

COMPARISON OF EFFICACY OF PTERYGIUM RESECTION WITH CONJUNCTIVAL AUTO GRAFT VERSUS AMNIOTIC MEMBRANE GRAFT TO REDUCE THE RECURRENCE RATE

Fatima Rauf^{1*}, Muhammad Rizwan Khan², Sabahat Aslam³, Jahanzaib Aslam⁴

¹Postgraduate Resident, Allied Hospital 1 Faisalabad, Pakistan.

²Associate Professor, Head of Department Ophthalmology, Allied Hospital 1 Faisalabad, Pakistan

³Postgraduate Resident, Allied Hospital Faisalabad, Pakistan.

⁴Consultant Ophthalmologist, Allied Hospital Faisalabad, Pakistan.

*Corresponding author: Fatima Rauf, Email: fatemahrauf@gmail.com

ABSTRACT

Background: Conjunctival autograft (CAG) and amniotic membrane graft (AMG) are established methods for reconstructing the ocular surface after pterygium excision, but comparative recurrence estimates vary across settings and surgical protocols. We compared 3-month recurrence after CAG versus AMG in adults undergoing primary pterygium excision at a tertiary hospital in Pakistan.

Methods: This single-center, parallel-group randomized trial included 590 participants (295 per group), aged 20-50 years, with primary pterygium measuring 2-4 mm and symptom duration of 6 months or less. The primary outcome was fibrovascular corneal regrowth of at least 2 mm by 3 months. Analyses included risk difference (RD), risk ratio (RR), odds ratio (OR), number needed to treat (NNT), modified Poisson and logistic regression, marginal standardization with 2,000 bootstrap resamples, exploratory interaction analyses, and beta-binomial Bayesian sensitivity analyses.

Results: The primary outcome was available for all 590 participants. Recurrence occurred in 30/295 CAG participants (10.2%) and 53/295 AMG participants (18.0%). CAG reduced recurrence by 7.8 percentage points (95% CI 2.2-13.4), corresponding to an RR of 0.57 (95% CI 0.38-0.86; $P=0.006$) and an NNT of 12.8 (95% CI 7.5-45.8). The adjusted RR was 0.55 (95% CI 0.36-0.83), and the adjusted OR was 0.47 (95% CI 0.28-0.78). Standardized recurrence risks were 10.0% with CAG and 18.2% with AMG (adjusted RD -8.2 percentage points; bootstrap 95% CI -13.6 to -2.3). The posterior probability that CAG reduced recurrence was 99.69%.

Conclusions: CAG produced a clinically and statistically lower 3-month recurrence risk than AMG. The finding supports CAG as the preferred reconstruction for routine primary pterygium when healthy conjunctiva is available, while the short follow-up and absence of safety, visual, and patient-reported outcomes limit conclusions about overall comparative benefit.

KEYWORDS: pterygium; conjunctival autograft; amniotic membrane graft; recurrence; randomized controlled trial; ocular surface; risk ratio; Pakistan

Key messages

- Three-month recurrence was 10.2% with CAG and 18.0% with AMG (RR 0.57, 95% CI 0.38-0.86).
- The absolute recurrence reduction was 7.8 percentage points, equivalent to an NNT of 12.8 to prevent one recurrence by 3 months.
- Adjusted modified Poisson, logistic, standardized marginal, nonlinear, exact, and Bayesian analyses were directionally concordant.
- Clinical interpretation remains constrained by 3-month follow-up and the absence of recorded adverse events, visual outcomes, astigmatism, pain, cosmesis, operating time, and cost.

1. INTRODUCTION

Pterygium is a benign but potentially vision-limiting fibrovascular proliferation of conjunctival tissue across the limbus onto the cornea. Contemporary pathobiological models implicate chronic ultraviolet exposure, limbal epithelial injury, oxidative stress, inflammatory cytokines, extracellular-matrix remodeling, angiogenesis, and aberrant wound healing rather than simple degeneration. Clinically, progressive lesions may induce regular or irregular astigmatism, destabilize the tear film, cause chronic irritation and redness, impair cosmesis, restrict motility, and eventually threaten the visual axis. [1-5]

Disease burden is concentrated in sunny, dusty, low-latitude environments and among people with sustained outdoor exposure. Global meta-analyses identify age, male sex, rural residence, and occupational ultraviolet exposure as recurring risk factors, although effect sizes vary by population. Pakistan combines high ambient ultraviolet exposure with a large outdoor workforce and substantial barriers to longitudinal postoperative care. A community study in Punjab documented pterygium or pinguecula among common non-vision-impairing ocular

conditions, while hospital-based Pakistani series confirm that recurrence remains a practical clinical and economic problem. [2,6-8]

Surgery is the definitive treatment for progressive, visually significant, symptomatic, or cosmetically unacceptable pterygium. Bare-sclera excision has largely been abandoned because of high recurrence. Modern surgery therefore combines complete fibrovascular excision with ocular-surface reconstruction. CAG restores autologous conjunctival tissue and may re-establish a limbal barrier, whereas AMG provides a basement-membrane scaffold with anti-inflammatory, anti-fibrotic, and pro-epithelialization properties while preserving bulbar conjunctiva. The choice is clinically important because recurrence after a first operation can be more vascular, scarred, and difficult to manage. [9,10,18]

This randomized trial compared CAG and AMG after excision of primary pterygium at Allied Hospital Faisalabad. The primary objective was to estimate the absolute and relative effect of assigned graft technique on recurrence at 3 months. Secondary analytic objectives were to assess whether the treatment contrast persisted after covariate adjustment, examine clinically plausible effect modification, and evaluate inferential robustness using marginal standardization and Bayesian probability statements.

2. LITERATURE REVIEW AND STUDY RATIONALE

CAG was established as a recurrence-prevention strategy after early reports showed favorable outcomes in advanced and recurrent disease. A thin autologous graft provides immediate epithelial coverage, avoids donor-tissue transmission risk, and can include a limbal edge. Its limitations include donor-site morbidity, greater technical demand, graft edema or displacement, and consumption of superior conjunctiva that may later be needed for glaucoma filtration surgery. Outcomes are sensitive to graft thickness, residual Tenon tissue, limbal orientation, fixation method, surgeon experience, and postoperative inflammation. [10,21-24]

AMG offers a biologically different reconstruction. The amniotic basement membrane supports epithelial migration, while stromal components downregulate inflammation, fibrosis, and neovascularization. It is particularly attractive for large defects, bilateral disease, compromised conjunctiva, or anticipated glaucoma surgery. However, it is a temporary scaffold and does not reproduce the structural limbal barrier of an autograft. Processing, preservation, orientation, fixation, and degradation can influence results. [12,13,19]

Randomized comparisons have been heterogeneous. Luanratanakorn and colleagues reported higher recurrence with AMG overall, whereas other trials found smaller or nonsignificant differences depending on whether primary and recurrent lesions were pooled, follow-up duration, adjunctive mitomycin C, and fixation technique. The Cochrane synthesis concluded that CAG was associated with lower 6-month recurrence than AMG, although estimates for primary pterygium alone were less precise. A 2022 meta-analysis and a 2023 comprehensive review reaffirmed that recurrence depends not only on graft category but also on adjuvant therapy and fixation. [11-19]

Regional evidence remains limited. A Pakistani comparison from Peshawar reported 3-month recurrence of 10% with CAG and 18% with AMG, but provided limited information on randomization, allocation concealment, effect estimates, and harms. Contemporary reporting standards require transparent participant flow, prespecified outcomes, absolute and relative effects with uncertainty, and clear distinction between confirmatory and exploratory analyses. The present study addresses these reporting and analytic gaps in a larger, equally allocated sample. [8,26,27]

3. METHODS

3.1 Study design and setting

This was a single-center, two-arm, parallel-group randomized controlled trial conducted in the Department of Ophthalmology, Allied Hospital Faisalabad, Pakistan from 1st Dec 2025 to 1st April 2026. The manuscript follows CONSORT 2010 and incorporates updated CONSORT 2025 reporting recommendations where information was available. Recruitment dates were not contained in the supplied analytic files and should be inserted from the trial master file before submission. [26,27]

3.2 Participants

Eligible participants were adults aged 20-50 years with primary pterygium measuring 2-4 mm and a reported duration of 6 months or less. Both sexes and either eye were eligible. Exclusion criteria in the study protocol were recurrent pterygium, chronic ocular-surface disease, long-term topical corticosteroid or non-steroidal anti-inflammatory drug use, previous conjunctival surgery, and pterygium outside the specified size range. The analytic unit was one participant and one treated eye; participant identifiers were unique.

3.3 Randomization, allocation concealment, and masking

Participants were allocated 1:1 to CAG or AMG using the lottery method specified in the study protocol. The operating surgeon could not be masked to the assigned procedure. The analytic database did not record the personnel responsible for sequence generation or allocation, the mechanism used to conceal assignment before surgery, or whether the 3-month assessor was masked. These operational details must be verified from source documentation because inadequate concealment and unmasked outcome ascertainment can bias surgical trials.

3.4 Interventions

All participants underwent primary pterygium excision followed by coverage of the scleral defect with either a conjunctival autograft (Group A) or an amniotic membrane graft (Group B), according to randomized

assignment. The supplied files did not specify anesthesia, dissection and Tenon-removal technique, graft dimensions and thickness, limbal inclusion, donor-site location, amniotic-membrane source and preservation, epithelial/stromal orientation, fixation with sutures, fibrin glue or autologous blood, adjunctive mitomycin C, surgeon number and experience, or the postoperative antibiotic-steroid regimen. These intervention details are essential for reproducibility and should be inserted from the operative protocol before submission.

3.5 Outcomes and follow-up

The primary outcome was recurrence by 3 months, defined as postoperative fibrovascular regrowth extending at least 2 mm onto the cornea on slit-lamp examination. Efficacy was the exact complement of recurrence. The database contained a complete binary primary outcome for every randomized participant. No variables captured exact recurrence date, standardized photographic grade, best-corrected visual acuity, refraction, keratometry or corneal topography, pain, epithelial healing, graft loss or displacement, granuloma, infection, scleral thinning, diplopia, cosmesis, satisfaction, reoperation, operating time, or cost. Consequently, recurrence was the only comparative clinical endpoint analyzed.

3.6 Sample-size calculation

The design assumed recurrence risks of 10% with CAG and 18% with AMG (equivalent to efficacy of 90% and 82%), a two-sided alpha of 0.05, 80% power, and equal allocation. A standard two-sample proportion calculation yields approximately 290 participants per group; the target of 590 participants provided 295 per group and approximately 81% nominal power under these assumptions. The trial database contained the full target sample.

3.7 Data management and quality assurance

The dataset contained a raw data sheet, codebook, summary statistics, and quality checks. Range, coding, logical consistency, and uniqueness checks were independently repeated. Age, duration, and lesion size were within protocol limits; treatment, sex, occupation, comorbidity, laterality, recurrence, and efficacy codes were valid; participant and admission identifiers were unique; and efficacy equaled one minus recurrence for every record. No values were missing for modeled variables. No imputation was therefore required.

3.8 Statistical analysis

Participants were analyzed according to assigned group. Continuous variables were summarized using mean and standard deviation; categorical variables using frequency and percentage. Baseline comparability was evaluated with standardized mean differences (SMDs), with $|SMD| > 0.10$ interpreted as a potentially meaningful descriptive imbalance rather than a significance test.

The primary analysis estimated recurrence risk in each group, the unadjusted RD, RR, OR, and NNT, each with 95% confidence intervals. Group-specific risks used Wilson intervals; the RD and RR used score-based two-sample intervals. Pearson chi-square, continuity-corrected chi-square, and Fisher exact tests were reported. Because the outcome was not rare, the RR and RD were emphasized over the OR.

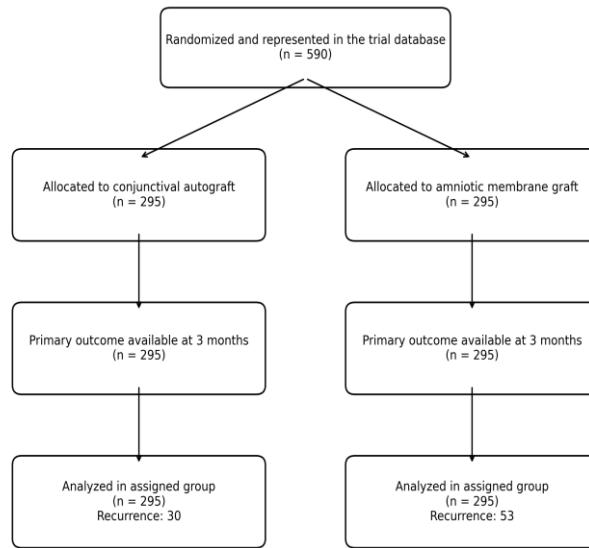
Two adjusted models included treatment, age, sex, outdoor occupational exposure, any recorded comorbidity, pterygium duration, lesion size, and laterality. Modified Poisson regression with robust standard errors estimated adjusted RRs; logistic regression estimated adjusted ORs. Age was scaled per 5 years, duration per month, and size per 0.5 mm. Parametric standardization predicted each participant twice, once under CAG and once under AMG, then averaged predictions over the observed covariate distribution. Percentile confidence intervals for standardized risks, RD, and RR were obtained from 2,000 nonparametric bootstrap resamples.

Exploratory subgroup analyses evaluated age group, sex, occupational exposure, comorbidity, duration, size, and laterality. Treatment effects were summarized as stratum-specific RRs, and heterogeneity was assessed with treatment-by-subgroup interaction terms in logistic models. These analyses were not powered for interaction and were not adjusted for multiplicity. A sensitivity model added quadratic terms for age, duration, and size. Bayesian sensitivity analyses assigned independent Beta(1,1) and Jeffreys Beta(0.5,0.5) priors to each group recurrence probability and used 1,000,000 Monte Carlo draws to estimate posterior RRs, RDs, and clinically interpretable probabilities. Two-sided $P < 0.05$ defined statistical significance for the primary analysis. Analyses were conducted in Python using NumPy, SciPy, and statsmodels.

4. RESULTS

4.1 Participant disposition and data completeness

The database contained 590 randomized participants, with 295 allocated to each surgical group. All participants had a recorded 3-month primary outcome and were included in the assigned-group analysis. The supplied database did not contain the screening log, reasons for exclusion, treatment crossovers, protocol deviations, or adverse-event records; therefore, the participant-flow figure begins at randomization.



Screening and exclusion counts were not present in the supplied analytic database.

Figure 1. Participant flow based on the available database. All 590 randomized participants had a recorded 3-month recurrence outcome. Counts assessed for eligibility and excluded before randomization were not available in the supplied analytic files.

4.2 Baseline characteristics

Mean age was 35.58 ± 7.61 in the CAG group and 35.10 ± 7.34 in the AMG group. Mean pterygium size was 3.01 ± 0.45 and 3.02 ± 0.46 , respectively. The largest descriptive imbalances were duration (SMD 0.177), hypertension (SMD 0.150), and male sex (SMD -0.117).

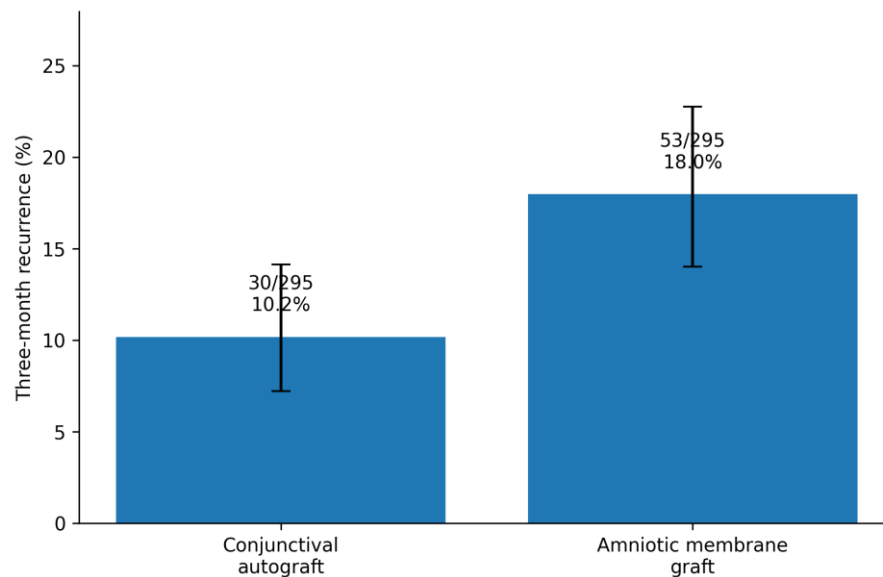
Table 1. Baseline characteristics by randomized group

Characteristic	CAG (n=295)	AMG (n=295)	SMD
Age, years	35.58 ± 7.61	35.10 ± 7.34	0.064
Duration of pterygium, months	3.82 ± 1.51	3.56 ± 1.48	0.177
Pterygium size, mm	3.01 ± 0.45	3.02 ± 0.46	-0.027
Male sex	162 (54.9%)	179 (60.7%)	-0.117
Outdoor occupation	114 (38.6%)	103 (34.9%)	0.077
Diabetes mellitus	20 (6.8%)	23 (7.8%)	-0.039
Hypertension	35 (11.9%)	22 (7.5%)	0.150
Current smoking	40 (13.6%)	36 (12.2%)	0.040
Any recorded comorbidity	89 (30.2%)	79 (26.8%)	0.075
Right-eye pterygium	150 (50.8%)	156 (52.9%)	-0.041

Values are mean $\pm$ SD or n (%). CAG, conjunctival autograft; AMG, amniotic membrane graft; SMD, standardized mean difference. Outdoor occupation comprised farmer, outdoor laborer, and driver/transport work. Baseline P values were not used.

4.3 Primary outcome

Recurrence occurred in 30/295 CAG participants (10.2%; Wilson 95% CI 7.2-14.1) and 53/295 AMG participants (18.0%; Wilson 95% CI 14.0-22.7). The unadjusted RR was 0.57 (95% CI 0.38-0.86), representing a 43.4% relative reduction. The RD was -7.8 percentage points (95% CI -13.4 to -2.2), equivalent to 7.8 fewer recurrences per 100 operations and an NNT of 12.8 (95% CI 7.5-45.8).



Risk ratio 0.57 (95% CI 0.38-0.86); risk difference -7.8 percentage points

Figure 2. Crude 3-month recurrence by graft technique. Bars show observed recurrence percentages and Wilson 95% confidence intervals. The risk ratio compares CAG with AMG.

Table 2. Primary 3-month recurrence analysis

Outcome/effect	CAG	AMG	Estimate (95% CI)	P value
Recurrence, n/N (%)	30/295 (10.2%)	53/295 (18.0%)	—	—
No recurrence, n/N (%)	265/295 (89.8%)	242/295 (82.0%)	—	—
Risk difference, percentage points	—	—	-7.8 (-13.4 to -2.2)	0.006
Risk ratio	—	—	0.57 (0.38-0.86)	0.006
Odds ratio	—	—	0.52 (0.32-0.84)	0.006
Number needed to treat	—	—	12.8 (7.5-45.8)	—
Pearson chi-square (1 df)	—	—	7.42	0.006
Continuity-corrected chi-square	—	—	6.79	0.009
Fisher exact test	—	—	—	0.009

Negative risk differences favor CAG. Confidence intervals for the NNT were obtained by inverting the absolute risk-difference limits and are asymmetric.

4.4 Adjusted analyses

After covariate adjustment, CAG remained associated with lower recurrence in both modified Poisson and logistic models. The adjusted RR was 0.55 (95% CI 0.36-0.83; $P=0.005$) and the adjusted OR was 0.47 (95% CI 0.28-0.78; $P=0.0036$). Older age, longer duration, and larger pterygium size were independently associated with higher recurrence. Sex, occupational exposure, aggregate comorbidity, and laterality were not independently associated with recurrence.

Table 3. Multivariable models for 3-month recurrence

Predictor	Adjusted RR (95% CI)	P	Adjusted OR (95% CI)	P
CAG vs AMG	0.55 (0.36-0.83)	0.005	0.47 (0.28-0.78)	0.004
Age (per 5 years)	1.32 (1.16-1.51)	<0.0001	1.41 (1.19-1.69)	0.0001
Female vs male	0.86 (0.56-1.33)	0.506	0.81 (0.46-1.43)	0.470
Outdoor vs indoor/other	0.71 (0.47-1.10)	0.123	0.64 (0.36-1.14)	0.131
Any comorbidity	1.07 (0.70-1.65)	0.754	1.10 (0.64-1.89)	0.728
Duration (per month)	1.20 (1.06-1.37)	0.006	1.26 (1.07-1.50)	0.007
Size (per 0.5 mm)	1.64 (1.32-2.04)	<0.0001	1.87 (1.40-2.51)	<0.0001
Left vs right eye	1.17 (0.80-1.72)	0.426	1.20 (0.73-1.96)	0.472

Modified Poisson regression used robust standard errors. Logistic and Poisson models included all listed predictors simultaneously. Age is per 5 years, duration per month, and lesion size per 0.5 mm.

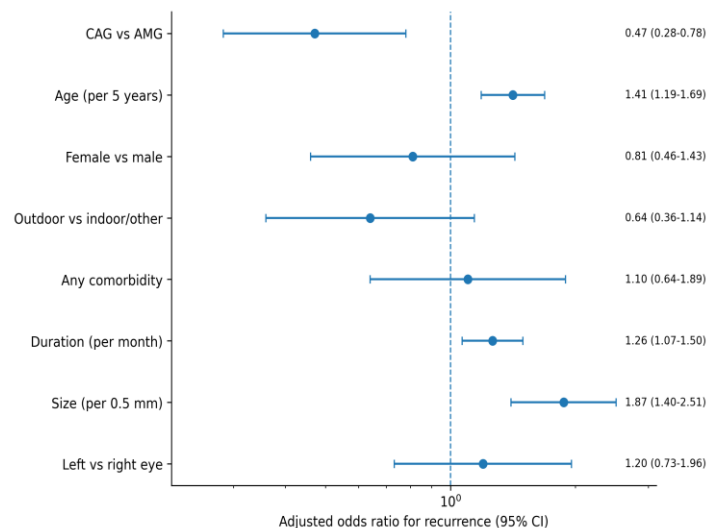


Figure 3. Adjusted odds ratios for recurrence from the multivariable logistic model. Horizontal lines indicate 95% confidence intervals; the vertical reference line is 1.0.

Marginal standardization yielded adjusted recurrence risks of 10.0% under CAG and 18.2% under AMG, with an adjusted RD of -8.2 percentage points (bootstrap 95% CI -13.6 to -2.3) and an adjusted RR of 0.55 (bootstrap 95% CI 0.35-0.85). The closeness of crude and standardized estimates indicates that observed baseline imbalances did not materially account for the treatment effect.

Table 4. Marginal standardization and model diagnostics

Measure	Estimate	95% CI or note
Standardized recurrence risk: CAG	10.0%	6.6-13.4%
Standardized recurrence risk: AMG	18.2%	13.7-22.5%
Adjusted risk difference	-8.2 percentage points	-13.6 to -2.3
Adjusted risk ratio	0.55	0.35-0.85
C statistic	0.727	Descriptive, in-sample
Brier score	0.109	Lower is better
McFadden pseudo-R ²	0.110	Model explanatory fit
Recurrence events per non-intercept coefficient	10.4	83 events; 8 coefficients

Standardized confidence intervals were based on 2,000 nonparametric bootstrap resamples. Performance measures are descriptive and were calculated in the modeling sample; they are not validation statistics.

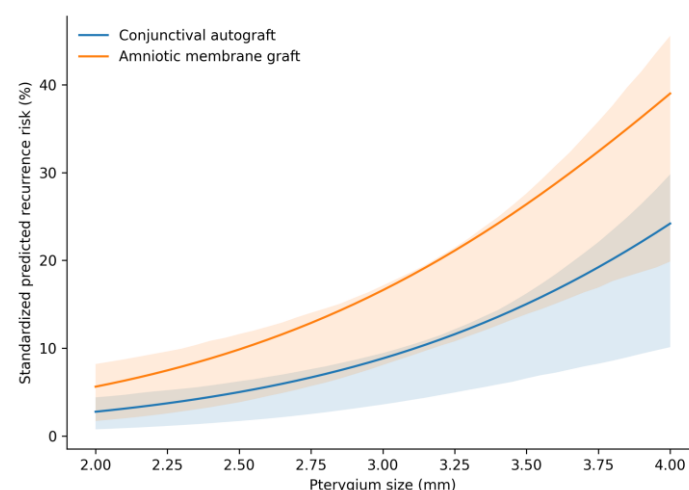


Figure 4. Standardized predicted recurrence risk across the observed pterygium-size range. Curves are marginal predictions from the adjusted logistic model, averaging over the observed distributions of age, sex, occupation, comorbidity, duration, and laterality. Shaded bands are model-based 95% confidence intervals.

4.5 Exploratory subgroup analyses

Point estimates favored CAG in every examined subgroup, although several confidence intervals crossed the null. The only nominal interaction involved duration (P for interaction=0.043): the RR was approximately 0.98

among participants with duration of 1-3 months and 0.41 among those with duration of 4-6 months. Because seven subgroup domains were examined, the trial was not powered for interaction, and the finding did not meet a conservative multiplicity-adjusted threshold, it should be treated as hypothesis-generating.

Table 5. Exploratory subgroup effects on recurrence

Domain	Level	CAG recurrence	AMG recurrence	RR (95% CI)	P interaction
Age group	20-30 years	5/79 (6.3%)	7/79 (8.9%)	0.71 (0.24-2.16)	0.845
	31-40 years	14/133 (10.5%)	29/143 (20.3%)	0.52 (0.29-0.94)	
	41-50 years	11/83 (13.3%)	17/73 (23.3%)	0.57 (0.29-1.13)	
Sex	Male	18/162 (11.1%)	31/179 (17.3%)	0.64 (0.37-1.10)	0.493
	Female	12/133 (9.0%)	22/116 (19.0%)	0.48 (0.25-0.92)	
Occupational exposure	Indoor/other	19/181 (10.5%)	37/192 (19.3%)	0.54 (0.33-0.91)	0.746
	Outdoor	11/114 (9.6%)	16/103 (15.5%)	0.62 (0.30-1.28)	
Comorbidity	None	18/206 (8.7%)	37/216 (17.1%)	0.51 (0.30-0.87)	0.587
	Any	12/89 (13.5%)	16/79 (20.3%)	0.67 (0.34-1.32)	
Pterygium duration	1-3 months	12/124 (9.7%)	14/142 (9.9%)	0.98 (0.47-2.04)	0.043
	4-6 months	18/171 (10.5%)	39/153 (25.5%)	0.41 (0.25-0.69)	
Pterygium size	2.0-3.0 mm	10/153 (6.5%)	21/155 (13.5%)	0.48 (0.24-0.99)	0.674
	>3.0 mm	20/142 (14.1%)	32/140 (22.9%)	0.62 (0.37-1.02)	
Laterality	Right	13/150 (8.7%)	29/156 (18.6%)	0.47 (0.25-0.86)	0.388
	Left	17/145 (11.7%)	24/139 (17.3%)	0.68 (0.38-1.21)	

RR compares CAG with AMG. Interaction P values are domain-level tests and were not adjusted for multiplicity. Subgroup analyses were exploratory.

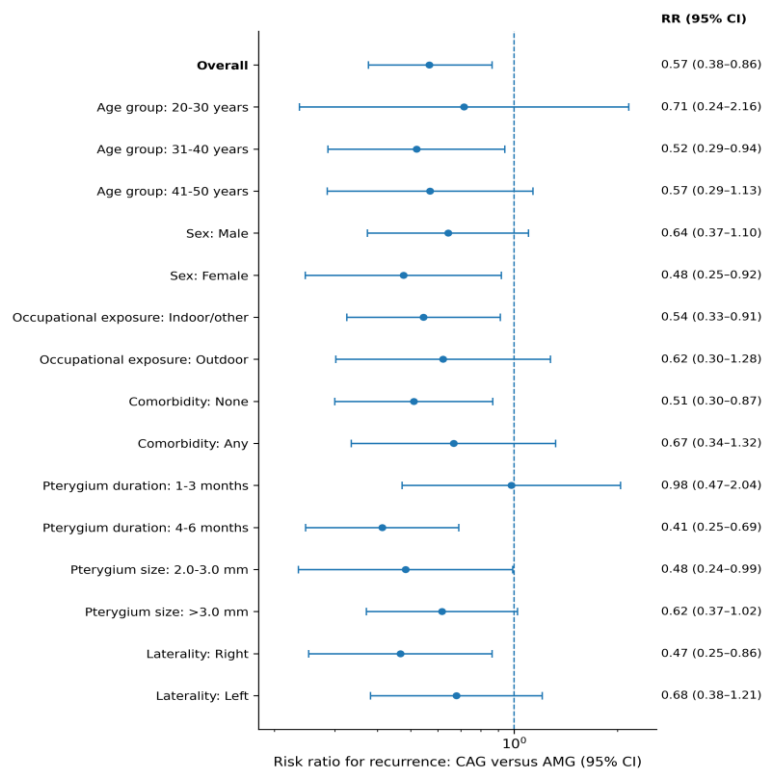


Figure 5. Exploratory subgroup risk ratios for 3-month recurrence. The duration interaction was nominal and did not withstand conservative multiplicity control. CAG, conjunctival autograft; AMG, amniotic membrane graft.

4.6 Sensitivity and Bayesian analyses

Frequentist and Bayesian analyses were concordant. Under independent Beta(1,1) priors, the posterior median RR was 0.57 (95% credible interval 0.37-0.86). The posterior probability that CAG reduced recurrence was 99.69%; the probabilities that the absolute reduction exceeded 3 and 5 percentage points were 95.3% and 83.3%, respectively. Jeffreys priors produced nearly identical results. A model allowing quadratic age, duration, and size effects also retained a treatment association (adjusted OR 0.48, 95% CI 0.29-0.80).

Table 6. Frequentist and Bayesian sensitivity analyses

Analysis	Effect metric	Estimate (95% CI/CrI)	Interpretation
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Crude randomized comparison	Risk ratio	0.57 (0.38-0.86)	Primary analysis
Modified Poisson adjustment	Adjusted risk ratio	0.55 (0.36-0.83)	Robust standard errors
Logistic adjustment	Adjusted odds ratio	0.47 (0.28-0.78)	Same covariates
Marginal standardization	Adjusted risk difference	-8.2 pp (-13.6 to -2.3)	2,000 bootstrap resamples
Quadratic covariate model	Adjusted odds ratio	0.48 (0.29-0.80)	Nonlinear sensitivity
Bayesian Beta(1,1)	Posterior risk ratio	0.57 (0.37-0.86)	Pr(CAG better) 99.69%
Bayesian Jeffreys	Posterior risk ratio	0.57 (0.37-0.85)	Pr(CAG better) 99.69%

CrI, credible interval; pp, percentage points. Bayesian probabilities condition on the specified prior and observed trial data. Subgroup interactions were not used to redefine the primary result.

5. DISCUSSION

In this randomized trial of 590 adults with primary pterygium, CAG reduced 3-month recurrence from 18.0% to 10.2%. The RR of 0.57 corresponds to a relative reduction of 43.4%, while the absolute reduction of 7.8 percentage points indicates approximately eight fewer recurrences per 100 procedures. The NNT was 12.8, although its confidence interval was broad. Covariate adjustment, modified Poisson estimation, marginal standardization, nonlinear modeling, exact testing, and Bayesian analysis all supported the same direction and a similar magnitude of effect.

The findings are directionally consistent with the Cochrane review, which favored CAG over AMG for recurrence at 6 months, and with several randomized and comparative studies. The effect estimate is also close to the 3-month Pakistani comparison by Alam and colleagues. However, recurrence estimates vary materially across studies because of differences in primary versus recurrent disease, lesion morphology, amount of Tenon removal, limbal inclusion, fixation method, amniotic-membrane processing, adjunctive mitomycin C, postoperative steroid regimens, surgeon experience, outcome definition, and follow-up duration. [8,11-19]

Recent evidence adds nuance rather than eliminating the treatment distinction. The 2023 comprehensive review found that average recurrence in observational practice was influenced strongly by fixation technique; AMG fixed with fibrin glue performed substantially better than sutured AMG in the included cohorts. The 2024 meta-analysis of CAG fixation also emphasized that sutureless and glue-free techniques may alter recurrence, discomfort, and complications. These data imply that “CAG versus AMG” is an incomplete surgical description unless the operative protocol is reported in detail. [19,24]

CAG may reduce recurrence through immediate replacement of like-for-like conjunctival tissue, restoration of epithelial continuity, physical exclusion of residual subconjunctival fibrovascular tissue, and reconstitution of a limbal barrier when limbal epithelium is included. AMG supports epithelialization and suppresses inflammation and fibrosis, but it is gradually resorbed and does not provide the same autologous structural barrier. Residual Tenon fibroblasts, incomplete pterygium-body excision, excessive cautery, graft edge separation, membrane inversion, or inadequate postoperative inflammation control may therefore differentially influence recurrence. [1,4,18,19]

Age, longer duration, and larger lesion size were associated with recurrence in the adjusted model. The size association is clinically plausible because larger lesions imply greater fibrovascular burden and a larger excision bed. Duration may capture lesion maturity or cumulative inflammatory exposure. The direction of the age association should be interpreted cautiously because prior series have sometimes linked younger age to more aggressive healing. These covariate findings were secondary, derived from only 83 events, and require external confirmation. [20,21,25]

For a patient population with an AMG recurrence risk near 18%, the observed absolute effect implies that treating approximately 13 patients with CAG rather than AMG would prevent one recurrence by 3 months. This favors CAG for routine primary pterygium when healthy conjunctiva is available and the surgeon is experienced. AMG remains clinically relevant when the conjunctival defect is extensive, bilateral disease limits donor tissue, superior conjunctiva should be preserved for possible glaucoma filtration surgery, or broader ocular-surface reconstruction is required.

The recurrence advantage cannot alone establish overall superiority. A decision must also account for pain, epithelial-healing time, graft displacement or loss, granuloma, infection, cosmesis, surgical time, tissue-bank availability, direct cost, future glaucoma risk, and patient preference. These outcomes were not recorded in the supplied database. A longer follow-up is particularly important because 3 months can miss delayed recurrence; at least 6- and 12-month assessments with standardized photography and time-to-event analysis would provide a more clinically complete comparison. [16-19,25]

Strengths include equal allocation, complete primary outcome ascertainment in the analytic database, reporting of absolute and relative effects with confidence intervals, a clinically interpretable NNT, covariate adjustment using both RR and OR models, marginal standardization, bootstrap uncertainty, explicit interaction testing, and Bayesian sensitivity analysis. The large sample provides substantially greater precision than many previous single-center comparisons.

Several limitations are important. First, the primary endpoint was measured at only 3 months; later recurrence was not captured. Second, the database did not contain adverse events, visual acuity, refraction, corneal topography, pain, cosmesis, satisfaction, reoperation, operating time, or cost. Third, the supplied files did not fully document allocation concealment, masked outcome assessment, intervention fidelity, surgeon effects,

fixation method, amniotic-membrane processing, adjunctive medication, or postoperative treatment. Fourth, exact surgery and recurrence dates were unavailable, preventing survival analysis. Fifth, occupational category is an imprecise proxy for ultraviolet and dust exposure. Sixth, the age restriction to 20-50 years and single-center setting limit generalizability. Seventh, subgroup and prognostic analyses were exploratory and potentially unstable because only 83 recurrences occurred. Finally, the screening log and reasons for pre-randomization exclusion were unavailable, so the full CONSORT enrollment flow could not be reconstructed.

6. CONCLUSION

Conjunctival autograft reduced 3-month recurrence after primary pterygium excision compared with amniotic membrane graft. The absolute reduction was 7.8 percentage points, the RR was 0.57, and the adjusted analyses were concordant. These results support CAG as the preferred reconstruction for routine primary pterygium when adequate conjunctiva is available. Confirmation with fully documented surgical protocols, masked standardized outcome assessment, adverse-event reporting, and follow-up to at least 6-12 months is necessary before concluding that CAG provides superior overall patient benefit.

DECLARATIONS

Competing interests: No competing interested declared by the authors

Funding: No specific funding was received.]

Use of AI-assisted technologies: Generative AI was used to support language editing, document formatting, and drafting of statistical code.

Abbreviations

AMG, amniotic membrane graft; CAG, conjunctival autograft; CI, confidence interval; CrI, credible interval; NNT, number needed to treat; OR, odds ratio; RD, risk difference; RR, risk ratio; SMD, standardized mean difference.

REFERENCES

1. Shahraki T, Arabi A, Feizi S. Pterygium: an update on pathophysiology, clinical features, and management. *Ther Adv Ophthalmol*. 2021;13:25158414211020152. <https://doi.org/10.1177/25158414211020152>
2. Rezvan F, Khabazkhoob M, Hooshmand E, et al. Prevalence and risk factors of pterygium: a systematic review and meta-analysis. *Surv Ophthalmol*. 2018;63(5):719-735. <https://doi.org/10.1016/j.survophthal.2018.03.001>
3. Zhou WP, Zhu YF, Zhang B, Qiu WY, Yao YF. The role of ultraviolet radiation in the pathogenesis of pterygia. *Mol Med Rep*. 2016;14(1):3-15. <https://doi.org/10.3892/mmr.2016.5223>
4. Chui J, Di Girolamo N, Wakefield D, Coroneo MT. The pathogenesis of pterygium: current concepts and their therapeutic implications. *Ocul Surf*. 2008;6(1):24-43. [https://doi.org/10.1016/S1542-0124\(12\)70103-9](https://doi.org/10.1016/S1542-0124(12)70103-9)
5. Coroneo M. Ultraviolet radiation and the anterior eye. *Eye Contact Lens*. 2011;37(4):214-224. <https://doi.org/10.1097/ICL.0b013e318223394e>
6. Liu L, Wu J, Geng J, Yuan Z, Huang D. Geographical prevalence and risk factors for pterygium: a systematic review and meta-analysis. *BMJ Open*. 2013;3(11):e003787. <https://doi.org/10.1136/bmjopen-2013-003787>
7. Hussain A, Awan H, Khan MD. Prevalence of non-vision-impairing conditions in a village in Chakwal district, Punjab, Pakistan. *Ophthalmic Epidemiol*. 2004;11(5):413-426. <https://doi.org/10.1080/09286580490888799>
8. Alam A, Rehman M, Khan B, Alam K, Ahmad A. Comparison of pterygium resection with conjunctival autograft versus amniotic membrane graft. *Pak J Ophthalmol*. 2015;31(4):182-187.
9. Sanchez-Thorin JC, Rocha G, Yelin JB. Meta-analysis on recurrence rates after bare sclera resection with and without mitomycin C and conjunctival autograft placement in primary pterygium surgery. *Br J Ophthalmol*. 1998;82(6):661-665. <https://doi.org/10.1136/bjo.82.6.661>
10. Kenyon KR, Wagoner MD, Hettinger ME. Conjunctival autograft transplantation for advanced and recurrent pterygium. *Ophthalmology*. 1985;92(11):1461-1470. [https://doi.org/10.1016/S0161-6420\(85\)33831-9](https://doi.org/10.1016/S0161-6420(85)33831-9)
11. Luanratanakorn P, Ratanapakorn T, Suwan-apichon O, Chuck RS. Randomised controlled study of conjunctival autograft versus amniotic membrane graft in pterygium excision. *Br J Ophthalmol*. 2006;90(12):1476-1480. <https://doi.org/10.1136/bjo.2006.095018>
12. Ma DHK, See LC, Liao SB, Tsai RJF. Amniotic membrane graft for primary pterygium: comparison with conjunctival autograft and topical mitomycin C treatment. *Br J Ophthalmol*. 2000;84(9):973-978. <https://doi.org/10.1136/bjo.84.9.973>
13. Tananuvat N, Martin T. The results of amniotic membrane transplantation for primary pterygium compared with conjunctival autograft. *Cornea*. 2004;23(5):458-463. <https://doi.org/10.1097/01.icc.0000116522.57227.97>
14. Kucukerdonmez C, Akova YA, Altinors DD. Comparison of conjunctival autograft with amniotic membrane transplantation for pterygium surgery: surgical and cosmetic outcome. *Cornea*. 2007;26(4):407-413. <https://doi.org/10.1097/ICO.0b013e318033b3d4>
15. Toker E, Eraslan M. Recurrence after primary pterygium excision: amniotic membrane transplantation with fibrin glue versus conjunctival autograft with fibrin glue. *Curr Eye Res*. 2016;41(1):1-8. <https://doi.org/10.3109/02713683.2014.999947>

16. Clearfield E, Muthappan V, Wang X, Kuo IC. Conjunctival autograft for pterygium. *Cochrane Database Syst Rev.* 2016;(2):CD011349. <https://doi.org/10.1002/14651858.CD011349.pub2>
17. Clearfield E, Hawkins BS, Kuo IC. Conjunctival autograft versus amniotic membrane transplantation for treatment of pterygium: findings from a Cochrane systematic review. *Am J Ophthalmol.* 2017;182:8-17. <https://doi.org/10.1016/j.ajo.2017.07.004>
18. Taher NO, Alnabihi AN, Hersi RM, et al. Amniotic membrane transplantation and conjunctival autograft combined with mitomycin C for management of primary pterygium: a systematic review and meta-analysis. *Front Med.* 2022;9:981663. <https://doi.org/10.3389/fmed.2022.981663>
19. Paganelli B, Sahyoun M, Gabison E. Conjunctival and limbal conjunctival autograft vs amniotic membrane graft in primary pterygium surgery: a 30-year comprehensive review. *Ophthalmol Ther.* 2023;12(3):1501-1517. <https://doi.org/10.1007/s40123-023-00689-x>
20. Ghiasian L, Samavat B, Hadi Y, Arbab M, Abolfathzadeh N. Recurrent pterygium: a review. *J Curr Ophthalmol.* 2021;33(4):367-378. https://doi.org/10.4103/joco.joco_153_20
21. Aidenloo NS, Motarjemizadeh Q, Heidarpahan M. Risk factors for pterygium recurrence after limbal-conjunctival autografting: a retrospective single-centre investigation. *Jpn J Ophthalmol.* 2018;62(3):349-356. <https://doi.org/10.1007/s10384-018-0582-9>
22. Ti SE, Chee SP, Dear KB, Tan DT. Analysis of variation in success rates in conjunctival autografting for primary and recurrent pterygium. *Br J Ophthalmol.* 2000;84(4):385-389. <https://doi.org/10.1136/bjo.84.4.385>
23. Koranyi G, Seregard S, Kopp ED. Cut and paste: a no-suture, small-incision approach to pterygium surgery. *Br J Ophthalmol.* 2004;88(7):911-914. <https://doi.org/10.1136/bjo.2003.032854>
24. Aljahdali F, Khayyat W, BinYamin AT, et al. Modified sutureless and glue-free method versus conventional sutures for conjunctival autograft fixation in primary pterygium surgery: a systematic review and meta-analysis. *BMJ Open Ophthalmol.* 2024;9(1):e001621. <https://doi.org/10.1136/bmjophth-2023-001621>
25. Noguera SI, Nicanor KSA, Ang RET, et al. Clinical outcomes of pterygium surgery over a ten-year period: a review of recurrence and complication rates. *BMC Ophthalmol.* 2025;25:380. <https://doi.org/10.1186/s12886-025-04196-4>
26. Schulz KF, Altman DG, Moher D; CONSORT Group. CONSORT 2010 statement: updated guidelines for reporting parallel-group randomised trials. *BMJ.* 2010;340:c332. <https://doi.org/10.1136/bmj.c332>
27. Hopewell S, Chan AW, Collins GS, et al. CONSORT 2025 statement: updated guideline for reporting randomised trials. *BMJ.* 2025;389:e081123. <https://doi.org/10.1136/bmj-2024-081123>