Intraoperative OCT-Assisted DMEK: 14 Consecutive Cases

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Purpose: To describe the utility of a new intraoperative optical coherence tomographer (OCT) to evaluate endothelio-Descemet graft orientation during Descemet membrane endothelial keratoplasty (DMEK) procedures.

Methods: Prospective, observational, and single-center pilot case series including 14 eyes of 14 patients consecutively scheduled for DMEK surgery. After injecting the graft into the anterior chamber, the graft orientation was assessed with the help of anterior segment OCT. The surgical time and unfolding time were measured. The postoperative measurements included best-corrected visual acuity, central pachymetry, and specular microscopy at 1 month.

Results: Using the OCT images, it was possible to evaluate the graft orientation in all cases. The mean unfolding time was 6.1 ± 3.0 minutes, the mean best-corrected visual acuity was 0.3 ± 0.3 logarithm of the minimum angle of resolution, the mean decrease in central pachymetry was 213 ± 177 μm, and the mean central endothelial cell count was 1906 ± 319 cells per square millimeter.

Conclusions: Live intraoperative OCT is useful to visualize and assess graft orientation in DMEK surgery. It enables faster graft positioning with less graft manipulation in the presence of severe corneal edema.

Key Words: DMEK, OCT, live OCT, lamellar keratoplasties

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Keratoplasty techniques have evolved tremendously in recent decades.[1,2] Anterior and posterior lamellar keratoplasties have replaced penetrating keratoplasty in most cases. For stromal diseases with a normal endothelium, deep anterior lamellar keratoplasty nowadays represents the procedure of choice to preserve the recipient endothelium and limit the rejection risk.[3] For endothelial diseases, Descemet membrane endothelial keratoplasty (DMEK) has proven to provide the fastest and best visual acuity compared with other keratoplasty techniques.[2,4–6] However, both anterior and posterior keratoplasty techniques (deep anterior lamellar keratoplasty and DMEK) have a slow learning curve that limits the rapid adoption of the technique.[7] In DMEK, in addition to graft preparation, the unfolding of the graft in the correct orientation is often difficult.[8] Different surgical techniques were developed to evaluate the graft orientation perioperatively. However, inverted grafts are still reported mainly during the learning curve.[8,9] We previously described a technique that enables the graft orientation to be confirmed in the early postoperative period using optical coherence tomography (OCT).[10] The curling properties of Descemet membrane permit the evaluation of the graft orientation. More recently, spectral domain OCTs were coupled to a surgical microscope to allow direct perioperative visualization of the different structures of the eyes.[11,12] Using the intraoperative OCT integrated into a surgical microscope (RESCAN 700; Carl Zeiss Meditec), the objective of our study was to describe the ability of this new intraoperative OCT to evaluate endothelio-Descemet graft position and orientation during DMEK procedures.

PATIENTS AND METHODS

A prospective, observational, single-center pilot case series was performed at the Rothschild Foundation, Paris. Consecutively scheduled adult patients for DMEK surgery were included. No exclusion criteria were applied. The surgical procedures were performed under general or locoregional anesthesia by 1 surgeon (A.S.) following a previously described technique.[1] All endothelio-Descemet rolls were prepared in the operating room at the time of the surgery by the scuba technique and colored with Vision Blue (D.O.R.C. International). The graft size varied from 8 to 8.5 mm depending on the recipient's corneal size and the disease. After stripping the endothelio-Descemet from the recipient's cornea (Fig. 1A), the donor roll was sucked into a dedicated injector (Geuder, Heidelberg, Germany) (Fig. 1B) and injected inside the anterior chamber. The graft orientation was then assessed by turning on the anterior segment OCT and focusing on the graft.

The graft was unrolled with a no-touch technique, and the anterior chamber was completely filled with an air bubble to maintain the graft adherence to the posterior stroma (Fig. 1C). After 30 minutes, the air bubble was reduced to 70% of the anterior chamber. The patient was allowed to leave the operating room but was asked to maintain a lying position for the next 4 hours.

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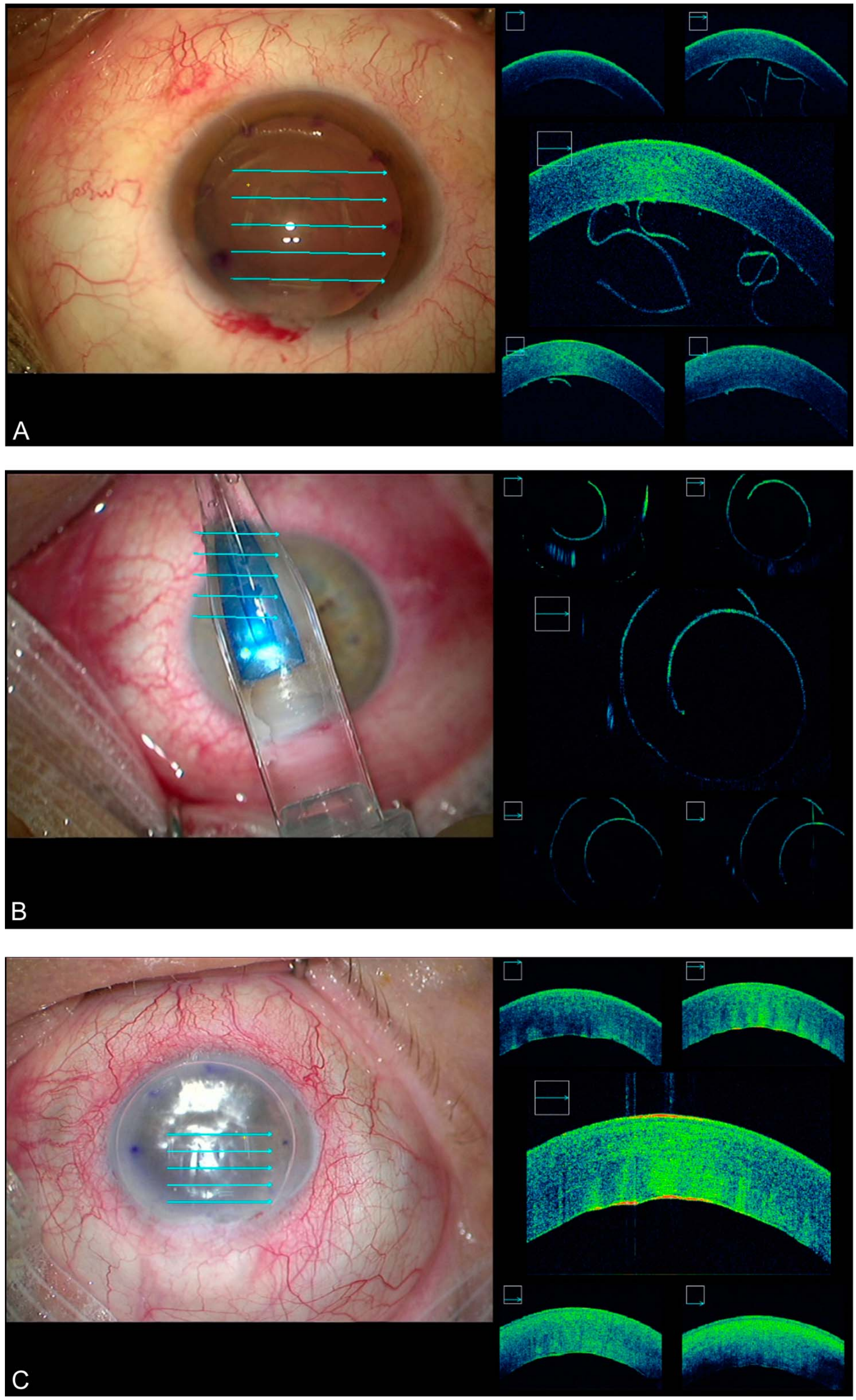
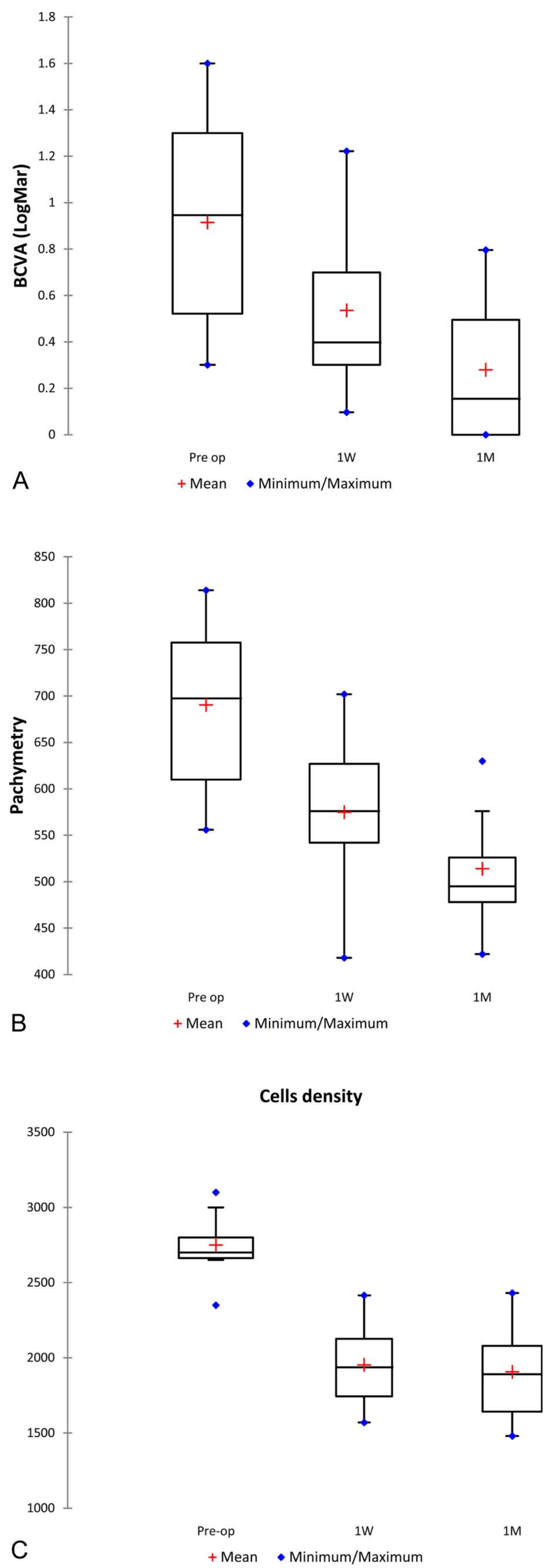


FIGURE 1. A, Descemet stripping visualized by OCT images. B, Attached graft without fluid interface between the graft and the posterior stroma. C, Assessment of the graft orientation inside the dedicated injector (Geuder).

All surgical procedures were recorded and the surgical time and unfolding time were also assessed. Postoperative measurements included best-corrected visual acuity (BCVA), central pachymetry (Visante OCT; Zeiss, Oberkochen, Germany), and specular microscopy (Nidek, Gamagori, Japan). Approval from the institutional review board was obtained and the study was conducted in accordance with the ethical principles established in the Declaration of Helsinki.



RESULTS

Fourteen eyes of 14 patients undergoing DMEK were included in the study. Six patients had Fuchs endothelial dystrophy, 2 patients had endothelial failure in a penetrating graft for keratoconus, 3 had pseudophakic bullous keratopathy, and 3 had endothelial failure after multiple previous intraocular surgeries. The mean age was 61 ± 13 years, ranging from 42 to 83 years. The mean donor age was 67 ± 7 years. Three patients had combined phacoemulsification and DMEK procedures (see Table, Supplemental Digital Content 1, http://links.lww.com/ICO/A274).

In all cases, the graft orientation was correctly evaluated by using the OCT images. The mean unfolding time was 6.1 ± 3.0 minutes. At 1 month, the mean BCVA was 0.3 ± 0.3 logarithm of the minimum angle of resolution (Fig. 2A), the mean central pachymetry was 514 ± 59 μm (Fig. 2B), and the mean decrease in central pachymetry was 213 ± 177 μm. The mean central endothelial cell count was 1906 ± 319 cells per square millimeter (Fig. 2C). One patient needed rebubbling at 1 week for peripheral detachment and all grafts were well attached at 1 month. One patient presented a recurrence of preexisting cystoid macular edema. No other complications were reported.

DISCUSSION

We found that live intraoperative OCT is useful to visualize and assess graft orientation in DMEK surgery. In all cases, OCT images were acquired with enough quality to assess graft orientation, and thus our findings confirm the previous study of Steven et al[11] but with a different system, as we used a commercially available spectral domain OCT embedded in the microscope (Rescan; Zeiss). This system has an 840-nm central wavelength that performed 27,000 A scans per second. Intraoperative OCT imaging included recording of high-resolution videos and images of 5-μm axial resolution.

Even in complicated cases associated with major corneal edema (see Table, Supplemental Digital Content 1, http://links.lww.com/ICO/A274, cases 1, 5, 8, 13) (Fig. 3, case 13; Fig. 4, case 1), in which direct visualization of the graft was compromised, the OCT images facilitated the graft orientation evaluation. This permits the avoidance of additional graft manipulation to confirm graft orientation. Case 13 (Fig. 3) had a graft decompensation caused by an anterior chamber intraocular lens. The bullous keratopathy was complicated by epithelial keloid and stromal neovascularization. The primary etiology was corneal decompensation, and so to limit the rejection risk, we decided to perform DMEK surgery first and then evaluate the recovery.

OCT images also allowed the surgeon to confirm graft rotation in the event that the graft was primarily in the wrong orientation (Figs. 5A–C). Montsouris described a very useful

FIGURE 2. A, Box plots representing the BCVA (logarithm of the minimum angle of resolution) preoperative at 1 week and at 1 month. B, Box plots representing the central pachymetry preoperatively, at 1 week and at 1 month. C, Box plots representing the cell density (cells/mm^2) postoperatively, at 1 week and at 1 month.

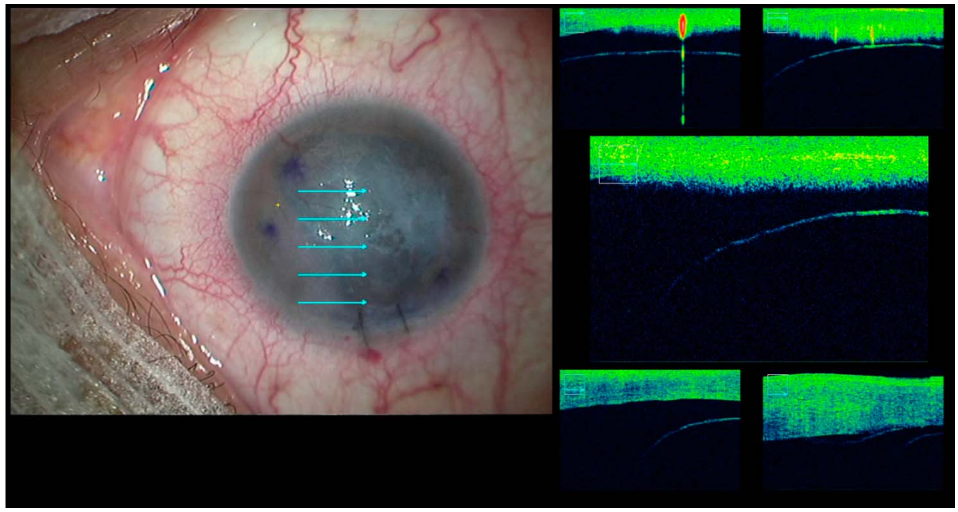


FIGURE 3. Case 13: Graft wrongly oriented in the anterior chamber (edge of the graft rolling toward the anterior chamber) visualized by the OCT images in the presence of severe corneal edema.

technique to evaluate graft orientation inside the anterior chamber. However, this technique needs the insertion of an instrument inside the endothelio-Descemet roll and may in some cases lead to contact with the graft.[13] In addition, in advanced corneal edema, this technique may be difficult to perform. For the identification of anterior–posterior orientation, Bachmann et al[14] used a 1-mm trephine to excise 3 semicircles at the margin of the endothelial–Descemet membrane layer. The clockwise order of the trephined marks changes whether the graft is in the correct orientation or not. However, the area removed by trephining the marks from the edge of the endothelial–Descemet membrane layer accounts for approximately 2.5% of the total graft area that results in the loss of a small number of endothelial cells.

In 3 of our cases, graft orientation was very difficult to assess without the help of anterior segment OCT because of severe corneal edema impairing acceptable visualization of the anterior chamber. Such cases might be indicated for Descemet stripping automated endothelial keratoplasty surgery if live OCT is not available. The ability to evaluate graft position and orientation with live OCT despite severe corneal edema might help to expand DMEK indications.

The OCT was directly linked to the microscope and its image could be visualized on a screen connected to the surgical microscope and located inside the right ocular of the surgeon. The external monitor was used to evaluate the graft orientation. The scan areas could be modified using the microscope pedals that easily make the images readily available without long manipulations. Indeed, the graft unfolding time was fast: 6.1 ± 3.0 minutes. The time was measured from the graft insertion inside the anterior chamber up to the injection of the air bubble in the anterior chamber and included the time needed to look at and evaluate the OCT images. As a comparison, the unfolding time of the previous 14 cases with similar surgical indications performed by the same surgeon without this technology was 8.9 ± 4.5 minutes. It was previously shown that the tendency of the graft to scroll was related to the donor's age.[11] Our series of procedures only included donors aged 59 years and older and the unfolding time was not related to the donor age in this case series.

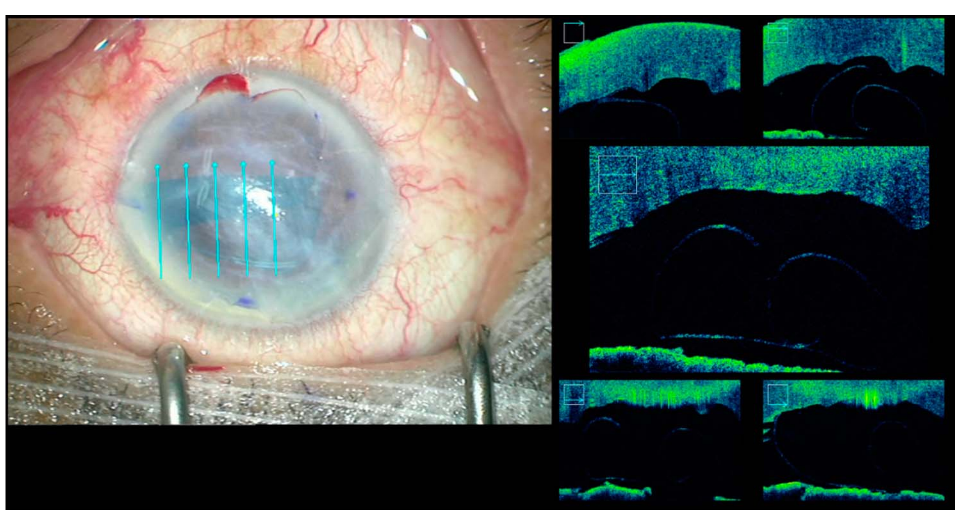


FIGURE 4. Case 1: Graft in the correct orientation (edge of the graft rolling toward the posterior stroma) visualized by the OCT images in the presence of severe corneal edema.

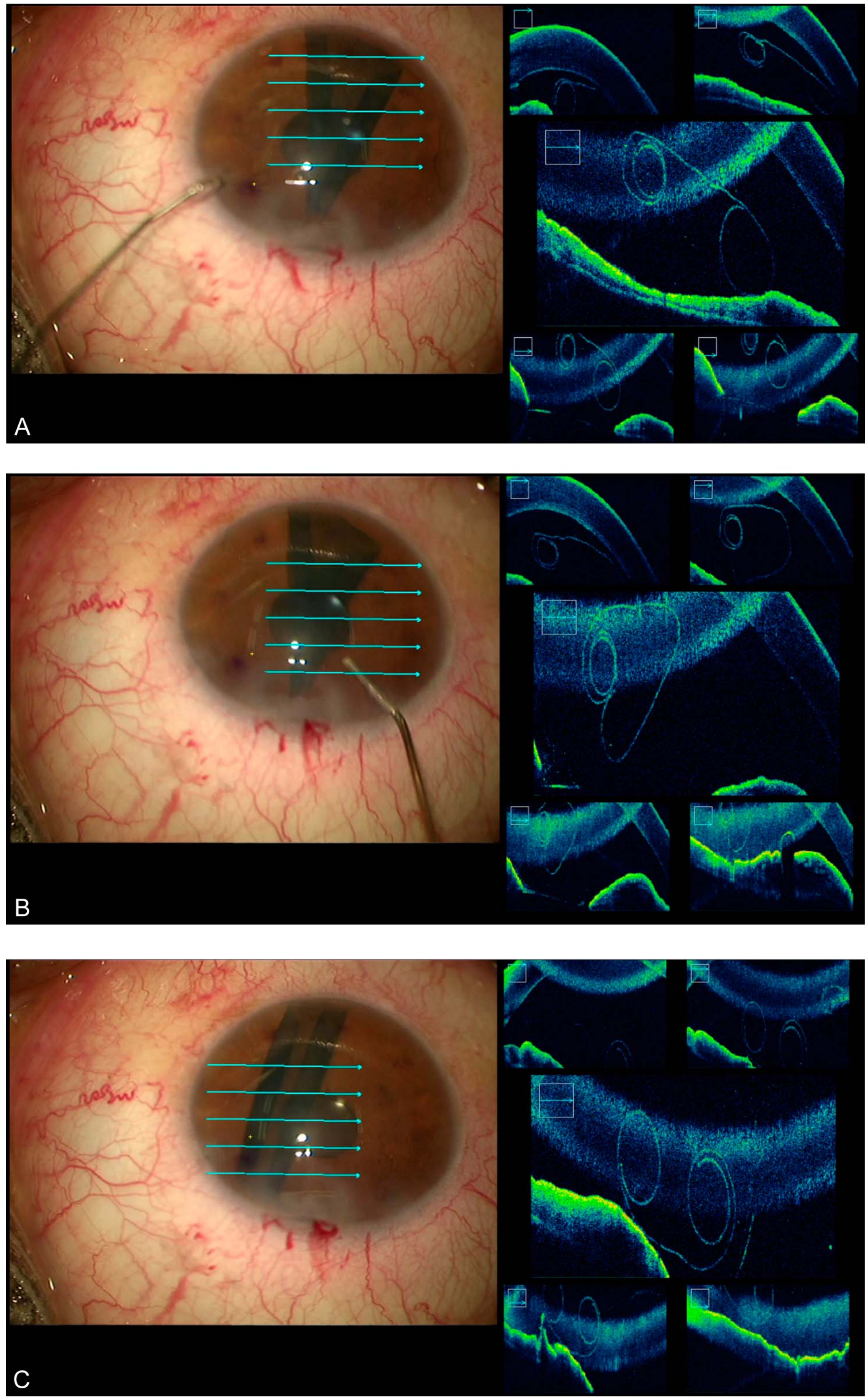


FIGURE 5. A, Graft wrongly oriented. B, Injection of balanced salt solution at one border of the graft to rotate it. C, Graft in the correct orientation.

All patients except 1 (see Table, Supplemental Digital Content 1, http://links.lww.com/ICO/A274, case 9: Cystoid Macular Edema) improved their BCVA significantly (Fig. 1). The postoperative BCVA at 1 month in patients with no other comorbidities was 0.1 ± 0.1 logarithm of the minimum angle of resolution. Endothelial cell counts revealed 1906 cells per square millimeter at 1 month, which is slightly higher than what was found by Parker et al[15] and Bachman et al[14] in their series. However, in 5 cases, specular microscopy measurements were not possible; this reduces the validity of this finding. This report objectivizes the benefits of live OCT images for posterior lamellar corneal surgery. In the presence of severe corneal edema, live OCT images might allow for faster graft positioning with less graft manipulation. We suppose that this might preserve endothelial cells but this needs to be proven in a larger series.

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