

Gonioscopy-Assisted Transluminal Trabeculotomy (GATT): Efficacy, Safety, and Long-Term Outcomes in Open-Angle Glaucoma

Hany Abdelhafeez Elbially, Adel Abdelrazik Farag, Ayman Ahmed Alkawas, Abdelrahman Ahmed Abdelrahman Tolba, Tamer Gamal Elsayed

Ophthalmology Department, Faculty of Medicine, Zagazig University, Egypt

***Corresponding author:** Abdelrahman Ahmed Abdelrahman Tolba

Email: abdelrahmanelshobary604@gmail.com

Abstract:

Gonioscopy-assisted transluminal trabeculotomy (GATT) is an ab interno, conjunctival-sparing minimally invasive glaucoma surgery that reduces resistance at the trabecular meshwork and the inner wall of Schlemm's canal. It has emerged as an effective option for lowering intraocular pressure and reducing dependence on antiglaucoma medications in patients with open-angle glaucoma, while preserving the conjunctiva for possible future filtration procedures. Reported advantages include the absence of bleb-related complications, a low risk of prolonged hypotony, possible synergy with cataract extraction, and relatively rapid postoperative recovery. Current evidence demonstrates meaningful and sustained intraocular pressure reduction with generally favourable safety outcomes, although long-term failure and reoperation may occur, particularly in patients with high preoperative intraocular pressure or postoperative pressure spikes. Transient hyphema is the most frequently reported complication, whereas serious late complications are uncommon. GATT has also shown potential effectiveness in advanced, refractory, and previously operated open-angle glaucoma, provided that patients are carefully selected and closely followed. Overall, the available literature supports GATT as a safe and effective conjunctival-sparing alternative to conventional glaucoma surgery, with the additional advantage of maintaining future surgical options.

Keywords: Gonioscopy-assisted transluminal trabeculotomy; GATT; primary open-angle glaucoma; intraocular pressure; minimally invasive glaucoma surgery; Schlemm's canal; trabecular meshwork.

Introduction:

Gonioscopy is a technique of viewing the iridocorneal angle: the area between the iris and cornea where the trabecular meshwork is located and where aqueous humour drains out of the eye. Gonioscopy lenses are needed to view the angle, as light from this area would not otherwise reach the observer (1)

Gonioscopy allows the identification of structures of the anterior chamber angle and an estimation of the angle width; it is also necessary during any procedures affecting the angle, such as laser or surgery (2)

Anything which impedes drainage through the trabecular meshwork can cause an increase in the intraocular pressure. It is therefore critical that all potential and newly diagnosed glaucoma patients undergo a thorough gonioscopy examination as part of their ophthalmic assessment so that the mechanism of raised intraocular pressure can be established (3)

Structures of the iridocorneal angle

From anterior (towards the cornea) to posterior (towards the iris), the structures seen are:(4)

1. Schwalbe's line. Demarcates Descemet's membrane from the anterior trabeculum. It can be located by identifying the corneal wedge (**Fig 1**).
2. Non-pigmented trabecular meshwork. A pale area adjacent to Schwalbe's line which does not drain aqueous humour.
3. Pigmented trabecular meshwork. Brown/pigmented area where aqueous humour drains from the eye; it is critical to identify whether or not it is visible on gonioscopy.
4. Scleral spur. A narrow, dense, whitish band posterior to the trabeculum; a consistent landmark in all eyes.
5. Ciliary body. A dull, brown band posterior to the scleral spur.

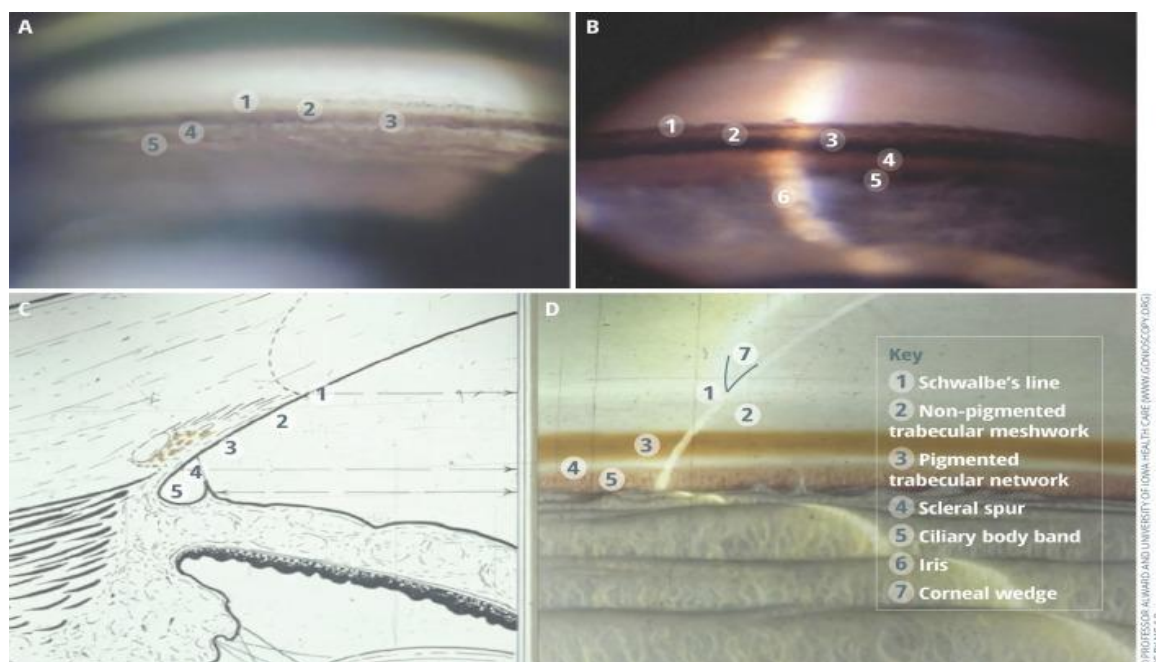


Fig. 1 Two photographs (A and B) and two drawings (C and D) showing the structures seen on gonioscopy of an open angle. B shows a patient with pigment dispersion where the angle is densely pigmented, especially the pigmented trabecular meshwork. Some patients may have very little pigment present (hypopigmented angle) and identifying the different structures can be challenging. The bottom left image shows a cross-section of the corresponding image on the bottom right. The corneal wedge is shown where the reflections from the inner and outer aspects of the cornea meet, showing the position of Schwalbe's line, helpful in hypopigmented angles (**1**)

Gonioscopy lenses

Direct gonioscopy lenses (**Fig. 2 a**), such as the Swan-Jacobs lens, act as prisms and provide a direct, panoramic view of the angle. They are used for surgical procedures on the angle, with the patient lying on their back in the operating theatre (**5**)

Indirect gonioscopy lenses (**Fig. 2 b**), such as the Goldmann and Magnaview goniolenses, combine a prism and a mirror to provide a reflected image of the opposite angle. Gonioscopy is carried out at the slit lamp, with the patient in a sitting position (**5**)

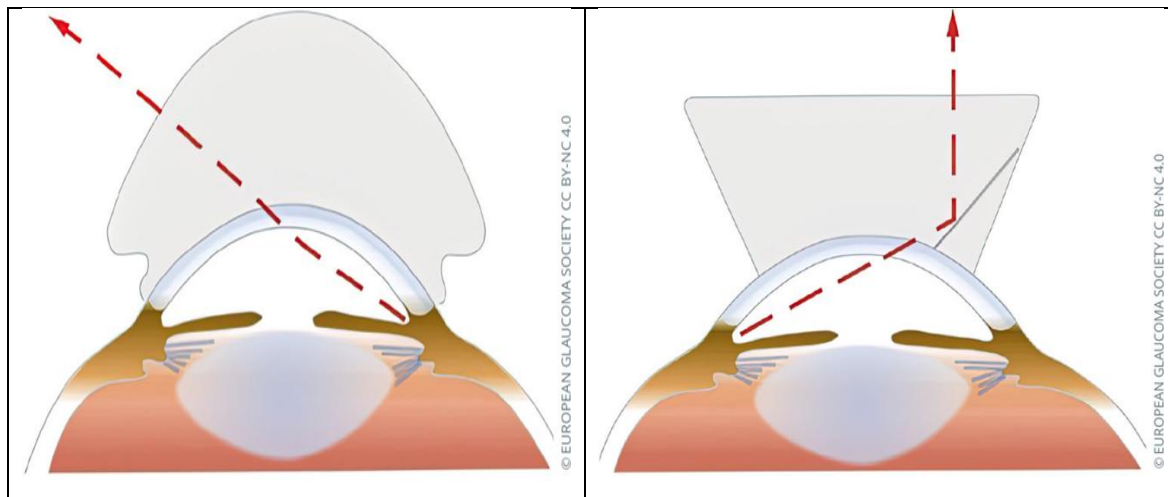


Fig. 2 From left to right: a)Direct gonioscopy, b)Indirect gonioscopy (1)

- **Gonioscopy-assisted transluminal trabeculotomy (GATT)**

Glaucoma can be devastating for young patients because of its asymptomatic nature, and a significant proportion of them may present with monocular vision. Conventionally, partial-thickness procedures such as trabeculectomy have been the first procedure of choice for glaucoma in young patients. Any primary glaucoma surgery which spares the conjunctiva offers significant clinical advantages to the patient as it offers more options for future interventions (6)

Gonioscopy-assisted transluminal trabeculotomy (GATT), originally described in 2014 by Grover *et al.*, is an ab interno conjunctival sparing minimally invasive glaucoma surgery (MIGS) that works by reducing resistance at the level of the trabecular meshwork and the inner wall of Schlemm's canal. GATT has been shown to be an effective method of reducing IOP and glaucoma medications in patients with open angle glaucoma, with low rates of post-operative complications (6)

A recently published systematic review and meta-analysis of ten GATT studies reported a combined IOP reduction of 9.81 mmHg and an 85% surgical success rate. The majority of published literature on GATT deals with cases of mild to moderate glaucoma, in accordance with the large randomized controlled trials on trabecular bypass MIGS. Data on GATT in patients with advanced glaucoma are limited (7)

The potential advantages of GATT over trabeculectomy are significant: a step-wise approach with the possibility of filtering procedures later in the course of the disease, no bleb-related complications, lower rates of hypotony, possible synergism with cataract extraction, and easier recovery and follow-up. Nevertheless, GATT has not been widely adopted in cases of advanced glaucoma. This is likely because of concerns of insufficient IOP lowering and lack of safety data (8)

Advantages and Disadvantages

A primary benefit of GATT is eliminating the need to incise the conjunctiva and sclera in order to navigate the trabecular meshwork. An ab interno approach also allows direct visualization of a so-called trabecular shelf that, when present, indicates an open, cleaved collector system commonly associated with a positive postoperative outcome (9)

Other advantages include no conjunctival bleb formation, few postoperative complications, and successful outcomes in juvenile and adult glaucoma. As there is no violation of the conjunctiva, GATT employs a physiologic approach that leaves other options available for future filtration surgery (10)

On the downside, surgeons without experience performing gonioscopy-assisted procedures may initially struggle with GATT. GATT also requires a reasonably clear cornea to visualize the nasal angle, and therefore, a cloudy cornea would preclude this ab interno approach. Introducing instruments into the anterior chamber also poses an increased risk for damage to intraocular structures (11)

Efficacy and Safety

In a retrospective comparative study, 4-year data on the safety and efficacy of GATT in open-angle glaucoma in 74 eyes with at least 36 months follow-up were provided. At 4 years, the cumulative failure rate was 53.9% and the reoperation rate was 42.0%. There were no significant differences in the failure and reoperation rates between the POAG and SOAG groups. Among the 31 eyes at the 4-year follow-up who did not undergo subsequent glaucoma surgery, GATT produced significant reductions in IOP, from baseline of 27.0 mmHg to 14.8 mmHg at 4 years, with an average decrease of 0.9 medications. The IOP reduction represents a 45% decrease from baseline (12)

The study's cumulative failure rates for GATT were comparable to those reported in previous retrospective studies with shorter follow-up durations. Specifically, it found a 27.0% failure rate at 12 months and 31.1% at 24 months. These rates align with Rahmatnejad et al.'s report of 37% at 12 months and Grover et al.'s range of 18% to 48% at 24 months, depending on glaucoma type and lens status. Thus, the study's outcomes are consistent with earlier research using similar success/failure criteria (12)

Thirty eyes required reoperation for glaucoma by 4 years after GATT, representing a cumulative reoperation rate of 42.0%. Patients who underwent glaucoma reoperation after GATT most commonly underwent a trabeculectomy or tube shunt. Large-scale prospective studies reporting outcomes of tubes and trabeculectomies showed failure rates ranging from 30% to 53% at 5 years, with reoperation rates ranging from 9% to 29% (13)

GATT showed higher overall failure and reoperation rates compared to traditional glaucoma surgeries like tube shunts and trabeculectomies. However, this may be partly due to surgeons being more inclined to reoperate after GATT, given its conjunctival-sparing nature, which makes future surgical options more viable. In some cases, GATT might be intentionally chosen as an initial, less invasive step before resorting to more complex procedures. Notably, in patients who did not require further glaucoma surgery after undergoing GATT, the reduction in intraocular pressure (IOP) was similar to that achieved with tube shunts and trabeculectomies, indicating comparable efficacy in successful cases (14)

Key risk factors for GATT failure at 4 years, include postoperative intraocular pressure (IOP) spikes, elevated preoperative IOP, and black race. These factors were also associated with failure at 12 months, with many reoperations occurring within the first year—often after IOP spikes. Black patients have shown higher failure rates in various glaucoma surgeries and may have a greater tendency for postoperative inflammation. Although no clinical inflammation was observed by one month post-surgery, subclinical inflammation may contribute to outflow pathway closure and surgical failure (15)

There was also a slightly higher risk of failure in patients with higher preoperative IOP, suggesting that GATT may not provide sufficient IOP reduction in some of these patients. The episcleral venous fluid wave has been suggested as an intraoperative gauge of trabecular outflow patency during angle procedures and correlates with outcomes after trabeculectomy at 12 months. This wave was not associated with surgical success at 4 years. It is possible that venous blanching has a stronger correlation with short-term outcomes after angle surgery, which would be an interesting topic for future investigation (16)

Neither concurrent nor previous cataract surgery significantly influenced the outcomes of GATT at the 4-year mark. Although the subgroup of patients who had cataract surgery was relatively small, this finding aligns with earlier research, which also showed no notable difference in intraocular pressure (IOP) reduction at 12 or 24 months post-GATT among those with or without cataract surgery. However, some evidence from prior studies suggests that pseudophakic patients with primary open-angle glaucoma (POAG) may experience a higher cumulative failure rate after GATT by 24 months, indicating a potential area for further investigation (17)

GATT showed a strong safety profile at 4 years, and there were no detected late-onset complications attributed to the procedure. As an angle-based procedure that does not involve an implant or a bleb, GATT avoids many delayed complications reported for tubes and trabeculectomies, such as hypotony, bleb leak, bleb-related endophthalmitis, and tube erosion. Consistent with previous reports, transient hyphema was the most common complication. Almost all of these resolved without surgical intervention. Postoperative IOP spike was also a

common occurrence. Most of these occurred in the absence of a hyphema and may be an indicator for early surgical failure **(18)**

Best-correct visual acuity remained stable throughout the 4-year follow-up period. A small number of eyes (11) lost 3 lines or more of Snellen acuity, and 8 of these eyes (72.7%) underwent reoperation for glaucoma. This is likely due to the advanced nature of disease in these eyes and not directly attributable to GATT **(19)**

In a case series describing the intermediate-term benefits of the GATT procedure in young glaucoma patients. Conventional trabeculectomy carries the risk of wipeout syndrome because of the prolonged hypotony during the procedure. In GATT, the risk of prolonged hypotony is minimal as all steps of the procedures require a well-pressurized globe **(20)**

Eight eyes did not require glaucoma medication after the initial 2-month visit. All patients maintained their pre-operative visual acuity, and none of them developed cataracts during the follow-up period **(19)**

Aktas *et al.* 2019 included 36 eyes of primary open-angle glaucoma (POAG) and 22 eyes of SOAG which had undergone only GATT. Their pre-GATT IOP was 24.36 mmHg and at 18 months showed an IOP reduction of 40.1%. **(21)**

The incidence of complications included hyphema, which resolved within 5–10 days. One patient had a small iridodialysis. The results are comparable to that of Baykara *et al.*, wherein all patients did develop self-limiting hyphema, which was transient and did not last beyond the initial 10 days **(6)**

To conclude, the available evidence demonstrates that the GATT procedure is effective in reducing intraocular pressure in South Indian patients with open-angle glaucoma. The ideal candidates appear to be individuals with a normal, open anterior chamber angle and without systemic comorbidities, particularly those not taking anticoagulant or antihypertensive medications **(22)**.

In a study evaluating the efficacy and safety of gonioscopy-assisted transluminal trabeculotomy (GATT) in patients with advanced glaucoma. It was concluded that GATT is a viable surgical option in cases of advanced glaucoma. Careful patient selection and attentive post-operative management are imperative **(8)**

A previously failed filtering procedure is a well recognized risk factor for subsequent bleb failure. In a study evaluating the safety and efficacy of gonioscopy assisted transluminal trabeculotomy (GATT) for patients with open angle glaucoma (OAG) who had undergone and failed prior incisional glaucoma surgery, the authors demonstrated that GATT remained both safe and effective in managing refractory OAG. Their findings suggest that GATT can serve as a viable option even in eyes with a history of unsuccessful filtering or incisional procedures **(15)**.

In a study aiming to provide 4-year data on the efficacy and safety of gonioscopy-assisted transluminal trabeculotomy (GATT) in patients with open-angle glaucoma. It was concluded that gonioscopy-assisted transluminal trabeculotomy can be a safe and effective conjunctival-sparing surgery for treating various forms of open-angle glaucoma at 4 years **(12)**

In a study designed to assess the first two years of a surgeon's learning curve with gonioscopy assisted transluminal trabeculotomy using the thermally blunted suture technique, researchers also evaluated factors that might influence surgical outcomes. The study found that GATT, in addition to being an apparently safe procedure, achieved satisfactory success rates even during the surgeon's initial learning period. Moreover, the technique proved effective in lowering intraocular pressure and reducing the number of glaucoma medications required **(23)**.

In a study conducted to compare the efficacy and safety of gonioscopy assisted transluminal trabeculotomy (GATT) with bent ab interno needle goniectionomy (BANG) in patients with open angle glaucoma (OAG), the findings indicated that GATT achieved a greater and more sustained reduction in intraocular pressure. Additionally, GATT demonstrated higher long term success rates compared with BANG, supporting its role as a more reliable surgical option for the management of OAG **(24)**.

Trabeculectomy (TRAB) has long been regarded as the gold standard surgical treatment for primary open angle glaucoma (POAG), whereas gonioscopy assisted transluminal trabeculotomy (GATT) has emerged as a minimally invasive alternative used across various open angle glaucoma (OAG) subtypes. In a comparative study evaluating the efficacy and safety of GATT versus TRAB for the management of POAG, the authors found that GATT achieved intraocular pressure (IOP) reduction, medication burden reduction, and visual field preservation comparable to those of TRAB. These findings support the role of GATT as a minimally invasive yet effective and safe option for lowering IOP in patients with POAG (14).

In another study comparing ab interno canaloplasty (ABiC) with GATT in patients with OAG, preliminary results demonstrated that GATT provided superior IOP reduction at 12 months postoperatively while maintaining a favourable safety profile. These outcomes suggest that GATT may offer a greater therapeutic advantage over ABiC in achieving effective pressure control in OAG patients (25).

Conclusion

GATT has been shown to be a safe and effective treatment modality, particularly well suited for JOAG patients who present significant therapeutic challenges. This includes individuals with advanced visual field loss, a history of previous glaucoma filtering surgeries, and markedly elevated preoperative intraocular pressure. Although such patients typically carry a higher risk of surgical failure, the use of GATT significantly reduced postoperative complications and maintained stable intraocular pressure control throughout long term follow up. These findings highlight GATT's value not only as a minimally invasive surgical option but also as a viable alternative for managing more complex JOAG cases. Furthermore, the study by Hu et al., 2025 emphasizes the influence of factors such as the duration of postoperative IOP spikes and the extent of peripheral anterior synechiae (PAS) on surgical outcomes, providing important insights that may guide more personalized treatment strategies for JOAG patients in the future (19).

References

1. Nolan, W., & Onakoya, A. (2022). Gonioscopy skills and techniques. *Community Eye Health*, 34(112), 40. <https://pmc.ncbi.nlm.nih.gov/articles/PMC8862628/>
2. Laroche, D., & Nwokeji, I. (2023). The Importance of Gonioscopy and Angle Assessment in Ocular Hypertension. *Ocular Hypertension - New Advances*. <https://doi.org/10.5772/INTECHOPEN.1003173>
3. Khazaeni, B., Zeppieri, M., & Khazaeni, L. (2023). Acute Angle-Closure Glaucoma. *StatPearls*. <https://www.ncbi.nlm.nih.gov/books/NBK430857/>
4. Albis-Donado, O., Ortiz-Arismendi, G. E., & Bhartiya, S. (2023). New Gonioscopy Technique for Finding Schwalbe's Line: The Ortiz Maneuver. *Journal of Current Glaucoma Practice*, 17(1), 37. <https://doi.org/10.5005/JP-JOURNALS-10078-1399>
5. Alward, W., & Longmuir, R. (2017). Principles of Gonioscopy - American Academy of Ophthalmology. <https://www.aao.org/education/disease-review/principles-of-gonioscopy>
6. Venkataraman, G., Manju, M., Chandran, P., Dhavalikar, M., Vimalanathan, M., & Sahu, A. (2022). Gonioscopy-assisted transluminal trabeculotomy (GATT) in Indian eyes – A description of 1-year follow-up results of the GATT procedure in a series of patients with open-angle glaucoma in South India. *Indian Journal of Ophthalmology - Case Reports*, 2(4), 891–893. https://doi.org/10.4103/IJO.IJO_947_22
7. Bao, W., Kawase, K., Huang, H., Sawada, A., & Yamamoto, T. (2019). The long-term outcome of trabeculotomy: Comparison with filtering surgery in Japan. *BMC Ophthalmology*, 19(1). <https://doi.org/10.1186/S12886-019-1107-0>
8. Dar, N., Haim, L. N. Ben, Yehezkeili, V., Sharon, T., & Belkin, A. (2023). Gonioscopy-assisted transluminal trabeculotomy in patients with advanced glaucoma. *Indian Journal of Ophthalmology*, 71(8), 3024. https://doi.org/10.4103/IJO.IJO_2769_22
9. Barrett, A., & Chaya, A. (2015). Gonioscopy-Assisted Transluminal Trabeculotomy: Blending Tradition With Innovation - Glaucoma Today. *Surgical Pearls*. <https://glaucomatoday.com/articles/2015-jan-feb/gonioscopy-assisted-transluminal-trabeculotomy-blending-tradition-with-innovation>

10. Maheshwari, D., Gupta, S., Tara, T. D., Pillai, M. R., Drishti, C., & Ramakrishnan, R. (2022). Gonioscopy-assisted transluminal trabeculotomy: Passing the right way decoding suture. *Indian Journal of Ophthalmology*, 70(10), 3746. https://doi.org/10.4103/IJO.IJO_1104_22,
11. Liu, W. W., Petkovsek, D., Shalaby, W. S., Arbabi, A., & Moster, M. R. (2023). Four-year Surgical Outcomes of Gonioscopy-assisted Transluminal Trabeculotomy in Patients with Open-Angle Glaucoma. *Ophthalmology Glaucoma*, 6(4), 387–394. <https://doi.org/10.1016/j.ogla.2023.01.005>
12. Saheb, H., Gedde, S. J., Schiffman, J. C., & Feuer, W. J. (2014). Outcomes of Glaucoma Reoperations in the Tube Versus Trabeculectomy (TVT) Study. *American Journal of Ophthalmology*, 157(6), 1179. <https://doi.org/10.1016/J.AJO.2014.02.027>
13. Wang, L., Wang, C., Wang, P., Dai, C., Kurmi, R., Zhang, W., Wu, J., & Guo, H. (2024). Comparison of efficacy and safety between gonioscopy-assisted transluminal trabeculotomy and trabeculectomy for primary open-angle glaucoma treatment: a retrospective cohort study. *BMC Ophthalmology*, 24(1), 1–9. <https://doi.org/10.1186/S12886-024-03798-8/FIGURES/1>
14. Wang, X., Wang, M., Liu, H., Mercieca, K., Prinz, J., Feng, Y., & Prokosch, V. (2023). The Association between Vascular Abnormalities and Glaucoma—What Comes First? *International Journal of Molecular Sciences*, 24(17), 13211. <https://doi.org/10.3390/IJMS241713211>
15. Junttila, T. L., Alberto, N., Winkels, M., & Greenwood, M. D. (2020). Successful Reduction of Intraocular Pressure in a Patient with Glaucoma Secondary to Sturge–Weber Syndrome Using a Suprachoroidal Shunt. *Journal of Current Glaucoma Practice*, 14(1), 43. <https://doi.org/10.5005/JP-JOURNALS-10078-1266>
16. Baykara, M., Poroy, C., & Erseven, C. (2019). Surgical outcomes of combined gonioscopy-assisted transluminal trabeculotomy and cataract surgery. *Indian Journal of Ophthalmology*, 67(4), 505–508. https://doi.org/10.4103/IJO.IJO_1007_18,
17. Ćwiklińska-Haszcz, A., Żarnowski, T., Wróbel-Dudzińska, D., & Kosior-Jarecka, E. (2023). The Efficacy and Safety of the GATT Procedure in Open-Angle Glaucoma—6-Month Results. *International Journal of Environmental Research and Public Health*, 20(3). <https://doi.org/10.3390/IJERPH20032759>,
18. Hu, T., Xu, L., Chen, X., Liu, B., & Zhang, H. (2023). Visual Acuity and Visual Field Changes in Patients with End-Stage PACG with Tubular Visual Field after Cataract Surgery. *Ophthalmic Research*, 66(1), 620. <https://doi.org/10.1159/000529778>
19. Cubuk, M. O., Ucgul, A. Y., & Unsal, E. (2020). Gonioscopy-assisted transluminal trabeculotomy as an option after failed trabeculectomy. *International Ophthalmology*, 40(8), 1923–1930. <https://doi.org/10.1007/S10792-020-01364-X>,
20. Aktas, Z., Ucgul, A. Y., Bektas, C., & Sahin Karamert, S. (2019). Surgical Outcomes of Prolene Gonioscopy-assisted Transluminal Trabeculotomy in Patients With Moderate to Advanced Open-Angle Glaucoma. *Journal of Glaucoma*, 28(10), 884–888. <https://doi.org/10.1097/IJG.0000000000001331>,
21. Cakir, I., Balci, A. S., Alagoz, N., Yalcinkaya Cakir, G., Altan, C., & Yasar, T. (2024). Efficacy of gonioscopy-assisted transluminal trabeculotomy and trabeculectomy in patients with primary open-angle glaucoma and pseudoexfoliative glaucoma: A single surgeon's experience. *Indian Journal of Ophthalmology*, 72(Suppl 5), S821. https://doi.org/10.4103/IJO.IJO_644_24
22. de Faria, B. M., Daga, F. B., Rebouças-Santos, V., de Araújo, R. B., Neto, C. M., Jacobina, J. S., & de Faria, M. A. R. (2021). Gonioscopy-assisted transluminal trabeculotomy (GATT) outcomes in eyes with open-angle glaucoma resistant to maximum treatment. *Arquivos Brasileiros de Oftalmologia*, 84(6), 587–593. <https://doi.org/10.5935/0004-2749.20210083>
23. Yin, P., Li, J., Shi, Y., Cao, K., Han, Y., Wang, H., Liu, H., Xin, C., Wang, Y., Oatts, J., Wang, J., Sang, Q., Cheng, Z., & Wang, N. (2024). Ab interno canaloplasty versus gonioscopy-assisted transluminal trabeculotomy in open-angle glaucoma: a randomised controlled trial. *British Journal of Ophthalmology*, 108(5), 687–694. <https://doi.org/10.1136/BJO-2022-323163>