Original Article

Acute endophthalmitis after penetrating and endothelial keratoplasty at a tertiary eye care center over a 13-year period

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Purpose: To evaluate the clinico-microbiological profile, donor cornea risk factors, and outcomes of postkeratoplasty endophthalmitis at a tertiary care center. **Methods:** Retrospective analysis of charts of 28 consecutive patients (28 eyes) of acute endophthalmitis following either an endothelial keratoplasty (EK) or an optical penetrating keratoplasty (PK) surgery, performed between 2006 and 2018 (13-year period). Positive microbiology, identification and classification of predisposing factors, surveillance of utilized paired donors, treatment outcomes, and differences in the rate and severity of the event between optical penetrating and endothelial keratoplasty. **Results:** The estimated incidence of endophthalmitis was 0.23% in the entire cohort; it was 0.34% and 0.15%, after EK and PK, respectively ($P = 0.049$). The median time of endophthalmitis was 4.5 days postsurgery. Donor-related endophthalmitis was recognized in 7/28 (25%) eyes. Culture positivity was 68% ($n = 19$ of 28). Bacteria was isolated in 84% ($n = 16$ of 19) instances; Gram-negative bacilli were more common (87.5%; 14 of 16), and *Pseudomonas* species (50%; 7 of 14) was the most common Gram-negative bacterium. Majority (>75%) of the Gram-negative bacteria were resistant to all fluoroquinolones, aminoglycosides, 3rd generation cephalosporins, and meropenam; 1/3rd were resistant to imipenem; and 90% were sensitive to colistin. Treatment included intraocular antibiotic injections (96.4%), vitrectomy (42.9%), and therapeutic keratoplasty (50%). In 85.7% (24 of 28), globe was salvaged. The final vision was 20/200 or better in 39.1% (9 of 23) eyes. **Conclusion:** EK carried a higher risk of endophthalmitis than PK in this cohort. Bacterial infection was more common in this series, with Gram negative bacilli being the commonest organisms. Multidrug resistance was common (~75%) in Gram negative isolates.

Key words: Endothelial keratoplasty, penetrating keratoplasty, post keratoplasty endophthalmitis

Endophthalmitis is a sight-threatening complication after keratoplasty. The various causes of postkeratoplasty endophthalmitis are preoperative contamination of the donor cornea (that can occur during retrieval, storage, and processing), inadequate asepsis during surgery, and postoperative factors (such as septic focus in the recipient, trauma, and wound leaks).[1,2] The standard of care to reduce the risk of contamination during donor cornea harvesting includes appropriate donor screening, instillation of povidone iodine and antibiotic in the cul-de-sac before cornea excision, and incorporation of antibiotics in the corneal preservation medium.[3-6] Despite many preventive measures adopted during cornea harvesting, storage, and surgery, the risks of postkeratoplasty endophthalmitis are never completely eliminated. There is no definite correlation between positive donor corneal rim cultures and the development of

postoperative endophthalmitis.[7,8] The unquantifiable factors such as load, virulence, and type of microorganisms, in addition to the recipient factors, may be the other predisposing risk factors for postkeratoplasty infections.[2,9,10] There are fewer published papers on endophthalmitis following endothelial keratoplasty (EK) compared to endophthalmitis following penetrating keratoplasty (PK). Gram-positive bacteria and *Candida* species are the most common microorganisms identified in post PK and post EK endophthalmitis, respectively.[9,11-15]

In this study, we report the incidence, clinico-microbiological profile, and outcomes of endophthalmitis following optical PK and EK in a large referral tertiary eye care center in South India over a 13-year period.

Methods

The study was approved by the Institutional Review Board and adhered to the tenets of the Declaration of Helsinki. This was a retrospective observational study of patients who

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developed endophthalmitis after optical PK or EK, operated between January 2006 and December 2018 at a tertiary eye care center in South India. The data were obtained from the eye bank, documented in manual records until 2011 and electronic records (iTransplant, Transplant Connect, Santa Monica, CA, USA) thereafter.

The comprehensive details included patient demographics, indication and type of surgery, and intra and postoperative events. Details of donor death or medical history, eye bank retrieval, and preservation techniques were documented. Wherever available, paired donor cornea details were acquired. Causative organisms were identified by microscopy and cultures of a variety of samples such as the corneal scrapings, vitreous biopsy, anterior chamber (AC) fluid, corneal buttons, donor storage medium, and donor corneoscleral rim, depending upon the availability. Only significant culture results were considered.[16] Antibiotic susceptibility was performed by the disc diffusion and/or epsilometer test (E-test) method. The final anatomical and visual outcomes were analyzed.

Definitions

- Acute postkeratoplasty endophthalmitis was defined as the one occurring within six weeks of primary surgery. The diagnosis was based on the clinical features of graft infiltrate, anterior chamber exudates, vitreous exudates, and/or vitreous echoes on B-scan. These were subclassified into microbiologically proven and clinical (microbiology negative) endophthalmitis cases.
- Donor-related endophthalmitis was the one when the same organism was isolated from the patient (cornea/anterior chamber/vitreous) and the donor cornea (storage medium/corneoscleral rim preserved after keratoplasty).

Eye bank processes and protocols before and after reporting of adverse events following keratoplasty

The institute affiliated eye bank retrieves donor corneas through Hospital-based Cornea Retrieval Program (HCRP), voluntary eye donations, and from its affiliated cornea collection centers.[17] The institute protocol of cornea retrieval, in brief, consists of cleaning the surgical site with 5% povidone iodine, decontamination of the ocular surface and cul-de-sac with 2.5% povidone iodine with a contact time of 5 min. The donor corneas are preserved in McCarey–Kaufman (MK) medium. As MK medium is prepared in the eye bank and is cost-effective, it is the favored mode of corneal preservation at the eye bank. Following endothelial imaging using specular microscope and a detailed slit lamp evaluation, the donor cornea is allocated for keratoplasty. The precut preparation for EK using microkeratome device (Moria Microkeratome system, MoriaInc, Antony, France) was performed by the surgeon in the operating room until 2012 and by a trained technician in a clean room at the eye bank under a laminar flow hood thereafter.

Following keratoplasty, the peripheral corneoscleral rim is returned to the eye bank and preserved for 4–6 days. The institute infection control protocol calls for a detailed microbiological investigation of the preserved corneoscleral rim in the event of an adverse event (keratitis or endophthalmitis) notification in the early postkeratoplasty period. The underlying causes (donor-related or others) and protocol deviations, if any, are ascertained. The mate pair of the donor cornea is traced for any evidence of infection in the recipient eye. Corneal scrapings are taken if the graft shows epithelial defect and superficial

infiltration. Diagnostic AC taps with or without vitreous biopsy are sent for microbiological analysis. In the event of a therapeutic PK performed after the diagnosis of endophthalmitis, one half of the corneal button is sent for microbiology and the other half for histopathology evaluation. B- scan ultrasonography is performed wherever vitreous evaluation is not possible using indirect ophthalmoscope at highest illumination. All clinically confirmed cases of endophthalmitis are primarily managed in the retina service in close consultation with the cornea service and microbiology laboratory.

The management decision in the retina service was based on the comprehensive clinical examination and the ultrasonography.[18] As a general guideline, all eyes were advised endophthalmitis vitrectomy study (EVS) and recommended intravitreal antibiotics initially (vancomycin 1.0 mg in 0.1 ml and ceftazidime 2.25 mg in 0.1 ml).[19] Further management was based on the clinical appearance, anatomical integrity of the globe, and security of primary corneal graft; generally a pars planavitrectomy (PPV) when the graft appeared secured, therapeutic PK when the graft did not appear secured, and evisceration when either procedures were not possible was performed.

Statistics

Statistical analysis was performed using statistical software Origin v7.0 (Origin Lab Corporation, Northampton, MA, USA). Continuous data were checked for the normality of distribution by Shapiro–Wilk test and described by either mean and standard deviation for data with normal distribution or median and inter-quartile range (IQR) if otherwise. Equality of variance was assessed by Levene test. Categorical data were described in proportions. Continuous parametric data with equal variance between EK and PK groups were compared by t-test and nonparametric data or parametric data with unequal variance by Mann–Whitney test. Categorical data were compared by Chi-square test or Fisher exact test. A P value of <0.05 was considered statistically significant.

Results

Table 1 summarizes the demographics and the donor characteristics of patients who developed endophthalmitis
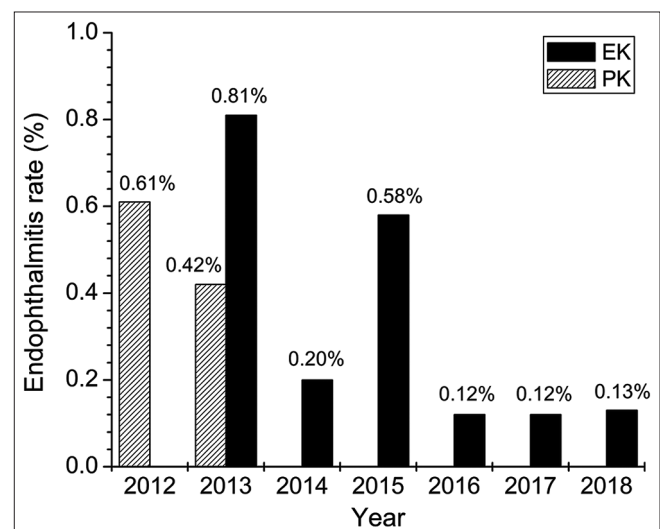

Figure 1: Annual Trends in the rate of endophthalmitis

Table 1: Demographics, donor details, and clinical characteristics of eyes with acute postkeratoplasty endophthalmitis

Parameters	Overall (*n*=28)	PK (*n*=10)	EK (*n*=18)	*P*
Demographics				
Age (years), mean±SD	50.9±16.7	48.8±17.8	52.0±16.4	0.64
Male:Female	20:8	9:1	11:7	0.19
Donor Parameters				
DTP time, median (IQR)	4.3 (2-5.5)	3.3 (1.5-5)	4.5 (2.8-6)	0.43
Preservation time, median (IQR)	46 (26-72)	42.5 (26-49)	48 (30-73)	0.30
Place of donor recovery				
Home calls	6 (21.4%)	2 (33.3%)	4 (30.8%)	0.91
Hospital wards	13 (46.4%)	1 (16.7%)	3 (23.1%)	0.67
Mortuary	9 (32.2%)	3 (50%)	6 (46.1%)	0.90
Donor on ventilator	6 (21.4%)	1 (10%)	5 (27.8%)	0.38
Size of graft (mm), mean±SD	8.15±0.47	8.44±0.35	7.96±0.44	**0.01**
Endothelial cell density (cells/mm^2), mean±SD	2796±292.4	2654.2±306.6	2879.4±257.1	0.051
Donor age (years), mean±SD	47.6±18.8	54.4±20.7	43.9±17.1	0.16
Duration between keratoplasty and recognition of endophthalmitis (days), median (IQR)	4.5 (1-6)	5 (2-22)	3 (1-6)	0.26
Donor-related endophthalmitis	7 (25%)	0 (0%)	7 (38.9%)	0.06

DTP=Death to preservation time; EK=Endothelial keratoplasty; IQR=Inter-quartile range; PK=Penetrating keratoplasty; SD=Standard deviation. Bold values denote statistical significance at the *P*<0.05 level

Table 2: Annual trends in rate of endophthalmitis: Optical penetrating keratoplasty (PK) versus endothelial keratoplasty (EK)

Year	PK			EK			*P*
	Endophthalmitis	Surgeries	Rate	Endophthalmitis	Surgeries	Rate	
Overall 2006-2018	10	6750	0.15%	18	5315	0.34%	**0.049**
#2006-2011	5	2668	0.19%	8	1255	0.64%	**0.02**
2012-2018	5	4082	0.12%	10	4060	0.25%	0.30
2012	3	493	0.61%	0	295	0.00%	0.30
2013	2	479	0.42%	3	372	0.81%	0.66
2014	0	529	0.00%	1	500	0.20%	0.30
2015	0	482	0.00%	3	514	0.58%	0.25
2016	0	665	0.00%	1	802	0.12%	0.36
2017	0	791	0.00%	1	805	0.12%	0.32
2018	0	643	0.00%	1	772	0.13%	0.36

#Year wise break up of PK and EK done only at the institute was not possible between 2006 and 2011, as data were entered in manual registers and not on electronic records. Bold values denote statistical significance at the *P*<0.05 level

after keratoplasty. Table 2 and Fig. 1 summarize the year wise incidence (by type of keratoplasty) of postkeratoplasty acute endophthalmitis at the institute over the last thirteen years.

In the 13-year study period, from January 2006 to December 2018, a total of 12,065 corneas were used for keratoplasty - 56% (*n* = 6750) corneas for optical PK and 44% (*n* = 5315) corneas for EK. Acute endophthalmitis developed in 0.23% (*n* = 28) eyes - 0.15% (10 of 6750) after optical PK and 0.34% (18 of 5315) after EK. Overall, the incidence of postEK endophthalmitis was significantly greater than postoptical PK endophthalmitis [*P* = 0.049; odds ratio EK: PK = 2.29 (95% confidence interval 1.06–4.97). There was no significant difference between post PK and post EK endophthalmitis between 2012 and 2018. Further, there were no occurrence of endophthalmitis postoptical PK in the last 5 years. Prior to 2012, donor preparation for EK was done by surgeons and thereafter by the technicians in the eye bank. The endophthalmitis rates following EK when donor was prepared by surgeons was 0.64% and when prepared in eye bank was 0.25% (*P* = 0.04).

Demographics

Mean age of the patients was 50.9 ± 16.7 years (range, 11–81 years). There were 20 (71.4%) males and 8 (28.6%) females. Pseudophakic corneal edema (32.1%; *n* = 9 eyes) was the major primary indication for keratoplasty; other indications included vascularized corneal scar, Fuchs endothelial corneal dystrophy, failed previous PK, macular stromal dystrophy, aphakic corneal edema, and iridocorneal endothelial syndrome. Thirteen of 28 eyes (46.4%) received additional intervention [10 - Cataract extraction with intraocular lens (IOL) implantation, 2 - IOL implantation, 1 - IOL explantation] at the time of keratoplasty. The median interval from keratoplasty to the occurrence of endophthalmitis was 4.5 days (IQR, 1–6 days); there was no significant difference in the occurrence of endophthalmitis following EK and PK (median 3 days in EK, IQR, 1–6 days and median 5 days in PK, IQR, 2–22 days, respectively; *P* = 0.26).

Donor characteristics

The mean age of the donors was 47.6 ± 18.8 years (range, 18–80 years). The major causes of donor death were road traffic

accident (39.3%; *n* = 11) and cardiorespiratory arrest (35.7%; *n* =10), Table 1. Nearly half of the donor corneas were harvested from the hospital (46.4%; *n* = 13) and the remaining from mortuary and home (32.2%, *n* = 9; and 21.4%, *n* = 6), respectively. Median death-to-preservation time was 4.3 h (IQR, 2–5.5 h). Median duration of preservation was 46 h (IQR, 26–72 h). All donor corneas were preserved in MK medium. Two donor corneas were shifted to Cornisol preservation medium after precut preparation for EK. Mean endothelial cell density of donor cornea was 2796 ± 292.4 cells/mm^2.

Microbiological spectrum [Table 3]

The samples for microbiology were obtained from the corneal scrapings (*n* = 10 eyes), undiluted vitreous (*n* = 24 eyes), and half of the corneal button (*n* = 14 eyes). Culture was positive in 67.9% (*n* = 19 of 28) instances - 84.2% (16 of 19) bacterial and 15.8% (3 of 19) fungal. Gram-negative bacteria were more common (14 of 16; 87.5%) and *Pseudomonas spp.* (7 of 14; 50%) was the commonest Gram-negative isolate. Majority (>75%) of the Gram-negative bacteria were resistant to all fluoroquinolones, aminoglycosides, 3rd generation cephalosporins, and meropenam; 1/3rd were resistant to imipenem; and 90% were sensitive to colistin.

Donor-related endophthalmitis

Seven (25%) of the 28 cases of endophthalmitis were definitively attributable to donor contamination after microbiological work up. In these 7 eyes, same microorganism grew from the recipient eye with endophthalmitis and the donor cornea (MK medium and peripheral skirt of corneo-scleral rim). All these 7 cases of endophthalmitis were after EK. Six eyes had multidrug-resistant Gram-negative bacilli (of which one had mixed infection with *Corynebacterium jeikeium* and *Proteus spp.*) and one eye grew *Staphylococcus aureus*. Out of 7, the cause of donor's death was road traffic accident in six and electric shock in one. In 2/7 cases, the recipient of the mate cornea also developed endophthalmitis with the same species of microorganisms. The mate pairs of 5/7 cases were not utilized for keratoplasty; however, the microbiological cultures of the storage media and the rim showed the same spectrum of organisms as in the recipient in 4/5 donor mates.

Non donor related endophthalmitis

Of the 21 eyes, 10 eyes had PK and 11 had EK. In 8/21 (38.1%) eyes (3 PK and 5 EK), the organism isolated was Gram-negative bacilli, one eye had Gram-positive bacilli and 3 eyes grew fungus. Microbiology was negative in the remaining 9 eyes. The causes of donor's death were road traffic accident in 6, natural cause of death in 2, cardiac arrest in 9, carcinoma stomach in 2, acute pancreatic necrosis in 1, and suicidal burn related death in 1.

Management and outcome [Table 4]

All medical and surgical interventions were performed after a detailed discussion of all available options and consent of the patient (one of the parents in case of a minor). The common surgical management included intraocular antibiotics injections in all eyes, but one where primarily evisceration was decided after due consideration of the status of the eye at clinical presentation. The eviscerated contents in this patient grew *Pseudomonas aeruginosa*, which was multidrug resistant but was sensitive to imipenem and colistin. The intravitreal antibiotic injections were given either alone or along with another surgical intervention (PPV in 12 eyes, therapeutic PK in 14 eyes, and lenticule extraction in 1 eye). Another eye was eviscerated because of poor response despite PPV and multiple intravitreal antibiotics. Two eyes eventually developed phthisis bulbi. The parameters such as type of keratoplasty (PK/EK), donor related infection implicated microorganisms, and multidrug resistance showed no significant bearing on the anatomical globe restoration.

Median follow-up after diagnosis of endophthalmitis was 9 months (IQR, 2–36 months). At the time of diagnosis of endophthalmitis, 22 eyes had a median best-corrected visual acuity (BCVA) of 1.48 logMAR (Snellen equivalent 20/604)

Table 3: Microbiological details of clinical samples

Microorganisms	Number of eyes (*n*=28)	Corneal scrapings (*n*=10)	Vitreous biopsy (*n*=24)	Corneo-scleral rim and MK medium* (*n*=7)	Half corneal button (*n*=14)	Mate cornea (*n*=12)	Susceptibility profile (*n*=13 eyes)
Gram negative bacteria	14 (50%)	5 (50%)	8 (33.3%)	6 (85.7%)	6 (42.9%)	5 (41.7%)	Majority (>75%) of the
Pseudomonas aeruginosa	6	2	3	1	3	0	gram-negative organisms were
Pseudomonas pultida	1	1	0	0	0	0	resistant to all fluoroquinolones,
*Enterobacter cloacae***	3	2	1	3	1	2	aminoglycosides, and 3rd
Burkholderia mallei	1	0	0	1	1	1	generation cephalosporins and
Klebsiella pneumoniae	1	0	1	1	1	1	meropenem, one-third were
Escherichia coli	1	0	1	0	0	0	resistant to imipenem and 90%
Aeromonas hydrophila	1	0	1	0	0	0	were susceptible to colistin.
Gram positive bacteria	2 (7.1%)	1 (10%)	1 (4.2%)	1 (14.3%)	1 (7.1%)	1 (8.3%)	*Staphylococcus aureus*
Staphylococcus aureus	1	1	0	1	1	1	was 100% susceptible to
Unidentified bacillus	1	0	1	0	0	0	moxifloxacin
Fungus	3 (10.7%)	0 (0%)	2 (8.4%)	0 (0%)	2 (14.3%)	0 (0%)	-
Aspergillus flavus	1	0	0	0	1	0	
Aspergillus fumigatus	1	0	1	0	0	0	
Candida spp.	1	0	1	0	1	0	
No organisms	9 (32.1%)	4 (40%)	13 (54.1%)	0 (0%)	5 (35.7%)	6 (50%)	Not applicable

*Cornea-scleral rim and McKarey-Kaufman (MK) medium: Both provided the same microbiological spectra on independent cultures. **One culture of *Enterobacter cloacae* showed co-growth of *Corynebacterium jeikeium* and *Proteus mirabilis* in anterior chamber tap and/or vitreous biopsy, corneo-scleral rim, MK medium, and half corneal button

Table 4: Management and outcomes in eyes with acute post-keratoplasty endophthalmitis

Parameters	Overall (*n*=28)	PK (*n*=10)	EK (*n*=18)	P
Management strategies				
Intraocular antibiotic injections	27 (96.4%)	10 (100%)	17 (94.4%)	1.00
Pars plana vitrectomy	12 (42.9%)	6 (60%)	6 (33.3%)	0.40
Therapeutic penetrating keratoplasty	14 (50%)	2 (20%)	12 (66.7%)	0.15
Evisceration	2 (7.1%)	1 (10%)	1 (5.6%)	1.00
Lenticule extraction	1 (3.6%)	N/A	1 (5.6%)	N/A
Outcomes				
Anatomical Restoration	22 (78.6%)	9 (90%)	13 (72.2%)	0.38
Clear graft	6 (21.4%)	2 (20%)	4 (22.2%)	1.00
Failed graft	16 (57.1%)	7 (70%)	9 (50%)	0.43
Evisceration	2 (7.1%)	1 (10%)	1 (5.6%)	1.00
Phthisis bulbi	2 (7.1%)	0 (0%)	2 (11.1%)	0.52
Lost to follow-up	2 (7.1%)	0 (0%)	2 (11.1%)	0.52
Visual outcome				
BCVA 20/200 or better	9/23 (39.1%)	3/9 (33.3%)	6/14 (42.9%)	0.69

BCVA=Best-corrected visual acuity; PK=Penetrating keratoplasty; EK=Endothelial keratoplasty; N/A=Not applicable

(IQR, 0.70 to 3.00 logMAR) and four eyes had vision of light perception or projection. At the last follow-up, 7 of 28 eyes (25%) maintained clear grafts. Excluding 4 eyes (2 where evisceration was done and 2 that developed phthisis), median BCVA was 1.00 logMAR (Snellen equivalent 20/200) (IQR, 0.48 to 2.09 logMAR) in 17 eyes, light perception in 4 eyes, and no PL in 2 eyes.

Discussion

The incidence of endophthalmitis after PK has been variably reported and ranges between 0.1% and 2.47% from various centers of the world.[2,9,12,13] EK has gained popularity since late 1990s, and hence, the literature on post EK endophthalmitis is relatively sparse. Some studies have reported a higher risk endophthalmitis after EK, and could be related to (1) additional steps in the donor cornea preparation for EK, (2) the warming cycle in precut preparation for EK (believed to increase the risk of fungal infection), and (3) additional intraoperative manipulation.[20,21] However, a recent report has suggested a lower incidence of endophthalmitis following EK and PK.[22]

In the 13-year period, the overall incidence of endophthalmitis after PK (0.15%) and EK (0.34%) at our institute was 0.23%, and it is comparable with prior reports in literature. Comparing the two periods, 2006–2011 (6 years) and 2012–2018 (7 years) there was decrease in the incidence of endophthalmitis following PK (0.19% to 0.12%) and following EK (0.64% to 0.25%) [Table 2].We are unable to ascribe to any specific reasons though; we presume it must be related to better screening of patients before surgery.

Many authors have reported fungal endophthalmitis following EK.[15,16,21-23] But in our series, bacterial infection was the commonest (16 of 28; 57%), of which Gram-negative bacteria were more common. *Pseudomonas* species was the predominant Gram-negative bacterial isolate. Majority of post EK endophthalmitis was also Gram-negative bacterial infection. This is similar to our earlier reports on postoperative and posttrauma endophthalmitis.[24] Fungus was isolated in 3 of 28 (10.7%) eyes, 1 post EK and 2 after PK, and these were two molds (*Aspergillus*) and one yeast (*Candida*). We identified that >75% of the Gram-negative organisms were resistant

to all fluoroquinolones, aminoglycosides, 3rd generation cephalosporins, and meropenam; one-third were resistant to imipenem; and 90% were susceptible to colistin. Three-fourths of Gram-negative organisms resistant to multiple antibiotics did not appear surprising in view of the increasing bacterial resistance in hospital premises from where the cornea was retrieved.[19,25] Looking at the spectrum of postkeratoplasty endophthalmitis and the antibiotic sensitivity pattern of these organisms, we wonder if there is a need to add an additional antibiotic such as polymixin E or colistin in the donor cornea storage medium, after appropriate studies in laboratory and human cornea. The new antibiotics should be capable of inhibiting filamentous fungi and *Candida spp*; incidentally both polymixin B and colistin are known to inhibit these microorganisms.[26]

We routinely use MK medium for corneal preservation as against Optisol in developed countries. This choice is purely based on economic reasons. The antibiotics in the two preservation media are comparable, however, the preservation time is shorter in MK medium than Optisol medium, and hence the preservation to utilization time is likely to be shorter in MK medium preserved corneas.

This may be speculated as one of the reasons for the differences in the microbiological spectrum between our cohort compared to the reports from US.

The anatomical restoration of the eyes was favorable in a majority (85.8%) of the patients. The visual outcomes were poor. Multidrug resistant-Gram-negative bacteria isolated in the 4 eyes needed evisceration or resulted in phthisis bulbi. The final vision was 20/200 or better in over 40% of patients.

The limitation of the study is that the analysis of risk factors was done in a retrospective manner. Hence, the information on details of donor's death, treatment strategy, and antibiotic regimen used during their hospitalization could not be covered extensively. Also, elaborate details of intraoperative factors such as tissue handling, surgical difficulties, and prolonged surgical time could not be studied.

To conclude, the microbiological spectrum of organisms in endophthalmitis after keratoplasty in India is different than the ones reported in the Western literature. Multidrug resistance

is an important concern. Further studies are needed to add or replace the current antibiotic policy in MK medium often used for corneal preservation in India.

Conclusion

In our study, the rate of endophthalmitis was higher in EK than in PK, as reported previously. Bacterial endophthalmitis was commoner than fungal endophthalmitis, contrary to other publications. Multi-drug resistant *Pseudomonas spp*. was noted in this study as a frequent pathogen.

Conflicts of interest

There are no conflicts of interest.

References

1. Leveille AS, McMullan FD, Cavanagh HD. Endophthalmitis following penetrating keratoplasty. Ophthalmology 1983;90:38-9.

2. Taban M, Behrens A, Newcomb RL, Nobe MY, McDonnell PJ. Incidence of acute endophthalmitis following penetrating keratoplasty: A systematic review. Arch Ophthalmol 2005;123:605-9.

3. Pels E, Vrensen GF. Microbial decontamination of human donor eyes with povidone-iodine: Penetration, toxicity, and effectiveness. Br J Ophthaknol 1999;83:1019-26.

4. Salisbury CD, Kirk CN, Lee WB, Hamilton SM, Kozarsky AM, Meinecke E, *et al*. Increasing povidone-iodine exposure in endothelial keratoplasty tissue processing and fungal infection impact. Cornea 2019;38:1093-6.

5. Hagenah M, Winter R. Disinfection of human donor corneas during preparation and preservation. Klin Monbl Augenheilkd 1996;209:1-6.

6. Smith TM, Popplewell J, Nakamura T, Trousdale MD. Efficacy and safety of gentamicin and streptomycin in Optisol-GS, a preservation medium for donor corneas. Cornea 1995;14:49-55.

7. Wilhelmus KR, Hassan SS. The prognostic role of donor corneoscleral rim cultures in corneal transplantation. Ophthalmology 2007;114:440-5.

8. Everts RJ, Fowler WC, Chang DH, Reller LB. Corneoscleral rim cultures: Lack of utility and implications for clinical decision-making and infection prevention in the care of patients undergoing corneal transplantation. Cornea 2001;20:586-9.

9. Alharbi SS, Alrajhi A, Alkahtani E. Endophthalmitis following keratoplasty: Incidence, microbial profile, visual and structural outcomes. Ocul Immunol Inflamm 2014;22:218-23.

10. Chaurasia S, Muralidhar R, Garg P, Gopinathan U. Donor corneal button-related endophthalmitis after penetrating keratoplasty. Clin Exp Ophthalmol 2010;38:75-6.

11. Kunimoto DY, Tasman W, Rapuano C, Recchia F, Busbee B, Pearlman R, *et al*. Endophthalmitis after penetrating keratoplasty: Microbiologic spectrum and susceptibility of isolates. Ophthalmol 2004;137:343-5.

12. Kloess PM, Stulting RD, Waring GO 3rd, Wilson LA. Bacterial and fungal endophthalmitis after penetrating keratoplasty. Am J Ophthalmol 1993;115:309-16.

13. Chen JY, Jones MN, Srinivasan S, Neal TJ, Armitage WJ, Kaye SB. NHSBT Ocular Tissue Advisory Group and Contributing Ophthalmologists (OTAG Audit Study 18). Endophthalmitis after penetrating keratoplasty. Ophthalmology 2015;122:25-30.

14. Palioura S, Sivaraman K, Joag M, Sise A, Batlle JF Jr, Miller D, *et al*. Candida endophthalmitis after Descemet Stripping Automated Endothelial Keratoplasty with grafts from both eyes of a donor with possible systemic candidiasis. Cornea 2018;37:515-8.

15. Weng CY, Parke DW 3rd, Walter SD, Isom RF, Chang JS, Flynn HW Jr. Candida glabrata endophthalmitis transmitted from graft to host after descemet stripping automated endothelial keratoplasty. JAMA Ophthalmol 2014;132:1381-3.

16. Sharma S, Jalali S, Adiraju MV, Gopinathan U, Das T. Sensitivity and predictability of vitreous cytology, biopsy and membrane filter culture in endophthalmitis. Retina 1996;16:525-9.

17. Chaurasia S, Mohamed A, Garg P, Balasubramanian D, Rao GN. Thirty years of eye bank experience at a single centre in India. Int Ophthalmol 2020;40:81-8.

18. Das T, Kunimoto DY, Sharma S, Jalali S, Majji AB, Nagaraja Rao T, *et al*. Relationship between clinical presentation and visual outcome in postoperative and posttraumatic endophthalmitis in South Central India. Indian J Ophthalmology 2005;53:5-16.

19. Endophthalmitis Vitrectomy Study Group. Results of the endophthalmitis vitrectomy study. Arch Ophthalmol 1995;113:1479-96.

20. Edelstein SL, DeMatteo J, Stoeger CG, Macsai MS, Wang CH. Report of the Eye Bank Association of America medical review subcommittee on adverse reactions reported from 2007 to 2014. Cornea 2016;35:917-26.

21. Aldave AJ, DeMatteo J, Glasser DB, Tu EY, Iliakis B, Nordlund ML, *et al*. Report of the Eye Bank Association of America medical advisory board subcommittee on fungal infection after corneal transplantation. Cornea 2013;32:149-54.

22. Borkar DS, Wibbelsman TD, Buch PM, Rapuano SB, Obeid A, Ho AC, *et al*. Endophthalmitis rates and clinical outcomes following penetrating and endothelial keratoplasty. Am J Ophthalmol 2019;205:82-90.

23. Brothers KM, Shanks RMQ, Hurlbert S, Kowalski RP, Tu EY. Association between fungal contamination and eye bank-prepared endothelial keratoplasty tissue: Temperature-dependent risk factors and antifungal supplementation of optisol-gentamicin and streptomycin. JAMA Ophthalmol 2017;135:1184-90.

24. Kunimoto DY, Das T, Sharma S, Jalali S, Majji AB, Gopinathan U, *et al*. Microbial spectrum and susceptibility of isolates. Part I. Post-operative endophthalmitis. Am J Ophthalmol 1999;128:240-2.

25. Jindal A, Pathengay A, Khera M, Jalali S, Mathai A, Poppuru RR, *et al*. Combined ceftazidime and amikacin resistance among Gram negative isolates in acute postoperative endophthalmitis: Prevalence, antimicrobial susceptibility, and visual acuity outcome. J Ophthalmic Inflamm Infect 2013;3:62.

26. Yousfi H, Ranque S, Rolain JM, Bittar F. *In vitro* polymyxin activity against clinical multi drug resistant fungi. Antimicrob Resist Infect Control 2019;8:66.