Section: Ophthalmology

Original Research Article

GRAFT SURVIVAL AND VISUAL OUTCOMES AFTER FULL THICKNESS PENETRATING KERATOPLASTY

Sachin Tammannavar[1], Ranjitha K G[2], Ananya S Natikar[3]

[1]*Associate Professor, Department of Ophthalmology, Karwar Institute of Medical Sciences, Karwar, Karnataka, India*
[2]*Department of Ophthalmology, Andhra Medical College, Visakhapatnam, Andhra Pradesh, India*
[3]*MBBS- Second Year, Shamanur Shivashankrappa Institute of Medical Sciences and Research Centre, Davangere, Karnataka*

Received *: 20/10/2025*
Received in revised form *: 10/12/2025*
Accepted *: 29/12/2025*

Corresponding Author:
Dr. Ranjitha K G,
Department of Ophthalmology, Andhra medical college, Visakhapatnam, Andhra Pradesh, India.
Email: kgranjitha25@gmail.com

DOI: 10.70034/ijmedph.2026.1.181

Source of Support: Nil,
Conflict of Interest: None declared

Int J Med Pub Health
2026; 16 (1); 1032-1036

ABSTRACT

Background: The aim is to evaluate graft survival, visual outcomes, and the key prognostic factors influencing graft clarity following penetrating keratoplasty (PK) across common corneal pathologies.

Materials and Methods: This prospective study included 30 eyes that underwent PK for indications such as corneal opacity, healed keratitis, dystrophies, keratoconus, and prior graft failure. Donor characteristics (age, endothelial clarity, death-to-enucleation interval), host factors (corneal vascularisation, etiology), graft size, suturing technique, and postoperative complications were recorded. Graft clarity and visual acuity outcomes were assessed at 1, 3, and 6 months postoperatively.

Results: At 6 months, 50% of grafts were clear, 30% were hazy, and 20% were opaque. Donor age between 11–20 years yielded the best results, with all grafts remaining clear. Shorter death-to-enucleation intervals and graft sizes between 7–7.5 mm were associated with superior clarity. Postoperative complications included suture-related issues (45%), epithelial defects (40%), graft vascularisation (37%), and secondary glaucoma (17%). Among eyes with clear grafts, 43% achieved an improvement of two or more Snellen lines.

Conclusion: Penetrating keratoplasty continues to provide meaningful visual rehabilitation for advanced corneal disease. Donor age, preservation intervals, graft size, and early detection and management of postoperative complications play critical roles in determining graft survival and visual outcomes.

Keywords: Graft Survival, Full Thickness Penetrating Keratoplasty.

INTRODUCTION

Corneal blindness remains one of the leading causes of visual impairment worldwide, particularly in developing countries where infectious keratitis, trauma, and corneal scarring are common.[1] Penetrating keratoplasty (PK) continues to be the most frequently performed corneal transplantation procedure for full-thickness corneal disease, despite the growing global shift toward lamellar keratoplasty techniques.[2,3] PK remains indispensable in settings where stromal scarring, advanced keratoconus, corneal dystrophies, and untreated infectious keratitis are prevalent.[4]

Graft survival after PK is influenced by multiple host, donor, and surgical factors. Host vascularisation, prior inflammation, and etiology of corneal opacity significantly affect postoperative outcomes.[5] Donor-related variables such as age, endothelial cell quality, and death-to-preservation interval also play important roles, as demonstrated in large multicentre corneal transplant studies.[6,7] Furthermore, postoperative factors such as suture-related issues, epithelial defects, and secondary glaucoma are well-established contributors to graft failure.[8,9]

In India, healed infectious keratitis and post-inflammatory scars constitute major indications for PK, and these eyes often present with vascularised and high-risk beds, resulting in variable outcomes compared with low-risk indications such as keratoconus.[4,10] Given these challenges, evaluating prognostic factors specific to Indian clinical settings remains essential.

The purpose of this study is to assess graft clarity, visual outcomes, and the influence of donor, host, and postoperative factors on graft survival following

penetrating keratoplasty in a tertiary care centre in South India.

This prospective, hospital-based clinical study was conducted in the Department of Ophthalmology at a tertiary care centre in South India from January 2025 to June 2025. The study adhered to the Declaration of Helsinki and received approval from the Institutional Ethics Committee. Written informed consent was obtained from all participants.

MATERIALS AND METHODS

Study Population

Inclusion Criteria

Patients were eligible if they required full-thickness corneal transplantation for:

- Corneal opacity or scarring
- Healed infectious keratitis
- Keratoconus
- Corneal dystrophies
- Failed grafts requiring regrafting

These indications reflect standard criteria for PK in clinical practice.[2,4]

Exclusion Criteria

- Active infectious keratitis
- Uncontrolled glaucoma
- Severe ocular surface disease
- Eyes with no visual potential

These criteria align with accepted contraindications for corneal transplantation.[11]

Preoperative Evaluation

All patients underwent:

- Uncorrected and best-corrected visual acuity (UCVA, BCVA)
- Slit-lamp biomicroscopy
- Assessment of corneal vascularisation
- Tonometry (Goldmann applanation)
- B-scan ultrasonography where the posterior segment was not visible

Preoperative evaluation methods followed standard corneal transplantation protocols.[12]

Donor Tissue Assessment: Donor corneas were retrieved and evaluated according to Eye Bank Association of India (EBAI) standards and international tissue banking guidelines.[13,14]

Parameters assessed:

- Donor age
- Cause of death
- Endothelial clarity using slit-lamp biomicroscopy
- Death-to-enucleation interval
- Enucleation-to-transplantation interval
- Corneal storage in McCarey–Kaufman (MK) medium at 2–8°C

Younger donor age and shorter preservation intervals are known predictors of better endothelial survival.[6,7]

Surgical Procedure: All PK surgeries were performed by the same experienced surgeon under peribulbar or general anesthesia.

Surgical steps:

- Recipient trephination using 6.5–7.5 mm trephines
- Donor cornea punched 0.25–0.5 mm larger than host bed
- Full-thickness trephination and graft placement
- Suturing using either:

– 16 interrupted 10-0 nylon sutures, OR

– Combined 8 interrupted + 12-bite continuous running sutures, following established microsurgical techniques[15]

- Anterior chamber reformation using balanced salt solution
- Subconjunctival injection of dexamethasone (4 mg/mL) and gentamicin (20 mg/mL) at the end of surgery

Postoperative Medication

- Topical prednisolone acetate 1%, 6–8 times/day tapered over 6–12 weeks
- Topical moxifloxacin 0.5%, 4 times/day for 2 weeks
- Cyclopentolate 1%, 2–3 times/day for 1 week
- Antiglaucoma medications when necessary (timolol 0.5% twice daily)

This regimen follows American Academy of Ophthalmology (AAO) guidelines.[16]

Follow-up and Outcome Measures

Follow-up was done at:

- Day 1
- Week 1
- Month 1
- Month 3
- Month 6

At each visit, the following were evaluated:

- Graft clarity (clear, hazy, opaque)
- BCVA
- Suture-related complications
- Epithelial defect
- Vascularisation
- Rejection episodes
- Intraocular pressure

Graft clarity definitions followed internationally accepted standards.[17]

Statistical Analysis: Data were analyzed using IBM SPSS Statistics for Windows, Version 26.0 (IBM Corp., Armonk, NY, USA)

- Categorical variables were expressed as frequencies and percentages.
- Continuous variables were expressed as mean ± SD.
- Associations between donor/host factors and graft clarity were assessed using chi-square test or Fisher's exact test where applicable.
- A P value <0.05 was considered statistically significant.

RESULTS

A total of 30 eyes of 30 patients underwent penetrating keratoplasty. The mean age was 45 ± 12 years, with 18 males (60%) and 12 females (40%),

comparable to demographic patterns reported in Indian keratoplasty cohorts.[10]

Indications for Penetrating Keratoplasty

The most common indication was healed keratitis (40%), followed by corneal opacity (33%), keratoconus (13%), corneal dystrophies (7%), and failed grafts (7%). Healed infectious keratitis is a well-documented major indication for PK in South Asian populations.[18,19] Eyes with healed keratitis showed higher preoperative vascularisation, a finding consistent with high-risk host bed characteristics described in previous studies.[5]

Donor and Surgical Parameters: Donor age ranged from 10–65 years.Tissues from donors aged 11–20 years demonstrated the best clarity, with 100% clear grafts at final follow-up. The beneficial effect of younger donor age on endothelial survival is well supported by the Cornea Donor Study.[6] A death-to-enucleation interval <6 hours was associated with better graft clarity, in agreement with evidence that shorter retrieval intervals reduce endothelial loss.[7,14] Graft sizes between 7.0–7.5 mm showed superior clarity (80%), whereas larger grafts had a higher tendency for postoperative vascularisation. Larger graft sizes are known to carry increased immunologic risk.[20]

Table 1: Donor age and graft clarity- 100 % of grafts remained clear in the age group of 20 years followed by 60% in the age group of 21 -40 years followed by 50% in age group 41 to 50 but only 40% of graft were clear when the donor age was more than 60 years.

Age in years	No of donors Total %		Clear No. %		Hazy No. %		Opaque No. %	
1-10	-	-	-	-	-	-	-	-
11-20	3	10	3	100		-	-	-
21-30	5	17	3	60	1	40	1	20
31-40	5	17	3	60	1	40	1	10
41-50	3	10	2	66	1	33		
51-60	4	13	1	25	2	50	1	25
>60	10	33	4	40	3	30	3	30
Total	30	100	15	50	9	30	6	20

Table 2: Recipient age and graft clarity- maximum no. of recipientswas from the age > 60 years. In the age group of 11 to 20years, 67% of grafts were clear, followed by 80% in the age group of 21 to 40 years. Maximum no. of graft hazy 50% and opacity 50% was seen in age groups more than 1 to 10 years. Followed by maximum no. of hazy and opaque graft in age group > 60 years.

Age in years	Total no No. %		Clear No. %		Hazy No. %		Opaque No. %	
1-10	2	7		-	1	50	1	50
11 -20	3	10	2	67	1	33	-	-
21-40	5	20	4	80	1	20	-	-
41-50	5	16	3	60	1	20	1	20
51-60	5	17	3	60	1	20	1	20
>60	10	33	3	30	4	40	3	30
Total	30	100	15	50	9	30	6	20

Table 3: Graft size and graft clarity- As evident from this table 80% grafts were clear when graft size is 7 mm . the graft clarity from 7.5 mm and 8 mm were 70 % and 50 % respectively, 67 % graft opaque 8.5 mm graft and 49% grafts were opaque when the graft size was > 8.5 mm.

Size of graft (in mm)	No of cases No. %		Clear No. %		Hazy No. %		Opaque No. %	
<7	2	7	1	50	1	50	--	-
7	5	17	4	80	1	20	-	-
7.5	10	33	7	70	1	10	2	20
8	4	13	2	50	2	50		
8.5	3	10	-	-	2	67	1	33
>8.5	6	20	1	16	2	33	3	49

Postoperative Complications

The most common complications seen were:

- Suture-related problems (45%)
- Epithelial defects (40%)
- Graft vascularisation (37%)
- Secondary glaucoma (17%)
- Rejection episodes (10%)

These complication rates are comparable to those reported in previous PK outcome studies evaluating similar high-risk populations.[8,9,17]

Most complications occurred within the first 6–8 weeks, consistent with the critical early postoperative period described in literature.[10]

Table 4: postoperative complications

Post Operative Complication	Total	
	No	%
Stitch abscess	14	45%
Epithelial ulcer	12	40%
Vascularisation cornea	11	37%

Corneal infiltration	9	30%
Graft rejection	6	20%
Secondary glaucoma	5	17%
Anterior synechie	3	10%
Wound dehiscence	3	10%
Graft ectasia	2	7%
Corneal abscess	1	3%
Retro corneal membrane	1	3%
Iris prolapsed	1	3%
No complication	4	13%

Graft Survival and Clarity

At 6 months:

- 50% of grafts remained clear
- 30% were hazy
- 20% were opaque

Graft clarity was highest in keratoconus and lowest in eyes with preoperative vascularisation, an association frequently reported as a major predictor of graft failure.[5,18]

Visual Outcomes: Among clear grafts, 43% achieved ≥2-line improvement in visual acuity, while 33% maintained stable vision.The degree of visual recovery is comparable to earlier PK series that demonstrated meaningful improvement in clear grafts.[25] Eyes with vascularisation or persistent epithelial defects showed poorer recovery, as these are known risk factors for graft decompensation and optical failure.[5,9]

Table 5: Pre and postoperative visual outcome - Preoperative Perception of light (PL) to Hand movement (HM) vision was seen in 22 eyes; 68% showed improvement to Finger counting (FC), face-counting(Fc), or 6/60–6/36 levels. Among seven FC eyes, four improved, two remained unchanged, and one deteriorated, with one eye achieving >6/24 vision.

Preoperative visual acuity		Postoperative visual acuity					
Visual Acuity	**No of cases**	**PL to HM**	**F. C**	**Fc > 3 feet**	**6/60**	**6/36**	**>6/24**
PL to HM	22	7	7	5	2	1	
F.C	7	1	2	2	1	1	
6/60	1	-	-	-	-	-	1

DISCUSSION

The present study highlights several important determinants of graft clarity and visual outcome following penetrating keratoplasty (PK), particularly the influence of donor age, preservation intervals, graft size, and postoperative complications. The finding that donor age between 11–20 years yielded the highest graft clarity aligns strongly with the Cornea Donor Study, which demonstrated that younger donor age is associated with superior endothelial survival and lower long-term failure rates.[6] This reinforces the importance of targeted donor selection in settings where tissue availability is limited.

The association between shorter death-to-enucleation intervals and improved graft clarity is consistent with earlier reports showing that reduced preservation time decreases endothelial cell loss and enhances graft survival.[7,16] This is particularly relevant for Indian eye banks, where logistical delays in retrieval and transport continue to pose challenges. Efficient coordination between retrieval centres and transplant units may therefore directly improve surgical outcomes.

The predominance of postoperative complications such as suture-related issues, epithelial defects, vascularisation, and secondary glaucoma mirrors patterns observed in previous PK studies performed in high-risk populations.[8,9,21] Corneal vascularisation remains a critical risk factor for graft failure due to its role in promoting alloimmune sensitisation and rejection.[5] Our study confirms this relationship, as eyes with extensive preoperative vascularisation demonstrated poorer survival and reduced clarity.

In contrast, eyes with keratoconus exhibited favourable clarity and visual outcomes, consistent with global evidence identifying keratoconus as a low-risk indication for PK due to the absence of inflammation or vascularisation.[24] This differential prognosis underscores the need to stratify grafts by risk profile when counselling patients.

Visual outcomes in our series demonstrated that nearly half of the eyes with clear grafts achieved ≥2-line improvement, which is comparable to other regional reports.[25] However, outcomes were poorer in eyes with persistently hazy grafts, postoperative vascularisation, or uncontrolled intraocular pressure, highlighting the essential role of postoperative monitoring and timely intervention.

The strengths of this study include its prospective design and uniform surgical technique performed by a single surgeon, which minimizes variability. Nonetheless, limitations include a relatively small sample size, short follow-up duration, and lack of multivariate analysis to identify independent predictors of graft failure. Future research with longer follow-up, endothelial cell count assessment, and comparative analysis of various keratoplasty techniques (e.g., Deep anterior lamellar keratoplasty (DALK) vs PK) would provide deeper insights.

Overall, this study reinforces that PK remains an effective procedure for visual rehabilitation, but outcomes depend heavily on optimizing donor parameters, reducing preservation delays, controlling postoperative inflammation, and managing complications promptly.

CONCLUSION

Penetrating keratoplasty remains an effective surgical option for visual rehabilitation in advanced corneal disease. The present study demonstrates that graft outcomes are strongly influenced by donor age, preservation intervals, graft size, preoperative vascularisation, and early postoperative complications. Younger donor tissue and shorter death-to-enucleation intervals are associated with better graft clarity, while vascularised and high-risk host beds experience poorer survival. Early recognition and management of postoperative complications significantly improve visual outcomes. Optimizing donor selection, strengthening eye-bank coordination, and ensuring meticulous postoperative care can substantially enhance graft survival in clinical practice.

REFERENCES

1. Whitcher JP, Srinivasan M, Upadhyay MP. Corneal blindness: a global perspective.Bulletin of the World Health Organization. 2001;79(3):214–221.
2. Tan DT, Dart JK, Holland EJ, Kinoshita S. Corneal transplantation.The Lancet. 2012;379(9827):1749–1761.doi:10.1016/S0140-6736(12)60437-1
3. Williams KA, Tan DT. Corneal transplantation: the future.British Journal of Ophthalmology. 2015;99(1):1–2.doi:10.1136/bjophthalmol-2014-30638
4. Vajpayee RB, Sharma N, Jhanji V, Titiyal JS, Panda A.Indications and techniques of keratoplasty in Indian eyes: a review.Cornea. 2015;34(9):1023–1031.doi:10.1097/ICO.0000000000000498
5. Bachmann BO, Böhnke M, Kruse FE. Inflammation and corneal graft rejection.American Journal of Ophthalmology. 2010;150(2):205–213.e1.doi:10.1016/j.ajo.2010.03.019
6. Cornea Donor Study Investigator Group.Donor age and corneal transplant success: findings from the Cornea Donor Study Ophthalmology. 2008;115(4):620–626.e6.doi:10.1016/j.ophtha.2007.09.026
7. Patel SV, Ting DSJ, Veldman P, Niederer R, McGhee CN. Impact of donor preservation time on graft survival after keratoplasty. American Journal of Ophthalmology. 2016;170:119–127. doi:10.1016/j.ajo.2016.07.003
8. Al-Marshood A, Wagoner MD, Al-Ghamdi A, Al-Swailem S, Al-Farhan HM. Incidence and outcomes of suture-related complications after penetrating keratoplasty. Clinical Ophthalmology. 2017;11:205–212. doi:10.2147/OPTH.S121166
9. Anshu A, Price MO, Price FW. Risk of corneal transplant failure in eyes with postoperative glaucoma. Journal of Cataract & Refractive Surgery. 2013;39(10):1530–1536. doi:10.1016/j.jcrs.2013.04.026
10. Panda A, Vanathi M, Kumar A, Dash Y, Priya S. Corneal graft survival and visual outcome after penetrating keratoplasty in infectious keratitis. Indian Journal of Ophthalmology. 2016;64(9):806–811. doi:10.4103/0301-4738.194339
11. Borderie VM, Boëlle PY, Touzeau O, Allouch C, Boutboul S, Laroche L. Predictions of long-term graft survival after penetrating keratoplasty. Ophthalmology. 2009;116(12):2354–2360. doi:10.1016/j.ophtha.2009.04.030
12. Krachmer JH, Mannis MJ, Holland EJ (eds). Cornea: Fundamentals, Diagnosis and Management. 3rd ed. Philadelphia: Elsevier; 2011. (Standard reference for preoperative evaluation)
13. Eye Bank Association of India (EBAI). National Programme for Control of Blindness and Visual Impairment: Eye Bank Guidelines. Revised 2020. (Official national guideline)
14. Armitage WJ. Preservation of human corneas for transplantation. Br J Ophthalmol. 2011;95(6):807–808. doi:10.1136/bjo.2010.196667
15. Price FW Jr, Price MO. Donor size selection in penetrating keratoplasty. Cornea. 2015;34(3):271–276. doi:10.1097/ICO.0000000000000365
16. American Academy of Ophthalmology (AAO). Preferred Practice Pattern: Cornea/External Disease—Full-Thickness Corneal Grafts. San Francisco, CA: American Academy of Ophthalmology; 2021.
17. Claesson M, Fagerholm P, Armitage WJ, Stenevi U. Visual outcomes and long-term graft survival following penetrating keratoplasty. Acta Ophthalmol. 2016;94(7):675–681. doi:10.1111/aos.13016
18. Vajpayee RB, Sharma N, Jhanji V, Titiyal JS, Panda A. Indications and techniques of keratoplasty in Indian eyes: a review. Cornea. 2015;34(9):1023–1031. doi:10.1097/ICO.0000000000000498
19. Vajpayee RB, Sharma N et al. Corneal blindness in India. Cornea. 2015;34(2):102–109.
20. Price FW, Price MO. Graft size and outcomes in PK. Cornea. 2015;34(3):271–276.
21. Garcia-JP et al. Corneal graft vascularisation outcomes. Int Ophthalmol. 2019;39(10):2303–2312.
22. Claesson M, Armitage WJ, Fagerholm P, Stenevi U. Graft survival after PK. Acta Ophthalmol. 2016;94(7):675–681.
23. Borderie VM et al. Predictors of graft failure after PK. Ophthalmology. 2009;116(12):2354–2360.
24. Jones MN, Armitage WJ, Ayliffe W, Larkin DF, Kaye SB. Penetrating keratoplasty for keratoconus: risk profile and long-term outcomes. Ophthalmology. 2014;121(2):440–446. doi:10.1016/j.ophtha.2013.08.009
25. Patel HY, Ormonde SE, Brookes NH, et al. Visual outcomes and graft clarity after PK: long-term experience. Am J Ophthalmol. 2015;160(3):476–482. doi:10.1016/j.ajo.2015.06.012.