



Research Article

Outcomes of Trabeculectomies Utilizing Two Distinct Conjunctival Flap Designs in Various Glaucoma Types

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Abstract

Purpose: This study aims to assess the surgical outcomes of limbus-based versus fornix-based conjunctival flaps in trabeculectomy procedures.

Materials and Methods: A retrospective analysis was conducted involving 42 patients who underwent trabeculectomy with a limbus-based conjunctival flap (Group I) and 42 patients who received a fornix-based conjunctival flap (Group II). The comparison focused on surgical success, additional interventions, medication usage, complications, and bleb morphology over a 12-month postoperative period follow up. The success of trabeculectomy was categorized based on postoperative Intraocular Pressure (IOP) as complete (<18 mmHg), partial (18-21 mmHg), and failed (>21 mmHg).

Results: No statistically significant differences were observed between the groups concerning IOP measurements taken on postoperative day 1, as well as at week 1 and at 1, 3, 6, 9, and 12 months. The success rates of trabeculectomy at 6 and 12 months were comparable between the groups. Additionally, no differences were noted between the groups in terms of bleb morphologies at 6 and 12 months, postoperative complications, the necessity for additional interventions or medical therapy, or the requirement for revision or reoperation at the conclusion of the 12-month follow-up period.

Conclusions: The two distinct conjunctival flap designs (limbus and fornix) demonstrated comparable outcomes in trabeculectomy procedures.

Keywords: Fornix Based; Glaucoma; Limbus Based; Trabeculectomy

Introduction

Glaucoma is a chronic and progressive ocular disease that substantially impacts patients' daily lives [1]. It ranks as the second leading cause of irreversible blindness in developed nations [2,3]. With the rise in life expectancy, the prevalence of glaucoma is anticipated to affect over 111 million individuals by 2040 [4]. Primary Open-Angle Glaucoma (POAG) is the most prevalent form of glaucoma and is generally, though not invariably, associated with elevated Intraocular Pressure (IOP) [5]. This

condition results in optic nerve damage and peripheral vision loss. Patients with normal-tension glaucoma exhibit similar symptoms despite maintaining intraocular pressure within the normal range [6]. Other etiologies of glaucoma include pigment dispersion and trauma. For all glaucoma types, the primary therapeutic strategy involves reducing IOP to a level that does not harm the optic nerve. When effectively managed, disease progression can be decelerated or halted. Treatment modalities encompass pharmacotherapy, laser therapy, and surgical interventions. Medications function by either decreasing aqueous humor production or enhancing its outflow [7]. Laser treatments, such as argon laser trabeculoplasty and selective laser trabeculoplasty, promote aqueous drainage

[8]. Surgical interventions for glaucoma include procedures such as trabeculectomy, drainage tube implantation, and ciliary body ablation, with trabeculectomy regarded as the most appropriate surgical option for various glaucoma types [9]. Despite the advent of novel and minimally invasive techniques and various implants, trabeculectomy remains the preferred surgical option for many glaucoma types, with a success rate ranging from 60% to 94% [10]. This procedure is indicated as a primary intervention or when other treatments (medical or laser) prove ineffective in patients with progressive visual field loss, those intolerant to topical medical therapies, or individuals living alone who cannot administer their own drops. Trabeculectomy is favored for nearly all glaucoma types, including primary open-angle glaucoma, Angle-Closure Glaucoma (ACG), Pseudoexfoliation Glaucoma (PEXG), juvenile glaucoma, pigmentary glaucoma, congenital glaucoma, and secondary glaucoma. Trabeculectomy was initially described by Cairns in the 1960s, utilizing a limbus-based conjunctival flap. By creating a flap in the sclera and excising a portion from the trabeculum, the aqueous humor can drain into the episcleral veins. Over time, it has undergone numerous modifications, such as the size of the scleral flap, suture management, limbal or fornix-based conjunctival flap configuration, and the use of antimetabolites [11-14]. Previous studies have investigated the effects of limbus- or fornix-based conjunctival flap designs on trabeculectomy success and bleb morphology, yielding similar results [15-17]. This study aimed to compare the IOP-lowering success and complication rates of two different conjunctival flap designs used in trabeculectomies performed for various types of glaucoma over a one-year postoperative period.

Methods

A retrospective review was conducted on the medical records of patients who underwent trabeculectomy surgery. Data were systematically collected, including demographic information, glaucoma type, preoperative mean Intraocular Pressure (IOP), the number of topical medical treatments administered preoperatively, cup/disc ratio (C/D), flap design (limbus-based or fornix-based), use of antimetabolites, IOP at postoperative week 1 and months 1, 3, 6, 9, and 12, bleb morphology at months 3 and 12, complications, any additional postoperative medical treatment required, and further interventions within the one-year period (such as suture manipulations, needling, use of 5-FU, revision, and repeat trabeculectomy). Patients were excluded if they had a history of ocular trauma, had undergone intraocular surgery or laser treatment prior to trabeculectomy, or failed to attend the scheduled clinical follow-up visit one year postoperatively. The study included the medical records of 42 patients who underwent trabeculectomy surgery with a limbus-based conjunctival opening (Group I) and 42 patients with a fornix-based opening (Group II).

Surgical Technique In Trabeculectomy

Limbus-Based Procedure

A 4-0 silk traction suture was applied to the superior rectus muscle to enhance visualization of the surgical field. The conjunctiva was dissected in a curved manner using Westcott scissors in the superior quadrant, positioned 8 mm from the corneoscleral limbus and measuring 6-8 mm in width. Additionally, when necessary, the Tenon capsule was separated by either blunt or sharp dissection, 2 mm anterior to the conjunctival incision. The conjunctiva and Tenon capsule were sutured continuously using 8-0 polyglycolic acid, 8-0 braided lactomer, or 8-0 polyglyactin suture material.

Fornix-Based Procedure

In the fornix-based conjunctival flap procedure, a 7-0 or 8-0 polyglyactin traction suture was placed on the cornea to improve visualization of the surgical area. The limbal conjunctiva was dissected from its corneal attachment using Westcott scissors. Furthermore, the Tenon capsule was removed by blunt dissection. The conjunctival flap thus created was then reflected back to provide an unobstructed view of the surgical field. In all surgical procedures, a 4x4 mm limbus-based scleral flap was meticulously fashioned using a surgical blade, ensuring the flap's thickness reached up to half the full thickness of the sclera. Mitomycin-C (MMC) was administered to younger patients (under 35 years of age) and those with a thick Tenon's layer identified intraoperatively. Three or four small surgical sponges, saturated with a 0.33 mg/ml MMC solution, were positioned beneath the scleral flap, away from the conjunctival incision sites, for a duration of three minutes before removal. The MMC-treated area was subsequently irrigated with 150 ml of saline solution. At the surgical limbus's edge, the trabecular meshwork was excised using a Kelly punch. This was succeeded by a peripheral iridectomy, and the scleral flap was secured with 2-5 10-0 nylon sutures. Fornix-based conjunctival flaps were closed using 10-0 polyglycolic acid sutures. All procedures were conducted by the same surgeon.

In the postoperative phase, topical tobramycin and cycloplegic agents were administered for two weeks, while topical dexamethasone drops were continued for 10-12 weeks. Patients were subjected to follow-up examinations on postoperative day 1, week 1, and subsequently at months 1, 3, 6, 9, and 12. During each follow-up examination, best-corrected visual acuity, biomicroscopy, intraocular pressure measurement via Goldmann applanation tonometry, and fundus examination with documentation of the C/D ratio were recorded for all patients. Special attention was given to the Seidel test, bleb morphology, anterior chamber depth, lens clarity, and complications (such as anterior chamber loss, malignant glaucoma, choroidal effusion, hyphema, blebitis, and corneal erosion) during biomicroscopic

examination. Bleb morphologies were documented.

The Classification Of Bleb Morphology Is As Follows:

- **No bleb:** This category is characterized by the presence of surgical incision scars on the conjunctiva, with an absence of bleb formation.
- **Flat bleb:** In this type, the conjunctiva exhibits a slight elevation.
- **Diffuse bleb:** This type is identified by an elevated conjunctiva, where the borders are not distinctly discernible.
- **Elevated bleb:** This category is marked by a distinctly elevated conjunctiva with clearly defined borders.
- **Cystic bleb:** This type involves the presence of small or large cysts within the conjunctiva, specifically in the region corresponding to the scleral flap.
- **Encapsulated bleb:** This type is characterized by the formation of a fibrous capsule by Tenon's tissue in the area of the scleral flap.

During the follow-up period, intensive steroid therapy was administered to encapsulated blebs, with needling performed when steroid therapy was insufficient. For eyes exhibiting extensive fibrosis, where areas revealed by needling were anticipated to potentially close, 0.1 ml of the antifibrotic agent 5-Fluorouracil (5-FU) (5 mg/ml) was injected every 5-7 days post-needling at a site distant from the bleb. In evaluating the success of trabeculectomy, patients whose Intraocular Pressure (IOP), as measured by Goldmann applanation tonometry at the 6th month and 1st year postoperatively, was less than 18 mmHg were classified as achieving "complete success." Those with IOP between 18-21 mmHg were deemed to have "partial success," while those with IOP exceeding 21 mmHg, irrespective of additional medication use, were categorized as "failure." All analyses were conducted using SPSS for Windows version 15.0 (SPSS, Inc., Chicago, IL). Following normality testing, differences between continuous variables were analyzed using either Student's t-test or the Mann-Whitney U test, as appropriate. Categorical data and ratios were analyzed using the Chi-square test. P-values less than 0.05 were considered statistically significant.

Results

The study included the medical records of 84 patients who had no prior history of trauma or intraocular surgery and who underwent trabeculectomy for the first time, with full adherence to follow-up visits for 12 months postoperatively. Of these patients, 42 underwent trabeculectomy with a limbus-based conjunctival flap (Group I), while the remaining 42 underwent trabeculectomy with a

fornix-based conjunctival flap (Group II). The glaucoma diagnoses of the patients were categorized into three groups: Primary Open-Angle Glaucoma (POAG), Angle-Closure Glaucoma (ACG), and Pseudoexfoliation Glaucoma (PEXG). Cases diagnosed with congenital glaucoma, traumatic glaucoma, and neovascular glaucoma were excluded from the study. Patients in both groups were comparable in terms of mean age, preoperative mean Intraocular Pressure (IOP), presence of concomitant systemic disease, gender distribution, and preoperative Cup-Disc (C/D) ratio. In Group I, 21 patients (50%) were diagnosed with POAG, 14 (33.3%) with PEXG, and 7 (16.7%) with ACG. In Group II, 26 patients (61.9%) were diagnosed with PEXG, 12 (28.6%) with POAG, and 4 (9.5%) with ACG. Regarding the number of preoperatively used antiglaucomatous agent molecules: in Group I, 11 patients used a single molecule, 9 used two molecules, 12 used three molecules, and 10 used four molecules. In Group II, 2 patients used a single molecule, 1 used two molecules, 13 used three molecules, and 26 used four molecules.

There was no statistically significant difference between the two groups in terms of IOP levels measured with the Goldmann applanation tonometer on postoperative day 1, week 1, and at months 1, 3, 6, 9, and 12. The postoperative IOP levels and p values of the cases are summarized.

Upon comparing the two groups with respect to bleb morphology at the 6th and 12th months, no significant differences were observed between cases with limbus-based conjunctival incisions and those with fornix-based incisions. A summary of the bleb morphologies is presented.

Upon comparing the two groups with respect to postoperative complication rates, no statistically significant differences were observed. These results are detailed.

In a comparative analysis of the groups regarding the number of additional procedures required during the 12-month postoperative period, needling was conducted in 7 patients within the limbus-based group and in 8 patients within the fornix-based group. Administration of 5-FU injections occurred in 10 patients in the limbus-based group and in 9 patients in the fornix-based group. Argon laser suture lysis was performed on 9 patients in the limbus-based group and on 14 patients in the fornix-based group. In both groups, trabeculectomy revision was undertaken in 2 patients. A second trabeculectomy was performed in 1 patient in the limbus-based group and in 3 patients in the fornix-based group. There was no statistically significant difference between the groups concerning postoperative additional interventions, including the mean number of needling procedures, 5-Fluorouracil (5-FU) injections, argon laser suture lysis, trabeculectomy revision, and second trabeculectomy. A summary of all additional interventions

and the p-value is presented.

In both groups, topical anti-glaucoma medications were administered to patients who did not attain the targeted Intraocular Pressure (IOP) values following trabeculectomy. In the limbus-based cohort, 14 patients, and in the fornix-based cohort, 15 patients required additional topical anti-glaucoma medication at 6 and 12 months postoperatively. To assess the success of trabeculectomy surgery, irrespective of the necessity for supplementary topical medications, cases with an IOP below 18 mmHg, as measured by Goldmann applanation tonometry at 6 and 12 months postoperatively, were categorized as complete successes. Those with IOP values between 18–21 mmHg were classified as partial successes, and those exceeding 21 mmHg were deemed failures. At 6 months postoperatively, in the limbus-based cohort, trabeculectomy was classified as a complete success in 31 patients (73.8%), a partial success in 9 patients (21.4%), and a failure in 2 patients (4.8%). In the fornix-based cohort, 32 patients (76.2%) achieved complete success, 6 patients (14.3%) partial success, and 4 patients (9.5%) failure. There was no statistically significant difference between the two cohorts in terms of trabeculectomy success at 6 months postoperatively ($p=0.506$, Fisher's Exact Test). When evaluating trabeculectomy success at 12 months postoperatively, in the limbus-based cohort, 26 patients (61.9%) achieved complete success, 11 patients (26.2%) achieved partial success, and 5 patients (11.9%) experienced failure. In the fornix-based cohort, 35 patients (83.3%) achieved complete success, 5 patients (11.9%) partial success, and 2 patients (4.8%) failure. Statistically, there was no significant difference between the two cohorts regarding the success of trabeculectomy at 12 months postoperatively ($p=0.054$, Fisher's Exact Test).

Discussion

Despite significant advancements in medical technology, trabeculectomy continues to be the most commonly preferred surgical procedure for glaucoma in cases where target Intraocular Pressure (IOP) cannot be achieved through medical treatment and laser applications. The limbus-based conjunctival opening in trabeculectomy was initially described by Cairns in 1968, while Luntz introduced the fornix-based conjunctival flap in 1980 [18]. Since these initial descriptions, numerous modifications have been made to the trabeculectomy procedure, including variations in the size and type of the scleral flap, the design of the conjunctival flap, the use of antimetabolites during and after surgery, suture materials, and adjustable suture techniques, all of which have been extensively discussed in the literature [19-21]. In the present study, we conducted a retrospective comparison of complication rates and success rates in achieving target IOP among 84 patients who underwent trabeculectomy, with one-year follow-up data available (42 patients with a limbus-based and 42 with a fornix-based

conjunctival flap). A significant difference was observed between the two groups concerning the type of glaucoma. Specifically, the number of patients with Pseudoexfoliation Glaucoma (PEXG) was higher in the fornix-based group, whereas patients with primary Open-Angle Glaucoma (POAG) more frequently underwent limbus-based surgery. However, the two patient groups were comparable in terms of preoperative IOP values. Sipahier et al. demonstrated that the type of glaucoma does not affect the surgical success of trabeculectomy performed with either limbus- or fornix-based conjunctival flaps in patients with Primary Open-Angle Glaucoma (POAG), Primary Angle-Closure Glaucoma (PACG), juvenile glaucoma, and secondary glaucoma [22]. Conversely, Fernandez's study on patients diagnosed with POAG, Pseudoexfoliation Glaucoma (PEXG), and PACG reported the highest surgical success in POAG patients [23]. Consequently, the unequal distribution of glaucoma types among our patient groups may represent a limitation of our study. While Mitomycin-C (MMC) was utilized in only one patient undergoing the limbus-based procedure, it was necessary to employ MMC in 26 patients who underwent the fornix-based procedure. We attribute this to the fornix-based procedures being conducted at a later stage, when the use of MMC had become more prevalent. Given the disparity in the number of patients in whom MMC was used between the two groups, we excluded these patients from the statistical analysis. We posit that the reason patients who underwent fornix-based flap design utilized preoperative topical medical treatments with a greater number of active molecules, compared to those who underwent limbus-based flap design, is attributable to the more recent timing of these surgeries, coinciding with a period of increased diversity in medical treatment options. Our findings indicate comparable success rates at the 6th and 12th postoperative months across both patient groups. However, we encountered challenges in comparing our success rates with those reported in previous studies due to the use of varying success criteria in the literature [24]. The present study aligns with the research conducted by Fontana et al. in terms of MMC dose, success criteria, and surgical outcomes [25]. Bleb morphology was observed to be similar in both groups at the 3rd and 12th months postoperatively, with the elevated bleb type being the most prevalent morphology in both groups. The literature presents conflicting reports regarding bleb morphology. Studies by Shuster et al. and Traverso et al. demonstrated similar bleb morphologies with both surgical methods in the absence of MMC [26,27]. In contrast, Brincker et al. reported that, in the absence of MMC, diffuse blebs were more frequently observed in fornix-based flaps, while avascular blebs were more common in limbus-based flaps.

Similarly, Agbeja and Dutton noted a higher incidence of diffuse blebs in patients with fornix-based flaps and more cystic blebs in those with limbus-based flaps following surgery without MMC

[28]. Variability in bleb morphology has been documented in cases involving different conjunctival flap designs in conjunction with MMC. Wells et al. reported a higher incidence of cystic bleb formation in patients undergoing a limbus-based flap procedure [29]. Hirooka et al. observed that, at the 12-month follow-up of 90 fornix-based trabeculectomy procedures utilizing MMC, an avascular bleb morphology was present in 31% of cases [30]. Conversely, Sacu et al. found that, on average, 4.45 ± 1.4 months postoperatively, 24.4% of 49 limbus-based trabeculectomy procedures with MMC resulted in cystic bleb formation, while 16.3% exhibited encapsulated bleb morphology [31]. In the current study, both limbus-based and fornix-based flap groups demonstrated a lower incidence of cystic or encapsulated bleb morphology compared to existing literature. This may be attributed, particularly in the limbus-based group, to the administration of a lower dose or shorter duration of MMC, as well as early interventions (steroids, needling, 5-FU) for patients exhibiting signs of encapsulation. Kuroda et al. conducted a comparative analysis of surgical outcomes between limbus-based and fornix-based trabeculectomy in 26 eyes with conjunctival scars, all of which had previously undergone ocular incisional surgery, such as cataract or trabeculectomy [32]. Their findings indicated no statistically significant differences between the two techniques concerning success rates, Intraocular Pressure (IOP) values, or the number of glaucoma medications required post-trabeculectomy. Furthermore, the complication rates observed during the two-year follow-up period were comparable. Al-Haddad et al. performed a meta-analysis of six studies, encompassing a total of 361 participants, to compare fornix-based and limbus-based trabeculectomy [33]. The analysis revealed no significant differences in efficacy between the two surgical approaches. Postoperative IOP measurements and the number of glaucoma medications needed after surgery did not differ significantly between the methods. However, the limbus-based approach was associated with a significantly increased risk of postoperative shallow anterior chamber. In conclusion, the present study identified similar success rates, additional interventions, and complication profiles in trabeculectomy surgeries utilizing limbus-based and fornix-based conjunctival flap design.

Statements and Declarations

Conflicts of Interest: The author declares that there is no conflict of interest to disclose.

Interests: The author declares that the study received no funding.

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