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Comparison of Perioperative and Postoperative Outcomes of Different Surgical Techniques for Pterygium: An Observational Study

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ABSTRACT

Background: Pterygium is a common ocular surface disorder requiring surgical excision, with multiple operative techniques available. However, comparative evidence regarding perioperative efficiency, postoperative recovery, complications, and recurrence across commonly practiced surgical techniques remains limited, particularly in real-world tertiary care settings.

Purpose: To compare perioperative and postoperative outcomes of five surgical techniques for primary pterygium, including operative time, postoperative pain, early complications, and recurrence.

Methods: This observational study included 106 consecutive patients with primary pterygium who underwent surgery at a tertiary care center. Surgical techniques comprised sutured conjunctival autograft (SCAG; n=65), amniotic membrane transplantation (AMT; n=12), sutureless conjunctival autograft (SLCAG; n=11), conjunctival opposition technique (COT; n=10), and bare sclera technique (BST; n=8). Baseline demographic and clinical characteristics were recorded. Operative time, postoperative pain using the Visual Analog Scale (VAS) on postoperative day 1, day 7, and 1 month, early postoperative complications, and recurrence were compared among groups using one-way analysis of variance and chi-square tests, with statistical significance defined as $p<0.05$.

Results: The mean age of participants was 52.25 ± 14.47 years, and 63.2% were female. Grade II pterygium accounted for 75.5% of cases. Operative time differed significantly among surgical techniques ($F=115.425$, $p<0.001$), ranging from 21.13 ± 2.17 minutes for BST to 55.32 ± 6.82 minutes for SCAG. Postoperative pain also varied significantly on day 1 ($F=4.484$, $p=0.002$) and day 7 ($F=24.164$, $p<0.001$), with lower pain scores observed following SLCAG compared with sutured techniques; pain was minimal and comparable across groups at 1 month ($p=0.326$). Early postoperative complications occurred in 26.4% of patients, predominantly subconjunctival hemorrhage (19.8%), without significant differences between techniques ($\chi^2=12.410$, $p=0.134$). Overall recurrence was 7.5%, with the highest proportion following BST (25.0%) and no recurrence after SLCAG or AMT; however, differences in recurrence among techniques were not statistically significant ($\chi^2=5.458$, $p=0.243$).

Conclusion: Surgical technique significantly influenced operative duration and early postoperative pain but was not associated with significant differences in early postoperative complications or recurrence in this cohort. Sutureless conjunctival autograft demonstrated shorter operative time, lower early postoperative pain, and no observed recurrence during follow-up, suggesting favorable short-term clinical performance. Larger prospective studies with balanced treatment groups and longer follow-up are warranted to confirm comparative long-term effectiveness.

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Keywords*:* Pterygium, Recurrence, Conjunctival Autograft, Amniotic Membrane Graft, Postoperative Pain, Visual Analog Scale.

INTRODUCTION

Pterygium is one of the oldest documented ocular surface disorders, with descriptions dating back over three millennia. Early attempts at management ranged from chemical cauterization in ancient civilizations to surgical excision described by Susruta around 1000 BC—an approach conceptually analogous to modern bare sclera excision.[1] Despite substantial advances in microsurgical techniques and pharmacologic adjuvants, postoperative complications and recurrence remains the principal limitation of surgical management.

Clinically, pterygium manifests as a wing-shaped fibrovascular proliferation of conjunctival and limbal tissue encroaching onto the cornea. Its pathogenesis is multifactorial, characterized by disruption of ocular surface homeostasis, altered limbal stem cell function, chronic inflammation, fibrovascular proliferation, extracellular matrix remodeling, and Bowman's layer disruption.[2] Ultraviolet (UV) radiation is the predominant environmental risk factor, inducing oxidative stress, DNA damage, and cytokine-mediated proliferative signaling.[3] Environmental exposure to dust and wind, outdoor occupation, advancing age, male gender in certain populations, and lifestyle factors further modulate disease risk, particularly in tropical and rural settings.[4] Molecular studies implicate dysregulated expression of transcription factors and angiogenic mediators, including cAMP response element–binding protein, phospholipase D, cytochrome P450 1A1, and aquaporins, providing mechanistic insight into both progression and recurrence.[5]

Although often considered benign, progressive pterygium may induce chronic irritation, tear film instability, astigmatism, visual impairment, and cosmetic morbidity.[2] Surgical excision therefore remains the definitive treatment for symptomatic or advancing lesions.[6] However, recurrence continues to represent the most significant postoperative complication.[7] The bare sclera technique, while technically straightforward, has historically been associated with recurrence rates of 40–60%,[7,8] and recurrence remains the most frequently reported late complication in contemporary practice.[9]

To mitigate recurrence, conjunctival autografting (CAG), with or without limbal inclusion, has emerged as the current gold standard, primarily due to restoration of the limbal barrier and consistently lower recurrence rates.[10] A meta-analysis of 20 randomized controlled trials encompassing 1,947 eyes demonstrated a 47% reduction in six-month recurrence risk with CAG compared to amniotic membrane transplantation (AMT), increasing to 55% in recurrent cases, although early three-month outcomes were comparable.[13] AMT, valued for its anti-inflammatory and anti-fibrotic properties, has shown improved recurrence rates of 13–20% in more recent series, though earlier reports documented substantially higher failure rates.[11,12]

Adjunctive pharmacologic strategies further aim to suppress fibroblast proliferation. Intraoperative mitomycin C (MMC) and 5-fluorouracil (5-FU) reduce recurrence following primary excision; however, concerns regarding delayed epithelial healing, scleral thinning, and rare but vision-threatening complications have limited universal adoption. Comparative data suggest superior efficacy and cosmetic outcomes with MMC relative to 5-FU, albeit with acknowledged toxicity risks.[14] Emerging approaches, including subconjunctival anti–vascular endothelial growth factor therapy and mini-simple limbal epithelial transplantation (mini-SLET), offer promising early results, though high-quality long-term evidence remains limited.[15,16]

Despite the breadth of available techniques and adjuvants, no universally optimal approach exists. Recurrence risk must be balanced against operative duration, postoperative pain, complication profile, preservation of conjunctival tissue, and resource availability—considerations particularly pertinent in rural and resource-constrained populations with high UV exposure. Importantly, comparative real-world data evaluating operative efficiency, postoperative discomfort, early complications, and recurrence across multiple surgical modalities remain limited.

In this context, we conducted a prospective observational study to compare demographic characteristics, operative time, postoperative pain assessed by the Visual Analog Scale (VAS), early complications, and recurrence rates among five commonly practiced surgical techniques for primary pterygium at a tertiary care center serving a predominantly rural population. By systematically evaluating clinically relevant outcomes, this study seeks to inform pragmatic surgical decision-making aimed at optimizing recurrence prevention while preserving ocular surface integrity and patient comfort.

METHODS

Study Design and Setting

This prospective observational study was conducted at an eye care centre in Kishanganj, India, over a 10-month period from January 2025 to October 2025. The study adhered to the tenets of the Declaration of Helsinki and received approval from the Institutional Ethics Committee prior to commencement. Written informed consent was obtained from all participants before enrolment.

Participants

Consecutive adult patients presenting with primary nasal pterygium and scheduled for surgical excision during the study period were screened for eligibility. Inclusion criteria were age ≥18 years, symptomatic primary nasal pterygium causing ocular irritation, redness, cosmetic concern, or visual impairment, and willingness to undergo surgery and comply with follow-up visits.

Patients with recurrent pterygium, double-headed pterygium, previous ocular surgery in the affected eye, significant ocular surface disease (including severe dry eye or cicatricial disorders), autoimmune or connective tissue disorders, or active ocular infection were excluded. A total of 106 eyes from 106 patients fulfilled the eligibility criteria and were included.

Preoperative Assessment and Variables

All patients underwent a comprehensive ophthalmic examination including best-corrected visual acuity (BCVA), slit-lamp biomicroscopy, Goldmann applanation tonometry, and dilated fundus examination. Pterygium severity was graded according to corneal extension observed on slit-lamp examination: **Grade I:** Confined to the limbus (or without corneal extension), **Grade II:** Extending from the limbus onto the peripheral cornea, **Grade III:** Extending toward the pupillary margin but not involving the visual axis, **Grade IV:** Extending beyond the pupillary margin or involving the visual axis. Baseline demographic and clinical variables including age, sex, occupation, residential status (urban/rural), laterality, duration of symptoms (years), and average daily ultraviolet (UV) exposure (hours/day) were recorded using a standardized data collection form.

Surgical Interventions

All procedures were performed by experienced ophthalmic surgeons under peribulbar anaesthesia using standard aseptic techniques. Following insertion of a lid speculum, the pterygium head was dissected from the cornea, fibrovascular tissue was excised, and the scleral bed was meticulously cleared of residual Tenon's tissue. Minimal bipolar cautery was used whenever required to achieve haemostasis.

The choice of surgical technique was based on surgeon preference and intraoperative clinical judgement. Five techniques were evaluated:

1. **Sutured conjunctival autograft (SCAG):** A free conjunctival autograft harvested from the superotemporal bulbar conjunctiva with minimal Tenon's tissue was positioned limbus-to-limbus over the scleral defect and secured using interrupted 8-0 polyglactin (Vicryl) sutures.
2. **Sutureless conjunctival autograft (SLCAG):** A similarly harvested conjunctival autograft was positioned over the scleral bed and allowed to adhere using autologous blood without the use of sutures or fibrin glue.
3. **Amniotic membrane transplantation (AMT):** Cryopreserved amniotic membrane was trimmed to the required size, placed epithelial side upward over the scleral defect, and secured with interrupted 8-0 polyglactin sutures.
4. **Conjunctival opposition technique (COT):** Adjacent conjunctival tissue was mobilized and advanced to cover the bare sclera without harvesting a free graft and was secured with interrupted 8-0 polyglactin sutures.
5. **Bare sclera technique (BST):** Following pterygium excision, the scleral bed was intentionally left uncovered without placement of a conjunctival graft or amniotic membrane.

All surgeons followed standardized operative steps for tissue handling and graft placement to minimize variability.

Postoperative Management and Follow-up

All patients received a standardized postoperative regimen consisting of topical antibiotic-corticosteroid combination eye drops administered four times daily for two weeks and tapered over the subsequent four weeks, together with preservative-free lubricating eye drops for four weeks. Oral analgesics were prescribed as needed during the immediate postoperative period. Sutures were removed approximately two weeks after surgery where applicable. Patients were evaluated on postoperative day 1, postoperative day 7, at 1 month, and during subsequent routine follow-up visits. Slit-lamp examination was performed at each visit to assess graft integrity, ocular surface healing, inflammation, postoperative complications, and recurrence.

Outcome Measures

The primary outcome measures were operative time, postoperative pain, early postoperative complications, and recurrence. Operative time was recorded in minutes from the initial conjunctival incision until completion of the final surgical step. Postoperative pain was assessed using a 10-point Visual Analog Scale (VAS), where 0 represented no pain and 10 represented the worst imaginable pain. VAS scores were documented on postoperative day 1, postoperative day 7, and at 1 month. Early postoperative complications including subconjunctival haemorrhage, graft retraction, graft oedema, graft displacement, granuloma formation, corneal melt, and other adverse events were recorded during follow-up. Recurrence was defined as fibrovascular tissue crossing the limbus onto the cornea at the site of previous excision as confirmed by slit-lamp examination. Time to recurrence was recorded in months.

Statistical Analysis

Data were entered into Microsoft Excel and analysed using IBM SPSS Statistics version 29.0 (IBM Corp., Armonk, NY, USA). Continuous variables are presented as mean ± standard deviation (SD), while categorical variables are expressed as frequencies and percentages.

Differences in continuous outcomes (operative time and postoperative VAS scores) among the five surgical techniques were assessed using one-way analysis of variance (ANOVA). Associations between surgical technique and categorical variables, including suture use, early postoperative complications, recurrence, and time to recurrence categories, were evaluated using Pearson's chi-square test. All statistical tests were two-tailed, and a p-value <0.05 was considered statistically significant.

RESULTS

Results

Baseline sociodemographic and clinical characteristics

A total of 106 patients with primary pterygium were included in the study. The mean age of the study population was 52.25 ± 14.47 years, with an age range of 24 to 82 years. Females constituted the majority of the cohort, accounting for 67 patients (63.2%), while 39 patients (36.8%) were male. A slight rural predominance was observed, with 58 patients (54.7%) residing in rural areas and 48 patients (45.3%) from urban areas. The left eye was affected in 57 patients (53.8%) and the right eye in 49 patients (46.2%) (Table 1).

With respect to occupation, homemakers represented the largest group, comprising 58 patients (54.7%), followed by farmers; 36 patients (34.0%). Other occupational groups included laborers, students, office workers, teachers, and factory workers. Clinically, Grade II pterygium was more common than Grade III, being observed in 80 patients (75.5%) compared with 26 patients (24.5%) with Grade III disease. The mean daily ultraviolet exposure was 4.85 ± 1.50 hours, and the mean duration of symptoms was 5.92 ± 2.98 years (Table 1).

Distribution of surgical techniques

Among the five surgical techniques evaluated, sutured conjunctival autograft was the most frequently performed procedure, used in 65 patients (61.3%). This was followed by amniotic membrane transplantation in 12 patients (11.3%), sutureless conjunctival autograft in 11 patients (10.4%), conjunctival opposition technique in 10 patients (9.4%), and bare sclera technique in 8 patients (7.5%) (Table 2).

Suture use differed significantly according to the operative technique. Sutures were used in all patients undergoing sutured conjunctival autograft, amniotic membrane transplantation, and conjunctival opposition technique, whereas no sutures were used in the sutureless conjunctival autograft and bare sclera groups. This difference was statistically significant, as expected from the procedural design ($\chi^2 = 106.000$, df = 4, $p < 0.001$) (Table 3).

Operative time and postoperative pain

Operative time differed significantly among the five surgical techniques ($F = 115.425$, $p < 0.001$). The longest mean operative time was observed in the sutured conjunctival autograft group, 55.32 ± 6.82 minutes, followed by amniotic membrane transplantation, 49.92 ± 4.48 minutes. The sutureless conjunctival autograft group had a mean operative time of 33.73 ± 4.22 minutes, while the conjunctival opposition technique and bare sclera technique groups had shorter mean operative times of 26.60 ± 3.47 minutes and 21.13 ± 2.17 minutes, respectively (Table 4).

Postoperative pain, assessed using the Visual Analog Scale, also differed significantly among the surgical groups on postoperative day 1 and day 7. On day 1, the highest mean VAS score was observed in the conjunctival opposition technique group, 7.20 ± 1.23, followed by the sutured conjunctival autograft group, 7.00 ± 1.23. Lower mean day 1 VAS scores were observed in the sutureless conjunctival autograft group, 5.73 ± 1.27, and the amniotic membrane transplantation group, 6.00 ± 0.74. The between-group difference in day 1 VAS scores was statistically significant ($F = 4.484$, $p = 0.002$) (Table 4).

By postoperative day 7, VAS scores had decreased across all groups. The sutured conjunctival autograft group had a mean VAS score of 3.54 ± 0.77, while the conjunctival opposition technique group had a mean score of 3.40 ± 0.52. Lower day 7 scores were observed in the sutureless conjunctival autograft group, 1.55 ± 0.52, and the bare sclera group, 2.00 ± 0.76. The difference in day 7 VAS scores among techniques was statistically significant ($F = 24.164$, $p < 0.001$). At 1 month, mean VAS scores were minimal across all groups and did not differ significantly among surgical techniques ($F = 1.176$, $p = 0.326$) (Table 4).

Serial VAS scores demonstrated a marked decline from postoperative day 1 to day 7 and further to 1 month across all surgical groups. However, formal repeated-measures ANOVA values could not be reported from the available summarized data alone, as subject-level repeated VAS measurements or the within-subject covariance structure would be required to calculate the exact within-patient time effect and time × technique interaction (Table 4).

Early postoperative complications

Overall, 78 patients (73.6%) had no early postoperative complication. Among the recorded complications, subconjunctival hemorrhage was the most frequent, occurring in 21 patients (19.8%), followed by graft retraction in 7 patients (6.6%). No cases of graft edema, graft sliding, granuloma, recurrence recorded as an early complication code, or corneal melt were observed in the supplied complication crosstab (Table 5).

The highest proportion of any early complication was observed in the sutureless conjunctival autograft group, 4 of 11 patients (36.4%), followed by the sutured conjunctival autograft group, 22 of 65 patients (33.8%), and the amniotic membrane transplantation group, 2 of 12 patients (16.7%). No early complications were recorded in the conjunctival opposition technique or bare sclera technique groups. The overall distribution of early complication categories did not differ significantly among the five surgical techniques ($\chi^2 = 12.410$, df = 8, p = 0.134) (Table 5).

Recurrence and time to recurrence

Recurrence was observed in 8 of 106 patients, giving an overall recurrence rate of 7.5%. The highest recurrence proportion was seen in the bare sclera technique group, where 2 of 8 patients (25.0%) developed recurrence. Recurrence was also observed in 5 of 65 patients (7.7%) in the sutured conjunctival autograft group and 1 of 10 patients (10.0%) in the conjunctival opposition technique group. No recurrence was observed in the sutureless conjunctival autograft or amniotic membrane transplantation groups. After combining duplicate recurrence labels in the source data, the difference in recurrence across surgical techniques was not statistically significant ($\chi^2 = 5.458$, df = 4, p = 0.243) (Table 6).

Among patients with recorded recurrence timing, recurrence occurred between 4 and 15 months postoperatively. In the sutured conjunctival autograft group, recurrence was recorded at 5, 7, 8, 10, and 14 months. In the conjunctival opposition technique group, recurrence was recorded at 15 months, while in the bare sclera technique group, recurrence was recorded at 4 months. The distribution of time to recurrence did not differ significantly among the surgical groups ($\chi^2 = 33.350$, df = 32, p = 0.401), although this analysis was limited by sparse cell counts (Table 7).

RESULTS TABLES

Table 1. Sociodemographic and baseline clinical characteristics of the study population

Characteristic	Category / Statistic	Value
Age, years	Mean ± SD	52.25 ± 14.47
	Range	24–82
Sex	Female	67 (63.2%)
	Male	39 (36.8%)
Residence	Rural	58 (54.7%)
	Urban	48 (45.3%)
Affected eye	Left	57 (53.8%)
	Right	49 (46.2%)
Occupation	Homemaker	58 (54.7%)
	Farmer	36 (34.0%)
	Laborer	4 (3.8%)
	Student	3 (2.8%)
	Office worker	2 (1.9%)
	Teacher	2 (1.9%)
	Factory worker	1 (0.9%)
Clinical grade	Grade II	80 (75.5%)
	Grade III	26 (24.5%)
Daily ultraviolet exposure, hours	Mean ± SD	4.85 ± 1.50
	Range	2–8
Duration of symptoms, years	Mean ± SD	5.92 ± 2.98
	Range	1–18

Table 2. Distribution of patients according to surgical technique

Surgical technique	n (%)
Sutured conjunctival autograft	65 (61.3%)
Sutureless conjunctival autograft	11 (10.4%)
Amniotic membrane transplantation	12 (11.3%)
Conjunctival opposition technique	10 (9.4%)
Bare sclera technique	8 (7.5%)
Total	**106 (100.0%)**

Table 3. Suture use according to surgical technique

Suture use	Sutured conjunctival autograft n = 65	Sutureless conjunctival autograft n = 11	Amniotic membrane transplantation n = 12	Conjunctival opposition technique n = 10	Bare sclera technique n = 8	Total N = 106
No	0 (0.0%)	11 (100.0%)	0 (0.0%)	0 (0.0%)	8 (100.0%)	19 (17.9%)
Yes	65 (100.0%)	0 (0.0%)	12 (100.0%)	10 (100.0%)	0 (0.0%)	87 (82.1%)

Pearson chi-square: $\chi^2 = 106.000$, df = 4, $p < 0.001$.

Table 4. Operative time and postoperative VAS scores according to surgical technique

Outcome	Sutured conjunctival autograft n = 65	Sutureless conjunctival autograft n = 11	Amniotic membrane transplantation n = 12	Conjunctival opposition technique n = 10	Bare sclera technique n = 8	Statistical test	Test statistic	p value
Operative time, min	55.32 ± 6.82	33.73 ± 4.22	49.92 ± 4.48	26.60 ± 3.47	21.13 ± 2.17	One-way ANOVA	F = 115.425	<0.001
VAS day 1	7.00 ± 1.23	5.73 ± 1.27	6.00 ± 0.74	7.20 ± 1.23	6.50 ± 1.07	One-way ANOVA	F = 4.484	0.002
VAS day 7	3.54 ± 0.77	1.55 ± 0.52	2.92 ± 0.67	3.40 ± 0.52	2.00 ± 0.76	One-way ANOVA	F = 24.164	<0.001
VAS 1 month	0.18 ± 0.39	0.09 ± 0.30	0.08 ± 0.29	0.00 ± 0.00	0.00 ± 0.00	One-way ANOVA	F = 1.176	0.326
Overall change in VAS over time	D1: 7.00 ± 1.23; D7: 3.54 ± 0.77; 1M: 0.18 ± 0.39	D1: 5.73 ± 1.27; D7: 1.55 ± 0.52; 1M: 0.09 ± 0.30	D1: 6.00 ± 0.74; D7: 2.92 ± 0.67; 1M: 0.08 ± 0.29	D1: 7.20 ± 1.23; D7: 3.40 ± 0.52; 1M: 0.00 ± 0.00	D1: 6.50 ± 1.07; D7: 2.00 ± 0.76; 1M: 0.00 ± 0.00	Repeated-measures ANOVA		

Table 5. Early postoperative complications according to surgical technique

Complication	Sutured conjunctival autograft n = 65	Sutureless conjunctival autograft n = 11	Amniotic membrane transplantation n = 12	Conjunctival opposition technique n = 10	Bare sclera technique n = 8	Total N = 106
No complication	43 (66.2%)	7 (63.6%)	10 (83.3%)	10 (100.0%)	8 (100.0%)	78 (73.6%)
Subconjunctival hemorrhage	18 (27.7%)	2 (18.2%)	1 (8.3%)	0 (0.0%)	0 (0.0%)	21 (19.8%)
Graft retraction	4 (6.2%)	2 (18.2%)	1 (8.3%)	0 (0.0%)	0 (0.0%)	7 (6.6%)
Any early complication	22 (33.8%)	4 (36.4%)	2 (16.7%)	0 (0.0%)	0 (0.0%)	28 (26.4%)

Pearson chi-square for complication category across surgical techniques: $\chi^2 = 12.410$, df = 8, $p = 0.134$.

Complication coding: 0 = no complication; 1 = subconjunctival hemorrhage; 2 = graft edema; 3 = graft retraction; 4 = graft sliding; 5 = granuloma; 6 = recurrence; 7 = corneal melt. Only codes 0, 1, and 3 were observed in the supplied complication crosstab.

Table 6. Recurrence according to surgical technique

Recurrence	Sutured conjunctival autograft n = 65	Sutureless conjunctival autograft n = 11	Amniotic membrane transplantation n = 12	Conjunctival opposition technique n = 10	Bare sclera technique n = 8	Total N = 106
No recurrence	60 (92.3%)	11 (100.0%)	12 (100.0%)	9 (90.0%)	6 (75.0%)	98 (92.5%)
Recurrence	5 (7.7%)	0 (0.0%)	0 (0.0%)	1 (10.0%)	2 (25.0%)	8 (7.5%)

Table 7. Time to recurrence according to surgical technique

Time to recurrence, months	Sutured conjunctival autograft n = 65	Sutureless conjunctival autograft n = 11	Amniotic membrane transplantation n = 12	Conjunctival opposition technique n = 10	Bare sclera technique n = 8	Total N = 106
No recurrence / not applicable	59 (90.8%)	9 (81.8%)	11 (91.7%)	9 (90.0%)	7 (87.5%)	95 (89.6%)
Missing / not recorded	1 (1.5%)	2 (18.2%)	1 (8.3%)	0 (0.0%)	0 (0.0%)	4 (3.8%)
4 months	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (12.5%)	1 (0.9%)
5 months	1 (1.5%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.9%)
7 months	1 (1.5%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.9%)
8 months	1 (1.5%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.9%)
10 months	1 (1.5%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.9%)
14 months	1 (1.5%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.9%)
15 months	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (10.0%)	0 (0.0%)	1 (0.9%)

Pearson chi-square: $\chi^2 = 33.350$, df = 32, p = 0.401.

DISCUSSION

Pterygium is a multifactorial ocular surface disorder characterized by fibrovascular proliferation of conjunctival tissue onto the cornea, typically arising from the nasal limbus.[2] Although several surgical techniques have been developed to reduce recurrence and improve postoperative outcomes, there remains no universally accepted procedure that simultaneously minimizes operative time, postoperative discomfort, complications, and recurrence. The present prospective observational study compared five commonly employed surgical techniques—sutured conjunctival autograft (SCAG), sutureless conjunctival autograft (SLCAG), amniotic membrane transplantation (AMT), conjunctival opposition technique (COT), and bare sclera technique (BST)—in 106 patients with primary pterygium. The principal findings were that operative time and early postoperative pain differed significantly among surgical techniques, whereas early postoperative complications and recurrence rates did not demonstrate statistically significant differences. Although recurrence was numerically highest following the bare sclera technique and absent in the SLCAG and AMT groups, these observations should be interpreted cautiously because of the relatively small sample size within individual surgical groups.

Pterygium has traditionally been regarded as a degenerative lesion; however, accumulating molecular and histopathological evidence supports its classification as a proliferative ocular surface disorder involving chronic inflammation, extracellular matrix remodeling, epithelial-mesenchymal transition, limbal stem cell dysfunction, and dysregulated wound healing.[2,17] Ultraviolet (UV) radiation remains the predominant environmental risk factor, initiating oxidative stress, cytokine activation, and fibrovascular proliferation that ultimately results in progressive corneal encroachment.[3] Meta-analytic evidence has demonstrated significantly increased disease risk among individuals with prolonged sunlight exposure, particularly those engaged in outdoor occupations and residing in rural environments.[18]

The demographic characteristics of our cohort are consistent with this established pathogenic paradigm. The mean age of the study population was 52.25 ± 14.47 years, reflecting the cumulative effect of chronic ultraviolet exposure over several decades. Similar age distributions have been reported in previous epidemiological studies, where disease prevalence increases steadily after the fourth decade of life.[18,19] Unlike several population-based studies that reported male predominance, females constituted nearly two-thirds (63.2%) of our study population. This finding likely reflects local sociocultural and occupational practices within the study region, where women frequently participate in agricultural

activities and outdoor household work, resulting in prolonged environmental exposure comparable with or exceeding that of men. Rather than contradicting previous literature, this observation emphasizes that occupational exposure, rather than biological sex itself, is probably the more important determinant of disease occurrence.

A slight predominance of rural residence (54.7%) was observed in the present study, further supporting the recognized association between environmental exposure and pterygium development. Rural populations typically experience greater cumulative exposure to ultraviolet radiation, wind, dust, and dry climatic conditions, all of which contribute to chronic ocular surface inflammation.[18] The mean reported ultraviolet exposure of approximately 4.85 hours daily is consistent with this environmental risk profile and reinforces the importance of preventive strategies including protective eyewear, hats with broad brims, and public awareness regarding ultraviolet protection.

Clinically, patients demonstrated a relatively prolonged duration of symptoms (5.92 ± 2.98 years), indicating that pterygium often remains untreated until progressive corneal involvement or persistent symptoms interfere with visual function or quality of life. The predominance of Grade II (75.5%) over Grade III lesions (24.5%) suggests that most patients presented after appreciable corneal extension but before involvement of the visual axis. This pattern is consistent with routine clinical practice, in which surgical intervention is generally reserved for progressive lesions producing irritation, recurrent inflammation, induced astigmatism, visual disturbance, or significant cosmetic concern rather than for early asymptomatic disease.[2]

Among the five surgical techniques evaluated, SCAG was the most frequently performed procedure (61.3%), followed by AMT (11.3%), SLCAG (10.4%), COT (9.4%), and BST (7.5%). This distribution reflects current clinical practice, where conjunctival autografting remains the preferred reconstructive procedure for primary pterygium because of its favorable long-term outcomes and relatively low recurrence rates compared with bare sclera excision.[20,21] Restoration of the limbal barrier together with coverage of the exposed scleral bed is believed to inhibit postoperative fibrovascular proliferation, thereby reducing the likelihood of recurrence. Consequently, SCAG continues to serve as the benchmark against which newer surgical modifications are compared.

Operative duration differed significantly among surgical techniques (ANOVA, $p<0.001$). SCAG required the longest operative time (55.32 ± 6.82 minutes), followed by AMT (49.92 ± 4.48 minutes), whereas substantially shorter operative times were observed for SLCAG (33.73 ± 4.22 minutes), COT (26.60 ± 3.47 minutes), and BST (21.13 ± 2.17 minutes). These findings are biologically plausible and primarily reflect procedural complexity. Harvesting an adequately sized conjunctival graft, preserving limbal orientation, meticulous graft positioning, and multiple interrupted suture placements inevitably prolong operative duration compared with techniques that eliminate graft harvesting or suture fixation.

Previous studies similarly report shorter operative times with sutureless fixation methods, including autologous blood and fibrin glue, largely because suture placement and knot tying are avoided.[21–23] Some investigators have reported operative times between 15 and 25 minutes for sutureless techniques.[21] Direct comparison with the present study, however, should be interpreted cautiously because operative time definitions differ considerably across studies. Many published reports measure only the period from pterygium excision to graft fixation, whereas operative time in the present study represented the complete surgical procedure from the initial conjunctival incision to completion of the final surgical step. Furthermore, differences in lesion size, surgical complexity, surgeon preference, and meticulous limbal graft preparation may also contribute to variation in reported operative durations.

From a practical perspective, reduced operative time offers several advantages, including improved operating room efficiency, reduced anaesthetic exposure, greater patient throughput, and potentially lower healthcare costs. Nevertheless, operative efficiency should not be considered in isolation. Selection of the most appropriate surgical technique requires balancing procedural duration against graft stability, postoperative comfort, complication profile, recurrence risk, surgeon expertise, and resource availability. Consequently, although SLCAG and BST demonstrated shorter operative times in the present study, operative duration alone should not be interpreted as evidence of overall surgical superiority.

Postoperative pain is an important determinant of patient satisfaction and quality of recovery following pterygium surgery. In the present study, significant differences in postoperative pain were observed among the five surgical techniques on postoperative day 1 ($F = 4.484$, $p = 0.002$) and postoperative day 7 ($F = 24.164$, $p < 0.001$). By contrast, pain scores at one month were minimal across all groups and no longer differed significantly ($F = 1.176$, $p = 0.326$), indicating that the influence of surgical technique on pain is primarily confined to the early postoperative period.

On postoperative day 1, the highest mean Visual Analog Scale (VAS) scores were observed following COT (7.20 ± 1.23) and SCAG (7.00 ± 1.23), whereas lower pain scores were recorded after SLCAG (5.73 ± 1.27) and AMT (6.00 ± 0.74). Intermediate pain levels were observed following BST (6.50 ± 1.07). By postoperative day 7, pain had decreased substantially in all groups, with the greatest reduction observed in the SLCAG group (1.55 ± 0.52). Pain scores at one

month were negligible irrespective of the surgical technique employed, suggesting that differences in postoperative discomfort are transient and largely resolve following conjunctival healing.

The higher early postoperative pain associated with SCAG is biologically plausible and consistent with previous reports. Sutures act as foreign bodies, producing localized mechanical irritation, conjunctival inflammation, and increased tear film instability during the early postoperative period.[21,23,25] Tissue manipulation during graft harvesting and repeated suture placement may further amplify the inflammatory response, contributing to increased postoperative discomfort. Similar observations have been reported in randomized and comparative studies demonstrating significantly lower pain scores with sutureless conjunctival autografting and fibrin glue fixation compared with conventional sutured techniques.[21,23,29]

The comparatively lower pain scores observed following SLCAG in our study are also consistent with existing literature. Elimination of suture-related inflammation reduces mechanical irritation of the ocular surface while preserving the biological advantages of conjunctival autografting. Studies evaluating autologous blood fixation have similarly reported improved early postoperative comfort together with shorter surgical duration, although graft stability remains dependent on meticulous surgical technique and careful patient selection.[21] These findings support the concept that sutureless conjunctival autografting represents an effective alternative where fibrin glue is unavailable or cost prohibitive.

Interestingly, COT demonstrated postoperative pain comparable with SCAG despite avoiding free graft harvesting. This finding likely reflects the extensive conjunctival mobilization required during advancement of adjacent conjunctival tissue, resulting in postoperative inflammation despite the absence of graft suturing over a separate donor site. Conversely, AMT demonstrated relatively low pain scores, which may be attributable to reduced conjunctival manipulation and the intrinsic anti-inflammatory and anti-fibrotic properties of the amniotic membrane.[20]

Although statistically significant differences in pain were observed during the first postoperative week, these differences disappeared by one month, indicating that the choice of surgical technique influences early postoperative recovery rather than long-term patient comfort. This observation is clinically relevant because early postoperative pain often affects patient satisfaction, return to work, adherence to topical medications, and willingness to undergo surgery in the fellow eye when indicated.

Early postoperative complications constitute another important consideration when selecting an operative technique. In the present study, 73.6% of patients experienced an uncomplicated postoperative course, while complications occurred in only 26.4% of cases. Subconjunctival hemorrhage was the most frequently observed complication (19.8%), followed by graft retraction (6.6%). No cases of graft edema, graft displacement, granuloma formation, corneal melt, or other serious postoperative complications were observed during the early postoperative period.

These findings compare favorably with published literature, in which subconjunctival hemorrhage, graft edema, graft retraction, and graft displacement are consistently reported as the most common early postoperative events following pterygium surgery.[9,24,25] The predominance of subconjunctival hemorrhage in our study is unsurprising because conjunctival dissection inevitably disrupts superficial episcleral vessels despite meticulous surgical technique. Importantly, subconjunctival hemorrhage is generally self-limiting, resolves spontaneously within several weeks, and rarely influences long-term visual or surgical outcomes.

Graft retraction occurred in only seven patients (6.6%) and was managed conservatively. Previous studies have reported considerably higher frequencies of graft retraction, particularly when autologous blood fixation is used or when excessive Tenon's tissue remains attached to the graft.[24,25] The relatively low incidence observed in the present study may reflect meticulous graft preparation, careful limbus-to-limbus orientation, appropriate graft sizing, and standardized intraoperative tissue handling by experienced surgeons.

Notably, no cases of graft edema, graft displacement, granuloma, or corneal melt were encountered. Although these complications have been described in previous studies, their occurrence is generally infrequent following pterygium surgery.[9,25] The absence of severe postoperative complications in the present cohort suggests that all five surgical techniques can be performed safely when meticulous surgical principles and standardized postoperative care are followed. The overall distribution of early postoperative complications did not differ significantly among the five surgical techniques ($\chi^2 = 12.410$, $p = 0.134$). Although numerically higher complication rates were observed following SLCAG (36.4%) and SCAG (33.8%) compared with the remaining procedures, these differences did not reach statistical significance. This finding should be interpreted cautiously because the relatively small number of patients in the SLCAG, AMT, COT, and BST groups limited statistical power to detect modest between-group differences. Consequently, the observed variation in complication frequency may reflect random variation rather than true differences in surgical safety.

Taken together, the postoperative findings of the present study indicate that while surgical technique significantly influences operative duration and early postoperative pain, its impact on early postoperative complications appears

considerably less pronounced. This observation supports previous reports suggesting that meticulous surgical technique, careful tissue handling, and appropriate postoperative management may contribute more substantially to complication prevention than the choice of reconstructive procedure itself.[9,24,25]

Limitations of the Study

Several limitations should be acknowledged. The observational, non-randomized design introduces the possibility of selection bias, as the choice of surgical technique was based on surgeon preference and intraoperative clinical judgment rather than random allocation. The study was conducted at a single eye care centre, which may limit the generalizability of the findings to other populations and practice settings. Although the overall sample size was adequate, the relatively small numbers in the SLCAG, AMT, COT, and BST groups reduced statistical power for between-group comparisons, particularly for recurrence analysis. In addition, recurrence was an infrequent event, limiting the ability to detect statistically significant differences among surgical techniques. Finally, only patients with primary pterygium were included; therefore, the findings cannot be extrapolated to recurrent or more complex pterygium.

CONCLUSION

This prospective observational study demonstrates that the choice of surgical technique is associated with differences in operative time and early postoperative pain in the management of primary pterygium, while early postoperative complications and recurrence rates were comparable across techniques during the follow-up period. SCAG required the longest operative time, whereas SLCAG and BST were associated with shorter operative durations. SLCAG also showed lower early postoperative pain, although pain improved in all groups by one month. Although recurrence was numerically highest following BST and was not observed following SLCAG or AMT, these differences were not statistically significant and should be interpreted cautiously because of the small sample sizes. These findings suggest that, beyond recurrence, factors such as operative efficiency, postoperative comfort, surgeon experience, tissue availability, and resource constraints should be considered when selecting the most appropriate surgical technique. In settings where fibrin glue is unavailable or cost-prohibitive, sutureless conjunctival autografting using autologous blood may represent a practical alternative for appropriately selected patients. As this was an observational study with limited sample size and follow-up duration, larger multicentre prospective studies, ideally randomized controlled trials with longer follow-up, are needed to confirm these findings and better establish the comparative long-term effectiveness of different surgical techniques.

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CONFLICTS OF INTEREST

The authors declare that they have no competing interests or conflicts of interest related to this study.

DATA AVAILABILITY STATEMENT

The datasets generated and/or analyzed during the current study are not publicly available due to institutional policies and the need to protect patient confidentiality. However, the data are available from the corresponding author upon reasonable request and with the permission of the Institutional Ethics Committee.