Original Article

Deep Anterior Lamellar Keratoplasty with Large Descemet's Membrane Perforation: Should We Stop Conversion to Penetrating Keratoplasty?

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Abstract

Purpose: To evaluate the outcome of eyes with large Descemet's membrane (DM) perforation during deep anterior lamellar keratoplasty (DALK).

Methods: A retrospective, interventional case series of 12 eyes with completed DALK, despite DM perforation larger than 4 mm in its widest dimension. The main outcome measures included graft clarity, endothelial cell density (ECD), corrected distance visual acuity (CDVA), and DM detachment.

Results: The mean age of patients was 26.8 ± 11.4 years. Preoperative pathology included keratoconus (n = 10), macular dystrophy (n = 1), and postmicrobial keratitis corneal scar (n = 1). The average size of DM perforation was 6.5 mm ± 1.3 mm. At the end of the follow-up period (median 15 months, range 6–53 months), the mean CDVA was 0.32 ± 0.09 logMAR and the mean ECD was 1830.8 ± 299.7 cells/mm^2. Nine patients (75%) developed DM detachments postoperatively and was managed by intracameral air injection once in six eyes, and twice in three eyes. Other complications included persistent localized stromal edema at the site of DM defect in one eye and Urrets Zavalia syndrome in one eye.

Conclusion: Completing DALK in eyes with large DM perforation provides good visual acuity, endothelial cell count and may be superior to penetrating keratoplasty regarding long-term graft survival if confirmed in future comparative studies.

Keywords: Deep anterior lamellar keratoplasty, Descemet's membrane, Keratoplasty, Macroperforation

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Introduction

Deep anterior lamellar keratoplasty (DALK) is an increasingly practiced surgical technique for treating corneal stromal pathology with a healthy endothelium. DALK has several advantages over penetrating keratoplasty (PKP) as the maintenance of globe integrity, absence of endothelial rejection, and a low rate of chronic endothelial cell loss (ECL).[1-3]

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The big bubble (BB) technique is the most popular DALK technique. The rate of BB formation varies from 50% to 90%.[4-6] In eyes with failed BB formation, other techniques may be used as layer by layer dissection, viscodissection, hydrodelamination, and the microbubble incision technique.[7-10]

Having an intact Descemet's membrane (DM) is the aim of DALK surgery. However, due to various causes, DM perforation may occur, which may range from micro to macro

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perforation. Eyes with DM perforation are at higher risk of a double anterior chamber (AC), ECL, and possibly graft failure than those with intact DM. These complications may be challenging to both surgeon and patient in the postoperative period.[4,6,11] Most corneal surgeons convert to PKP in eyes with macro perforation, but there is no consensus about when to convert a DALK to PKP.

Size of DM tear, location of the tear, the timing of the perforation, and AC collapse, were all previously used parameters to justify conversion to PKP; with surgeons prefer to convert to PKP if perforation size is larger than half the trephination size, perforation occurring early during surgery hindering the dissection to DM, or when AC cannot be reformed with air.[11-13]

We herein report the outcome of a case series of 12 eyes with completed DALK despite large DM perforations.

Methods

A retrospective review of all eyes that had DALK performed from February 2014 to August 2018. Eyes with DM perforation larger than 4 mm in its widest dimension were included in the study. The size of the DM tear was measured intraoperatively by caliper and later confirmed by the study of video recordings, estimating the dimensions of the DM tear from comparison with the size of trephination. DM tears were further categorized as linear tears (with apposable edges), tears with rolled edges creating a DM defect, and defects with actual missing parts of DM (loss of tissue).

This study was conducted in accordance with the tenets of the Declaration of Helsinki and was approved by the Institutional Ethics Committee.

Surgical technique

All procedures were performed using the BB technique described by Anwar and Teichmann[4] with some modifications from the original technique such as; performing a paracentesis before bubble formation for injecting small air bubbles in the AC and using a Fogla 27g air-injection cannula (Bausch and Lomb, Rochester, NY) to create the BB.

Eyes with failed BB were completed using the microbubble incision technique.[10] In the event of perforation, a centripetal dissection was adopted avoiding the area of DM tear and dissecting the stroma peripherally, and then completing dissection over the perforated area.[14,15] In posthydrops scars, the techniques of peripheral dissection and scar peeling was used.[14]

Eyes with large perforations were continued as DALK regardless of the location or size of perforation. Maneuvers to unfold the edges were carried out in all DM tears to convert defects to linear tears, such as fluid jets and manual unfolding [Video 1]. A DM off corneal graft was sutured with 16 interrupted sutures. Peripheral iridotomy was not done. Instead, the AC was completely filled with air for 1 h, after which some of the air was released, leaving half the AC filled, and the patient was instructed to posture in a position so that the air bubble seals the tear.

Patients received topical gatifloxacin (Zymar, Allergan, Irvine) every 6 h for 30 days and topical prednisolone (Predforte, Allergan, Irvine) every 6 h tapered over 2–3 months and then replaced by topical fluorometholone (Flucon, Alcon Laboratories, FW). Topical lubricants were administered to hasten epithelial healing. Follow-up examinations were scheduled at 1, 3, 7, and 30 days postoperative, and every 2 months thereafter. Patients with persistent DM detachment were scheduled for re-bubbling using air or 20% sulfur hexafluoride (SF6).

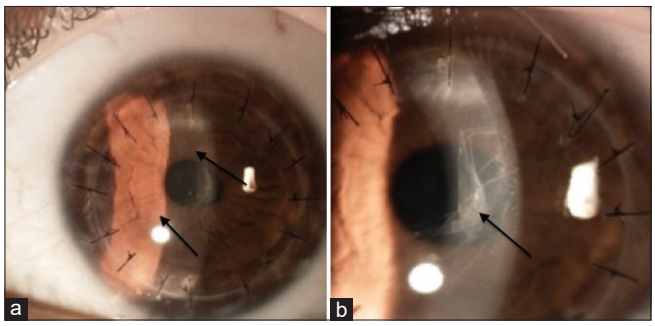

Figure 1: Case 1; (a) 18 months following deep anterior lamellar keratoplasty with large perforation due to bursting of bare Descemet's membrane (DM) during suturing, there was 270 degrees dehiscence of DM, folded in the lower third of the cornea, unfolding of DM was done and re-bubbling twice, cornea was clear after 6 weeks including the area not covered with DM (arrows). (b) Higher magnification showing folded DM (arrows)

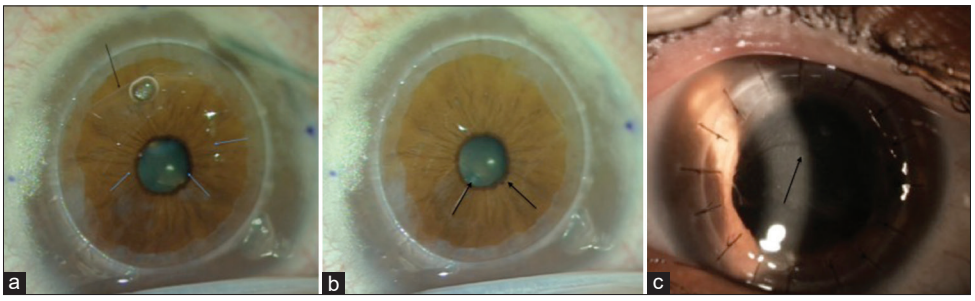

Figure 2: Case 3; (a) Intraoperative picture showing Descemet's membrane (DM) perforation after extension of DM tear, creating a flap (black arrow) and a large defect (blue arrows), (b) after reposition of the flap and transforming the defect into a linear tear (black arrows), (c) 24 months following surgery showing clear cornea despite DM tear, and dilated pupil (Urrets-Zavalia)

Results

Among 288 DALK procedures performed, 83 eyes (28.8%) had intraoperative DM perforation. Twelve eyes (4.2%) of 12 patients (6 males and six females) met the inclusion criteria [Figures 1-4]. The mean age of included patients was 26.8 ± 11.4 years. Preoperative pathology included keratoconus (n = 10), macular dystrophy (n = 1), and postmicrobial keratitis corneal scar (n = 1).

Type 1 BB was formed in 4 eyes, while three eyes had Type 2 BB and five eyes had failed BB formation. DM perforation occurred during air injection with the bursting of BB in 4 eyes, during deep lamellar dissection in three eyes, during the introduction of air injection cannula in one eye, during suturing in one eye, and during peeling of the stroma in 2 eyes with preexisting DM tears (posthydrops). The average size of the perforation was 6.5 ± 1.3 mm.

The median duration of follow-up was 15 months (range, 6–53 months). Only one patient (Case 4) was lost to follow-up after 6 months and was excluded from the statistical analysis of the postoperative outcome. At the final follow-up, the mean logMAR corrected distance visual acuity was 0.32 ± 0.09 and endothelial cell density was 1830.8 ± 299.7 cells/mm^2. Nine patients (75%) developed DM detachments in the first postoperative week, managed by intracameral air injection once in 6 eyes, and twice in three eyes with SF6 was used during the second injection. Table 1 shows the intraoperative and early postoperative data of all cases.

Postoperative stromal edema was significant in areas not covered by DM. Nevertheless, all edema resolved after 1–6 weeks depending on the size of the defect. One patient had persistent edema [Case 4, Figure 3], 6 months postoperative. In this case, part of DM was accidentally excised during stromal removal leaving a large defect, with resultant localized edema over the defect. This patient was lost to follow-up and hence was excluded from the statistical analysis of postoperative outcomes. No stromal haze was observed in any case, just posterior surface irregularities at the location of DM tear.

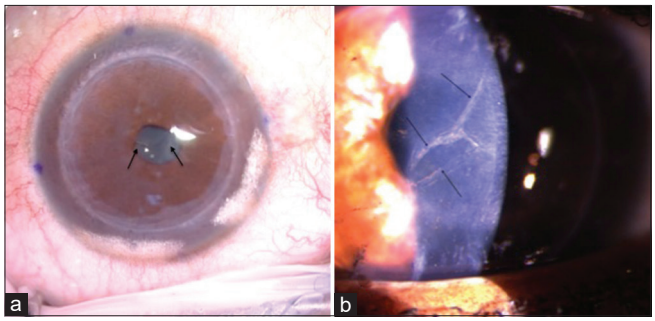

Figure 3: Case 4; (a) Intraoperative picture showing 6 mm tear with tissue loss (arrows) creating a large defect. (b) 6 months following surgery showing persistent corneal edema (arrows) at the site of Descemet's membrane defect (this patient was lost to further follow-up)

Discussion

DALK with DM perforation is considered a surgical challenge with a reported incidence of 4.4%–39%.[1,5,16-18] Despite the widespread use of DALK, the management of such perforation remains a contentious topic, and there is variation in current practice toward the conversion to PKP. Since 2014, we started the implementation of a new concept, completing DALK surgery regardless of the size or the site of DM tears. Conventionally, loss of endothelial cells has been considered permanent, however, there are several reports of spontaneous clearing of corneal edema after accidental descemetorhexis during phacoemulsification.[19,20] and corneal clearance in spite of graft detachment after endothelial keratoplasty.[21-24] These studies showed that corneal clearing started peripherally at the site of graft detachment, and endothelial cell migration into the areas of DM defects was detected with specular microscopy.[24] Descemetorhexis without endothelial keratoplasty for Fuchs dystrophy achieved clinical improvement in central edema and comparable visual outcomes to those of Descemet membrane endothelial keratoplasty with a significantly lower rate of complications.[25]

Few studies in the literature discussed the outcomes of intraoperative DM perforations during DALK. Leccisotti[12] reported eight eyes with micro-perforation among his DALK series with good functional results; mean ECL was 14% ± 12% after 1 year, no statistically significant difference in visual acuity between eyes with micro-perforations and those with intact DM. One eye needed conversion to PKP due to persistent DM detachment. Huang *et al*.[26] studied 101 eyes that had intraoperative DM perforations, among which 15 eyes had macro perforations defined as a sizeable tear or gap 0.5 mm or more in length resulting in persistent AC collapse. There were no statistically significant differences in the postoperative uncorrected, best corrected visual acuity, graft failure, or repeat corneal grafts among eyes with or without DM perforations.

On the other hand, another study by Den *et al*.[11] using the Melles technique on 25 eyes with DM perforation (6 eyes with macro-perforations) reported a higher rate of endothelial decompensation in those with DM perforations compared to those without a perforation. They defined macro-perforation

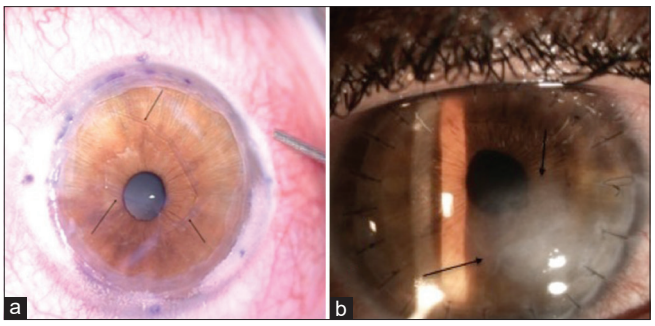

Figure 4: Case 7; (a) Intraoperative picture showing 5 mm tear with rolled edges (arrows). (b) 24 months following surgery showing Descemet's membrane defect (arrows) with clear graft

Table 1: Demographic data, preoperative pathology, intraoperative, and early postoperative data of cases included in this study

	Age	Gender	Preoperative pathology	Timing of perforation	Size of perforation	Last logMAR CDVA	Endothelial cell density	Complications	Duration of follow-up (months)
1	18	Female	Postmicrobial keratitis corneal scar	Burst Type 2 BB during suturing with 270° dehiscence of DM, folded in the lower third of the cornea	8 mm tear with rolled edges	0.3	2365	DM detachment	53
2	29	Female	KC (posthydrops scar)	Centripetal dissection, perforation during peeling of stroma	5 mm with rolled edges	0.2	2158	DM detachment	31
3	17	Male	Macular dystrophy	One peripheral tear due to bursting of Type 2 BB, accidently enlarged during stromal removal	8 mm central U shaped tear, creating a DM flap	0.2		DM detachment, Urrets - Zavallia	44
4	34	Male	KC (posthydrops scar)	Centripetal dissection, a large DM defect was accidently created during stromal removal	6 mm with tissue loss	0.8		DM detachment, persistent stromal edema	6
5	19	Male	KC	Introduction of air injection cannula, surgery was completed by centripetal dissection of stroma	5 mm linear tear	0.2	1743	DM detachment	13
6	23	Male	KC	Manual dissection	5 mm linear tear	0.3	1930	DM detachment	25
7	10	Male	KC	Burst Type 1 BB, surgery was completed by centripetal dissection of stroma	5 mm with rolled edges	0.2		None	15
8	16	Male	KC	Burst Type 1 BB, surgery was completed by centripetal dissection of stroma	8 mm tear with rolled edges	0.5	1580	None	15
9	43	Female	KC	Air injection	6 mm tear with rolled edges	0.3	1700	DM detachment	15
10	30	Female	KC	Manual dissection	5.5 with rolled edges	0.3	1680	DM detachment	15
11	36	Female	KC (posthydrops scar)	Centripetal dissection, perforation during peeling of stroma	6 mm tear with rolled edges	0.3	1490	None	15
12	46	Female	KC	Manual dissection	8 mm tear with rolled edges			DM detachment	12

CDVA: Corrected distance visual acuity, DM: Descemet's membrane, KC: Keratoconus, BB: Big bubble

as a tear more than one mm in either length or width and conversion to PKP was done if the size of the tear was more than half the size of trephination.

To our knowledge, the current DALK case series harbors the largest-sized DM perforations and includes all criteria necessitating conversion to PKP mentioned in previous studies. Focusing on the previous criteria surgeons previously followed to convert to PKP, the size of the DM should not be an automatic indication for conversion, especially, if away from the central area. Furthermore, in PKP, there is chronic endothelial attrition with possible late graft failure, contrary to DALK, which has ECL similar to normal corneas.[27,28] Finally, a double AC can easily be managed by air or SF6 with protocols as those applied in endothelial keratoplasty.

Some surgeons advocate intraoperative measures to address intraoperative DM perforations, such as stromal patching, adjunctive use of fibrin glue, and suturing of perforation.[12] In our series, we did not adopt any of these maneuvers, as they may contribute to additional endothelial damage, or interface irregularities, haze and preventing endothelial cell migration to the side of defect. All DM detachments in this study were successfully fixed using an intracameral injection of air or SF6.

Recent studies have shown that the use of topical Rho kinase inhibitor may increase endothelial proliferation with subsequent resolution of corneal edema.[29,30] Further studies are needed to show if its use can increase the success rate of DALK with large perforation.

Only one eye [Case 4, Figure 3] showed a failure of complete clearing of graft stroma, with localized and persistent edema at the site of DM defect. In this case, there was a large DM tear 6 mm in its widest dimension, with rolled edges and missing parts of DM that was accidentally excised during removal of the stroma. Our current thought in such cases is if a sizeable DM defect due to tissue loss occurs, we would consider converting to PKP as the migration of the endothelial cells may not cover the whole defect resulting in persistent corneal

edema and nonclearing of the graft. Complications of air or SF6 injections include cataract, pupillary block, AC inflammation, and endothelial toxicity.[31]

One of our earlier cases was complicated by Urrets-Zavalia syndrome due to pupillary block [Case 3, Figure 2]. Close attention in the early postoperative hours was applied in the following patients to avoid this complication. Furthermore, performing peripheral iridotomy can reduce the risk of pupillary block.

Mean visual acuity in this study may be slightly lower compared to eyes with PKP or DALK with an intact DM. This is because DM membrane tears may contribute to DM folds and posterior surface irregularities, with the possible reduction in visual acuity and induction of higher-order aberrations.[32]

Limitations in this study were the small number of cases, absence of serial follow-up, the short duration of follow-up in some of the cases, and lack of preoperative endothelial cell count. However, we feel this study number is sufficient based on the novelty of the concept of completing DALK in large DM perforations.

Preoperative endothelial cell count was not feasible in most of the cases, either due to advanced keratoconus or corneal scarring making reliable specular readings impossible. Although intraoperative ECL was not reported, we documented maintained graft clarity and good endothelial cell counts at the end of the follow-up period, which are important indicators for long-term graft survival. Another limitation is the absence of a control group, this is since we stopped the conversion of DALK to PKP, and also the results and long-term outcome of PKP have been well reported in the literature.

Despite the limitations, we consider this case series supportive of the completion of DALK surgery in eyes with large DM perforation. It certainly shows it is possible not to convert.

In conclusion, completing DALK in eyes with large DM perforation provides a comparable visual acuity and better endothelial cell count than PKP. Despite the drawbacks of the technique as posterior corneal surface irregularities and the possible need for complex postoperative management due to higher chance of re-bubbling and the slow visual recovery, preserving the recipient endothelium overshadows all other drawbacks and should be considered, especially when high-quality graft material is unlikely to be available.

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Nil.

Conflicts of interest
There are no conflicts of interest.

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