Original Article

Intraoperative optical coherence tomography-guided donor corneal tissue assessment and preparation

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Purpose: To evaluate the role of intraoperative optical coherence tomography (i-OCT) in donor grading, selection, and preparation during different types of keratoplasty. **Methods:** Seventy-one consecutive donor corneas collected over 6 months, after clinical grading, were observed by an experienced corneal surgeon under an i-OCT equipped microscope. The donor preparation (manual/automated) for different types of keratoplasty procedures was also undertaken under i-OCT. **Results:** The mean central corneal thickness of optical and nonoptical grade tissues was 533 ± 19 and 662 ± 52 µm, respectively. The i-OCT-based grading matched with clinical grading in 98.5% cases. Irregular thickness, anterior stromal hyperreflectivity, and previous scars were appreciated in 1.4, 1.4, and 7.04% donors, respectively. During Descemet stripping automated endothelial keratoplasty, i-OCT facilitated selection of appropriate microkeratome head for automated donor preparation in all cases, besides allowing manual dissection of partially dissected lenticule, identification of site of inadvertent perforation, and eccentric trephination in one case each. During Descemet membrane endothelial keratoplasty, i-OCT-based assessment of preexisting scar (five cases) guided careful tissue selection (2/5) and preparation. During predescemetic endothelial keratoplasty, precise needle advancement allowed successful type-1 bubble formation in all cases. All manually punched donors demonstrated an extra endothelial ledge, while those with automated preparation showed tapering donor margins. **Conclusion:** i-OCT might serve as a useful imaging tool for objective assessment of donor characteristics. The modality may complement clinical evaluation for donor grading, selection, and preparation.

Key words: Donor cornea, DMEK, DSAEK, i-OCT, lenticule

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Corneal transplant is the most common and the most successful human organ transplant worldwide.[1] Donor tissue selection and preparation play a crucial role in the anatomical and functional success of any keratoplasty procedure. Routinely, donor cornea tissues are subjectively graded on a slit-lamp biomicroscope as optical and nonoptical grade based on epithelial, stromal, and endothelial characteristics outlined by corneal donor study.[2-4] The objective assessment of endothelial cell status by means of specular microscopy techniques specially designed to assess donor corneal endothelium complement this subjective grading. Once the grading process is complete, selected donor tissues are prepared for transplantation, commonly under a conventional ophthalmic microscope. Microscope-integrated optical coherence tomography (i-OCT) is a recent addition to the armamentarium of corneal surgeons.[5,6] The equipment provides real-time high-resolution, cross-sectional images of the surgical site during intraoperative maneuvers and plays a valuable role in enhancing the surgical success of different types of corneal transplant procedures.[5] However, most of the studies have discussed the benefits of this modality during recipient manipulation and only a few studies have focused on its utility in donor cornea maneuvering.

Presently, we describe our observations noted when this device was employed for donor tissue selection and preparation for different types of keratoplasty at our center.

Methods

This observational study was approved from the ethics committee of the tertiary care institute and adhered to the Declaration of Helsinki. A written informed consent was obtained from all donor families for surgical and academic use of the donor tissues.

The institute is equipped with an Eyebank that procures (hospital retrieval and voluntary donation) and stores its own donor tissues. After serological testing by trained personnel, the procured tissues are graded by experienced corneal surgeons as optical and nonoptical grade tissues. Donor tissues for both full thickness and lamellar keratoplasties are freshly prepared by the operating surgeon immediately before surgery.

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All consecutive donor corneas collected within 6 months from the onset of the study were graded independently by an experienced corneal surgeon (RA) based on the donor eligibility criteria formulated by the cornea donor study. Optical grade tissues were selected for penetrating keratoplasty (PKP), Descemet's stripping automated endothelial keratoplasty (DSEAK), Descemet's membrane endothelial keratoplasty (DMEK), and pre-Descemet's endothelial keratoplasty (PDEK) and nonoptical grade tissues for reserved for automated anterior lamellar keratoplasty (ALK), deep anterior lamellar keratoplasty (DALK), and tuck-in lamellar keratoplasty (TILK). All tissues were used within 24 h of procurement.

Each selected donor was placed on a Teflon block with its endothelial side up and reexamined under aseptic precautions by another blinded corneal surgeon (NS) under the guidance of i-OCT equipped microscope (OPMI LUMERA 700 and RESCAN 700, Carl Zeiss, Germany). A note down of qualitative features such as epithelial integrity, stromal clarity, and Descemet membrane (DM) folds and quantitative features such as stromal thickness and its distribution and depth and extent of DM folds were made after evaluation, and this was matched with the prior clinical grading (All the donors need to be routinely placed on Teflon block during their preparation at our center as they are freshly prepared by the operating surgeon immediately before surgery, the only added step being examination of these tissues under an i-OCT equipped microscope. This does not carry any extra risk of contamination as the imaging modality is noncontact and noninvasive).

For PKP, the donors were directly punched with a disposable hand-held trephine (Nanoedge corneal trephines, Madhu Instruments, India), while for DALK, the endothelium was scraped off before trephination. For ALK and DSAEK, the donor corneas were mounted on an artificial anterior chamber (AAC, Moria Inc, Doylestown, PA), their thickness was remeasured, and microkeratome head of suitable size was selected to prepare a desirous lamellar graft.[7] For TILK, the donor was secured on AAC and marked with an 8 mm trephine.[8] Following this, the peripheral anterior stroma was dissected manually up to one-third of its thickness to create a 360° partial thickness peripheral flange. The TILK and DSAEK grafts were then transferred to a Teflon block with their endothelial side up and trephined to obtain the final graft of the required size. The dissected donor tissues were reassessed after trephination for their margins and thickness. The DMEK and PDEK donor scrolls were prepared manually under the guidance of the i-OCT microscope according to the techniques described by Basak *et al*. and Sharma *et al*.[9,10]

Results

Donor tissue grading and selection

A total of 71 tissues were included in the study. The distribution of tissues was as follows: 47 optical grade tissues (for 10 PKP, 20 DSEAK, 13 DMEK, 4 PDEK) and 24 nonoptical grade tissues (for 8 automated ALK, 15 DALK, 1 TILK). The mean age, central corneal thickness, and specular count of the optical and nonoptical grade tissues was 43.02 ± 12.95 years, 533 ± 19 µm, and 2382 ± 125 cells/mm^2 and 73.29 ± 9.11 years, 662 ± 52 µm, and 1142 ± 242 cells/mm^2, respectively. All nonoptical grade tissues were noted to have disrupted epithelium, increased donor thickness, and DM folds extending more than one-third of stromal thickness, while the optical grade tissues demonstrated an intact epithelium, compact stroma, and minimal to absent DM folds. The i-OCT-based grading matched with clinical grading in all but one cases where a clinically labeled optical grade tissue was downgraded to nonoptical grade due to increased thickness (690 µm). One optical grade donor was irregularly thick and one showed presence of anterior stromal hyperreflectivity that was missed clinically. Five optical-grade tissues depicted corneal scar from prior intraocular surgery that corroborated with clinical findings. Three of these tissues were utilized for PKP due to the scar approaching the paracentral cornea, and the remaining two were employed for DMEK.

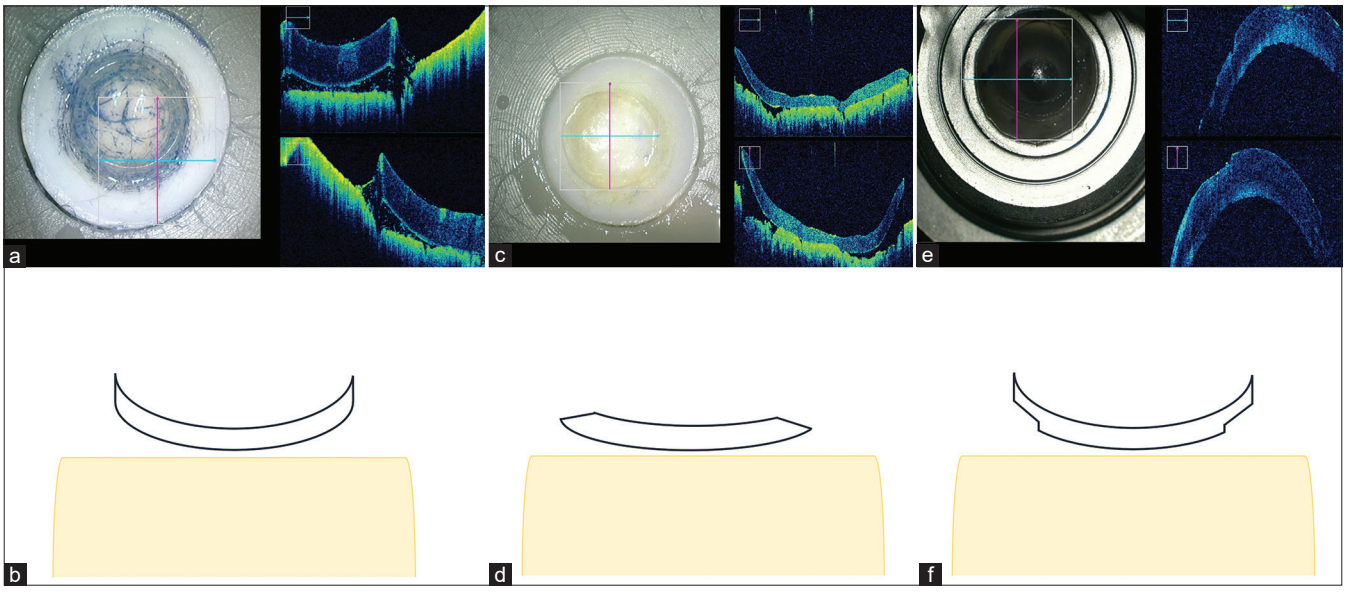

Figure 1: Endothelial ledge after manual punching in PKP donor (a and b), tapering donor margins of automated ALK tissue (c and d), and peripheral flange of TILK donor (e and f)

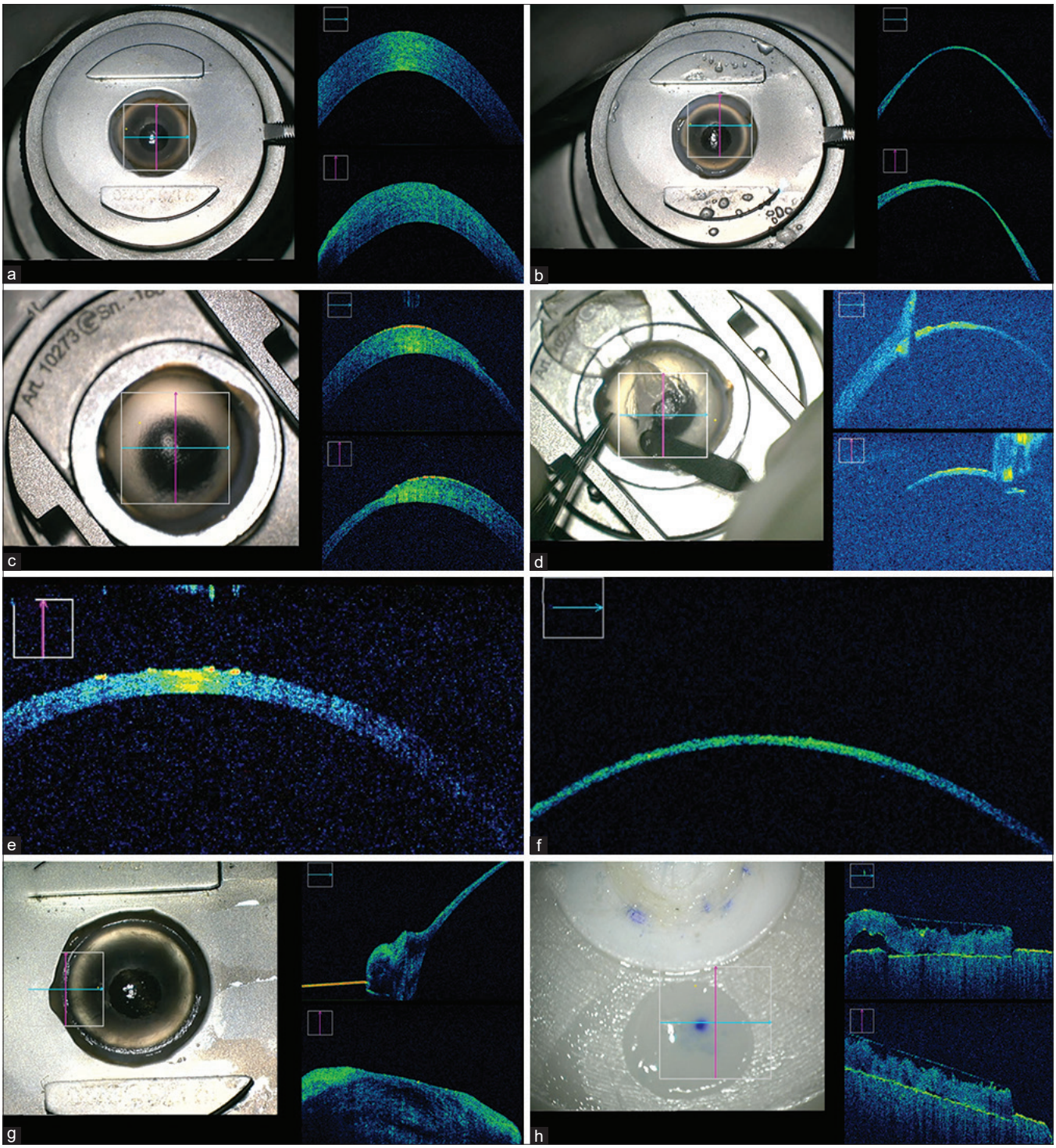

Figure 2: DSAEK donors; asymmetrical donor thickness before and after dissection (a and b); thick lenticule before and after second pass (c and d) partial automated dissection (e) completed manually with lamellar dissector (f) and donor margins before and after punching with hand-held trephine (g and h)

Donor tissue preparation

PKP

The trephine size ranged from 7 to 7.75 mm. After trephination, an extra endothelial ledge [Fig. 1a and b] was noted in all donors (10/47). In all cases, i-OCT confirmed the presence of punched donors on the Teflon block.

ALK

The mean donor thickness before and after automated dissection for ALK was 630 ± 46 and 250 ± 59 μm, respectively. These anterior lamellar donors demonstrated tapering margins [Fig. 1c and d], while donors punched for DALK demonstrated extra endothelial ledge similar to PKP donors.

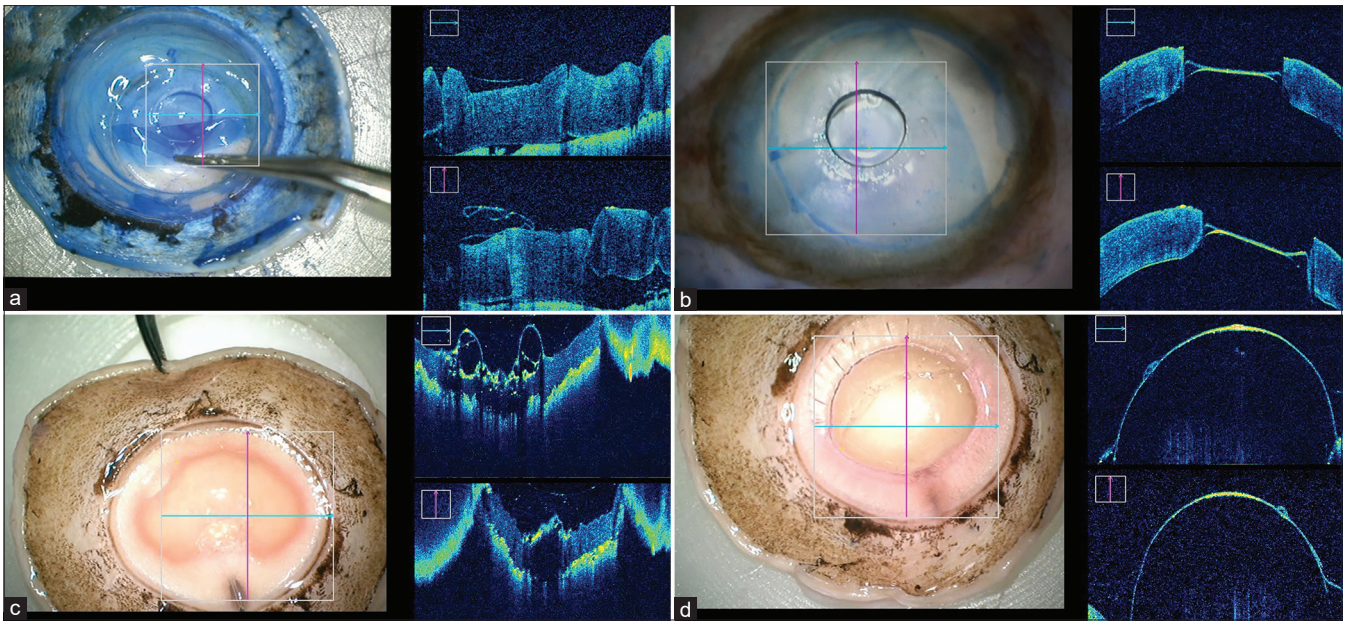

Figure 3: DMEK graft: full-thickness stromal punch for S-marking (a and b); PDEK graft: multiple air bubble formation (c) followed by successful type 1 big bubble formation in the same tissue (d)

During donor preparation for TILK, the i-OCT constantly guided the depth of manual dissection and allowed the formation of a 450 µm thick uniplanar peripheral flange [Fig. 1e and f].

DSAEK

The mean central donor thickness before and after dissection was 537 ± 15 and 82.5 ± 10 µm, respectively. The i-OCT allowed objective assessment of central donor thickness and its distribution in all four quadrants. One tissue was found to be asymmetrically thick [Fig. 2a and b]. In one case with partial automated dissection, i-OCT guided a smooth and uniplanar manual dissection of the residual donor tissue [Fig. 2c and d]. In one case with inadvertent perforation of donor tissue during dissection, i-OCT aided in visualization of perforation site as peripheral, thereby guiding an eccentric trephination, hence preventing tissue wastage (the site was also visible on naked eye examination with flowing air into the AAC and watching where the air escapes from). Similarly, i-OCT demonstrated asymmetric thickness in one lenticule, thereby guiding an eccentric trephination, hence providing a uniformly thick lenticule. In one case where the donor lenticule was 280 µm thick, i-OCT favored a successful second pass to yield an ultrathin lenticule (80 µm) [Fig. 2e and f].

The trephine size ranged from 7.25 to 8.0 mm. After trephination, all lenticules had a concavo–convex shape with a larger endothelial surface area and sharp margins [Fig. 2g and h].

DMEK

The site of adhesions at preexisting scar was well visualized on i-OCT in two donor tissues, and this guided careful DM peeling in these areas thereby preventing loss of donor tissue. The depth and completeness of the stromal punch made for placing S-mark and the type of scroll formed after complete peeling of DM (single roll, double roll or flat role) were also confirmed in all cases [Fig. 3a and b].

PDEK

The depth of the needle, as well as orientation and direction of the bevel, could be well appreciated on i-OCT. In one case where multiple air bubbles were formed, the presence of Type -1 big bubble could be well appreciated on i-OCT, thereby allowing precise advancement of the needle for a successful bubble expansion. During donor excision with scissors, few residual adhesions were identified in one case which were then severed successfully under guidance of i-OCT [Fig. 3c and d].

Discussion

It can be seen in the present study that i-OCT-assisted evaluation of donor tissue characteristics such as epithelial integrity, stromal thickness, and degree and depth of DM folds matched and complemented routine clinical grading. Real-time imaging of other details such as small superficial corneal opacities and irregular donor thickness and the site and extent of previous scars allowed optimal redistribution of donor tissues to appropriate surgeries, thus facilitating effective utilization of precious donor tissues thereby minimizing their wastage.[11]

For numerous years, endothelial cell count has been the single-most objectively measurable donor corneal characteristic. However, recently, the importance of stromal thickness in donor tissue grading and in predicting graft rejection and graft survival is being actively investigated. Previous studies have potentiated the benefits of anterior segment optical coherence tomography (ASOCT) for the routine analysis of donor corneal tissues. In contrast to ultrasonic pachymetry, ASOCT is a noncontact and minimally observer-dependent procedure that allows dynamic visualization of entire donor cornea without any indentation or additional stress on the donor endothelium, thereby providing more repeatable measurements which can be better correlated with postoperative readings.[12] While i-OCT works on a similar principle, it does not require additional custom adaptors, glass phials, or plastic viewing chambers

necessary for ASOCT-based measurements and therefore circumvents unnecessary tissue manipulation or risk of contamination. Objective assessment of stromal thickness by i-OCT may also reduce the chances of interobserver discrepancy in tissue grading, especially in centers where tissues are procured and prepared themselves.[2-4] We believe that large comparative studies employing this modality in the future may pave way for formulation of standard objective criteria for grading of donor corneas on the basis of stromal thickness. However, in addition to its cost and restricted availability, i-OCT-based grading is limited by the inability of the tool to directly analyze donor endothelial cell details such as their anatomy and function. Therefore, i-OCT can be presently best employed as a complementary and not as a supplementary tool for donor cornea evaluation.

Kobayashi *et al*.[13] have previously employed i-OCT for evaluating donor details such as precut lines, defects, and detritus on the endothelial surface in precut DSAEK donors and concluded that transoperative OCT was an excellent alternative to observe the state of the donor tissue. In the present study, we have utilized this modality during the preparation of donor corneas for different types of keratoplasties. During lamellar surgeries, i-OCT-based measurement of corneal thickness in different quadrants facilitated selection of an appropriately sized microkeratome head, thereby preventing inadvertent tissue perforation.[14] Once dissected, tissue details such as flap/lenticule thickness, curvature, and margins could also be assessed conveniently on this modality. The high-definition cross-sectional images obtained on this modality also guided a uniform, and uniplanar manual dissection of the donor during TILK, and in partially dissected DSAEK lenticules. These findings are important as a nonuniform donor thickness profile may influence the definitive refractive outcome of a graft.[15] Although not undertaken in our study, we believe that detailed imaging of donor margins on i-OCT can also facilitate appropriate host preparation for best apposition of graft–-host junction, thus minimizing the risk of wound leak, step formation, and astigmatism in the postoperative period.

A major limitation of the present study was its observational nature, lack of controls for comparison, and nonextrapolation of i-OCT-based observations to postoperative clinical outcomes. Further larger long-term multicenteric randomized controlled trials are therefore required to vividly elucidate the role of i-OCT in this donor cornea grading, selection, and preparation and its effects on clinical outcomes.

Conclusion

To conclude, i-OCT might complement clinical evaluation for donor grading, selection, and preparation. Ophthalmic centers equipped with this imaging modality may employ it routinely for donor assessment and preparation during all types of keratoplasty procedures.

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Conflicts of interest

There are no conflicts of interest.

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