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Evaluating DSAEK Graft Deturgescence in Preservation Medium after Microkeratome Cut with Optical Coherence Tomography

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Abstract

Purpose—To evaluate the DSAEK graft deturgescence in preservation medium after microkeratome cut using Fourier-domain optical coherence tomography (FD-OCT).

Methods—The central and peripheral thickness of DSAEK graft was measured by FD-OCT immediately after microkeratome cuts as well as 1 hour, 2 hours, 3 hours, and 4 hours afterwards. All measurements were taken when the grafts were stored in 4°C preservation medium. The hourly change in central graft thickness and graft shape (peripheral – central graft thickness) was calculated and tracked over time.

Results—Five DSAEK grafts were measured. The average central graft thickness was 188.7 $\mu\text{m} \pm 44.4\mu\text{m}$ (range: 146 μm ~ 255 μm) immediately after microkeratome cuts. The average central graft thickness was 147.5 $\mu\text{m} \pm 33.0\mu\text{m}$ (range: 116 μm ~ 190 μm) after 4 hours in preservation medium ($p < 0.001$). The average hourly change in central graft thickness was -30.5 μm ($p = 0.0051$), -8.6 μm ($p = 0.055$), -2.0 μm ($p = 0.42$) and 0.0 μm ($p = 0.93$) at 1 hour, 2 hours, 3 hours, and 4 hours after microkeratome cuts. The average hourly change in graft shape was insignificant.

Conclusion—DSAEK grafts become thinner after microkeratome cut and stabilize at about 2 hours. Therefore, DSAEK graft thickness should be measured at 1.5 – 3 hours after microkeratome cut.

Introduction

Descemet's stripping automated endothelial keratoplasty (DSAEK) has become an attractive alternative to full-thickness penetrating keratoplasty for endothelial dysfunction because of its faster visual recovery, lower risk of wound complications, and more predictable refractive outcome.^{1, 2} Many surgeons in the United States have been using pre-sectioned posterior lamellar tissue from eye banks to simplify the procedure.³ During eye bank preparation, the donor cornea is positioned on an artificial anterior chamber and sectioned by a trained eye bank technician using a microkeratome. Thickness measurements are necessary after sectioning. However, it is necessary to standardize the timing of thickness measurement because of the graft thickness change after microkeratome cut resulting from corneal deturgescence.

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Optical coherence tomography (OCT) provides high-resolution, cross-sectional images of internal biological microstructures. It was first used by ophthalmologists to image the retina⁴ and then more recently the anterior segment.⁵ OCT has proven to be a useful tool in evaluating different eye bank tissue processing techniques for lamellar keratoplasty⁶ and optimizing the thickness of corneal grafts prepared by microkeratome.⁷

In this study, we examined the utility of FD-OCT as a tool in evaluate the DSAEK graft deturgescence in preservation medium after microkeratome cut.

Materials and Methods

Consecutive DSAEK grafts prepared at Lions Vision Gift (formally the Lions Eye Bank of Oregon) were included in the study. The corneoscleral rims were immersed in Optisol-GS (Bausch & Lomb, Irvine, CA) inside a corneal viewing chamber (Krolman, Boston, MA) throughout the measurement process.

OCT Scanning of Corneas with Anterior Stromal Pathology

The DSAEK grafts were scanned with the RTVue FD-OCT instrument (Optovue, Inc, Fremont, CA). The RTVue scan rate was 26,000 axial scans per second with 5 μm resolution. The corneoscleral disk was scanned through the transparent window of the corneal viewing chamber which was held in place by a custom-built attachment. (Figure 1)

The OCT scan pattern consists of 8 evenly-spaced radial scans. Each radial scan is 8mm in length. On each radial scan, central and peripheral graft thickness was measured at the 1mm ring and 5mm ring respectively (Figure 2). The measurements from 8 meridians were averaged to get central and peripheral graft thickness.

Results

Five DSAEK grafts were measured. The average central graft thickness was $188.7 \mu\text{m} \pm 44.4 \mu\text{m}$ (range: $146\mu\text{m} \sim 255\mu\text{m}$) immediately after microkeratome cuts. The average central graft thickness was $147.5 \mu\text{m} \pm 33.0 \mu\text{m}$ (range: $116\mu\text{m} \sim 190\mu\text{m}$) after 4 hours in preservation medium ($p < 0.001$, Figure 3). The average hourly change in central graft thickness was $-30.5 \mu\text{m}$ ($p = 0.0051$), $-8.6 \mu\text{m}$ ($p = 0.055$), $-2.0 \mu\text{m}$ ($p = 0.42$) and $0.0 \mu\text{m}$ ($p = 0.93$) at 1 hour, 2 hours, 3hours, and 4 hours after microkeratome cut (Figure 4). The average hourly change in graft shape was insignificant (Table 1). The graft shape variation is the smallest at 2-3 hours after microkeratome cut (Figure 4).

Discussion

Recent years have seen a marked increase in the use of lamellar surgery techniques that selectively replace damaged corneal layers while preserving healthy tissue.^{8,9} The ideal endothelial keratoplasty graft would have a thin, planar profile with equal thickness at the center and periphery. Many corneal surgeons want precise graft thickness measurement from the eye bank. There have been many studies relating the visual outcome of corneal lamellar surgeries to the graft thickness though the topic is still controversial.¹⁰⁻¹³ One possible reason for the controversy may be errors in graft thickness measurement. Therefore, accurately measuring the thickness of each donor cornea could provide valuable information for surgeons and for future studies. In the current study, we evaluated corneal deturgescence in preservation medium after microkeratome cut by using anterior segment OCT. Our results suggest that the central graft thickness reaches it steady state after 2 hours in in preservation medium.

Beside graft thickness, the shape of the graft may also affect the refractive outcome. For example, the natural meniscus shape of the endothelial graft may be related to hyperopic shift after endothelial keratoplasty^{9, 14, 15}. Accurate graft shape measurement may be helpful to improve our understanding of the mechanism behind the refractive shift after endothelial keratoplasty. In this study, we found there is no difference in the deturgescence rate between the central and peripheral cornea which makes the change in graft shape insignificant. However, the variation in graft shape is smallest at 2-3 hours after microkeratome cut.

The likely source of tissue swelling after microkeratome cut is the irrigation of the interface with balanced salt solution (BSS) to ensure no debris is present prior to replacing the cap. During tissue dismount, the BSS cascades over the cornea as it is removed from the anterior chamber, which causes even more swelling in the absence of an epithelium which is typically removed during processing. There are numerous techniques of tissue dismount, epithelial removal, and backing solutions (or lack of one), so the effects of tissue thinning may be different in other circumstances.

The main limitation of the study is the small sample size. In addition, the cornea's position in the cradle of the viewing chamber is not fixed: the cornea can shift slightly when the chamber is moved, making exact alignment difficult. We used the average thickness over the 1mm diameter ring to obtain central graft thickness to minimize the error. The slight mismatch in the refractive index of the preservation medium and cornea will also introduce error in corneal thickness measurement.

In conclusion, DSAEK grafts become thinner after microkeratome cut and stabilize at about 2 hours. Therefore, DSAEK graft thickness should be measured at approximately 2 hours after microkeratome cut.

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References

1. Chen ES, Terry MA, Shamie N, et al. Precut tissue in Descemet's stripping automated endothelial keratoplasty donor characteristics and early postoperative complications. *Ophthalmology*. 2008; 115(3):497–502. [PubMed: 18221999]
2. Price FW Jr, Price MO. Descemet's stripping with endothelial keratoplasty in 200 eyes: Early challenges and techniques to enhance donor adherence. *J Cataract Refract Surg*. 2006; 32(3):411–8. [PubMed: 16631048]
3. Rose L, Briceno CA, Stark WJ, et al. Assessment of eye bank-prepared posterior lamellar corneal tissue for endothelial keratoplasty. *Ophthalmology*. 2008; 115(2):279–86. [PubMed: 17599413]
4. Huang D, Swanson EA, Lin CP, et al. Optical coherence tomography. *Science*. 1991; 254(5035): 1178–81. [PubMed: 1957169]
5. Izatt JA, Hee MR, Swanson EA, et al. Micrometer-scale resolution imaging of the anterior eye in vivo with optical coherence tomography. *Arch Ophthalmol*. 1994; 112(12):1584–9. [PubMed: 7993214]
6. Brown JS, Wang D, Li X, et al. In situ ultrahigh-resolution optical coherence tomography characterization of eye bank corneal tissue processed for lamellar keratoplasty. *Cornea*. 2008; 27(7): 802–10. [PubMed: 18650667]
7. Tang M, Ward D, Ramos JL, et al. Measurements of microkeratome cuts in donor corneas with ultrasound and optical coherence tomography. *Cornea*. 2012; 31(2):145–9. [PubMed: 22157571]
8. Price FW, Price MO. Adult keratoplasty: has the prognosis improved in the last 25 years? *Int Ophthalmol*. 2008; 28(3):141–6. [PubMed: 18196207]

9. Chen ES, Terry MA, Shamie N, et al. Descemet-stripping automated endothelial keratoplasty: six-month results in a prospective study of 100 eyes. *Cornea*. 2008; 27(5):514–20. [PubMed: 18520497]
10. Shinton AJ, Tsatsos M, Konstantopoulos A, et al. Impact of graft thickness on visual acuity after Descemet's stripping endothelial keratoplasty. *Br J Ophthalmol*. 2012; 96(2):246–9. [PubMed: 22028474]
11. Van Cleynenbreugel H, Remeijer L, Hillenaar T. Descemet stripping automated endothelial keratoplasty: effect of intraoperative lenticule thickness on visual outcome and endothelial cell density. *Cornea*. 2011; 30(11):1195–200. [PubMed: 21926566]
12. Neff KD, Biber JM, Holland EJ. Comparison of central corneal graft thickness to visual acuity outcomes in endothelial keratoplasty. *Cornea*. 2011; 30(4):388–91. [PubMed: 21045647]
13. Terry MA, Shamie N, Chen ES, et al. Precut tissue for Descemet's stripping automated endothelial keratoplasty: vision, astigmatism, and endothelial survival. *Ophthalmology*. 2009; 116(2):248–56. [PubMed: 19091414]
14. Dupps WJ Jr, Qian Y, Meisler DM. Multivariate model of refractive shift in Descemet-stripping automated endothelial keratoplasty. *J Cataract Refract Surg*. 2008; 34(4):578–84. [PubMed: 18361978]
15. Holz HA, Meyer JJ, Espandar L, et al. Corneal profile analysis after Descemet stripping endothelial keratoplasty and its relationship to postoperative hyperopic shift. *J Cataract Refract Surg*. 2008; 34(2):211–4. [PubMed: 18242442]

Figure 1. Setup for FD-OCT imaging. The viewing chamber containing the corneoscleral disc is placed in the holding device while the cornea is scanned.

Figure 2.
Central and peripheral graft thickness measurements on a radial scan

Figure 3.
Central Graft Thickness Change in Preservation Medium

Figure 4.
Hourly change in central and peripheral graft thickness as well as graft shape

Table 1

Graft thickness changes in preservation medium

		0-1 hour	1-2 hour	2-3 hour	3-4 hour
Peripheral graft thickness (μm)	Mean $\pm$ SD	-33.0 $\pm$ 13.3	-7.9 $\pm$ 8.1	-3.7 $\pm$ 5.4	2.6 $\pm$ 5.9
	Range	-47.2 ~ -17.4	-18.2 ~ 0.2	-9.2 ~ 2.5	-3.1 ~ 9.6
	p - value	<u>0.0051</u>	0.092	0.26	0.44
Central graft thickness (μm)	Mean $\pm$ SD	-30.5 $\pm$ 11.8	-8.6 $\pm$ 7.1	-2.0 $\pm$ 5.1	0.0 $\pm$ 6.9
	Range	-40.9 ~ -12.2	-15.3 ~ 0.7	-7.5 ~ 3.0	-5.3 ~ 9.8
	p - value	<u>0.0044</u>	0.055	0.48	0.99
Graft shape $\ddagger$ (μm)	Mean $\pm$ SD	-2.5 $\pm$ 11.3	0.6 $\pm$ 6.0	-1.6 $\pm$ 2.1	2.6 $\pm$ 11.7
	Range	-15.8 ~ 10.3	-5.2 ~ 10.4	-4.0 ~ 1.1	-11.2 ~ 14.9
	p - value	0.64	0.82	0.21	0.68

 $\ddagger$ Graft shape = peripheral graft thickness - central graft thickness