Excimer Laser Trabeculotomy – A Novel, Minimally Invasive Procedure for Patients with Glaucoma

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Introduction

Primary open angle glaucoma is one of the world’s leading causes of blindness\(^1\)-\(^2\). Lasers play an important role in the management of open angle glaucoma. Various methods of laser treatment along with the newer surgical procedures like viscocanalostomy and deep sclerectomy have been attempted which are aimed at minimizing the complications of trabeculectomy (with antimetabolites) like hypotony, shallow anterior chamber, wash out phenomenon and a range of bleb related complications like bleb leak, endophthalmitis\(^3\) and most commonly eventual failure of the filtering bleb itself\(^4\). The newer surgical procedures have not become popular because of the longer learning curve and difficulty in doing the procedure even in experienced hands and the uncertain and often less desired outcome in terms of intraocular pressure reduction.

The Excimer Laser Trabeculotomy

The trabecular meshwork and the inner wall of the Schelmm’s canal constitute 75% of the outflow resistance of the aqueous\(^5\). Attempts to improve the outflow facility with laser procedures like Argon laser trabeculoplasty, Selective laser trabeculoplasty and Nd: YAG puncture have yielded less satisfactory outcomes because they produce thermal effects with coagulation of trabecular meshwork\(^5\). Consequently, the irregular edges of the opening created never produce a successful hole due to the healing response and subsequent scar tissue formation that they inherently stimulate.

To be successful, a procedure has to bypass the outflow obstruction at the juxtacanalicular trabecular meshwork accurately and stealthily producing little or no healing response. Excimer laser trabeculotomy (ELT) ab interno – a new, minimally invasive surgical procedure to reduce the intraocular pressure in patient with open-angle glaucoma or ocular hypertension – precisely fulfills both these requirements. The 308 nm wavelength used in this procedure allows the removal of trabecular meshwork by photoablation without inducing thermal damage. Therefore it minimizes healing response and scar formation. ELT reestablishes physiological aqueous outflow through the endogenous drainage pathway without creating an external filtration bleb\(^6\).

Theoretical and Physical Aspects

Ablation of tissue structures containing and surrounded by water differs from tissue ablation at a surface, not only theoretically but also in its outcome. In contrast to the situation often observed with surface ablation, trabecular meshwork in the anterior chamber of the eye can be ablated cleanly and accurately with excimer laser without causing collateral thermal damage\(^7\). The reason for this is that in the trabecular meshwork, the ratio of radiation-absorbing tissue to water –
which absorbs very little energy – is very small. A marked cooling effect thus results, which permits the development of only a very small amount of collateral damage at the boundaries of the ablation zone. Therefore with the excimer laser, tissue can be removed with minimal thermal effects, necrosis and negligible scar tissue formation.

**Histopathological Studies**

The aim of ELT is to create an open communication between the anterior chamber and the Schelmm's canal. With the excimer laser a selected ablation of the trabecular meshwork and the inner wall of the Schelmm's canal are done to create pores and enhance outflow facility. Histopathological changes studied in animal models have shown mild stimulation signs with very little obvious inflammation. Local fractures in the trabecular meshwork and openings into the Schelmm's canal were detected in all tissues samples. Mitochondria were found to be turgescent and endoplasmic reticulum was found to be dilated under electronic microscope in the early postoperative period. With time, all trabecular cells returned to normal, however no fibroblasts were detected.

**The Excimer Laser Settings**

The excimer laser used is XeCl, with wavelength of 308 nm, instead of the standard argon fluoride (193 nm) excimer laser which has been used for ab-externo photoablation. The surgeon applies laser energy (AIDA Excimer laser system, TuiLaser, AG, Germering, Munich, Germany) directly to the trabecular meshwork by means of fiber – optic delivery system (LAGO 200 or LAGO 200 ENDO; TuiLaser AG)\(^8\). The pulse energy available is 1.2 mJ at the fiber tip, the laser pulse duration is between 10 ns to 60 ns and the repetition rate is 20 Hz\(^8\).

**The Procedure**

Excimer laser trabeculotomy (ELT) is indicated in patients with open-angle glaucoma or ocular hypertension and having -

1. increased IOP under maximum tolerated medical therapy
2. progressive glaucomatous damage
3. allergies or intolerance to medications
4. non – compliance with medical therapy

It is contraindicated in patients with -

1. narrow anterior chamber angle (Shaffer I – II) and higher levels of angle closure either appositional or synechial
2. an abnormal iris configuration
3. dysplasia of trabecular meshwork
4. neovascularistion of iris
5. poor visualization of the angle structures due to hazy media

Prior surgery does not constitute a contraindication to performing ELT but procedures that compromise distant outflow channels such as argon laser trabeculoplasty (ALT) may compromise the efficacy of ELT.

The technique involves using a microscope and visualizing the angle using a modified Trokel goniolens\(^9\). The pupil is constricted to open the angle and enhance visibility of the trabecular meshwork. Under full aseptic precautions and after a regional anesthesia, the anterior chamber is entered with a paracentesis incision. The anterior chamber is filled well with viscoelastic and the probe is passed across the anterior chamber via the paracentesis incision towards the opposite chamber angle to contact the trabecular meshwork (figure 1).

**Fig. 1.** This schematic diagram of ELT shows how the fiber-optic approaches the trabecular meshwork across the anterior chamber.
The modified Trokel goniolens is placed on the cornea and the probe is placed so that its edge rests on the Schwalbe's line. The probe is gently aligned to the angle and up to 10 shots (trabeculostomies) are fired with each shot being 1 to 2 probe diameters away distributed over one quadrant (approximately 90°). The surgeon monitors the fiber position with either the goniolens or an endoscope (figure 2).

2 – 4 hours after the procedure and the next day. The intraocular pressure is reassessed after 4 – 8 weeks. The patient is advised to continue all pre-procedure ocular hypotensive medications. Steroid eye drop is prescribed for a few days after the procedure. Once the intraocular pressure stabilizes, glaucoma medications are sequentially discontinued.

Complications include hyphema, increased intraocular pressure especially if all the viscoelastic is not removed. All complications related to a procedure involving entry into the anterior chamber are possible. However, since the chamber is water tight throughout and after the procedure chances of sudden ocular decompression, choroidal detachment, hypotony and shallow anterior chamber are negligible.

**Pressure Reduction with Excimer Laser Trabeculotomy**

The reduction of intraocular pressure occurs from 4 to 6 weeks after the procedure. Studies have shown that a stable intraocular pressure is achieved between 4 months to one year post-operatively and the pressure lowering effect reduces overtime necessitating an increase in the glaucoma medications or performing surgery to lower the pressure. Erbium laser trabeculotomy can be combined with cataract surgery and can be performed through the same corneal incision. ELT has been found to reduce the intraocular pressure for at least 1 to 2 years and in combination with phacoemulsification is more effective in intraocular pressure reduction than when performed alone. It is
also more effective in patients with high preoperative intraocular pressure levels.

**Drawbacks of Excimer Laser Trabeculotomy**

Excimer laser trabeculotomy is an invasive procedure. It requires good aseptic conditions and operation theatre setup. The instrumentation is expensive. The effect of procedure like other laser procedures wanes with time as shown by the few long term studies available.

**Role of Excimer Laser Trabeculotomy**

Excimer laser trabeculotomy is at best an additional procedure to lower the intraocular pressure and subsequent use of multiple glaucoma medications in patients who are already on maximum medical treatment or who are unfit, unwilling or waiting for filtration surgery. The effect of this procedure appears to be transient and thus cannot completely replace the role of surgery or medical treatment. The lack of long – term studies and the high cost of this equipment along with the need for theatre settings have precluded the widespread acceptance of this procedure.

No serious complication of ELT has been reported so far. ELT creates no filtering bleb or hypotony and leaves the conjunctiva intact. Moreover, the microsurgical method of pinpoint ablation of the trabecular meshwork results in very minimal trauma to the eye which leaves all other options of subsequent successful surgical intervention open. ELT thus holds promise as a new, minimally invasive procedure for patients with glaucoma.

**Reference**

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