Sclerothalamotomy (STT)
Ab Interno in the Treatment of Glaucoma

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Chapter 20

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Abstract

Objective

In what follows, we describe the initial results obtained from a prospective study involving a new method for the treatment of glaucoma. The results are drawn from the treatment of the first 53 eyes in 53 different patients. The aim of the continuing study is to demonstrate the effectiveness of this new procedure.

Methods

A group of 53 sclerothalamotomies ab interno in 53 patients with open angle glaucoma between 1 April 2002 and 31 July 2002 were carried out. The average preoperative intraocular pressure (IOP) in the 53 consecutively treated patients measured 25.6 ± 2.3 mmHg. The sclerothalamotomies ab interno were carried out with a special high-frequency diathermic probe known as the STT Glaucoma tip (Figure 2 a-b).

Results

After a follow-up period of 24 months, the average IOP dropped to 15.0 ± 1.6 mmHg, an outcome which is statistically (p<0.005) highly significant. While temporary IOP elevation was observed in 12 of 53 eyes (22.6%), this responded well to pressure-reducing therapy which we were then able to gradually withdraw in a majority of the cases within 3 months. In general, IOP dropped continuously over the course of 6 months and then levelled off.

Conclusion

Sclerothalamotomy ab interno is a minimally invasive method of treating glaucoma that leads to stable postoperative IOP regulation.

Keywords: Sclerothalamotomy (STT) ab interno, glaucoma surgery, sclerotomy.

Introduction

There is still no satisfactory surgical procedure for glaucoma that promises long-term IOP reduction, the elimination of supplementary pressure-reducing medication and low complication rates. Trabeculectomy, a procedure first described in the sixties (1,2), is today probably the most widespread form of glaucoma surgery. The literature indicates a trabeculectomy success rate of 32 to 96% (2-16). This broad range in the likelihood of success can largely be explained in terms of the various diagnoses, the various degrees of surgical experience and the various follow-up periods involved. The intent of the procedure is to circumvent the resistance caused by the trabecular meshwork by channelling directly to the Schlemm
It has become evident that obtaining of a clinically promising reduction in IOP following trabeculotomy is primarily owing to the presence of a filtering bleb\(^{(17)}\).

The method, known as non-penetrating deep sclerectomy, was first used by Fjodorov in the seventies\(^{(18)}\). Koslov\(^{(19)}\) expanded upon this method by introducing a collagen implant. Here, the literature indicates a success rate of 58 to 74% without the collagen implant and 74 to 90% with the collagen implant\(^{(20, 21)}\).

In 1976, Benedikt\(^{(22)}\) made a description of ciliary body exposure (i.e. a form of penetrating sclerectomy) that led to stable, long-term IOP regulation in 27 of 38 cases involving neovascular, aphakic and irreversible angle-closure glaucoma after initially failed fistula (filtering) surgery. This technique was the basis for a later development involving perforating deep sclerectomy, a method which has been deployed since 1985 in our clinic and which was first presented under the designation of sclerothalamectomy in a publication from the year 2000\(^{(23)}\). The bypassing of the trabecular meshwork permits an alternative route for the outflow of aqueous humor from the anterior chamber to the Schlemm canal, and is thus the basis for non-penetrating glaucoma surgery, in particular, for deep sclerectomy and viscocanalostomy. These surgical procedures show good IOP regulation as well as a reduction in the risk associated with the formation of a filtration bleb as has been observed in the case of conventional filtration surgery\(^{(24, 25, 26)}\). So far the utility of these surgical procedures has been limited by the difficulty of their performance and the lack of predictability with respect to their pressure-reducing effect.

The reason why the trabecular meshwork is to be circumvented centers on the fact that pathologic outflow resistance is caused primarily by the juxta-canalicular conjunctive tissue of the trabecular meshwork and, in particular, by the inner wall of the Schlemm canal\(^{(27, 28)}\). Only one further publication in this area indicates that 35% of the outflow resistance arises distally to the inner wall of the Schlemm canal\(^{(29)}\).

Spiegel et al\(^{(30)}\) have described a new surgical technique involving the use of an implanted tube, the so-called trabecular meshwork bypass tube shunt, which permits a direct connection between the Schlemm canal and the anterior chamber. This surgical technique avoids the disadvantage of non-penetrating deep sclerectomy associated with its technical difficulty, especially the difficulty of carrying out the microperforation of the trabecular meshwork so as to ensure the permeability of the Descemet membrane. Furthermore, this treatment technique minimizes filtration bleb formation and all its associated disadvantages.

All surgical procedures for glaucoma involving the creation of external access entail the risk of fibroblast proliferation and filtration closure. The novel surgical procedure that we have introduced allows one to avoid all of the above-mentioned disadvantages while obtaining excellent postoperative IOP regulation. We refer to this technique as sclerothalamotomy ab interno.

**Patients and Methods**

Before beginning the clinical study phase, the tips used for the STT ab interno procedure were developed using a large number of pigs' eyes. The effect of the STT ab interno treatment on the human eye was then examined histologically using a pathologic human eye.

We carried out 53 sclerothalamotomies ab interno in 53 patients with open-angle glaucoma between 1 April 2002 and 31 July 2002. The main criterion used to determine patient inclusion in the study was insufficient response to medical IOP control. Study results were gathered and evaluated prospectively. The average patient age was 69 years (range: 10-82 years). The gender ratio was 32% female to 68% male. The eye side ratio was 47.4% right side to 52.6% left side.

A complete ophthalmologic status check was carried out in each patient prior to the surgical intervention. The items examined included: vision sc, cc, aplanatic IOP, anterior segment and retina (in particular, the papilla). We also carried out a automated visual field testing investigation.

Complete ophthalmologic status checks were carried out postoperatively at days 1, 2, 3 and 4, weeks 1, 2 and 4, and months 2, 3, 6, 12, 15, 18, 21 and 24.
Surgical Procedure

The anterior chamber is opened (clear corneal) temporally with a 1.2 mm paracentesis. A further paracentesis at a 120° angle to the first incision, are performed. The anterior chamber is filled with Healon GV. The high-frequency diathermic probe is inserted into the temporally paracentesis opening. Visual inspection of the surgical zone (i.e. in the opposing iridocorneal angle, nasal) is secured via a 4-mirrored gonioscopic lens. The STT ab interno tip penetrates 1mm nasal into the sclera through the trabecular meshwork and Schlemm canal, forming a deep sclerotomy (i.e. thalami) of 0.3 mm thickness and 0.6 mm width (Figure 1). This procedure is repeated 4 times until 4 thalami are performed. Healon GV is evacuated from the anterior chamber. Tobradex is then applied for 1 month and Pilocarpin 2% for 10 days.

High-Frequency Diathermic Probe

The high-frequency diathermic probe is equipped with an inner platinum electrode which is isolated from one of the returning coaxial electrodes. The platinum probe tip, named STT glaucoma tip, has a length of 1 mm and a width of 0.3 mm and is bent at an angle of 15° (Figure 2a,b). The outer diameter of the probe measures 0.9 mm. The modulated 500 kHz current generates a temperature of 130°C at the tip of the probe. A bipolar current generator creates an electric field only at the tip of the probe. As a result, the diffusion of heat remains local to the tip of the probe and expands physically the form of an elliptical rotation body. No coagulation effects were detected in the surrounding tissue.

Evaluation of the Results

For purposes of statistical evaluation, we used the SPSS Program Version 10. The two-tailed Student t-test was used for the significance calculations, with p<0.05 being designated as significant.

Results

The preoperative average IOP in 53 patients with open-angle glaucoma treated consecutively measured 25.6 ± 2.3 mmHg (18 to 48 mmHg). This value declined to 16.9 ± 2.5 mmHg (9 to 44 mmHg) after a follow-up period of 1 month, 15.1 ± 1.8 mmHg (11 to 20 mmHg) after 3 months, 14.7 ± 1.7 mmHg (11 to 20 mmHg) after 6 months, 14.8 ± 1.7 mmHg, a result which, at p<0.005, is statistically highly significant (Figure 3). For all patients the follow-up was 24 months.

The average preoperative administration of pressure-reducing eye drops corresponded to 2.6 ± 1.0. Following STT ab interno treatment, this value was decreased to 0.45 ± 0.72 after 1 month, to 0.38 ± 0.60 after 3 months to 0.38 ± 0.69 after 6 months, to 0.19

Figure 1: Sclerothalamotomy (STT) Ab Interno Surgical Procedure. The anatomical relationships are of great value as a guide to localize the selected structures. In this view we can observe how the STT ab interno tip (T) penetrates into the sclera through the trabecular meshwork and Schlemm canal (S). (Art from Highlights of Ophthalmology).
± 0.52 after 12 months and to 0.21 ± 0.53 after 24 months, i.e. after 24 months, it was necessary to administer medication in only 5 eyes, a figure which corresponds to 9.6% of all cases.

 Temporary IOP elevation was observed in 12 of 53 eyes (22.6%). These patients responded well to pressure-reducing treatment and we were then able to gradually withdraw treatment in a majority of these patients. We observed a single case of hypotension (1.9%) that lasted for 3 days post surgery and that was most likely a result of a decrease of ciliary body aqueous production. We observed hyphema in 6 cases (11.4%), including all 3 cases of neovascular glaucoma, with reabsorption taking place within the first 2 weeks post surgery. One eye (1.9%) exhibited temporary fibrin formation at pupillary level. The fibrin dissolved within one day pursuant to the intensive application of topical steroids (Table 1).

 The histological investigation of the pathologic human eye revealed no indirect signs of necrosis in the tissue bordering on the STT ab interno excision site, i.e. no signs of a reduction in cell fluid content and no protein decomposition were observed as one would expect to find in the case of coagulation necrosis.

**Discussion**

This study centers on the introduction of a new surgical technique for treating glaucoma. The STT ab interno method involves the creation of a direct channel between the anterior chamber and the Schlemm canal. Furthermore the STT ab intern tip forms a penetrating deep sclerotomy transcameral. This enables one to bypass the outflow resistance of the trabecular meshwork. In light of the fact that roughly 85% of the aqueous humor drains (in physiological terms) trans-trabecularly\(^{(31)}\), we suspect an additional route for aqueous humor absorption in the case of elevated IOP. In the context of a study entitled *Sclerothalamectomy* (penetrating deep sclerectomy) (German title: *Die Sklerothalamektomie*) published in 2000\(^{(23)}\), it was ascertained that those eyes in which no filter bleb was detected post surgery exhibited very stable long-term IOP regulation. In addition to the bypassing of trabecular outflow resistance afforded by STT ab interno treatment, outflow resistance is further reduced by thinning the sclera at the base of the thalamus, and a portion of the aqueous humor is presumably absorbed by the ciliary body\(^{(23, 32)}\). After the initial post surgery IOP reduction, which comes primarily from bypassing the drainage resistance of the trabecular meshwork, the average IOP continued to drop gradually over a period of 6 months before levelling off. The explanation for the additional aqueous humor absorption and IOP reduction would seem to center on the newly formed blood vessel and lymph vessel links to the surgical site, a suggestion that can be verified with the use of fluorescein and that is also supported by Benedikt\(^{(22)}\). To sum up, the aqueous flow on the one side into the Schlemm’s canal, on the other side into the uveoscler-
The large advantages that the STT ab interno method enjoys over trabeculectomy and perforating and non-perforating deep sclerectomy include a clear reduction in the likelihood of postoperative complications and very stable long-term IOP regulation. In contrast to trabeculectomy, perforating deep sclerectomy and non-perforating deep sclerectomy, postoperative hypotension is observed only in exceptional cases, as we observed in a single case that was associated with a temporary secretion stop. However, IOP peaking (which can be effectively brought under control with the use of topical medication) may occur in the first 6 weeks. In most cases, the pressure-reducing therapy can be gradually withdrawn after 3 weeks post surgery. While it was necessary to continue pressure-reducing therapy in 5 of 53 eyes, this therapy proved effective at achieving stable intraocular pressures (Figure 4).

Further advantages to STT ab interno include the comparative simplicity and quickness of the surgical procedure itself. This study points out, that the performance of 4 thalami has so far proved optimal. This discussion represents an examination of initial treatment results. The technique will be further developed and optimized as the prospective study continues and more knowledge of clinically important factors is gained.

### Table 1

<table>
<thead>
<tr>
<th>Complication</th>
<th>Number</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temporary IOP elevation</td>
<td>12</td>
<td>22.6%</td>
</tr>
<tr>
<td>Temporary hypotension</td>
<td>1</td>
<td>1.9%</td>
</tr>
<tr>
<td>Hyphema</td>
<td>6</td>
<td>11.4%</td>
</tr>
<tr>
<td>Temporary fibrin formation</td>
<td>1</td>
<td>1.9%</td>
</tr>
</tbody>
</table>

**Figure 3:** The change of intraocular pressure (IOP) after Sclerothalamotomy (STT) ab interno surgery for all 53 cases at each follow up visit.
Figure 4: The change of intraocular pressure (IOP) preop compared with 24 month postop for all 53 cases

References

Equipment required to perform STT treatment of glaucoma

The STT function is available on all latest Oertli surgery equipment.

Klöti Bipolar Unit
This state of the art bipolar diathermy unit provides not only STT, but also Klöti r.f. capsulotomy to perform capsulotomies under poorest conditions of visibility, even underneath the iris, as well as macro and endo diathermy.

- VC810100 Klöti Bipolar Unit incl. diathermy and capsulotomy instruments
- VE810010A Glaucoma option
- VE201750 STT glaucoma tip

CataRhex® swissTech®
The portable phaco unit which fits on the I/V pole and offers the performance of latest big phaco machines without compromise. Extremely easy to use, ideal for private praxis and ambulatory centres with small to highest volume in any part of the world. Allows combined cataract and glaucoma surgery.

- VS820100S or VS820100SP CataRhex® swissTech® phaco system
- VE201750 STT glaucoma tip

OS3 small incision surgery system
Available in an anterior only or anterior/posterior configuration, OS3 offers a venturi/peristaltic double pump fluidics system and extensive programmability. It is an ideal machine for large surgery centres and clinics, including universities and high volume ambulatories. Allows combined cataract and glaucoma surgery as well as combined cataract and vitreoretinal surgery.

- VS830100 or VS830200 OS3 small incision surgery system
- VE201750 STT glaucoma tip