Ab interno infrared laser trabecular ablation: preliminary short-term results in patients with open-angle glaucoma

Abstract - Background: Outflow obstruction of trabecular drainage structures results in elevation of intraocular pressure (IOP) in various forms of chronic open-angle glaucoma. In vitro studies have shown that laser trabecular ablation (LTA) with opening of Schlemm’s canal can be reproducibly performed by use of infrared lasers with minimal damage to collateral tissue structures. - Methods: In order to investigate the clinical applicability and efficacy of ab interno contact laser photoablation of trabecular meshwork in the surgical treatment of human glaucoma, we conducted a pilot study using an erbium: YAG laser (2.94 µm) with a quartz fiber endoprobe (320 µm core diameter) applying 10–20 single laser pulses (5–7 mJ) to the trabecular meshwork. - Results: Under goniocopic visualization trabecular tissue was photovaporized in eight patients with primary or secondary chronic open-angle glaucoma. Intraoperatively, moderate reflux bleeding occurred from laser-induced craters. No major intra- or postoperative complications occurred. Preoperative and postoperative gonioscopy of the treated area demonstrated successful removal of trabecular tissue. Mean IOP was reduced from 36.1 mmHg to 21.3 mmHg at a limited follow-up of 3 months. - Conclusion: With modifications this technique may have clinical potential in the surgical management of glaucoma. Prospective long-term studies with more patients are warranted to evaluate the outcome of LTA.

Introduction

Pathological outflow obstruction within trabecular meshwork is the main key to increased intraocular pressure (IOP) in various forms of chronic open-angle glaucoma [4, 21]. Conventional surgical procedures, such as goniotomy and trabeculotomy, aim at a mechanical dissection and disruption of trabecular tissue in order to create an aperture connecting the anterior chamber to Schlemm’s canal. Both surgical modalities have been approved as reliable in treatment of developmental glaucomas [1, 2, 11, 24, 27]; trabeculotomy has even been recommended in chronic open-angle glaucoma or in combined cataract-glaucoma interventions [8, 28].

In the early 1970s Krasnov [19, 20] developed a new surgical method, producing micro-perforations of the angular drainage structures by use of a ruby laser system; some years later, Ticho [29] tried an argon laser trabeculotomy in primates. Photodisruptive neodymium: YAG goniotomucure as performed by Melamed et al. [22, 23] and Epstein et al. [7] in the 1980s yielded relatively good results in juvenile glaucoma, although it did not succeed in controlling chronic open-angle glaucoma. Vogel et al. [30, 31] described a laser trabecular puncture of human trabecular meshwork using an Excimer laser in a contact mode. In contrast to ultraviolet radiation [10], infrared laser wavelengths are not under suspicion of being carcinogenic and teratogenic.
Infrared laser trabecular ablation (LTA) has been proposed as a potential treatment of open-angle glaucoma in several experimental in vitro or animal studies [12–15, 17, 18]. Outflow facility measurements in porcine cadaver eyes and in living monkeys have demonstrated that infrared LTA is able to decrease outflow resistance significantly [13, 15]; however, this is the first time that ab interno infrared LTA has been applied to human glaucoma surgery. The aim of the current study is to describe our preliminary clinical experience with this surgical modality of pressure-reducing intervention, a new promising alternative in the non-filtering treatment of human chronic open-angle glaucoma.

**Methods**

### Laser

We used an erbium: YAG laser (MCL 29, Aesculap Meditec, Heroldsberg, Germany) emitting its infrared radiation (2940 nm) via a contact endprobe articulated to a zirconium fluoride fiber (350 μm diameter, length 150 cm). The endprobe was an endfiring quartz fiber tip with a 320-μm core diameter and a 385-μm coating diameter. The fiber tip end stood out in a fixed distance of 2 mm from a surrounding stationary metal tube (800 μm outer diameter). Laser energy was delivered by a macropulse of 200 μs. Single pulse energy ranged between 5 and 7 mJ and was preoperatively controlled by an external joulemeter (Fieldmaster; Coherent, Palo Alto, Calif.). All used endprobes were gassterilized before surgery. The zirconium fluoride fiber was preoperatively draped with sterile single-use plastic sheets.

### Surgery

The interventions were performed with the patients under retrobulbar anesthesia; the pupil was maximally constricted by pilocarpine 2%. At 15–20 min before surgery, mannite infusion (osmofundin, 125 ml, intravenously) was given; oculopression (30–40 mmHg) was performed for 10 min.

Under an angulated operating microscope a 2-mm clear cornea incision was made at a temporal position. Viscoelastic material (Healon GV) was injected in order to deepen the anterior chamber and to guarantee the best gonioscopic view of the angle structures. The laser endprobe was inserted into the anterior chamber (Fig. 1) and approached transcamerally close to the nasal chamber angle. A Swan-Jacob gonioscopy lens with a filling fluid (hydroxypropylmethylcellulose 2.5%) was placed on the cornea. Under gonioscopic visualization and the highest magnification, the quartz fiber tip was slightly pressed onto the trabecular meshwork structures (Fig. 2) and single laser pulses were emitted. Between 10 and 20 neighboring single laser pulses were applied to the trabecular meshwork. Following the laser procedure, the viscoelastic material, as well as blood and tissue debris, was removed from the anterior chamber by aspiration-irrigation maneuvers; the corneal incision was closed with a single 10-0 monofilament nylon suture. Immediately after surgery, subconjunctival injections of dexamethasone and mezlocillin were performed.

During the first few weeks of postoperative recovery, each patient was treated with topical steroid drops, with an additive antibiotic ointment at night. In order to avoid synechiae of the treated chamber angle we gave pilocarpine 1% drops three times daily for at least 4 weeks after laser surgery.

### Patients

A preliminary study is under way including eight patients with primary or secondary chronic open-angle glaucoma, all suffering from medically uncontrolled IOP progressive visual field loss, extensive glaucomatous damage to the optic disc, and an open chamber angle suitable for goniosurgery. Exclusion criteria were young age (<40 years), visual acuity >20/200 in the treated eye, and worse visual function in the contralateral eye. Further exclusion criteria were chronic angle-closure glaucoma and secondary glaucoma due to inflammation or trauma.

Consent was obtained from all patients after they had been fully informed about the experimental mode of the surgical intervention. The study protocol was designed according to the guidelines of the Helsinki Declaration and approved by the Human Research and Ethics Committee of the University of Cologne. For ethical reasons, our preliminary trial was confined to a limited number of glaucoma patients, as this kind of surgery had never been performed before.