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Selective laser trabeculoplasty versus argon laser trabeculoplasty in patients with uncontrolled open-angle glaucoma

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PURPOSE. *To compare the efficacy of selective laser trabeculoplasty (SLT) to argon laser trabeculoplasty (ALT) as treatment and retreatment to lower intraocular pressure (IOP) in patients with uncontrolled open-angle glaucoma (OAG) on maximally tolerated medication therapy with a follow-up of 12 months.*

METHODS. *A total of 120 eyes of 120 patients with uncontrolled OAG were enrolled in the study. Group A included patients with IOP >22 mmHg on maximal medical therapy. A total of 43 eyes underwent SLT treatment and 41 eyes underwent ALT treatment. At the end of the follow-up IOP was <18 mmHg. Group B included patients with IOP >20 mmHg at 3 months follow-up after SLT or ALT treatment. These patients were retreated randomly, 18 with SLT and 18 with ALT.*

RESULTS. *In Group A at the end of the follow-up there was no statistically significant difference in IOP lowering between SLT (6.01 mmHg) and ALT (6.12) (p=0.794). In Group B at the end of the follow-up patients undergoing SLT presented IOP lowering statistically significant to ALT treatment (6.24 mmHg and 4.65 mmHg, respectively, p<0.01).*

DISCUSSION. *SLT is effective as treatment for patients with OAG and appears to be equivalent to ALT in IOP lowering at 12 months only in patients without a prior treatment. In case of retreatment SLT appears to be better than ALT in IOP lowering. (Eur J Ophthalmol 2009; 19: 429-34)*

KEY WORDS. *Selective laser trabeculoplasty, Argon laser trabeculoplasty, Intraocular pressure, Open-angle glaucoma*

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INTRODUCTION

In 1979, when Wise and Witter (1) demonstrated that argon laser trabeculoplasty (ALT) lowered intraocular pressure (IOP), it added an additional therapeutic option to the treatment of open-angle glaucoma (OAG). It was hoped that ALT would postpone or eliminate the need for incisional or cyclodestructive surgical intervention. Other laser therapies, such as the krypton or diode lasers, have been used in trabeculoplasty with similar results to that of ALT (2-4). However, histologic studies have shown that laser therapy causes coagulation damage and scarring of the trabecular meshwork (TM) (5-7). This theoretically can limit the success of future retreatment of the TM by ALT. Recently, Latina and Park (8) used a 532 nm Q-switched Nd:YAG laser to selectively target pigmented TM cells in vitro with low threshold radiant exposures without producing collateral damage to adjacent nonpigmented cells or structures. This laser gives a single pulse of short duration (in the microsecond range) and low fluence (energy/area). At these values, unlike in ALT, thermal diffusion from targeted cells to surrounding nonpigmented trabecular meshwork cells is minimized; therefore, the technique has been named selective laser trabeculoplasty (SLT). A

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histologic study in human cadaver eyes treated with SLT or ALT within 18 hours of death confirmed that selective treatment appears to cause no coagulation damage to the TM and less structural damage than ALT (9). Following the results of the study by Latina and Park (8), the clinical application of a Q-switched Nd:YAG laser for SLT was proposed as a new laser treatment for chronic open angle glaucoma (10). The possibility of avoiding relevant thermal or coagulative damage in the TM with SLT represents a major improvement over conventional ALT. As a consequence, SLT might be applied many times in the same eye without determining coagulative scarring that focally reduces or prevents aqueous outflow. The aim of the present study was to compare the success rates of patients who underwent ALT versus SLT as treatment and retreatment to lower IOP in patients with OAG with a follow-up of 12 months.

METHODS

A prospective randomized clinical trial was approved by the Institutional Review Board of the University of Foggia. The patients included in this trial were those referred to the glaucoma clinic at the University of Foggia. All of the patients had uncontrolled chronic OAG on maximally tolerated medication therapy. All patients provided informed consent after the potential risks, benefits, and alternatives of the procedures were explained fully. Patients with evidence of glaucoma other than OAG and patients with prior glaucoma or cataract surgery were excluded from the study. Patients with pseudoexfoliation or pigment dispersion glaucoma were not included in the study. A total of 120 eyes of 120 patients with uncontrolled OAG were enrolled in the study. Preoperative data obtained for each patient included age, gender, ocular history, number of antiglaucoma drugs used at that time, best-corrected visual acuity logMar (best-corrected visual acuity), IOP measured by Goldmann applanation, slit-lamp examination, gonioscopy, fundus biomicroscopy, and visual field testing by Humphrey visual field analyzer using the 30-2 threshold SITA Standard program. Postoperatively, IOP, number of antiglaucoma medications, and complications were recorded on the first day and at 1, 3, 6, and 12 months. The observer who performed the Goldmann applanation tonometry was masked to the allocation of the patients to the SLT or the ALT group.

On the day of treatment, patients were assigned randomly to either ALT treatment (60 eyes) or SLT treatment (60 eyes), based on glaucoma clinic chart number (patients with even numbers were assigned to ALT treatment and patients with odd numbers were assigned to SLT treatment); chart numbers were not assigned until the day of treatment. Group A included patients with IOP >22 mmHg on maximal medical therapy; 43 eyes underwent SLT treatment and 41 eyes underwent ALT treatment. At the end of the follow-up, IOP was <18 mmHg. Group B (36 eyes) included patients with IOP >20 mmHg at 3 months follow-up after SLT or ALT treatment, 17 patients belonging to the SLT group and 19 patients belonging to the ALT group. These patients were retreated randomly: 18 with SLT and 18 with ALT. The operative techniques used in the SLT group were followed as described by Latina et al (9). Topical oxibuprocain 0.4% was used as anesthesia for the treatment. The Lumenis Selecta II Glaucoma Laser System, a frequency-doubled q-switched neodymium:yytrium–aluminum–garnet laser, was used to treat these patients. The laser was emitting at 532 nm with a pulse duration of 3 nanoseconds and a spot size of 400 µm. The pigmented TM was targeted, and 60, but nonoverlapping, laser spots were placed over 360° of the TM. In SLT, the energy level for treatment was initially set at 0.8 mJ and ranged from 0.6 to 1.0 mJ. If the energy level was too high (demonstrated by cavitation bubbles or if disruption of the TM was visualized), the pulse energy was decreased by increments of 0.1 mJ until minimal bubble formation or disruption to the TM was visualized. The total number of pulses delivered at each energy level and the total amount of energy delivered, as indicated on the laser control panel, were recorded. The lens of Latina was used to perform the laser treatment. All SLT and ALT procedures were performed by the same surgeon (V.R.). Patients undergoing ALT were treated with a Coherent 900 laser, argon blue–green, with a 0.1-second pulse duration and a spot size of 50 µm. From 470 to 1,150 mW of energy was delivered. Energy was titrated to achieve a blanching effect in the TM. Laser spots were placed over 360° of the TM. Post-treatment management of both groups was similar. One drop of topical indomethacin 0.1% 4 times daily was prescribed 4 times daily for 1 week. The IOP was checked at 1 hour after both ALT and SLT. Patients who previously had been treated by ALT or SLT underwent an additional 360° of ALT or SLT treatment. Statistical analysis was carried out using chi-square test. Values below 0.05 were considered statistically significant.

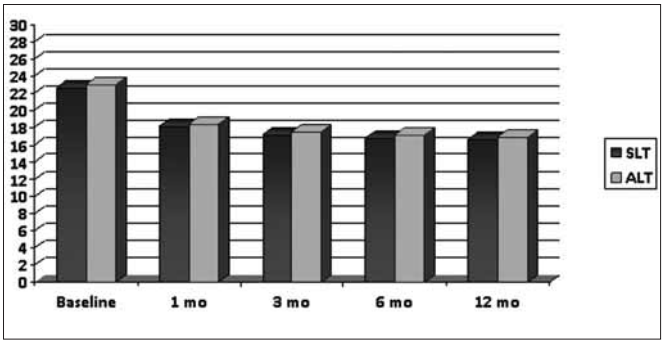

Fig. 1 - *Graph illustrating intraocular pressure (mmHg) in patients who underwent selective laser trabeculoplasty (SLT) or argon laser trabeculoplasty (ALT). In SLT and ALT groups, compared to baseline, values were significantly lower at all time points (p<0.05).*

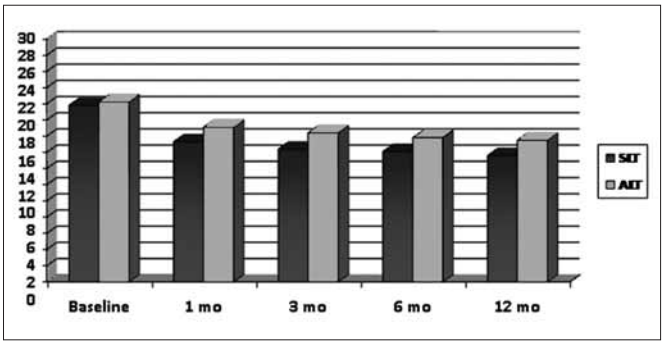

Fig. 2 - *Graph illustrating intraocular pressure (mm Hg) in patients who underwent retreatment with selective laser trabeculoplasty (SLT) or argon laser trabeculoplasty (ALT). Compared with ALT groups, values for SLT group were significantly lower at all time points (p<0.05).*

RESULTS

A total of 120 eyes of 120 patients were included. All baseline characteristics including IOP were similarly distributed in the two groups. The baseline characteristics of these patients are summarized in Tables I, II, and III. Both treatments were free of bleeding. Patients did not complain of any pain during treatment with either laser. We defined pretreatment IOP as the average IOP of the two diurnal curves of the two visits before the date when laser trabeculoplasty was performed. When comparing pretreatment IOP with all follow-up times, there was a significant reduction in IOP (Fig. 1) in Group A. The last follow-up IOP (12 months) was similar between the ALT and SLT groups (ALT, 16.9±1.9 mmHg vs SLT, 16.7±1.7 mmHg; $p > 0.05$). The mean IOP percent reduction at each follow-up visit was similar between ALT and SLT treatment groups (Tab. IV). There was no significant difference in the reduction of the number of medications in the ALT and SLT groups at all time points (Tab. V). In Group B, at the end of the follow-up, patients undergoing SLT presented statistically significant IOP lowering compared to ALT treatment, 6.24 mmHg and 4.65 mmHg, respectively ($p<0.01$) (Fig. 2). There was no significant difference in the number of medications in the ALT and SLT retreatment groups at all time points (Tab. VI). As listed in Tables VII

TABLE I - PRETREATMENT PATIENT CHARACTERISTICS

Characteristics	Selective laser trabeculoplasty (n=60)	Argon laser trabeculoplasty (n=60)
Age, yr (mean ± SD)	57.8±5.3	59.1±3.2
Male	23 (38.4%)	22 (36.6%)
Female	37 (61.6%)	38 (63.3%)
Mean preoperative IOP (mmHg)	22.7±1.2	23±1.1
Mean preoperative glaucoma medications	2.3±1.3	2.4±1.1

TABLE II - PRETREATMENT PATIENT CHARACTERISTICS (GROUP A)

Characteristics	Selective laser trabeculoplasty (n=43)	Argon laser trabeculoplasty (n=41)
Age, yr (mean ± SD)	57.8±5.3	59.1±3.2
Male	19 (44.1%)	16 (39%)
Female	24 (55.8%)	25 (61%)
Mean preoperative IOP (mmHg)	22.7±1.2	23±1.1
Mean preoperative glaucoma medications	2.3±1.3	2.4±1.1

TABLE III - PRETREATMENT PATIENT CHARACTERISTICS (GROUP B)

Characteristics	Selective laser trabeculoplasty (n=18)	Argon laser trabeculoplasty (n=18)
Age, yr (mean ± SD)	56.5±4.3	57.6±3.8
Male	7 (38.8%)	8 (44.4%)
Female	11 (61.2%)	10 (55.5%)
Mean preoperative IOP (mmHg)	21.8±1.6	22.2±1.1
Mean preoperative glaucoma medications	2.1±1.5	2.4±1.1

TABLE IV - INTRAOCULAR PRESSURE PERCENT REDUCTION IN SELECTIVE LASER TRABECULOPLASTY AND ARGON LASER TRABECULOPLASTY GROUPS

Time	Selective laser trabeculoplasty, % decrease (n=43)	Argon laser trabeculoplasty, % decrease (n=41)
1 mo	19.9*	20*
3 mo	24.3*	23.5*
6 mo	26*	25.3*
12 mo	26.5*	26.6*

*p>0.05.

TABLE V - MEAN NUMBER OF MEDICATIONS IN SELECTIVE LASER TRABECULOPLASTY AND ARGON LASER TRABECULOPLASTY GROUPS AT TIME PERIODS

Time	Selective laser trabeculoplasty (n=43)	Argon laser trabeculoplasty (n=41)
Pretreatment	2.3±1.3*	2.4±1.1*
3 mo	2.1±1.1*	2.3±1.2*
6 mo	2.2±1.2*	2.3±1.2*
12 mo	2.2±1.1*	2.3±1.2*

*p>0.05.

TABLE VI - MEAN NUMBER OF MEDICATIONS IN SELECTIVE LASER TRABECULOPLASTY AND ARGON LASER TRABECULOPLASTY GROUP B AT TIME PERIODS

Time	Selective laser trabeculoplasty (n=18)	Argon laser trabeculoplasty (n=18)
Pretreatment	2.1±1.5*	2.4±1.1*
3 mo	2.2±1.1*	2.4±1.2*
6 mo	2.1±1.2*	2.3±1.2*
12 mo	2.0±1.1*	2.2±1.2*

*p>0.05.

and VIII, after surgery, 66 (78.5%) of 84 patients in Group A and 25 (69.4%) of 36 patients in Group B experienced a mild-to-moderate anterior chamber reaction. This was visible within 1 hour after treatment and usually decreased within 24 hours. To date, there were no cases of persistent iritis. The anterior chamber reaction improved in all cases and resolved completely within 3 days. There

TABLE VII - ADVERSE EVENTS (TREATED EYE ONLY) GROUP A

Event	Selective laser trabeculoplasty (n=43)	Argon laser trabeculoplasty (n=41)
Anterior chamber inflammation (mild to moderate)	32 (74.4%)	34 (82.9%)
IOP elevation (within 2 hr postoperation) >6 mmHg	6 (13.9%)	7 (17%)
Peripheral anterior synechiae formation	0	0

Values are n (%).

TABLE VIII - ADVERSE EVENTS (TREATED EYE ONLY) GROUP B

Event	Selective laser trabeculoplasty (n=18)	Argon laser trabeculoplasty (n=18)
Anterior chamber inflammation (mild to moderate)	12 (66.6%)	13 (72.2%)
IOP elevation (within 2 hr postoperation) >6 mmHg	3 (16.6%)	4 (22.2%)
Peripheral anterior synechiae formation	0	0

Values are n (%).

was no evidence of peripheral anterior synechiae formation in any group after treatment. A transient increase in IOP of 6 mmHg or greater than the preoperative IOP occurred in 13 eyes (15.4%) in Group A and 7 (19.4%) in Group B. This occurred within 2 hours after treatment. The IOP elevations were treated with one tablet of acetazolamide 250 mg and resolved in all cases within 24 hours. There was no change in visual acuity or visual field throughout the study in the two groups.

DISCUSSION

ALT, introduced in 1979 (1), rapidly became a standard option in the clinical management of OAG. SLT is a potentially useful addition to the techniques available for glaucoma therapy (11). The main advantage of SLT over tradi-

tional argon laser techniques is considered to be selective targeting of the pigmented trabecular meshwork cells, avoiding thermal damage to nonpigmented cells or other local structures, such as the scleral beams of the meshwork tissue (12). Furthermore, the repeated use of ALT is limited with increased risk of scarring and loss of outflow (13). This difference has led the proponents of SLT to postulate that SLT may have an increased long-term success rate as compared with ALT. Therefore, we compared the long-term success rate, reduction of IOP, and medical dependency of OAG patients who underwent SLT versus ALT as treatment and retreatment with a follow-up of 12 months. Our results showed that, at the end of follow-up, there was no statistically significant difference in the intraocular pressures and medical dependence in the patients with medically uncontrolled OAG undergoing ALT or SLT, according with other authors (14-16). Because SLT does not cause coagulative damage, it is proposed that SLT is effective in repeat treatments on the same eye (17). The current study shows that patients who have received a previous laser trabeculoplasty can still benefit from SLT, showing a IOP lowering better than ALT treatment, confirming that SLT is effective and safe in repeat treatments on the same eye. No significant adverse effects were noted in patients who underwent laser trabeculoplasty. In summary, SLT appears to be equivalent to ALT in lowering IOPs in patients with OAG. Interestingly, patients with previous failed ALT or SLT had a better outcome when treated with SLT vs ALT. There are two limitations that need to be acknowledged and addressed regarding the present study. The first limitation concerns the small sample size of Group B (n = 36). The second limitation concerns that patients of Group B were randomly allocated again to the ALT or the SLT treatment group. Therefore, four possible combinations of SLT and ALT are thinkable. However, these results are encouraging and suggest that SLT should be investigated further as an IOP lowering treatment in OAG, especially in patients with previously failed ALT or SLT.

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