Comparison of Descemet-On Versus Descemet-Off Deep Anterior Lamellar Keratoplasty

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Purpose: To determine the effect of retained donor Descemet membrane (DMs) on visual outcomes, contrast sensitivity (CS), higher-order aberrations (HOAs), and central graft thickness after deep anterior lamellar keratoplasty (DALK) using the big-bubble technique.

Methods: In this retrospective comparative study, keratoconic eyes undergoing a DALK using the big-bubble technique were enrolled. A bared DM was achieved in all cases. A donor cornea without (group 1; 48 eyes) or with (group 2; 22 eyes) DM was sutured to the recipient bed. The 2 groups were compared in terms of best spectacle-corrected visual acuity, keratometric astigmatism, refractive error, CS, HOAs, and central graft thickness at least 3 months after complete suture removal. Additionally, the rate of postoperative pseudoanterior chamber formation was compared between the study groups.

Results: The mean follow-up duration was 23.2 ± 6.9 months in group 1 and 26.5 ± 6.5 months in group 2 ($P = 0.61$). The postoperative best spectacle-corrected visual acuity was 0.18 ± 0.08 logMAR and 0.24 ± 0.30 logMAR, respectively ($P = 0.36$). The 2 groups had comparable postoperative keratometric astigmatism, spherical equivalent refraction, and HOAs. In terms of CS, however, group 1 demonstrated better results at a low spatial frequency. The mean postoperative central graft thickness was greater in group 2 (589.8 ± 34.5 μm) than in group 1 (523.6 ± 63.0 μm; $P < 0.001$). A pseudoanterior chamber developed in 3 eyes of group 1 and in 2 eyes of group 2 ($P = 0.23$). All cases were successfully managed by giving an intracameral air injection.

Conclusions: DALK performed using the big-bubble technique for keratoconus may give better results in terms of CS if a donor cornea without DM is transplanted.

Key Words: keratoconus, deep anterior lamellar keratoplasty, big-bubble technique, donor Descemet membrane

(*Cornea* 2013;32:1437–1440)

Deep anterior lamellar keratoplasty (DALK) removes and replaces the affected corneal stroma while preserving the healthy host endothelium. It has a minimal effect on the endothelial cell count[1,2] and eliminates the risk of endothelial graft rejection.[3] Visual outcomes after performing a DALK are comparable with those after performing a penetrating keratoplasty (PK), provided that a smooth donor–recipient interface can be achieved.[4–11] Different techniques of dissection[12–16] have been introduced to create a uniform recipient bed, thereby reducing complications, such as interface irregularity and opacity, encountered with conventional lamellar keratoplasty.[17]

A smooth donor surface may also contribute to an optically clear donor–recipient interface. Currently, 2 options exist for the preparation of donor tissues. Some surgeons prefer to remove the donor endothelium and the Descemet membrane (DM) to enhance the adhesion between donor and recipient corneas, which has the additional benefit of reducing the antigenic load of the graft. However, there is concern that the interface will be less regular if a donor lenticule without the DM is used. Leaving the donor DM in place may lead to a more regular donor–recipient interface and could theoretically yield better visual outcomes. This approach shortens the duration of the operation and reduces damage to the graft epithelium. One drawback of this technique is that in the event of DM perforation, a double anterior chamber may persist if the endothelium has not been removed from the donor.

To the best of our knowledge, no study has yet reported the impact of preserving the donor DM on visual functions after a DALK has been performed. In this study, we evaluate the effect of the retained donor DM on visual outcomes, including visual acuity, refractive error, contrast sensitivity (CS), higher-order aberrations (HOAs), and central graft thickness, in a group of eyes with keratoconus undergoing DALK using the Anwar big-bubble technique.

MATERIALS AND METHODS

In this retrospective comparative study, data of consecutive patients undergoing the Anwar big-bubble DALK for moderate [mean keratometry 48–55 diopters (D)] and advanced (mean keratometry >55 D or immeasurable keratometry) keratoconus between January 2007 and December 2010 were compiled. The Ethics Committee at the Ophthalmic Research Center approved the study.

Received for publication April 4, 2013; revision received July 5, 2013; accepted July 10, 2013.

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The authors have no funding or conflicts of interest to disclose.

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Preoperatively, no ocular pathologies, such as cataract, glaucoma, or retinal abnormalities, were observed in any participant. No deep stromal scar or defect in the DM indicating previous hydrops was detected. Preoperatively, a complete ocular examination was performed, which included manifest refraction (when possible), uncorrected visual acuity (UCVA), and best spectacle-corrected visual acuity (BSCVA) using the Snellen acuity chart, slit-lamp biomicroscopy, tonometry, and dilated fundus examination. Corneal topography (TMS-1 Topographic Modeling System, version 1.61; Computed Anatomy Inc, New York, NY) was performed in all eyes before the surgery was performed.

All procedures were performed under general anesthesia using the Anwar big-bubble technique as described in detail elsewhere.[18] A bared DM was achieved in all cases. The donor corneas, oversized by 0.25 mm, were punched from the endothelial side with the Barron punch (Katena, Denville, NJ). In a subgroup of participants, the donor DM was gently stripped off with a dry cellulose sponge or forceps (group 1), whereas in the rest, full-thickness grafts with an intact endothelium and DM were transplanted onto the recipient bed (group 2). In both study groups, the combined suturing technique, consisting of a 16-bite single running and 8-bite interrupted nylon sutures (Sharpoint, Angiotech), was used. The operations were performed by 2 surgeons using an identical technique (group 1 by S.F. and group 2 by M.Z.).

At least 3 months after complete suture removal, BSCVA (expressed in logMAR notations), manifest refraction, intraocular pressure (IOP) using a Goldmann applanation tonometer (AT 020; Carl Zeiss Meditec Inc, Dublin, CA), CS, HOAs, and central graft thickness using an ultrasonic pachymeter (US-10000, Nidek, Kamagori, Japan) were measured.

CS Measurement

Monocular CS was measured using sine-wave gratings at 6 spatial frequencies [1, 2, 3, 6, 12, and 20 cycles per degree (cpd)] using the Metrovision Moniteur Ophtalmologique "STATphot" program (Metrovision, Pérenchies, France). The chart was viewed from a distance of 2 m with full correction in place. After the initial demonstration of the procedure, contrast thresholds were measured for each spatial frequency. All the patients were tested under both scotopic and photopic conditions. Contrast thresholds at each spatial frequency and the area under the log contrast sensitivity function (AULCSF), calculated according to the Applegate method,[19] were compared between the study groups.

Wave Front Aberration Measurement

After measuring the CS, cyclopentolate 1% eye drops were instilled to achieve a pupil diameter of at least 6 mm, and wave front analysis was performed using the Zywave II aberrometer (Zywave version 5.2; Bausch & Lomb, Rochester, NY) in a dark room. HOAs were measured in terms of Zernike polynomials up to the fifth order. Three measurements were taken from each eye, and the average value was used for calculating the root mean square (RMS).

Statistical Analysis

Statistical analysis was performed using SPSS (version 21; SPSS Inc, Chicago, IL). Data were presented as mean ± SD after their normal distribution was confirmed and compared between the study groups using the independent *t* test. The χ^2 and Fischer exact tests were performed to compare the qualitative parameters between the 2 groups. Significance level was set at 0.05.

RESULTS

Overall, 70 eyes of 67 consecutive keratoconic patients including 45 male subjects were enrolled in the study; 48 eyes received a graft without a DM (group 1) and 22 eyes had a full-thickness graft with a retained DM (group 2). The mean age at the time of the surgery was 27.1 ± 7.6 (range, 15–44) years and 24.8 ± 5.4 (range, 17–39) years for the patients of groups 1 and 2, respectively ($P = 0.21$). The mean follow-up duration was 23.2 ± 6.9 (range, 16.2–36.4) months for group 1 and 26.5 ± 6.5 (range, 14.8–31.5) months for group 2 ($P = 0.61$).

All grafts were found to be clear at the final follow-up examination. The mean final BSCVA was 0.18 ± 0.08 (range, 0.0–0.4) logMAR in group 1 versus 0.24 ± 0.30 (range, 0–0.4) logMAR in group 2 ($P = 0.36$). The corresponding figures for UCVA were 0.63 ± 0.34 (range, 0.18–1.5) logMAR and 0.63 ± 0.48 (range, 0.0–1.6) logMAR, respectively ($P = 0.96$). Postoperatively, UCVA ≥ 20/40 was achieved in 23.1% and 33.3% of the eyes in groups 1 and 2, respectively ($P = 0.52$). Similar figures for BSCVA ≥ 20/40 were 95.5% and 81.0%, respectively ($P = 0.08$).

Groups 1 and 2 were comparable in terms of postoperative spherical equivalent refractive error (−4.18 ± 3.69 vs. −3.98 ± 3.36 D, respectively; $P = 0.85$), mean keratometry (45.72 ± 3.27 vs. 46.46 ± 2.26 D, respectively; $P = 0.38$), and keratometric astigmatism (2.77 ± 1.82 vs. 3.65 ± 1.95 D, respectively; $P = 0.08$). However, postoperative IOP (11.4 ± 3.0 vs. 14.3 ± 1.9 mm Hg, respectively; $P = 0.001$) and central graft thickness (523.6 ± 63.0 μm vs. 589.8 ± 34.5 μm, respectively; $P < 0.001$) were significantly higher in group 2.

Scotopic and photopic CS values at all spatial frequencies were higher in group 1 as compared with those in group 2. However, only the difference at 1 cpd reached a significant level (Fig. 1 and Table 1). No statistically significant difference was observed between the 2 groups in terms of scotopic AULCSF (1.43 ± 0.17 for group 1 vs. 1.36 ± 0.22 for group 2; $P = 0.26$). However, the photopic AULCSF was significantly better in group 1 (1.46 ± 0.18 vs. 1.31 ± 0.24; $P = 0.04$).

Table 2 compares the HOAs between the study groups. The RMS of all HOAs was comparable in both groups.

DM perforation resulting in double chamber formation occurred in 3 patients in group 1 and 2 patients in group 2 ($P = 0.23$). All the cases were successfully managed by giving an intracameral air injection.

DISCUSSION

Different techniques of lamellar keratoplasty have evolved over time to achieve visual outcomes comparable

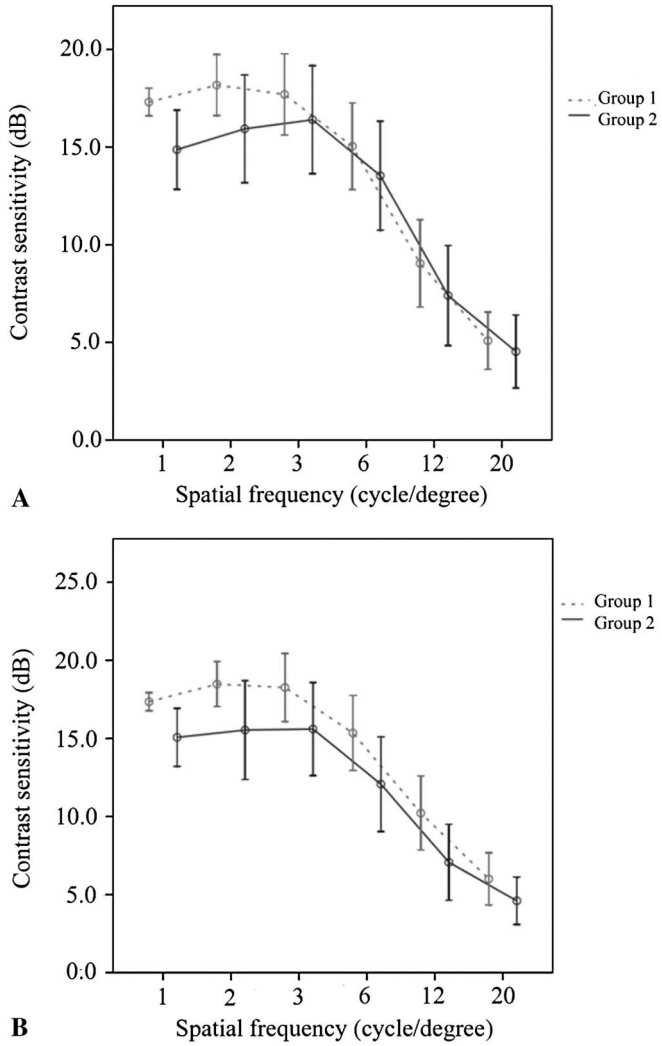

FIGURE 1. Scotopic (A) and photopic (B) CS function in the study groups.

with those of PK. Among these techniques, DALK in which the maximum depth of the corneal stroma is removed has gained popularity for the management of corneal stromal pathologies not involving the endothelium. Although, certain studies[4–11] have reported comparable visual outcomes after DALK and PK, other investigators[20] have demonstrated less favorable results after a DALK has been performed. The observed difference in certain studies may be attributed to the quality of the donor–recipient interface, which is contributed by the recipient bed on 1 side and the posterior donor surface on the other side.

It has been demonstrated that when the recipient corneal stroma is removed down to DM, the optical quality of the interface is excellent and comparable with that of PK.[21] However, there is no report on the effect of the posterior donor surface on visual outcomes after DALK. This explains our decision to conduct this study.

Retention or removal of donor DM during the preparation of donor tissues remains controversial. Some surgeons[6–11] prefer to remove the donor endothelium and DM, whereas others[12,22] use a full-thickness donor with the DM in place. The results of this study indicate no statistically significant difference between these 2 donor preparation techniques in terms of UCVA, BSCVA, refractive error, and RMS of HOAs. However, the CS was better when the DM and endothelium were removed from the donor.

Previous studies have reported that when a bared DM is achieved and the donor DM is removed, photopic and scotopic CSs after a DALK are comparable with[4,11,21,23] or even better[8] than those after a PK. This study indicates that the retention of the donor DM can negatively influence this fine aspect of visual function. This observation cannot be explained by refractive errors or HOAs, because these measurements were similar in both groups.

This difference could possibly result from the increased central graft thickness in group 2 per se regardless of whether the donor DM was retained or not. Additionally, the healing response between donor and recipient corneas can be affected by the method of preparation of donor tissues. It has been demonstrated that healing is delayed at the donor–recipient interface and a subclinical cleft (pseudoanterior chamber)

TABLE 1. Comparison of Scotopic and Photopic CSs Between the Study Groups

Spatial Frequency (cpd)		Group 1	Group 2	*P*
1	Scotopic	17.30 ± 1.64	14.87 ± 3.66	0.03
	Photopic	17.35 ± 1.34	15.07 ± 3.35	0.02
2	Scotopic	18.17 ± 3.61	15.93 ± 4.99	0.15
	Photopic	18.48 ± 3.33	15.53 ± 5.72	0.09
3	Scotopic	17.70 ± 4.81	16.40 ± 5.0	0.43
	Photopic	18.26 ± 5.05	15.60 ± 5.38	0.14
6	Scotopic	15.04 ± 5.14	13.53 ± 5.04	0.38
	Photopic	15.35 ± 5.54	12.07 ± 5.48	0.08
12	Scotopic	9.04 ± 5.17	7.37 ± 4.63	0.33
	Photopic	10.22 ± 5.49	7.07 ± 4.40	0.06
20	Scotopic	5.09 ± 3.40	4.53 ± 3.38	0.63
	Photopic	6.0 ± 3.87	4.60 ± 2.75	0.20

TABLE 2. Comparison of RMS of Higher-Order Aberrations Between the Study Groups

RMS (μm)	Group 1	Group 2	*P*
Trefoil	1.49 ± 0.77	1.42 ± 0.88	0.79
Coma	1.23 ± 0.68	0.89 ± 0.58	0.11
Spherical	0.83 ± 0.44	0.64 ± 0.39	0.18
Tetrafoil	0.56 ± 0.36	0.36 ± 0.30	0.08
Secondary astigmatism	0.21 ± 0.18	0.21 ± 0.15	0.90
Pentafoil	0.13 ± 0.13	0.14 ± 0.13	0.82
Secondary coma	0.08 ± 0.09	0.07 ± 0.06	0.51
Secondary trefoil	0.07 ± 0.07	0.06 ± 0.06	0.63
Third order	2.04 ± 0.79	1.74 ± 0.92	0.32
Fourth order	1.10 ± 0.43	0.82 ± 0.43	0.06
Fifth order	0.19 ± 0.16	0.18 ± 0.15	0.85
Total higher order	2.35 ± 0.83	2.0 ± 0.88	0.23

usually develops when a full-thickness graft with a retained DM is used.[24] These persistent pseudoanterior chambers may decrease the visual acuity and diminish the theoretical optical advantages of the retained donor DM. It is also conceivable that the retention of the donor DM promotes scarring in the surgical interface, which may interfere with visual performance. We are conducting an ongoing study on these 2 groups using in vivo confocal microscopy to evaluate the effect of donor DM retention on the healing process at the interface.

Another important finding is the significant difference observed between the study groups in terms of central graft thickness and IOP. The results of this study indicate that when the donor DM is retained, a thicker graft and hence the overestimation of IOP should be expected. It was previously observed that after a big-bubble DALK is performed using a donor without the DM, the central graft thickness is comparable with that after a PK.[4,11,21] During DM removal, one attempts to only strip off the DM and the endothelium. However, the removal of the DM and the endothelium using forceps may engage the stroma and create a false tissue plane within the posterior stroma. This may explain why the difference in the central graft thickness between the study groups (66.2 μm) was greater than expected from normal DM thickness (12 μm). Using optical coherence tomography to measure donor, recipient, and total corneal thickness will determine to what extent this speculation is true.

In summary, this study suggests that the retention of the donor DM is associated with a lower CS after a DALK is performed using the big-bubble technique despite comparable visual acuity results. Retention of the DM may also lead to less reliable IOP measurements as a result of increased central corneal thickness.

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