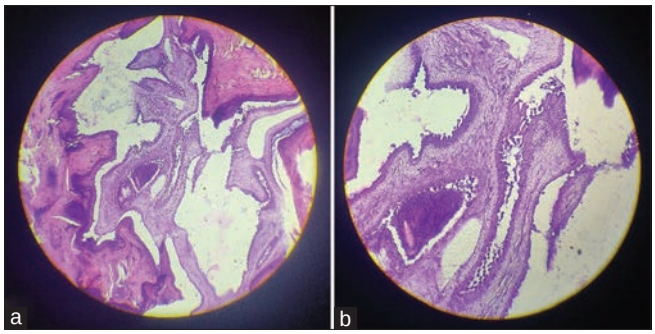



**Figure 5: (a), (b): Histopathological section (5a-10x; 5b-40x) showing cystic cavity containing larval form composed of duct-like invaginations lined by double-layered eosinophilic membrane and scolex with hooklets**

ocular involvement is mostly observed in the posterior segment of the eye, while subconjunctival cysts are more frequent in India.[1,2]

Cysts arising from extraocular muscles commonly present as periocular swelling, ptosis, ocular pain, restriction of ocular motility, diplopia, strabismus, lid edema, and orbital cellulitis like a clinical picture. One or more extraocular muscles may be simultaneously involved, with the lateral rectus and superior rectus being the more common sites.[3,4]

Early diagnosis of cysticercosis can be ensured on computed tomography and ultrasound imaging. The characteristic feature of cysticercosis on CT is a hypodense mass with a central hyperdensity suggestive of the scolex. A solitary cyst with wall enhancement may be also observed.

Treatment of ocular cysticercosis depends upon the site involved. In general, combination therapy with oral albendazole and steroids effectively manages extraocular muscle cysticercosis.[5] Surgical removal may be advocated for subconjunctival and eyelid cysticercosis. In our case, the cyst was mobile on examination with unrestricted, painless ocular movements. Also, CT findings did not suggest cysticercosis or any extraocular muscle involvement. Therefore, excision was planned. Since the cyst was growing along the superficial fibers of the tendon, the cyst could be excised without much damage to the muscle fibers, thereby keeping ocular movements intact.

## CONCLUSION

Our case adds to the limited knowledge of ocular myocysticercosis. It also presents an unusual scenario where, intraoperatively, a mobile subconjunctival cyst was found to be growing from a muscle tendon. If a cyst is adherent only to the superficial muscle fibers, excision may be continued; otherwise, it would be a better option to close the case and give a trial of medical treatment. The risk of surgical damage to underlying tissues should be weighed against the benefits of continuing with cyst excision.

### Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

### Financial support and sponsorship

Nil.

### Conflicts of interest

There are no conflicts of interest.

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Case Report

# CM – T flex: Case report of a novel secondary IOL in pediatric ectopia lentis


## ABSTRACT

To report a case of pediatric subluxated clear lens managed with lensectomy and CM-T flex intraocular lens. A 5-year-old boy presented with chief complaints of blurring of vision in his right eye since 2 years of age. On examination, he had the subluxated clear lens in the right eye with loss of zonules and the presence of vitreous in the anterior chamber. Lensectomy with CM T flex intraocular lens implantation was performed for this patient. Following surgery his vision improved. CM-T flex is a good option as a secondary IOL in pediatric ectopia lentis.



**Keywords:** CM T flex intraocular lens, ectopia lentis, pediatric


## INTRODUCTION

Ectopia lentis is the hereditary or acquired displacement of the natural crystalline lens.[1] The cause can be traumatic or secondary due to systemic diseases. Systemic associations include Marfans syndrome, Weil marchesani syndrome, homocystinuria, hyperlysinemia, sulfite oxidase deficiency, and Ehler Danlos syndrome. Cycloplegic refraction and glasses are the medical management of Ectopia lentis. Surgical correction is indicated when there is a marked lens displacement leading to poor vision and amblyopia.[2]

## CASE REPORT

A 5-year-old boy referred from the peripheral hospital, presented to us with chief complaints of defective vision and photophobia in the right eye since 2 years of age. There is no history of trauma or falls. Birth history revealed maternal gestational anemia. There was no consanguinity. The child was born of a full-term caesarian section due to fetal distress with a birth weight of 3 kg. A history of NICU admission for neonatal hyperbilirubinemia was present. The child had normal developmental milestones. On ocular examination, uncorrected visual acuity in the right eye was 5/60 with no improvement in the pinhole, and the left eye was 6/6, N6. The anterior segment of the right eye showed a slight bluish sclera and subluxated clear lens with loss of zonules with vitreous in the anterior chamber. The clear lens was observed to bisect the undilated pupil causing significant visual distortion [Figure 1]. The posterior segment of the right eye was found to be normal. The anterior segment and fundus evaluation of the left eye were normal with normal intraocular pressure in both eyes. On systemic evaluation, smallmouth, blunt fingertips, soft palms, and bilateral pes planus were noted. There was no gross joint hypermobility. Echocardiography, plasma lactate levels, and CPK creatine kinase were within normal limits. The child was clinically diagnosed with unilateral ectopia lentis.

Considering the zonular weakness of more than 6 clock hours resulting in the visually significant subluxation, right eye- Lensectomy with anterior vitrectomy and CM T flex intraocular lens implantation was performed for this patient.


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The surgical procedure is as follows Figure 2: Capsulorrhexis was performed using Utrata's forceps and lens aspiration was performed followed by anterior vitrectomy. Using the Ashwin glued IOL marker, 0 to 180 degrees marked. Using a crescent blade, 2 partial thickness scleral flaps were created around either side of the marking. Using a 23G needle, 2 sclerotomies are made 1.5 mm from the limbus on either side under the scleral flap. The CM T flex intraocular lens is [Figure 3] a foldable hydrophilic lens with specialized T-shaped haptics. The CM T flex IOL was injected and the T junction of the IOL was grasped first using Praniv T flex forceps. The rest of the IOL was injected gently and trailing haptic was kept at the wound. Praniv forceps were gently brought out through the sclerotomy sites. Using Nishi grasping forceps through the side port, the arm of the IOL was held. Using the handshake technique, the T junction was transferred to the second forceps and brought out through the other sclerotomy site. IOL power measured was 29 D. IOL power of 25 D was placed with a planned under correction of 3D.

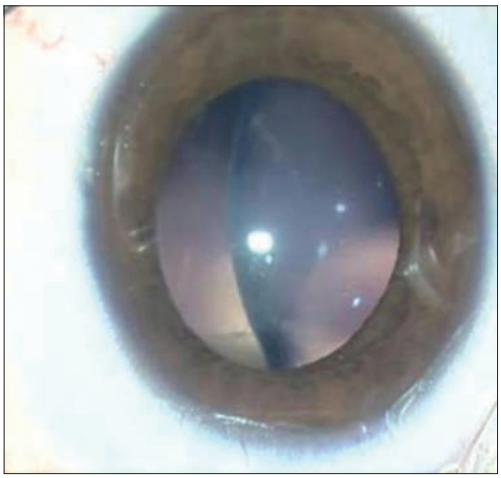


Figure 1: Pre-operative picture

At 1-month follow up, UCDVA was 6/60 improving to 6/18 with +2.00/+1.25*40. Anterior segment evaluation of the right eye showed clear cornea, well-centered IOL with pigments on IOL [Figure 4]. Scleral flaps were well secured and intraocular pressure was 14 mm of Hg.

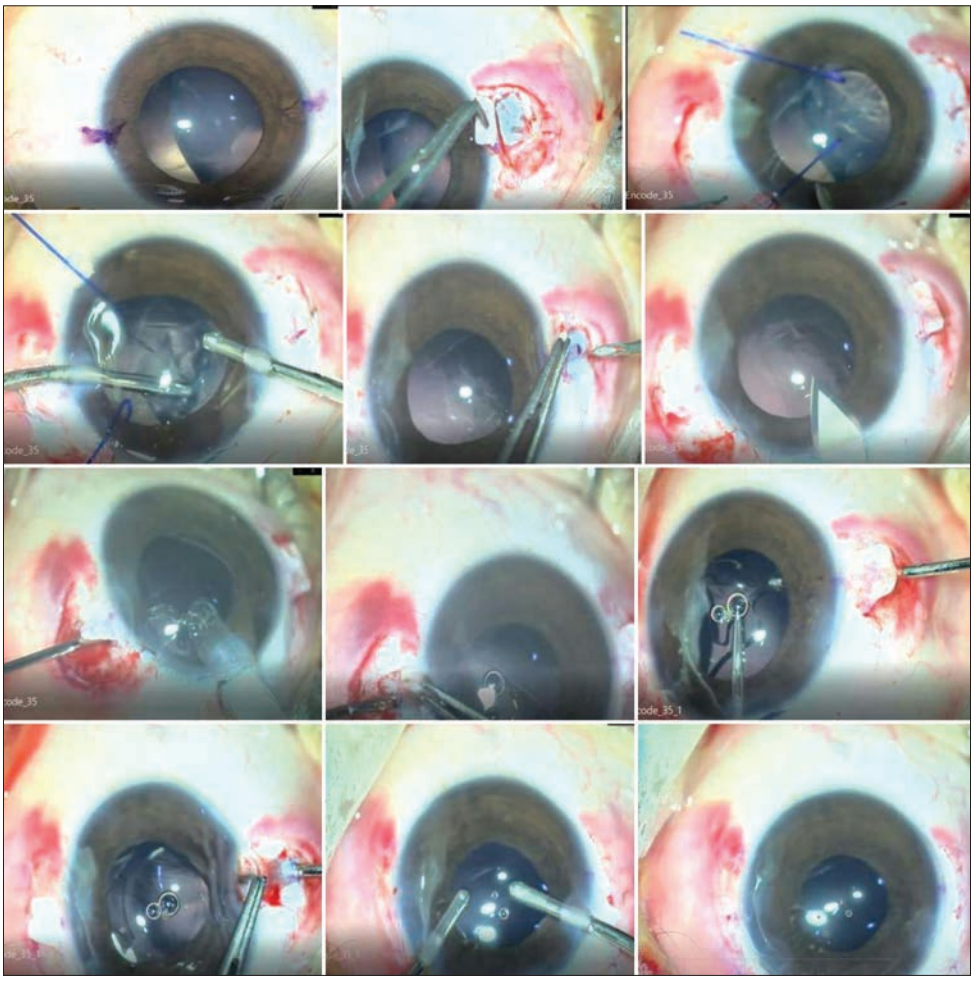


Figure 2: Surgical steps



Figure 3: CM T flex Intraocular lens

## DISCUSSION

The first line of treatment in ectopia lentis is refractive error correction by spectacles or contact lenses to prevent amblyopia. Cycloplegics like atropine and homatropine are used in cases of dislocation into the anterior chamber. Antiglaucoma medications are used to reduce intraocular pressure. Surgical management includes pars plana vitrectomy with lensectomy in cases where the subluxation is visually significant. The surgical method is very challenging due to weak zonules and loss of the posterior capsular bag. In the bag, IOL, scleral fixated IOL, anterior chamber, or iris claw are the options.[3]

Retro pupillary fixated iris claw lenses and scleral fixated IOL (SFIOL) are usually preferred in children as the long-term effects of anterior-chamber IOL (ACIOL) on the endothelium are poor.[4] However, there are significant long- term effects of these lenses. Iris claw lenses can potentially create pigment dispersion glaucoma, create unwanted astigmatism due to lens tilt and its long-term stability in pediatric patients warrants evidence. Cevik *et al*.[5] used Iris claw IOL in treating ectopia lentis. A study showed post operative complications like lens dislocation, hypotony, and retinal detachment.

Scleral fixated IOLs may also have poor stability in a growing eye with reports that observe loosening of the haptic or scleral melt in eyes that have weak collagen, especially Marfan's syndrome. Complications include post operative hypotony, ocular hypertension, cystoid macular edema, IOL dislocation and tilt, suprachoroidal and vitreous hemorrhage, and retinal detachment in patients with Marfan's syndrome.[6,7]

The CM-T flex is a novel lens introduced by Nivean *et al*.[8] It has a unique T-shaped haptic that provides a stop effect on the

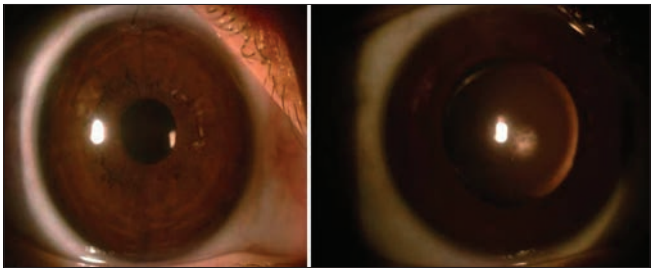


Figure 4: First month post operative picture

sclera and may prevent the slippage of the haptic in growing eyes. There is no need for suturing and haptic tuck, so less time consuming and less trauma to ocular tissue. This may provide a good IOL solution for pediatric eyes with ectopia lentis.

Madanagopalan *et al*.[9] managed 9 aphakic eyes with CM T flex IOL in adult patients. The study showed an improvement in visual acuity with no major complications.

This is the first case report of the use of CM T flex in a pediatric eye for ectopia lentis. The limitations of our case report are the lack of a concrete etiology for the ectopia lentis and the lack of long-term follow up. Future long-term studies that can compare the effect of scleral fixated and iris fixated IOLs with CM T flex can bring more light to the more appropriate solution for this complex etiology in children.

### Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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### Conflicts of interest

There are no conflicts of interest.

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Case Report

# Case report: A tale of weeping bleb


## ABSTRACT

An 82-year-old lady, with a known case of primary open-angle glaucoma who underwent trabeculectomy in both eyes ten years back, presented with left eye watering, visual acuity of counting fingers, a thin cystic bleb with a positive Seidel's test, shallow anterior chamber, intraocular pressure (IOP) of 2 mmHg, and vertical cup-to-disc ratio of 0.8 with 360-degree choroidal detachment. The patient underwent bleb revision with a scleral patch graft. At 1-week postoperative visit, visual acuity of 6/18 was achieved with a well-formed anterior chamber, IOP of 22 mmHg, and complete resolution of choroidal detachment.



**Keywords:** Bleb leak, hypotony, intraocular pressure, Seidel, trabeculectomy


## INTRODUCTION

Filtration surgery to control intraocular pressure (IOP) is well-established, safe, and effective and remains the gold-standard surgical procedure in glaucoma management.[1] Although the surgical outcome has greatly improved with the adjunctive usage of antimetabolites such as Mitomycin C (MMC) and 5-fluorouracil (5-FU), the incidence of late bleb leaks also increased along with other complications.[2] The use of antimetabolites and fornix-based incisions are notable risk factors for bleb leak.[3] Bleb leak resulting in hypotony is reported in 11%–17.6% of cases, most occurring soon after surgery.[4] Incidence of a late bleb leak in thin cystic and avascular blebs is 5.2% to 6%.[5] Late-onset bleb leaks occur from three months to years after surgery; the mean time reported was 27.9 months.[6]

## CASE REPORT

An 82-year-old lady diagnosed with primary open-angle glaucoma on antiglaucoma medications travoprost at night and betaxolol eyedrop two times a day, underwent trabeculectomy in both eyes, 10 years back elsewhere. Details on the use of any antimetabolite were unavailable to the patient. She presented with a sudden onset of continuous watering in her left eye for 1 week followed by a diminution of vision 5 days later. No history of trauma or eye rubbing was found. Left eye visual acuity was counting fingers at 2 meters. A slit-lamp examination of the same eye revealed a cystic bleb [Figure 1] with positive Seidel's test [Figure 2], shallow anterior chamber (AC), and posterior-chamber intraocular lens. On applanation tonometry, IOP was 2 mmHg. Fundus examination showed a vertical cup-to-disc ratio of 0.8 with 360-degree choroidal detachment.

The cause for epiphora in the left eye was attributed to the late onset leaking bleb for which a surgical bleb revision was performed. A fornix-based conjunctivo-tenon flap was dissected just behind the leaking bleb, and the flap was undermined. Debridement and then excision of the cystic and leaking conjunctiva were performed. Scleral flap underneath was intact with no thinning or buttonholing. A partial-thickness quadrangular donor scleral flap was anchored over the sclera with four 10-0 nylon sutures. Anterior chamber was reformed with saline through the side port. Conjunctiva was undermined, and advancement of the


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adjacent conjunctiva was performed. Watertight conjunctival closure was achieved with two 10-0 nylon sutures and a negative Seidel's test. Postoperatively the patient was started on antibiotic-steroid combination drop in the left eye in weekly tapering doses and homide three times a day for two weeks. At 1-week postoperative visit, best-corrected visual acuity dramatically improved to 6/18, with IOP of 22 mmHg, and a bleb with well-formed anterior chamber [Figure 3]. There was complete resolution of choroidal detachment. Travoprost and betaxolol eyedrops were restarted in the left eye as the IOP was raised. Until the last follow-up of 3 months, the patient is doing well with IOP of 16 mmHg on two antiglaucoma medications.

## DISCUSSION

A leaking filtration bleb is a common complication of trabeculectomy that can occur days, months, or years after the initial surgery.[7] The conjunctival tissue of a bleb can become thinned and cystic because of the constant flow of aqueous, and the thinnest and most avascular areas are most susceptible to developing a leak.[8]

Common signs of bleb leakage include a newly tearing eye, a decrease in vision, redness, or a drop in IOP from baseline. Suspect a bleb leak and perform a Seidel's test if a patient with cystic bleb presents with watering. The complications of leaking bleb include hypotony, shallow anterior chamber, hypotony maculopathy, choroidal detachment, cataract formation, epithelial downgrowth, chronic inflammation, and filtration bleb failure.[7] The dreaded consequences of late bleb leaks are blebitis and endophthalmitis.

Our patient had initial symptoms of watering which she attributed to allergy and medical help was sought when there was a drop in vision. A late leaking bleb diagnosis was made, and she was taken up for bleb revision in the operating room. Immediate identification and appropriate management of bleb leak in this case helped us salvage the eye from serious complications.

In a case series by Mandal *et al.*,[7] a known case of glaucoma, presented with pain, redness, and watering, 20 years after glaucoma filtration surgery. He was diagnosed to have a bleb infection with endophthalmitis from a bleb leak. He received intravitreal antibiotics after vitreous tap and underwent a sliding conjunctival-Tenon flap for revision of the fistula. Another case reported by Yalniz-Akkaya Z *et al.*[6] with postpenetrating keratoplasty and trabeculectomy presented with a diminution of vision, 7 years after the surgical procedure. A late bleb leak was diagnosed in this case and surgically treated with bleb revision.

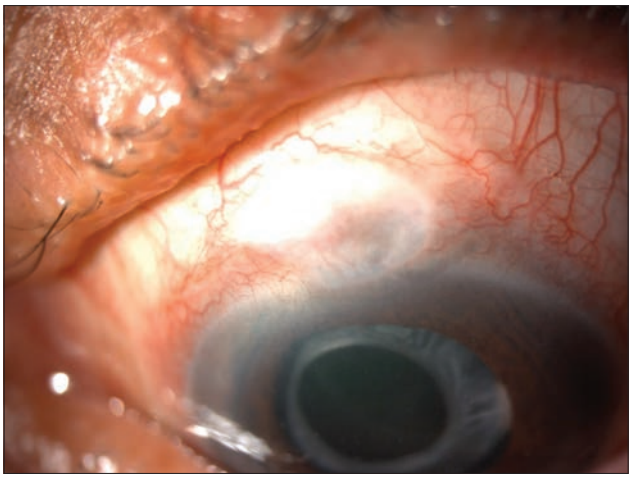


Figure 1: Cystic bleb with shallow AC

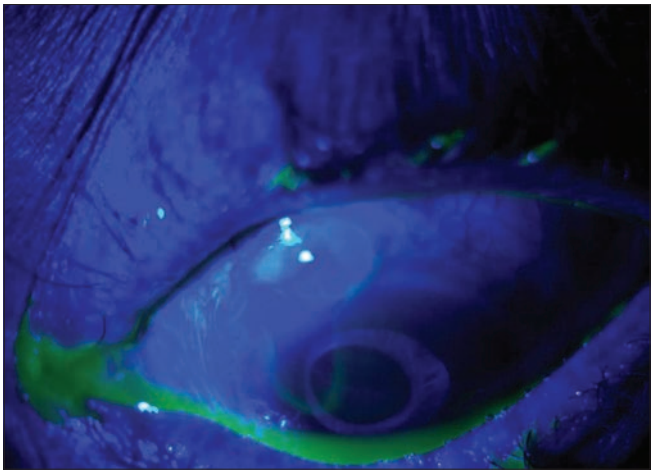


Figure 2: Positive Seidel's test viewed under cobalt blue filter

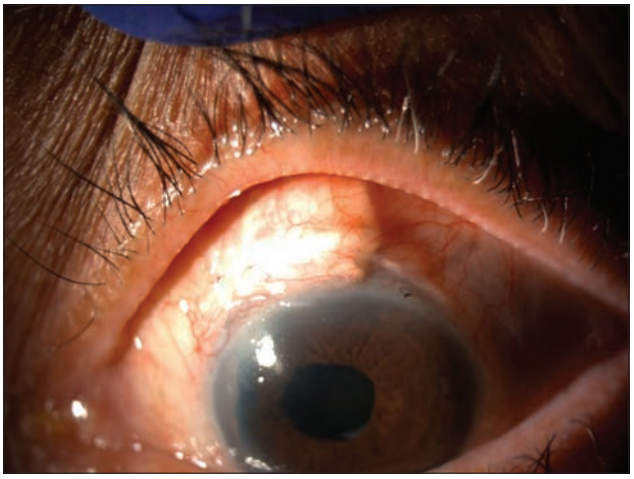


Figure 3: Postoperative picture showing bleb with scleral patch graft and well-formed anterior chamber

It is vital to identify the cause of hypotony, such as bleb leak or overfiltration, to address the underlying cause. Small leaks may close with conservative treatment such as observation with or without aqueous suppressants, patching,

and an ophthalmic antibiotic ointment. Other nonsurgical approaches include the placement of a bandage contact lens, a symblepharon ring, or a Simmons shell; cryotherapy; the administration of trichloroacetic acid; argon laser therapy with or without dye enhancement; the application of fibrin glue; and the injection of autologous blood.[6]

The advancement of conjunctival tissue from the adjacent conjunctiva or Tenon's layers and free conjunctival autografts are the two surgical techniques most frequently employed today.[9] Amniotic membrane grafts may be used in eyes with inadequate conjunctiva to advance. Autologous Tenon and partial-thickness scleral patch grafts have been found safe and effective for closing excessively draining fistulas. Bleb excision and repair of the scleral defect with a full-thickness scleral graft, followed by coverage with the advancement of a conjunctival flap or by a free conjunctival autograft, have also been useful for the treatment of leaks in association with full-thickness scleral defects.

## CONCLUSION

This case report highlights the importance of early diagnosis and appropriate management of late bleb leaks to prevent sight-threatening complications. It is important to educate the patient with a cystic bleb about the rare presentation of epiphora and to seek immediate medical help to prevent sight-threatening complications.

### Declaration of patient consent

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### Conflicts of interest

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Case Report

# An intriguing case of ocular sarcoidosis


## ABSTRACT

Sarcoidosis is a multisystem chronic noncaseating granulomatous disease with still unidentified conclusive etiology. Various structures within the eye as well as the adnexa can be affected by sarcoidosis. Treatment involves the use of systemic steroids and immunosuppressants. This case report shows a few peculiar findings that were seen in a patient with ocular sarcoidosis.



**Keywords:** Amyloidosis, sarcoidosis, type 1 diabetes mellitus


## INTRODUCTION

Sarcoidosis is a multiorgan inflammatory disease. Jonathan Hutchinson is credited with identifying the disease for the first time, wherein he observed certain peculiar skin lesions and named them as "Mortimer's malady." The first ocular manifestation of sarcoidosis was picked out by Heerfordt in 1909.

## CASE REPORT

A 35-year-old male, who was on insulin since the last 20 years for type 1 diabetes mellitus, was referred for a diabetic retinopathy screening. He was asymptomatic and had an uncorrected visual acuity of 6/6 in OU. Fundus examination disclosed moderate nonproliferative diabetic retinopathy (NPDR) changes (Modified Early Treatment of Diabetic Retinopathy—ETDRS Classification) in both eyes with no macular edema. He was advised regarding the importance of maintaining a tight metabolic control and educated on the schedule of his follow-up visits. However, he was lost to follow up.

Eight months later he presented to the casualty with complaints of sudden onset pain, photophobia, and defective vision in OU of one-day duration. On enquiry regarding his nonadherence to regular follow-up, he stated that he had adopted the ayurvedic line of management. In his current presentation, he did not have any other ocular or systemic issues. Examination revealed circumcorneal congestion, mutton fat keratic precipitates, and 1+ flare (Standardization of Uveitis Nomenclature SUN classification) in both eyes. 3+ cells were noted in OD and 1+ cells were noted in OS (SUN Classification) with the best corrected visual acuity of 6/60 in OD and 6/18 in OS [Figure 1]. An isolated thick broad-based posterior synechiae was noted at a 2'o clock position in the left eye [Figure 2]. Grade 2 vitritis (National Eye Institute Classification) was noted in the OD [Figure 3], while the media was clear in OS [Figure 4]. Minimal mid-peripheral venous sheathing was noted in the right eye fundus. Systemic examination was normal.

He was started on topical steroid (1% prednisolone acetate) and cycloplegic (2% homatropine hydrobromide) in both eyes and a uveitis workup was initiated. Positive findings were an elevated serum ACE level of 69.77 (Normal lab value of 8–52), high borderline serum calcium level of 10.56 (Normal lab value of 8.1–10.4), and bilateral hilar shadows on chest X-ray [Figure 5]. Mantoux and HLA-B27 were negative. HRCT


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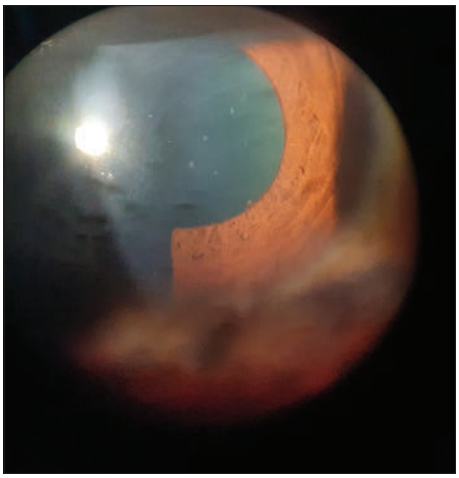


Figure 1: Right eye showing multiple large KP

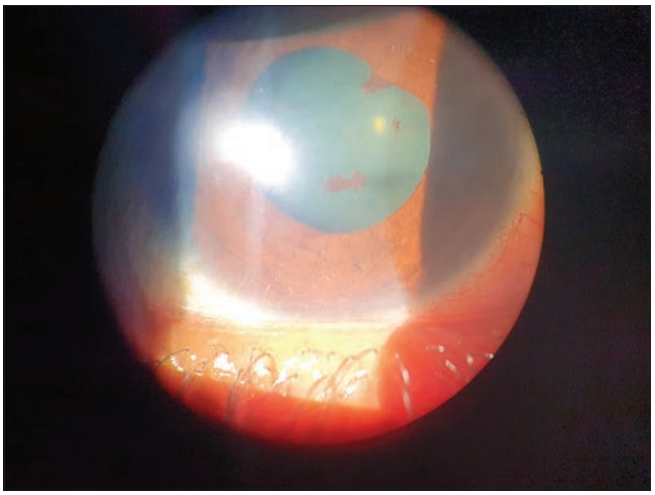


Figure 2: Left eye showing posterior synechiae at 2'o clock

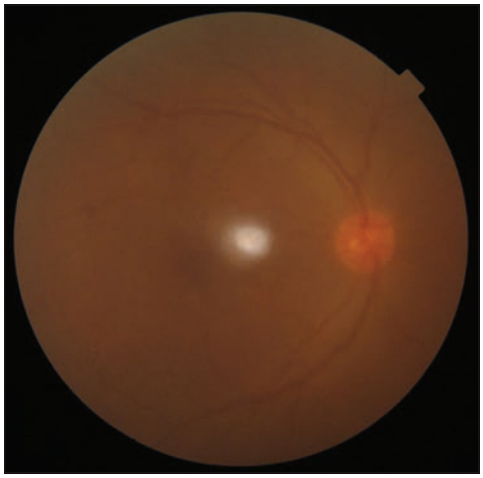


Figure 3: Right eye fundus showing grade 2 vitritis



Figure 4: Left eye fundus showing clear media

of the chest revealed multiple enlarged mediastinal and right hilar lymph nodes with no evidence of necrosis or calcification which was suggestive of pulmonary sarcoidosis. He was referred to a pulmonologist and was again lost to follow up.

Another eight months later, a chance encounter happened with the patient, wherein he disclosed the following.

He underwent an ultrasound-guided fine needle aspiration cytology of the right cervical level 4 lymph node, and the findings were small and mature lymphocytes with clusters of macrophages and no definite granuloma. A mediastinal lymph node biopsy was performed and the specimen showed features of granulomatous lymphadenitis with amyloid deposition.

Following the detection of amyloid, serum beta2-microglobulin levels were assessed and they were found to be elevated to a value of 4078 (Normal lab value of 609–2366). Due to the inconclusiveness of the obtained findings with the clinical picture, a repeat mediastinal lymph node biopsy was done at a different facility and the report stated amyloid lymphadenopathy with granulomatous reaction in the lymph node to the deposits of amyloid.

A repeat lab workup was performed, wherein his blood investigations showed a mildly impaired renal function with urine protein at 196 (Normal 0–150) and serum creatinine at 1.74 mg/dL (Normal 0.7–1.35 mg/dL). USG Abdomen showed normal kidney morphology and his serum complement C3 levels were 141. He subsequently underwent renal biopsy and the report showed findings suggestive of renal amyloidosis.

His case created a conundrum among the clinicians of different specialties treating him and they came to a consensus that it was a case of pulmonary and ocular sarcoidosis along with renal amyloidosis. He was started on mycophenolate mofetil 500 mg BD and has since been doing well with a quiet eye bilaterally and no relapse.

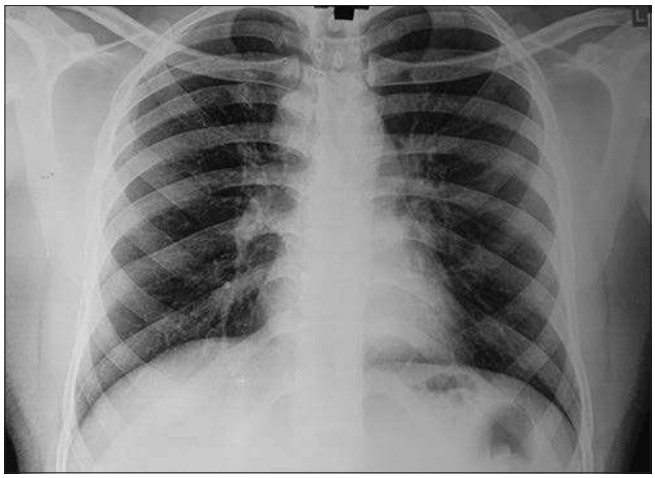


Figure 5: Chest X Ray showing bilateral hilar shadows

Table 1. Comparison of prevalence of autoimmune diseases (AID) detected in the two largest cohorts recently investigating the association between sarcoidosis and AID.

| Brito-Zeron *et al.* [94] AID | $n=1737$ Frequency | Wu *et al.* [95] AID | $n=1237$ Frequency |
|---|---|---|---|
| All associated AID | 283 (16.3%)[a] | All associated AID | 218 (17.6)[a] |
| Autoimmune thyroid disease | 94 (5.4%%) | Autoimmune thyroid disease | 143 (11.6)[a] |
| Sjogren's syndrome | 31 (1.7%)[a] | Sjogren's syndrome | 19 (1.54)[a] |
| Ankylosing spondylitis | 13 (0.74%)[a] | Ankylosing spondylitis | 45 (3.64)[a] |
| Systemic lupus erythematosus | 7 (0.4%)[a] | Systemic lupus erythematosus | 6 (0.49) |
| Myasthenia gravis | 1 (<0.1%) | Myasthenia gravis | 3 (0.24) |
| Systemic sclerosis | 8 (0.46%)[a] | Systemic sclerosis | 1 (0.08) |
| Psoriasis | 29 (1.67%) | Psoriasis | 12 (0.97) |
| Rheumatoid arthritis | 9 (0.52%) | Rheumatoid arthritis | 2 (0.16) |
| Inflammatory myopathies | 2[a] | Dermatomyositis | 2 (0.16) |
| Vitiligo | 3 (0.17%) | Vitiligo | 2 (0.16) |
| Alopecia aerata | c | Alopecia aerata | 5 (0.40) |
| DM type 1 | 10 (0.57%) | DM type 1 | 0 |
| Multiple sclerosis | 8 (0.46%)[a] | Multiple sclerosis | 0 |
| Primary biliary colangitis | 9 (0.52%)[a] | Primary biliary colangitis | c |
| Celiac disease | 7 (0.4%) | Celiac disease | 0 |
| Psoriasic arthritis | 5 (0.29%)[a] | Psoriasic arthritis | c |
| Antiphopsholipid syndrome | 6 (0.34%)[a] | Antiphopsholipid syndrome | c |
| Ulcerative colitis | 4 (0.23%) | Inflammatory bowel diseases | 0 |
| Autoimmune hepatitis | 3 (0.17%)[a] | Autoimmune hepatitis | 0 |
| CVID | 10 (0.57%)[a] | CVID | c |
| Immune thrombocytopenia[b] | 9 (0.52%)[a] | Immune thrombocytopenia | c |
| Haemolytic anaemia[b] | 3 (0.17%)[a] | Haemolytic anaemia | c |
| Familial Mediterranean Fever | 1 (<0.1%)[a] | Familial Mediterranean Fever | c |

[a]Increased compared to normative population/controls of the same study.
[b]Autoimmune cytopenia's are a classical feature of CVID, but the study does not specify if and in which percentage immune thrombocytopenia or haemolytic anaemia occurred in concomitance with a diagnosis of CVID.
[c]Not detected in cases and not investigated in control group.
0 = not detected in cases but investigated and eventually detected in control group.

## DISCUSSION

Sarcoidosis is a heterogeneous disorder affecting several tissues, although lungs and intrathoracic lymph nodes are the most common localizations of the disease.[1] A wide spectrum of variation in its proposed etiopathology, prevalence, clinical manifestations, course, and outcome have been documented. Consensus has been achieved on two fronts with respect to sarcoidosis, viz., the characteristic histological finding in sarcoidosis is noncaseating granulomas and its management involves the use of corticosteroids and immunomodulators.

This case report has some peculiar findings as described below.

(1) The highest incidence of sarcoidosis is reported in Northern European and African-American individuals, while Japanese populations are the least affected.[2] Our patient is thus representative of a rare disease entity reported from the Asian population.

(2) Type 1 DM is an autoimmune disease with autoantibodies generated against the islet cells of the pancreas. The association between sarcoidosis and autoimmune disorders has been described in several case reports and in large cohort studies.[3-5] Sarcoidosis, in itself, is now being classified as a specific autoimmune disorder, and hence, this association is not surprising as clustering is a classical feature of autoimmune diseases.[6] Two large cohort studies of similar sample sizes, but of Eastern and Western origin, have indicated that one in every six sarcoidosis patients presents an associated immune-mediated complication.[3,4] Type 1 Diabetes mellitus is an rare association of sarcoidosis.[1] The association between sarcoidosis and type 1 diabetes is indeed rare.[7]

(3) The combination of sarcoidosis and amyloidosis has been rarely reported[8-14] Proposed mechanism for the same is that the chronic inflammation caused by sarcoidosis induces a secondary amyloidosis.[10,11,13] However, a consensus is still not attained on the reason for this particular combination of diseases. Our patient is definitely a beholder of this rare combination—hardly ever been reported in published literature.

Two very rare diseases were seen in combination with sarcoidosis in this patient, viz., type 1 diabetes mellitus and amyloidosis. This case also shows how the eye acted as a window into the body—as both sarcoidosis and amyloidosis were brought to the forefront during the workup of this seemingly well and systemically asymptomatic gentleman which then enabled a timely intervention with immunomodulators and thereby a better quality of life.

### Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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### Conflicts of interest

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Case Report

# Takayasu arteritis, ocular ischemic syndrome, and neovascular glaucoma—A case report


## ABSTRACT

Takayasu arteritis (TA) is an idiopathic, autoimmune rare inflammatory granulomatous large vessel vasculitis affecting males more than females. Ocular involvement occurs in up to 45% of cases due to ocular hypoperfusion. The most common ocular manifestations are Takayasu retinopathy and neovascular glaucoma. Central retinal artery occlusion and anterior ischemic optic neuropathy are rare manifestations of TA. The mortality rate in ocular ischemic patients is quite high, secondary to cardiovascular disease (66%) and stroke. Herein, we are presenting a case of unilateral neovascular glaucoma, anterior ischemic optic neuropathy, and Takayasu retinopathy as a complication of TA.



**Keywords:** Anterior ischemic optic neuropathy, central retinal artery occlusion, neovascular glaucoma, ocular ischemic syndrome, Takayasu arteritis, Takayasu retinopathy


## INTRODUCTION

Takayasu arteritis (TA) is an idiopathic, autoimmune rare inflammatory granulomatous large vessel vasculitis mainly affecting the aorta and its major branches.[1] Ocular ischemic syndrome (OIS) is a rare sight-threatening condition of TA.[1] Herein, we are presenting a case of unilateral neovascular glaucoma (NVG), anterior ischemic optic neuropathy (AION), and Takayasu retinopathy (TR) as a complication of TA.

## CASE REPORT

A 55-year-old female presented to us with complaints of watering and redness in her right eye for three day's duration. She had mild ocular pain on ocular movements. There was no discharge, diplopia, or visual problems. For the last few months, she had mild-to-moderate temporal headache, vertigo, exertional dyspnea, claudication of her right leg, and episodes of memory loss. There was history of multiple joint pains, neck pain, jaw claudication, myalgia, and sudden obscuration of vision. She had no such previous episodes of red eyes. One year back, she had an episode of seizure disorder without any underlying cause identified and was on a tablet of sodium valproate. There were no other known systemic illnesses. On ophthalmological examination, her vision was 6/12, and intra-ocular pressure was 20 mmHg in both eyes. The pupillary reaction was sluggish in the right eye. Extra-ocular movements were full and associated with mild pain. On slit lamp examination, there was neovascularization of the iris (NVI) in the right with ectropion uveae [Figure 1a]. On the left, there was only ectropion uveae [Figure 1b]. Gonioscopicaly, there was angle neovascularization (NVA) in the right [Figure 1c], and the left was normal [Figure 1d]. There were no signs of uveitis and hyphema. A dilated examination revealed both eyes have immature cataracts. There was mild optic disc pallor with peripapillary splinter hemorrhages in the right, along with sclerosed retinal arteries and superficial hemorrhages [Figure 1e]. Left eye fundus examination was normal [Figure 1f].


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On general examination, her blood pressure was 100/70 mmHg in the right arm and 140/90 mmHg in the left arm. Her brachial and radial pulses of both arms were not appreciable. A bruit over the right subclavian artery was noticed. There were vasculitic skin lesions on the nose tip and cheeks [Figure 2a]. There was no cyanosis [Figure 2b] but mild pallor was present [Figure 2c]. There was moderate temporal artery tenderness on the right side. Her urgent blood sugar was 100 mg%, creatinine 2.5 and ESR was 20 mm/Hour. Color Doppler temporal artery showed thickened walls with classical Hallo sign suggestive of temporal arteritis in the right [Figure 3a], whereas there was near total occlusion of the right carotid artery [Figure 3b]. Electrocardiography (ECG) showed ischemic changes with arrhythmia [Figure 3c], and on echo-cardiography, there was hypokinesia. On angiography, there was a block of the left anterior descending coronary artery [Figure 3d]. A percutaneous coronary angioplasty (PCA) was performed and put on ecosprin, nitrocontin, atorvastatin, and ramipril tablets. Her investigations for rheumatoid factor, ANA factor, thyroid profile, homocysteine level, HLA B5, and lipid profile were normal. Her hemoglobin was 8.5 gm/dl. Because of recent cardiac surgery and high creatinine, fundus fluorescence angiography (FFA) was not performed. An intravitreal and intra-cameral Ranibizumab was given after taking high-risk consent. Topical steroids, homatropine, and brimonidine were added. After a month, she developed raised intra-ocular pressure in the right [36 mmHg] without regression of neovascularization. Topical dorzolamide and oral acetazolamide were added. Her left eye intra-ocular pressure was 20 mmHg and did not show any signs of neovascularization. After a while, she experienced severe arrhythmia and underwent cardiac pacemaker implantation. Before her next visit, we lost our patient because of cardiac death.

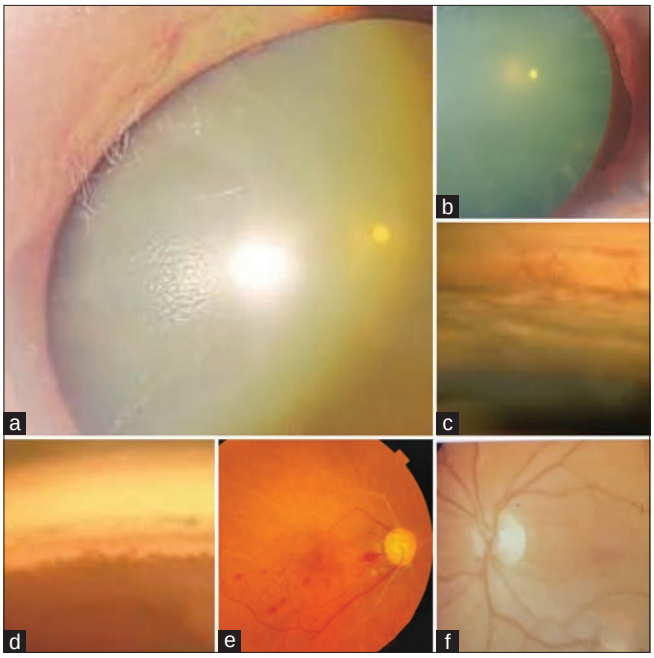



**Figure 1: Clinical presentation. (a) Iris neovascularization and ectropion uveae right eye. (b) Ectropion uveae left eye. (c) Angle neovascularization on gonioscopy right eye. (d) Normal angle on gonioscopy left eye. (e) Takayasu retinopathy with AION right eye. (f) Normal fundus left eye**

## DISCUSSION

TA affects males more than females with M:F ratio of 2:1 and ocular involvement occurs in up to 45% of cases due to ocular hypoperfusion.[2] Ocular ischemic syndrome may manifest as a decline in visual acuity and as ocular pain. The most common manifestations are Takayasu retinopathy (TR) and NVG. Central retinal artery occlusion (CRAO) and AION are rare manifestations of TA.[3] In our case, there were TR, NVG, and CRAO.

American College of Rheumatology has mentioned six criteria for the classification of TA. These six criteria were selected for the traditional format classification: onset at age less than or equal to 40 years, claudication of an extremity, decreased brachial artery pulse, greater than 10 mm Hg difference in systolic blood pressure between arms, a bruit over the subclavian arteries or the aorta, and arteriographic evidence of narrowing or occlusion of the entire aorta, its primary branches, or large arteries in the proximal upper or lower extremities. The presence of 3 or more of these six criteria demonstrated a sensitivity of 90.5% and a specificity of 97.8%.[1-3] During the late stages of the disease, patients often present with pulseless extremities, claudication, hypertension, Raynaud syndrome, aortic regurgitation, congestive heart failure, stroke, seizure disorder, and




**Figure 2: General examination. (a) Vasculitic lesion at tip of the nose. (b) No cyanosis. (c) Mild pallor clinically**

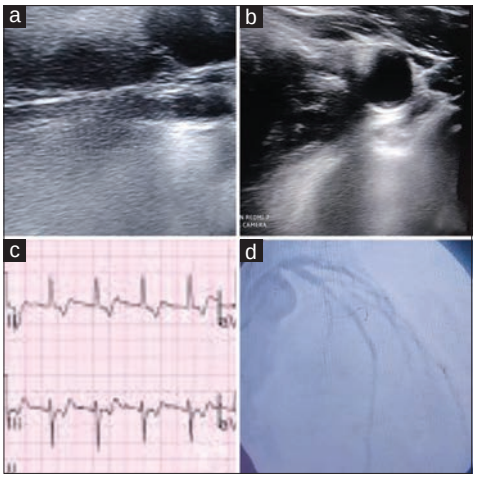



**Figure 3: Cardiological evaluation, (a) Color Doppler right temporal artery showing Hallo sign suggestive of temporal arteritis in the right, (b) Color Doppler right carotid artery showing near total occlusion, (c) ECG is showing ischemic changes with arrhythmia, (d) Cardiac angiography,showing a block of the left anterior descending coronary artery**

myocardial infarction. In our case, she had a seizure disorder, claudication, and coronary artery disease.[4] The mortality rate in ocular ischemic patients is quite high, secondary to cardiovascular disease (66%) and stroke.[5] Carotid artery imaging and fundus fluorescein angiography (FFA) are important investigations for establishing the diagnosis of ocular ischemic syndrome.[6] We did not perform FFA because of her recent coronary artery disease.

The primary goals in the management of active disease flares are suppressing inflammation with high doses of steroids or methotrexate with a low dose of aspirin and preserving the vasculature.[7,8] Invasive treatment procedures, including stent placement, bypass grafts, and angioplasty.[9] In our case, she had undergone PCA with subsequent pacemaker implantation.

Topical steroids are given to suppress the anterior segment inflammation and cycloplegics, to restrict the iris movements and thereby decrease chances of spontaneous hyphema.[7-9] We treated our case with cycloplegic, steroid, and anti-glaucoma drugs along with intravitreal and intra-cameral Ranibizumab after taking high-risk consent.[10] Before, we performed FFA, retinal laser, subsequent anti-VEGF, and glaucoma surgery on our next visit; we lost our patient because of cardiac death.

## CONCLUSION

Managing TA is a multi-disciplinary approach and examination of the pulse may be a clue in reaching the diagnosis.

### Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

### Financial support and sponsorship

Nil.

### Conflicts of interest

There are no conflicts of interest.

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Case Series

# Challenging equality of pupils: A case series of anisocoria during a current epidemic of viral conjunctivitis in India


## ABSTRACT

To report three cases of anisocoria during a current epidemic of conjunctivitis in India. Three healthy patients presented with bilateral red eyes amid the eye flu epidemic in India, with associated photophobia. On examination, they were detected to have anisocoria. The first case was found to have Holme's Adie syndrome with Adie's tonic pupil and absent deep tendon reflexes. The other two cases had anisocoria, but the light reaction was present in the affected pupil. Pharmacological testing with diluted 0.1% pilocarpine resulted in constriction of the larger pupil with no change in the normal pupil in all the three cases. Pupillography was utilized as a key tool to substantiate our findings. In all the three patients, the anisocoria decreased with the resolution of the conjunctivitis which reinforces the possible association. This case series highlights the importance of meticulous ocular examination even during an epidemic of eye flu, which would prevent prejudice of any preexisting or coexisting ocular findings.



**Keywords:** Anisocoria, conjunctivitis, eye flu, Holme's Adie syndrome, pilocarpine, pupillography


## INTRODUCTION

Anisocoria is a vital clinical cue that may be a harbinger of grave neurological conditions. However, it may also be physiological. The cut-off for anisocoria has been defined as ≥0.6 mm with its presence under all lighting conditions.[1] Adie's pupil is a rare neurological disorder characterized by enlargement of the pupil with poor reaction to light and light-near dissociation. It has a prevalence of 2/1000 cases and is usually a unilateral condition reported in women with a mean age of onset of 32.2 years.[2] It has occasionally been reported in patients with viral illnesses, Sjögren syndrome, Vogt–Koyanagi–Harada syndrome, and even as a sequalae to COVID-19.[3-5]

The influenza viruses have a unique trait that links it to conjunctivitis in human beings. The probable reason is its ability to acquire specific genetic compatibility, which is not necessarily unique to the H7 subtype.[6]


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## CASE REPORTS

### Case 1

A 47- year - old male, resident of Jorhat, Assam, India reported to the eye department amid the eye flu epidemic with complaints of redness in both eyes (BE) for two days. It was associated with early morning stickiness of eyelashes and watering. He also experienced photophobia in the left eye (LE). The patient gave a history of fever and headache of 2 days duration preceding the redness of eyes. He conveyed no prior history of any ocular surgery or trauma. Also had no known


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comorbidities. On examination at the initial presentation, uncorrected distance and near visual acuity was 6/6 and N6 BE. The anterior segment examination of BE revealed petechial hemorrhagic bulbar conjunctival congestion temporally [Figure 1a]. The light reaction of the pupil of the right eye (RE) was brisk and it was central, and circular. However, the LE was not reacting to light. The anisocoria was more appreciable in the scotopic as compared to photopic conditions [Figure 1b]. Pupillography (Sirius + Scheimpflug tomographer by CSO, Italy) was performed to quantify the change in pupil size in response to light. RE pupil showed a response to a change in light conditions, whereas the LE pupil showed no significant change [Figure 1c and d]. On pupillography, the RE pupil was 2.18 mm in size [Figure 1e] and the LE pupil was 3.86 mm in size with a very slight vermiform reaction after prolonged illumination [Figure 1f]. The patient did not have any lymph node enlargement. Ocular motility was full and free in all gazes. The reaction to accommodation was normal for BE. The rest of the anterior and posterior segments were within normal limits (WNL). Intraocular pressure by no-contact tonometer was 16 mm Hg in BE. The neurological examination revealed bilateral absent deep tendon reflexes (DTR). Pharmacological testing with diluted 0.1% pilocarpine revealed constriction of only the dilated pupil of LE and no change in the RE pupil, suggesting cholinergic hypersensitivity of LE [Figure 1g]. Based on the clinical findings and response to diluted pilocarpine diagnosis of Holme's Adie syndrome, secondary to viral conjunctivitis

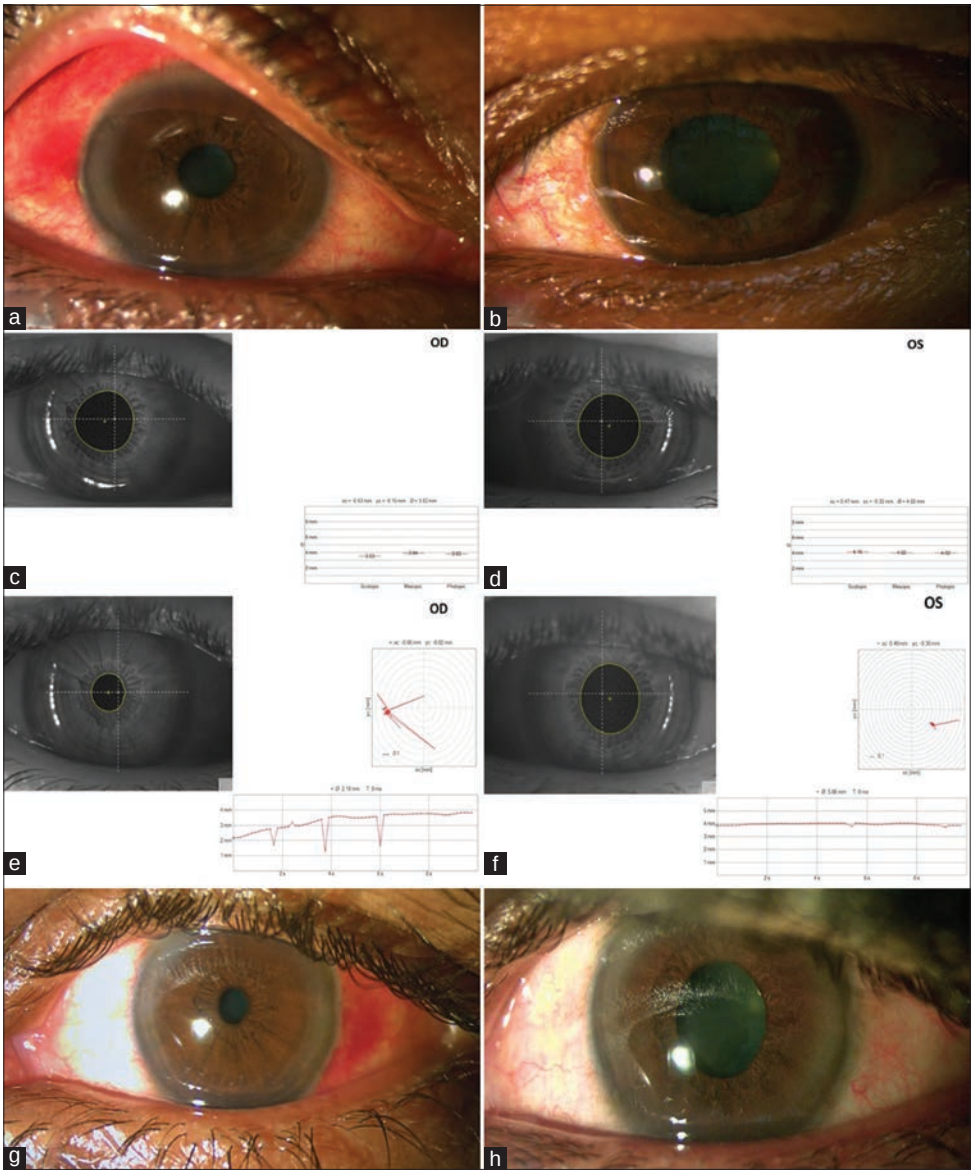



**Figure 1: (a and b) Petechial hemorrhagic conjunctival congestion noted temporally with anisocoria (LE pupil > RE pupil). (c and d) Pupillography revealing the anisocoria. (e and f) Dynamic pupillography denoting the pupil reactions of both eyes with LE>RE pupil and former not reacting to light with very slight vermiform reaction after prolonged illumination. (g) Cholinergic super sensitivity of the tonic LE pupil to diluted 0.1% pilocarpine. (h) Day 8 of follow-up – Relative decrease in LE pupil size with a decrease in conjunctival congestion**

was made which is the first such case. On day 8 of follow-up, the patient was symptomatically better with a decrease in conjunctival congestion and anisocoria noted to be relatively lesser [Figure 1h]. The absence of DTR was persistent.

### Case 2

A 30-year-old, female presented with bilateral red eyes for 2 days. It was associated with excessive watering BE, blurring of vision, and photophobia LE. This was preceded by fever with a headache of 2 days duration. On examination, her distance uncorrected visual acuity (UCVA) was 6/6 BE and near vision was N6 RE and N8 LE. Slit-lamp examination revealed bilateral diffuse bulbar conjunctival congestion and anisocoria (LE>RE) [Figure 2a and b]. The pupillary reflexes were normal except for the LE pupil reacting sluggishly to light. The anisocoria was better appreciated in light as compared to dark. Pupillography quantified the anisocoria with RE pupil measuring 4.79 mm and LE pupil 6.16 mm in mesopic light conditions [Figure 2c and d]. The patient did not have any lymph node enlargement. Ocular motility was full and free in all gazes. The reaction to accommodation was normal for BE. The rest of the anterior and posterior segments were WNL. The neurological examination was essentially normal. Pharmacological testing with diluted 0.1% pilocarpine revealed constriction of only the dilated pupil of LE and no change in the RE pupil. The anisocoria decreased on recovery from the conjunctivitis on day 14 of follow-up.

### Case 3

A 27-year-old, female presented with bilateral red eyes for 2 days. It was associated with photophobia RE. On examination, her distance UCVA was 6/6 BE and near vision was N6 BE. Slit-lamp examination revealed bilateral petechial sub conjunctival hemorrhage and anisocoria (RE>LE) [Figure 3a and b]. The pupillary reflexes were normal except for the RE pupil reacting sluggishly to light. The anisocoria was better appreciated in light as compared to dark. Pupillography quantified the anisocoria with the RE pupil measuring 6.83 mm and the LE pupil 5.98 mm in mesopic conditions [Figure 3c and d]. The patient did not have any lymph node enlargement. Ocular motility was full and free in all gazes. The reaction to accommodation was normal for BE. The rest of the anterior and posterior segments was WNL. The neurological examination was essentially normal. Pharmacological testing with diluted 0.1% pilocarpine revealed constriction of only the dilated pupil of RE and no change in the LE pupil. The anisocoria decreased on recovery from the conjunctivitis on day 12 of follow-up.

Written and Informed consent has been obtained from the patients for the publication of their demographic data and clinical pictures.

## DISCUSSION

Anisocoria is an important clinical cue for grave ocular as well as neurological conditions. Its detection and systematic approach toward determining its cause can navigate us through a multitude of causes to finally determine the underlying pathology or just help label its presence as a mere physiological condition. Anisocoria more appreciable in light could be due to Horner's syndrome, physiological or an Adie's pupil, also called tonic pupil. The latter was first reported by the British neurologist

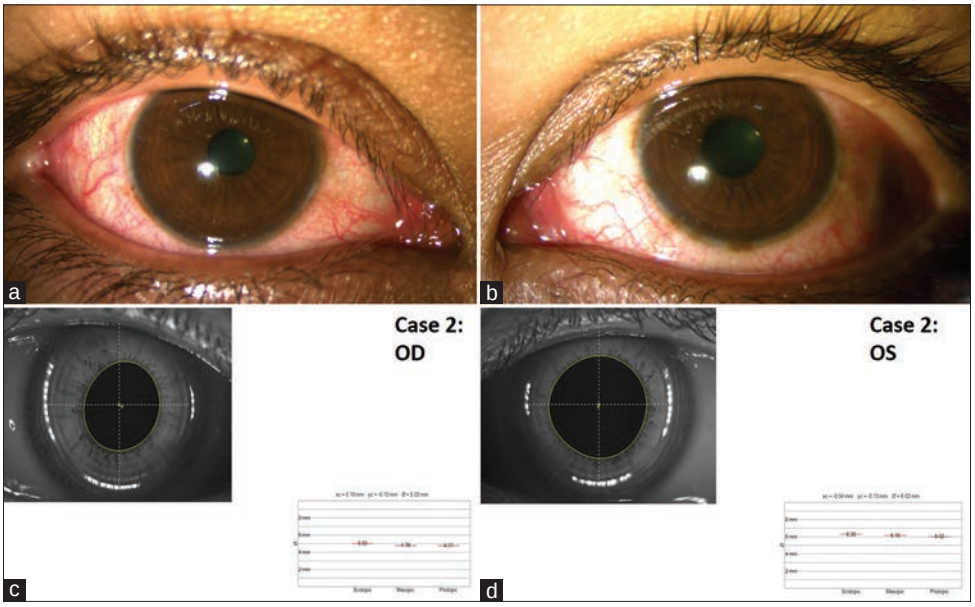



Figure 2: (a and b) Bilateral conjunctival congestion with anisocoria (LE>RE). (c and d) Pupillography quantifying anisocoria

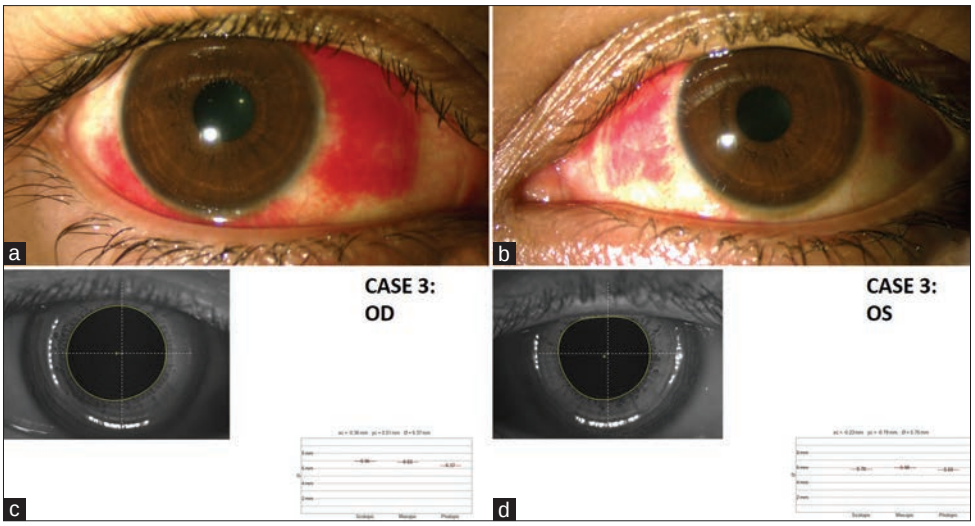



**Figure 3: (a and b) Bilateral petechial hemorrhagic conjunctival congestion with anisocoria (RE>LE). (c and d) Pupillography quantifying anisocoria**

William John Adie in 1931. Pathogenesis of Adie's pupil is complex; some lack corresponding specific diseases and are insidious. It manifests as a unilateral condition in 80% of cases with a female preponderance in the age group of 20–40 years.[7] The pupillary abnormality may be isolated or may be accompanied by the weakening or disappearance of deep reflexes known as Holme's Adie syndrome as in our first case. Additionally, when associated with segmental anhidrosis, it is known as Ross syndrome. The complexity of its pathogenesis often leads to difficulty in its identification and the possible-related diseases, by ophthalmologists and neurologists. It is caused by damage to the ciliary ganglion and its parasympathetic postganglionic fibers caused by viral and bacterial infection and is generally considered a peripheral neuropathy.[8] The much denser neuronal innervation to ciliary muscle as compared to the iris sphincter contributes to the light near dissociation. Hence, when the ciliary ganglion is damaged, fibers innervating the ciliary muscle have a greater chance of survival followed by aberrant regeneration of parasympathetic nerve fibers. Various etiologies have been described for Adie's pupil, namely, idiopathic which is the most common cause but may also occur secondary to ocular infections, tumors, paraneoplastic syndromes, autoimmune diseases, and trauma and may also be associated with systemic diseases with autonomic dysfunction.[5] All the possible causes were excluded in our patient before attributing the occurrence of Holme's Adie syndrome to viral conjunctivitis in our case 1. Also, the anisocoria is more evident under light conditions in Adie's pupil, but in this case, it was prominently noted under scotopic conditions which cannot be explained. In cases 2 and 3, there was no neurological association like the absence of DTR. Also, the reaction to light was sluggish and not delayed or vermiform as in case 1. The comparative pupillography in different light conditions reveals a difference of more than 1 mm in cases 2 and 3, also ruling out physiological anisocoria [Table 1]. In case 1, though the pupil size difference is not more than 1 mm, the reaction and other clinical signs suggest it to be a component of Holme's Adie syndrome. Nonetheless, the response to 0.1% pilocarpine was surprisingly similar in all the three cases with increased constriction of the larger pupil and no response of the normal pupil. The pupillary abnormalities and ophthalmic symptoms if any usually disappear after treatment of the primary disease. The relative decrease in anisocoria with a decrease in conjunctival congestion in all our cases reinforces this statement. All possible primary diseases must be ruled out before giving a diagnosis of Idiopathic Adie's.[9] Within 5–7 days of denervation, cholinergic super sensitivity of the tonic pupil to diluted 0.1% pilocarpine begins. If the iris sphincter has cholinergic super sensitivity, the larger pupil (tonic pupil) becomes smaller than the normal pupil with no effect on the latter, 30–45 min after instillation of the dilute pilocarpine. Dilute pilocarpine is prepared by mixing 0.1 mL of 1% pilocarpine with 0.9 mL of sterile saline in a 1 mL tuberculin syringe. Pilocarpine has both diagnostic and therapeutic roles, the latter by relieving symptoms of blurred vision. In our cases, it primarily aided in diagnosis and we chose not to continue the patients on the same as pilocarpine is proinflammatory and could have delayed the resolution of conjunctivitis. Even amid a sharp rise in eye flu cases when every case of red eye may be disposed of as conjunctivitis, meticulous ocular evaluation prevents missed diagnosis and misdiagnosis. This is the first case series of anisocoria secondary to viral conjunctivitis, including Holme's Adie syndrome highlighting that an epidemic of eye flu should not prejudice the treating ophthalmologist of any pre-existing or coexisting ocular findings.

**Table 1: Comparative pupillography quantifying anisocoria under varied light conditions**

| Eye | Case 1(mm) | | | Case 2(mm) | | | Case 3(mm) | | |
|---|---|---|---|---|---|---|---|---|---|
| | S | M | P | S | M | P | S | M | P |
| RE | 3.53 | 3.94 | 3.83 | 5.03 | 4.79 | 4.77 | 6.96 | 6.83 | 6.37 |
| LE | 4.16 | 4.02 | 4.02 | 6.30 | 6.16 | 6.02 | 5.78 | 5.98 | 5.69 |

S=Scotopic. M=Mesopic. P=Photopic

## Statement of ethics

Hospital ethical committee approval was taken on 02-Oct-2023.

## Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

## Financial support and sponsorship

Nil.

## Conflicts of interest

There are no conflicts of interest.

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Case Series

# Orbital myocysticercosis: A case series


## ABSTRACT

Ocular dissemination of cysticercus cellulosae is a well known disease entity, but orbital cysticercosis (OCC) is a rare presentation. OCC has varied presentations, which may pose a diagnostic challenge to health professionals. We present four cases of OCC which presented with ptosis and orbital cellulitis, one of which had neurocysticercosis (case 4) in a tertiary care hospital in Kolkata. Our clinical diagnosis was confirmed on orbital imaging. All the cases were managed conservatively with albendazole and systemic steroids. Cysticercosis resolved with significant improvement of symptoms in all the cases, except one, where residual ptosis was present. Early diagnosis and timely management can prevent blindness and optimize visual outcomes.



**Keywords:** Blindness, orbital cysticercosis, ptosis


## INTRODUCTION

Cysticercosis, a parasitic infestation, involving extraocular and intraocular contents, is a preventable cause of blindness if diagnosed at the right time. It is an endemic in India.[1] It is a caused by Cysticercus cellulosae, a larval form of Taenia solium. In 1829, the first case was detected by Soemmering.[2] It is recognized as major health issue worldwide by World Health Organization. Neurocysticercosis is an important cause of epilepsy.[3] It tends to affect children and young adults with no sex predilection.[4,5]

### Case 1

A 7 year boy presented with fever, painful swelling, and pain on eye movement in the left eye since 5 days. His best corrected visual acuity (BCVA) right eye (OD) was 6/6 and left eye (OS) was 6/9. Clinical examination of the left eye revealed mild nonaxial proptosis (downward and outward) with mild adduction deficit [Figure 1a]. Left eye showed lid edema and conjunctival congestion. On palpation, a firm, ill-defined nonpulsatile mass with mild tenderness in the supero-nasal quadrant of left eye was noted [Figure 1b]. Ultrasound B-scan showed a well-defined cystic lesion with clear contents with a hyperechoic area suggestive of a scolex [Figure 1c]. Computed tomography (CT) scan brain and orbit showed a small, nonenhancing, well-defined, hypodense lesion in the medial rectus muscle of left orbit with thickening of the muscle [Figure 1d].

The child was diagnosed with orbital myocysticercosis, and he was treated with oral steroid 1.5 mg per kg body weight tapered over a month along with tablet Albendazole 15 mg per kg body weight for 1 month. At his follow-up visit, there was reduction in proptosis and the mass resolved and extraocular movements also improved [Figure 1e].

### Case 2

A 22-year-old adult presented with redness, ptosis, and pain with swelling of upper eyelid of the right eye since 2 weeks. His BCVA was 6/18 OD and 6/6 OS [Figure 2a]. Clinical examination of the right eye revealed upper eyelid


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edema and severe conjunctival congestion. Posterior segment examination showed a cystlike formation in the macula [Figure 2b]. Magnetic resonance imaging (MRI) scan showed involvement of the right medial rectus with the lesion abutting the globe posteriorly [Figure 2c].

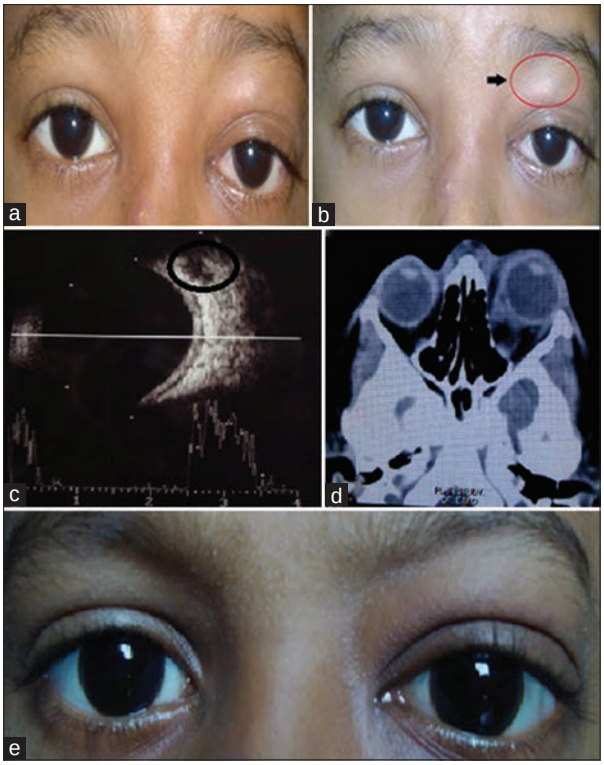



**Figure 1: (a) Mild proptosis in left eye; (b) firm nonpulsatile palpable mass. (c) Ultrasound B-scan showing cystic lesion with hyperechoic areas suggestive of scolex. (d) Axial view of CT scan shows small nonenhancing well-defined, hypodense lesion in medial rectus muscle. (e) Post-treatment clinical picture**

Treatment was started with oral steroid 1.5 mg per kg bodyweight tapered over a month along with tablet Albendazole 15mg per kg body weight for a month. At his follow-up visit, the conjunctiva was clear and the mass in the fundus had resolved.

## Case 3

A 13-year boy presented with restriction of upward movement in left eye and upper eyelid swelling since 1 week. His BCVA was 6/18 OS and 6/6 OD. Clinical examination of left eye showed restricted elevation with upper lid edema. Rest of the examination was within normal limits [Figure 3a]. CT scan revealed ring enhancing lesion with surrounding calcification in the superior rectus, suggestive of cysticercosis [Figure 3b and c]. Oral steroid was started with 1.5 mg per kg body weight, followed by tablet Albendazole 400 mg twice daily for 28 days. At his follow-up visit, the extraocular movements were full and free in all directions and lid edema had resolved.

## Case 4

A 13-year-old girl presented with inability to open the right eyelid for the last 1 month with history of pain, swelling, and bulging of the right eye, which was reduced partially with analgesics [Figure 4a]. On examination, there was ptosis of right eye and restricted elevation. Ultrasound showed a well-defined scolex [Figure 4b]. MRI showed thickened superior rectus muscle [Figure 4c]. CT imaging showed multiple scattered hyperintense lesions, suggestive of neurocysticercosis [Figure 4d]. The patient was treated with oral steroid and albendazole. After treatment, patient symptoms improved and ptosis resolved spontaneously after 4 months of treatment.

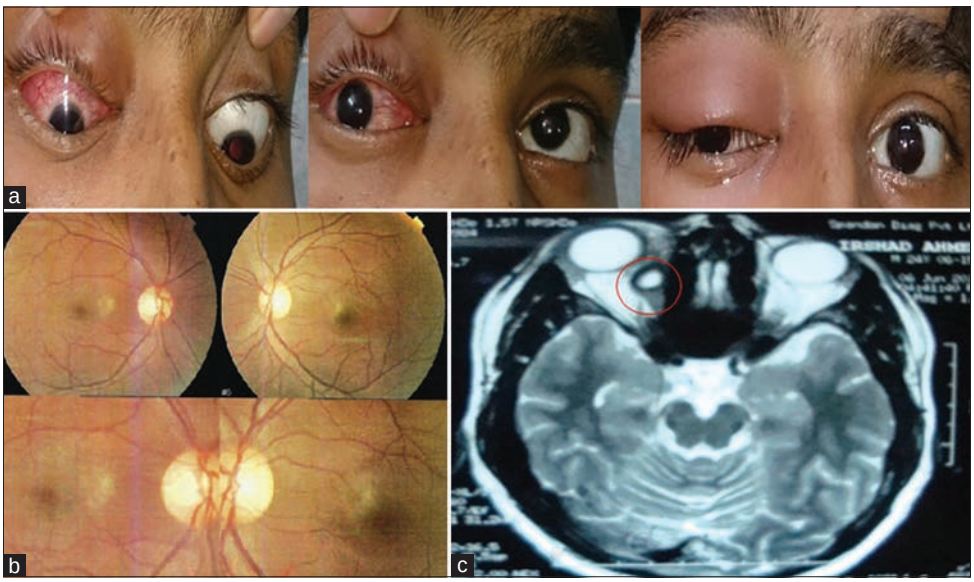



**Figure 2: (a) (from top) Severe conjunctival congestion, movement restriction of right eye, and right eye ptosis. (b) Fundus photography. (c) T2-gated noncontrast-enhanced magnetic resonance tomography scan shows right medial rectus involvement**




Figure 3: (a) Eye lid swelling with upward movement restriction. (b) Axial section of contrast-enhanced CT scan shows ring enhancing lesion with muscle infiltration and thickening. (c) Axial section of contrast-enhanced CT scan with the better view of the lesion

## DISCUSSION

Ocular dissemination of cysticercus cellulosae is a well-known entity. Sommering[2] first reported a case of ocular cysticercosis in 1980. In the eye, the most common site for cysticerus cellulosae is vitreous and the subretinal spaces,[4-9] followed by orbit and adnexal tissues. Ocular involvement is usually unilateral, but bilateral involvement may occur in cases of disseminated cysticercosis. Left eye is more commonly involved compared to the right, possibly because larvae may be preferentially routed to the left internal carotid artery, which directly originates from the aorta. The extraocular muscle is the commonest site of orbital and adnexal cysticercosis.[10-13] Cysts can be detected in the subconjunctival space, which is another common site, followed by the eyelid, optic nerve, retro-orbital space, and lacrimal gland.[14-18] The clinical manifestations of orbital or adnexal cysticercosis are entirely different and depend on the location, size, relation to the adjacent structures, and the stage of evolution of the cyst.

Cysticercosis of extraocular muscles usually presents as recurrent pain, redness, proptosis, ocular motility restriction, diplopia, and ptosis. In some cases, optic nerve compression by the cyst may cause decreased vision, disc edema, and painful ocular movements. An enlarging cyst may lead to axial proptosis or restricted ocular motility or may even present as atypical optic neuritis. Two different studies on myocysticercosis reveal inferior rectus and medial rectus as the commonest muscles to get affected.[8,9] The problem is common in children because of their unhygienic habits.

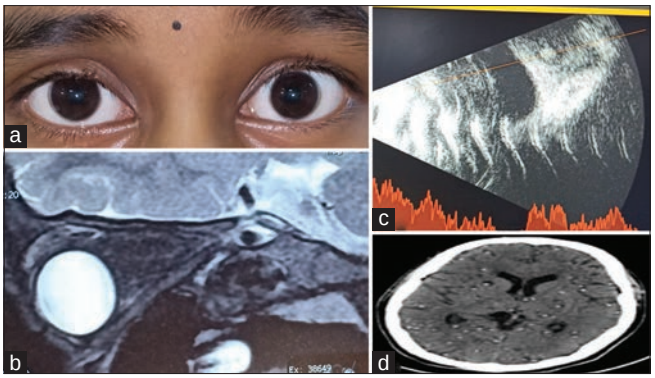



Figure 4: (a) Clinical picture showing mild ptosis of right eye after treatment. (b) Ultrasound B-scan showed hyperechoic well-defined cyst wall with scolex. (c) Sagittal section of T2-gated MRI showed thickened superior rectus muscle. (d) Axial section of contrast-enhanced CT scan shows neurocysticercosis

In our case series, patients presented with fever, unilateral proptosis, pain on eye movements, restriction of eye movements, ptosis, swelling of eyelid, and decreased vision of recent onset. All cases responded well with early diagnosis and prompt treatment.[19-22]

Diagnosis of cysticercosis is based mainly on orbital imaging because of its specific appearance.[8] Tissue diagnosis is not essential for initiating treatment. Serial B-scan ocular tissue or CT scan of the orbit helps to follow the resolution of the cyst by the disappearance of the scolex. It is important to have CT scan of the brain done to rule out cysts in the brain before starting cysticidal drugs. In patients with associated cysticercosis of the brain, the patient should be hospitalized and the cysticidal drug administration should be under neurological supervision as these agents can provoke severe anaphylactic reaction.[19-21] One of our cases had neurocysticercosis; treatment was the same, but the opinion of neuromedicine was sought, and during the initial treatment phase, the patient was hospitalized for 1 week for monitoring.

Medical therapy with albendazole and oral steroid is recommended for the extraocular muscle form and retro orbital cysticercosis, where dramatic improvement has been reported.[21-23] In our study, all the cases have responded actively with albendazole and oral steroid given for a period of 1 month.

Surgical removal is advocated for the subconjunctival and eyelid cysticercosis. Because of the limited number of cases with optic nerve and lacrimal gland cysticercosis, their treatment is controversial. Surgical intervention was not required in the treatment in our case series.

## CONCLUSION

In the cases we encountered, we have found varied clinical presentations and all the cases had responded well with medical therapy. It is very crucial that prompt diagnosis with clinical suspicion and imaging guarantees a good visual outcome.

### Acknowledgement

We have published this article in name unregistered state journal 2 years ago.

### Ethical Approval

Approval from the ethic committee was obtained. The study was discussed in ethical committee meeting and permission obtained on 12th February , 2023.

### Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient (s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Nil.

### Conflicts of interest

There are no conflicts of interest.

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# Artificial intelligence in ophthalmic electronic medical records, health records, and registries


## ABSTRACT

The integration of electronic health records (EHRs) and electronic medical records (EMRs) is fundamentally transforming ophthalmology by generating vast amounts of clinical data. This shift, coupled with the advancements in Big Data analytics and artificial intelligence (AI), is enhancing patient care, optimizing treatment strategies, and streamlining healthcare delivery. Beyond evaluating imaging and numerical data, AI can be seamlessly integrated into EMRs and EHRs, creating unprecedented opportunities for research, improved clinical decision-making, and advanced patient management. While EMRs represent digital charts within a single institution, EHRs offer a broader, longitudinal collection of patient information from multiple providers, forming the essential foundation for "big data" initiatives such as ophthalmic registries. The transition to a paperless healthcare future, driven by EMRs, offers significant benefits by eliminating inefficient paper-based processes and providing instant access to vital patient information at the point of care, thereby enhancing patient safety and facilitating informed decisions. The article explores the evolving landscape of ophthalmic data, highlighting the crucial role of natural language processing in extracting insights from unstructured text within EHRs, and the application of supervised machine learning and deep learning for disease diagnosis, risk assessment, and treatment planning. It details various prominent global ophthalmic registries that serve as "big data" repositories, and reviews numerous studies demonstrating AI's effectiveness in predicting ocular diseases, triaging patients, and informing Clinical Decision Support Systems. This synergy of digital records, big data, and AI promises a future of more precise, proactive, and collaborative ophthalmic care.


**Keywords:** AI, CDSS, EMR, EHR, ML, NLP, ophthalmic registries

## INTRODUCTION

The landscape of modern ophthalmology is being significantly reshaped by the widespread adoption of electronic health records (EHRs) and electronic medical records (EMRs), which have led to the collection of massive amounts of clinical data. Big data and artificial intelligence (AI) are profoundly transforming patient care and research in ophthalmology by enabling unprecedented data analysis, enhancing diagnostic and predictive capabilities, optimizing treatment, and streamlining various aspects of healthcare delivery. In addition to evaluation of imaging and numerical data from various ophthalmic equipment, AI can also be integrated into our EMRs and EHRs, creating unprecedented opportunities for research, clinical decision-making, and patient management through the application of AI. The difference between EMR and EHR is that EMR refers to a digital version of a patient's chart within a single hospital, whereas EHR is a broader term that implies more comprehensive and longitudinal collection of a patient's health information from multiple healthcare providers, serving as the foundation for "big data" initiatives like the Ophthalmic Registries.[1]


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## THE INEVITABLE ELECTRONIC MEDICAL RECORD REVOLUTION: TOWARDS A PAPERLESS HEALTHCARE FUTURE

The cumbersome stacks of paper patient charts, once the backbone of every healthcare institution, are rapidly becoming a relic of the past, increasingly replaced by the efficiency and accessibility of EMRs. This digital transformation streamlines every facet of patient care, from registration and scheduling to diagnosis, treatment, and billing. Medical Records Departments (MRD) will no longer be full of dusty shelves of yellowing papers, but the electronic hum of sleek computer servers. No longer will clinicians waste precious minutes sifting through physical folders, battling illegible handwriting, or waiting for a chart to be retrieved from a labyrinthine MRD. With EMRs, vital patient information is instantly available at the point of care, enabling faster, more informed decisions, enhancing patient safety, and fostering a truly interconnected and responsive healthcare ecosystem. Though there may indeed be an initial slowdown of physician workflow when switching from a routine paper charting to a new electronic record system, it is temporary, and Gali *et al*. have shown that time spent per patient and time spent on documentation is not significantly different for either. Of course, percentage of time spent on documentation increased with early EHR use, but improved subsequently.[2]

To solve the cost problem, a few Free and Open Source Software Ophthalmic EMRs are available, including OpenEyes and OpenEMR, which can help smaller and cost-conscious practices easily transition from paper charts to electronic case records. Some EMRs now have voice to text features and some under development have AI features that can listen to the live history-taking interaction between the patient and the healthcare provider (ophthalmologist or optometrist) and automatically detect keywords to fill in symptoms and their duration along with other relevant history. Atleast one of these EMRs can reportedly translate seamlessly from a Malayalam history-taking interaction into English medical terminology in a structured format in the case record. This is of course followed by the ophthalmologist dictating examination findings, while visualizing through the slitlamp, 90D lens, indirect ophthalmoscope or other tests such as extraocular movements or ptosis measurements. This would be akin to having a virtual ophthalmic scribe, or Jonathan, as Dr Glaucomflecken (Dr William E. Flanary, M.D) would like to call it [Figure 1].[3] Further, the AI may automatically think about possible diagnosis with each additional piece of new information, and suggest relevant history questions and examination findings to look for, before suggesting the final diagnosis and differential diagnosis.



**Figure 1: AI generated image of Dr Glaucomflecken examining a patient while ophthalmic scribe Jonathan enters the data into an EMR. Primary image generated using Google Gemini (https://gemini.google.com/) and faceswapped with Dr Glaucomflecken and Jonathan images using AI FaceSwap (https://aifaceswap.io/). Prompt used "An ophthalmologist's office with Dr. Glaucomflecken examining a patient at a slit lamp, while his scribe Jonathan is in the background typing into a computer. Jonathan in blue scrubs." EMR = Electronic medical record, AI = Artificial intelligence**

## THE EVOLVING LANDSCAPE OF OPHTHALMIC DATA

EHRs contain a diverse range of patient data, including demographics, diagnoses, laboratory test results, prescriptions, detailed eye examination findings, imaging, and surgical records. EHRs are inevitable, but have their pros and cons.[4] While EHRs provide a rich source of information, a significant challenge lies in the fact that up to 80% of this data exists as unstructured free-text from clinical notes. This unstructured nature historically hindered effective analysis and secondary use of the data. The complexity and heterogeneity of EHR data necessitate advanced strategies like AI to extract meaningful insights. AI techniques, particularly machine learning (ML), deep learning (DL), and natural language processing (NLP), are crucial for interpreting these multimodal datasets.

## NATURAL LANGUAGE PROCESSING

NLP is a subfield of AI specifically designed to extract and process text data, including written and spoken words.[5] It is vital for unlocking the vast amount of information contained within unstructured free-text clinical notes. Newer Ophthalmic EMRs use a lot of structured data, and critical information such as visual acuity, intra ocular pressure (IOP), and even examination findings mentioned in structured fields, but there are still instances where unstructured text is used, for example, in plan of care. NLP can be used for tasks such as[5]:

- Text extraction: Retrieving specific parameters like visual acuity, demographic data, intraocular pressure, and other clinical information

- Named entity recognition: Identifying crucial entities like disease names, treatment plans, and drug dosages from medical records, even handling specialized ophthalmic vocabulary
- Predictive modeling: Incorporating free-text data into AI models to improve predictive performance. For example, DL models incorporating free-text data have outperformed those using only structured inputs in predicting glaucoma progression requiring surgery
- Summarization and question-answering: Future applications of NLP may include developing search engines for data within notes, cleaning notes, and automated question-answering systems.

## SUPERVISED MACHINE LEARNING AND DEEP LEARNING

These AI techniques are widely applied to EHR data for various clinical purposes. Commonly used algorithms include random forest, logistic regression, support vector machines, gradient boosting, Least Absolute Shrinkage and Selection Operator, AdaBoost, and classification and regression tree. SL, a subset of ML based on artificial neural networks, further extends these capabilities with techniques like convolutional neural networks. They can be used for:

- Disease diagnosis and screening: AI models trained on EHR data improve the diagnosis of ocular diseases such as glaucoma, diabetic retinopathy (DR), age-related macular degeneration (AMD), and cataracts. They can efficiently screen large populations and assist with early detection
- Risk Assessment and progression prediction: AI can predict the need for surgical intervention in glaucoma, identify risk factors for cataract surgery complications, and assess DR risk among diabetic patients. Such predictions enable clinicians to tailor treatments and prevent irreversible vision loss
- Clinical management and treatment planning: AI aids in improving intraocular lens power calculations for cataract surgery and can support personalized treatment plans
- Patient triage and referral: AI models can identify and triage at-risk patients from primary care physicians (PCPs) for referral to eye care specialists, using commonly collected data in EHRs.

## BIG DATA OPHTHALMIC REGISTRIES

Ophthalmology generates a large volume of data – images, scans, topography maps, field tests, refraction, IOP values, and much more. The economics of big data explores how the massive (high volume), diverse (high variety), and fast-moving (high velocity) datasets can be leveraged to create economic value.[6] There are several key ophthalmic registries and large datasets that are crucial for leveraging AI in eye care [Table 1][7]:

### Intelligent Research in Sight Registry - American Academy of Ophthalmology, USA

It is recognized as the world's largest specialty clinical data registry. Collects de-identified data from a vast number of ophthalmologists across the United States, including patient demographics, medical and ocular history, clinical examination findings, diagnoses, procedures, and medications.

### European Registry of Quality Outcomes for Cataract and Refractive Surgery

This is a prominent multinational registry, primarily focused on cataract and refractive surgery, with participation from numerous European countries and Australia. It aims to improve the quality of cataract and refractive surgery by collecting data on patient outcomes and surgical techniques.

### Save Sight Registries (Australia)

"Save Sight Registries" in Australia encompasses a range of disease-specific registries, such as the Save Sight Dry Eye Registry and the Fight Retinal Blindness! registry. Focuses on efficiently capturing high-quality real-world data for specific eye conditions, contributing to a better understanding of disease progression and treatment effectiveness.

### International vitreoretinal B-Cell lymphoma registry

Ophthalmologists across the globe contribute to the International vitreoretinal B-cell lymphoma Registry by lodging retrospectively collected, management-focused data without patient identifiers via a secure online platform.

### European Reference Network for Rare Eye Diseases

European Reference Network for Rare Eye Diseases (REDs) connects healthcare providers and patient organizations across Europe to facilitate diagnosis and treatment of REDs. As part of this, various registries exist for specific rare conditions, such as the EYERD Registry. These networks emphasize international collaboration for conditions that are less common, pooling data to gain significant insights.

### National and regional registries (various countries)

Many countries have their own national or regional ophthalmic registries, often focusing on specific diseases or procedures. Examples include:

- Swedish National Cataract Register: One of the earliest and most influential national registries for cataract surgery outcomes

**Table 1: List of existing Rare Eye Disease registries (credits to Sharma *et al*. and AAO for the list and information under Creative Commons Attribution-Non Commercial-Share A like 4.0 License)[11]**

| Registry | Coverage | Country |
|---|---|---|
| Columbian National Registry for Rare diseases | National | Columbia |
| Bone cone monochromatism- Patient registry | International | Germany |
| National Registry for Mycotic Keratitis | National | Germany |
| Patient registry for retinal degeneration PRO RETINA | National | Germany |
| ReTDis database: clinical descriptions of patients and families with inherited eye diseases | International | Germany |
| Neuromyelitis Optica | National | Germany |
| Myasthenia Gravis Registry | National | Spain |
| Spanish patient registry of hereditary retinal dystrophy | National | Spain |
| Behcet's Disease Registry | National | Spain |
| The Finnish Register of visual impairment | National | Finland |
| Cohort of patients with hereditary dystrophies of Retina | National | France |
| REDgistry: An interoperable sustainable European Rare Eye Disease Registry | Europe | France |
| Establishment of children and adolescent cohort in Behcet's disease in France | National | France |
| French cohort creation in retinitis pigmentosa | National | France |
| French patient registry in chorioretinopathy, birdshot type | National | France |
| French registry of patients affect by Leber amaurosis and retinitis pigmentosa to assess the clinical trial in gene therapy | National | France |
| National cohort on inherited retinal dystrophies | National | France |
| Behcet's disease registry | National | Italy |
| Italian Retinoblastoma Registry | National | Italy |
| ERN-EYE disease | Europe | 26 European countries |
| United Kingdom Neuromyelitis Optica | National | United Kingdom |
| Myasthenia Gravis Patient Registry | National | USA |
| Blue cone Monochromatism Families Foundation | International | USA |
| Curing Retinal Blindness Foundation | International | Africa |
| Fighting Blindness Canada Patient Registry | National | Canada |
| Retinoblastoma Registry | National | Kuala Lumpur |

- Korean registries: Korean Ophthalmological Society (KOS) maintains a registry of ophthalmic data, with a focus on clinical and experimental studies in all fields of ophthalmology and visual science. The Korean Journal of Ophthalmology (KJO) is their official English journal and publishes research from the registry and other submissions
- German Registries: Several registries in Germany focus on conditions like mycotic keratitis, neuromyelitis optica, and retinal degeneration (e.g. PRO RETINA)
- Spanish Registries: Examples include registries for hereditary retinal dystrophy and Behcet's Disease
- A list of existing RED registries worldwide is shown in Table 1.

## Indian Ophthalmic Registries

Initiatives like Ophthatome™ in India are building comprehensive databases of ophthalmic diseases, with a unique focus on the Asian Indian population, the last update mentioned 524 distinct ophthalmic diseases.[8] While Ophthatome is developed from the PARAS EMR data of Narayana Nethralaya, EyeSmart is the EMR from LV Prasad Eye Institute, SN TCS Ophthalmic EMR is from Sankara Nethralaya and eyeNotes is from Aravind Eye Hospital.

"A Hospital-Based Multicentre Registry for common medical retinal diseases" for four diseases (DR, AMD, retinal vein occlusion and CNVM) is being developed under the clinical trial network led by Amrita Institute of Medical Sciences-Kochi with collaboration from Regional Institute of Ophthalmology (RIO)-Trivandrum, Aditya Jyot Eye Hospital-Mumbai, Sadguru Netra Chikitsalaya (SNC) – Chitrakoot, RIO-Patna, and Sri Sankaradeva Netralaya, Guwahati.[9]

A proposal for Eye Injury Registry (EIR) model for Indian Armed Forces was made by Mishra *et al*.[10]

The RED project was started in 2020 by Women Ophthalmologists Society (WOS) of India aiming to highlight REDs which require close attention.[11] National registries are being created for 10 REDs under this wing.

Tan *et al*. listed 97 registries worldwide.[12] Some of the ophthalmic registries in that list from India include Aravind Eye Hospital cataract registry, National Eye Bank Corneal Transplant Registry, Endophthalmitis Registry at L. V. Prasad Eye Institute and National Retinoblastoma Registry.

## VARIOUS STUDIES ON ARTIFICIAL INTELLIGENCE IN ELECTRONIC MEDICAL RECORDS

There are several studies on the use of AI in EMRs. As healthcare data is inherently multimodal with text, numbers and images, more so in ophthalmology, some AI studies focused on fusing health records and imaging data.[13] Interestingly, Ravindranath and Wang did the opposite, using AI models to identify patients at risk of developing glaucoma from EHR data of 64,735 participants, without the use of ophthalmic imaging or even clinical data.[14] In another study, Wang *et al*. used an NLP technique called word embeddings, which are representations of words as numerical vectors to understand relationships between various words, to show that clinical notes can be used by DL models to predict prognosis of visually impaired patients.[15] In yet another study, Wang *et al*. developed a DL predictive model that used EHR data including clinical information to predict subsequent need for glaucoma surgery.[16] They also showed that unstructured free-text data was useful to improve the predictive performance. Recently, from the same team, Koornwinder *et al*. developed a multimodal algorithm combining EHR data with optical coherence tomography scans to predict need for glaucoma surgery.[17] Baxter *et al*. did the same prediction of need for glaucoma surgery using systemic and medication data in the absence of eye-specific data.[18] They showed that higher mean systolic blood pressure increased the chances of nedding glaucoma surgery, whereas some medications reduced the odds.

De-identifying clinical data is very important for patient privacy and exposing Protected Health Information violates the Health Insurance Portability and Accountability Act. Therefore, Chen *et al*. used a de-identifying algorithm "Philter," to process 480 clinical notes of glaucoma patients, containing 5520 annotated sentences to create an open dataset and published it online on GitHub.[19]

Lin *et al*. reviewed a few studies that use EHR data to predict glaucoma, DR, AMD, and cataract.[20]

Felfeli *et al*. did a systematic review and meta-analysis and found 41 studies that used AI models on EHR data for predicting ocular diseases.[21] The diseases predicted in various studies included DR, glaucoma, optic neuritis, proliferative vitreoretinopathy, fungal ocular involvement, neovascular age related macular degeneration, Retinal Vein Occlusion, Diabetic Macular Edema, Retinopathy of Prematurity, Myopia, Microbial keratitis, Keratoconus, Herpes Zoster Ophthalmicus, and Cataract.

Interestingly, Tran *et al*. found that application of AI to clinical registries is constrained by poor accessibility to registry data and lack of standardization.[7]

Young *et al*. looked at a different aspect, building an ML model applied to EHRs of PCPs capable to triaging patients for referral to ophthalmologists.[22]

Kortüm *et al*. from Germany developed a data warehouse from EMR data where complex search queries could be done.[23] They explain that this can be used for developing clinical decision support software.

## CLINICAL DECISION SUPPORT SYSTEM

Clinical Decision Support Systems (CDSS) are advanced technological tools designed to enhance clinical decision-making by integrating patient data with evidence-based medical knowledge.

Initially, CDSS were often rule-based systems, providing simple "if-then" recommendations based on pre-programmed clinical guidelines. However, advancements in computing power, the availability of large datasets, and the development of sophisticated algorithms have propelled their evolution, particularly through the integration of AI and ML. ML-based CDSS can learn from extensive datasets, improving their accuracy, predicting disease progression, customizing treatment strategies, and even detecting conditions with precision comparable to human specialists. In newer EMRs, CDSS is often implemented as a chatbot in the corner of the screen where the clinician can ask questions and get evidence-based answers.

Ho *et al*. discussed the role of CDSS in primary care in Australia for better diagnosis and management of retinal disease.[24] Guo *et al*. showed that CDSS helps improve both diagnostic efficiency and accuracy for both experienced and junior doctors, with junior doctors benefiting more. They also suggest that it expedites their professional growth and prevents delays in patient treatment.

Tanya *et al*. developed a simple cloud-based decision tree CDSS to help standardize the triage and referral process while improving provisional diagnosis and identifying urgency of referral.[25]

## CONCLUSION

The move from paper to digital records in ophthalmology, with the widespread use of EHRs and EMRs, has created a wealth of data that, when combined with AI, is revolutionizing

eye care. This digital shift not only makes daily clinic operations more efficient and safer but also forms the basis for powerful "Big Data" initiatives like global ophthalmic registries. These large databases, along with AI tools like NLP and ML, help us understand diseases better, improve diagnoses, predict outcomes, and personalize treatments. The future of ophthalmology, driven by this blend of digital records, vast data, and smart AI, promises more precise, proactive, and collaborative eye care for everyone.

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## Conflicts of interest

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Photo Essay

# Gonioscopy-assisted transluminal trabeculotomy in post-bleb repair corneal patch graft


## ABSTRACT

A 48-year-old patient presented with primary angle closure glaucoma (PACG) who underwent combined phacoemulsification–trabeculectomy with mitomycin C in both eyes, 7 years ago. The best-corrected visual acuity in the right eye (RE) was 6/6 and in the left eye (LE) was 6/18. Intraocular pressure was 13 and 5 mmHg in RE and LE, respectively. On anterior segment examination, RE showed a diffuse bleb and LE revealed a thin cystic leaking bleb [Figure 1] with normal anterior chamber depth (Van Herricks grade 4) and foldable intraocular lens. Dilated fundus examination showed 0.85 cupping in both eyes, with choroidal folds in LE. Bleb repair using a corneal patch graft was conducted in LE [Figure 2]. On a 2-month follow-up, BCVA was 6/9 and IOP 12 mmHg. The patient was lost to follow-up. After 1 year, the patient presented with high intraocular pressure of 26 mmHg in LE with maximum medical therapy. Gonioscopy-assisted transluminal trabeculotomy [Figures 3 and 4] was conducted for uncontrolled IOP. Thereafter, after a 2-week follow-up and on subsequent visits up to 6 months, IOP was maintained at 16 mmHg without any antiglaucoma medications.



**Keywords:** Corneal patch graft, gonioscopy assisted transluminal trabeculotomy, primary angle closure glaucoma


## INTRODUCTION

Trabeculectomy is the most commonly performed for the management of glaucoma. Vision-threatening complications associated with traditional surgical intervention have motivated naive surgeons to opt for lesser invasive procedures. GATT is a minimally invasive surgical technique in which the trabecular meshwork is circumferentially bypassed via a suture or catheter as described by Grover *et al.*[1] It is usually performed for open and easily accessible angles.[2] However, it has been shown to be efficacious in adults, children, and patients with previous failed trabeculectomy and angle closure glaucoma.[2-4]

## DISCUSSION

Trabeculectomy is the gold standard filtration procedure against which all types of glaucoma surgeries are compared.[5] *Early and late vision-threatening complications associated with trabeculectomy are hypotony, bleb leaks, anterior chamber shallowing, choroidal detachments, and bleb-related infections.* Late bleb leak is a recognized complication that may occur months or years after the initial surgery.[6] In our patient, to avoid hypotony-related complications, bleb repair with a corneal patch graft was conducted in LE. This helped to achieve postoperative vision of 6/9 and intraocular pressure of 12 mmHg. Later, after 1 year, the patient presented with uncontrolled IOP and was on maximal medical therapy; gonioscopy-assisted transluminal trabeculotomy was conducted, which helped to achieve an IOP of 16 mmHg.


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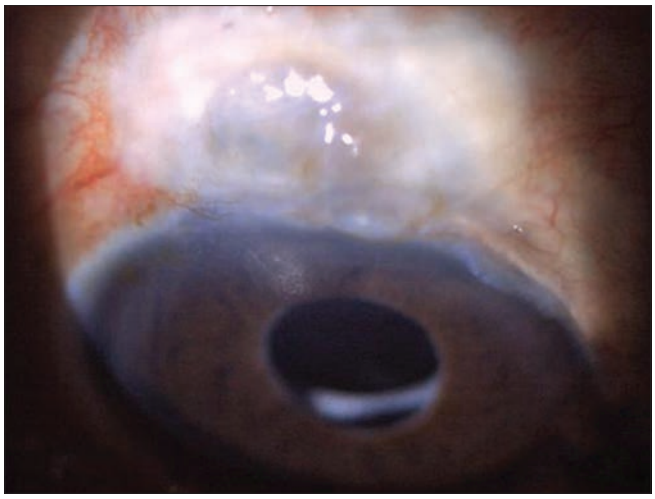


Figure 1: Diffuse slit-lamp thin cystic bleb

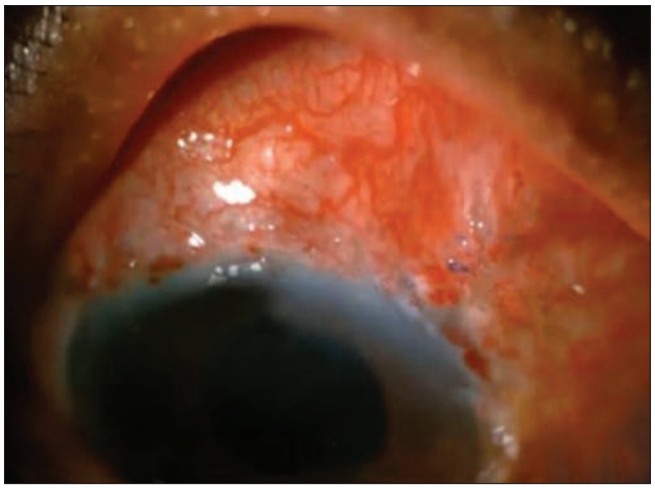


Figure 2: Diffuse slit-lamp bleb repair with a corneal patch graft

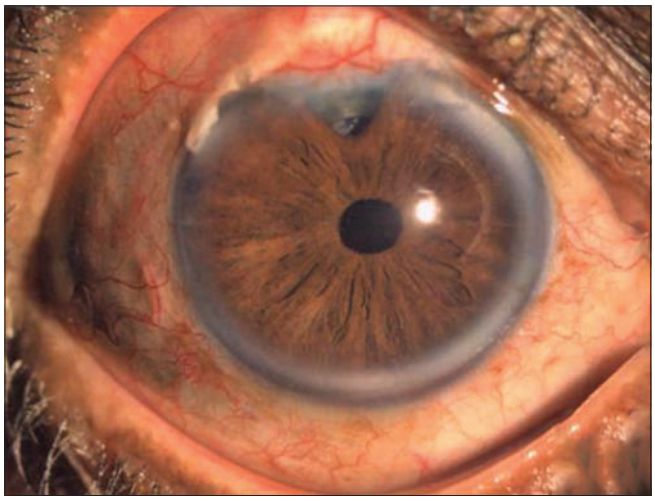


Figure 3: Diffuse slit-lamp showing flat bleb with surgical peripheral iridectomy

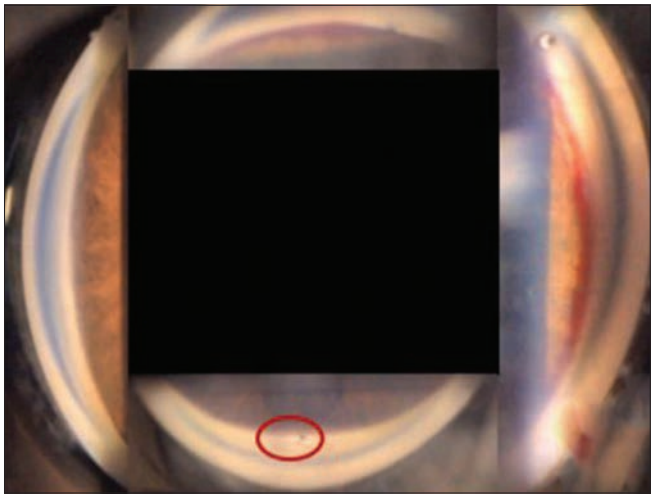


Figure 4: Gonioscopic image of LE showing scarred ostium and blood in temporal and superior angles following GATT

Cubuk *et al.*[7] demonstrated GATT in a previous trabeculectomy incisional surgery and showed a decrease in the mean IOP value (13.4 ± 4.3 (pseudo-exfoliative glaucoma [14 patients]) versus 17.1 ± 4.4 (primary open-angle glaucoma [12 patients]) from a baseline value of 25.3 ± 5.4 (16–45) mmHg and the average number of AGMs decreased from 3.8 ± 0.4 to 1.2 ± 0.8 at last follow-up visit of 12 months.

Grover *et al.*[2] showed a decrease in the mean preoperative IOP (SD) from 24.6 mmHg (6.4) to 16.7 mmHg (5.6) and AGMs from 3.2 (1.0) to 2.1 (1.4) in the follow-up of 24 months in patients with failed trabeculectomy.

## CONCLUSION

*Gonioscopy-assisted transluminal trabeculotomy* proved to be effective in controlling intraocular pressure in refractory glaucoma post-incisional surgery.

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### Conflicts of interest

There are no conflicts of interest.

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Photo Essay

# Giant keratoacanthoma of upper eyelid


**ABSTRACT**

An asymptomatic, rapidly growing ulcer of the upper eyelid in a 43-year-old female turned out to be a giant, benign keratoacanthoma on excision biopsy.



**Keywords:** Eyelid, keratoacanthoma, largest keratoacanthoma, massive keratoacanthoma, squamous cell carcinoma, ulcerative


## CASE PRESENTATION

A 43-year-old woman with a rapidly expanding ulcerative lesion on her left eyelid, present for the previous two and a half months, reported to our outpatient department (Figure 1a, taken with a *12-megapixel Nikon Coolpix S570 camera*). She made no claims of discomfort, bleeding, or discharge from the lesion.

On examination, a well-defined firm lesion (40 mm × 30 mm) was attached to the upper lid with a narrow base (30 mm × 30 mm) immediately above the lid crease, and was hanging partly below the lid margin. The edges were rounded, brownish, and erythematous, with a few telangiectatic vessels. The lesion was somewhat movable, and the surrounding skin appeared normal, ruling out the possibility that it was fixed to the deep tissues. The surface appeared to be crater like and filled with yellowish-white material. There was no oozing, bleeding, or tenderness. A provisional diagnosis of keratoacanthoma was made, and complete excision was performed with margin control, followed by a skin graft. Histopathology confirmed the diagnosis, and squamous cell carcinoma was ruled out [Figure 1b]. The patient was followed up for about one year, and no recurrence was noted.


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## DISCUSSION

To the best of our knowledge, it might be one of the most notable 'giant', or 'largest' keratoacanthomas of the upper eyelid reported till date.

Keratoacanthoma, a clinically benign skin lesion on the eyelid that can expand quickly over weeks to months, has been speculated to be a marker for underlying histological changes associated with squamous cell carcinoma.[1] Immunosuppression, advanced age, sun exposure, human papilloma virus (HPV), and existing scars have all been identified as risk factors. Although keratoacanthoma has a distinct clinical course and may sometimes regress to an atrophic scar or the nodule may fall off within a few months to a year, especially if less than 30 mm in size, full excision biopsy with margin management is preferred to masterly inaction.[2,3] As a differential diagnosis, a "giant" molluscum


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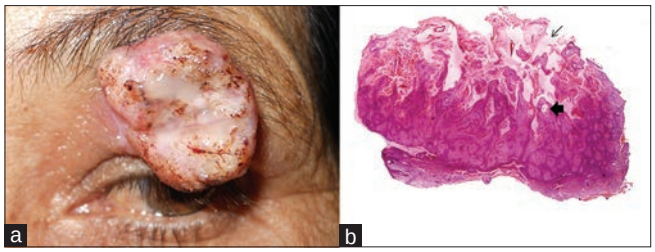


**Figure 1: (a) Clinical photograph showing an elevated, large ulcerating lesion on left upper lid. (b) Whole mount view shows a lobular lesion composed of well differentiated squamous epithelium (*thick arrow*) with a central keratin filled crater (*thin arrow*). There is marked acanthosis and hyperkeratosis with chronic inflammatory cell infiltrate present around the lesion. (H and E stain)**

of the eyelid in a tropical climate might present as an asymptomatic, self-regressing, nodular cutaneous lesion with keratinizing at its apex.[4]

A dramatic cure after intralesional 5-flurouracil (5-FU) or methotrexate (Mtx) has been demonstrated by some ophthalmologists in biopsy-proven, atypically large keratoacanthoma. Hamou *et al.* used 5-FU in a giant lesion 60 mm × 40 mm of the upper eyelid, while Krema *et al.* used Mtx in an indolently large lesion, 32 mm × 28 mm of lower eyelid, where also magnetic resonance imaging (MRI) was also required to rule out deep invasion.[3,5]

Although, in cases where alternative therapies such as deep curettage, radiotherapy, cryotherapy, systemic retinoids (acitretin), local antineoplastic agents, or interferon are planned, a deep incision biopsy of the lesion, including adjacent healthy skin at the specimen to assess for dysplasia at the skin-tumour transition zone favouring the diagnosis of keratoacanthoma, could be acceptable. However, a huge tumor mass may have topographical diversity, and an incisional biopsy specimen may fail to capture representative tissue exhibiting malignant alterations.[6]

Therefore, we believe that the histology of the "en-bloc" resected material is the most reliable approach to determine the true nature of large keratoacanthoma.

## Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

## Financial support and sponsorship

Nil.

## Conflicts of interest

There are no conflicts of interest.

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# Navigating results, discussion, conclusion, and referencing for crafting an impactful research manuscript


## ABSTRACT

A research manuscript's main objective is to disseminate scientific knowledge through the synergistic interaction of its results, discussion, conclusion, and references. To maintain scholarly integrity and reproducibility, it places a strong emphasis on presenting results objectively, evaluating their relevance within a larger context in the discussion, synthesizing major findings into a clear conclusion, and carefully citing all sources.


**Keywords:** Conclusion, discussion, referencing, results

## INTRODUCTION

A well-structured research manuscript successfully communicates scientific discoveries and contribute to an academic debate. While the entire paper requires precise attention, the results, discussion, and conclusion sections, together with appropriate reference, are especially important in conveying the study's significance and validity. This article intends to guide researchers, particularly those with developing experience, through the complexities of framing these parts and learning the referencing styles.[1,2]

## SALIENT POINTS

### Results

a. **The unveiling of findings:** Meticulously presents your study's findings clearly, concisely, and logically, without offering any interpretation or opinion.
b. **Clarity and visual appeal:** Tables and figures are effective tools. Make sure the titles, legends, and axis labels are all self-explanatory. They should complement the text, not duplicate it.
c. **Order of presentation:** Arrange the findings logically, usually in accordance with the order of your research questions or objectives.
d. **Negative results are still results:** Don't be afraid to share unexpected or insignificant results. They add to the overall picture of your study and help other researchers to explore it.

### Discussion

a. **Critical thinking**: Don't merely restate your results; go beyond the description. Explain why your findings are important and describe what they mean by comparing them with other studies.
b. **Counter-arguments and discrepancies:** Address results that contradict your hypothesis or prior study. Offer credible reasons for these disparities.
c. **Acknowledge limitations:** No study is flawless. Openly address your study's limitations and how they may have influenced your findings. This improves the credibility of your work


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d. **Future directions**: In light of your findings and constraints, recommend directions for additional study. This exhibits foresight and advances on ongoing scientific investigation.

### Conclusion

a. **Direct answer to research question**: Provide a solution to the research question, derived directly from your findings.
b. **Novel contribution**: Explain how your study contributes to the field. What new information has been generated?
c. **Broader implications**: Give a brief explanation of how your findings may affect theory, practice, or policy more broadly.

### References

a. **Journals guideline first**: Prioritize the journal's special referencing style. This information is usually found under the "Author Guidelines" or "Instructions for Authors" section.
b. **Reference management software**: Use software such as Zotero, Mendeley, or EndNote to handle your references efficiently and accurately. These programs can automatically format citations and bibliographies in a variety of styles.
c. **In-text citation**: Understand the in-text citation standards for your selected style, such as author-date or numerical format.

## COMMON MISTAKES/PITFALLS

- **Cherry-picking data**: Only presenting results that support your hypothesis.
- **Overgeneralization**: Making broad claims in the discussion part that are not fully supported by your results.
- Repeating Abstract in Conclusion
- **Inconsistency**: Mixing different referencing styles or inconsistent formatting within the same style.

## TAKE HOME MESSAGES

- **Crisp and clear results**: Be objective, organized, and let the data speak for itself.
- Be critical while interpreting results, explain their significance, and contextualize them within the existing body of knowledge.
- Impactful conclusion summarizes the important findings and emphasizes their significance.
- Accurate and consistent referencing is paramount for academic integrity.

### Financial support and sponsorship

Nil.

### Conflicts of interest

There are no conflicts of interest.

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# Curated article summaries

## 1. EARLY OUTCOMES OF BENT *AB INTERNO* NEEDLE GONIOTOMY AND ESPAILLAT GONIOTOMY WITH PHACOEMULSIFICATION IN OPEN-ANGLE GLAUCOMA

Maheshwari D, Pillai MR, Dev SR, Nagdev NG, Ramakrishnan R. Early outcomes of bent *ab interno* needle goniotomy and Espaillat goniotomy with phacoemulsification in open-angle glaucoma. Indian J Ophthalmol. 2025 Mar 1;73(Suppl 2):S352-S353. doi: 10.4103/IJO.IJO_2078_24. Epub 2025 Feb 21. PMID: 39982103; PMCID: PMC12013306.

Minimally invasive glaucoma surgery (MIGS) has emerged as a revolutionary approach for reducing intraocular pressure (IOP) effectively with a good safety profile. It uses an *ab interno* approach with minimal tissue trauma and faster recovery. Among the array of MIGS procedures, the goniotomy procedures have the added advantage of balancing IOP reduction and limiting the damage to the trabecular meshwork (TM)–Schlemm's canal (SC) complex.

Bent *ab interno* needle goniotomy (BANG) uses a 25-gauge needle bent at the tip to excise TM. A novel technique, Espaillat juxtacanalicular goniotomy, was recently described by Dr. Alejandro Espaillat, where TM is engaged and stretched bulldozed with the blunt tip of the Espaillat goniotome until it makes an initial separation and opening into SC, without stripping TM.

In this prospective, comparative case series, 23 patients underwent BANG and 23 patients underwent Espaillat goniotomy with phacoemulsification. The mean baseline IOP in BANG showed 20% reduction, while for Espaillat, 28.6% reduction at 6 months. Antiglaucoma medications (AGMs) reduced from 1.04 to 0.17 in the BANG group and from 0.61 to 0 in the Espaillat group. Complete success of 81% and qualified success of 33.3% were noted in the BANG group, and complete success of 85.7% and qualified success of 40% were observed in the Espaillat group.

### WHY THIS ARTICLE?

This is the first reported study on Espaillat goniotomy in India. Espaillat juxtacanalicular space (JCS) goniotomy, a novel technique of MIGS, is safe and efficacious as BANG in mild to moderate open-angle glaucoma and has the added advantage of avoiding TM stripping. Both procedures had an equivocal reduction in IOP and postoperative need for AGMs.

## 2. SHORT-TERM OUTCOMES OF TANITO MICROHOOK *AB INTERNO* TRABECULOTOMY COMBINED WITH PHACOEMULSIFICATION IN PRIMARY OPEN-ANGLE GLAUCOMA—A PILOT STUDY

Sasidharan, Ajita; Shah, Paraali; Thulasidas, Mithun. Short-term outcomes of Tanito microhook *ab interno* trabeculotomy combined with phacoemulsification in primary open-angle glaucoma—A pilot study. Indian Journal of Ophthalmol 73(Suppl 2):p S250-S253, March 2025. | DOI: 10.4103/IJO.IJO_723_24.

Tanito microhook (TMH) *ab interno* trabeculotomy is a MIGS procedure using a metal hook to incise the trabecular meshwork that has been noted to effectively reduce IOP and decrease dependency on antiglaucoma medications. TMH is a single-blade trabecular microhook with an oblique tip surface for effective tissue management and a unique hook with a circular edge for incising the TM.

The purpose of this prospective interventional study was to evaluate the surgical efficacy and safety profile of TMH *ab interno* combined trabeculotomy with phacoemulsification in Indian patients with primary open-angle glaucoma (POAG).

Patients with mild-to-moderate POAG and visually significant cataract with IOP between 21 and 28 mmHg were included. TMH *ab interno* trabeculotomy was preceded by phacoemulsification cataract surgery through a 2.8-mm wide, clear corneal incision at the temporal location. The mean IOP reduced from 23.57 ± 1.65 to 17.33 ± 2.84 at 3 months ($P < 0.001$). Postoperative complications (day one) included corneal stromal edema in eight (26.7%) eyes, grade 1 hyphema (less than one-third of the anterior chamber) in four (13.3%) eyes, and IOP spike in one (3.3%) eye, which might be due to the surgical manipulation. Corneal edema and hyphema resolved at 1 month postoperatively. No re-bleeding was noted during the 3-month follow-up.


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TMH *ab interno* trabeculotomy with phacoemulsification was effective in lowering IOP with minimal complications and could be an option worth considering for mild-to-moderate POAG.

## WHY THIS ARTICLE?

This study found this combined approach to be both effective and safe in patients with mild-to-moderate POAG, with a significant reduction in intraocular pressure (IOP) observed postsurgery. The TMH tip is small, reducing tissue damage with less chance of damaging the iris root and corneal endothelium. Conjunctival and scleral sparing with the *ab interno* technique, short surgical time (<10 min), moderate IOP reduction, and no bleb-related complications enhance the safety profile with favorable outcomes.

### Financial support and sponsorship
Nil.

### Conflicts of interest
There are no conflicts of interest.

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# Ophthalmoplegia unveiled

**ABSTRACT**

Ophthalmoplegia work up is a diagnostic challenge.A perfect knowledge of the anatomy of the the orbital apex, superior orbital fissure, and cavernous sinus is essential for accurate localization and timely intervention .This article provides an overview into the anatomy and applied importance of the orbit,superior orbial fissure and cavernous sinus.The algorithms provided helps you reach a diagnosis in ophthalmoplegia.

**Keywords:** Cavernou sinus, orbial apex, ophthalmoplegia, superior orbital fissure

Ophthalmoplegia workup is a diagnostic challenge that lies at the crossroads of neuroanatomy and clinical ophthalmology. The intricate network of cranial nerves traversing the orbital apex, superior orbital fissure, and cavernous sinus forms a compact yet clinically significant corridor. Understanding this anatomical nexus is essential for accurate localization and timely intervention in cases of ocular motor dysfunction.

## ORBITAL APEX

Bony orbits are cavities containing the globe, muscles, fat, nerves, and blood vessels.[1] It is pear-shaped, tapering posteriorly to the apex and optic canal. Nerves for extraocular movements, optic nerve, and the blood vessels travel through various important parts like the cavernous sinus, orbital apex, superior orbital fissure, and finally reach the orbit. Diseases of these areas invariably affect the nerves and vessels, manifesting as ophthalmoplegia and sometimes associated with defective vision Figures 1 and 2.

The orbital apex is anatomically the posterior part of the orbit, positioned at the craniofacial junction located where the four orbital walls converge; it is the narrowest part of the orbit. The orbital apex incorporates the optic canal and the superior orbital fissure. Anatomically, the superior orbital fissure is lateral to the optic canal.

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### Boundaries

- Roofless wing of the sphenoid bone
- Lateral wall-greater wing of sphenoid bone
- Medial wall-ethmoidal sinus
- Floor-orbital plate of the palatine bones

### Contents of optic canal

- Optic nerve and ophthalmic artery

## SUPERIOR ORBITAL FISSURE

It is a slit linking the cranium and orbit between greater and lesser wing of sphenoid bone. It is divided into three parts by a common tendinous ring [Figure 3].

Contents of the superior orbital fissure

Superior portion

Lacrimal nerve (Cranial nerve $V_1$($CNV_1$)), frontal nerve ($CNV_1$), trochlear nerve (CNIV), superior branch of the ophthalmic vein,

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Middle portion

Nasociliary nerve (CN $V_1$), abducens nerve (CNVI), and the superior and inferior branches of the oculomotor nerve (CNIII).

Inferior portion

Inferior ophthalmic vein.

## CAVERNOUS SINUS[2]

They are dural venous sinuses that communicate with each other.

Relations
- Laterally temporal bone
- Inferiorly sphenoid bone
- Medially pituitary gland in the sella turcica
- Superiorly optic chiasma

The superior and inferior ophthalmic veins drain anteriorly into the sinus.

Superficial, middle cerebral veins, deep cerebral veins (via the sphenoparietal sinus), and inferior cerebral veins also drain into the cavernous sinus Figure 4.

Contents

On the lateral wall
- 3rd nerve
- 4th nerve
- Ophthalmic and maxillary division of the 5th nerve

The cavernous part of the internal carotid artery lies in the cavernous sinus. Postganglionic, third-order sympathetic fibers run on the internal carotid artery (ICA), CN VI, and then CN $V_1$

CN VI lies freely inferolateral to the ICA and medially to the other CNs.

**Figure 5**

## CAVERNOUS SINUS SYNDROME[3]

1. Present with ophthalmoplegia, which can be partial or total due to involvement of the 3rd, 4th, and 6th nerve.

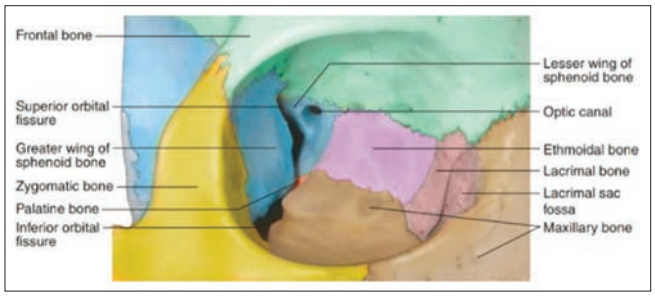



Figure 1: Bony Orbit. Courtesy: AAO neuro-ophthalmology 2023-2024, Page no: 6




Figure 2: Orbital apex. Courtesy: AAO neuro-ophthalmology 2023-2024, Page no: 8

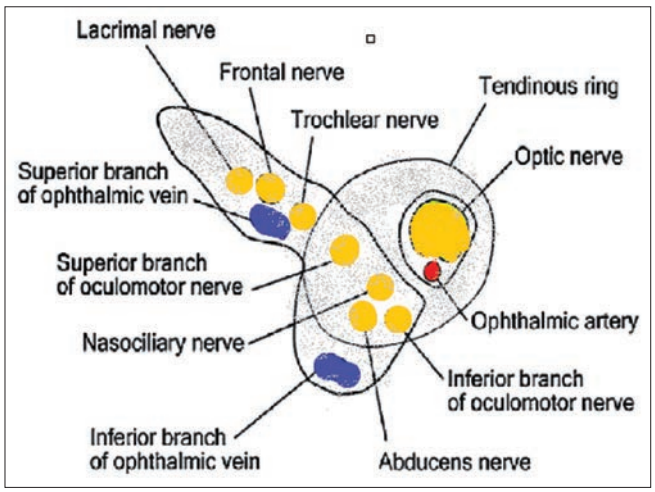



Figure 3: Superior orbital fissure

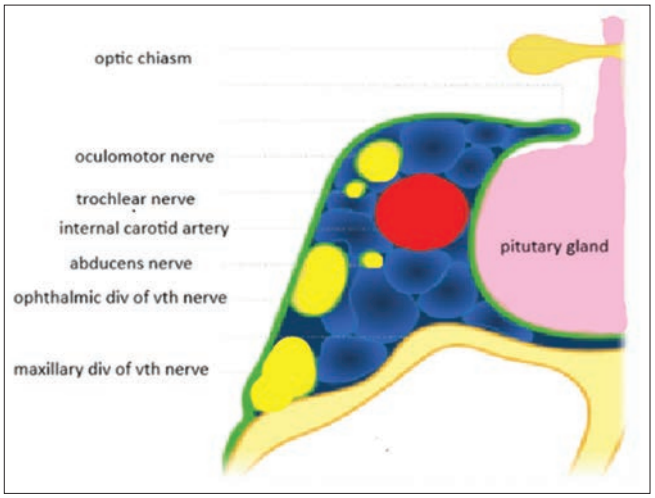



Figure 4: Cavernous sinus and relations

2. Facial sensory changes due to involvement of $V_1$, $V_2$
3. Horner's syndrome-due to the involvement of the postganglionic sympathetic plexus travelling on the ICA and CN VI, damage can cause an ipsilateral loss of sympathetic tone

Causes: Trauma, tumors, inflammatory causes, vascular lesions, infections.

### Orbital apex syndrome

Manifests as ophthalmoplegia with variable diplopia, mydriasis, and ptosis due to CNIII, IV, and VI involvement. There is visual loss due to optic nerve involvement.

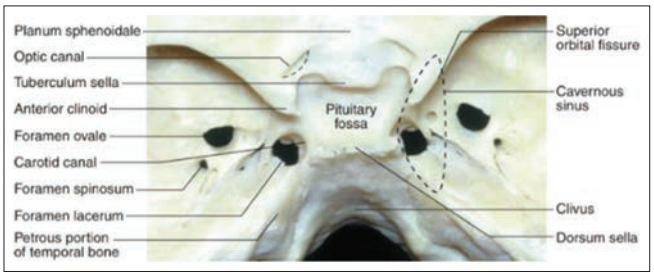



**Figure 5: Parasellar bony anatomy showing the cavernous sinus. Courtesy: AAO neuro-ophthalmology 2023-2024, page no: 6**

Causes: Trauma, tumors, inflammatory causes, vascular lesions, infections.

### Superior orbital fissure syndrome

1. Includes CNIII, CNIV, $CNV_1$, CNVI, and the ophthalmic veins.
2. Present with ophthalmoplegia and forehead sensation loss/hypoesthesia
3. The optic nerve is usually spared.

## TOLOSA-HUNT SYNDROME

Idiopathic, sterile inflammation of the cavernous sinus. It may extend into the superior orbital fissure and the orbital apex and may also affect the optic nerve.

Painful ophthalmoplegia is the hallmark of Tolosa-Hunt syndrome.

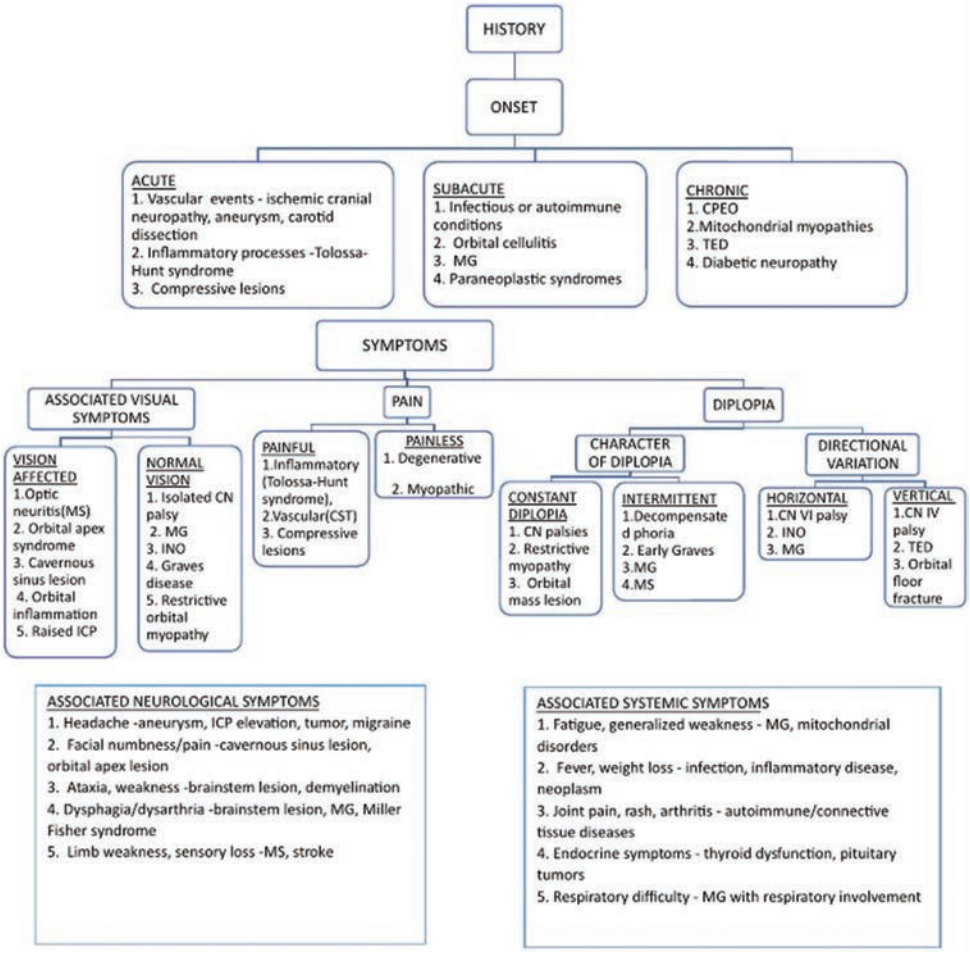



**Figure 6: Onset and symptoms**

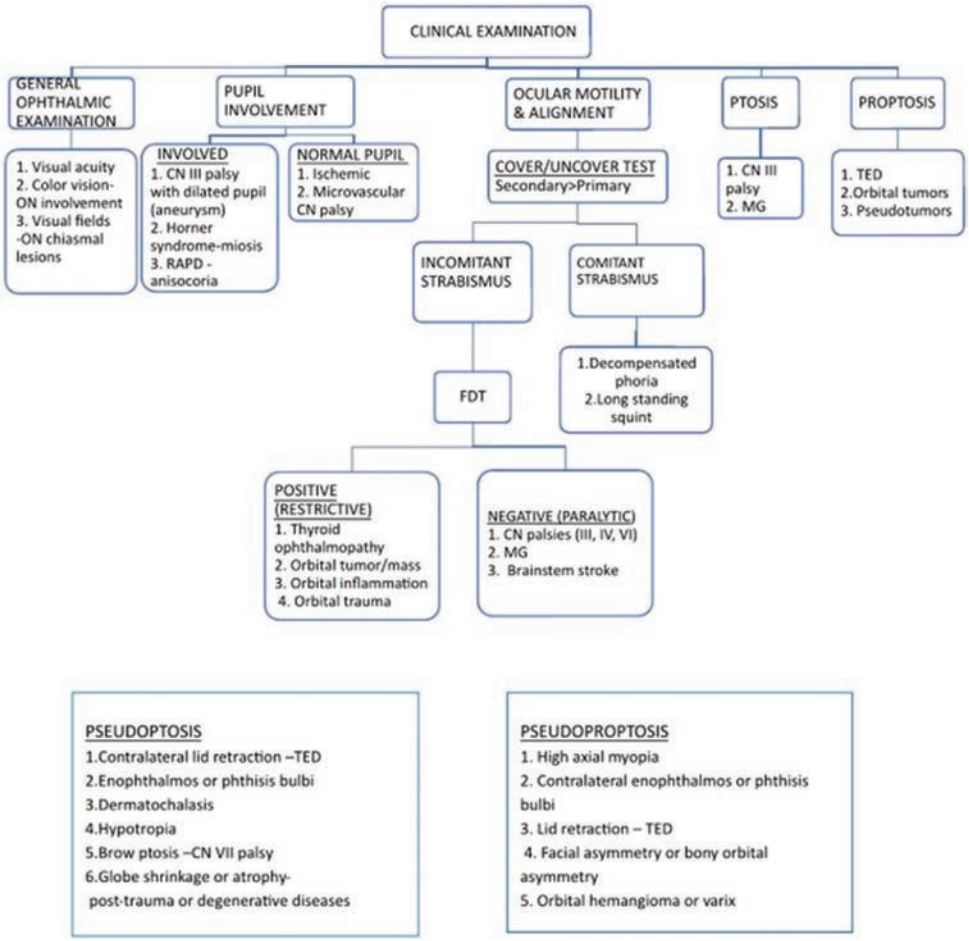



**Figure 7: Clinical examination**

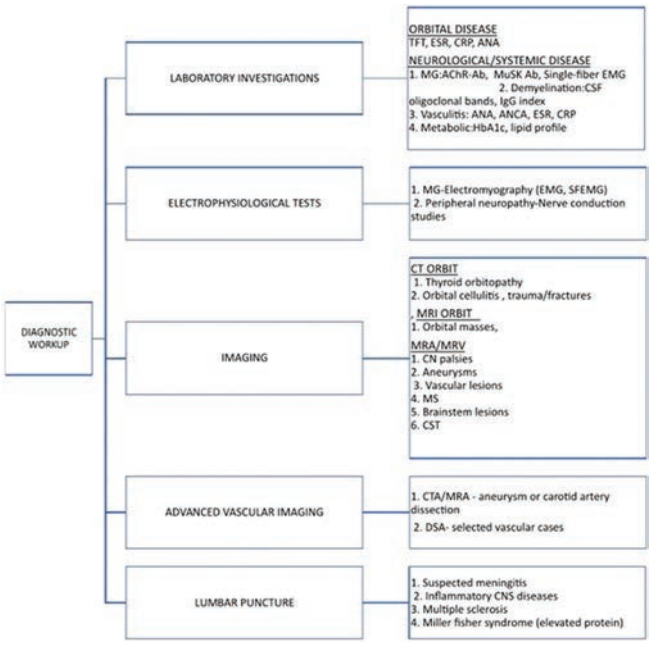



**Figure 8: Diagnostic workup**

## CLINICAL EVALUATION OF OPHTHALMOPLEGIA [FIGURES 6-8] [4-9]

ABBREVIATIONS USED

1. MS, multiple sclerosis
2. MG, myasthenia gravis
3. TED, thyroid eye disease
4. ON, optic nerve
5. CN, cranial nerve
6. CPEO, chronic progressive external ophthalmoplegia
7. FDT, forced duction test
8. CST, cavernous sinus thrombosis
9. CTA/MRA, CT/MR angiography
10. DSA, digital subtraction angiography.

Figure 6: ONSET AND SYMPTOMS
Figure 7: CLINICAL EXAMINATION
Figure 8: DIAGNOSTIC WORKUP

Test yourself:

A 40-year-old woman presents with binocular diplopia, left eye proptosis, and pain on eye movement. Clinical examination reveals restricted elevation and abduction, ptosis, and RAPD in the left eye. MRI orbit shows a diffusely enhancing lesion involving the orbital apex. Which of the following is the most likely diagnosis and the best next step in confirming it?

A. Myasthenia gravis: perform single-fiber EMG
B. Cavernous sinus thrombosis: perform CT venography
C. Tolosa-Hunt syndrome: perform contrast-enhanced MRI brain and orbit
D. Thyroid eye disease: order thyroid function tests and orbital ultrasound.

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### Conflicts of interest

There are no conflicts of interest.

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# Spiral capsulorhexis in intumescent white cataract


## ABSTRACT

Intumescent cataract is characterized by swelling and thickening of the lens due to increased intralenticular fluid accumulation. Capsulorhexis in such cases is particularly challenging due to the risk of anterior capsular rupture (Argentina flag sign), runaway rhexis, and a poor red reflex. Several capsulorhexis techniques have been described to minimise the risk of complications like spiral capsulorhexis, phacocapsulotomy, mini rhexis, and vacuum capsulorhexis. Among them, Spiral capsulorhexis is one of the commonly employed techniques in an intumescent cataract. In this video, we demonstrate the key surgical steps and important precautions for performing spiral capsulorhexis using a cohesive ophthalmic viscoelastic device (OVD) in an intumescent cataract.


**Keywords:** Argentina flag sign, capsulorhexis, intumescent cataract, spiral capsulorhexis

## FOCUS POINTS

The important key steps in the making of spiral capsulorhexis[1,2] under high cohesive ophthalmic viscoelastic devices (OVDs) in an intumescent cataract [Video 1][1-5] are:

1. The anterior chamber should be formed using a high-cohesive ophthalmic viscoelastic device[3] (OVD).
2. A small initial nick, approximately 1 mm in length, should be made from the center toward the temporal side (in the right eye) or nasal side (in the left eye).
3. The liquefied cortex should be aspirated using a 25G cannula, followed by the injection of a cohesive OVD (e.g., sodium hyaluronate) to maintain chamber stability and counteract the high intralenticular pressure.
4. The initial round of the spiral rhexis should be approximately 2 mm in diameter.
5. During the spiral rhexis procedure, if we feel the intralenticular pressure is high or rhexis is about to run away, cohesive OVD should be injected, and the cortical fluid should be aspirated, followed by the reinjection of cohesive OVD to decompress the bag and stabilize the capsular flap.
6. During the procedure, a small ribbon of anterior capsule may prolapse into the main incision; this should be trimmed to prevent undue traction on the capsular flap.
7. The spiral rhexis can be continued in multiple spiralling rounds until an adequately sized capsulorhexis (~5-5.5 mm) is achieved.

## CONCLUSION

Spiral capsulorhexis is one of the commonly used techniques for managing capsulorhexis in intumescent and white cataracts. With appropriate technique and necessary precautions, a successful spiral capsulorhexis can be achieved with minimal risk of extension or capsular complications.


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# RNFL defects in patients on ATT

Dear Editor,

We studied the recently published article titled "Ocular toxicity of daily anti-tubercular treatment regimen: A prospective observational study" by Arun KT *et al*.[1] We have a few queries for the esteemed authors. The authors have mentioned that color vision was assessed using the Ishihara chart and color vision abnormality was noted in 14 eyes. We feel the color abnormalities should be specifically quantified in the methods section. In other words, it should be clearly mentioned the number of color slides which the patient cannot read for it to be considered abnormal. It will be interesting to know if patients with history of hypertension, diabetes, cigarette smoking, anemia, etc., were excluded from the study. These factors can affect the quantification of the retinal nerve fiber layer (RNFL) parameters and can confound the results. In the results, it will be informative to know the different types of tuberculosis which were included in the study.

The authors have mentioned that there was a statistically significant difference in RNFL values. However, the RNFL values following treatment are still within the normal range for age and sex. Follow-up RNFL measurement using optical coherence tomography should be carefully interpreted as any misalignment of the scanning circle can give grossly different values. It will also be informative for the readers to know about the clinical significance of the study. The authors have mentioned that RNFL thinning happens before any fundus or visual change. So, do the authors recommend stopping ethambutol therapy just on the basis of statistically significant RNFL thinning in the absence of clinical symptoms? Is this study powered to determine the maximum decrease in RNFL thickness at which vision might decrease? It will be interesting to know if the authors advised for discontinuing ethambutol therapy in all patients who had vision and color vision defects during the course of treatment. Ethambutol is a very important drug in the management of tuberculosis. The decision on discontinuing the drug should be based on the results of multiple modalities of investigation. It is more important that the patients be counseled regarding the potential side effects of the medication so that they can present at the earliest before significant damage has happened.


## Financial support and sponsorship

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## Conflicts of interest

There are no conflicts of interest.


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