Original Article

Effect of Donor Graft Thickness on Clinical Outcomes after Descemet Stripping Automated Endothelial Keratoplasty

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Abstract

Purpose: To evaluate the effects of donor graft thickness on postoperative best spectacle-corrected visual acuity (BSCVA), refractive outcomes, endothelial cell density (ECD) and function, intraocular pressure (IOP), and postoperative complications after Descemet stripping automated endothelial keratoplasty (DSAEK).

Methods: This retrospective, interventional case series enrolled 77 eyes of 64 patients who underwent DSAEK with or without simultaneous cataract surgery. Clinical outcomes, including BSCVA, refraction, keratometric astigmatism, IOP, and ECD were assessed at the final follow-up examination. Univariate analyses were used to investigate the effects of postoperative donor graft thickness on clinical outcomes and complications.

Results: The mean patient age was 62.3 ± 15.6 years, and the patients were followed for 26.2 ± 20.9 months postoperatively. The mean postoperative central graft thickness was 102.4 ± 31.6 μm. In the univariate analysis, postoperative central graft thickness was significantly associated with postoperative IOP ($P = 0.005$), central recipient thickness ($P = 0.002$), and ECD ($P = 0.016$). No significant association was found for central graft thickness with postoperative BSCVA ($P = 0.70$), spherical equivalent refraction ($P = 0.33$), keratometric astigmatism ($P = 0.27$), graft detachment ($P = 0.16$), graft decentration ($P = 0.17$), high IOP ($P = 0.53$), or endothelial rejection ($P = 0.88$).

Conclusion: This study failed to demonstrate any significant correlation between graft thickness and BSCVA. Attempting to minimize graft thickness might not have the desired outcome regarding endothelial cell density and function. Increased graft thickness could negatively impact the accuracy of IOP measurements after DSAEK.

Keywords: Clinical Outcomes; Descemet Stripping Automated Endothelial Keratoplasty; Donor Graft Thickness; Descemet Stripping Automated Endothelial Keratoplasty

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INTRODUCTION

Descemet stripping automated endothelial keratoplasty (DSAEK) is now preferred over full-thickness penetrating keratoplasty (PK) for corneal decompensation

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secondary to endothelial dysfunction. Currently, 89% of patients with Fuchs' endothelial dystrophy and 55% of patients with post-cataract corneal edema are treated with endothelial keratoplasty.[1] This selective approach has several advantages over PK in terms of faster visual rehabilitation, less surgically induced astigmatism, a lower incidence of graft rejection, and preservation of biomechanical properties.[2] Additionally, the risk of traumatic wound dehiscence is decreased by endothelial keratoplasty.[2] However, visual performance is often sub-optimal following DSAEK, and fewer patients than expected achieve best-corrected visual acuity (BCVA) of 20/20 despite healthy grafts and no ocular comorbidities.[3-6] The reasons for these visual outcomes remain unclear, with theories including sub-epithelial and anterior stromal changes, differences in graft thickness and regularity, the nature of the donor-recipient interface, and induced high order aberrations.[5-7]

There has been a great interest in whether corneal thickness plays a role in post-DSAEK visual performance, and it has been assumed that thinner grafts are better for visual outcomes and anatomic success. However, there has been no clear evidence about the effects of graft thickness on post-DSAEK visual acuity. Although a handful of studies have demonstrated correlations between better visual acuity and lower total corneal or graft thickness after endothelial keratoplasty,[8-13] many others have failed to demonstrate any significant correlation.[14-27] Because of a lack of strong evidence to support the use of thin grafts, the goal of this study was to determine the impacts of graft thickness on visual and refractive outcomes, endothelial cell loss, and postoperative complications after DSAEK.

METHODS

This retrospective, interventional case series enrolled consecutive eyes that underwent DSAEK between April 2006 and September 2015 and had clear grafts at the final follow-up examination. The patients had endothelial decompensation from Fuchs' endothelial dystrophy or pseudophakic bullous keratopathy. The diagnosis of Fuchs' endothelial dystrophy in pseudophakic eyes was attained when the unoperated fellow eye demonstrated stromal edema and central guttata. A minimum 3-month postoperative follow-up was required for inclusion in this study. The presence of other ocular comorbidities, except the indication for corneal transplantation, was a criterion for patient exclusion. In addition, none of the eyes had the accompanying risks of anterior chamber intraocular lenses, filtering blebs, or tubes. This research followed the tenets of the Declaration of Helsinki and was approved by the Institutional Ethics Committee of the Ophthalmic Research Center, which is affiliated with Shahid Beheshti University of Medical Sciences,

Tehran, Iran. Informed consent was obtained from all the participants after explaining the purpose of the study.

Donor Examinations and Preparation

All donor corneas with a qualitative grading of very good and excellent were procured from the Central Eye Bank of Iran. The donor data obtained from the Eye Bank included age and sex, cause of death, death-to-preservation time (hours), and storage time (days). Contact ultrasonic pachymetry (A/B scan; Sonomed Inc., Lake Success, NY, USA) was used to measure central corneal thickness. Precut corneal tissue was prepared on whole globes by the same eye bank using a CB-microkeratome (Moria Inc., Doylestown, PA, USA). The microkeratome head size (350 or 400 μm) was chosen based on the central donor corneal thickness. For central thickness values up to 520 μm ($n = 55$; 71.4%), the 350-μm microkeratome head was used, and for thicker donor corneas ($n = 22$; 28.6%), the 400-μm head was used. After lamellar dissection, corneoscleral buttons were separated and preserved at 4°C in Optisol medium (Optisol-GS preservative; Chiron Vision, Irvine, CA, USA). A noncontact specular microscope (Topcon SP-3000P; Topcon Corporation, Tokyo, Japan) was used to photograph the central donor corneal endothelium, and the specular photomicrographs were evaluated for endothelial cell density (ECD), mean cell area, coefficient of variation of the endothelial cell area, and percentage of hexagonal cells. The quality of the donor cornea used for transplantation was graded as very good or excellent based on the results of the specular microscopy.

Surgical Technique

All the DSAEK procedures were performed by the same surgeon (M.A.J.) under retrobulbar or general anesthesia. The central recipient epithelium was marked to outline where to strip the Descemet membrane and to place the donor tissue. The anterior chamber was filled with air through a paracentesis incision, and the recipient Descemet membrane was scored in a circular pattern under the area of the epithelial marking using a reverse Sinskey hook. The Descemet membrane and endothelium were stripped using a Descemet stripper and were removed through a 5.0-mm clear corneal incision, while the anterior chamber was formed using an anterior chamber maintainer.

The donor tissue was cut from the endothelial side using a Barron donor punch (Katena, Denville, NJ, USA) before the anterior stroma was removed. No orientation marks were made on the graft stroma. The size of the trephine selected was 3 mm less than the horizontal corneal diameter to yield the largest diameter graft possible but one that would also avoid overlap with the anterior chamber angle. The donor lamella was inserted into the anterior chamber using the pull-through technique with a Busin glide and forceps (Moria Inc.,

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Doylestown, PA, USA). An air bubble was introduced to unfold and attach the donor lamella to the posterior stromal surface. After securing the wound with interrupted 10-0 Nylon sutures, the reverse Sinskey hook was inserted from the paracentesis incision for donor centering, and the anterior chamber was filled completely with air for 10 minutes. Subsequently, the air was reduced to approximately 60% of the anterior chamber volume. No venting incisions were created in the recipient cornea. In eyes with significant lens opacity, DSAEK was combined with phacoemulsification using the divide and conquer technique and implantation of a posterior chamber intraocular lens (IOL). The power of the posterior chamber IOL was selected to have a postoperative refraction of −1.0 to −2.0 D. This target refraction was considered because the placement of a donor lenticule can cause a hyperopic shift up to 4 D. Cataract extraction was performed before the DSAEK surgery through a 2.8-mm clear corneal incision. The incision, then, was enlarged to 5.0 mm for donor graft insertion. Postoperatively, the patients rested in the supine position for 12 hours.

Postoperative Course

Postoperatively, the patients were examined at days 1, 2, 3, 7, and 30. Subsequent follow-up examinations were performed at months 3 and 6 and every 6 months thereafter. The patients had free access to the surgeon when any complications developed. Postoperatively, all the patients received topical chloramphenicol 0.5% and topical hypertonic 5% sodium chloride eye drops every 6 hours for 14 days and topical 0.1% betamethasone eye drops every 6 hours for 4 weeks, which were then tapered over 2 to 3 months based on the ocular inflammation. Pseudophakic patients were maintained on 1 steroid drop per day for the long term to prevent graft rejection. If indicated, topical lubricants were added to hasten epithelial healing. Acute endothelial rejection reactions of the corneal transplants were treated by frequent topical 0.1% betamethasone eye drops. High intraocular pressure (IOP >21 mmHg) was treated by steroid reduction and topical anti-glaucoma medications (except carbonic anhydrase inhibitors, as these may precipitate decompensation in patients with endothelial dysfunction).

Ophthalmic Examinations and Measurements

Preoperative ocular examinations included uncorrected visual acuity (UCVA) and best spectacle-corrected visual acuity (BSCVA) using a Snellen acuity chart (expressed in LogMAR notations), manifest refraction (when possible), keratometry, slit-lamp biomicroscopy, tonometry using Goldmann applanation tonometry, and dilated funduscopy. The same examinations were repeated at each follow-up examination. The preoperative and postoperative examinations and measurements

were performed at the same location with the same equipment during the study period. All the sutures were removed by the time of the final examination when confocal microscopy (Confoscan 3; NIDEK Technology, Padova, Italy) was used to measure central recipient and donor corneal thickness and endothelial cell density and morphology. The full thickness of the central cornea was scanned from the endothelium to the epithelial surface, and a maximum of 350 digital images (25 images per second) were captured with a digital video camera. Using three Z-scan graphs in each cornea, total central corneal thickness (distance between the epithelial and endothelial reflectivity peaks) and central graft thickness (distance between the interface and endothelial reflectivity peaks) were calculated and averaged. Central recipient corneal thickness was measured by subtracting graft thickness from total corneal thickness. A clear image of the endothelial layer was selected for endothelial evaluation. Automatic cell count processing within a 0.1-mm^2 standardized region of interest in the central cornea was performed to obtain postoperative endothelial cell density, mean cell area, the percentage of hexagonality, and the coefficient of variation.

Statistical Analysis

The patients were divided into one of two groups based on the postoperative donor graft thickness (<100 μm versus ≥100 μm). This cutoff point (100 μm) was used to categorize the study groups because, for many surgeons, it is considered the cutoff for ultrathin DSAEK surgery.[13] The data were analyzed using SPSS statistical software, version 21 (IBM Corp., Armonk, NY, USA). The values indicating means, standard deviations, ranges, and percentages were used to express the data. The normal distribution of continuous variables was verified using the Kolmogorov-Smirnov test and a Q-Q plot. Continuous variables were compared between the study groups using Student's independent samples *t*-test or the Mann-Whitney test. The Chi-squared test and Fisher's exact test were applied to compare qualitative parameters between these two groups. Comparisons between the pre- and postoperative values in each study group were performed using the paired *t*-test or Wilcoxon signed rank test. Correlations between variables were illustrated by calculating Spearman's correlation coefficient, considering all the DSAEK participants as one group. This analysis was used to analyze the influence of graft thickness on postoperative outcomes and complications, including BSCVA, spherical equivalent refraction, keratometric astigmatism, intraocular pressure (IOP) readings, endothelial cell density and morphology, graft decentration and detachment, high IOP, and endothelial rejection. A *P* value <0.05 was considered to be statistically significant. All the reported *P* values were two-sided.

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RESULTS

Recipient and Donor Characteristics

Eighty-seven consecutive eyes of 73 patients underwent DSAEK during the study period. Four eyes were excluded from the study because they did not have a minimum follow-up of 3 months postoperatively. The presenting diagnoses were congenital hereditary endothelial dystrophy (n = 2) and corneal decompensation after glaucoma surgery (n = 1). One eye had an anterior chamber IOL. An additional two eyes received repeat DSAEK replacing the original grafts that failed. These six eyes were also excluded. Therefore, 77 eyes (38 right eyes) of 64 patients (34 female subjects) were included in this study; 38 eyes (49.4%) were diagnosed with Fuchs' endothelial dystrophy, and 39 eyes (50.6%) had pseudophakic bullous keratopathy. All the eyes in the latter group had a posterior chamber IOL. Forty-six eyes (59.7%) underwent stand-alone DSAEK, whereas 31 eyes (40.3%) received DSAEK combined with cataract surgery.

The studied eyes were divided into one of the two groups, based on the postoperative central graft thickness. Group 1 (35 eyes; 45.5%) received donor grafts with a central thickness of <100 μm, whereas central graft thickness was ≥100 μm in group 2 (42 eyes; 54.5%). The mean ages of the patients were 60.4 ± 19.1 years (range, 19 to 84 years) in group 1 and 64.1 ± 14.6 years (range, 24 to 86 years) in group 2 (P = 0.48). The mean follow-up durations after DSAEK were 33.5 ± 18.8 months (range, 5 to 72 months) and 28.0 ± 17.7 months (range, 4 to 77 months) in groups 1 and 2, respectively (P = 0.36). The two study groups were comparable in patient sex, eye laterality, preoperative diagnosis, lens status at the time of surgery, and surgical technique [Table 1]. Furthermore, there were not any significant differences between the two groups in terms of donor characteristics, including age, sex, endothelial cell density, death-to-preservation time, graft storage time, donor quality or donor trephination size [Table 2].

Clinical Outcomes and Complications

Preoperative BSCVA was 1.32 ± 0.59 LogMAR (range, 0.48 to 2.40 LogMAR) in group 1 and 1.17 ± 0.63 LogMAR (range, 0.30 to 2.40 LogMAR) in group 2 (P = 0.51). Postoperatively, BSCVA significantly improved to 0.46 ± 0.33 LogMAR (range, 0.10 to 1.0 LogMAR) in group 1 (P < 0.001) and 0.36 ± 0.20 LogMAR (range, 0.10 to 1.0 LogMAR) in group 2 (P < 0.001). The two groups were comparable in postoperative BSCVA (P = 0.71). Postoperatively, BSCVA ≥20/40 was achieved in 52.6% and 68.4% of eyes in groups 1 and 2, respectively (P = 0.51). Visual acuity and refractive error were measured in all the participants (100%) at 1 and 3 months postoperatively. In group 1, such measurements were obtained in 27 (77.1%), 25 (71.4%), 19 (54.3%), and 16 (45.7%) eyes at postoperative months 6, 12, 18, and 24, respectively. In group 2, the corresponding figures were 32 (76.2%), 29 (69.1%), 23 (54.8%), and 20 (47.6%), respectively. The two groups gained BSCVA at the same rate, with no significant difference at any time point post-DSAEK [Figure 1].

The mean postoperative spherical equivalent refractive errors were −0.31 ± 1.66 D (range, −4.50 to +2.25 D) in group 1 and +0.40 ± 1.65 D (range, −2.75 to +3.75 D) in group 2 (P = 0.21). The mean postoperative keratometric astigmatism was 1.27 ± 1.10 D (range, 0.0 to 3.0 D) and 1.47 ± 1.05 D (range, 0.0 to 3.50 D) in that order (P = 0.56). Preoperatively, the mean IOP was 13.0 ± 3.07 mm Hg (range, 9.0 to 18.0 mm Hg) versus 12.77 ± 3.35 mm Hg (range, 9.0 to 17.0 mm Hg) in groups 1 and 2, respectively (P = 0.88). The mean postoperative IOP was 11.50 ± 3.41 mm Hg (range, 8.0 to 16.0 mm Hg) in group 1 and 13.91 ± 2.45 mm Hg (range, 10.0 to 18.0 mm Hg) in group 2 (P = 0.01). Compared to the preoperative values, there was a significant decrease in postoperative IOP in group 1 (P = 0.002), whereas there was no statistically significant difference in postoperative IOP in group 2 (P = 0.67).

No complications, such as vitreous loss or choroidal effusion/hemorrhage, occurred intraoperatively. Postoperative complications are presented and compared

Table 1. Comparisons of the demographic and operative data of the patients who received donor grafts with postoperative central thickness of <100 μm (group 1) versus ≥100 μm (group 2) during Descemet stripping automated endothelial keratoplasty (DSAEK)

Recipient features	Group 1 (n=35)	Group 2 (n=42)	P
Sex (male/female)	14/18	16/16	0.18
Laterality (OD/OS)	21/14	19/23	0.35
Preoperative diagnosis (n; %)			0.23
Fuchs' dystrophy	19 (54.3)	17 (40.5)	
Bullous keratopathy	16 (45.7)	25 (59.5)	
Lens status at the time of surgery (n; %)			0.52
Phakic	16 (45.7)	17 (40.5)	
Pseudophakic	19 (54.3)	25 (59.5)	
Surgical technique (n; %)			0.99
Stand-alone DSAEK	21 (60.0)	25 (59.5)	
DSAEK combined with cataract surgery	14 (40.0)	17 (40.5)	

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Table 2. Comparisons of data relevant to donor grafts with postoperative central thickness of <100 μm (group 1) versus ≥100 μm (group 2) that were transplanted during Descemet stripping automated endothelial keratoplasty

| Donor features	Group 1 (*n*=35)	Group 2 (*n*=42)	*P*
Age (years)	29.9±10.5	30.6±10.8	0.83
Sex (male/female)	28/7	40/2	0.17
Death-to-preservation time (*n*; %)			0.29
<20 h	9	6	
20 to <30 h	9	21	
30 to 40 h	17	15	
Storage time (days)	1.42±0.61	1.37±0.60	0.79
Endothelial cell density (cells/mm^2)	3045.6±298.9	3140.2±263.5	0.29
Mean cell area (μm^2)	331.9±32.4	322.4±27.2	0.34
Hexagonality (%)	61.5±12.3	62.2±12.5	0.87
Coefficient of variation	34.5±6.2	33.6±7.4	0.70
Donor quality (*n*; %)			0.99
Excellent	7 (20.0)	8 (19.1)	
Very good	28 (80.0)	34 (80.9)	
Trephination size (mm)	8.0±0.22	8.04±0.19	0.63
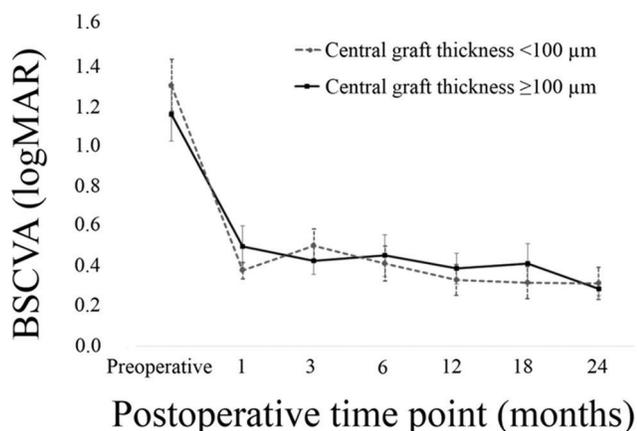
Figure 1. Comparison of change in best spectacle-corrected visual acuity (BSCVA) from baseline to 2 years between the two groups of eyes receiving different donor graft thicknesses (<100 μm versus ≥100 μm) during Descemet stripping automated endothelial keratoplasty (*P* > 0.05 for all comparisons).

Table 3. Comparisons of the prevalence of postoperative complications (*n*; %) in the two groups that underwent Descemet stripping automated endothelial keratoplasty and received donor grafts with postoperative central thickness <100 μm (group 1) versus ≥100 μm (group 2)

Postoperative complications	Group 1 (*n*=35)	Group 2 (*n*=42)	*P*
Graft non-attachment	2 (5.7)	0	0.22
Graft decentration	0	3 (7.1)	0.49
Interface haziness	0	1 (2.4)	>0.99
Graft folding	1 (2.9)	0	>0.99
Urrets-Zavalia syndrome	1 (2.9)	0	>0.99
Iridocorneal adhesion	1 (2.9)	2 (4.8)	>0.99
High intraocular pressure	7 (20.0)	8 (19.1)	>0.99
Endothelial graft rejection	13 (37.1)	12 (28.6)	0.58

between the study groups in Table 3. There was no significant difference between the two groups in terms of postoperative complications. Graft non-attachments were partial, and they resolved spontaneously. Graft decentrations were subtle and did not require repositioning. High postoperative IOP returned to normal levels with the use of anti-glaucoma eye drops and/or steroid reduction in all the eyes, and no eyes required glaucoma surgery. All the rejection episodes were treated successfully with frequent topical corticosteroid therapy, and no grafts were lost due to endothelial rejection.

Confocal Scan Findings

The mean central corneal thicknesses were 569.3 ± 44.1 μm (range, 512.0 to 666.0 μm) in group 1 and 588.0 ± 41.2 μm (range, 502.0 to 641.0 μm) in group 2 (*P* = 0.15). The mean

central graft thicknesses were 74.3 ± 12.8 μm (range, 51.0 to 92.0 μm) and 125.8 ± 21.7 μm (range, 102.0 to 174.0 μm) in groups 1 and 2, respectively (*P* < 0.001). The mean central thicknesses of the recipients' corneas were 495.0 ± 43.1 μm (range, 450.0 to 594.0 μm) versus 462.2 ± 46.1 μm (range, 328.0 to 542.8 μm) in that order (*P* = 0.02). A comparison between groups 1 and 2 in terms of postoperative endothelial cell density and morphology is presented in Table 4. Group 1 had a significantly lower postoperative ECD and larger mean cell area than group 2 [Table 4]. The mean decreases in endothelial cell density were 1587.2 ± 647.0 cells/mm^2 (range, 405.0 to 2503.0 cells/mm^2) and 1107.8 ± 693.7 cells/mm^2 (range, 318.0 to 2880.0 cells/mm^2) in groups 1 and 2, respectively (*P* = 0.03). The study groups were comparable in terms of postoperative hexagonality and coefficient of variation.

Correlations

Univariate regression analysis was performed considering all the DSAEK participants as one group. Postoperative

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central graft thickness had positive, significant correlations with postoperative IOP (r = 0.42, P = 0.005), and ECD (r = 0.36, P = 0.016), and it had a negative, significant association with postoperative recipient thickness (r = –0.46, P = 0.002) [Figures 2-4]. No significant associations were found between the central lenticular thickness and other postoperative outcomes and complications, including BSCVA (P = 0.70), spherical equivalent refraction (P = 0.33), keratometric astigmatism (P = 0.27), graft detachment (P = 0.16) or decentration (P = 0.17), high IOP (P = 0.53), and endothelial rejection (P = 0.88). Total corneal thickness was not correlated with postoperative BSCVA (P = 0.74) or IOP reading (P = 0.56).

DISCUSSION

The present study investigated the effects of donor graft thickness on clinical outcomes and complications after DSAEK. Central graft thickness was measured at least 4 months after DSAEK, when graft thickness is no longer changing.[14] Our results showed that visual acuity following ultrathin DSAEK does not differ substantially from that after conventional DSAEK. Additionally, we evaluated the influence of lamellar thickness on visual recovery, and we failed to show that the time to achieve BSCVA varied between the two groups, indicating that graft thickness had no relationship with the rapidity of visual recovery. Several studies have been published with contradictory evidence regarding the relationship between graft thickness and visual results. Some studies have demonstrated correlations between better visual acuity and lower total corneal or graft thickness after endothelial keratoplasty.[8-13] Better visual outcomes achieved with thinner grafts could be attributed to several mechanisms, including a reduction in induced posterior aberrations, closer approximation of the physiologic curvature of healthy corneas, and fewer stromal irregularities and hence better interface quality.[6,10,28] In contrast, many other studies have failed to demonstrate any significant correlation between graft thickness and visual acuity.[14-27] Even ultrathin DSAEK maintains a stroma-stroma interface, which results in increased light scatter and has a lower optical quality than the Descemet membrane-stroma interface achieved with Descemet membrane endothelial keratoplasty.[4]

A hyperopic shift of up to 1.5 D has been reported after DSAEK, caused by the thickness profiles of the donor grafts.[29,30] The hyperopic shift is correlated with central graft thickness and graft trephine diameter, as
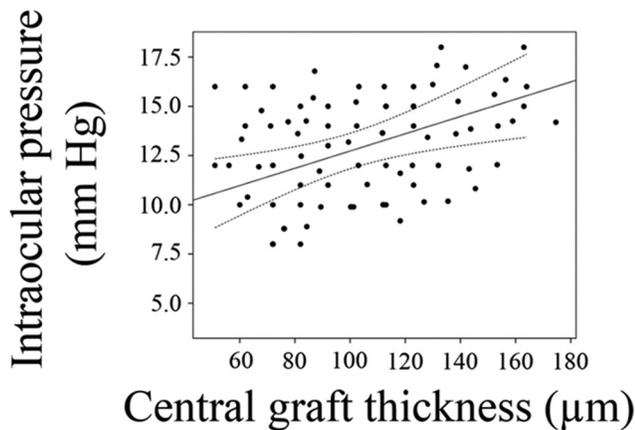

Figure 2. A scattergram illustrating a positive, significant correlation between postoperative central graft thickness and intraocular pressure in eyes undergoing Descemet stripping automated endothelial keratoplasty (r = 0.42, P = 0.005). Dotted lines indicate 95% confidence intervals for the regression line.
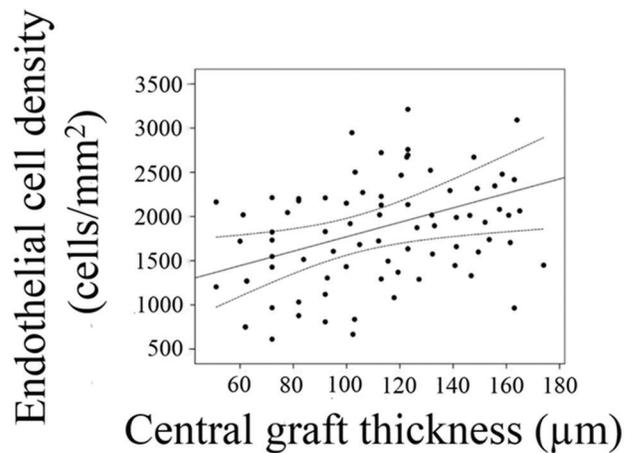

Figure 3. A scattergram illustrating a positive, significant correlation between postoperative central graft thickness and endothelial cell density in eyes undergoing Descemet stripping automated endothelial keratoplasty (r = 0.36, P = 0.016). Dotted lines indicate 95% confidence intervals for the regression line.

Table 4. Comparisons of postoperative endothelial cell features (mean±standard deviation; range) between the two study groups that underwent Descemet stripping automated endothelial keratoplasty and received donor grafts with postoperative thickness of <100 μm (group 1) versus ≥100 μm (group 2)

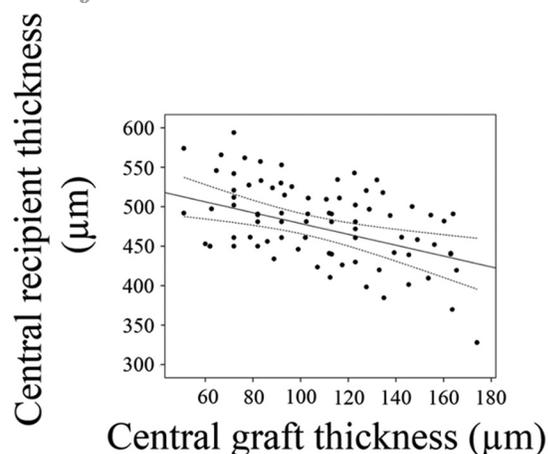| Endothelial cell features	Group 1 (n=35)	Group 2 (n=42)	P
Density (cells/mm^2)	1458.4±571.6 (612.0 to 2213.0)	2075.8±715.9 (666.0 to 3213.0)	0.004
Mean cell area (μm^2)	814.3±363.4 (452.0 to 1633.9)	571.0±300.0 (311.2 to 1501.7)	0.02
Hexagonality (%)	50.6±11.7 (32.1 to 78.4)	53.6±12.0 (16.7 to 74.0)	0.42
Coefficient of variation	37.6±7.2 (17.8 to 43.5)	35.9±7.3 (21.9 to 57.9)	0.60

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Figure 4. A scattergram illustrating a negative, significant correlation between postoperative central graft thickness and recipient thickness in eyes undergoing Descemet stripping automated endothelial keratoplasty (r = −0.46, *P* = 0.002). Dotted lines indicate 95% confidence intervals for the regression line.

well as the thickness gradient between the center and periphery of the graft.[31,32] Transplantation of thinner grafts can produce a smaller hyperopic shift (0.75 D) and can result in only slight changes in astigmatism.[13] In the current study, no significant associations were observed of the lenticular thickness with postoperative spherical equivalent refraction and keratometric astigmatism. We empirically selected IOL implants to have postoperative refraction of −1.0 to −2.0 D in DSAEK cases combined with cataract surgery to reduce the likelihood of unintended postoperative hyperopic results. In a subset of patients who underwent simple DSAEK without cataract surgery in whom refraction was measurable preoperatively (*n* = 36), we found no significant association between hyperopic shift in refraction and postoperative central graft thickness (data not shown). This finding supported the results of a previous study by Jun et al[31] who found a nonsignificant association between graft thickness and refractive change after DSAEK.

High IOP (>21 mm Hg) was encountered in 19.5% of the eyes in the current study. Other investigators have reported rates between 35% and 45%, indicating that increased IOP is common after DSAEK.[33-35] It is therefore necessary not only to monitor IOP throughout the postoperative course but also to ensure that these IOP measurements are accurate. Increased corneal thickness after DSAEK could negatively impact the accuracy of IOP measurements.[36] Our study found that postoperative IOP was significantly decreased compared to preoperative values when graft thickness was <100 μm. However, IOP was almost identical before and after DSAEK when graft thickness was ≥100 μm. Furthermore, we found that postoperative IOP readings were significantly correlated with graft thickness but not with total corneal thickness.

Based on these results, it could be concluded that graft thickness, but not total corneal thickness, could affect the accuracy of IOP measurements after DSAEK. In sharp contrast, Vajaranant et al[37] reported that IOP measured by Goldmann applanation tonometry was not correlated with total corneal thickness, graft thickness, or recipient corneal thickness post-DSAEK. Similarly, Daoud et al[20] reported no correlation between preoperative donor graft thickness and IOP measurement 6 months after DSAEK. Both investigator groups assumed that partial thickness grafts did not influence corneal biomechanics because the grafts were only attached centrally, without being attached at the limbus.[20] Based on this assumption, they concluded that IOP measurement might be influenced more by the thickness of the recipient than by the total corneal thickness after DSAEK.[37] However, we recently demonstrated that corneal biomechanical parameters were significantly increased after DSAEK, attaining the values measured in normal eyes.[38] Improvement in the corneal biomechanics of the host-graft complex after DSAEK could be more prominent when a thicker graft is transplanted, which would explain the significant association between graft thickness and postoperative IOP observed in the current study.

Our results suggested that lenticular thickness was an influential factor and had a positive, significant correlation with postoperative ECD. This association could be explained by tissue thinner than 100 μm being more difficult to insert and unfold than thicker tissue, which could potentially cause increased endothelial cell damage due to over-manipulation of the tissue. Some authors have suggested that thin grafts resulted in significantly less loss of ECD compared to eyes with thick grafts because delivering thick grafts through the surgical wound can squeeze the tissue, resulting in greater endothelial cell loss.[13] The results of the current study, however, indicated that DSAEK grafts with thickness of <175 μm could be delivered through a 5-mm clear cornea incision by means of a Busin glide, without squeezing damage to the donor tissue. A study by Van Cleynenbreugel et al[15] found no association between intraoperative donor lamella pachymetry and ECD at postoperative month 6. Similarly, Terry et al[39] reported that preoperative donor graft thickness was not significantly associated with donor endothelial cell loss at 6 months or 12 months. Comparisons between our results and the results of Van Cleynenbreugel et al[15] and Terry et al[39] could not be accurately performed because both investigator groups examined preoperative donor lenticular thickness to assess the relationship between donor lamella thickness and ECD, whereas our study examined the postoperative value. It is possible that the thickness of the graft reported preoperatively has a tenuous relationship with graft thickness postoperatively.[29,30]

In addition to endothelial cell count, the function of the corneal graft endothelium was compared between the

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study groups by comparing central recipient thickness. The recipient thickness was significantly lower in the group that received donor grafts with a thickness ≥ 100 μm, and a negative, significant association was observed between central donor and recipient thickness. This observation indicated that not only the cell count but also the pumping function of the corneal graft endothelium might improve as the thickness of the graft increases.

The current study investigated the effects of lenticular thickness on postoperative complications. Graft thickness was not correlated significantly with graft folding, high IOP (>21 mm Hg), iridocorneal adhesion, or endothelial graft rejection. The number of some complications (graft non-attachment and decentration, graft folding, and iridocorneal adhesion), however, was very small, and this study might have had limited statistical power to show any interaction between graft thickness and these complications.

There were certain limitations to our study. Our study was limited by the absence of contrast sensitivity and high order aberration measurements. Although graft thickness did not affect high contrast visual acuity, it is still possible that fine aspects of visual performance, such as contrast sensitivity function, might have deteriorated as donor graft thickness increased. Additionally, posterior corneal aberration could increase after DSAEK due to the disruption of posterior surface regularity by the addition of donor tissue, and thicker grafts might be associated with increased high order aberrations.[26] The other limitations are the wide range of postoperative follow-up, which can affect postoperative ECD and graft thickness, and the inclusion of a heterogeneous group of patients in the study.

In conclusion, our results failed to demonstrate any significant association between graft thickness and postoperative visual acuity or endothelial cell density. These results, however, should be interpreted in the context of the study limitations.

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Conflicts of Interest

There are no conflicts of interest.

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