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Frequency-doubled neodymium yttrium aluminum garnet (Nd:YAG) laser trabeculoplasty as adjuvant therapy for open-angle glaucomas

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ABSTRACT

The thermal frequency-doubled Nd:YAG (neodymium: yttrium-aluminum-garnet) laser was used sparingly for trabeculoplasty. Our goal was to assess the efficacy and safety of frequency-doubled Nd:YAG laser trabeculoplasty as an adjunct therapy to anti-glaucoma medications in open-angle glaucoma. Laser trabeculoplasty was performed on 41 eyes of 22 adults with open-angle glaucomas using a thermal frequency-doubled Nd:YAG laser (Green laser photocoagulator GYC-500® 532 nm, Nidek, Japan). To assess the laser's effectiveness, patients were monitored for intraocular pressure (IOP) reduction, control, and complications at 1 hour, 1 week, and then monthly for a year. Primary open-angle glaucoma was the most common diagnosis in 31 (75.6%) eyes. The pre-laser baseline IOP was 18.87±3.66 mmHg. The mean IOP was 14.9±2.54 mmHg at Week 1 ($p = 0.000$), 14.65±2.50 mmHg at Month 1, 14.53±2.60 mmHg at Month 3, 15.85±2.30 mmHg at Month 6, and 15.14±2.17 mmHg at Month 12 ($p=0.000$). A significant percentage reduction in IOP was achieved at 1, 3, 6, and 12 months: 21.78%, 22.48%, 16.73%, and 18.53%, respectively. Patients used an average of 2.73±1.00 topical drugs before laser treatment. There was a significant reduction in medicines after laser treatment on all occasions, at 1, 3, 6, and 12 months ($p = 0.000$). Complications included some degree of peripheral anterior synechiae (PAS) in 20 (51.3%) eyes; an IOP spike in one patient only, bilaterally (5.1%) at 1 hour after therapy; and mild anterior uveitis in four (9.75%) cases. To summarize, frequency-doubled Nd:YAG laser trabeculoplasty is a safe and effective adjuvant therapy for open-angle glaucoma that reduces intraocular pressure and medication use.

Key words: glaucoma, open-angle, intraocular pressure, laser trabeculoplasty, frequency-doubled Nd:YAG, complications.

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Introduction

The burden of glaucoma

Glaucoma, the 'sneak thief of sight,' is the leading cause of irreversible blindness, affecting over 60 million people worldwide.[1] According to the World Health Organization's statistics, this debilitating disease blinds 4.5 million people globally, accounting for more than 12% of the burden of global blindness.[2] Therapy for open-angle glaucoma relies mainly on intraocular pressure (IOP) lowering strategies.[3]

The evolution, mechanism, and types of laser trabeculoplasty

Laser trabeculoplasty (LTP) for open-angle glaucoma was first introduced in 1979 by Wise and Witter. They utilized argon laser trabeculoplasty (ALT) to target the trabecular meshwork (TM). They believed that multiple mechanisms contributed to the increased outflow of aqueous solutions, both mechanical and biological. Laser-induced thermal burns led to collagen and tissue contraction, reduction of the diameter of the inner trabecular ring, tightening, stretching, and widening of TM spaces, and opening of Schlemm's canal, thereby improving aqueous outflow. Other mechanisms include increased phagocytic and macrophage activity to clear TM debris, cytokine release, increased DNA replication, and elevated levels of trabecular meshwork metalloproteinases. Later, Anderson and Parrish introduced the concept of selective photothermolysis (SP) targeting melanin within the trabecular meshwork. Selective laser trabeculoplasty (SLT), introduced by Latina and Park in 1995, employs the non-thermal Q-switched frequency-doubled Nd:YAG (Neodymium:yttrium-aluminium-garnet) to selectively target pigmented tissue, sparing other structures. It employs a shorter pulse duration than ALT to minimize collateral damage. Newer trabeculoplasty lasers include micropulse laser trabeculoplasty (MLT), titanium-sapphire laser trabeculoplasty, and pattern-scanning trabeculoplasty. Laser trabeculoplasty is a safer and more comfortable procedure compared to trabeculectomy, which presents several known complications, such as shallow anterior chamber, intraoperative bleeding, significant hypotony, hypotony maculopathy, cataract progression, infection, and bleb-related issues.[4-9]

The versatility of Nd:YAG laser in ophthalmology

The Nd:YAG laser is a solid-state laser that has many utilities for the human eye involving both *non-thermal* and *thermal* laser-tissue interaction. The *non-thermal effects* can be used for posterior capsulotomy or vitreolysis, when used at a *1064 nm* frequency and exposure times in the range of picoseconds and femtoseconds, which causes electrons to be stripped from atoms to create *plasma* and very fine tissue removal, but in combination also producing a *mechanical or acoustic shock wave* to create cavitation in the capsule. However, doubling the frequency to 532 nm, with exposure times in microseconds to a minute, this Nd:YAG laser can cause the generation of heat by light absorption upon incident tissue causing photocoagulation. These thermal effects can be used for retinal photocoagulation for retinal vascular disease, diabetic retinopathy, prophylactically to prevent retinal detachments or in the treatment of retinal breaks, trans-pupillary thermotherapy for malignant tumors, and wet age-related macular degeneration, but also for laser iridotomy to treat angle-closure glaucoma.[10-12]

However, it can also be utilized for trabeculoplasty in open-angle glaucomas similar to ALT. This type of laser has only been employed twice for LTP previously, with Kwasniewska et al.[13] and Agarwal et al.[14] reporting its safety and efficacy. Given our situation as a developing country, striving to offer a range of treatment options for the growing burden of glaucoma in our population, we considered using the available laser at our funded facility for LTP. The absence of conventional lasers for trabeculoplasty should not deter us from utilizing this valuable therapeutic modality.

Study aims and objectives

Our study aims to assess the efficacy and safety of the thermal frequency-doubled Nd:YAG laser trabeculoplasty in open-angle glaucomas in terms of IOP reduction, reduction in medication usage, and complications. To the best of our knowledge, we are the pioneers in our country to employ this laser for trabeculoplasty, and we employed settings similar to those used in ALT.

Materials and Methods

Patient recruitment

This prospective interventional study was conducted at the Department of Ophthalmology, Fauji Foundation Hospital, Rawalpindi, Pakistan. It aimed to assess the effect of laser trabeculoplasty on the 41 eyes of 22 consecutive Pakistani patients with open-angle glaucoma, who were recruited between November 27, 2018, and August 26, 2019, and whose one-year follow-up was completed on October 1, 2020. Data analysis was performed between September 1, 2019, and October 6, 2020. Ethical approval was obtained from the Ethical Review Committee of Foundation University Medical College (215/FF/FUMC/ERC) in accordance with the Declaration of Helsinki. The sample size calculation was conducted by our statistician using the WHO sample size calculator. Informed written consent was obtained from participants before recruitment. The inclusion criteria encompassed patients aged 40 or older with primary open-angle glaucoma (POAG), ocular hypertension, or secondary open-angle glaucomas such as pseudoexfoliative glaucoma (PXF), pigmentary glaucoma (PDS), pseudophakic glaucoma, or steroid responsiveness, who were willing to participate in our study. Additionally, patients who had undergone previous trabeculectomy but were now on multiple anti-glaucoma medications, or those with uncontrolled IOP after maximally tolerated medical therapy, were included. Patients with advanced glaucomatous damage at presentation, for whom incisional surgery posed a greater risk than laser, were also considered. Patient preference for trabeculoplasty as a treatment option was also taken into account if the patient was on topical anti-glaucoma medications. Patients with glaucoma, congenital, juvenile, other secondary open-angle glaucomas, angle-closure glaucomas, uveitic, traumatic, neovascular, aphakic, or severe ocular surface disease associated with systemic connective tissue disorders or ocular cicatrization were excluded. Normal tension glaucoma was also excluded due to the unlikely achievement of the required target pressure through laser trabeculoplasty.

Pre-laser examination

Baseline best-corrected visual acuity was recorded, and refraction was performed. A comprehensive slit lamp examination of the anterior and posterior segments were conducted, including Goldmann applanation tonometry (Haag-Streit AT 900®, Switzerland), ultrasonic pachymetry, and gonioscopy, which were noted on a performa. All assessments were carried out by the author. Patients were evaluated and monitored for glaucomatous damage at presentation, and progression was assessed through serial Humphrey perimetry and optical coherence tomography (OCT) of the optic nerve head and retinal nerve fiber layer.

Treatment procedure

All patients included in the study were already using glaucoma medications and were instructed to instill their morning dose as usual. Topical pilocarpine drops of 2% (Medicarpine®) were instilled twice, half an hour before trabeculoplasty, to constrict the pupil. Pre-laser baseline IOP was measured using an applanation tonometer and documented. The eye was anesthetized with topical proparacaine hydrochloride 0.5% eye drops (Alcaine®) before the procedure to minimize patient discomfort. These patients were already undergoing topical therapy for IOP control.

The frequency-doubled Nd:YAG laser [Green laser photocoagulator GYC-500® 532 nm, Nidek, Japan] used for retinal photocoagulation was employed to perform trabeculoplasty, as it is similar to the conventional Argon laser used for photocoagulation purposes and LTP. The Goldmann triple mirror lens (Haag-Streit®, Switzerland) was used with methylcellulose as a coupling agent, and the inferior angle was visualized as it is the widest. The laser settings mirrored those of ALT, including a 50 μm spot size, a 0.1-second duration, and a power range of 450-1000 mW (average 761 mW).[15] The laser spot was focused at the junction of the anterior non-pigmented and posterior pigmented trabecular meshwork. Power was increased until light blanching or a single, minute gas bubble was observed, which was considered an adequate reaction. The goal was to achieve a bubble after every 2-3 shots. Fifty or more burns were applied to the inferior 180° of the angle primarily, with one spot-size distance between two burns (Figure 1). For repeat laser, the superior angle was also considered, although it was technically more challenging to perform. Only 180° of laser therapy was administered at one time. Both eyes were treated on the same day. For patients who had undergone previous trabeculectomy, as the laser targeted the inferior 180°, there were no issues, as the trabeculectomy site was superior in all cases.

Post-procedure care and follow-up

In the post-procedure phase, the intraocular pressure (IOP) was measured 1 hour after the procedure to assess the laser's effect and identify any occurrence of an IOP spike. Fluorometholone eye drops 0.1% (Ocuflur®) were prescribed to be instilled thrice a day for 1 week, in addition to the continued use of topical anti-glaucoma drops. After the first week, patients were scheduled for follow-up appointments in the outpatient department

(OPD). During this appointment, visual acuity estimation, anterior chamber reaction assessment, gonioscopy, and fundoscopy were conducted to evaluate the treatment's effect. Subsequently, patients were monitored every month for one year through comprehensive eye examinations.

The target intraocular pressure was determined based on the severity of glaucomatous damage. For early-stage glaucoma, a target pressure in the high teens was established. In cases of moderate glaucoma, the mid-teens were deemed appropriate, while for advanced glaucoma, the early teens were considered suitable.[16] Success with laser trabeculoplasty (LTP) was defined as a decrease in IOP of ≥20% from the baseline value. Following a significant reduction in IOP to the target pressure, a gradual reduction of the anti-glaucoma drops was implemented. Additionally, Humphrey perimetry and optical coherence tomography (OCT) were performed as needed to assess disease progression. If there was an elevation in IOP or a progression of glaucomatous damage during the follow-up period, LTP was repeated, or medications were introduced to prevent further damage.

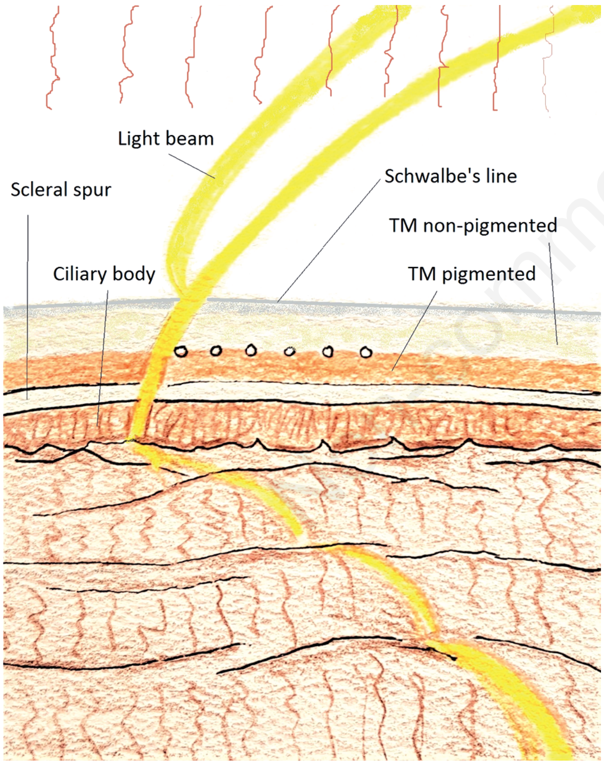

Figure 1. The anatomy of the anterior chamber angle showing the location of the laser trabeculoplasty burns at the junction of anterior non-pigmented and posterior pigmented trabecular meshwork. The yellow streak indicates the light beam as observed during gonioscopy. TM, trabecular meshwork; o, laser burn.

Data analysis

The collected data was analyzed using SPSS version 20. Frequencies and percentages were calculated for all variables. Depending on the context, unpaired and paired sample t-tests were employed for data analysis. A p-value of less than 0.05 was considered statistically significant.

Results

Patient Characteristics: A total of 41 eyes from 22 patients were included in this study. The mean age was 60.5±6.24 years, with a range of 49 to 70 years. The majority of patients were female, constituting 20 cases (92.7%). Primary open-angle glaucoma was the prevailing diagnosis in the majority of cases, accounting for 31 eyes (75.6%; Table 1). Among the cases studied, left eyes comprised the majority, representing 21 cases (51.2%).

The mean pre-laser baseline intraocular pressure (IOP) was 18.87±3.66 mm Hg, ranging from 12 to 31 mm Hg. The mean central corneal thickness (CCT) was 515.26±33.81 µm. The mean number of pre-laser topical drugs used by the patients was 2.77±0.98, with a range of 1 to 4. These drugs included combinations of dorzolamide and timolol, latanoprost and timolol, brimonidine tartarate, or latanoprost alone. All these medications were part of the maximally tolerated therapy regimen involving the four agents.

The average power of the laser employed was 760.9±122 mW, with a range of 450 to 1000 mW. The average number of laser spots required to achieve the desired outcome was 62.7±6.78. Among the patients, 18 (92.3%) underwent bilateral procedures, either on the same day or at different times. The laser was applied to the inferior 180° of the angle in 38 eyes (92.7%), while a 360° laser (superior 180°) was utilized in 3 eyes (7.3%) where previous therapies yielded little or no effect. Single sessions were performed in 36 eyes (87.2%), while 5 eyes (12.2%) required repeat sessions.

Intraocular Pressure and Medication Changes: The mean pre-laser baseline IOP was 18.88±3.66 mm Hg, ranging from 12 to 31 mm Hg. The IOP measurements at 1 hour, 1 week, 1 month, 3 months, 6 months, and 12 months are graphically represented in Figure 2. Correspondingly, the percentage reduction in IOP is presented in Figure 3.

The mean IOP at 1 hour was 16.2±4.93 mm Hg (p=0.001), at 1 week it was 14.95±2.54 mm Hg (p=0.000), at 1 month it was 14.66±2.50 mm Hg (p=0.000), at 3 months it was 14.54±2.60 mm Hg (p=0.000), at 6 months it was 15.85±2.35 mm Hg (p=0.000), and at 12 months (1 Year) it was 15.15±2.17 mm Hg (p=0.000). The discrepancy between the baseline pre-laser and post-laser IOP was statistically significant across all time points, thus confirming the success of laser trabeculoplasty at the 12-month mark (Table 1). The number of pre-laser anti-glaucoma drugs ranged from 1 to 4, with a mean of 2.73±1.00 drugs (Table 1). Furthermore, there was a notable reduction in medication use

Table 1. Baseline patient characteristics, laser trabeculoplasty, and intraocular pressure characteristics.

Age, years (mean±SD) range, years	60.5±6.24 (49-70)
Gender N (%)	
Male	3 (7.3)
Female	38 (92.7)
Eye N (%)	
Right	20 (48.8)
Left	21 (51.2)
Glaucoma diagnosis N (%)	
POAG[×]/OHT[∞]	31 (75.6)
PXF[¶]	9 (22)
Pseudophakic	1 (2.4)
No. of pre-laser anti-glaucoma drugs (range)	2.73±1.00 (1-4)
Central corneal thickness (CCT) µm (mean±SD) range	515.26±33.81 (455-570)
Visual field defects N (%) humphrey 30-2	
Generalized depression/borderline	8 (19.5)
Arcuate	10 (24.4)
Central/paracentral scotomas	3 (7.3)
Nasal step/temporal wedge	5 (12.2)
Double arcuate/ring scotomas	10 (24.4)
LTP degrees N (%)	
180°	38 (92.7)
360°	3 (7.3)
LTP location N (%)	
Inferior	38 (92.7)
Inferior and superior	3 (7.3)
LTP sessions N (%)	
Single session	36 (87.8)
Repeat sessions	5 (12.2)
LTP power mW (mean±SD) range	760.9±122 (450-1000)
LTP number of spots (mean±SD) range	62.7±6.78 (50-76)
LTP complications N (%)	
Anterior uveitis	4 (9.75)
PAS[α]	18 (43.9)
IOP spike+PAS[α]	2 (4.9)
Pre-laser baseline IOP mm Hg (mean±SD) range	18.87±3.66 (12-31)
IOP at 1 hour mm Hg (mean±SD) range	16.1±4.93 (7-32)
IOP at week 1 mm Hg (mean±SD) range	14.95±2.54 (10-23)
IOP at month 1 mm Hg (mean±SD) range	14.65±2.50 (8-19)
IOP at month 3 mm Hg (mean±SD) range	14.53±2.60 (8-21)
IOP at month 6 mm Hg (mean±SD) range	15.85±2.30 (10-20)
IOP at 1 year mm Hg (mean±SD) range	15.14±2.17 (10-21)

[×]Primary open angle glaucoma; [∞]ocular hypertension; [¶]pseudoexfoliative glaucoma; [α]peripheral anterior synechiae.

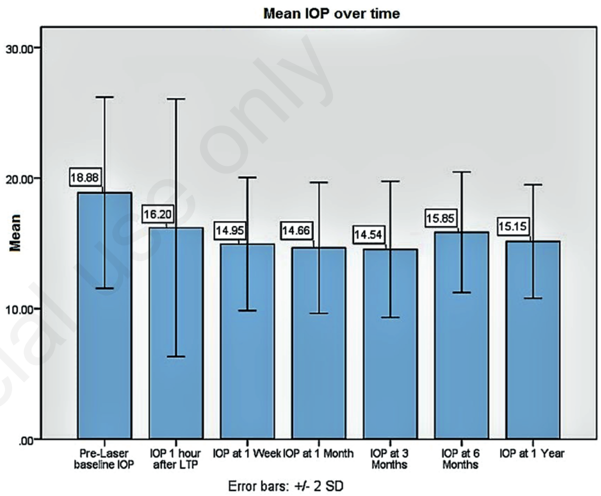

Figure 2. Bar chart showing IOP (mean±SD) over time.

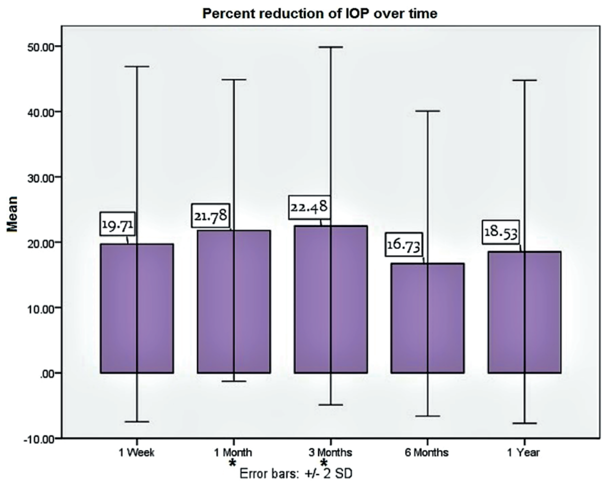

Figure 3. Bar chart showing percent reduction of IOP (mean±SD) over time. Asterisk indicates significant reduction in IOP.

post-laser (p=0.000) at all-time points—1, 3, 6, and 12 months—leading to a mean decrease in the number of drugs to 2.29±0.98, 1.95±0.86, 1.83±0.77, and 2.05±0.92, respectively. The most significant reduction in drug usage was observed at 1 month and 12 months (Figure 4).

Complications and follow-up

Complications included an IOP spike in only 1 patient, bilaterally (5.1%), occurring 1 hour after the procedure. This was effectively managed with topical anti-glaucoma therapy administered on the same day. Peripheral anterior synechiae (PAS) of varying degrees were observed in 20 eyes (51.3%). Mild anterior uveitis occurred, with its presence waning after a week of topical fluorometholone 0.1% treatment. Persistent mild uveitis at 1 week was seen in 4 eyes (9.75%), and it was effectively managed with topical ketorolac tromethamine 0.5% eye drops over a 4-week period (Table 1).
Throughout the study period, visual acuity, visual fields, and OCT were serially monitored, with any progressive damage addressed through additional laser treatment or the introduction of new medications. On average, these patients were followed up for 13.34±1.68 months.

Discussion

Living in a developing country with limited resources leaves us with few options to assist our glaucoma population. Due to the absence of access to conventional lasers for laser trabeculoplasty, we decided to utilize the thermal frequency-doubled Nd:YAG laser (532 nm), which is conventionally used for retinal photocoagulation. We applied this laser for trabeculoplasty in open-angle glaucoma patients who were already on anti-glaucoma therapy. We aimed to observe its effects on lowering intraocular pressure, facilitating topical drug reduction, and identifying any complications arising from its use. Our study successfully demonstrates the laser's effectiveness in reducing IOP levels in both uncontrolled and well-controlled open-angle glaucoma patients undergoing topical therapy.
The mean post-laser IOP in our study was consistently lower than the baseline IOP of 18.88±3.66 mm Hg. Specifically, the mean IOP at Hour 1 was 16.2±4.93 mm Hg (p=0.001), at Week 1 it was 14.95±2.54 mm Hg (p=0.000), at Month 1 it was 14.66±2.50 mm Hg (p=0.000), at Month 3 it was 14.54±2.60 mm Hg (p=0.000), at Month 6 it was 15.85±2.30 mm Hg (p=0.000), and at Month 12 it was 15.14±2.17 mmHg (p=0.000). There was a consistent reduction in anti-glaucoma drug usage post-laser at 1, 3, 6, and 12 months, resulting in the mean number of drugs decreasing to 2.29±0.98, 1.95±0.86, 1.83±0.77, and 2.05±0.92, respectively. The most substantial reduction in drug usage occurred at Month 1 and continued through Month 12 of follow-up. Additionally, we observed a significant percentage reduction in mean IOP on all occasions, with reductions of 21.8%, 22.5%, 16.7%, and 18.5% at 1, 3, 6, and 12 months, respectively. This relative increase in IOP at 6 and 12 months might be attributed to decreased topical therapy, although we do observe that its impact is diminishing over time.

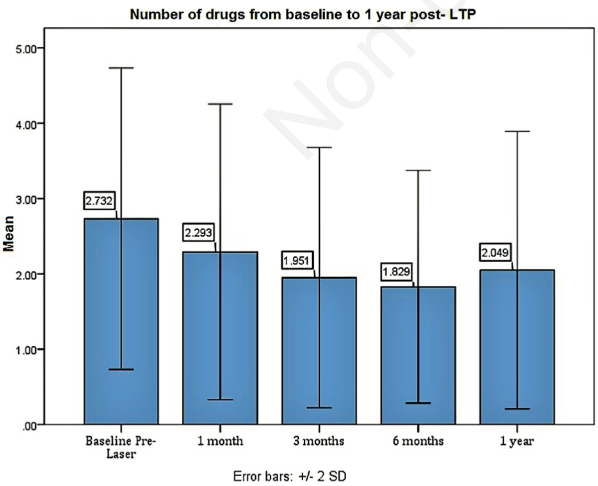

Figure 4. Bar chart depicting baseline number of drugs and reduction over time (mean±SD).

Comparative studies and benefits

Only two studies on thermal frequency-doubled Nd:YAG laser trabeculoplasty have been published. Kwasniewska *et al.*[13] previously utilized the continuous wave Nd:YAG laser for trabeculoplasty and found it to be both safe and effective. However, they employed this laser in continuous wave mode with different settings, including a spot size of 100 μm, an exposure duration of 0.2-0.4 seconds, and a total energy per session ranging from 90 to 180 J. Similarly, Agarwal *et al.*[14] reported comparable success with both the Nd:YAG and diode laser trabeculoplasty, employing a similar spot size of 100 μm, a duration of 0.2 seconds, and a power range of 800 to 1270 mW. In our study, we used identical settings to those of ALT, with a spot size of 50 μm, a duration of 0.1 seconds, and a power range of 450-1000 mW (averaging 761 mW).

In their study, Holló[17] listed the low-energy, Q-switched Nd:YAG laser as an alternative to ALT. Robin and Pollack[18] found that Q-switched Nd:YAG laser trabeculoplasty resulted in a reduction of intraocular pressure (IOP) in 68% of patients. Previous studies on ALT in Pakistan include Mahar and Jamali's work in 2008,[19] demonstrating positive outcomes in 95% of open-angle glaucoma patients using ALT as primary therapy. More recently, in 2019, Fasih and colleagues[20] reported on the safety and efficacy of ALT as an adjuvant therapy in primary open-angle glaucoma. Additionally, Gra ner[21] reported a 71% success rate for SLT as adjunctive therapy and noted favorable results with the primary use of this laser. Kurysheva *et al.*[22] observed an 87% success rate for SLT in their study. However, Belitsky et al.[23] reported a lower success rate of 52% with SLT, suggesting that it might be effective only in certain patients and not universally.

In this context, we believe that we are the first in Pakistan to utilize the frequency-doubled Nd:YAG laser for trabeculoplasty, achieving positive and sustained results.

Laser trabeculoplasty (LTP) is often thought of as a serendipity.[24] Many believe it to be equivalent to medical monotherapy.[15] It stands as a safe and effective procedure for achieving target intraocular pressures (IOPs) in open-angle glaucoma patients as adjuvant therapy. This includes those who cannot afford topical drops, are non-compliant with medication regimens, experience ocular or systemic side effects from topical therapy, exhibit uncontrolled IOPs despite maximally tolerated medical treatment, decline conventional trabeculectomy, or present with advanced glaucomatous damage. Moreover, it suits individuals with a single functional eye, for whom trabeculectomy risks the 'wipe-out syndrome',[25] as laser trabeculoplasty avoids significant hypotony or damage to the optic nerve head. It may also offer greater cost-effectiveness for patients compared to long-term topical therapy. At our institute, we provide entitled patients with free laser therapy, making it a cost-effective solution for them.

Considerations and implications

While argon laser trabeculoplasty (ALT) was once considered the gold standard, selective laser trabeculoplasty (SLT) is now predominantly favored due to its gentler 'photochemical effect' rather than the 'coagulative effect' of ALT. Both modalities exert mechanical, biochemical, and cellular effects on the trabecular meshwork.[26] In eyes with substantial pigmentation, ALT prevails over SLT and proves more efficacious.[27] Nonetheless, considering the considerable glaucoma burden at our institution, we opted to employ the laser available to us for photocoagulation—the frequency-doubled Nd:YAG laser—yielding promising results. These encompass effective IOP reduction, diminished need for glaucoma medication, and enhanced safety. Much like ALT, this Nd:YAG laser suits pigmented eyes as well.

ALT has demonstrated sustained IOP control in 67-80% of cases at 1 year, 35-50% at 5 years, and 5-30% at 10 years.[6] LTP finds its prime application in primary open-angle glaucoma, pseudoexfoliative glaucoma, pigmentary glaucoma, and steroid-response glaucoma. On the other hand, SLT employs the Q-switched frequency-doubled Nd:YAG laser (532 nm) with a larger spot size of 400 μm and a pulse duration of 3 nanoseconds. Our laser, while akin to SLT, functions as a photocoagulator. We employed ALT settings with our frequency-doubled Nd:YAG laser (532 nm), using a 0.1-second duration and a 50 μm spot size.

LTP has proven successful in the majority of conducted studies. It can be offered as a primary therapeutic option as well as to reduce reliance on eye drops. Wang *et al.*[28] demonstrated that ALT and SLT exhibit similar efficacy, side effects, and retreatment success at 6 months. Some experts argue that SLT is more repeatable than ALT, given its less damaging impact on surrounding structures and minimal scarring. A higher baseline IOP, pigmented trabecular meshwork, and pseudoexfoliation are predictive of a more substantial IOP-lowering effect with LTP. Additionally, we achieved some success by repeating LTP with higher power than the initial treatment in 5 (12.2%) patients.[25-38]

We encountered a few complications during our careful patient monitoring. The much-dreaded IOP spike occurred bilaterally in only one patient (5.1%) an hour after the laser treatment. Persistent mild uveitis at one week of follow-up was observed in only four eyes (9.75%). Any degree of peripheral anterior synechiae (PAS) was found in 18 (43.9%) eyes. Richardson,[39] in their review of ALT, reported an incidence of IOP spikes in 20% of cases and PAS in 20-46% of cases. Other reported complications encompass hyphema, corneal burns, corneal decompensation, cystoid macular edema, and foveal burns. ALT might adversely affect subsequent filtration procedures.[6,13,22,40,41]

The strength of our study lies in its unique status as the first of its kind in Pakistan, to the best of our knowledge.

Moreover, we conducted a considerable one-year follow-up period, during which we meticulously tracked all patients, ensuring no loss to follow-up. We have successfully achieved IOP control and medication reduction without encountering significant vision-threatening complications. We are confident that our study's outcomes will inspire others with access to the frequency-doubled Nd:YAG laser, as opposed to argon lasers or SLT machines, to explore this option as a therapy for open-angle glaucoma.

Limitations and future research

However, our study does come with limitations. The small sample size and its determination using the WHO sample size calculator are notable constraints. A larger sample of glaucoma patients would be necessary for a more comprehensive assessment of this laser's effectiveness. Additionally, our patient population is predominantly female due to our facility's focus on serving female family members of retired army personnel. This does introduce some bias to our study. However, prior research has failed to demonstrate gender's influence on LTP treatment efficacy in glaucoma.[42-44] It's worth noting that we treated only the inferior 180° of the angle in all patients. Some may argue that treating the entire 360° would be more effective or warranted. However, visualizing the superior angle is challenging and could hinder therapy in that area. Moreover, using this thermal laser for the full angle might provoke more inflammation than SLT. In my practice, I've utilized the superior 180° for laser repetition only in three cases, and laser repetition was necessary in just five cases.
Our future research will be dedicated to exploring this laser as a primary therapy in open-angle glaucoma patients, aiming to eliminate the inconvenience of topical drug therapy. It is crucial to report the effectiveness of this laser with its settings in open-angle glaucoma patients on topical therapy, enabling others in similar situations to capitalize on this laser's potential and help their patients achieve target IOPs.

Conclusions

The findings of this study indicate that the thermal frequency-doubled Nd:YAG laser trabeculoplasty, when used as an adjuvant therapy alongside anti-glaucoma drugs, is effective in reducing intraocular pressure and medication usage in patients with open-angle glaucoma. The observed complications were consistent with previous reports and did not outweigh the benefits of the treatment.
Further research and longer-term studies are warranted to confirm these findings and assess the long-term benefits and complications of this approach.

Conflict of interest: the author declares no potential conflict of interest, and all authors confirm accuracy.

Funding: none.

Ethics approval: the Ethical Review Committee of Foundation University Medical College approved this study (215/FF/FUMC/ERC). The study is conformed with the Helsinki Declaration of 1964, as revised in 2013, concerning human and animal rights.

Informed consent: all patients participating in this study signed a written informed consent form for participating in this study.

Patient consent for publication: written informed consent was obtained from a legally authorized representative(s) for anonymized patient information to be published in this article.

Availability of data and materials: all data generated or analyzed during this study are included in this published article. The data for this study is available from Open Science Framework with the DOI 10.17605/OSF.IO/GEJRN and link: https://osf.io/gejrn/?view_only=23964234ed3f405c96f4f8f9601f1003

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