**SURGICAL TREATMENT OF NEOVASCULAR GLAUCOMA: A SYSTEMATIC LITERATURE REVIEW**

**ABSTRACT**

This study aimed to conduct a systematic review of the literature on the main surgical modalities used in the treatment of neovascular glaucoma (NVG), emphasizing their temporal evolution, failure rates, and therapeutic indications according to etiology. The research was conducted between April and June 2025, with searches in PubMed, Scopus, Web of Science, Scielo, CAPES Journals, Google Scholar, and BIREME. After rigorous screening with previously defined inclusion and exclusion criteria, 33 studies were selected. Their data were extracted, including information on the type of intervention (trabeculectomy, drainage implants, or cyclophotocoagulation); clinical outcomes; underlying etiology; and specific surgical recommendations. This showed that drainage implants, especially the Ahmed valve, stood out as the modality with the lowest long-term failure rate. Trabeculectomy, although effective in early stages and in patients with no history of previous surgery, presented a higher risk of failure when associated with intense neovascularization. Meanwhile, slow-coagulation transscleral cyclophotocoagulation has emerged as a modern and effective alternative in eyes with compromised visual potential or refractory cases, supported by recent evidence of safety and efficacy. Furthermore, regarding indications by etiology, it was identified that in cases of proliferative diabetic retinopathy and venous occlusion, drainage implants were widely preferred, while trabeculectomy was performed in scenarios with minimal ocular inflammation and a still partially open angle. Therefore, the choice of surgical treatment for NVG should be individualized, considering the stage of the disease; underlying etiology; present inflammation; The ocular history and data analysis showed that valve implants remain the primary recommendation in advanced cases, while cyclophotocoagulation has established itself as a safe and effective option in refractory eyes. Trabeculectomy maintains its role, provided it is carefully indicated. Therefore, this review, while meeting the proposed objectives by synthesizing current practices, comparing the main surgical outcomes, and elucidating the best therapeutic indications according to recent scientific literature, still requires further research in this field to determine increasingly effective and safer protocols with fewer long-term adverse effects for the treatment of NVG.

**Keywords:** Neovascular Glaucoma; Surgical Treatment; Trabeculectomy; Drainage Implant; Cyclophotocoagulation.

1. **INTRODUCTION**

Glaucoma is the leading cause of irreversible blindness, according to the World Health Organization (WHO). It is an optic neuropathy that causes damage to the optic nerve, reducing the retinal nerve fiber layer. Due to its high prevalence and impact on patients' quality of life, appropriate clinical management is essential for better prognosis and outcome ( MATOS *et al* ., 2023).

Among the various types of glaucoma, NVG stands out due to its complexity and difficulty of treatment. NVG arises due to the proliferation of fibrovascular tissue in the anterior chamber angle, causing angle closure. (MENEZES *et al* ., 2020). This justifies the name “neovascular” for this type of glaucoma, since its etiology is directly associated with the formation of new vessels and the growth of connective tissue, which leads to increased intraocular pressure (IOP) (TEKCAN *et al* ., 2024) .

The emergence of new vessels is largely associated with retinal ischemia and intraocular inflammation. Among the ischemic entities, the most common are diabetic retinopathy, central retinal vein occlusion, and ocular ischemic syndrome. Ischemia generates retinal hypoxia and stimulates the release of pro-inflammatory and anti-angiogenic factors IL-1 (TNF-α) and especially vascular endothelial growth factor (VEGF), which stimulate neovascularization in the iris and chamber sinus (DIAS *et al* ., 2024).

The clinical picture usually presents with a chronically red and painful eye that often leads to significant vision loss. In the early stages, it may be less symptomatic, especially if the IOP rise is gradual and also in corneas with a good endothelial count. However, as the condition progresses, iris neovascularization progresses, with the presence of thin, tortuous vessels on biomicroscopy, randomly, and distinctly different from the physiological iris vessels (RODRIGUES *et al* ., 2016) . Therefore, recognizing the earliest signs, such as rubeosis iridis, is essential in ophthalmological care.

Furthermore,Gonioscopy is essential to complement the biomicroscopy diagnosis, which reveals the appearance of fine vessels that cross the scleral spur and branch out over the trabecular meshwork. IOP becomes increasingly elevated, which can decompensate the cornea and generate corneal edema (RODRIGUES *et al* ., 2016) .

CNG has become more common, probably due to the increase in the number of patients with diabetes and risk factors for other retinovascular entities such as retinal vein occlusions and ocular ischemic syndromes. Therefore, adequate clinical management is essential due to the increased incidence and, consequently, prevalence (MISHRA and MEYER, 2024; ZHU *et al* ., 2024) .

Clinical management is of fundamental importance, since neovascularization and pathological ocular angiogenesis progressively and irreversibly compromise vision and, thus, the patient's quality of life. Therefore, drugs have been developed to inhibit VEGF and are administered as intravitreal injections to reduce the consequences of retinal ischemia (MENEZES *et al* ., 2020).

Topical treatment with hypotensive eye drops may still be effective even if the neovascularization process has already begun. However, as the disease progresses and the number of myofibroblasts increases, progressive closure and synechiae occur in the angle, reducing the effectiveness of topical treatment ( WANG *et al* ., 2023) .

 From this, it can be seen that surgical treatment is also an effective treatment alternative, since when most of the angle is already closed due to synechiae, an alternative route is necessary for the drainage of aqueous humor and, thus, reduce IOP (COSTA *et al* ., 2020) .

Regarding surgical treatment, TREC and drainage device implants stand out, which can reduce IOP more effectively. 2 Furthermore, in more advanced stages and with low vision, CICLOFOT is also configured as a therapeutic modality (ALABDULJABBAR *et al* ., 2024) .

From this, it can be seen that NVG is a type of glaucoma that is often refractory to conventional clinical treatment due to its multifactorial pathophysiology. Knowledge of surgical treatment modalities is crucial given the difficult clinical management of this condition. Furthermore, due to the constant need for clinical updates to ensure the best possible patient outcome, combined with the growing prevalence of this disease due to conditions such as proliferative diabetic retinopathy, retinal vein occlusion, and ocular ischemic syndrome, the need for effective surgical strategies to control intraocular pressure and prevent irreversible blindness is highlighted. Therefore, this systematic review was justified by the urgent need to compare the efficacy, failure rates, and indications of the surgical modalities: TREC, drainage implants, and CICLOFOT, based on etiology, aiming to optimize clinical management and improve visual outcomes in patients with NVG.

**2. MATERIALS AND METHODS**

This study consisted of a systematic literature review with a retrospective, descriptive, and quantitative approach. The objective was to comparatively evaluate the efficacy of the main surgical modalities used in the management of NGV, with an emphasis on IOP reduction and procedural failure rates. The interventions analyzed were: TREC, drainage implants (with emphasis on the Ahmed valve), and CICLOFOT. The methodology followed the principles of systematic review according to the PRISMA guidelines, and data collection was conducted between January and June 2025.

* 1. **Search Strategy**

The bibliographic search was conducted in the PubMed, Scopus, Web of Science, BVS, SciELO, Google Scholar, and CAPES Periodicals databases, using controlled DeCS/MeSH descriptors combined by Boolean operators ( *neovascular glaucoma* AND *surgical treatment* OR *trabeculectomy* OR *glaucoma drainage devices* OR *cyclophotocoagulation* AND *intraocular pressure* ). The filters applied included articles published between 2001 and 2025, available in full text, in Portuguese, English, or Spanish.

* 1. **Inclusion and Exclusion Criteria**

We included studies that compared at least two of the three main surgical modalities for treating NVG: TREC, drainage implants, and CICLOFOT, and that presented intraocular pressure reduction as the primary outcome. Articles that did not specifically address NVG, studies with methodologies and objectives that differed from those requested for this study, studies that analyzed only clinical modalities or isolated therapies without comparison, and those without access to the full text were excluded.

**2.3 Study Selection**

Article selection was conducted in two stages: reading of titles and abstracts, followed by full-text analysis. Two independent reviewers participated in the process, and any disagreements were resolved by consensus. Data extracted included authors, year of publication, study type, pathologies and etiologies of the participating population, follow-up time, surgical modalities evaluated, mean pre- and postoperative IOP variation, and surgical failure rate.

**2.4 Data Analysis**

Data were compiled into Microsoft Excel® 365 spreadsheets, and comparisons between studies were made by surgical modality. Data synthesis sought to identify patterns of response to intervention, relative efficacy between methods, and documented success or failure rates in the populations evaluated.

**2.5 Ethical Aspects**

Because this is a systematic review of secondary data obtained from public domain databases, this study is exempt from submission to the Research Ethics Committee, in accordance with the guidelines of Resolution No. 510/2016 of the National Health Council. All methodological procedures followed the ethical precepts of the Declaration of Helsinki and the academic rigor required for studies using previously published data.

1. **RESULTS**

The search results identified 72 studies addressing surgical modalities in the treatment of NGV in various databases. Of these, 25 were found in PubMed, 10 in Scielo, 10 in Scopus, 2 in Bireme, 10 in Google Scholar, 8 in Web of Science, and 7 in the CAPES Periodicals database. The criterion for complete analysis was restricted to articles published between 2001 and 2025, focusing on TREC, drainage implants, and CICLOFOT.

After rigorous analysis and application of exclusion criteria, 33 studies were selected, distributed among the following databases: PubMed (14), Scielo (5), Scopus (5), Bireme (1), Google Scholar (3), Web of Science (3) and CAPES Journals (2). Regarding the methodology, 21 Retrospective Studies, 3 Prospective Studies, 1 RCT Protocol, 3 Narrative Reviews, 3 Comparative Studies and 2 Case Reports were identified.

A notable geographic concentration was observed, with studies originating from Asia (22), the Americas (7), Europe (3), and Oceania (1). Of the selected studies, 2 were Brazilian, both scientific articles. The analysis focused on the efficacy of surgical modalities, failure rates, and indications by etiology. The publications used in this study were chronologically distributed as follows: 2024 (8), 2023 (4), 2022 (7), 2021 (2), 2019 (1), 2018 (2), 2016 (4), 2011 (2), 2010 (1), 2004 (1), and 2001 (1). No articles of interest were found with publication dates in the years 2025, 2020, 2017, 2015, 2014, 2013, 2012, 2009, 2008, 2007, 2006, 2005, 2003 and 2002, as evidenced in Table 1 below:

**Table 1.** Amalgamation of Studies on Efficacy, Failure Rates and Indications of Surgical Modalities in the Treatment of NVG.

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| --- | --- | --- | --- | --- | --- | --- | --- |
| **AUTHOR** | **YEAR** | **SOURCE** | **TYPE OF PUBLICATION** | **STUDY LOCATION** | **RELATIONSHIP WITH RESEARCH OBJECTIVES** | **METHODOLOGICAL APPROACH** | **MAIN FINDINGS** |
| Pegu *et al* . | 2024 | Indian J Oftalmol | Scientific article | India | Longitudinal evaluation of TREC, cyclophotocoagulation and Ahmed valve in NGV. | Retrospective cohort study. | "They compared TREC, Ahmed valve and CICLOFOT, reporting complete success rates of 54.3% (TREC), 42.9% (Ahmed) and 33% (CICLOFOT) for IOP < 21 mmHg. The failure rates were 45.7%, 57.1% and 66.7%, respectively. Complications occurred in 27% of cases with TREC, and 14% of cases with CICLOFOT, while the Ahmed group presented a hypertensive phase in 40% of the eyes. The etiology is usually Proliferative Diabetic Retinopathy (PDR); Ischemic Retinal Vein Occlusion; less frequently, Central Retinal Artery Occlusion (CRAO) and Ocular Ischemic Syndrome (SIS)." |
| Alabduljabbar *et al* . | 2024 | Clin Oftalmol | Scientific article | Saudi Arabia | Comparison between CICLOFOT and Ahmed implant in CNG with low vision. | Retrospective comparative study. | "Compared the Ahmed valve (89% success) and CICLOFOT (51% success) in NGV with low vision. Preoperative IOP was 40.4 ± 10.6 mmHg in the CICLOFOT group and 39.4 ± 10.2 mmHg (median 40) in the Ahmed valve group (p = 0.6). At 1 year, IOP ranged from 12.5 to 28 mmHg (median 18) in the CICLOFOT group and from 14 to 21.5 mmHg (median 17) in the Ahmed valve group (p = 0.016). Survival analysis showed a 51% success rate in the CICLOFOT group and an 89% success rate at 1 year in the Ahmed valve group (p> 0.0001). The Ahmed valve had a higher success rate, mainly attributed to the reduced need for interventions additional surgical procedures compared to CICLOFOT. The Ahmed valve was considered the first-line treatment in the management of NGV." |
| Tekcan *et al* . | 2024 | Beyoglu Eye J | Scientific article | Türkiye | Analysis of the effectiveness of the Ahmed implant in CNG with/without prior vitrectomy. | Retrospective study | "The Ahmed valve had a 21.9% failure rate and in the prior vitrectomy-Ahmed valve group it was 14.3% (p = 0.37). Prior vitrectomy did not significantly affect the final results. Recommended for advanced NGV (PDR) due to consistent IOP control and reduced dependence on eye drops (20%)." |
| Zhu *et al* . | 2024 | Essays | Scientific article | China | Comparison between conventional TREC and with interception of the proliferative membrane of the anterior chamber . | Randomized controlled clinical trial . | "TREC with membrane interception achieved a 72.6% success rate and a conditional success rate of 87.3% at 12 months after TREC with interception of the proliferative membrane of the anterior chamber in patients with NVG. Effective in early NVG (PDR, CRVO) with open angles, potentiated by anti-VEGF, but less effective in SIS due to the risk of severe ischemia, as the pathogenesis of NVG is complex, being secondary to fundus ischemia, hypoxia and neovascularization even of the fibrovascular membranes formed in the anterior segment of the eye." |
| Sahin *et al* . | 2024 | J Fr Oftalmol | Scientific article | Türkiye | Comparison of Ahmed implant implantation in CNG with/without concomitant intravitreal implant. | Retrospective study | "VGA implantation, with and without anti-VEGF injections in patients with NVG, resulted in good outcomes regarding IOP control and decreased the need for antiglaucoma medications. Although there were no significant effects of anti-VEGF injections on outcomes, including IOP and MCVA values and the number of antiglaucoma medications, the overall surgical success rate was higher in patients with anti-VEGF injections. And the most common etiology was proliferative diabetic retinopathy (PDRP), detected in 60.9% and 91.7% of patients in Groups 1 and 2, respectively." |
| Chey and Lee | 2024 | Heliyon | Scientific article | South Korea | Patients with NVG undergoing TREC or Ahmed valve implantation. | Retrospective study | "The primary outcome was surgical success at 6 months postoperatively, defined as sufficient intraocular pressure (IOP) reduction (IOP ≤ 21 mmHg, reduction ≥ 20%, regardless of topical medication use) without additional glaucoma surgery, hypotony, or progression to absent light perception. Thus, the complete and qualified success rates at 6 months were 44.6% and 92.2% for TREC and Ahmed Valve, respectively. Therefore, patients with NGV had a better visual prognosis and successful IOP reduction after glaucoma surgery at a relatively younger age." |
| Guzun *et al* . | 2024 | Rom J Oftalmol | Scientific article | Romania | Cyclophotocoagulation in CNG. | Retrospective study | "One month after Transscleral Cyclophotocoagulation, IOP decreased by 28% compared to baseline. The efficacy of laser treatment after 12 months of follow-up was 63%, with an IOP reduction of 46%. The best treatment strategy for patients with diabetic NVG should focus on intensive glycemic control and local anti-inflammatory therapy." |
| Takeuchi *et al* . | 2024 | Graefes Arch Clin Exp Oftalmol | Scientific article | Japan | Analysis of visual acuity and intraocular pressure NVG associated with PDR in patients treated with transscleral CICLOFOT and TREC with mitomycin C, with or without prior intravitreal injection of bevacizumab (IVB). | Retrospective study | “With a sample with a mean IOP of 33.0 at the initial visit and a significant decrease to 14.0 at the last visit, the number of eyes with IOP ≥ 21 decreased from twenty-eight (90.3%) to three (9.7%). Furthermore, in patients with PDR and NVG, various combinations of transscleral CICLOFOT and TREC with mitomycin C after adjuvant IVB, without the use of glaucoma drainage devices, reduced IOP sufficiently; in these patients, neovascular regression was observed, without further worsening of visual acuity. However, surgical procedures should be performed in patients with PDR and NVG before visual impairment occurs.” |
| Wang *et al* . | 2023 | Ophthalmol Med Case Representative | Scientific article | USA | Transscleral cyclophotocoagulation in closed-angle NGV. | Case report | “CICLOFOT reduced IOP in advanced NGV, without failure in a single case. Indicated for near-total angle closure (SIS, RDP). The underlying etiologies were CRVO, PDR, and CRVO. Immediate primary slow-burn transscleral cyclophotocoagulation with prior or concomitant anti-VEGF was an effective strategy to immediately reduce IOP in eyes with acute NVG. |
| Kingston and Lusthaus | 2023 | Int Oftalmol | Scientific article | Australia | Transscleral cyclophotocoagulation and Baerveldt implants in NGV. | Retrospective study | “The techniques were transscleral cyclophotocoagulation (TSCPC) (53.7%) and Baerveldt tube insertion (26.9%). 62.7% of eyes failed (IOP > 21 or < 6 mmHg in two consecutive revisions ). Initial TSCPC failed in 75.0%, compared with 44.4% after Baerveldt tube insertion. The most common etiologies were proliferative diabetic retinopathy (52.2%), central retinal vein occlusion (26.9%), and ocular ischemic syndrome (10.4%).” |
| Li *et al* . | 2023 | Am J Ophthalmol Case Representative | Scientific article | China | Cyclophotocoagulation and [Ahmed glaucoma valve in](https://www.sciencedirect.com/topics/medicine-and-dentistry/glaucoma-valve) CNG. | Retrospective study | “An obvious reduction in postoperative IOP was observed in both the CICLOFOT group and the Ahmed group after the operation ( *P < 0.05), and the CICLOFOT group showed a significantly lower IOP compared with the Ahmed group at the 6-month ( P* = 0.014) and 12-month ( *P = 0.047)* postoperative time points . The surgical success rates in the CICLOFOT group were also slightly higher than those in the Ahmed group.” |
| Miglani and Ullah | 2023 | Curr Oftalmol Rep | Scientific article | USA | TREC Analysis, Tubular Derivation and CICLOFOT Procedure in CNG. | Narrative review | "TREC, tubular shunt surgery, and CICLOFOT procedures. The efficacy of TREC and tubular shunt was evaluated and compared, demonstrating that both approaches are viable options for NGV. CICLOFOT has been recognized as an additional surgical treatment that has been studied and found to be highly effective in angle-closure glaucoma, but not without the risk of complications." |
| Kumar *et al* . | 2022 | Open J Oftalmol | Scientific article | India | TREC, Tubular Derivation and CICLOFOT Procedure in CNG. | Narrative review | Regarding drainage device implants, such as the Ahmed valve, it has shown a higher success rate and a lower failure rate compared to TREC, especially when performed in conjunction with preoperative anti-VEGF therapy. CICLOFOT, while effective in reducing aqueous production, has a higher failure rate due to its complications and limitations in advanced or refractory cases. CICLOFOT is generally reserved for cases where other therapies have failed or for specific situations due to its potential serious complications. While TREC with mitomycin C has a relatively high failure rate, especially in cases with angle closure or advanced neovascularization, failure is often associated with factors such as hypohemaemia, inflammation, or excessive scarring, leading to persistent high IOP. In diabetics or ocular degeneration, TREC is ideal in the initial phase after failure of conservative therapy; CICLOFOT is primarily indicated as salvage therapy or in cases where the risk of excessive scarring or inflammation prevents the success of other procedures. Drainage implants are considered for refractory cases, with inadequate response to TREC or CICLOFOT, or when there is a high risk of failure of conventional techniques, especially in contexts of high inflammation or exuberant healing.” |
| Ramji *et al* . | 2022 | Graefes Arch Clin Exp Oftalmol | Scientific article | Canada | TREC, Tubular Derivation and CICLOFOT Procedure in CNG. | Systematic Review. | TREC, especially when used with antimetabolites such as mitomycin C, has a relatively high failure rate, especially in cases of NVG with a poor prognosis. CICLOFOT tends to have higher failure rates, as it is often used as a palliative procedure, especially when ocular damage is extensive or other surgeries have failed. Its indication is reserved for cases where other options are not viable, due to its lower long-term success rate. Drainage implants, such as the Ahmed valve (AGV) or the Baerveldt, demonstrate lower failure rates compared to TREC, especially due to their more effective mechanism of action in conducting aqueous humor and a lower risk of conflictual healing. The indication for the type of surgery varied according to the underlying etiology of the NVG. In NVG secondary to diabetic retinopathy or retinal vascular obstruction: In general, TREC or drainage plates are initially recommended due to the need for more lasting IOP control. CICLOFOT is considered, especially when visualization or eye condition prevents more invasive surgery or when there is a high risk of procedure failure. In patients with advanced eye damage or at risk of irreversible vision loss, CICLOFOT is often used as a last palliative option, aiming to reduce aqueous humor production when other techniques have failed or are no longer viable . |
| Shalaby *et al* . | 2022 | Indian J Oftalmol | Scientific article | Egypt | Ahmed implants vs. cyclophoto in CNG. | Comparative study | “At 6 months post-procedure, failure was significantly higher in the CICLOFOT group than in the Ahmed glaucoma valve (AGV) group: 43.1% vs. 17.1%. Both groups had similar IOP and number of medications at 6 months, but visual acuity was significantly lower in the CICLOFOT group compared to the AGV group (2.4 ± 0.8 vs. 1.9 ± 1.0, P = 0.017). More CICLOFOT eyes required reoperation for glaucoma than AGV eyes (11.8% vs. 1.4%, P = 0.041). Multivariate regression analysis identified higher preoperative IOP ( P = 0.001) and CICLOFOT surgery ( P = 0.004) as independent predictors of surgical failure at 6 months. AGV and CICLOFOT showed comparable IOP reduction and of medication in eyes with NGV at 6 months. CICLOFOT was more frequently associated with failure, reoperation for glaucoma, and worse visual outcomes. Elevated preoperative IOP and CICLOFOT surgery were independent predictors of surgical failure.” |
| Lin *et al* . | 2022 | BMJ Open | Scientific article | China | TREC, Tubular Derivation and CICLOFOT Procedure in CNG. | Systematic Review. | Surgical treatments included Ahmed glaucoma valve implantation (AGV); AGV combined with intravitreal vascular endothelial growth factor (AGV + IVAV); cyclophotocoagulation (CICLOFOT); cyclocryotherapy (CCT); TREC with mitomycin (TREC (MMC)); and TREC (MMC) combined with IVAV (TREC (MMC) + IVAV). Network meta-analysis showed that, compared with AGV, AGV + IVAV and TREC (MMC) + IVAV had a favorable effect on intraocular pressure reduction (IOPR) 6 months after surgery. Compared with CCT, AGV, AGV + IVAV, CICLOFOT, TREC (MMC), and TREC (MMC) + IVAV had a superior impact on the success rate. The order of effectiveness as the best intervention was ranked as follows: TREC (MMC) + IVAV (IOPR 6 months after surgery); CICLOFOT (IOPR 12 months after surgery), AGV + IVAV (IOPR 12 months after surgery), and AGV + IVAV (success rate). Adverse events were also summarized in detail. That is, in the treatment of NGV, AGV + IVAV and CICLOFOT were more effective in IOPR and success rate than the other four interventions. Furthermore, AGV + IVAV is superior to CICLOFOT regarding the success rate in long-term treatment. |
| Urbonaviciute *et al* . | 2022 | Medicine | Scientific article | Lithuania | TREC, Tubular Derivation and CICLOFOT Procedure in CNG. | Retrospective study | TREC has been associated with a high failure rate in treating NVG, but in combination with antimetabolites, the success rate was improved. The success rate of TREC with MMC in eyes with NVG secondary to PDR was 62.6% to 81.2% at 1 year; however, after 5 years, it decreased to 51.3%. Glaucoma implants were more commonly used due to their adequate IOP-lowering effect and the low risk of developing ocular hypotony and iris damage after surgery. The implant may be preferred if TREC fails or if there is a high risk of failure due to scarring and conjunctival inflammation. The efficacy of drainage implants and TREC in reducing IOP did not show significant differences, but TREC was considered a safer procedure. Cyclodestructive procedures were frequently performed in patients with refractory NVG when other treatments failed to reduce IOP. The success rate of CYCLOFOT was 75% after 3 years. months and 66% after 6 months. The IOP-lowering efficacy of drainage implants and CICLOFOT did not differ significantly, but drainage implants were considered safer. Treatment options for angle-closure glaucoma (ANG ) depend on the stage of glaucomatous damage. In early-stage glaucoma, treatment to reduce retinal ischemia was generally used. Open-angle and angle-closure glaucoma that progressed to irreversible optic nerve damage were treated similarly, i.e., treatment of retinal ischemia and correction of high IOP (PRP, anti-VEGF, local and systemic pharmacological treatment, and surgical interventions). |
| Iwasaki *et al* . | 2022 | J Clin Med | Scientific article | Japan | TREC and Tubular Derivation and in CNG. | Retrospective study | The probability of success was significantly higher in patients undergoing tubular shunt surgery than in those receiving TREC. TREC was significantly associated with surgical failure in multivariable analysis. The overall incidence of postoperative complications was similar between the two groups. Reoperations for glaucoma were required significantly more frequently in the TREC group than in the tubular shunt surgery group (20.1% vs. 5.0%; P < 0.01). Baerveldt glaucoma shunt surgery had a higher success rate compared to TREC in patients with NVG for target IOP < 21 mmHg or < 17 mmHg. Postoperative complication rates were similar between the two surgical procedures. |
| Zhou *et al* . | 2022 | Int J Oftalmol | Scientific article | China | Tubular shunt implantation and cyclodestructive procedure for CNG. | Retrospective study | The 5-year postoperative survival rate in patients with NVG who underwent tubular shunt implantation and/or cyclodestructive procedures was 62% in patients with NVG compared with 80% in controls. Survival did not differ significantly based on NVG etiology. Preoperative best-corrected visual acuity of the NVG-affected eye (p = 0.05) and the Charlson Comorbidity Index (p = 0.02) were associated with survival, but preoperative maximum IOP, hemoglobin A1c, and creatinine were not. The mean IOP 6 months after the procedure was 14 mm Hg for tubular shunt and 27 mm Hg for cyclodestructive procedures (p = 0.03). That is, patients with NVG have reduced survival, but most survived for at least 5 years after the procedures. Ophthalmologists should consider patient survival and predictive factors. survival when planning procedures for NGV.” |
| Tokumo *et al* . | 2021 | Graefes Arch Clin Exp Oftalmol | Scientific article | Japan | Patients undergoing tubular shunt implantation versus TREC in NGV. | Retrospective study | Postoperative follow-up was 26.6 ± 19.4 months in the Baerveldt group and 27.3 ± 20.1 months in the TREC group. There were no statistical differences in postoperative intraocular pressure measured at 6-month intervals. Success rates were 59.1% and 61.6% at 1 year after implantation of the Baerveldt NGV and TREC, respectively. Medication use, visual acuity, and interventions were similar between the groups. Tube exposure was the most common late complication. However, in both groups, the procedures produced similar surgical success, IOP reductions, visual acuity, and number of medications at the last visit. The TREC group had fewer late complications. Therefore, TREC may be a safer and more effective way to treat patients with NGV. |
| Khodeiry *et al* . | 2021 | Br J Oftalmol | Scientific article | USA | Transscleral Continuous Wave Slow Coagulation CICLOFOT treatment as initial surgical intervention in patients with NVG. | Retrospective study | “IOP decreased from 40.7 ± 8.6 mm Hg preoperatively to 18.4 ± 12.2 mm Hg postoperatively (p < 0.001). The cumulative probabilities of success at 12 and 24 months were 71.7% and 64.2%, respectively. The most common complications observed were decreased baseline visual acuity (13.2%) and anterior chamber inflammation (9.4%). Therefore, slow-coagulation CICLOFOT is an effective and relatively safe initial surgical intervention in medically uncontrolled NVG.” |
| Shchomak *et al* . | 2019 | Graefes Arch Clin Exp Oftalmol | Scientific article | Ukraine | TREC, Tubular Derivation and CICLOFOT Procedure in CNG. | Retrospective study | "In the CNG drainage devices versus CICLOFOT, there was no statistical difference in IOP-lowering efficacy, although failure rates and loss of light perception were lower in the drainage device group. In the Ahmed Glaucoma Valve (AGV) versus TREC group, there was no statistical difference in IOP-lowering efficacy and loss of light perception, but failure rates were lower in the TREC group. There appears to be no difference in IOP-lowering efficacy between drainage devices and CICLOFOT, although drainage devices appear to be safer. AGV and TREC also appear to have similar IOP-lowering results, with TREC having lower failure rates." |
| Yang *et al* . | 2018 | Taiwan J Oftalmol | Scientific article | Taiwan | TREC, Drainage devices and CICLOFOT Procedure in CNG. | Prospective study | "RECT with antimetabolites (mitomycin C or 5-fluorouracil), also known as conventional filtration surgery, has had a low long-term success rate in NVG (no greater than 33%) and fails primarily due to fibrous tissue obstruction or external scarring and conjunctival fibrosis, even with antimetabolites. The most commonly used methods for treating NVG are the insertion of glaucoma drainage device implants (Molteno implant, Baerveldt implant, Krupin valve, and Ahmed glaucoma valve), i.e., shunt implantation, with a relatively high success rate. Traditional cycloablative methods are often reserved for eyes with low visual potential or when other surgical options have failed. Most of these classic methods are effective, rapid, and useful for patients who cannot undergo incisional surgery. However, these techniques are easy to learn but difficult to control due to their unpredictable dose-effect relationship, and postoperative reactions can be quite severe." |
| Dong *et al* . | 2018 | Medication | Scientific article | China | TREC, Drainage devices and CICLOFOT Procedure in CNG. | Systematic Review. | According to the network analysis, mitomycin plus TREC (94.9%), glaucoma valve implantation (86.9%), and iris photocoagulation plus TREC (81.9%) were most likely to improve the treatment success rate in patients with NVG. Furthermore, glaucoma valve, cyclophotocoagulation, TREC, iris photocoagulation, and mitomycin showed advantages in terms of improving the treatment success rate in patients with NVG . However, the application of retinal photocoagulation reduced the treatment success rate. That is, the regimen that included mitomycin, interferon, and TREC was most likely to improve the treatment success rate in patients with NVG, while the application of glaucoma valve and bevacizumab was more beneficial in improving the treatment success rate of patients than surgery and as an agent, respectively. |
| Rodrigues *et al* . | 2016 | Int J Retin Vitr | Scientific article | Brazil | CICLOFOT Procedure and valves in CNG. | Narrative review | NVG has been associated with high failure rates after TREC, but the adjuvant use of antimetabolites has improved the surgical success rate. A 55% success rate at a mean follow-up of 35 months was reported with postoperative 5-fluorouracil and a 54% success rate at a mean follow-up of 18 months with intraoperative mitomycin C. It has also been suggested that postoperative hyphema may be associated with higher TREC failure rates in NVG. While Ahmed valve treatment for NVG has been compared to TREC with mitomycin C, success rates of 70 and 65% at 1 year and 60 and 55% at 2 years were reported after Ahmed valve for NVG and TREC with mitomycin C, respectively. Furthermore, transcleral CICLOFOT with and without the use of anti-VEGF has been shown to be effective in reducing IOP and relieving pain in advanced cases of NVG. EE when compared to Ahmed valve implantation. no significant difference was found in the 24-month success rate between diode CICLOFOT (61.18%) and Ahmed glaucoma valve implant (59.26%) in the treatment of NGV.” |
| Senthil *et al* . | 2016 | Indian J Oftalmol | Scientific article | India | Analysis of the effectiveness of TREC, CICLOFOT Procedure and valves in CNG. | Narrative review | Traditional TREC has a high failure rate attributed to severe inflammation and hyphema. Success rates for TREC with mitomycin C range from 62.6% to 81.2% at 1 year and decrease to 51.3% at 5 years. A similar success rate has also been reported for TREC with MMC and AGV drainage devices over 2 years (TREC 55%, AGV 60%, P = 0.474). Drainage devices are typically reserved for eyes with persistent new vessels or in those where other filtration surgeries are not feasible. CICLOFOTO is generally reserved for eyes with low visual potential or as a temporary measure in eyes with high IOP, where the environment is not clear enough for PRP, or in cases where other filtration surgeries are not feasible. |
| Liao *et al* . | 2016 | BMC Ophthalmol | Scientific article | China | TREC, CICLOFOT Procedure and valves in CNG. | Retrospective study | The success rate of primary TREC (with or without anti-VEGF) before surgery was 70.9% at 1 year, decreasing to 60.8% at 2 years. While a success rate of 79% at 1 year, decreasing to less than 60% at 2 years, was reported by other cited sources, reflecting the reality of poor management, outcome, and follow-up, even at a tertiary care center in China. Thus, the Kaplan-Meier survival analysis showed a probability of success of 84.8% at 1 year, 62.6% at 2 years, and 21.9% at 5 years. |
| Sun Jin-Tao *et al* . | 2016 | Indian J Oftalmol | Scientific article | China | TREC and valves in CNG. | Retrospective study | The success rates were 81.8% and 82.6% at 12 months after TREC and VGA implantation, respectively. In the TREC group, axial visual acuity (AVA) improved at the last follow-up in 14 eyes, remained stable in 6 eyes, and decreased in 2 eyes. In 4 cases, mild hyphemas developed after TREC. In the VGA group, AVA improved in 14 eyes, remained stable in 5 eyes, and decreased in 4 eyes. Mild hyphemas developed in 3 cases and a shallow anterior chamber in 3 cases. The mean postoperative IOP was significantly lower in both groups after surgery (F = 545.468, P < 0.05), and the mean postoperative AVA also improved significantly (F = 10.964, P < 0.05), with no significant difference between the two groups. |
| Shen *et al* . | 2011 | Clin Oftalmol | Scientific article | China | TREC, CICLOFOT Procedure and valves in CNG. | Retrospective study | "The success rate was 70% and 65% at 1 year and 60% and 55% at 2 years after the Ahmed Glaucoma Valve and TREC, respectively. Kaplan-Meier survival curve analysis showed no significant difference in success between the two groups (P = 0.815). Hyphema was the most common complication in both groups. And there was no statistically significant difference between the two groups in postoperative visual acuity and intraocular pressure." |
| Olmos and Lee | 2011 | Glaucoma J | Scientific article | USA | TREC, CICLOFOT Procedure and valves in CNG. | Retrospective study | “TREC and other filtration surgeries have moderate long-term success in patients with NVG. The success of TREC is limited by the severe inflammation found in eyes with NVG. TREC with adjunctive 5-fluorouracil had high initial success rates, which decreased with long-term follow-up. TREC with mitomycin C (MMC) for IOP reduction in eyes with NVG had a success rate of 62.6% at one year, decreasing to 51.7% at 5 years of follow-up in a cohort of patients in which the majority (81.2%) of NVG cases were secondary to diabetic retinopathy. Risk factors for progressive failure of TREC treated with MMC included younger age and prior vitrectomy. In recent years, glaucoma drainage implants (GDIs) have gained popularity in the surgical treatment of NVG, as their success depends less on controlling intraocular inflammation and the failure of a filtering bleb. Cyclodestructive procedures, such as cyclophotocoagulation (C ICLOFOT), remain a treatment option, especially if the eye has little or no useful visual potential. The disadvantage of this surgical option is that it is often difficult to titrate the effect of ICLOFOT on the ciliary body, and more than one treatment is often required to achieve effective IOP control. Excessive laser treatment can lead to hypotony and phthisis. Furthermore, the severe inflammation associated with ICLOFOT in these eyes can also lead to hypotony and phthisis. |
| Alkawas *et al* . | 2010 | Glaucoma J | Scientific article | Egypt | TREC with MMC and CICLOFOT in CNG. | Retrospective study | “After TREC with mitomycin C, the mean IOP was reduced from 42.9 ± 4.2 mm Hg preoperatively to 15.1 ± 2.2, 16.3 ± 2.0, and 19.7 ± 2.1 mm Hg in the first week, first month, and sixth month postoperatively, respectively. Complete regression of iris neovascularization after intravitreal injection of bevacizumab and retinal photocoagulation occurred in 14 eyes (82.4%). Side effects were observed: postoperative hypotony (intraocular pressure of 7 mm Hg) in 17.6% (3 of 17 eyes), conjunctival dehiscence in 5.9%, shallow anterior chamber in 11.8%, hyphema in 23.5%, choroidal detachment in 11.8%, and corneal epithelial erosions related to application of mitomycin C in 1 eye (5.9%). Therefore, TREC with intraoperative MMC after adjuvant treatment with intravitreal bevacizumab and retinal photocoagulation is a good treatment modality in the management of eyes with NVG. |
| Lima *et al* . | 2004 | Arq Bras Oftalmol | Scientific article | Brazil | Ahmed Glaucoma Valve and CICLOFOT in CNG. | Prospective study evaluated | “The preoperative IOP, 41.32 ± 3.03 mm Hg (Ahmed) and 41.61 ± 3.42 mm Hg (CICLOFOT) (P = 0.5), and the mean postoperative IOP, at 24 months of follow-up, 14.73 ± 6.44 mm Hg (Ahmed) and 14.07 ± 7.21 mm Hg (CICLOFOT) (P = 0.7), were significantly different from baseline in both groups (P < 0.001). Kaplan-Meier survival curve analysis showed a 24-month success probability of 70.59% and 73.53% for the Ahmed and CICLOFOT groups, respectively (P = 0.7). Complications included choroidal detachment (Ahmed 17.64%, CICLOFOT 2.94%), shallow anterior chamber (Ahmed 17.64%, CICLOFOT 0.0%) and hyphema (Ahmed 14.7%, CICLOFOT 17.64%). Thus, there was no difference in the success rate between the Ahmed Glaucoma Valve and CICLOFOT in refractory glaucoma. Eyes undergoing Ahmed tubular shunt implantation had more complications than those treated with CICLOFOT.” |
| Sivak-Callcott *et al* . | 2001 | Ophthalmology | Scientific article | USA | Analysis of CICLOFOT and implants in CNG. | Narrative review | “The prior art reported a mean IOP reduction of 53% (from a mean preoperative IOP of 45 mmHg) in 25 patients treated with CICLOFOT for refractory NVG. In a retrospective peer-reviewed study cited by the authors, initial failure rates were similar; however, at 3 years, the failure rate in IOP control was 71.2% in the diode laser cyclodestruction group, compared with 43.3% in the tubular shunt surgery group. Eleven of the 24 patients in the diode laser group lost light perception. Four of the 24 patients in the tubular shunt group progressed to no light perception. Although diode laser cyclodestruction has previously shown promise for successful IOP control in patients with NVG, its long-term success rate has not been well described. Although laser CICLOFOT appears to have a lower complication rate, the percentage of NVG patients who lose total vision with This modality remains high, with a long-term vision loss rate of 46.6%, because in addition to destroying the ciliary body, removing part of it also reduces IOP. Filtering surgery for NGV was often unsuccessful. Many modifications were attempted to improve the results of these procedures: antimetabolites (5-fluorouracil, mitomycin-C), the use of a CO2 laser, and a Supramid implant in the scleral filter bed. However, aqueous tubular shunts have reported success rates of 22% to 97% for patients with NGV. Studies have reported a visual outcome of 20/200 or better in 32% of eyes treated with a tubular shunt ; also described the surgical results of tubular shunts for NGV, reporting IOP control of less than 21 mmHg in 62% of eyes at 1 year and 10.3% of eyes at 5 years. Furthermore, 48% of eyes lost light perception. Other previous research reported rates IOP success rates at 12 and 18 months of 79% and 56% in 36 patients undergoing Baerveldt glaucoma implant placement for medically uncontrolled NGV.” |

 **Source:** Authors (2025).

This research included studies that evaluated the efficacy of TREC, drainage implants and CICLOFOT, which were carried out in countries such as India, Saudi Arabia, Turkey, China, the United States, and Brazil, and included randomized clinical trials, retrospective cohort studies, and narrative reviews, reflecting a wide methodological and geographic diversity, focusing on IOP reduction; failure rates; complications; dependence on eye drops; and specific indications, as detailed in Table 1 above.

Based on these assumptions, different perspectives on the efficacy of surgical modalities in controlling IOP in NGV suggest that TREC, historically considered the standard procedure, showed clinical success rates above 50% in studies such as those by Pegu *et al* . (2024) and Rodrigues *et al* . (2016), especially when associated with the use of antimetabolites such as mitomycin C. However, these authors also reported considerable late failure rates, attributed to fibrovascular proliferation, compromising the function of the filtering bleb over the months. Thus, several authors have pointed to the limitations of TREC in patients with intense iris neovascularization. According to Zhu *et al* . (2024) and Dias *et al* . (2024), the presence of intraoperative hemorrhage and early fistula closure were frequent complications, leading to the need for reinterventions or subsequent association with valve implants. Nevertheless, Tekcan *et al* . (2024) reinforced that, in the initial stages of NGV and with prior control of neovascularization, TREC maintained promising results.

Regarding drainage implants, such as Ahmed valves, greater consistency in pressure control was demonstrated in refractory cases, as studies such as those by Alabduljabbar *et al* . (2024) and Shalaby *et al* . (2022) demonstrated, reducing upper IOP by 50% between 6 and 12 months, even in patients who had TREC failure, demonstrating that these devices are less dependent on conjunctival healing (a limiting factor in TREC) and presented a lower risk of encapsulation when implanted with an appropriate technique. However, the use of implants was not without complications, as Matos *et al* . (2023) and Menezes *et al* . (2020) reported, when exposing significant rates of hypotonia and tube migration, in addition to the maintenance of the use of eye drops in almost 2/3 of cases after one year, suggesting that, although effective in reducing IOP, the implants did not eliminate the need for complementary therapy in most patients. However, their applicability in cases with extensive neovascularization and closed angle makes them a viable alternative in the face of failure of other modalities.

Furthermore, transscleral cyclophotocoagulation, in turn, was recommended sparingly by several authors, such as Mishra and Meyer (2024) and Costa *et al* . (2020), who observed that this technique presents a rapid reduction in IOP, but with a high risk of complications, such as ocular phreatrophy and intense inflammation. The procedure, by partially destroying the ciliary body, drastically reduces the production of aqueous humor. However, this efficacy was accompanied by anatomical deterioration in some patients. However, even with this risk profile, Sahin *et al* . (2024) and Chey and Lee (2024) reported positive experiences using CYCLOPOT as primary treatment in selected cases. Additionally, these studies advocated its initial use in patients with limited visual prognosis, especially when other techniques would be contraindicated. Nevertheless, authors such as Wang *et al* . (2023) and Kingston and Lusthaus (2023) maintained the recommendation to reserve this modality for advanced and refractory cases, especially due to the unpredictability of anatomical results.

Furthermore, direct comparisons between the techniques, Li *et al* . (2023) and Iwasaki *et al* . (2022) concluded that drainage implants presented greater durability in blood pressure control than TREC, especially in follow-ups over 1 year. However, they also reported higher rates of need for revision procedures, or complementary use of hypotensive agents, suggesting that the choice should be personalized according to the patient's profile and degree of neovascularization. In addition, Brazilian studies, such as those by Menezes *et al* . (2020) and Costa *et al* . (2020), corroborated international findings, which also highlighted the importance of the etiological evaluation of NGV, with the most common association with diabetic retinopathies as a determining factor for therapeutic success, but the severity of the initial condition; the presence of hyphema; and the density of neovascularization were also elements that directly influenced clinical outcomes, regardless of the surgical technique used.

The methodological heterogeneity among studies, including retrospective, prospective, and comparative studies, was reflected in the variability of success and failure criteria. However, most publications converged on recommending a stepped approach, prioritizing TREC in early stages, followed by implants in refractory cases, and CICLOFOT as a last resort. This therapeutic algorithm is based on the safety and cost-effectiveness of the approaches (RODRIGUES *et al* ., 2016; PEGU *et al* ., 2024). Thus, the data consolidated in this research session reinforced the need for therapeutic individualization, taking into account not only the efficacy of IOP reduction, but also the complication profile; previous visual status; rehabilitation potential; and the technical feasibility of each intervention. And, with all due respect, surgical decision-making should consider the full spectrum of the pathology and the most robust state-of-the-art evidence.

1. **DISCUSSION**

The results of this research were analyzed in light of comparisons with similar and divergent findings in the literature, and by comparing their theoretical data with those of other studies. To this end, they were primarily compared with studies on the efficacy of the three different proposed surgical modalities, and secondarily with studies analyzing the proposed surgical modalities in association with different NGV treatments. Furthermore, correlated phenomena were observed to elucidate data not previously addressed. The most accessible and relevant studies in three categories were presented: to assess the state of the art, over time, of the different surgical therapeutic modalities (trabeculectomy, cyclophotocoagulation, and drainage implant) applied to NGV ; to compare the failure rate among the three different surgical therapeutic modalities applied to NGV ; and to analyze the indications for these surgical treatments according to NGV etiologies , in the different studies shown in Table 1 .

* 1. **THE STATE OF THE ART OF THE 3 DIFFERENT SURGICAL THERAPEUTIC MODALITIES APPLIED TO NGV**

Surgical treatment of NVG has evolved significantly over the past few decades, with distinct approaches reflecting technological advances, clinical needs, and different patient profiles. Therefore, this study observed that TREC occupied a central position in the first therapeutic approaches for NVG, long being considered the gold standard. Rodrigues *et al* . (2016) and Pegu *et al* . (2025) demonstrated that TREC, when combined with mitomycin C, achieved satisfactory blood pressure control rates, especially in less advanced stages of neovascularization. However, the authors also identified high rates of long-term failure, mainly associated with the intense healing response and closure of the filtering fistula. Furthermore, over the years, researchers have highlighted significant limitations of TREC in patients with extensive neovascularization, such as the findings of Zhu *et al* . (2024) and Dias *et al* . (2024), who pointed out that, in cases of advanced angle neovascularization, TREC presented a higher risk of complications, such as persistent hyphema and early bleb closure. However, Tekcan *et al* . (2024) suggested that, with adequate preoperative control of neovascularization, especially with the use of anti-VEGF and panphotocoagulation, the results of TREC could be comparable to those of implants, with lower costs and less surgical complexity. However, drainage devices, especially the Ahmed valve, emerged as a promising alternative, particularly in cases refractory to conventional treatment, as observed in studies such as those by Alabduljabbar *et al* . (2024) and Shalaby *et al* . (2022), which showed higher rates of intraocular pressure reduction, maintaining stable control over 12 months of follow-up, results that were also reinforced by Iwasaki *et al* . (2022), who demonstrated that the implant presented better pressure results compared to TREC, in addition to greater durability of surgical success. However, the use of implants was not without challenges, such as Matos *et al* . (2023) and Menezes *et al* . (2020) reported, mainly due to complications such as tube migration, plaque encapsulation, and refractory hypotonia, which required surgical revisions or adjuvant therapies . Despite this, these authors recognized that, in patients with severe neovascularization and completely closed angle, implants were more effective than any other modality, as well as Li *et al* . (2023) added that, although the devices reduced IOP more significantly, the continuous use of eye drops was still necessary in more than two-thirds of cases; moreover, transscleral cyclophotocoagulation also played a relevant role in the therapeutic arsenal against NGV, especially in patients with low visual expectation, as per Sahin *et al* . (2024) and Chey & Lee (2024) emphasized that, through immediate positive effects in IOP reduction, with minimal dependence on eye drops, it is especially useful in painful eyes with terminal glaucoma. And, although effective in reducing pressure, this approach was not free of complications, as Mishra & Meyer (2024) described through occurrences of severe inflammation, ocular atrophy, and phreatrophy, leading to caution in indicating the procedure as initial treatment. Furthermore, Costa *et al* . (2020) reinforced the view that CICLOFOT should be reserved for extreme situations, given its aggressive profile and the unpredictability of anatomical results. However, Guzun *et al* . (2024) observed good visual and anatomical outcomes in a sample of patients undergoing the technique with a fractionated protocol, indicating that adjustments in the parameters could minimize the risks and expand the indications for the technique. Furthermore, in the historical context, the findings of Sivak-Callcott *et al* . (2001) and Lima *et al* . (2004) had already indicated that TREC faced significant limitations in patients with advanced proliferative diabetic retinopathy, the main etiology of NGV. At the time, even with antimetabolites, efficacy was compromised by early closure of the drainage pathway, a pattern that was reiterated over time. According to Sun Jin-Tao *et al* . (2016) and Olmos & Lee (2011), the indication for TREC began to require greater discretion, with precise case selection and rigorous preoperative management. Thus, the 2010s saw the popularization and refinement of implantation techniques, with standardization of valve models and improvements in intraocular positioning, while ALKAWAS *et al* . (2010) and Shen *et al* . (2011) already indicated the relative superiority of implants over TREC in NVG settings, especially in prolonged IOP control, a trend that continued in subsequent years and was ratified by Ramji *et al* . (2022) and Tokumo *et al* . (2021), who identified lower reoperation rates in patients with Ahmed valves compared to those who underwent TREC alone. More recently, authors such as Takeuchi *et al* . (2024), Kingston & Lusthaus (2023), and Urbonaviciute *et al* . (2022) indicated that therapeutic decisions began to consider, in addition to pressure efficacy, factors such as preservation of visual acuity, quality of life, and cost-effectiveness of procedures. The use of individualized algorithms, which combine different approaches according to the stage of NVG, has become an increasingly adopted practice. Therefore, the state of the art in surgical treatment of NGV demonstrated clear evolution and refinement in its indications, with TREC remaining valid in the initial stages, as long as it is preceded by control of neovascularization; while implants were established as an effective and versatile alternative, especially in refractory or closed-angle cases, while CICLOFOT continued to be indicated for terminal or painful cases, in which visual preservation was no longer the primary objective. Therefore, these findings corroborated the need for personalized approaches, based not only on IOP results, but also on the clinical complexity of each patient.

* 1. **INDICATIONS FOR TRABECULECTOMY, CYCLOPHOTOCOAGULATION, AND CNG DRAINAGE IMPLANTS ACCORDING TO THEIR ETIOLOGIES**

When analyzing the surgical indications for NVG according to the etiology, a strong influence of the underlying disease on the therapeutic choice was evident. Therefore, researchers Ramji *et al* . (2022) and Sahin *et al* . (2024) described that patients with NVG secondary to central retinal vein occlusion had a better response to the implantation of drainage devices, especially when associated with persistent cystic macular edema. These findings also corroborated the data of Rodrigues *et al* . (2016), who also indicated greater benefit from the implantation in scenarios of extensive retinal ischemia, in which TREC demonstrated early failure. Furthermore, Wang *et al* . (2023) reinforced that, in cases secondary to advanced proliferative diabetic retinopathy, CYCLOFOT was often prioritized, especially in patients with low residual visual acuity . This approach was justified by the lower visual expectancy and higher inflammatory risk associated with traditional filtration surgeries. This argument was also defended by Li *et al* . (2023) and Dong *et al* . (2018), who demonstrated that the choice of less invasive techniques was more common when the anatomical and functional prognosis was poor. However, Takeuchi *et al* . (2024) described that, in patients with NVG due to chronic ocular ischemia, especially in conditions secondary to carotid obstruction, TREC associated with the use of antimetabolites was considered effective, as long as it was performed in the early stages of neovascularization, something that had also been reported and communicated by Iwasaki *et al* . (2022), who observed a higher success rate when filtration surgery was performed before complete closure of the iridocorneal angle. This contrasted with the data of Pegu *et al* . (2025), who preferred drainage implants in more advanced stages of the pathology, reinforcing that the evolutionary stage of NVG, and not just the primary etiology, should guide the surgical decision. In parallel, Tekcan *et al* . (2024) and Urbonaviciute *et al* . (2022) highlighted that, in eyes with previous ocular trauma or recent intraocular surgery, the option for CICLOFOT was more common, both due to less manipulation of the anterior segment and the increased risk of postoperative inflammation in more invasive techniques, an indication that was particularly evident in cases with pseudophakia, in which the anatomical alteration made it difficult to perform TREC safely. Furthermore, these findings coincided with the reports of Alkawas *et al* . (2010), who described a higher frequency of TREC failure in previously operated eyes. Regarding the choice of CICLOFOT, Khodeiry *et al* . (2021) introduced an important innovation by proposing the primary slow coagulation transscleral cyclophotocoagulation technique as an initial alternative for cases with high inflammatory risk, including patients with severe ocular ischemia secondary to vascular occlusions or advanced diabetes. The authors argued that slow dosimetry presented less induction of inflammatory peaks and a lower rate of complications, favoring its early use over more invasive techniques. This proposal was ratified by Chey and Lee (2024), who observed equivalent results in blood pressure control with less tissue aggressiveness. Thus, other researchers, such as Shen *et al* . (2011) and Sahin *et al* . (2024), also argued in favor of the selective use of CYCLOPOT in patients with zero visual expectation, especially in contexts of refractory ocular pain, suggesting that, although its main indication was not based on etiology, the general clinical condition of the eye directly influenced its applicability. In line with this, studies such as that by Kingston and Lusthaus (2023) questioned its primary indication, arguing that TREC or implants should precede cyclophototherapy in patients with preserved visual potential, regardless of the underlying etiology. Furthermore, in the context of proliferative diabetic retinopathy, Zhu *et al* . (2024) and Shalaby *et al* . (2022) reiterated the superiority of drainage implants over conventional TREC, observing greater pressure stability and a reduced need for reinterventions in patients with irregular glycemic control and active neovascularization. In this regard, the findings of Senthil *et al* . (2016) reinforced the indication for implants in these patients, particularly due to the lower risk of excessive scarring of the filtering bleb, a limiting factor in diabetic individuals. Regarding the combined approach, Yang *et al* . (2018) indicated a preference for valved implants, especially the Ahmed valve, combined with pars plana vitrectomy in patients with NVG secondary to vitreous hemorrhage, due to initial pressure stability. This approach was also described in a linear fashion by Kumar *et al* . (2022), who reported more favorable outcomes with valved devices in cases with intense fibrovascular proliferation, a finding with relevant implications for severe hemorrhagic or inflammatory etiologies. That said, Lima *et al* . (2004) and Liao *et al* . (2016) highlighted that, in cases of NVG with multiple concomitant etiologies, such as an association between diabetes, ocular ischemia and trauma, the therapeutic choice must be individualized, considering not only the primary disease, but the clinical complexity of the eye as a whole, and this personalized approach was also endorsed by Olmos and Lee (2011), who highlighted that surgical success in NVG is strongly related to the appropriate choice of technique, in relation to the clinical picture, more than to isolated etiologies.

* 1. **FAILURE RATE AMONG THE DIFFERENT SURGICAL THERAPEUTIC MODALITIES APPLIED TO NGV**

Over the past few decades, the search for effective surgical modalities for the treatment of NVG (NVG) has evolved significantly, and, in this regard, several researchers have investigated the failure rates associated with TREC, CICLOFOT, and drainage devices, allowing for fundamental comparisons for clinical practice. Such as Pegu *et al* . (2025), who postulated that drainage devices remained more stable in the long term, with a lower incidence of failure compared to TREC, particularly in patients with high iris vascularity; similarly, Alabduljabbar *et al* . (2024) showed that, among the 67 patients evaluated, the TREC failure rate reached 43.3% at 12 months, contrasting with 23.3% in the Ahmed valve group. They attributed this result to the greater propensity for subconjunctival fibrosis and early fistula closure in eyes with advanced NVG, data that corroborate the findings of Rodrigues *et al* . (2016), who also identified early failure in TREC, with a 45% failure rate at 6 months. Regarding CICLOFOT, Khodeiry *et al* . (2021) adopted an innovative approach by employing the slow coagulation transscleral cyclophotocoagulation technique, which resulted in a failure rate of less than 10% at 12 months, with a low incidence of inflammatory complications. This strategy proved particularly effective in eyes with a history of multiple surgical interventions, when compared to traditional CICLOFOT, which historically exhibits failure rates above 30% (DONG *et al* ., 2018). In contrast, Zhu *et al* . (2024) documented that the use of the Ahmed implant was associated with a cumulative surgical success rate of 77.3% at two years, results that were reinforced by Shalaby *et al* . (2022), when describing failure in only 22% of eyes with Ahmed valve versus 45% of those undergoing conventional transscleral cyclophotocoagulation, a contrast revealed the importance of the type of laser, applied dosimetry, and adequate patient selection for the success of CICLOFOT. Furthermore, it is important to emphasize that Khodeiry *et al* . (2021) justified the use of CICLOFOT with slow dosimetry in cases refractory to TREC or with a high risk of subconjunctival fibrosis, an approach that provided better tolerance to the procedure, a lower risk of severe inflammation, and functional preservation in patients with severe NVG . Thus, these findings reinforced the indication of CICLOFOT as first-line in monocular eyes or with a limited visual prognosis. Thus, Guzun *et al* . (2024) reported a 52% failure rate in TREC in patients with NVG secondary to central retinal vein occlusion, highlighting that the presence of active iridescent neovascularization preoperatively negatively influenced surgical success. However, Takeuchi *et al* . (2024) found a 68% success rate with drainage valves after 12 months, even in eyes with a history of previous vitrectomy. Meanwhile, the findings of Miglani and Ullah (2023) emphasized that the choice of surgical modality should consider the NVG stage and the visual status of the affected eye, thus describing that CICLOFOT demonstrated greater efficacy in advanced stages of the disease, while drainage implants performed better in intermediate stages, with less inflammatory reactivity. This line of action was ratified by Li *et al* . (2023), who reported progressive TREC failure after the 6th month due to intense fibrovascular proliferation. Furthermore, Kingston and Lusthaus (2023) highlighted that drainage devices presented less variability in intraoperative and postoperative results, a factor that contributed to lower reintervention rates, which thus attributed the lower failure rate to the engineering of the valved system, which allows progressive control of intraocular pressure, and, in contrast, Sahin *et al* . (2024) demonstrated that conventional TREC, even with mitomycin C, achieved success in only 53% of cases after one year. That said, the data analyzed in this research suggest that, although TREC is still widely used, its failure rate in NGV tends to be higher than that of other techniques, especially in eyes with a significant neovascular component. In addition, drainage devices stand out for their stable performance, especially in patients with multiple comorbidities or contraindications to TREC, while slow-coagulation transscleral cyclophotocoagulation (KHODEIRY *et al* ., 2021) has proven to be a promising alternative, especially in refractory eyes or those at high risk of failure of other approaches.

1. **CONCLUSION**

This research allowed us to chart, over the past two decades, the state of the art in surgical modalities applied to the treatment of NVG, highlighting technical advances; refinements in indications; and individualized strategies according to the underlying etiology. Furthermore, a combined analysis of the studies revealed not only the evolution of methods but also the idiosyncrasies that directly impacted the failure rate, technique choice, and functional outcomes. When examining the state of the art, it was observed that TREC, although historically considered the gold standard for the management of refractory glaucoma, had its efficacy progressively limited in the context of NVG, especially in the presence of intense neovascularization and inflammation. Therefore, drainage implants, particularly the Ahmed valve, have established themselves as the modality with the highest medium- and long-term success rate, especially when applied early. Whereas CICLOFOT emerged from what was once a palliative technique to become a promising therapeutic approach, especially with the adoption of the transscleral slow coagulation modality.

Furthermore, comparing failure rates between the approaches, the data reinforced the greater pressure stability and lower reoperation rates with valve implants, while TREC showed a greater propensity for ostium obstruction or early scar fibrosis. In contrast, CICLOFOT, especially in cases with low visual potential, demonstrated satisfactory performance and low cost, although with greater variability in results.

Thus, regarding therapeutic indications according to etiology, the findings were decisive: in cases of proliferative diabetic retinopathy and central retinal vein occlusion, drainage implants were preferred, especially in advanced stages with angle closure. In early cases or cases of mild ocular ischemia, TREC was still considered viable, especially when combined with antimetabolites. CICLOFOT, on the other hand, proved effective in scenarios with poor visual prognosis or refractory ocular pain, as a valid alternative even as a first-line treatment, provided the parameters are well-defined.

Therefore , it is concluded that there is no universal approach to the surgical treatment of NVG, and the choice of method should be guided by clinical, anatomical, and etiological criteria, always considering the disease's stage of development, visual potential, degree of inflammation, and previous ocular history. Advances in techniques such as slow-coagulation transscleral cyclophotocoagulation represent a milestone in the search for less invasive and safer therapies, while drainage devices continue to offer stability in complex cases. Therefore, the findings of this research corroborate the importance of a personalized approach to the management of NVG. Furthermore, it is clear that, while the literature evolves, the need for new randomized prospective studies to validate these approaches on a large scale remains clear, especially given the clinical complexity of NVG.

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