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GLAUCOMA

Clinical results of selective laser trabeculoplasty in silicone oil-induced secondary glaucoma

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Abstract
Background To analyze the efficacy of selective laser trabeculoplasty (SLT) on silicone oil-induced secondary glaucoma in terms of intraocular pressure (IOP).
Patients and Methods 42 patients (42 eyes) with silicone oil-induced secondary glaucoma were selected, and SLT was performed with 360° of the trabecular meshwork. During the 12-month follow-up, the complications, IOP, and antiglaucoma medication usage were observed.
Results The mean IOP decreased from 23.1±1.9 mmHg before treatment to 18.4±3.7 mmHg after treatment ($p<0.05$). Mean number of antiglaucoma medications used for IOP control also decreased from 2.17±1.21 to 1.25±0.89 ($p<0.05$). The 12-month success rate in the total sample was 59.5 %. The success rate was 60.7 % (17 eyes) and 57.1 % (eight eyes) for phakic and aphakic eyes, respectively ($p>0.05$)
Conclusions SLT is a safe and effective option for the treatment of patients with silicone oil-induced secondary glaucoma.

Keywords Selective laser trabeculoplasty · Silicone oil · Induced secondary glaucoma

Introduction

Silicone oil has been an important adjunct in the treatment of complicated retinal detachment for the past four decades. A known complication of its use has been the development of secondary glaucoma. Secondary glaucoma can occur at any time in the postoperative period, and result in a loss of vision [1]. The true incidence of glaucoma after silicone oil injection is difficult to ascertain from the literature. Studies reported the rates of glaucoma from 2.2 % in 6 months [2] to 56 % in 8 months [3]. Recent reports [4–7] have documented a somewhat lower prevalence (from 11 to 48 %) due to several recent developments. Conventional filtration surgery has a limited role and success rate in the management of glaucoma after pars plana vitrectomy (PPV) and silicone oil injection [8]. Trabeculectomy is technically difficult because of conjunctival scarring from the vitreoretinal surgery and carries a poor prognosis. Al-Jazaaf et al. reported that [9], 78 % of patients with glaucoma after PPV and silicone oil injection were medically treated. The use of topical and systemic antiglaucoma medications only controlled intraocular pressure (IOP) in 30 % of eyes [8]. Although several studies have evaluated several risk factors for developing an elevated IOP after silicone oil injection, the post-operative IOP is still a challenge.

Selective laser trabeculoplasty (SLT) has become an increasingly favored laser procedure for glaucoma because of its equivalent efficacy and its minimal destructive effects on tissues surrounding the trabecular meshwork [10]. In addition, SLT is well tolerated with a low incidence of post-procedure IOP elevations, blurred vision, and irritation [11]. Various clinical studies have demonstrated the efficacy and safety of SLT in producing a sustained reduction in IOP [12–14]. SLT has also been shown to be effective as both a primary treatment and an adjunct to medical therapy. [12–14].

As far as we know, there was no report on the efficacy of SLT in patients with silicone oil-induced secondary glaucoma. In this study, the efficiency of SLT was evaluated as the adjunctive treatment in patients with silicone oil-induced secondary glaucoma.

Methods

This study is a retrospective consecutive chart review of patients with silicone oil-induced secondary glaucoma who had undergone

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SLT at the Second People's Hospital of Jinan from July 2009 to July 2012. The protocol was reviewed and approved by the hospital's Institutional Ethics Committee. Each participant provided written informed consent before the procedure was performed and the study adhered to the tenets of the Declaration of Helsinki.

SLT was mainly performed as adjunctive therapy in this study. Patients who could not tolerate any topical antiglaucoma medications or who were noncompliant with medical therapy were offered SLT. The inclusion criteria for the study were: being older than 18 years of age; having no history of glaucoma or ocular hypertension before silicone oil injection; at least 1 month after silicone oil injection and without silicone oil emulsification in the vitreous cavity, anterior chamber or anterior chamber angles on gonioscopy; without pupillary block; with open, normal-appearing anterior chamber angles and there was no neovascular on the surface of iris or chamber angles on gonioscopy.

Excluded from the study were patients who had an advanced visual field defect within 10° of fixation; previous glaucoma surgery; severe corneal disease that resulted in inaccurate applanation measurements, or that inhibited the adequate visibility of the trabecular meshwork on gonioscopy; patients using systemic steroids; and/or patients suffering from endophthalmitis, or inflammatory or uveitic glaucoma.

All the patients were treated by the same operator. All the patients were treated with 1.0 % apraclonidine (Iopidine; Alcon, Fort Worth, TX, USA) 1 h before and just after the laser treatment to prevent a postoperative spike. Laser treatment was performed at 360° of the trabecular meshwork. The laser energy was initially set at 0.8 mJ and increased by 0.1-mJ increments until bubble formation occurred. When the bubble formation was seen, treatment was continued at this minimal energy level for bubble formation. The entire meshwork was treated with 93–102 non-overlapping spots. Postoperatively, the patients were prescribed 0.1 % fluorometholone (Allergan, Inc. Irvine, CA) eye drops four times daily for 7 days. Antiglaucoma medical therapy was continued after the laser treatment.

The follow-up schedule thereafter was as follows: 1 day; 1, 3, 6, and 12 months after treatment. The IOP, complications, and antiglaucoma medication usage were observed before treatment and at each follow-up visit. All patients had IOP measured by Goldmann applanation tonometry (AT900, HAAG- STREIT, Swiss). Three consecutive IOP measurements were recorded by the same doctor and the mean was used as the final IOP. All patients were under the same measurement conditions. Success was defined as an IOP reduction of ≥20 %, without additional medications, repeat laser trabeculoplasty, or glaucoma surgery.

We compared the changes in IOP and antiglaucoma medication usage using the *t* test. All analyses were done with the SPSS statistical software (ver. 18.0, SPSS, Inc., Chicago, IL, USA). Success rates were compared using Kaplan–Meier lifetable analysis and χ [2] test. p values<0.05 were considered statistically significant.

Table 1 Patient characteristics

Number of eyes	42
Age mean±SD, years	48.5±13.7
Male	28
Female	14
Type of diseases (reasons for silicone oil injection) diabetic retinopathy (%)	22 (52.4%)
Proliferative vitreoretinopathy (PVR) (%)	15 (35.7%)
Traumatic hemophthalmos with secondary retinal detachment (%)	5 (11.9%)
Lens status	
Phakic	28
Aphakic	14

Results

We analyzed the results of SLT in 42 eyes of 42 patients. Table 1 shows the characteristics of the patients.

Mean post-SLT IOP values at 1, 3, 6, and 12 months were 18.2, 17.1, 17.3, and 18.4 mmHg, respectively (Table 2). SLT treatment provided a significant decrease in IOP from baseline (23.1±1.9 mmHg) at each time point (p<0.05). Table 2 also shows the IOP reduction in amount and percentage during the study period. At last visit after SLT, the mean IOP reduction rate was 20.3 % (4.7 mmHg).

Mean number of antiglaucoma medications used before treatment was 2.17±1.21, which decreased to 1.25±0.89 by the last visit (t=3.62, p<0.05).

The 12-month success rate in the total sample was 59.5 %. The 12-month success rates for surgical success were 60.7 % (17 eyes) and 57.1 % (eight eyes) for phakic and aphakic eyes, respectively (p=0.824) (Figs. 1 and 2).

IOP spike (IOP elevation more than 6 mmHg) was observed in 11 eyes (26.2 %). All significant early IOP elevations were treated with topical drugs (fluorometholone 0.1 % eye drops four times daily for 7 days). No permanent adverse effects of SLT were noted in any of the patients. During follow-up, trabeculectomy was needed in three eyes (7.1 %)

Table 2 Mean baseline IOP (mmHg) and mean IOP reduction at follow-up visits

Time	*n*	IOP mean±SD (mmHg)	IOP reduction (mmHg) (%)
Pretreatment	42	23.1±1.9	
1 day	42	17.2±4.1	5.9±3.7 (25.5)
1 month	42	18.2±3.5	4.9±3.2 (21.2)
3 months	42	17.1±3.8	6.0±3.4 (25.9)
6 months	36	17.3±4.2	5.8±3.8 (25.1)
12 months	32	18.4±3.7	4.7±2.8 (20.3)

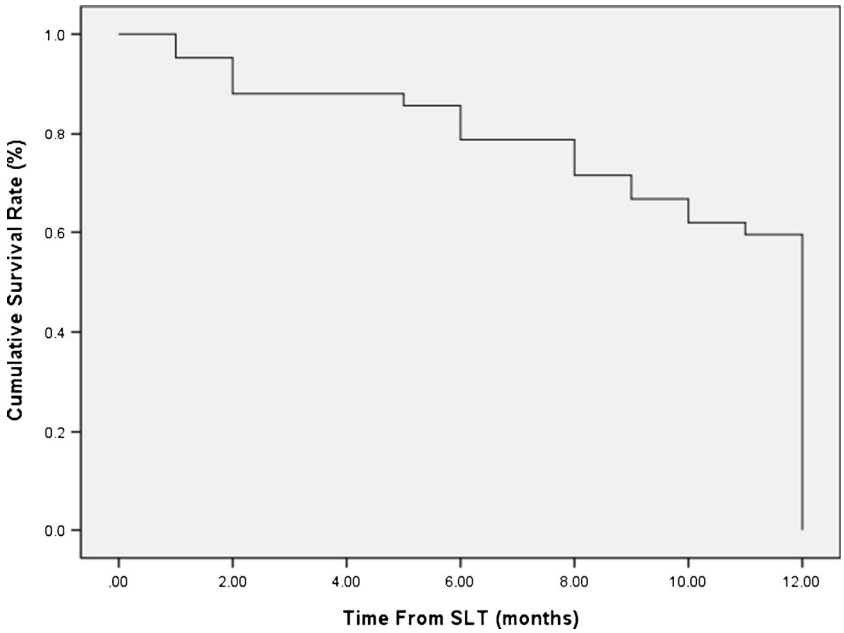

Fig. 1 Survival curve for the total sample

and silicone oil removal surgery was needed in seven eyes (23.8 %).

Discussion

A known complication of the use of silicone oil is secondary glaucoma. Until now, high IOP after silicone oil injection is mainly controlled by taking medication [9]. Studies have shown that drug treatment for silicone oil-induced secondary glaucoma was limited [8]. The therapy of silicone oil-induced secondary glaucoma is still a challenge. Clinical experiences with SLT have been described in a number of publications [15, 16], however, there were no reports on the efficacy of SLT in patients with silicone oil-induced secondary glaucoma. In this retrospective study,

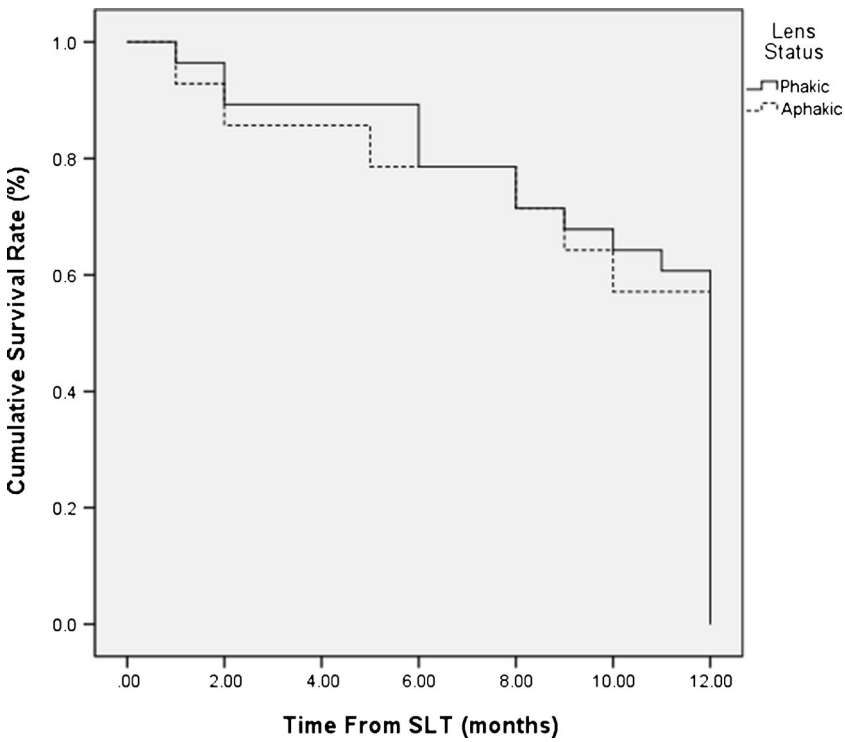

Fig. 2 Survival curve for phakic eyes and aphakic eyes

we evaluated the efficacy of SLT as the adjunctive treatment for these patients.

Our study excluded glaucoma caused by too much silicone oil injection or pupil block. Some studies [17, 18] reported that the success rate and IOP-lowering effect of SLT were not dependent on the type of glaucoma. In this study, we found a success rate of 59.5 % and an IOP reduction of 4.7 mmHg (20.3 %). The effect of SLT in lowering IOP has been reported earlier at around 5 mmHg from baseline and varied from 20–25 % in the IOP reduction rate [19, 20]. These reports are the same as our results.

Silicone oil, transported by the aqueous, can reach the trabecular system [21]. Trabecular meshwork and Schlemm's canal are complex tissues possessing a great variety of function pivotal for the active regulation of aqueous humor outflow from the anterior chamber. Some authors have proposed that silicone oil can be actively transported in macrophages [22–24]. Silicon-containing macrophages were found in various ocular tissues, including trabecular meshwork [22–24]. The accumulation of macrophages within the trabecular space results in an increased resistance to aqueous outflow and IOP elevation. SLT is known to target the ocular trabecular meshwork. Some authors have suggested that SLT treatment stimulates the release of cytokines and chemotactic factors, which can upregulate macrophages in the trabecular meshwork [25]. Alvarado et al. [26] reported that SLT also could increase the permeability of Schlemm canal cells. This could be explained by this hypothesis: after SLT, activation of endothelial cells of the trabecular meshwork and macrophages results in removal of more silicone oil and aqueous humor, and thus be able to reduce IOP. This requires further study of the pathology.

In our study, no statistically significant differences in success rate were seen between phakic and aphakic eyes. Goktug Seymenoglu et al. [27] indicated that there was no significant difference in the success rate between phakic and pseudophakic eyes. Further studies with a larger number of patients and longer follow-up are needed to further establish the role of SLT in aphakic eyes.

In our study, there were no serious complications. The SLT is theoretically repeatable because it causes less tissue damage. SLT did not induce any phenotypic alteration in trabecular meshwork samples and was able to modulate these functions at the post genomic molecular level without inducing damage either at molecular or phenotypic levels [28]. Hong et al. [29] reported that a repeat 360-degree SLT provided additional IOP reduction after an initially successful 360-degree SLT had failed.

Our study has several limitations. First, the mechanisms of secondary glaucoma following the use of silicone oil are complicated. We need further studies to provide a guidance for SLT. Second, according to current knowledge, SLT efficacy is only positively associated with the degree of IOP elevation before SLT treatment [30]. We need further evidence to indicate if this conclusion is correct in patients with silicone oil-induced secondary glaucoma.

In conclusion, the results indicated that SLT is a safe and effective means of IOP reduction in patients with silicone oil-induced secondary glaucoma. Further long-term prospective studies on a larger subject population may likely change our results.

Conflict of interest The authors have no conflicts of interest to report regarding this work. All the authors confirm that the manuscript, or any part of it, has not been and will not be submitted elsewhere for publication.

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