Repeat Selective Laser Trabeculoplasty in Silicone Oil-Induced Open Angle Glaucoma

Silikon Yağına Bağlı Açık Açılı Glokomda Tekrar Edilen Selektif Laser Trabekuloplasti

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ABSTRACT

Purpose: We aimed to evaluate the effectivness of repeat selective laser trabeculoplasty (SLT) in silicone oil (SO)-induced open angle glaucoma (OAG).

Materials and methods: Twelve eyes of 12 patients with high intraocular pressures (IOP≥21 mmHg), despite maximally tolerated antiglaucomatous treatment, were included in this study. Repeat SLT was carried out if the first SLT failed (IOP ≥21 mmHg). Patients had follow-ups at the 1 week and 1, 3, 6 and 9-month after treatments.

Results: The mean IOP before the first SLT was 25.00±1.54 mmHg which decreased to 20.25±1.76 mmHg 9 months later for all patients (p=0.001). Moreover after a mean of 13.0±3.26 months following the first SLT, 6 patients (50 %) received repeat SLT. In these patients, the mean IOP decreased from 23.50±1.76 mmHg to 19.83±1.83 mmHg after 6 months (p=0.004). At the end of a mean 19.0±3.68-month of study period, the IOP decreased to 20.58±1.62 mmHg in all patients (p=0.001). The overall success rate was 58.3% at the end of the study, and there were no significant differences between the first and repeat SLT success rates at similar control time points (p>0.05).

Conclusion: There was no significant difference between the first and repeat SLT effectiveness in SO-induced OAG patients. However, further studies are needed to validate the effects of a repeat SLT on SO-induced OAG.

Key words: Intraocular pressures, selective laser trabeculoplasty, silicone oil-induced open angle glaucoma, treatment.

ÖZ

Amaç: Silikon yağına (SY) bağlı gelişen açık açılı glokomda (AAG) tekrar edilen selektif laser trabeküloplastinin (SLT)'nin etkinliğinin incelenmesi.

Gereç ve Yöntem: Bu retrospektif çalışmaya, tolere edilebilen maksimum antiglokomatöz tedaviye rağmen göz içi basıncı (GİB) yüksek (GİB ≥ 21mmHg) olan 12 hastanın 12 gözü dahil edildi.Yapılan ilk SLT başarısız (GİB ≥ 21mmHg) hale gelince SLT ikinci defa tekrar uygulandı. Tedavilerden 1 hafta, 1, 3, 6 ve 9 ay sonra hastalar kontrol edildi.

Bulgular: Ortalama GİB tüm hastalarda ilk SLT öncesi 25.00±1.54 mmHg iken 9 ay sonra 20.25±1.76 mmHg' ya düştü (p = 0.001). İlk SLT'den ortalama 13.0±3.26 ay sonra 6 (%50) hastaya SLT tekrar uygulandı. Bu 6 hastada tekrar uygulanan SLT öncesi ortalama GİB 23.50±1.76 mmHg iken 6 ay sonra 19.83±1.83 mmHg oldu (p = 0.004). Tüm hastalarda ilk uygulanan SLT'den ortalama 19.0±3.68 ay sonra, ortalama GİB 20.58±1.62 mmHg olarak saptandı (p = 0.001). Çalışma sonunda başarı oranı % 58.3 idi. Benzer kontrol aralıklarında ilk uygulanan ve ikinci uygulanan SLT başarı oranları arasında anşamlı fark yoktu (p > 0.05).

Sonuç: SY'na bağlı gelişen AAG'de; ilk uygulanan SLT ile tekrar uygulanan SLT arasında etkinlik açaısından fark olmadığı gözlendi. Daha kesin sonuçlar için ileri çalışmalara ihtiyaç vardır.

Anahtar kelimeler: Göz içi basıncı, selektif laser trabeküloplasti, silikon yağına bağlı açık açılı glokom, tedavi.

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INTRODUCTION

Silicone oil (SO) has been widely used for several decades as a long-term intravitreal tamponade, to treat complex retinal detachments associated with proliferative vitreoretinopathy, giant retinal tear, proliferative diabetic retinopathy and trauma.[1] However, SO is associated with several complications, including cataract, keratopathy and glaucoma[2], and SO-induced glaucoma can occur at any time in the postoperative period.[3] The incidence of SO-induced glaucoma has been reported to be 2.2% to 56% between 6 and 8 months after surgery.[4,5] Silicone oil tamponade may cause an elevated intraocular pressure (IOP), as a result of either open angle glaucoma (OAG) or pupillary block glaucoma.[6] However, medical therapy with the removal of SO is often insufficient to control the IOP in SO-induced glaucoma.[7-9]

Selective laser trabeculoplasty (SLT) is a relatively new and safe treatment to decrease the IOP in OAG patients[10,11], and has been shown to be an adjunctive treatment to topical medical therapy in OAG.[12] The use of SLT has also been reported in the treatment of SO-induced OAG [13,14], but no studies exist describing the effects of a repeat SLT in SO-induced OAG. Thus, our objective in this study was to evaluate the effects of a repeat SLT as an adjunctive treatment in patients with OAG secondary to SO.

MATERIALS AND METHODS

Twelve eyes from 12 patients who were treated with SLT for SO-induced OAG, between January of 2010 and August of 2013, were included in this retrospective study. The study was conducted following the principles laid out in the Helsinki Declaration. Written informed consent was obtained from all patients before the procedures.

The demographic characteristics of the study population were collected, including gender, age, pre-existing retinal pathology requiring vitreoretinal surgery with SO tamponade, lens status, time between SO injection and SO removal, and number of topical glaucoma medications. In addition, the following measurements were performed including, Snellen best corrected visual acuity (BCVA) converted to LogMAR, IOP measurement with Goldmann applanation tonometry (Nikon 27640; Japan) and ultrasonic pachymetry (Nidek P 100; Japan) measurements. TheBCVA, IOP, gonioscopic examination, slit-lamp biomicroscopic examination and dilated fundus examination were performed before all interventions.

All of the patients had histories of pars plana vitrectomy (PPV) with 1000 centistoke SO endotamponade. No scleral buckling procedures were performed.

Silicone Oil Removal

The SO was removed via a standard 23-G 3-port pars plana entry with active aspiration. The fundus was assessed by an illumination probe for any re-detachment during SO removal, and SO-fluid, fluid-air and air-fluid exchanges were performed during the procedures. The anterior chamber was washed with a balanced salt solution (BSS Plus; Alcon Laboratories, FortWorth, Texas, USA) to remove all SO droplets, and the scleral incisions were closed with 7-0 vicryl sutures at the end of surgery.

All of the patients had high IOPs (IOP≥21 mmHg) after emulsified SO removal, and were using maximally tolerated anti-glaucomatous medical therapies. Moreover, all of the patients had multiple previous ocular surgeries and low visual potential. None of the patients agreed to have a trabeculectomy. They all preferred SLT.

The inclusion criteria for this study were the followings: (1) no history of glaucoma or ocular hypertension before SO injection, (2) no glaucoma laser or surgery before SLT, (3) the presence of emulsified SO particles in the anterior chamber or anterior chamber angle, (4) a completely attached retina, and (5) open angle, no pupillary block or neovascularization on the surface of the iris or anterior chamber angle.

SLT was performed after a minimum of 1 month following SO removal. It was applied when reaching IOP ≥ 21 mmHg, despite receiving maximally tolerated anti-glaucomatous medical therapy. Moreover, repeat SLT treatments were carried out if the first SLT failed (IOP ≥ 21 mmHg). Success was defined as an IOP < 21 mmHg with anti-glaucomatous medical therapy.

Selective LaserTrabeculoplasty

After the application of 0.5% proparacaine hydrochloride, the SLT was performed with a Q-switched frequency-doubled Nd: YAG laser (OptoSLT; Optotek, Slovenia) emitting a wavelength of 532 nm, with a pulse duration of 4 ns and a spot size of 400 µm. The pigmented trabecular meshwork (TM) was targeted, and the SLT was applied as 100 non-overlapping spots covering 360 degrees.The laser energy was initially set at 0.8 mJ, and was subsequently increased up to 1.1 mJ until bubble formation occurred. The treatment was continued at the minimal energy level needed for bubble formation, and all of the SLT procedures were performed by the same physician (HB). The patients were administered 1% apraclonidine (Iopidine; Alcon, Fort Worth, TX, USA) 1 h before and just after the SLT treatment to prevent a postoperative IOP spike. In addition, 0.1% fluorometholone (Allergan Inc., Irvine, CA, USA) eye drops were given four times a day for 1 week after the SLT treatment. Furthermore, the ophthalmic examinations were performed before the SLT treatment, and 1 week and 1, 3, 6 and 9 months after the SLT treatments.

The Number Cruncher Statistical System (NCSS) 2007 (Kaysville, Utah, USA) software was used for the statistical

analyses. A p <0.05 was considered to be statistically significant, and the confidence interval was 95%.

RESULTS

Twelve eyes from 12 patients (5 females, 41.7 %; 7 males, 58.3 %) with a mean age of 42.75 ± 9.19 years (25-56 years) were included in this study. The indications for PPV with SO endotamponade were rhegmatogenous retinal detachment with proliferative vitreoretinopathy in 5 eyes (41.7 %), and proliferative diabetic retinopathy with tractional retinal detachment in 7 eyes (58.3 %). Two eyes (16.7 %) were phakic, 2 eyes (16.7 %) were aphakic and 8 eyes (66.6 %) were pseudophakic. Inferior peripheral iridectomies were performed at the time of PPV with SO injections in the aphakic eyes. The time interval between the SO injection and SO removal was 15.73 ± 3.80 months (10-22 months).

Before the first SLT, the mean BCVA was 1.89±0.93 LogMAR (0.7-3.0 LogMAR). At the end of the 19.08±3.68-month (15-27 months) follow-up period, the mean BCVA was 1.96±0.80 LogMAR (1.0-3.0 LogMAR) in all patients (p>0.05). In addition, the mean central corneal thickness was 551.75±12.22 µm (528-564 µm), and the mean number of topical glaucoma medications was 3.66±0.48 (3-4). None of the antiglaucomatous medications were discontinued in any of the patients during the study.The time interval between the SO removal and the first SLT was 2.91±1.44 months (1-6 months). The parameters for the first and repeat SLT treatments are summarized in Table 1. The mean IOP before the first SLT was 25.00±1.54 mmHg (23-28 mmHg), and it decreased to 20.25±1.76 mmHg (18-24 mmHg) 9 months later for all of the patients (p=0.001). Moreover, 13.0±3.26 months (9-18 months) following the first SLT, 6 patients (50 %) underwent repeat SLT. In those patients having repeat SLT, the IOP decreased from 23.50±1.76 mmHg (22-26 mmHg) to 19.83±1.83 mmHg (18-22 mmHg) after 6 months (p=0.004). The last measured IOP following the repeat SLT was 20.67±2.16 mmHg (18-24 mmHg), which was measured at a mean of 7.80±1.34 months (6-9 months) after the 6-month visit after the repeat SLT (p=0.026).

The IOP changes and success rates are shown in Table 2, Table 3 and Figure 1, and the success rates of each time point after the first and repeat SLT treatments are summarized in Table 4. The IOP was decreased to 20.58±1.62 mmHg (18-

Table 1: *Treatment parameters at the first and repeat SLT sessions*

		Range	Mean±SD	[a]p
Number of spots	First SLT(n=12)	98-115	107.50±6.47	0.115
	Repeat SLT(n=6)	95-112	103.83±5.98	
Power (mJ)	First SLT(n=12)	0.8-1.1	0.95±0.14	0.480
	Repeat SLT(n=6)	0.8-1.1	0.98±0.12	

[a]*Wilcoxon Signed Ranks Test*
mJ: millijoule, SD: standard deviation, SLT: selective laser trabeculoplasty

Table 2: *Intraocular pressure changes and success rates after first SLT treatment.*

Time	N	IOP(mmHg) Range	IOP(mmHg) Mean±SD	N (Success rate)	[a]p
Before the first SLT	12	23-28	25.00±1.54		
1 week	12	17-23	20.08±1.98	6 (50.0%)	
1 month	12	17-21	19.08±1.62	7 (58.3%)	
3 months	12	16-20	18.08±1.38	12 (100%)	0.001*
6 months	12	17-22	19.00±1.60	10 (83.3%)	
9 months	12	18-24	20.25±1.76	8 (66.7%)	
Post Hoc Test					[b]p
Before the first SLT-1 week	12	-7 – -3	-4.92±1.16		0.002*
Before the first SLT -1 month	12	-7 – -5	-5.92±0.79		0.002*
Before the first SLT -3 months	12	-8 – -5	-6.92±1.00		0.002*
Before the first SLT -6 months	12	-7 – -4	-6.00±1.13		0.002*
Before the first SLT -9 months	12	-6 – -3	-4.75±0.87		0.002*

[a]*Friedman test* [b]*Wilcoxon Signed Ranks Test* **p<0.05*
IOP: intraocular pressure, SD: standard deviation, SLT: selective laser trabeculoplasty

Table 3. *Intraocular pressure changes and success rates after repeat SLT treatment.*

Time	N	IOP (mmHg) Range	IOP (mmHg) Mean±SD	N (Success rate)	[a]p
Before repeat SLT	6	22-26	23.50±1.76		
1 week	6	18-21	19.83±1.17	4 (66.7%)	
1 month	6	17-21	19.50±1.76	3 (50.0%)	0.004*
3 months	6	18-21	19.00±1.26	5 (83.3%)	
6 months	6	18-22	19.83±1.83	4 (66.7%)	
Post Hoc Test					[b]p
Before repeat SLT – 1 week	6	-5 – -2	-3.67±1.21		0.027*
Before repeat SLT– 1 month	6	-5 – -3	-4.00±0.89		0.026*
Before repeat SLT – 3 months	6	-6 – -4	-4.50±0.84		0.024*
Before repeat SLT – 6 months	6	-4 – -3	-3.67±0.52		0.023*

[a]*Friedman test* [b]*Wilcoxon Signed Ranks Test* *$p<0.05$

IOP: intraocular pressure, SD: standard deviation, SLT: selective laser trabeculoplasty

Table 4: *Comparison of success rates after the first and repeat SLT treatments.*

	First SLT Success (N=12) (%)		Repeat SLT Success (N=6) (%)		[a]p
	Success (-)	Success (+)	Success (-)	Success (+)	
1 week	6 (50.0%)	6 (50.0%)	2 (33.3%)	4 (66.7%)	0.63
1 month	5 (41.7%)	7(58.3%)	3 (50.0%)	3 (50.0%)	1.00
3 months	0 (0%)	12(100%)	1 (16.7%)	5 (83.3%)	0.33
6 months	2 (16.7%)	10(83.3)	2 (33.3%)	4 (66.7%)	0.57

[a]*Fisher's Exact test*

Success (+): Intraocular pressure <21 mmHg; Success (-): Intraocular pressure ≥ 21mmHg

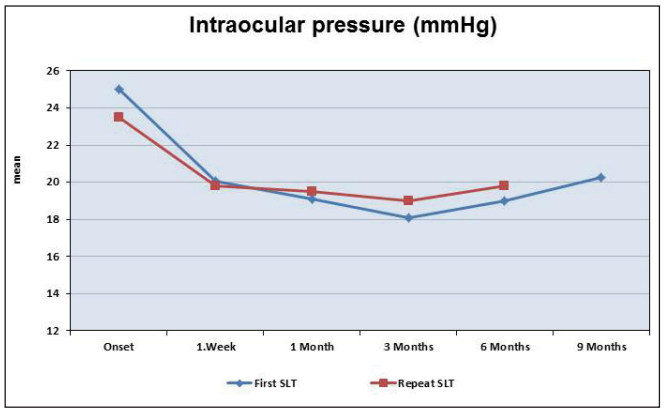

Figure 1: *Intraocular pressure changes after the first and repeat SLT treatments*

24 mmHg) in all of the patients (p=0.001), while the overall success rate was 58.3 % at the end of the 19.08±3.68-month follow-up period (15-27 months). An IOP spike was observed in 1 eye (8.33 %) after the first SLT, and a transient anterior chamber reaction was detected in 1 eye (8.33 %) following the repeat SLT. These complications were easily controlled with topical 0.5 % apraclonidine and 0.1 % fluorometholone drops.

DISCUSSION

Different mechanisms have been proposed for SO-induced glaucoma, including OAG due to the obstruction of the outflow with emulsified SO, angle closure and pupillary block, or the aggravation of pre-existing glaucoma with SO. Histological studies have also shown that SO loaded macrophages blocked the TM, eventually decreasing the outflow ability.[6,15,16] In the present study, we observed an open anterior chamber angle in all of the patients, and the increased IOP was more likely due to the decreased aqueous outflow by emulsified SO particles.

It has been previously shown that some degree of SO emulsification may be detected through slit-lamp examinations in up to 100 % of eyes, if the SO is left in place for one year.[7] In our study, the mean time interval between the SO injection and SO removal was 15.73±3.80 months (10-22 months), and all of the eyes had emulsified SO in the anterior chamber at the time of SO removal.

The removal of emulsified SO has not always facilitated IOP decreases in SO-induced glaucoma.[17] For example,

Casswell et al. reported a glaucoma incidence of 4.7 % following SO removal, while Lin et al.stated that the SO removal itself might cause IOP exacerbation by increasing the dispersion of emulsified SO, with subsequent obstruction of the TM.[18,19] The authors also emphasized the importance of anterior chamber irrigation to avoid IOP elevation secondary to emulsified SO. The emulsified SO was totally removed from the anterior chamber in our study. Moreover, the SO-fluid, fluid-air and air-fluid exchanges seemed to be effective in removing the emulsified SO microparticles.

The treatment of SO-induced secondary glaucoma remains a challenging issue, and studies have indicated that medical treatment has a limited ability to control high IOP in SO-induced OAG.[6,7] The conventional surgical methods for treating glaucoma have been reported to have greater risks for these patients, including hypotony.[9]In addition, SLT has already been reported to be a safe and effective treatment option in OAG patients. It has also been demonstrated that SLT increases the aqueous outflow in patients with OAG with minimal damage to the TM.[10,11] Several studies have reported successful results with SLT in lowering the IOP in SO-induced OAG. For instance, Zhang et al. reported a 59.5 % success rate (defined as an IOP reduction of ≥20% without any additional interventions) after SLT in SO-induced secondary glaucoma, with a mean IOP reduction of 4.7 mmHg at 12 months.[13] In addition, Alkin et al. showed a 91% success rate at 6 months after SLT treatment in SO-induced OAG, despite maximum topical antiglaucomatous treatment.[14]

The authors also suggested that increased aqueous outflow in SO-induced glaucoma depends on the effects of SLT activated SO-laden macrophages in the anterior chamber angle, which were similar to the effects of SLT in other OAG types.[20] We observed a significant IOP decrease from the baseline to 9 months after the first SLT treatment in the present study, which is similar to the abovementioned reports; however, 6 patients (50 %) showed higher IOP values (≥ 21 mmHg) and had repeat SLT 13.0±3.26 months (9-18 months) following the first SLT treatment. In one study, a repeat SLT treatment was shown to have a similar effect to the initial SLT in OAG, with a longer duration of treatment success.[21] Avery et al.reported the benefit of an additional SLT in maintaining a target IOP after the failure of the first SLT session.[22] In addition, Hong et al.demonstrated that a repeat SLT provided additional IOP reduction after the initial SLT failed.[23] We observed similar treatment success after the first and repeat SLT sessions in SO-induced OAG, with a 58.3% overall success rate at the end of the study. Moreover, we showed that a repeated SLT significantly decreased the IOP at 6 months after a repeat SLT, when compared to the IOP before SLT treatment.This result indicated that a repeat SLT is effective in maintaining a lower IOP in SO-induced OAG. However, the IOP (20.67±2.16 mmHg) was found to increase at 7.80±1.34 months after the 6-month control point (IOP=19.83±1.83 mmHg) of the repeat SLT, which showed that the effect of the repeat SLT was decreased over time in SO-induced OAG. Since our study had a relatively longer follow-up period when compared with studies evaluating the effects of SLT on SO-induced glaucoma, we can propose SLT as a repeatable treatment option in keeping the IOP at a desired level without any serious complications. However, this treatment option requires further investigation with long term studies in order to be fully adopted in SO-induced OAG.

It has been previously indicated that two SLT treatments in the same area of the TM had similar effects on the IOP reduction, compared with two SLT treatments in two different areas of the TM, when the initial SLT treatment had failed.[24] In our study, we applied the first and repeat SLTs to the same area of the TM with a similar power and number of spots, and found no significant difference in the treatment efficacy between the first and repeat SLT sessions.

Liu et al.[25] compared the effectiveness of argon laser trabeculoplasty (ALT) and SLT for lowering the IOP in younger patients (60 years old or younger).[25] They found that in younger patients, both the ALT and SLT have significant ocular hypotensive effects. In our study, the age of the patients was 42.75 ± 9.19 years (25–56 years), and this might have had an impact on our results.

Transient anterior chamber reactions, IOP spike and corneal failure have been reported following SLT.[11-13,26] Although rare, Bettis et al. reported that surgical intervention was needed after SLT procedure (e.g.; trabeculectomy, glaucoma drainage device implantation or corneal transplantation) due to a persistent IOP spike and corneal endothelial failure.[26] In another study, it was stated that a repeated SLT might lead to corneal endothelial damage, especially in the case of a compromised cornea with pigment deposits on the endothelium.[27] In the present study, we preferred not to use a heavy treatment modality for the SLT. As a result, we observed an IOP spike in 1 eye (8.33 %),as well as a transient anterior chamber reaction in 1 eye (8.33 %), which were successfully treated with topical medical therapy.

The limitations of our study were its retrospective design, patient selection bias and small number of patients involved. Furthermore, topical glaucoma medications were applied before and after SLT treatments, and this might be a limitation for precise evaluation. However, this report had novel findings, since it revealed the impact of repeat SLTs in SO-induced OAG.

Overall, the present study demonstrated that a repeat SLT provides successful IOP control after the first SLT in OAG secondary to emulsified SO. To the best of our knowledge, this is the first study evaluating the efficacy of a repeat SLT in SO-induced OAG. However, further studies are needed

to elucidate the effects of SLT on SO-induced glaucoma, to determine whether the SLT decreases the IOP after a given period of time.

A repeat session of SLT seemed to be effective for lowering the IOP in SO-induced OAG. However, further studies are needed in order to better understand the efficacy of a repeat SLT in SO-induced OAG.

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