ORIGINAL RESEARCH ORİJİNAL ARAŞTIRMA

DOI: 10.5336/ophthal.2023-100182

Comparison of Outcomes of 360-Degree Gonioscopy-Assisted Transluminal Trabeculotomy with or without Cataract Surgery in Pseudoexfoliation Glaucoma: A Retrospective-Comparative Study

Psödoeksfoliasyon Glokomunda Katarakt Cerrahisi ile Kombine Edilen ve Edilmeyen 360-Derece Gonyoskopi-Asiste Translüminal Trabekülotomi Sonuçlarının Karşılaştırılması: Retrospektif-Karşılaştırmalı Çalışma

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ABSTRACT Objective: To compare of outcomes of 360-degree gonioscopy-assisted transluminal trabeculotomy (GATT) with or without cataract surgery (CS) in pseudoexfoliation glaucoma (PXG). **Material and Methods:** Patients with PXG undergoing 360-degree GATT at a single centre were reviewed retrospectively. The intraocular pressure (IOP) and the medication numbers at postoperative first, third, sixth, 12th, 18th month and at the last visit were recorded. Complete success was defined as IOP reduction ≥20% from baseline and IOP<18 mmHg without medication and further glaucoma surgery. Comparisons were performed between standalone procedure (GATT group) and combined procedure (GATT-CS group). Complication rates were noted. Survival analysis was investigated by Kaplan-Meier test. **Results:** The preoperative IOP was significantly higher in GATT group (26.5±11.25, n=30) than GATT-CS group (20.5±6.75, n=40) (p=0.001). The GATT group showed significantly higher percentages of IOP reduction after third month, and remained so throughout the follow-up (p<0.05) without significant difference in medication numbers. At the last visit, IOP percentile reductions were 49.58±14.50 in GATT group and 32.73±17.65 in GATT-CS group (p<0.0001). Final median IOP levels were found insignificantly lower in GATT group (12.0±3.5) compared to GATT-CS group (14.0±4.0) (p=0.08). Complete success rates were 70% for GATT and 62.5% for GATT-CS (p=0.51). Two groups did not differ statistically from one another in terms of survival analysis and complication rates (p≥0.05). Toxic anterior segment syndrome was observed only in the combined group in four cases. **Conclusion:** GATT is an effective surgical method to control IOP in PXG. The IOP-lowering effect of GATT may be less when combined with CS.

Keywords: Cataract surgery; pseudoexfoliation glaucoma; trabeculotomy

ÖZET Amaç: Bu çalışmanın amacı, psödoeksfoliasyon glokomunda (PEG) katarakt cerrahisi (KC) ile birlikte veya KC olmadan yapılan 360-derece gonyoskopi-asiste translüminal trabekülotomi (GATT) sonuçlarının karşılaştırılmasıdır. **Gereç ve Yöntemler:** Tek merkezde 360-derece GATT uygulanan PEG hastaları retrospektif olarak incelendi. Ameliyat sonrası 1, 3, 6, 12, 18. aylarda ve son kontroldeki göz içi basıncı (GİB) ve ilaç sayıları kaydedildi. Cerrahi başarı, ilaç tedavisi ve ilave glokom cerrahisi olmaksızın GİB'nin başlangıca göre ≥%20 azalması ve GİB'nin <18 mmHg olması olarak tanımlandı. Sonuçlar GATT grubu ve kombine grup (GATT-KC grubu) arasında karşılaştırıldı. Komplikasyon oranları kaydedildi. Sağkalım analizi Kaplan-Meier testi ile yapıldı. **Bulgular:** Ameliyat öncesi GİB, GATT grubunda (26,5±11,25, 30 göz) GATT-KC grubuna (20,5±6,75, 40 göz) göre anlamlı derecede yüksekti (p=0,001). GATT grubu 3. aydan sonra anlamlı derecede daha yüksek GİB düşüşü yüzdeleri gösterdi ve ilaç sayılarında anlamlı bir fark olmaksızın takip boyunca bu şekilde kaldı (p<0,05). Son kontrolde GATT grubunda GİB yüzdelik düşüşü 49,58±14,50, GATT-KC grubunda ise 32,73±17,65 idi (p<0,0001). Son medyan GİB düzeyleri GATT grubunda (12,0±3,5), GATT-KC grubuna (14,0±4,0) göre anlamlı derecede düşük bulundu (p=0,08). Cerrahi başarı oranları GATT için %70, kombine grup için %62,5 idi (p=0,51). Sağkalım analizi ve komplikasyon oranları açısından iki grup birbirinden istatistiksel olarak farklı değildi (p≥0,05). Sadece kombine grupta 4 hastada toksik ön segment sendromu gözlendi. **Sonuç:** PEG'de GİB kontrolünü sağlamada GATT etkili bir cerrahi yöntemdir. GATT'nin GİB düşürücü etkisi, KC ile kombine edildiğinde daha düşük olabilir.

Anahtar Kelimeler: Katarakt cerrahisi; psödoeksfoliasyon glokomu; trabekülotomi

TO CITE THIS ARTICLE:
Tekcan H, İmamoğlu S, Özçelik Köse A, Ün Y, Kuğu S. Comparison of outcomes of 360-degree gonioscopy-assisted transluminal trabeculotomy with or without cataract surgery in pseudoexfoliation glaucoma: A retrospective-comparative study. Turkiye Klinikleri J Ophthalmol. 2024;33(3):137-46.

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Peer review under responsibility of Turkiye Klinikleri Journal of Ophthalmology.

Received: 06 Nov 2023 ***Received in revised form:*** 29 May 2024 ***Accepted:*** 10 Jun 2024 ***Available online:*** 14 Jun 2024

Pseudoexfoliation glaucoma (PXG) is the most common type of secondary open-angle glaucoma (OAG), which progresses rapidly and is accompanied by large intraocular pressure (IOP) fluctuations and severe optic nerve head damage.[1] Glaucoma surgery is often needed due to poor response to medical therapy. Pseudoexfoliation (PEX) accelerates cataract development, combined glaucoma and cataract surgery (CS) has been reported to be effective in controlling IOP in PXG patients.[2,3]

Gonioscopy-assisted transluminal trabeculotomy (GATT) is a blebless and sutureless, circumferential ab-interno trabeculotomy method that decreases aqueous outflow resistance through Schlemm's canal. The favorable efficacy and of GATT surgery in reducing the IOP and medication use have been previously established in different glaucoma types.[4-12]

Although patients with PEX have also been shown to have a significant reduction in IOP following phacoemulsification, it is also well known that PEX eyes have a higher risk of postoperative inflammation and IOP spikes than non-PEX eyes.[13-15] The recent two studies reported combining with CS does not change the results of GATT, in the eyes with PXG.[6,7] As these studies did not exclude eyes with prior ocular surgery and included patients undergoing partial and 360-degree GATT, there is still insufficient evidence to draw a conclusion on this issue. In this study, we compared the outcomes of 360-degree GATT with or without CS in the PXG eyes without a previous ocular surgery, and also examined the postoperative complications and possible factors that may affect the surgical success.[6,7]

MATERIAL AND METHODS

In this retrospective study, the records of 70 patients (70 eyes) with PXG who underwent 360-degree GATT at Haydarpaşa Numune Training and Research Hospital between September 2020 and February 2023, were investigated. The entire study was conducted in accordance with the principles of the Declaration of Helsinki, and protocol approval was obtained from the Haydarpaşa Numune Training and Research Hospital Ethical Committee (date: June 19, 2023, no: HNEAH-KAEK 2023/116) of the same hospital.

The visible PEX material on the lens and/or pupillary margin, glaucomatous optic nerve head changes, and visual field (VF) defects with computerised VF test (24-2, SITA Standard algorithm, Humphrey Visual Field Analyzer II; Carl Zeiss Meditec, Jena, Germany), were criteria of PXG diagnosis. The visibility of trabecular meshwork (TM) was confirmed with preoperative gonioscopic examination. Patients with uncontrolled IOP and with progressive loss in retinal nerve fiber layer and VF examinations despite maximum anti-glaucomatous medication, or patients who have intolerance to drops were included and GATT surgery was performed. Additionally if visually disabling cataract was present, GATT surgery was combined with CS. According to the surgery, the cases with minimum 6 months follow-up period, were included into GATT group and GATT-CS group.

The exclusion criteria included, unidentifiable TM (angle closure, corneal opacity), OAG other than PXG, a history of ocular surgery, operative complications (vitreous loss), anticoagulant medication usage and a history of bleeding disorder. The patients whom we failed to perform a complete 360-degree trabeculotomy were excluded from this study to prevent any bias. In patients undergoing bilateral surgery, only the first eye operated on was included.

SURGICAL TECHNIQUE

Two experienced glaucoma surgeons (SI, SK) performed all surgical procedures. Corneal incisions were formed in the superior and temporal quadrants with a 20-gauge knife. Ocular viscoelastic substance (VES) was administered into the anterior chamber. After tiltation of the patient's head and microscope, a blunted 6-0 prolene suture, was directed to the nasal angle through the superior incision. A 1-1.5 mm goniotomy was performed at the nasal angle using a direct gonioscopy lens. The suture was placed into the goniotomy and pushed through Schlemm's canal with microforceps introduced in the anterior chamber via the temporal incision. Subsequently, the distal edge of the suture protruding from the goniotomy was held, and both ends of the suture were pulled out

through the temporal incision and a 360-degree trabeculotomy was completed. In the patients with cataract, phacoemulsification (Infiniti Vision System, Alcon Laboratories, Fort Worth, TX, USA) and foldable, one-piece, acrylic hydrophobic intraocular implantation in the capsular bag were performed after GATT. At the end of the surgery, VES was aspirated and cefuroxime axetil (1 mg/0.1 mL) was administered into the anterior chamber. In the combined procedure, air was filled into the anterior chamber with a hydrodissection cannula. During the postoperative three weeks, moxifloxacin eye drops 0.5% (Vigamox; Alcon Labs Inc., Fort Worth, TX, USA) and prednisolone acetate ophthalmic suspension 1% (Pred Forte, Allergan, Ireland) were used 4 times per day.

DATA COLLECTION

The gender, patient age, preoperative data including IOP measurement (Goldmann applanation tonometer), anti-glaucomatous medication number scored according to the number of pharmacologic classes, corrected-distance visual acuity (CDVA) converted to the logarithm of the minimum angle of resolution (LogMAR), cup-to-disc ratio on biomicroscopic examination, mean deviation (MD) and pattern standard deviation of VF were recorded. Postoperative data included IOP and medication numbers at the first postoperative day, first week, 1st, 3rd, 6th, 12th, 18th months and the last follow-up, and also success rates and CDVA at the last follow-up.

IOP and the number of medications were recorded as primary outcomes. The rates of "complete success" (IOP reduction ≥20% from baseline and IOP≤17 mmHg with no medication and no further glaucoma surgery) and "overall success" (≥20% of IOP reduction and IOP≤17 mmHg with or without medication and no need for additional surgery) were secondary outcomes. If surgery was done for intolerance to medical therapy, in the eyes with preoperative IOP≤17 mmHg, postoperative IOP≤17 mmHg without treatment was accepted as complete success or with less medication compared to baseline was overall success. Preoperative and postoperative outcomes were compared between GATT group and GATT-CS group.

The postoperative complications including hyphema, toxic anterior segment syndrome (TASS) and early IOP spikes were recorded. Layered blood in the anterior chamber was considered as hyphema. Surgical evacuation was required when hyphema did not resolve despite subconjunctival atropine and dexamethasone enjection during the first 2 weeks. TASS was treated with topical 1% prednisolone acetate (12 times per day), and if the effect of topical steroid was limited, TASS was treated with subconjunctival dexamethasone injection. The treatment of an early IOP spike, determined as IOP≥26 mm Hg during postoperative first week, was performed with oral acetozolamid and intravenous injection of 20% mannitol solution. In addition, lens-related changes defined as CDVA loss by greater than two Snellen lines, prolonged corneal oedema or corneal decompensation, suprachoroidal or vitreous hemorrhage, hypotony (≤6 mmHg), hypotony maculopathy, or endophthalmitis were noted.

STATISTICAL ANALYSIS

The SPSS, version 20.0 for Windows (SPSS Inc., Chicago, IL, USA) was used for all statistical analysis. The distribution normality of variables were investigated by using Kolmogorov-Simirnov test or Shapiro-Wilk's test. Intergroup comparisons were performed with Independent-samples t-test or Mann-Whitney U test for continous variables, with chi-square test or Fisher's exact test for categorical variables. Paired student's t-test or Wilcoxon signed rank test was used to compare the preoperative and postoperative outcomes. Kaplan-Meier test was made for survival analysis of complete success and the survival rates were compared between two groups with the Mantel-Cox log-rank test. The prognostic factors for complete success were analyzed with univariate model of logistic regression analysis. According to the normality distribution, the values were given as mean±standard deviation (SD) or median±interquartile range (IQR), and categorical variables were presented as percentages (%). A p value <0.05 was statistically significant.

RESULTS

There were 30 eyes of 30 patients in GATT group and 40 eyes of 40 patients in GATT-CS group. There was no statistically significant intergroup difference

in age, gender, VF and follow-up time (p≥0.05) (Table 1). Cup-to-disc ratio was statistically significantly greater in the GATT group (median; 0.7) compared to the combined group (median; 0.5) (p=0.03).

IOP measurements before and after surgery are presented in Table 2. The preoperative IOP was statistically significantly higher in the GATT group than in the GATT-CS group (p=0.001). When compared to baseline, postoperative IOP was statistically significantly lower in both groups, during the follow-up (p<0.05). The difference in postoperative IOP measurements between two groups, were statistically significant at first day (p=0.02), month 3 (p=0.01) and month 6 (p=0.004). Percentages of IOP reduction at first day (p=0.001), 3rd month (p<0.0001), 6th month (p<0.0001), 12th month (p<0.0001), 18th month (p=0.03) and at the last visit (p<0.0001) were statistically significantly higher in the GATT group compared to the GATT-CS group.

In both groups, there was a statistically significant decrease in the number of medications after surgery compared to before surgery (p<0.05). The pre- and postoperative number of medications, and also the percentages of reduction in medication numbers

TABLE 1: Baseline patient characteristics.

	All patients (n=70)	GATT (n=30)	GATT-CS (n=40)	p value
Age (years±IQR)	70.5±8.0	69.0±13.5	71.0±7.7	0.09
Sex (Female/Male)	31/39	14/16	17/23	0.72
Follow-up (months±IQR)	12.0±18.0	12.0±18.0	12.0±16.5	>0.99
Cup-to-disc ratio (median±IQR)	0.60±0.43	0.70±0.40	0.50±0.50	0.03
Visual Field MD (dB±IQR)	-7.02±14.4 (n=50)	-8.83±19.9 (n=26)	-6.15±13.4 (n=24)	0.16
Visual Field PSD (dB±IQR)	4.87±6.5 (n=50)	6.02±5.8 (n=26)	3.64±7.4 (n=24)	0.37

GATT: Gonioscopy-assisted transluminal trabeculotomy; GATT-CS: Gonioscopy-assisted transluminal trabeculotomy with cataract surgery; IQR: Interquartile range; MD: Mean deviation; PSD: Pattern standard deviation.

TABLE 2: Preoperative and postoperative intraocular pressure measurements.

Time period	All patients	GATT	GATT-CS	p value
Preoperative (mmHg±IQR)	22.0±10.0	26.5±11.25 (n=30)	20.5±6.75 (n=40)	0.001
Day 1 (mmHg±IQR)	13.0±6.25	12.0±5.25 (n=30)	15.5±7.0 (n=40)	0.02
IOP reduction (%±SD)	*32.83±37.95*	*49.78±21.18*	*20.12±42.75*	*0.001*
Week 1 (mmHg±IQR)	13.0±6.0	13.0±5.25 (n=30)	12.5±6.0 (n=40)	0.88
IOP reduction (%±SD)	*40.05±28.83*	*45.00±33.85*	*36.35±24.19*	*0.21*
Month 1 (mmHg±IQR)	13.0±5.0	13.0±4.0 (n=30)	14.0±5.75 (n=40)	0.28
IOP reduction (%±SD)	*35.78±31.12*	*42.94±38.22*	*30.41±23.63*	*0.09*
Month 3 (mmHg±IQR)	12.0±4.0	12.0±3.0 (n=29)	14.0±4.0 (n=40)	0.01
IOP reduction (%±SD)	*40.26±25.97*	*52.05±15.09*	*31.72±19.91*	*<0.0001*
Month 6 (mmHg±IQR)	13.0±5.0	12.0±4.5 (n=29)	15.0±4.0 (n=40)	0.004
IOP reduction (%±SD)	*38.83±20.52*	*51.46±15.05*	*29.67±19.16*	*<0.0001*
Month 12 (mmHg±IQR)	13.0±3.0	12.0±4.0 (n=21)	14.0±4.0 (n=27)	0.09
IOP reduction (%±SD)	*41.09±20.10*	*52.56±16.19*	*32.17±18.43*	*<0.0001*
Month 18 (mmHg±SD)	13.6±2.9	13.6±2.7 (n=10)	13.60±3.2 (n=15)	>0.99
IOP reduction (%±SD)	*38.40±19.55*	*48.34±15.62*	*31.78±19.51*	*0.03*
Last visit (mmHg±IQR)	13.0±4.0	12.0±3.5 (n=29)	14.0±4.0 (n=40)	0.08
IOP reduction (%±SD)	*39.82±18.31*	*49.58±14.50*	*32.73±17.65*	*<0.0001*

GATT: Gonioscopy-assisted transluminal trabeculotomy; GATT-CS: Gonioscopy-assisted transluminal trabeculotomy with cataract surgery; IOP: Intraocular pressure; IQR: Interquartile range; Percentages of IOP reduction: Reduction in IOP after surgery/preoperative IOPx100; SD: Standard deviation.

did not differ statistically significantly between two groups, at any follow-up time (p≥0.05) (Table 3).

The baseline CDVA was statistically significantly worse in the GATT-CS group (0.84±0.77; median: 0.52) than GATT group (0.24±0.25; median: 0.20) (p<0.0001). After surgery, CDVA did not differ significantly between GATT-CS (0.22±0.44; median: 0.0) and GATT groups (0.24±0.34; median: 0.20) (p=0.05). Visual acuity improvement after combined surgery was statistically significant (p<0.0001). The mean visual acuity following surgery did not change statistically significantly from baseline in the GATT group (p=0.56).

Postoperative complications are shown in Table 4. There were no statistically significant differences between the two groups in the terms of hyphema and IOP spike frequencies (p≥0.05). TASS was occured in four of 40 eyes (10%) in the GATT-CS group, this was statistically insignificantly different compared to the GATT group in which there was no TASS in any eyes (p=0.07). Anterior chamber irrigation was required in one patient with hyphema and subconjunctival steroid injection was needed in one patient with TASS, in the combined group. A decrease in CDVA was observed in five eyes in the GATT group, the cause of worsening was cataract development in all these eyes. The eyes that underwent CS after GATT were excluded from the further statistical analysis. Other possible complications such as prolonged corneal oedema or corneal decompensation, suprachoroidal or vitreous hemorrhage, hypotony, hypotony maculopathy, or endophthalmitis were not occured in any cases.

The complete success rates at the last visit in the GATT group was 70% (21 eyes), and in the GATT-CS group was 62.5% (25 eyes) (p=0.51). The overall success rates in the GATT group was 96.7% (29

TABLE 3: Number of anti-glaucomatous medications before and after surgery.

Time period	All patients	GATT	GATT-CS	p value
Preoperative (median; range)	3.0; 1.0-4.0	3.0; 1.0-4.0 (n=30)	3.0; 1.0-4.0 (n=40)	0.24
Month 1 (median; range)	0.0; 0.0-4.0	0.0; 0.0-4.0 (n=30)	0.0; 0.0-3.0 (n=40)	0.61
Percentages of reduction	*100; 0.0-100.0*	*100; 25.0-100.0*	*100; 0.0-100.0*	*0.66*
Month 3 (median; range)	0.0; 0.0-4.0	0.0; 0.0-4.0 (n=29)	0.0; 0.0-3.0 (n=40)	0.86
Percentages of reduction	*100; 0.0-100.0*	*100; 0.0-100.0*	*100; 0.0-100.0*	*0.93*
Month 6 (median; range)	0.0; 0.0-4.0	0.0; 0.0-4.0 (n=29)	0.0; 0.0-3.0 (n=40)	0.76
Percentages of reduction	*100; 0.0-100.0*	*100; 0.0-100.0*	*100; 0.0-100.0*	*0.65*
Month 12 (median; range)	0.0; 0.0-3.0	0.0; 0.0-3.0 (n=21)	0.0; 0.0-3.0 (n=27)	0.91
Percentages of reduction	*100; 0.0-100.0*	*100; 25.0-100.0*	*100; 0.0-100.0*	*0.83*
Month 18 (median; range)	0.0; 0.0-3.0	0.5; 0.0-3.0 (n=10)	0.0; 0.0-3.0 (n=15)	0.46
Percentages of reduction	*100; 0.0-100.0*	*87.5; 25.0-100.0*	*100; 0.0-100.0*	*0.80*
Last visit (median; range)	0.0; 0.0-4.0	0.0; 0.0-4.0 (n=29)	0.0; 0.0-3.0 (n=40)	0.66
Percentages of reduction	*100; 0.0-100.0*	*100; 0.0-100.0*	*100; 0.0-100.0*	*0.46*

GATT: Gonioscopy-assisted transluminal trabeculotomy; GATT-CS: Gonioscopy-assisted transluminal trabeculotomy with cataract surgery; Percentages of reduction: Reduction in medication number after surgery/preoperative medication numberx100.

TABLE 4: Postoperative complications.

	All patients (n=70)	GATT (n=30)	GATT-CS (n=40)	p value
Hyphema (n; %)	17; 24.3%	8; 26.7%	9; 22.5%	0.68
TASS (n; %)	4; 5.7%	0; 0.0%	4; 10.0%	0.07
IOP spike (n; %)	7; 10.0%	2; 6.6%	4; 10.0%	0.48

GATT: Gonioscopy-assisted transluminal trabeculotomy; GATT-CS: Gonioscopy-assisted transluminal trabeculotomy with cataract surgery; Hyphema: Layered hyphema in the anterior chamber; IOP spike: Intraocular pressure >25 mmHg during postoperative first week; TASS: Toxic anterior segment syndrome.

eyes), and in the GATT-CS group was 95% (38 eyes) (p=0.60). IOP spikes did not last longer than one week except one case in the GATT group who required trabeculectomy at postoperative second month. This case was excluded from any further IOP, number of medication and CDVA analysis after trabeculectomy. There was no need for additional glaucoma surgery in the GATT-CS group. Mean survival times for complete success were 15.49±1.42 months and 17.01±1.21 months in the GATT group and GATT-CS group, respectively (p=0.60) (Figure 1).

Age, gender, cup-to-disc ratio, preoperative VF MD, preoperative IOP and medication numbers, presence of postoperative complications and combined surgery were investigated as potential factors that could affect the complete surgical success. In 70 eyes, there was no factor statistically signficantly related with complete success at the last visit (p≥0.05) (Table 5). When regression analysis was performed in the GATT and GATT-CS groups, any factor did not statistically significantly associate with complete success in both groups (p≥0.05).

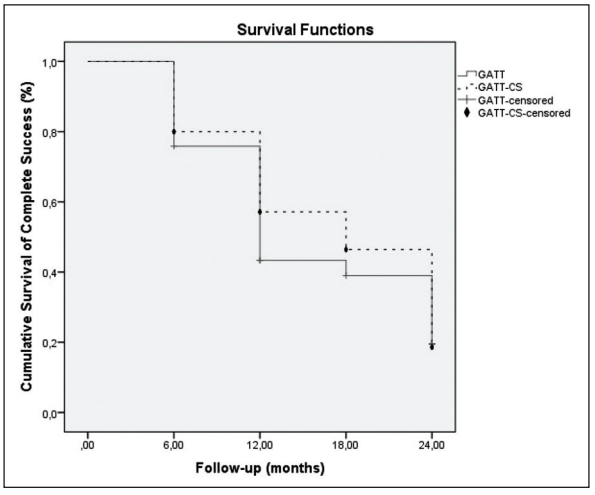

FIGURE 1: Kaplan-Meier analysis for complete success; complete success rates were 70.0% in GATT group and 62.5% in GATT-CS group (p=0.60, Mantel-Cox log-rank test).
GATT: Gonioscopy-assisted transluminal trabeculotomy; GATT-CS: Gonioscopy-assisted transluminal trabeculotomy combined with cataract surgery.

TABLE 5: Univariate logistic regression analysis of predictive factors for complete success in 70 eyes.

Factor	OR	95% CI	p value
Age (years)	0.984	0.915-1.058	0.66
Gender	1.176	0.434-3.189	0.75
Cup/Disc ratio	0.299	0.042-2.124	0.22
Visual Field MD (dB)	1.021	0.959-1.087	0.51
Preoperative IOP (mmHg)	1.000	0.930-1.075	0.99
Preoperative medication number	0.620	0.376-1.024	0.06
GATT-CS	0.714	0.260-1.961	0.51
Postoperative hyphema	1.970	0.564-6.880	0.28
Toxic anterior segment syndrome	0.500	0.066-3.791	0.50
Postoperative IOP spike	0.227	0.038-1.345	0.10

CI: Confidence interval; GATT-CS: Gonioscopy-assisted transluminal trabeculotomy with cataract surgery; Hyphema: Layered hyphema in the anterior chamber; IOP spike: Intraocular pressure >25 mmHg during postoperative first week; MD: Mean deviation; OR: Odds ratio. Complete success criteria; postoperative IOP<18 mmHg and ≥20% reduction from baseline without medication or additional glaucoma surgery.

DISCUSSION

GATT reduces the trabecular outflow resistance through a circumferential incision of the juxtacanalicular trabeculum and the inner wall of Schlemm's canal.[16] In several studies, the IOP-lowering effect of GATT in the PXG was reported without specifying the results of the groups combined with or without CS.[11,17-20] The more dramatic reduction in IOP following CS in the PEX eyes than non-PEX eyes, is assumed to be associated with various mechanisms such as aspiration of debris and removal of a part the anterior capsule, expansion of the anterior chamber and increased trabecular outflow.[21-24] Although the IOP-lowering potency of GATT combined with CS in mix glaucoma types have been substantiated, to our knowledge there are only two studies that reported the outcomes in PXG eyes by comparing the GATT alone procedure and combined procedure.[5-8,11,19,20,25] This study compared the efficacy and safety of 360-degree GATT between standalone and combined with CS procedure in the PXG eyes without a history of ocular surgery.

In the present study, the IOP and medication numbers were significantly lower compared to baseline, at all postoperative time points, in both GATT and GATT-CS groups. Percentages of reduction in IOP were significantly higher in the GATT group from the third postoperative month without significant difference in the medication numbers between groups and remained so throughout follow-up. TASS was observed in four eyes (10%) in the combined group.

It has been reported that simultaneous CS did not have a additive effect on IOP reduction in eyes that undergone GATT surgery.[5-8,11,20,25] However, many of these studies included mixed types of glaucoma, the majority of which was primary OAG and literature data specific to effect of combining GATT with CS on outcomes in PXG eyes are still limited.[5,8,20,25] A previous study by Sharkawi et al., compared the results of GATT with (50 eyes) or without CS (53 eyes) in PXG eyes and reported that IOP and the number of medications were significantly lowered following surgery during the 24-month follow-up, without significant intergroup difference.[6] The cumulative surgical success rate was 89.2%. The success rates were not specified in GATT and combined groups. In this recent study, 11 of 103 eyes had a history of glaucoma surgery, six eyes had partial trabeculotomy and also all patients included in the GATT group were pseudophakic.[6] Whereas it has been reported that the eyes with prior CS tended to have worse outcomes after GATT and trabeculectomy.[8,26,27] An another study by Aktas et al., that has investigated the outcomes of GATT surgery in PXG eyes, 14 eyes (12.6%) had a 270 to 300-degree trabeculotomy, the remaining 97 eyes had a 360-degree GATT. In this recent study, the comparative analysis revealed that the results of GATT combined with CS (n=32) did not differ from GATT alone results of phakic patients (n=44) in terms of reduction in IOP or medications during 20.4±14.1 months follow-up.[7] Cumulative success rates were higher in phakic eyes undergoing GATT-only (86.9%) than in those undergoing combined surgery (75.0%) without significance, however the IOP values and also percentages of IOP reductions were not specified in these subgroups.[7]

In our study, preoperative IOP was significantly higher in the GATT group than in the combined group. During follow-up, postoperative IOP was lower and the percentages of IOP reduction was more dramatic in the GATT group with no significant intergroup difference in the medication numbers. The difference in postoperative IOP was significant at only month 3 and month 6, however the difference in IOP reduction percentages was significantly greater from month 3 and remained so throughout the follow-up. At the last visit, in the GATT group, median IOP was 12.0 mmHg with 49.58% of mean IOP reduction from baseline, and in the GATT-CS group, median IOP was 14.0 mmHg with 32.73% of mean IOP reduction. This difference in the percentile changes of IOP may be explained with the preoperative higher IOP value in the GATT group. Despite the presence of higher preoperative IOP in the GATT group, the postoperative IOP values were lower in this group compared to the GATT-CS group, which can be interpreted as the GATT standalone procedure may be more effective than combined with CS procedure in PXG. Our findings were opposed to the previous studies by Sharkawi et al. and Aktas et al. in which preoperative IOP values were not compared between two groups.[6,7] Also, unlike these recent studies, we excluded the eyes with previous ocular surgery and we included only the eyes undergoing 360-degree GATT, to prevent additional factors that could change the efficacy of the surgery.

Bozkurt et al. compared groups, either GATT alone or GATT combined with CS, in 108 eyes with OAG, the majority of whom were PXG (66 eyes).[19] Final IOPs and success percentiles did not differ significantly, however significantly higher IOP percentile reduction was observed in GATT group (44.25%) than in GATT-CS group (32.29%). Although the results of GATT and GATT combined with CS were not specified in the eyes with PXG, Bozkurt et al.'s study outcomes are comparable with ours, as preoperative IOP was significantly lower in the GATT-CS group and predominantly included PXG eyes.[19]

The most common complication of our surgery was hyphemia (24.3%). In our study, at the end of the surgery, the VES was removed from the anterior chamber, in both groups and also an air bubble was instilled into the anterior chamber to help tamponade bleeding, in the combined group. Only one patient required surgical washout because of persistant hyphema. In the present study, an early IOP spike was observed in 6 of 70 eyes (8.5%). In Sharkawi et al.'s study and Aktas et al.'study, in which VES was inserted to fill 25% of anterior chamber at the end of the surgery, 25 eyes (24.5%) and 15 eyes (13.5%) with an early IOP spike were reported in PXG patients, respectively.[6,7] However, the rates of compli-

cations were not specified in the subgroups.[6,7] Our lower rates in IOP spike may be due to not filling the anterior chamber with VES while finishing the surgery.

In our study, TASS was seen in four patients and all of them were in the GATT-CS group (10%). Only one patient need subconjunctival steroid injection. Inflammatory reactions such as TASS or iritis have been reported after GATT in limited number of cases.[7,8,20] Relative anterior segment ischemia found in PEX eyes leads to an abnormal blood–aqueous barrier.[28] After phacoemulsification, this breakdown is more extensive in these eyes and may be a risk factor for intense postoperative inflammation.[29] In the current study, the difference in postoperative IOP and in IOP reduction between the two groups may be explained by the postoperative inflammation, in the combined group. We think that the frequency of TASS in our combined group may be due to filling the anterior chamber with air instead of VES. However, there was no TASS reported in the studies by Sharkawi et al. and Aktas et al. Viscoelastic leaving in the anterior chamber and subconjunctival steroid injection at the end of the surgery may have been effective to prevent the inflammatory reaction in these previous studies.[6,7]

Several risk factors for failure after GATT including eyes with previous trabeculectomy, pseudophakia, eyes with VF MD of worse than -15 dB, postoperative IOP spikes, and also duration of an IOP spike, non-circumferential trabeculotomy, have been reported.[5,8,30-32] In our study, we could not evaluate an relationship between complete success and age, gender, cup-to-disc ratio, VF MD, preoperative IOP and medication number, combined surgery, postoperative hyphema, TASS and IOP spike. We excluded the eyes with prior ocular surgery and included only 360-degree trabeculotomies. Although twenty patients (28.6%) did not have a baseline VF test caused by low visual acuity due to advanced glaucoma or cataract, not finding a relationship between MD and surgical success was consistent with many published studies.[10,20,31,33]

The retrospective nature of the study is major limitation of our study. There was a limitation in the follow-up, as we lost several patients especially at the 18-month follow-up visit. Furthermore, we could not analyze the effect of cataract density and surgical parameters such as cumulative dissipated energy of phacoemulsification or irrigation fluid dynamics on the results. Additionally, the baseline IOP was significantly higher in our GATT group than GATT-CS group. Further studies comparing the efficacy of GATT with and without CS in preoperative IOP-matched PXG eyes may give us more accurate results about the difference between groups.

CONCLUSION

In PXG, GATT performed alone or combined with CS, effectively lowers IOP and medication numbers. The efficacy of GATT in the eyes with PXG may be lower when combined with CS. Leaving an air bubble instead of VES in the anterior chamber at the end of the combined surgery may reduce the risk of postoperative IOP spikes, however, due to insufficient and short-term tamponade effect, care should be taken in terms of postoperative inflammation.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Hatice Tekcan;* ***Design:*** *Hatice Tekcan, Serhat İmamoğlu;* ***Control/Supervision:*** *Serhat İmamoğlu;* ***Data Collection and/or Processing:*** *Hatice Tekcan, Alev Özçelik Köse;* ***Analysis and/or Interpretation:*** *Hatice Tekcan, Alev Özçelik Köse, Yasemin Ün;* ***Literature Review:*** *Hatice Tekcan, Yasemin Ün;* ***Writing the Article:*** *Hatice Tekcan;* ***Critical Review:*** *Serhat İmamoğlu, Süleyman Kuğu;* ***References and Fundings:*** *Hatice Tekcan;* ***Materials:*** *Hatice Tekcan, Serhat İmamoğlu, Süleyman Kuğu.*

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