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ORIGINAL ARTICLE

Comparative evaluation of surgical outcomes of gonioscopy-assisted transluminal trabeculotomy and trabeculectomy in open-angle glaucoma

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Abstract

Purpose: To investigate the efficacy and safety of gonioscopy-assisted transluminal trabeculotomy (GATT) for open-angle glaucoma in comparison with trabeculectomy, the traditional gold standard.

Methods: A total of 22 patients who underwent surgical intervention between January 2021 and February 2022 were divided into 2 groups according to the surgery type: GATT (Group 1, n=11) and trabeculectomy (Group 2, n=11). Pre-operative and post-operative findings at 1st week, 1st, 3rd, 6th, and 9th months, including best-corrected visual acuity (BCVA), anterior and posterior segment findings, intraocular pressure (IOP), retinal nerve fiber layer (RNFL) thickness, complications, and topical and/or systemic medication requirements were recorded and compared between the groups.

Results: The mean age was 56.5±19.8 (18–80) years in Group 1 and 59.4±6.9 (16–77) years in Group 2 ($p>0.05$). The female/male ratio was 4/7 in both groups. Post-operative IOPs were significantly lower in both groups compared to the pre-operative IOPs ($p=0.01$). In addition, IOP values were similar between the groups in the pre-operative period and at all post-operative time points ($p>0.05$). BCVA and RNFL values remained stable as well. The number of topical anti-glaucomatous agents used decreased significantly and to a similar extent in the post-operative period in both groups. While hypotony was the most common complication in the TRAB group, hyphema was the most prevalent in the GATT group.

Conclusion: GATT is a safe and effective method of lowering IOP and reducing the amount of antiglaucomatous medication, and offers acceptable results that are comparable to trabeculectomy. GATT can be considered a viable alternative, especially in patients prone to serious complications, such as hypotony.

Keywords: Gonioscopy-assisted transluminal trabeculectomy; trabeculectomy; open-angle glaucoma.

Trabeculectomy is the most common procedure and considered as the gold standard for the surgical treatment of subtypes of glaucoma, one of the leading causes of permanent vision loss worldwide.^[1,2] Although the effectiveness and success of trabeculectomy have been known for many years, it is not an innocuous surgery due to early and late complications, such as hypotony, choroidal effusion, blebitis, endophthalmitis, bleb failure, or leakage,^[3,4] indicating a need for alternative methods. Minimally invasive glaucoma surgery (MIGS) is gaining

increasing interest due to its conjunctiva-sparing ab interno approach, high safety profile, absence of a filtering bleb, and rapid recovery after surgery.^[5] Gonioscopy-assisted transluminal trabeculotomy (GATT), first described by Grover et al.^[6] in 2014, is considered to be a MIGS subtype. In GATT, the trabecular meshwork and the inner wall of Schlemm's canal are opened by 360°, creating a direct connection between the aqueous humor and the collector channels, facilitating aqueous drainage. GATT was reported to be successful in various glaucoma subtypes, such as



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open-angle glaucoma, childhood glaucoma, and primary angle-closure glaucoma.^[7-10] However, since GATT is a relatively new technique, few studies have compared it with the gold standard, trabeculectomy. The present study aimed to examine the efficacy and safety of GATT surgery for open-angle glaucoma and compared the outcomes with trabeculectomy.

Materials and Methods

This prospective cross-sectional study was conducted in accordance with the principles of the Declaration of Helsinki with the approval of the Ege University Faculty of Medicine Ethics Committee for Clinical Studies (Ethics approval number: 21-1/3) and the financial support of the Ege University Scientific Research Projects Coordination Office (Project ID: 22201). Written informed consent was obtained from all participants.

Participants

The study included 22 patients over the age of 16 years who were regularly followed up at our clinic between January 2021 and February 2022. The intraocular pressure (IOP) of these patients could not be adequately regulated despite maximum tolerated medical treatment, or the patients were intolerant to glaucoma medications and therefore required surgical intervention. The glaucoma subtypes included in the study were primary open-angle glaucoma, pseudoexfoliative glaucoma, uveitic glaucoma, congenital glaucoma, silicone oil glaucoma, and traumatic glaucoma. Patients using anticoagulants or having a bleeding diathesis, eyes with any ocular surface disorder, concomitant anterior and posterior segment pathology that may cause difficulties in the diagnosis and follow-up, eyes with an unclear iridocorneal angle, narrow-angle glaucoma, and eyes with a low endothelial cell count were excluded from the study.

Pre-operative Assessment

Demographic data of the patients, such as age and gender, glaucoma subtype, number of topical antiglaucomatous drugs, systemic antiglaucomatous drug requirement, best corrected visual acuity (BCVA), anterior and posterior segment examination findings, IOP values, and retinal nerve fiber layer (RNFL) thickness, were recorded. The patients were randomly divided into two groups: GATT (Group 1, n=11) or conventional trabeculectomy (Group 2, n=11). The indication for glaucoma surgery and the type of surgery were determined by two experienced glaucoma specialists (S.G. and M.E.B.).

Surgical Method

Group 1 - GATT

A 23-gauge microvitrectomy (MVR) blade-assisted paracentesis was carried out in the nasal and temporal anatomic limbus, and the anterior chamber was filled with dispersive viscoelastic (OcuCoat, Bausch + Lomb Eye Health Products, Ontario, Canada). Subsequently, the patient's head and the microscope were tilted away from the surgeon. The angle was visualized using a gonioscope, and a 1–2 mm goniotomy was carried out in the pigmented part of the nasal trabecular meshwork with the help of an MVR blade. After visualization of the Schlemm's canal, a 5/0 blue monofilament prolene suture (Ethicon, Johnson and Johnson Company, New Jersey, USA) with its distal end blunted by manual cauterization was pushed forward into the canal. It's aimed to advance the suture 360° circumferentially within the canal. Traction was applied to the suture with the help of a micro forceps upon completion of the advancement and trabeculotomy was carried out. In cases where the suture could not be advanced by 360°, the procedure was repeated in the opposite direction. Surgeries in which more than 270° of cannulation and Schlemm's canal rupture could be conducted were considered to be successful. At the end of the surgery, the viscoelastic in the anterior chamber was cleaned by bimanual irrigation-aspiration, and cefuroxime (1 mg/0.1 mL) was applied to the anterior chamber.

Group 2 - Trabeculectomy

A half-thickness 3 × 4 mm rectangular scleral flap was created with a limbal-based approach. Mitomycin-C (MMC) was preferred as the antimetabolite. A sponge soaked with MMC at a concentration of 0.2 mg/mL was placed under the conjunctiva for 3 min, and then the surgical area was irrigated with physiological saline. Approximately 1 × 2 mm trabecular tissue was excised under the opened scleral flap and peripheral iridectomy was carried out. Next, suturing was carried out at the two corners of the scleral flap using 10/0 nylon sutures. The number and tightness of the sutures were adjusted to allow fluid leakage with gentle manual pressure on the globe. Finally, the conjunctiva was closed with 8/0 vicryl suture.

All patients were prescribed topical moxifloxacin (Vigamox, Novartis, Basel, Switzerland) and dexamethasone (Maxidex, Alcon, Geneva, Switzerland) 8 times a day for 1 week post-operatively. After the 1st week, the dosage was reduced to 4 times a day. For patients who underwent trabeculectomy, cyclopentolate hydrochloride (Sikloplejin 1%, Abdi Ibrahim, Istanbul, Turkey) was administered 3 times a day. All treatments were discontinued 1 month

after the surgery for patients who underwent GATT surgery. For those who underwent trabeculectomy, antibiotics and cyclopentolate were stopped after 4 weeks, while steroid treatment continued for up to 6 weeks. Antiglaucomatous drops were discontinued after the surgery, and any decision to restart the drops was made during the clinical follow-up.

Post-operative Assessment

BCVA, anterior and posterior segment examination findings, IOP values, RNFL thickness, complications, and the need for topical or systemic medication were recorded at the post-operative 1st week, 1st, 3rd, 6th, and 9th months. Surgical success was defined as IOP reduction $\geq 20\%$ from the baseline and an IOP between 6 and 21 mmHg without any further glaucoma surgery.^[11] Complete success was defined as attaining the targeted values without any medication, and partial success was defined as reaching the targeted values with topical medication.^[12] IOP, BCVA, RNFL thickness, and the number of medications used were examined comparatively in the pre- and post-operative periods and between the groups. Complications were evaluated as early (<1 month) and late (>1 month) according to occurrence during the post-operative period.

Statistical Analysis

Statistical analyses were carried out with the help of the IBM Statistical Package for the Social Sciences (SPSS) Statistics 25.0 (IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp.) Package program. Numerical data were calculated as mean and standard deviation, as well as median, minimum, and maximum values. For comparisons between groups, the t-test was used for parametric variables, and the Mann–Whitney U-test was used for non-parametric variables. For pre-and post-operative comparisons, the paired samples t-test or Wilcoxon test was used. Categorical variables were evaluated with chi-square analysis. A value of $p < 0.05$ was considered as statistically significant.

Results

The mean age was 56.5 ± 19.8 (18–80) years in Group 1 and 59.4 ± 6.9 (16–77) years in Group 2, with no statistically significant difference ($p = 0.8$). The female/male ratio was 4/7 in both groups. Demographic data, glaucoma subtypes, and pre-operative examination findings of the patients are summarized in Table 1. No significant difference was found when comparing the pre-operative and post-operative

Table 1. Demographic characteristics and pre-operative clinical examination data of both groups

Patient no.	Gender	Age	Glaucoma subtype	BCVA	IOP	Number of topical agents	Oral acetazolamide	C/D ratio	RNFL
Group 1									
1	M	71	PEXG	0.52	28	2	Yes	1.0	58
2	M	67	POAG	3.10	19	3	Yes	0.9	55
3	M	83	PEXG	3.10	39	3	Yes	1.0	55
4	M	65	POAG	0.52	40	2	Yes	0.2	71
5	F	18	CG	0.10	45	3	No	0.4	89
6	F	36	UG	0.80	32	3	Yes	0.4	90
7	M	50	SOG	3.10	51	2	Yes	0.2	90
8	F	38	PEXG	0.15	40	3	No	0.1	90
9	F	56	UG	1.00	34	2	Yes	0.8	89
10	M	58	SOG	1.00	33	2	Yes	0.3	65
11	M	80	POAG	3.10	44	3	Yes	1.0	50
Group 2									
1	M	77	TG	0.15	26	3	No	0.2	95
2	M	69	PEXG	0.70	26	3	No	0.9	42
3	F	71	PEXG	0.05	27	3	No	0.5	75
4	M	68	KG	3.10	32	3	Yes	1.0	65
5	F	16	CG	1.30	30	3	No	0.3	88
6	F	46	POAG	1.80	34	3	No	0.4	58
7	M	69	PEXG	1.30	32	3	Yes	0.9	48
8	M	74	PEXG	3.10	40	3	Yes	1.0	50
9	F	40	UG	0.22	24	3	Yes	0.4	72
10	M	61	PEXG	0.00	21	3	No	0.9	58
11	M	63	POAG	0.15	44	3	No	0.5	62

*BCVA: Best corrected visual acuity; IOP: Intraocular pressure; RNFL: Retinal nerve fiber layer; **PEXG: Pseudoexfoliation glaucoma; POAG: Primary open-angle glaucoma; CG: Congenital glaucoma; UG: Uveitic Glaucoma; SOG: Silicone oil glaucoma; TG: Traumatic glaucoma; KG: Keratoplasty glaucoma.

BCVAs at the 1st week, 1st, 3rd, 6th, and 9th months between the two groups (Fig. 1). As expected, the post-operative IOPs were statistically significantly lower in both groups compared to the values in the pre-operative period ($p=0.01$). Moreover, the post-operative IOP values did not differ between the groups in the pre-operative period and at all post-operative time points evaluated ($p>0.05$, for all, Fig. 2).

No statistically significant difference was identified in the number of topical antiglaucoma medications used during the pre- and post-operative periods between the two groups (Fig. 3). A comparison of the number of topical antiglaucomatous agents used pre-operatively and at the past post-operative examination indicated a statistically significant decrease in both groups ($p<0.001$ for both groups).

Oral acetazolamide was required pre-operatively in 9 patients in Group 1 and 5 patients in Group 2, while it was necessary post-operatively in only 1 patient in both groups, only at the first post-operative week. No difference in the use of acetazolamide was found between the two groups at the post-operative follow-up.

The pre-operative and post-operative mean RNFL thicknesses were 72.9 ± 16.9 (50–90) μm and 71.5 ± 15.0 (48–88) μm in Group 1, respectively, and 64.8 ± 16.5 (42–95)

μm and 63.1 ± 14.5 (40–92) μm in Group 2, respectively. The RNFL thickness was found to be stable in both groups at the clinical follow-up (Fig. 4).

An evaluation of post-operative complications indicated the presence of hyphema in 2 eyes and corneal edema in 3 eyes in Group 1. Subsequent trabeculectomy was required in 2 eyes in Group 1 because the targeted IOP could not be achieved (1 silicone oil glaucoma and 1 uveitic glaucoma). No complications were detected in Group 2 except for transient hypotony in two eyes. No significant complications were recorded in either group in the late period (>1 month). At the final examination, complete success was recorded as 54.5%, partial success as 27.3%, and failure rate as 18.2% in Group 1, while in Group 2, complete success was recorded as 72.8%, partial success as 27.2%, and failure rate as 0%.

Discussion

MIGS procedures stand out as successful options for mild to moderate glaucoma cases that do not respond to topical antiglaucomatous and/or laser therapy.^[13] GATT, a MIGS procedure, has also gained popularity recently and appears to be promising.^[14]

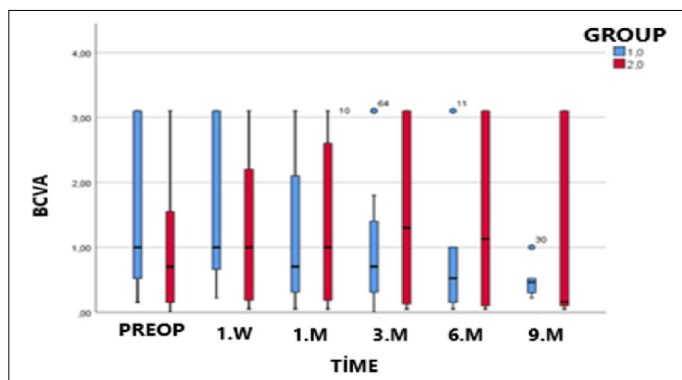


Fig. 1. Change of BCVA over time in both groups.

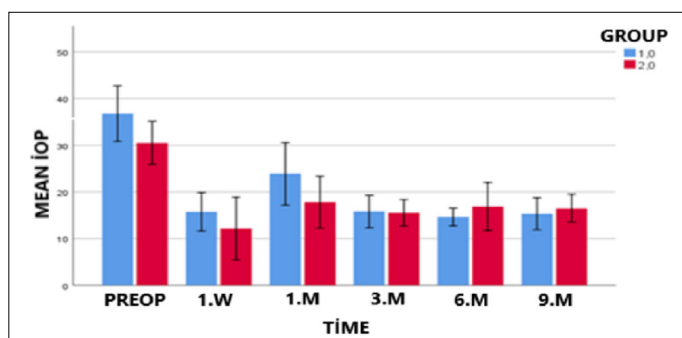


Fig. 2. Comparisons of mean preoperative and postoperative IOP between groups.

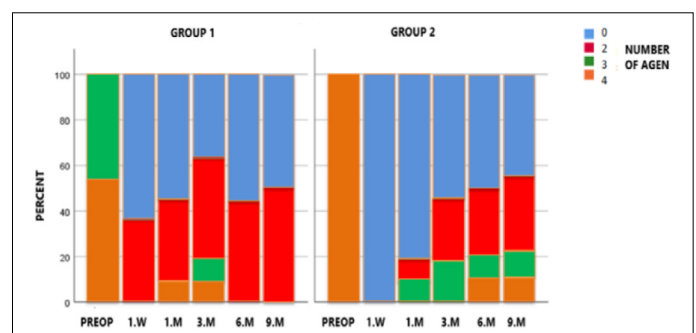


Fig. 3. The number of topical antiglaucomatous agents in preoperative and postoperative visits for both groups.

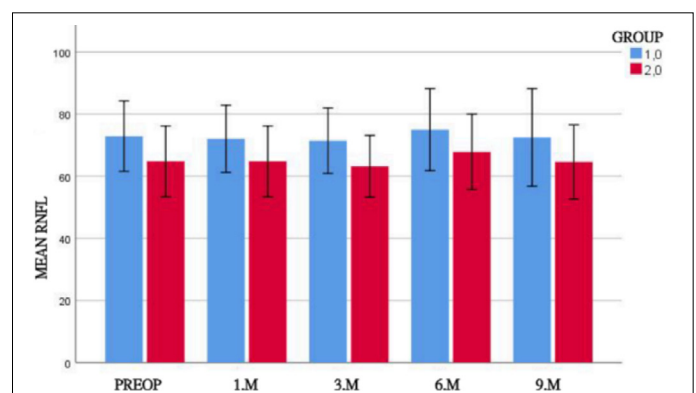


Fig. 4. Comparison of preoperative and postoperative RNFL thickness between groups.

Favorable clinical outcomes were first reported with GATT by Grover et al.^[6] These authors noted a 39.8% decrease in mean IOP after 12 months in patients undergoing primary open-angle glaucoma. Rahmatnejad et al.^[15] reported a 44% decrease in mean IOP at 12 months after GATT surgery. Similarly, Aktas et al.^[11] observed a 40.1% decrease in IOP with GATT at 19 months post-procedure. The effect of GATT on the mean number of topical medications was reported to decrease from 3.1 ± 1.1 to 1.2 ± 0.9 at the 12th month post-procedure ($p < 0.001$).^[15] Grover et al.^[6] reported a mean decrease of 0.9 in the number of topical medications at 6 months ($p < 0.001$) and a mean decrease of 1.1 in the number of drops at 12 months ($p = 0.013$) after GATT. In the present study, a mean decrease in IOP of 45% was observed in patients who underwent GATT surgery. Furthermore, the mean number of topical medications was also observed to decrease significantly.

Rahmatnejad et al.^[15] reported no statistically significant change in BCVA ($p = 0.346$) after the procedure. Similar outcomes were reported in different studies.^[8] Hyphema was reported to be the most common complication, with a mean prevalence of 30% at the 1st week post-operatively.^[11,15,16] Other clinically significant complications reported include steroid-induced IOP elevation in the post-operative 1st month in 2 patients and cystoid macular edema in the post-operative 3rd month in 1 case that underwent combined GATT and cataract extraction.^[16] In the present study, no significant difference was observed between pre-operative and post-operative BCVA, supporting the data from previous studies. Hyphema and corneal edema were the most common early complications. Subsequent trabeculectomy had to be carried out in one patient with silicone oil glaucoma and another with uveitic glaucoma who underwent GATT due to failure of IOP control.

The number of studies that have evaluated the outcomes of GATT in comparison to trabeculectomy is quite limited. Fontana et al.^[17] evaluated 61 patients undergoing trabeculectomy and 49 patients undergoing GATT and reported complete and partial success rates of 59% and 27% for trabeculectomy, and 46% and 31% for GATT, respectively ($p = 0.353$). The same study reported a comparable mean decrease in the number of topical antiglaucomatous medications; however, the percentage of IOP reduction compared to the pre-operative period was significantly higher in trabeculectomy than in GATT ($p < 0.001$).^[17] The IOP-lowering effect of trabeculectomy was better than that of GATT in the late post-operative stage.^[17] Of note, the cohort undergoing glaucoma surgeries was evaluated by Fontana et al.^[17] also underwent simultaneous cataract

surgery; therefore, the additional IOP-lowering effect of cataract surgery must be considered.^[18]

Wang et al.^[19] compared the effects of GATT and trabeculectomy in patients with open-angle glaucoma with no confounding factors. These authors reported that both procedures resulted in similar post-operative IOP and comparable reductions in IOP. In addition, the decrease in the number of topical medications used was to a similar extent in both groups. The complication rates were also similar, as 26.67% for GATT and 26.47% for trabeculectomy. The most common complications included bleb-related issues following trabeculectomy and hyphema following GATT. However, the authors reported that the RNFL thickness was significantly decreased at 12 months post-operatively compared to pre-operative levels in the GATT group ($p < 0.001$).

Çakır et al.^[12] compared the outcomes of 36 patients who underwent GATT and 39 patients who underwent trabeculectomy and reported no significant change in BCVA in either group in the post-operative period ($p > 0.05$), while IOP and the number of topical medications were significantly reduced in both groups ($p < 0.001$). These authors reported that the IOP was significantly higher in the GATT group in the 1st week after surgery ($p = 0.04$).^[12] In addition, the number of antiglaucomatous medications used in the 1st week and 1st month after surgery was significantly lower in the trabeculectomy group ($p = 0.004$ and 0.009 , respectively).^[12] Hyphema, choroidal detachment, and early hypotony were the prominent complications in the trabeculectomy group, while hyphema was the most common complication with a frequency of 55.5% in the GATT group.^[12] Fibrin reaction was a notable complication in the study, which was detected in seven patients (19.4%) in the GATT group.^[12]

Un et al.^[20] also compared the results of GATT and trabeculectomy in pseudophakic eyes with pseudoexfoliative glaucoma. These authors reported that the mean decrease in IOP was 52.1% in the GATT group and 56.4% in the trabeculectomy group. In addition, the surgical failure rates were similar in both groups, with 23.5% in the GATT group and 26.3% in the trabeculectomy group. Tekcan et al. also reported GATT to be an effective and safe method for glaucoma patients.^[21]

In the present study, post-operative IOP values were found to have decreased significantly in both groups compared to the pre-operative values. In addition, the IOPs were comparable between the groups at all time-points examined. The BCVA and RNFL values were also stable.

The number of topical antiglaucomatous agents used also decreased significantly in the post-operative period, with no significant difference between the two groups. Hypotony was the most common complication in the trabeculectomy group, and hyphema was the most prevalent in the GATT group. The outcomes of the present study, therefore, support the existing literature. However, unlike Wang et al.^[19] we observed that the post-procedure RNFL thickness was similar between the two groups.

Çakir et al.^[12] reported a complete success rate of 64.1% in patients undergoing trabeculectomy and 52.8% in patients undergoing GATT. In the present study, complete success was found to be slightly higher in patients undergoing trabeculectomy and comparable in patients undergoing GATT.

The prospective design, unlike most studies in the literature, makes this study stand out. Nonetheless, some of the most important limitations are the limited number of patients recruited, the heterogeneity of the diagnoses, and the lack of inclusion of the visual field, which is important in the follow-up of glaucoma. However, the inclusion of various glaucoma subgroups in the study, including primary open-angle glaucoma, pseudoexfoliative glaucoma, uveitic glaucoma, congenital glaucoma, silicone oil glaucoma, and traumatic glaucoma, can be considered as strength. Despite the limited number of patients evaluated, the present study suggests that GATT is especially successful in cases of primary open-angle glaucoma, providing adequate IOP reduction without any complications.

Conclusion

GATT can be considered as a safe and effective method for lowering IOP and reducing the amount of antiglaucomatous medication, and offers acceptable results compared to trabeculectomy, the gold standard and conventional method. GATT can be considered as a viable alternative, particularly in patients prone to serious complications, such as hypotony. However, due to the limited number of cases, these preliminary results need to be confirmed with future studies, including more cases and longer follow-up periods.

Ethics Committee Approval: The Ege University Ethics Committee granted approval for this study (date: 11.10.2022, number: 21-1/3).

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