Changing Demographic Trends, Indications and Clinical Outcomes of Keratoplasty: An Observational Study from a Tertiary Care Centre

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Abstract

Background: Corneal blindness has been significant cause of visual impairment in developing countries. The definitive surgical intervention for restoring vision or preserving globe integrity in advanced corneal disease. Institutional outcome analysis is essential to understand regional disease patterns and surgical results.

Objectives: To evaluate the demographic profile, clinical indications and postoperative outcomes of keratoplasty performed at a tertiary care centre.

Materials and Methods: This hospital-based observational study included patients undergoing keratoplasty for 18-months. Demographic details, clinical indications, type of keratoplasty, pre and postoperative visual acuity, graft clarity, central corneal thickness, postoperative complications were recorded. Patients followed for 6 months. Statistical analysis performed using SPSS, with $p \leq 0.05$ considered significant

Results: A total of 75 patients were included. As our eye bank is new, included number of patients are limited. The majority were aged 51–60 years (26.7%), with male predominance (60%) and rural/semi-urban residence (61.3%). Infective keratitis was the most common indication (37.3%), followed by corneal scarring (24%).Optical penetrating keratoplasty (37.3%) and therapeutic penetrating keratoplasty (36%) were the most frequently performed procedures. At six months 36.7% achieved best-corrected visual acuity ≥ 6/60 ($p < 0.001$) Clear or near-clear grafts (Grades 3–4) were observed in 67.7% of cases Graft failure occurred in 19.1%, predominantly in therapeutic and tectonic keratoplasty ($p = 0.002$)

Conclusion: Keratoplasty provides meaningful anatomical and functional visual improvement particularly for optical indications. Therapeutic and tectonic keratoplasty remain essential for globe preservation but associated with poorer outcomes. Early referral, improved postop compliance are crucial to improving results.

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Introduction

Vision plays a central role in an individual's quality of life, independence, and socioeconomic productivity. Good vision is essential for education, employment, mobility, and social interaction, and visual impairment can have profound psychological and economic consequences for both the individual and society. Among the various ocular structures, the cornea is vital for maintaining a clear visual axis and contributes nearly two-thirds of the eye's total refractive power. Its transparency and regular curvature are crucial for optimal visual acuity. Corneal diseases remain a major cause of preventable and treatable blindness

worldwide, particularly in developing countries such as India, where access to timely eye care may be limited. When medical therapy fails or irreversible corneal damage occurs, keratoplasty becomes an essential surgical option for restoring vision or, in severe cases, for preservation of the globe. [1, 2]

Corneal blindness continues to impose a substantial burden on public health systems, especially in low- and middle-income countries. In India, it is one of the leading causes of visual disability after cataract and accounts for a significant proportion of unilateral and bilateral blindness. Multiple factors such as ocular trauma, infectious keratitis, nutritional deficiencies, delayed access to ophthalmic care, harmful traditional eye practices, and poor awareness regarding eye health contribute to the high prevalence of corneal pathology. The burden is further compounded by occupational hazards and environmental factors. Many patients present at an advanced stage of disease, particularly those from peri-urban and rural areas where primary eye care services are limited or underutilized. As a result, potentially treatable corneal conditions often progress to irreversible scarring or perforation. Tertiary health care centres therefore play a pivotal role in managing advanced corneal diseases and act as referral hubs for surrounding districts. [3, 4, 5]

Demographic factors such as age, gender, occupation, place of residence, and socioeconomic status play a crucial role in determining both the indications for keratoplasty and postoperative outcomes. Younger patients commonly undergo keratoplasty for conditions such as keratoconus, congenital corneal disorders, or trauma-related corneal scars, where the goal is long-term visual rehabilitation. In contrast, older individuals are more likely to present with endothelial dysfunction, pseudophakic or aphakic bullous keratopathy, and post-surgical corneal edema.

In developed countries, endothelial disorders and keratoconus constitute the most common indications, reflecting effective management of infectious causes and earlier disease detection. In contrast, in developing regions like India, infectious keratitis, corneal scarring secondary to trauma, and ocular surface disorders continue to predominate. [6, 7]

Outcomes of keratoplasty are influenced by severity and duration of corneal disease, preoperative corneal status, associated ocular comorbidities, surgical technique employed, quality of donor tissue, and adequacy of postoperative care. Successful outcomes are not limited to graft survival alone but also encompass improvement in best-corrected visual acuity, long-term graft clarity, refractive stability, and absence of sight-threatening complications such as graft rejection, secondary glaucoma, cataract progression, or recurrent infection. [8, 9] This study aims to analyze the demographic profile, indications, and outcomes of keratoplasty performed at a tertiary health care centre in Western Uttar Pradesh. By correlating patient characteristics and clinical indications with surgical outcomes, the study seeks to generate meaningful data that can guide clinical practice, enhance patient care, and contribute to strategies aimed at reducing the burden of corneal blindness in the region.

Methods

Study Design and Setting

This is an institutional hospital-based observational study. The clinical setting comprised a Tertiary academic centre with dedicated department of ophthalmology and the study was carried for a total duration of 18 months after setting up of a newly recognized eye bank.

Study Population

All the patients undergoing keratoplasty at the institution during the study period were enrolled for the study. A total of 63 patients who underwent keratoplasty during the study period were included using universal sampling.

Ethical Considerations

Approval was obtained from the Institutional Ethics Committee prior to commencement of the study (IEC approval no. SU/R/2024/1350 [66]). Written informed consent was taken from all patients. The study adhered to the principles of the Declaration of Helsinki.

Inclusion criteria-

- All patients who were diagnosed with various corneal pathologies and underwent any of aforementioned Penetrating Keratoplasty, Anterior Lamellar or Posterior Lamellar Keratoplasty.
- All patients undergoing surgery who were willing to consent for the study.

Exclusion criteria

- Patients diagnosed with corneal pathologies and not willing for surgery or were treated with medical management.
- Patients with a history of not adhering to preoperative or postoperative care instructions, as this may distort results.
- Patients not willing to give consent for the study.

Data Collection

After obtaining informed consent, detailed data were collected using a pre-designed proforma.

A detailed and structured clinical history was obtained from each patient after securing informed written consent. Demographic details including age, gender, laterality, residence, and occupation were recorded for all patients.

Chief complaints were documented in detail, including Diminution of vision (onset, duration, progression), Pain, Redness, Photophobia, Watering, Discharge, History of corneal opacity or white spot. History of presenting illness focused on History of trauma (vegetative matter, foreign body, blunt or penetrating injury), Previous episodes of corneal infection or ulceration, Past ocular history and Systemic history was elicited to identify comorbidities that could influence graft survival and outcomes, including Diabetes mellitus, Hypertension, any Autoimmune disorders, Tuberculosis, any allergic disorders. Drug history and Personal history such as smoking, alcohol intake, and compliance with medications were also recorded. Visual acuity was assessed preoperatively and during postoperative follow-up using a standardized protocol. The distance visual acuity was measured using Snellen's visual acuity chart at a distance of 6 meters in a well-illuminated room. Ocular Examination- A comprehensive ocular examination was performed which included slit lamp examination of anterior segment and Posterior segment examination using indirect ophthalmoscopy where feasible. Corneal examination was done for Location, size, depth, and extent of corneal opacity or ulcer, nature of corneal lesion (scar, infiltrate, thinning,

perforation), presence of corneal vascularization, status of corneal epithelium, stromal involvement and depth, presence of descemetocele or corneal melt, signs of active infection. Anterior Segment Optical Coherence Tomography manufactured by Appasamy Associates, was done, the parameters measured were corneal thickness and depth of involvement, extent of stromal scarring or thinning, integrity of Descemet's membrane, presence of corneal edema, host–graft junction (postoperatively), interface quality in lamellar keratoplasty, anterior chamber depth where visible. This was useful in cases especially where examination with slit lamp was difficult due to corneal haze. Intraocular pressure measurement was done using Goldmann's Applanation tonometer, and B-scan ultrasonography in patients with opaque or hazy media was performed to evaluate the posterior segment. Baseline blood investigations were performed for all patients as part of preoperative evaluation, including: Complete blood count (CBC), Random blood sugar (RBS), Renal function tests (RFT), Liver function tests (LFT), Serological tests: HBsAg, Anti-HCV, HIV I & II, Blood grouping and Rh typing. Surgical Procedure-Keratoplasty was classified as optical, therapeutic, or tectonic penetrating keratoplasty, or lamellar keratoplasty. Procedures were performed under aseptic conditions by experienced corneal surgeons. Patients were followed up to six months. Outcomes assessed included Visual acuity improvement, Graft clarity (Grades 1–4), Graft survival or failure, Postoperative complications and central corneal thickness. All findings were meticulously recorded in the pre-designed proforma, including Preoperative clinical findings, Imaging results, Surgical details, Postoperative outcomes and complications.

Data Analysis

The data was collected and entered in MS excel 2010. Different statistical analysis was performed using Stata MP-17. The one-sample Kolmogorov – Smirnov test was employed to determine whether the data sets differed from a normal distribution or not. Normally distributed data was analyzed using parametric tests and non - normally distributed data was analyzed using non parametric tests. Descriptive statistics were calculated for qualitative and categorical variables. Graphical representation of the variable was shown to understand the results clearly and to measure the association for categorical dataset, Chi-Square test was used. Independent T-test or student t-test was applied to measure the mean difference between two groups. Correlation was estimated to measure the strength of relationship between two or more quantitative variables. If p value < 0.1, considered as statistically significant and if p-value > 0.1, then it is statistically insignificant.

Results

A total of 75 patients who underwent keratoplasty during the study period were included for analysis in the study. The demographic profile of the study population is summarized in Table 1. It can be derived that in a tertiary care setup, mostly the patients presenting with corneal pathologies who require and are undergoing surgical treatment for the same are middle aged to elderly males hailing from from rural/ semi urban areas. The reason for the same can be more external occupational exposure/ high risk occupation and gender biased role in that occupation with lack of education, awareness and external safety measures/precautions in resource limited settings.

Table 1: depicts Demographic profile of patients undergoing Keratoplasty

Age group (years)	%	Gender	%	Residence	%	Occupation	%
≤30	12.0	Male	60.0	Rural/Semi-urban	61.3	Labourer/Painter/Cook/Others	34.7
31–40	18.7	Female	40.0	Urban	38.7	Housewife	29.3
41–50	24.0					Businessman	22.7
51–60	26.7					Farmer	13.3
>60	18.6						

Most of the patients found out to be middle-aged or elderly, with the highest proportion in the 51–60-year age group (26.7%). Occupationally, Labourers (34.7%) were affected the most with Males constituting 60% of the study population, and the majority (61.3%) belonged to rural or semi-urban areas.

The distribution of clinical indications for keratoplasty is shown in Table 2. The most common indication is infective keratitis followed by corneal scarring secondary to trauma or healed ulcers attributing that the demographic profile is of working males with high risk occupations. Failed grafts constituted 16%, while bullous keratopathy and corneal dystrophies or degenerations together accounted for approximately one-fifth of cases.

Table 2: outlines the clinical indications for keratoplasty

Indication	Number (n)	Percentage (%)
Infective keratitis / corneal ulcer	28	37.3
Corneal scar (post-trauma / healed ulcer)	18	24
Failed graft	12	16
Bullous keratopathy	9	12
Corneal dystrophy / degeneration	8	10.7
Total	75	100

Infective keratitis or corneal ulcer was the most common indication (37.3%), followed by corneal scarring due to trauma or healed ulcers (24%). Failed grafts accounted for 16%, while bullous keratopathy (12%) and corneal dystrophies or degenerations (10.7%) constituted smaller proportions. This pattern reflects the continued dominance of infective and trauma-related corneal pathology in developing regions.

The types of keratoplasty performed are detailed in Table 3. The high proportion of optical and therapeutic penetrating keratoplasty reflects that most of the persons presenting to tertiary care setup are still at an advanced corneal disease or

are already complicated or not being treated at the primary level, and many of them require full-thickness grafting for visual rehabilitation or globe preservation. The relatively lower utilization of lamellar keratoplasty indicate that only carefully selected patients which are few in number fulfilled the indications for layer-specific corneal transplantation during the study period.

Table 3: Details the types of keratoplasty performed

Type of Keratoplasty	Number (n)	Percentage (%)
Optical Penetrating Keratoplasty (PK)	28	37.3
Lamellar Keratoplasty (Anterior / Posterior)	10	13.4
Therapeutic Penetrating Keratoplasty (PK)	27	36
Tectonic Penetrating Keratoplasty (PK)	10	13.3
Total	75	100

Optical penetrating keratoplasty (37.3%) and therapeutic penetrating keratoplasty (36%) were the most frequently performed procedures. Lamellar keratoplasty accounted for 13.4% of cases, reflecting selective use in appropriately indicated eyes.

The most commonly encountered complications in the study after the surgery are listed in Table 4. Majority patients had no complications (37.3%). Among those who developed complications, graft failure was the most common complication, occurring in 22.7%, followed by infection/corneal abscess in 14.7 %, secondary glaucoma/raised intraocular pressure in 13.3 %, and shallow anterior chamber in 12.0 % patients

Table 4: illustrates postoperative complications of keratoplasty

Complication	Number (n)	Percentage (%)
No complications	28	37.3
Graft failure	17	22.7
Infection / corneal abscess	11	14.7
Secondary glaucoma / raised IOP	10	13.3
Shallow anterior chamber	9	12
Total	75	100

With approximately more than 1/3rd of patients presenting with no complications followed by graft failure (22.7%). Around 14.7% of patients' eyes had infection/ corneal abscess and then secondary glaucoma and shallow anterior chamber.

Figure 1 shows the visual acuity distribution from preoperative to subsequent follow ups till the 6-month follow-up period. A progressive improvement in visual acuity was observed throughout the study. The proportion of patients achieving a best-corrected visual acuity (BCVA) of ≤1.0 logMaR increasing steadily from 18.7% preoperatively to 36.7% at six months. Improvement in visual acuity became evident from the first postoperative week and continued throughout the follow-up period, indicating continuous functional visual recovery following keratoplasty. Owing to patient attrition during follow-up, the number of eyes available for analysis decreased from 75 at baseline to 68 at six months

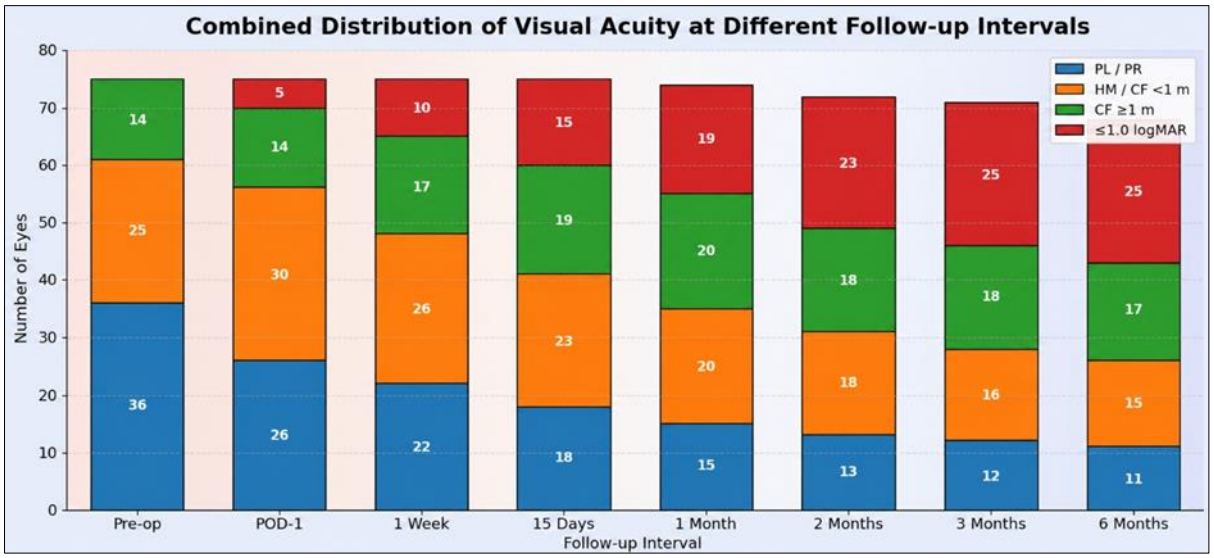

Fig 1: combined visual acuity distribution from preoperative to subsequent follow ups till the 6-month follow-up period after Keratoplasty

A progressive improvement in visual acuity was observed throughout the postoperative follow-up period. At baseline, 48.0 % eyes had visual acuity limited to perception of light (PL) or projection of rays (PR), while none achieved a visual acuity of ≤1.0 logMAR. The proportion of eyes with visual acuity ≤1.0 logMAR increased progressively from 6.7% on

postoperative day 1 to 33.3% at both 3 and 6 months. Concurrently, the number of eyes with severe visual impairment (PL/PR) decreased from 48.0% preoperatively to 14.7% at 6 months, indicating sustained postoperative visual improvement.

Figure 2 demonstrates the changes in graft clarity during the six-month postoperative follow-up. Serial improvement in graft clarity was noted throughout the follow ups. The proportion of clear grafts (Grade 4) increased steadily from 8.0% on the first postoperative day to 35.3% at six months. Similarly, Grade 3 grafts (mild haze) remained the predominant category during follow-up, accounting for 32.4% of grafts at the final visit. This shows that majority of patients recovered as expected post keratoplasty surgery as most of them were operated for optical and therapeutic clinical indications. In contrast, the proportion of Grade 2 grafts (moderate haze) decreased from 41.3% immediately after surgery to 13.2% at six months. Grade 1 grafts (failed grafts/severe haze) remained relatively stable throughout the follow-up period, graft failure at six months was observed in 19.1% of eyes. Overall, a significant shift toward higher graft clarity grades was observed during follow-up ($p < 0.001$), indicating good anatomical recovery after keratoplasty. This reflects effective surgical technique and postoperative management.

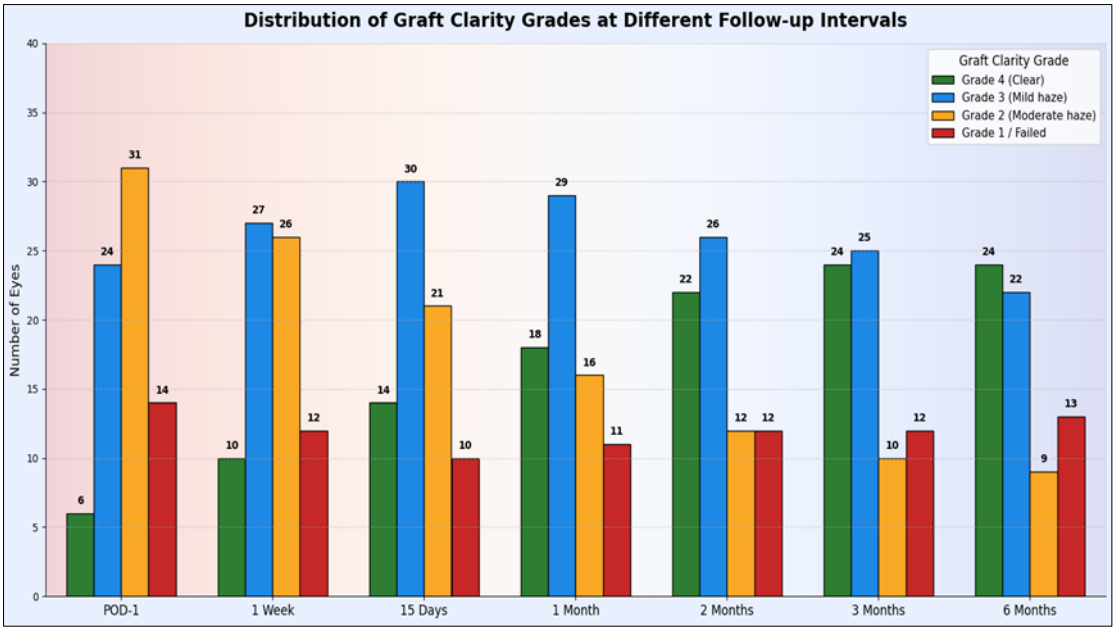

Fig 2: illustrates Distribution of graft clarity grades at different postoperative follow-up intervals after keratoplasty

Graft clarity demonstrated progressive improvement over the postoperative follow-up period. On postoperative day 1, Grade 2 (moderate haze) grafts were the most common (41.3%), followed by Grade 3 (mild haze) in 32.0% of eyes. The proportion of Grade 4 (clear) grafts increased steadily from 8.0% on postoperative day 1 to 32.0% at 3 months and remained stable at 32.0% at 6 months. Conversely, Grade 2 grafts decreased from 41.3% to 12.0% over the same period. Grade 3 grafts remained the predominant category during the early postoperative period before gradually declining, while failed grafts (Grade 1) constituted 13.3%–18.7% of cases throughout follow-up.

Figure 3 shows central corneal thickness(CCT) following surgery. An initial increase in mean Central Corneal Thickness was observed on postoperative day 1, attributable to surgical manipulation, endothelial trauma, and acute postoperative edema. Subsequently, a progressive and sustained reduction in corneal thickness was noted from 1 week onward, with maximum improvement observed by 6 months postoperatively. By the sixth postoperative month, mean CCT approached near-physiological values in a majority of eyes with clear or near-clear grafts. The reduction in corneal thickness over time was statistically significant ($p < 0.001$), indicating effective graft function and endothelial recovery. Eyes undergoing optical and lamellar keratoplasty demonstrated a more rapid normalization of corneal thickness compared to therapeutic and tectonic keratoplasty, consistent with trends reported in previous studies.

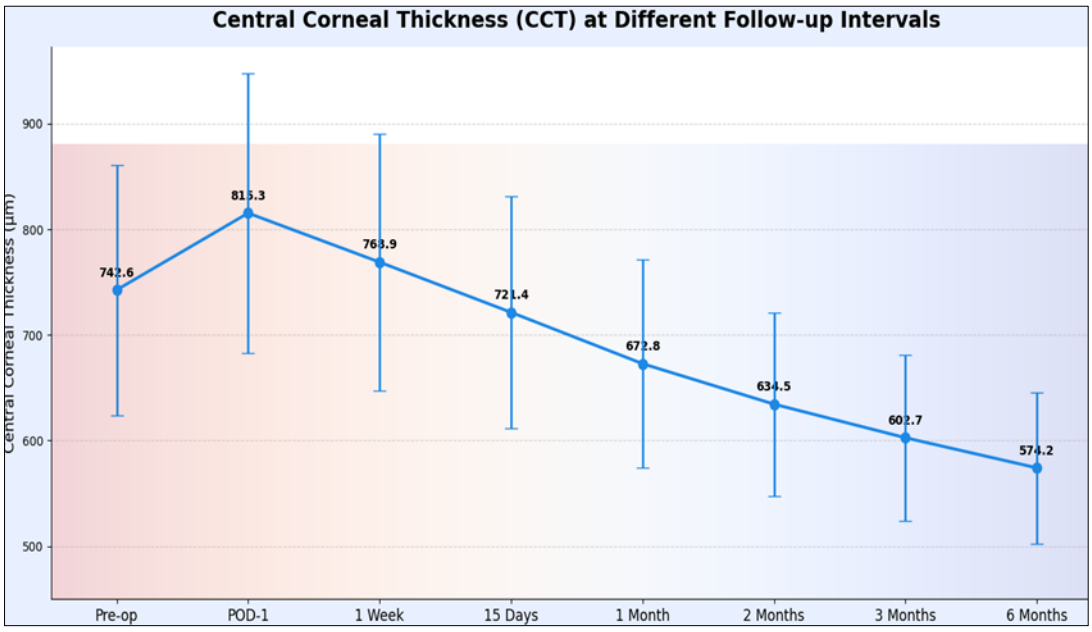

Fig 3: depicts Changes in central corneal thickness (CCT) at different postoperative follow-up intervals after keratoplasty.

The mean central corneal thickness demonstrates a progressive decline during the postoperative follow-up period. Mean CCT increased from 743.6 µm preoperatively to 815.3 µm on postoperative day 1, followed by a gradual reduction to 769.3 µm at 1 week, 721.4 µm at 15 days, 673.8 µm at 1 month, 633.5 µm at 2 months, 602.7 µm at 3 months, and 574.2 µm at 6 months. The greatest postoperative corneal thickness was observed on the first postoperative day, after which a consistent decrease was noted throughout the follow-up period.

Discussion

The present study evaluated the demographic profile, indications, surgical patterns, and outcomes of keratoplasty performed at a tertiary health care centre in Western Uttar Pradesh, reflecting real-world challenges in a developing country setting where late presentation and infective corneal pathology remain common. [10, 11, 12]

Most patients were middle-aged or elderly, with the highest proportion in the 51–60-year age group. This age distribution is consistent with Indian studies reporting cumulative corneal damage due to infection, trauma, endothelial dysfunction, and failed grafts over time. [13, 14] Male predominance and a higher representation from rural and semi-urban areas were observed, likely reflecting increased occupational exposure, delayed access to specialized care, and health-seeking barriers documented in earlier studies. [15, 16]

Infective keratitis was the most common indication for keratoplasty in the present study, followed by corneal scarring. This pattern mirrors findings from several Indian studies where microbial keratitis continues to be the leading cause of corneal blindness requiring transplantation. [14, 17] In contrast, studies from developed regions report endothelial disorders and keratoconus as predominant indications, reflecting regional differences in disease burden and healthcare accessibility.[6, 7]

Optical penetrating keratoplasty and lamellar keratoplasty together accounted for approximately half of the procedures, while therapeutic and tectonic keratoplasty constituted a substantial proportion. This reflects advanced disease at presentation, where the primary objective is globe preservation rather than visual rehabilitation. Similar trends have been reported in Indian tertiary care centres managing severe infectious keratitis. [2, 17]

Visual acuity showed a statistically significant improvement over the follow-up period, with more than one-third of patients achieving BCVA ≥6/60 at six months. Visual outcomes were significantly better in eyes undergoing keratoplasty for optical indications compared to infective or therapeutic indications, emphasizing the adverse impact of preoperative inflammation, infection, and corneal vascularization on postoperative recovery. [13, 18, 19] These findings are consistent with earlier reports demonstrating gradual visual rehabilitation following keratoplasty. [20, 21]

Graft clarity improved progressively over time and showed a strong correlation with final visual outcome, reinforcing graft transparency as a key determinant of surgical success. [7, 22] Higher graft failure rates observed in therapeutic and tectonic keratoplasty are consistent with poorer prognosis in eyes with active or prior infection. [14, 17]

Postoperative complications were common, particularly graft failure and secondary glaucoma, findings that have been well documented in eyes undergoing keratoplasty for infective indications. [17, 18] Central corneal thickness demonstrated gradual normalization over time, indicating recovery of graft function, particularly in optical and lamellar keratoplasty. [20] Loss to follow-up increased during the study period, reflecting socioeconomic and logistical barriers frequently encountered in tertiary care settings. [15, 19]

Strengths of this study

- This study shows real world keratoplasty data from a tertiary level institution whereas the patients it is serving are generally coming/ being referred from area of primary level healthcare. This helps to target the group of people frequently affected at primary level only, leading to less delay in diagnosis and treatmentof disease. Thus, reducing number of complications which arise when patient ultimately reaches the tertiary level of institution.
- Most of the previous studies evaluate only visual acuity or graft survival or type of keratoplasty individually but

this study assessed all these together under single umbrella, making it easier to compare and assess different clinical scenarios.
- Same patients were evaluated at multiple postoperative follow up visits (POD-1, 1 week, 15 days, 1 month, 2 months, 3 months, and 6 months), allowing assessment of the trend in visual recovery and graft clarity rather than a single endpoint
- There is limited published data from Western Uttar Pradesh/NCR on keratoplasty patterns. This study provides region-specific epidemiological information that may help in planning corneal services.
- Inclusion of different lamellar keratoplasty procedures reflects contemporary clinical practice and broadens the applicability of the findings.

Limitations of this study
- Results may sometimes not be applicable to other far away institution in different geographical area because referral patterns, donor tissue availability, surgical expertise, and patient characteristics vary from place to place.
- As the eye bank was newly recognized, the relatively limited number of patients may reduce statistical power and limit subgroup analyses for less common indications or surgical techniques as compared to high volume load setups with old and already established eye banks
- Six months is adequate for early outcomes but insufficient to assess long-term graft survival, endothelial cell loss, chronic rejection, and late complications.
- Attrition during follow-up could introduce bias, particularly if patients with poorer outcomes were less likely to return.

Future Research Prospects
- Multicentre studies with larger sample sizes would improve the generalizability of findings and that can further be applied to more and institutions with different geographical and socio-economic areas.
- Long-term follow-up is needed to evaluate graft survival, late graft rejection, endothelial cell loss, visual stability, and long-term complications.
- Due to limited number of patients of various type of keratoplasties. Future research should compare different keratoplasty techniques (PK vs DALK vs DSEK vs DMEK) using standardized outcome measures in more depth with appropriate samples of each type.
- Studies identifying independent predictors of graft failure and poor visual outcomes could help develop prognostic models for patient counseling and individualized management.

Conclusion

Overall, the findings of the present study align closely with previous Indian and international studies and reinforce the continued dominance of infective corneal pathology as an indication for keratoplasty in developing regions. Optical and lamellar keratoplasty yield superior visual and anatomical outcomes compared to therapeutic and tectonic procedures. Early detection, prompt referral, improved public awareness, and expansion of lamellar keratoplasty services are essential to improve outcomes and reduce the burden of corneal blindness.

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