Original Article

Laser intervention on trabeculo-Descemet's membrane after resistant viscocanalostomy: Selective 532 nm gonioreconditioning or conventional 1064 nm neodymium-doped yttrium aluminum garnet laser goniopuncture?

Huri Sabur, Mehmet Baykara, Basak Can

Purpose: To compare the results of conventional 1064 nm neodymium-doped yttrium-aluminum garnet laser goniopuncture (Nd:YAG-GP) and selective 532 nm Nd:YAG laser (selective laser trabeculoplasty [SLT]) gonioreconditioning (GR) on trabeculo-Descemet's membrane in eyes resistant to viscocanalostomy surgery. **Methods:** Thirty-eight eyes of 35 patients who underwent laser procedure after successful viscocanalostomy surgery were included in the study. When postoperative intraocular pressure (IOP) was above the individual target, the eyes were scheduled for laser procedure. Nineteen eyes underwent 532 nm SLT-GR (Group 1), and the remaining 19 eyes underwent conventional 1064 nm Nd:YAG-GP (Group 2). IOPs before and after laser (1 week, 1 month, 3 months, 6 months, 1 year, and last visit), follow-up periods, number of glaucoma medications, and complications were recorded for both groups. **Results:** Mean times from surgery to laser procedures were 17.3 ± 9.6 months in Group 1 and 13.0 ± 11.4 months in Group 2. Mean IOPs before laser procedures were 21.2 ± 1.7 mmHg in Group 1 and 22.8 ± 1.9 mmHg in Group 2 (P = 0.454). Postlaser IOP measurements of Group 1 were 12.1 ± 3.4 mmHg and 13.8 ± 1.7 mmHg in the 1st week and last visit, respectively; in Group 2, these measurements were 13.6 ± 3.7 mmHg and 14.9 ± 4.8 mmHg, respectively. There were statistically significant differences (P < 0.001) in IOP reduction at all visits in both groups; the results of the two groups were similar (P > 0.05). Mean follow-up was 16.6 ± 6.4 months after SLT-GR and 18.9 ± 11.2 months after Nd:YAG-GP. **Conclusions:** While conventional Nd:YAG-GP and SLT-GR, a novel procedure, are both effective choices in eyes resistant to viscocanalostomy, there are fewer complications with SLT-GR. SLT-GR can be an alternative to conventional Nd:YAG-GP.

Key words: Glaucoma, laser goniopuncture, neodymium-doped yttrium-aluminum garnet, selective laser trabeculoplasty, viscocanalostomy

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Viscocanalostomy is a nonpenetrating glaucoma surgery that allows filtration through a thin trabeculo-Descemet's membrane (TDM).[1,2]

Postoperative laser goniopuncture of TDM by neodymium-doped yttrium-aluminum garnet (Nd:YAG) laser reduces its resistance and enhances aqueous outflow by creating one to several tiny holes or slits.[3] The success rates of nonpenetrating glaucoma surgeries complemented by laser goniopuncture are high, which is similar to those of trabeculectomy.[4] Conventional 1064 nm Nd:YAG laser has been widely used for this purpose, whereas published results for frequency-doubled 532 nm Nd:YAG selective laser trabeculoplasty (SLT) are currently limited.[5,6]

To the best of our knowledge, this comparison results between conventional Nd:YAG laser goniopuncture (Nd:YAG-GP) and modified SLT gonioreconditioning (SLT-GR) is the first to be published in the relevant literature.

Methods

Thirty-eight eyes of 35 glaucoma patients were enrolled in this retrospective cohort study. The patients were identified from surgical logbooks and clinical databases at Department of Ophthalmology, Uludag University Faculty of Medicine. All of the patients had previously undergone viscocanalostomy for primary open-angle glaucoma (POAG) and secondary open-angle glaucoma (pseudoexfoliation, pigmentary, and postinflammatory glaucoma) between 2008 and 2014. The eyes with a history of trauma, with previously undergone glaucoma surgery, any eyes suffered from angle closure glaucoma, and insufficient data were excluded from the study.

Presurgery data included best-corrected visual acuity, assessed with the Snellen chart, Goldmann applanation tonometry, slit lamp biomicroscopy, fundoscopy, and gonioscopy. All the patients had uncontrolled glaucoma that was defined as progressive glaucomatous optic nerve morphology, on maximum tolerated medical therapy.

Viscocanalostomy was performed by one surgeon (author Mehmet Baykara) using the method described by

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Stegmann *et al*.[1] An upper fornix-based conjunctival flap was made. Then, a 5 mm × 5 mm, one-third thickness scleral flap was dissected 0.5 mm into the clear cornea. A second square scleral flap, 4 mm × 4 mm, two-third thickness, was dissected. Then, the inner scleral flap was excised. At the level of the scleral spur, Schlemm's canal was deroofed and peeled its floor. A 30-gauge cannula was used to inject sodium hyaluronate (1.4 mg/ml), both left and right Schlemm's canal. The superficial scleral flap was sutured with 10.0 polyglactin sutures, and the conjunctiva was closed with 10.0 polyglactin running sutures.

Postoperative laser procedure was performed in cases of higher postoperative intraocular pressures (IOPs) than targeted (IOPs equal to or higher than 21 mmHg with or without medications). Nineteen of the 38 eyes underwent SLT-GR (532-nm, frequency-doubled, Q-switched, Solo Lazer; Ellex, Adelaide, Australia) (Group 1), and the remaining 19 eyes underwent Nd:YAG-GP (conventional 1064-nm, free-running, Q-switched, Lpulsa SYL 9000; Lightmed, San Clemente, CA) (Group 2). Before laser intervention, all eyes underwent gonioscopic examination and any condition that can lead to complications such as neovascularization, convex peripheral iris configuration was ruled out. The laser was applied under topical anesthesia, over the surgical area only (TDM), by the same surgeon who carried out the viscocanalostomy (author Mehmet Baykara). Using a glass CGAL gonioscopy lens (Haag-Streit AG, Koeniz, Switzerland), the laser beam was aimed just anterior to the pigmented part of the TDM to avoid iris prolapse. Gonioscopic view of the surgery area and laser spots was shown in Fig. 1. The conventional Nd:YAG-GP was conducted with energy levels of 2–6 mJ, spot size of 8 μm, and 8–10 shots; the modified SLT-GR was performed with energy levels of 0.6–1 mJ, spot size of 400 μm, and 4–6 shots.

Laser procedures were applied at anterior and lateral edge of the TDM over the surgical area, starting with lower energy levels. Because of high iris incarceration risk, laser goniopuncture was avoided to perform at the center of the TDM with high energy levels, especially during Nd:YAG-GP. While performing Nd:YAG-GP, several tiny holes or slit was seen, at SLT-GR group champagne bubbles were seen, there were no visible holes. While sudden drop at IOP and bleb formation occurs right after Nd:YAG-GP, bleb distension happened at the midterm period after SLT-GR.

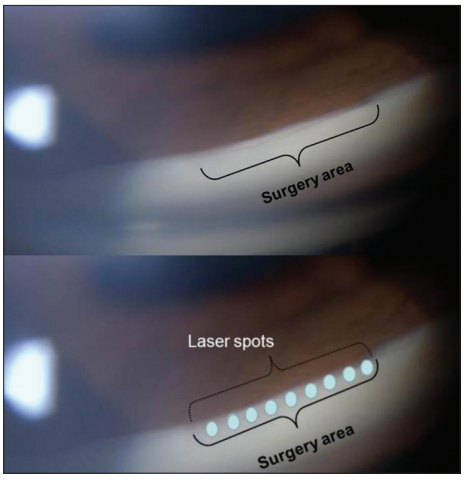

Figure 1: Gonioscopic view of the trabeculo-Descemet's membrane (surgery area) and aimed laser spots

After the laser procedure, examinations included Goldmann applanation tonometry, slit lamp biomicroscopy, fundoscopy, and gonioscopy were performed at 1 week, 1 month, 3 months, 6 months, and at 6-month intervals. The following data were recorded for each subject: sex, age, failure time after viscocanalostomy, IOPs (Goldmann applanation tonometer) before and after laser interventions (1 week, 1 month, 3 months, 6 months, 1 year, and last visit), number of glaucoma medications, complications from the laser procedures, and follow-up periods.

Success was defined as maintenance of IOP <20 mmHg for two consecutive visits without increasing prelaser glaucoma medications or 20% decrease from levels before laser procedure. If the IOP failed to drop to target levels, glaucoma medications were added and if the IOPs higher than 21 mmHg despite the laser procedures and topical antiglaucomatous treatment were defined as surgical failure. Those who failed underwent trabeculectomy.

SPSS 20.0 (IBM, Chicago, USA) was used to evaluate the results. Nonparametric data were analyzed using the Mann–Whitney U-test and Wilcoxon tests. All tests were two-tailed, and $P < 0.05$ was considered statistically significant. The study was approved by the Local Ethics Committee, according to the tenets of the Declaration of Helsinki. Fully informed consent was obtained from each patient.

Results

Thirty-eight laser procedures were performed during the specified period. Demographic characteristics of the subjects are listed in Table 1.

Mean times between viscocanalostomy and laser procedure were 17.3 ± 9.6 months in Group 1 and 14.0 ± 11.4 months in Group 2 ($P = 0.096$). IOP measurements before laser procedure were 21.2 ± 1.7 mmHg in Group 1 and 22.8 ± 1.9 mmHg in Group 2 ($P = 0.454$). IOP at 1 week after SLT-GR was 12.1 ± 3.4 mmHg; IOP at 1 week after conventional Nd:YAG-GP was 13.6 ± 3.7 mmHg ($P = 0.214$). Mean IOPs at the last visit were 13.8 ± 1.7 mmHg in the SLT group at 16.6 months follow-up and 14.9 ± 4.8 mmHg in the conventional Nd:YAG-GP group at 18.9 months follow-up ($P < 0.001$). IOP reduction rate after

Table 1: Patient demographic characteristics

	SLT-GR (*n*=19)	Nd:YAG-GP (*n*=19)	*P*
Age, years±SD	61.1±11.2	62.7±9.9	0.627
Male/female	10/8	9/8	0.746
Race	Caucasian	Caucasian	
POAG	12	11	
PXG	4	4	
INFG	2	3	
PDG	1	1	

SD: Standard deviation, POAG: Primary open-angle glaucoma, PXG: Pseudoexfoliation glaucoma, INFG: Postinflammatory glaucoma, PDG: Pigment dispersion glaucoma, SLT-GR: Selective laser trabeculoplasty gonioreconditioning, Nd:YAG-GP: Neodymium-doped yttrium-aluminum garnet laser goniopuncture

SLT-GR at the last visit was 34.9%; for Nd:YAG-GP, it was 34.6%. Comparing IO*P* values before laser procedures to all follow-u*P* values, the IOP-lowering effect was statistically significant in both groups ($P < 0.001$). IOP reductions at all follow-up visits were found to be consistent ($P = 0.214$, $P = 0.064$, $P = 0.242$, $P = 0.582$, $P = 0.473$ and $P = 0.703$ respectively). The follow-up results of both groups are listed in Table 2.

While SLT-GR success rate was 100.0% at 6 months, 94.7% at 12 months, Nd:YAG-GP success rate was 94.7% at 6 months, 89.4% at 12 months. One eye (pseudoexfoliation glaucoma) at SLT-GR group and two eyes (POAG) at Nd:YAG-GP were identified as a surgical failure despite laser goniopuncture procedures and medical treatment.

While mean number of glaucoma medications was 2.5 ± 1.1 (range 0–4) before laser intervention and 1.0 ± 0.9 (range 0–2) at the last follow-up examination ($P < 0.001$) at SLT-GR group, for Nd:YAG-GP, they were 2.4 ± 1.2 (range 0–4) and 1.1 ± 0.8 (range 0–2), respectively, ($P < 0.001$). Mean number of glaucoma medications was found to be consistent in both groups at pre- and post-laser periods ($P = 0.892$, $P = 0.716$, respectively).

The only complication that occurred after SLT-GR was iris incarceration through the puncture site in one eye. The iris incarceration was shown in Fig. 2. Given that the IOP was <20 mmHg, the subject was observed, and no further interventions were needed. Following conventional Nd:YAG-GP, iris incarceration was determined in three eyes and ocular hypotony was found in two eyes. Iris incarceration occurred acutely after the laser procedure in one eye, and ocular massage and pilocarpine 2% (Pilosed®) drops were successfully applied to treat it. In the other two eyes, iris incarceration presented during the longer follow-up periods, and pupil miotic medication was not sufficient. IOP could not be reduced below the target range by medical therapy alone, and trabeculectomy was performed.

Discussion

Nonpenetrating glaucoma surgery has been increasingly preferred over trabeculectomy in high-risk patients (uniocular, low vision, high cup/disc ratio, high IOP) due to the lower complication rates.[1,2] Therefore, the use of postoperative laser procedure has been a trending topic. According to the World Glaucoma Association guidelines, even if it is not needed as an adjunct for all cases, goniopuncture is recommended in cases of increased IOP, and it is not defined as postoperative failure.[7] The target of laser goniopuncture is to decrease TDM resistance and lower IOP. Both Nd:YAG laser and SLT have been used after nonpenetrating glaucoma surgeries. Conventional Nd:YAG-GP creates tiny holes or slits using a smaller spot size (8 µm) with higher energy power, whereas SLT only affects pigmentary TDM cells with a larger spot size (400 µm) and less energy per pulse. In the current study, gonioscopy revealed no visible holes after SLT-GR. We believe that SLT may be able to recondition TDM without creating a visible hole, as noted by Mansouri *et al*.[5]

In cases where maintaining the targeted IOP cannot be achieved after nonpenetrating glaucoma surgery, previous studies in the literature have suggested performing laser goniopuncture before topical antiglaucomatous treatment to prevent fibrosis of the TDM and scleral lake collapse.[3,8] In a previous study that examined the TDM with *in vivo* confocal microscopy, laser goniopuncture was not effective after TDM fibrosis.[9]

Laser goniopuncture rates after nonpenetrating filtering surgery have been reported as 4.7–72%.[2,4,10-18] The increasing numbers contribute to the higher success rates of nonpenetrating

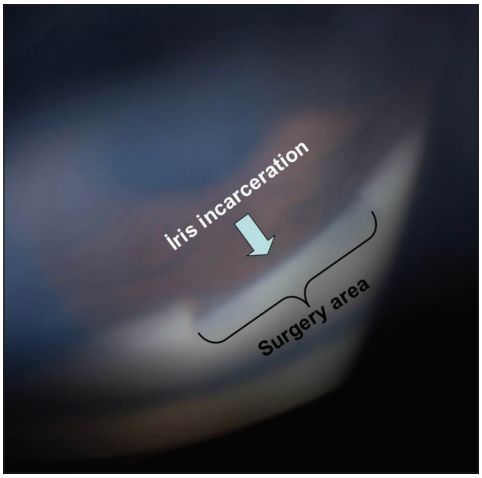

Figure 2: Iris incarceration to trabeculo-Descemet's membrane discovered on gonioscopic examination

Table 2: Intraocular pressure changes after selective laser trabeculoplasty gonioreconditioning and neodymium-doped yttrium-aluminum garnet laser goniopuncture procedures

IOP (mmHg)	SLT-GR		Nd:YAG-GP		*P*
	Mean±SD	Median (minimum-maximum)	Mean±SD	Median (minimum-maximum)	
Before laser	21.2±1.7	23 (21-26)	22.8±1.9	21 (21-25)	0.454
1 week	12.1±3.4*	12 (6-19)	13.6±3.7*	13 (5-26)	0.214
1 month	11.9±3.1*	11 (6-19)	14.4±3.8*	15 (5-29)	0.064
3 months	12.1±3.0*	11 (6-18)	13.8±4.3*	14 (5-25)	0.242
6 months	12.3±1.9*	12 (9-17)	12.7±4.0*	12 (6-24)	0.582
1 year	12.1±2.7*	12 (9-21)	13.1±4.4*	13 (6-26)	0.473
Last visit	13.8±1.7*	14 (11-21)	14.9±4.8*	13 (4-25)	0.703

Mann–Whitney U-test/Wilcoxon test/*IOP change before laser intervention $P<0.05$. IOP: Intraocular pressure, SD: Standard deviation, SLT-GR: Selective laser trabeculoplasty gonioreconditioning, Nd:YAG-GP: Neodymium-doped yttrium-aluminum garnet laser goniopuncture

filtering surgery. Conventional Nd:YAG-GP success rates have been reported as 49–95%.[2,4,10-18] Two previous studies, with 6- and 3-month follow-up periods, reported SLT-GR success rates of 90% and 100%, respectively.[5,6] In the current study, the success rates were 89.4% (17/19) at 18.9 months' follow-up for conventional Nd:YAG-GP and 94.7% (18/19) at 16.6 months' follow-up for SLT-GR. We believe these variable results depend on creating a proper TDM and the experience of the surgeon performing the laser procedure.

In the literature, previously reported complications of conventional Nd:YAG-GP include iris incarceration, hyphema, hypotony, hypotony with maculopathy, late-acute IOP rise, choroidal detachment, and blebitis.[19,20] No such complications have been reported after SLT-GR.[5,6] Higher complication rates occur with Nd:YAG-GP because the creation of a small hole with high energy levels leads to greater drainage and turbulence. Thus, the higher the IOP becomes, the more the complication risk increases. In our study, the IOPs of one patient with iris incarceration and two patients with postlaser hypotony were >30 mmHg. Tam *et al*.[3] suggested lowering the IOP to <25 mmHg to prevent iris incarceration after laser goniopuncture.

Although no complications have been previously reported with SLT-GR,[5,6] one eye in the current study had iris incarceration during long-term follow-up (2 months after laser intervention). That eye had a prelaser IOP of 21 mmHg, and it was pseudophakic. Iris incarceration was a probable result of sudden IOP peaks after the laser procedure. To minimize the risk of iris incarceration, Anand and Pilling[19] suggested that conventional Nd:YAG-GP should be avoided during the 1st postoperative month when the subconjunctival outflow resistance level is lower. Goniopuncture is best performed on the anterior edge of the TDM, rather than the center, starting with lower energy levels (2–3 mJ). Prophylactic argon iridoplasty may be an option in case of iris incarceration through the puncture site.[5]

Conventional Nd:YAG-GP and SLT-GR are both effective choices on eyes resistant to viscocanalostomy. Compared to conventional Nd:YAG-GP, SLT-GR is a newer procedure, and the rate of complications is lower. Thus, SLT-GR can be an alternative to conventional Nd:YAG-G. Further studies on larger groups with longer follow-up periods would help determine its long-term benefits and complications.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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