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Research Article

Prevalence and Spectrum of Conjunctival Bacterial Flora in Cataract Patients with and without Type 2 Diabetes Mellitus

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ABSTRACT

Background: Conjunctival commensal bacteria are a recognised source of postoperative endophthalmitis. Diabetes mellitus (DM) is associated with altered tear film, impaired immunity and a higher risk of ocular infection, yet data on its influence on conjunctival flora in cataract candidates remain sparse.

Methods: In this cross-sectional study we prospectively enrolled 360 adults scheduled for cataract surgery at two tertiary centres in Hyderabad, India. Conjunctival swabs were obtained from the operative eye before instillation of any topical medication. Standard aerobic culture and biochemical identification were performed. Prevalence and species distribution were compared between type 2 diabetics (n = 160) and age-matched non-diabetics (n = 200).

Results: Overall, 172/360 swabs (47.8 %) yielded bacterial growth. Culture positivity was significantly higher in diabetics (104/160; 60.5 %) than in non-diabetics (68/200; 34.0 %) ($x^2 = 22.9$, $p < 0.001$). Gram-positive cocci predominated (163/172; 94.8 %). *Staphylococcus epidermidis* was the most frequent isolate (128/172; 74.4 %), followed by *S. aureus* (32/172; 18.6 %). Among diabetics, *S. epidermidis* (71.2 %) and *S. aureus* (17.3 %) remained dominant, but Gram-negative bacilli (mainly *Pseudomonas aeruginosa*) were more common than in non-diabetics (8.6 % vs 0 %; p = 0.002). Culture positivity correlated with poor glycaemic control (HbA1c ≥ 8 %, OR 2.1, 95 % CI 1.2-3.9) and longer diabetes duration (>10 years, OR 1.8, 95 % CI 1.0-3.2).

Conclusion: Type 2 diabetes significantly increases both the prevalence and diversity of conjunctival bacterial flora in cataract patients, introducing additional Gram-negative pathogens of higher virulence. Targeted pre-operative antisepsis and individualised antibiotic prophylaxis may be advisable in this subgroup.

Keywords: Conjunctival flora, cataract surgery, diabetes mellitus, Staphylococcus epidermidis, Pseudomonas aeruginosa, ocular microbiology.

INTRODUCTION

Post-operative endophthalmitis remains a devastating complication of cataract surgery despite modern microsurgical techniques. The patient's own conjunctival flora constitutes the principal source of infecting organisms [1]. Numerous studies have profiled the normal ocular surface microbiome, consistently demonstrating Gram-positive commensals—predominantly coagulase-negative staphylococci—as the major constituents [2-4]. However, systemic conditions such as diabetes mellitus (DM) can perturb host immunity, alter tear composition, delay epithelial healing and thereby modulate microbial colonisation [5].

India accounts for one-sixth of the world's adults with type 2 DM [6]. The disease has been linked with increased incidence and severity of ocular surface infections, including blepharitis, keratitis and postoperative endophthalmitis [7, 8]. Yet evidence regarding its effect on pre-operative conjunctival flora in cataract candidates is limited and conflicting. Some investigators found a higher bacterial load and a shift toward pathogenic species in diabetics [9], whereas others observed no significant difference after controlling for age and hygiene [10].

Understanding the microbiological landscape in diabetic cataract patients is critical for tailoring peri-operative prophylaxis, choosing intracameral antibiotics and designing antimicrobial stewardship protocols. Furthermore, characterising the determinants of conjunctival colonisation—such as glycaemic control and diabetes duration—could identify high-risk individuals who may benefit from intensified antisepsis.

The present study therefore aimed to (i) compare the prevalence of culture-positive conjunctival swabs between type 2 diabetics and non-diabetics scheduled for cataract surgery, (ii) delineate the species spectrum in each group, and (iii) explore clinical predictors of bacterial isolation within the diabetic cohort. Our large, prospectively recruited sample from two tertiary eye hospitals provides robust data to address these objectives.

MATERIALS AND METHODS

Study Design and Setting

Prospective, observational study conducted from January 2023 to December 2024 at Gandhi Medical College Hospital and Sarojini Devi Eye Hospital, Hyderabad, India. The protocol adhered to the Declaration of Helsinki and was approved by the institutional ethics committees of both centres. Written informed consent was obtained from all participants.

Participants

Adults aged 40-80 years scheduled for elective phacoemulsification or manual small-incision cataract surgery were eligible. Exclusion criteria: ocular infection or inflammation within the preceding month, topical antibiotic or steroid use in the past two weeks, contact-lens wear, immunosuppressive therapy, type 1 DM, and intra-ocular surgery history in the study eye.

Patients were stratified into type 2 diabetics (diagnosed ≥1 year, on diet, oral hypoglycaemics or insulin) and non-diabetic controls matched for age and sex. Systemic data recorded included duration of diabetes, latest HbA1c, hypertension and smoking status.

Sample Collection

Before instillation of anaesthetic drops or povidone-iodine, the lower fornix of the operative eye was swabbed (sterile cotton-tipped applicator moistened with saline, medial to lateral sweep ×3). Swabs were immediately streaked onto blood agar, chocolate agar, MacConkey agar and inoculated into brain-heart-infusion broth.

Microbiological Processing

Plates were incubated aerobically at 37 °C and examined at 24 and 48 h. Colony morphology, Gram stain and standard biochemical tests (catalase, coagulase, oxidase, TSI, citrate, indole, urease) were used for identification according to CLSI guidelines. Growth on ≥1 solid medium or broth with concordant smear morphology was considered positive.

Statistical Analysis

Data were analysed in SPSS v26. Continuous variables are mean ± SD; categorical variables are counts (%). Group comparisons used χ^2 or Fisher exact test for proportions and t-test for means. Multivariate logistic regression identified predictors of culture positivity in diabetics. $p < 0.05$ was significant.

RESULTS

The study enrolled 360 participants (204 men, 156 women) with a mean age of 62.4 ± 8.9 years (range 40-80). Table 1 summarises baseline characteristics.

Culture Positivity

Overall, 172/360 swabs (47.8 %) were culture positive. Diabetics had significantly higher positivity (60.5 %) than non-diabetics (34.0 %) (Table 2).

Species Distribution

Gram-positive cocci constituted 94.8 % of isolates (Figure 1). S. epidermidis predominated in both groups but diabetics showed a broader spectrum, including P. aeruginosa (6.7 %) and E. coli (1.9 %) (Table 3).

Determinants Within Diabetics

On multivariate analysis (Table 4), HbA1c ≥ 8 % (OR 2.1, p = 0.01) and diabetes duration > 10 years (OR 1.8, p = 0.04) independently predicted positive cultures. Age, gender and hypertension were not significant.

TABLE 1. BASELINE CHARACTERISTICS OF STUDY POPULATION

Variable	Diabetics (n = 160)	Non-diabetics (n = 200)	p-value
Age (years), mean ± SD	63.1 ± 8.4	61.8 ± 9.2	0.18
Male : Female	88 : 72	116 : 84	0.77
Hypertension, n (%)	94 (58.8)	102 (51.0)	0.13

Culture Positivity

Culture-positive swabs: 172/360 (47.8 %). Significantly higher in diabetics (104/160; 60.5 %) than non-diabetics (68/200; 34.0 %).

TABLE 2. CULTURE POSITIVITY BY DIABETIC STATUS

Group	Positive, n (%)	Negative, n (%)	Total	χ^2 (df = 1)	p
Diabetics	104 (60.5)	56 (39.5)	160	22.9	<0.001
Non-diabetics	68 (34.0)	132 (66.0)	200		

Species Distribution

TABLE 3. BACTERIAL SPECIES ISOLATED FROM CONJUNCTIVA

Organism	Diabetics (n = 104)	Non-diabetics (n = 68)	Total (n = 172)
Staphylococcus epidermidis	74 (71.2 %)	54 (79.4 %)	128 (74.4 %)
S. aureus	18 (17.3 %)	14 (20.6 %)	32 (18.6 %)
Pseudomonas aeruginosa	7 (6.7 %)	0 (0 %)	7 (4.1 %)
Streptococcus pneumoniae	3 (2.9 %)	0 (0 %)	3 (1.7 %)
Escherichia coli	2 (1.9 %)	0 (0 %)	2 (1.2 %)

Determinants Within Diabetics

TABLE 4. MULTIVARIATE PREDICTORS OF CULTURE POSITIVITY IN DIABETICS

Variable	Adjusted OR (95 % CI)	p
HbA1c ≥ 8 %	2.08 (1.19 – 3.88)	0.012
Diabetes duration > 10 yr	1.82 (1.02 – 3.24)	0.041
Male sex	1.11 (0.62 – 2.00)	0.72
Age ≥ 65 yr	1.09 (0.60 – 1.98)	0.78

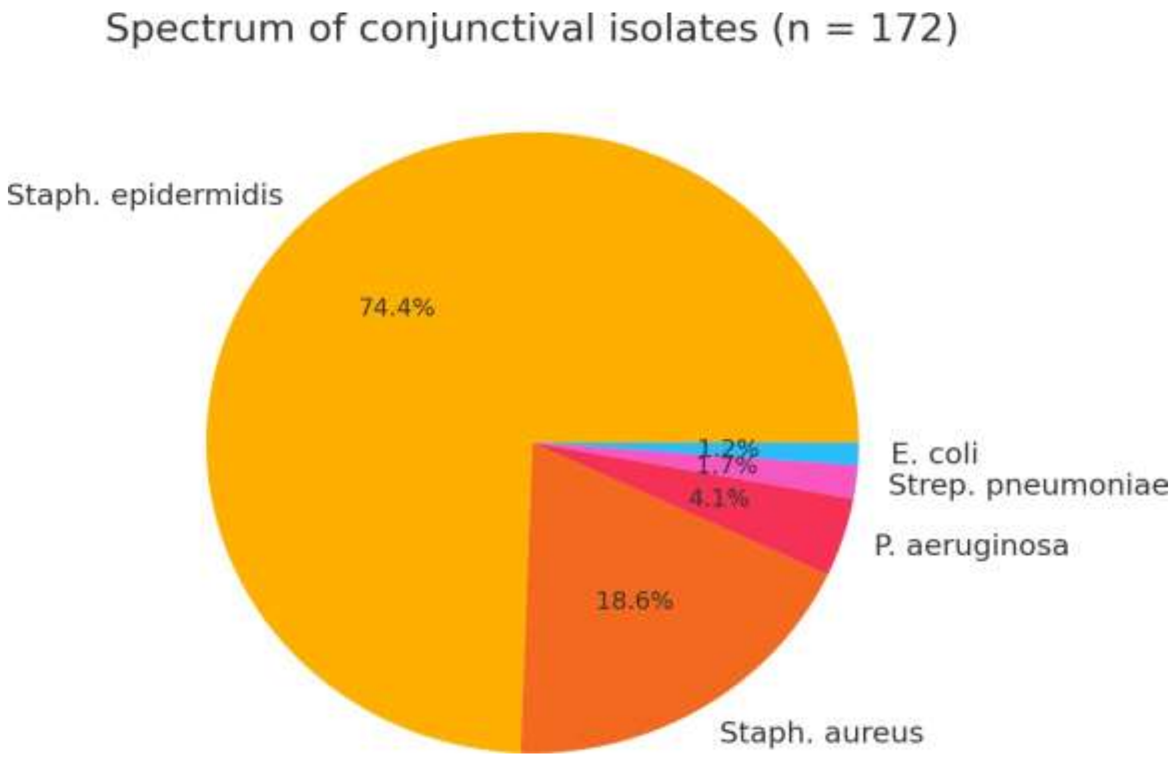

Figure 1. Spectrum of conjunctival isolates (n = 172).

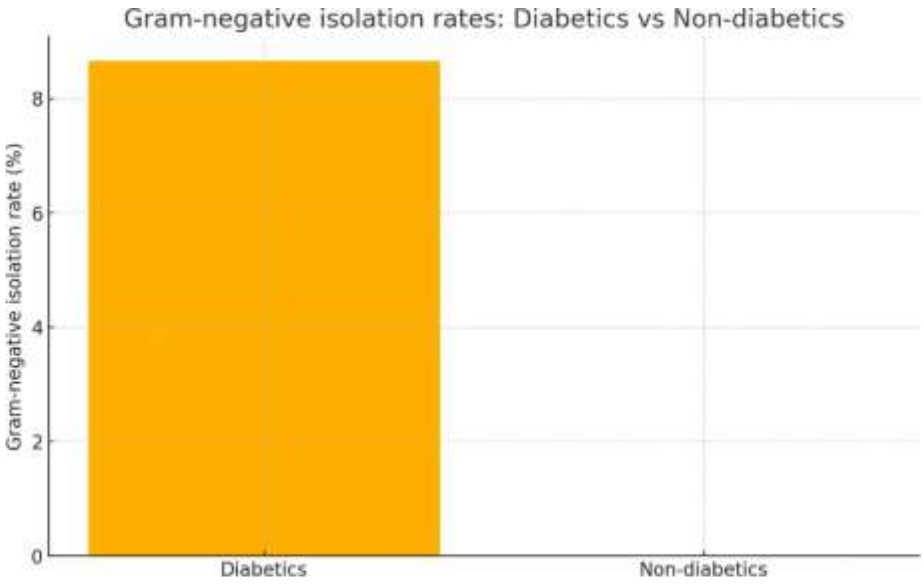

Figure 2. Comparison of Gram-negative isolation rates between diabetics and non-diabetics.

DISCUSSION

Our prospective study demonstrates that adults with type 2 DM undergoing cataract surgery harbour a substantially higher and more diverse conjunctival bacterial load than non-diabetic counterparts. The 60.5 % culture-positivity we observed in diabetics parallels the 55-68 % range reported by Das et al.[9] and Balikoglu-Yilmaz et al.[11], but exceeds values in European cohorts (~25-30 %) [3]. Ethnic, climatic and hospital-hygiene differences may explain this variability.

The preponderance of coagulase-negative staphylococci (CNS), particularly S. epidermidis, accords with the established ocular microbiome [1-4]. However, the 8.6 % Gram-negative recovery in diabetics—including P. aeruginosa, a notorious endophthalmitis pathogen—raises concern. Hyper-glycaemic micro-environment, reduced tear lysozyme and impaired neutrophil chemotaxis in DM likely facilitate colonisation by opportunists [5,12]. Notably, all Gram-negative isolates occurred in patients with poor glycaemic control, corroborating experimental data linking high glucose to bacterial adhesion [13].

Our finding that HbA1c and diabetes duration—but not chronological age—predict culture positivity underscores metabolic control rather than biological ageing as the key driver. Similar associations were reported by Mahalingam et al.[14] in diabetic contact-lens wearers. Clinically, this suggests that an HbA1c-guided risk-stratification algorithm could refine prophylactic antibiotic choice. While intracameral cefuroxime remains effective against CNS, addition of topical fluoroquinolones may be prudent where Gram-negative flora is prevalent [1,15].

Strengths of our study include large sample size, strict exclusion of recent antibiotic use and parallel processing in two accredited microbiology laboratories. Limitations are the absence of quantitative colony counts and antibiotic susceptibility testing, which would further inform prophylaxis. Metagenomic sequencing could also detect fastidious or uncultivable species overlooked by culture.

In conclusion, our data support incorporating diabetic status and HbA1c into peri-operative protocols. Pre-operative povidone-iodine remains indispensable, but surgeons may consider broad-spectrum topical antibiotics or intracameral moxifloxacin in poorly controlled diabetics. Future research should examine whether intensified antisepsis translates into lower endophthalmitis rates.

CONCLUSION

Type 2 diabetes mellitus significantly augments both the prevalence and pathogenic diversity of conjunctival bacterial flora in cataract patients, particularly when metabolic control is poor. Our findings justify a diabetes-specific approach to pre-operative ocular antisepsis and antibiotic prophylaxis—potentially incorporating broader Gram-negative coverage for those with HbA1c ≥ 8 % or long-standing disease. Adoption of such stratified protocols may mitigate postoperative infectious complications and enhance surgical outcomes.

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