Original Article

Outcome of deep anterior lamellar keratoplasty patients with intraoperative Descemet's membrane perforation: A retrospective cross-sectional study

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Purpose: To evaluate functional and anatomical outcome in patients undergoing deep anterior lamellar keratoplasty (DALK) with intraoperative Descemet's membrane (DM) perforation (macro and micro). **Methods:** A retrospective cross sectional study (January 2009 to December 2015) of sixteen eyes of sixteen patients which included nine patients of advanced keratoconus (KC), two patients with paracentral DM scarring post hydrops, KC with Bowman's membrane scarring, macular corneal dystrophy and one patient of advanced Pellucid Marginal Degeneration (PMD). All underwent DALK with intraoperative DM perforation. Big bubble technique was attempted in all except in the two patients with post hydrops DM scar. Preoperative and postoperative best corrected visual acuity (BCVA), astigmatism and endothelial count (EC) were compared. **Results:** Postoperative BCVA and astigmatism were found to be better and statistically significant ('p value' 0.00 and 0.003 respectively). BCVA preoperative and postoperative was 1.07± 0.3 and 0.28 ± 0.09 in LogMAR respectively and astigmatism pre and postoperative 4.14 ± 1.5 D and 2.7 ± 0.97 D respectively. Percentage decrease in EC at sixth postoperative week was 7.48% and at sixth month and 1 year postoperative was 15.1%. Two patients developed postoperative double anterior chamber and two patients developed pupillary block glaucoma and all were successfully managed. **Conclusion:** Not all patients of intraoperative DM perforation (including macro perforation) needs to be converted to penetrating keratoplasty. DALK can be successfully done if the perforation is identified early and managed adequately. This is the only known study which has shown a large series of successful DALK even with macro perforations.

Key words: Deep anterior lamellar keratoplasty, Descemet's membrane perforation, double anterior chamber, macro perforation, micro perforation

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Deep anterior lamellar keratoplasty (DALK) is preferred in cases where the disease is restricted to the anterior layers of cornea.[1] DALK compared with penetrating keratoplasty (PK) has certain advantages such as faster visual rehabilitation, lesser chances of immune endothelial rejection, and lesser vulnerability to traumatic complications.[2] However, they have a slightly steeper learning curve compared with the full-thickness procedures.[3] We report a study wherein intraoperative DM (Descemet's membrane) perforation occurred in 16 eyes of 16 patients while performing DALK with no conversion to PK, during the period of January 2009 to December 2015, performed by a single experienced surgeon. During the mentioned period, 176 eyes (DALK) were operated by the same surgeon and seven patients had to be converted to PK due to macroperforations (measuring > 1 mm and with total intraoperative chamber collapse which could not be formed even with intracameral air bubble injection) were not included in the present study and the remaining 169 eyes underwent DALK. Macroperforations which occurred very early during the procedure were also excluded as dissection is difficult in such cases. Central macroperforation involving visual axis was also excluded. Sixteen patients as mentioned (4 macroperforation and 12 microperforation)[4,5] in whom anterior chamber could be formed by intracameral air bubble (using adjusted technique of dissection from periphery first followed by dissection near the perforation area) were included in the study.

In all patients, the preoperative and postoperative visual acuity, astigmatism, and endothelial cell (EC) count were compared and stage at which DM perforation occurred was also noted. During DALK, there is always a risk of intraoperative DM perforation.[6] In case of a large perforation, many surgeons prefer to convert to PK.[7] We present a study wherein DALK was successfully done even in patients with paracentral macroperforation of DM. DM perforation can occur at any stage during the surgery.[2,7-11] However, if the perforation is identified and managed adequately, as shown in this study, conversion may not be necessary and outcome of such patients may be excellent.[12]

The cases in which macroperforation occurred were paracentral and not involving visual axis and were larger than 1 mm.[10] Two patients had a preoperative history of hydrops with paracentral DM scars and risk of intraoperative

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DM perforation was anticipated. Four patients developed immediate postoperative complications, but they were adequately managed. Successful outcome (in terms of visual outcome, astigmatism, and mean EC count) was achieved in all the patients with DM perforation in 1 year follow-up.

Methods

The study was conducted in a tertiary care eye hospital as a retrospective cross-sectional observational study from January 2009 to December 2015. All surgeries were performed by a single senior experienced surgeon and informed written consent was undertaken from all. Study protocol adhered to the levels of declaration approved by Institutional Review Board and tenets of the declaration of Helsinki.

Mean age of the patients was 29.6 ± 6.4 years, and male: female ratio was7:9 (43.8:56.3%). One patient had atopy, one had Down's syndrome, and the other had vernal keratoconjunctivitis.

Patient selection was based on the area of corneal involvement and a minimum EC count of 2,000 cells/mm^2 and above. Follow-up was continued at least up to 1 year postsurgery and thereafter. Preoperative full ocular examination was conducted using slit lamp bio microscopy, specular examination (TOMEY; EM-3000) for EC count, dilated fundus examination, subjective refraction, and topography (OCULUS Pentacam HR). Preoperative subjective acceptance was poor; hence, the astigmatism value was obtained from the Pentacam. Postoperative astigmatism between Pentacam and subjective refraction showed difference, and thus, subjective refraction value was taken for more reliability.

All patients were operated under local anesthesia (peribulbar block) with 2% lignocaine and were given preoperative intravenous mannitol (20%, 2 g/kg body weight over 30 min) to lower the intraocular pressure during surgery and topical pilocarpine (0.1%) to reduce chances of iatrogenic lens injury in case there was a need for conversion to PK.

The recipient cornea was trephined using a manual trephine of size 8–8.5 mm to approximately 300 microns depth and 0.5–1 mL of air bubble injected through a bent 30 gauge needle attached to a 2-cc syringe with air into a small stromal corneal pocket. The big-bubble technique as described by Anwar and Teichmann was attempted for all patients[13] except in two patients who had pre-existing DM scar. During this, seven patients developed perforation (five microperforation and two macroperforation). Air bubble was immediately injected through a peripheral paracentesis into the anterior chamber and further surgery was carried out by layer-by-layer dissection. One among them further had another microperforation at a different site while the incomplete bubble was being punctured by number 11 blade. It was managed similarly with anterior chamber air bubble injection. Among the remaining, seven patients developed microperforation while doing manual layer–by-layer dissection.[14,15] One among them developed microperforation at a different site while suturing donor cornea to host bed. No air bubble was injected in this case, but suture revision was done and chamber maintained. Of the two patients who had pre-existing DM scar, manual layer-by-layer dissection was attempted from the beginning as DM perforation was anticipated and macroperforation was noted at the site of previous scar while doing the same. Air bubble tamponade in anterior chamber was done and further surgery was carried out uneventfully. In all the perforation cases, the exact thickness at which perforation occurred could not be accurately measured as intraoperative OCT (Optical Coherence Tomography) was not available. However, in all cases, adjusted technique of dissection from periphery first followed by dissection near the perforation site was done.

Once host bed DM was exposed, donor tissue was prepared using a trephine size of 0.25 mm larger than host trephine size in cases all cases except in advanced KC where same size was used. The endothelial side was then stained with 0.06% Tryphan Blue (Auroblue) and peeled off along with the Descemet's membrane using nontoothed forceps. Matching of donor tissue thickness to host bed was not done. Donor graft was sutured using 12–16 interrupted sutures of 10-0 nylon (monofilament; Ethilon) at 80–90% depth. Few small air bubbles were noted in the interface in all these cases intraoperatively, but cleared eventually.

Postoperative day 1, two patients had a double anterior chamber and were taken to operation theater and interface wash along with air bubble injection in anterior chamber was done. Figs. 1 and 2 showing the same before and after management. Two others developed raised intraocular pressure in the immediate postoperative period due to acute pupillary block. Intravenous mannitol (20%, 2 g/kg body weight over 30 min) along with antiglaucoma topical drugs and intracameral air bubble release was done. All patients responded well and no further intervention was needed.

All patients were given topical antibiotics (fluoroquinolones) four times a day for 2 weeks and steroids topically six times a day for 3 months with slow tapering dose. Graft edema cleared in all patients by 2–3 weeks. None of the patients had persistent haze except for mild paracentral haze in the two patients with prior history of hydrops and did not contribute to any significant decrease in vision and required no additional intervention. By 1 year, all the sutures were removed, beginning around 6–7 months and were followed up for a minimum 1 year period (on day 1, first postoperative week, 3 weeks later, 6 weeks, 3 months, 6 months, and then at 1 year later). No complications were noted on the follow-up visits. On review, visual acuity, postoperative refraction, astigmatism, and EC count were noted. Figs. 3-6 shows outcome in macro and microperforation. Figs. 7-8 shows endothelial counts of a patient preoperative and postoperative respectively.

Statistical analysis was done using SPSS software version 19, and results were found to be clinically significant.

Results

The study evaluated the postoperative outcome at 6 weeks, 6 months, and 1 year interval. Outcome was documented in terms of postoperative uncorrected distance visual acuity, best corrected visual acuity (BCVA), astigmatism, and postoperative EC count. Both functional and anatomical outcomes were evaluated and were all found to be statistically significant. Stage of DM perforation was also noted. Table 1 shows the patient profile and postsurgery outcome. Tables 2–4 show BCVA, astigmatism, and EC count, respectively.

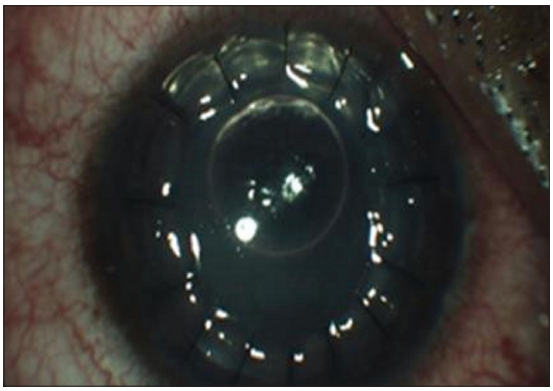


Figure 1: Patient with double anterior chamber

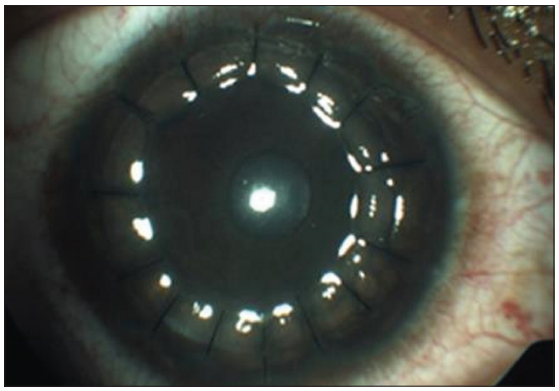


Figure 2: Patient after resolving of double chamber

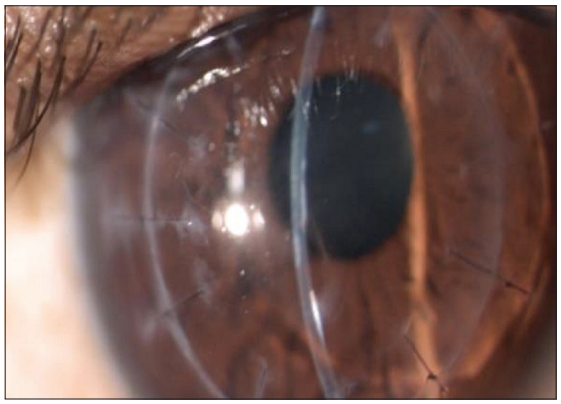


Figure 3: Patients with macroperforation during DALK and good postoperative outcome, at the end of 1 year

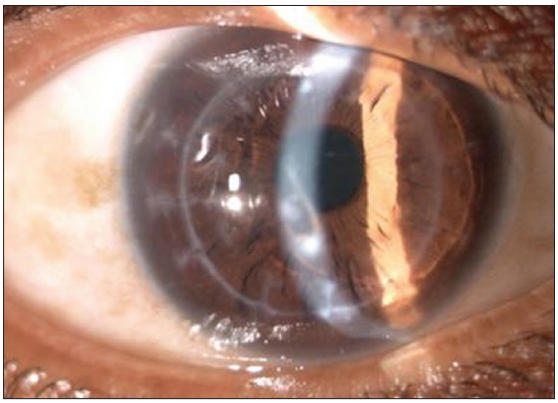


Figure 4: Patients with macroperforation during DALK and good postoperative outcome, at the end of 1 year

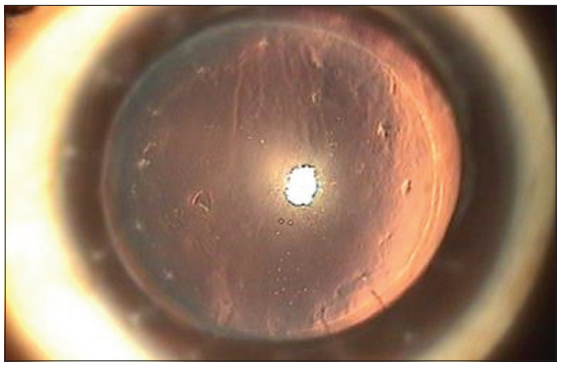


Figure 5: Microperforation during DALK and postoperative outcome, at 1 year

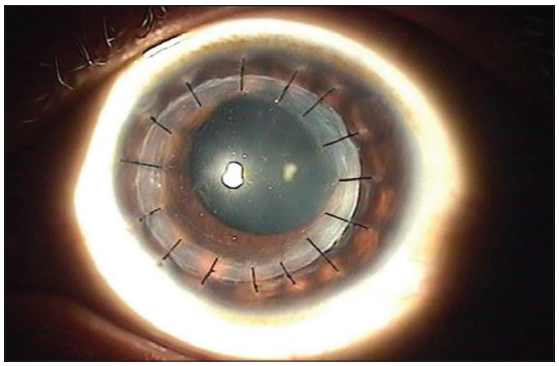


Figure 6: Microperforation during DALK and postoperative outcome, at 1 year

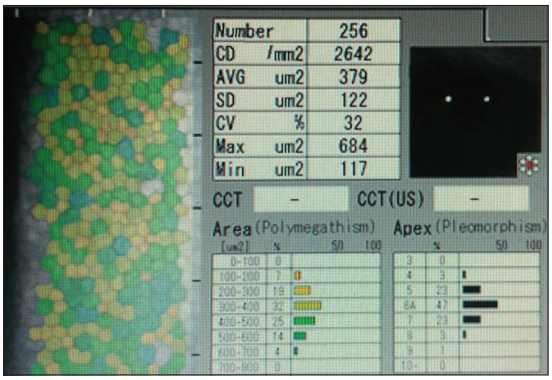


Figure 7: Specular image of patient preoperative

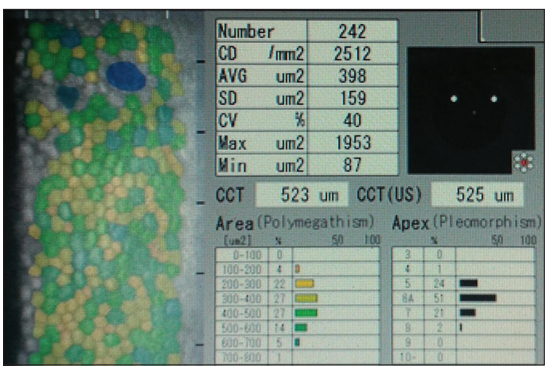


Figure 8: Specular image of the same patient at postoperative 6 weeks

Table 1: Patient profile and outcome following DALK with intraoperative DM perforation

Diagnosis	Complications	Preoperative BCVA	Postoperative BCVA at 1 y	Preoperative EC	Postoperative EC at 6 wk	Postoperative EC at 1 y	Preoperative astig (topo)	Postoperative astig (refr)
KC with DM scar (posthydrops)	Double AC	1.47	0.3	2,308	2,106	2,006	7.2	2
Advanced KC		1	0.18	2,652	2,388	2,207	3.7	2.75
Advanced KC		1	0.3	2,667	2,448		5.2	4.5
MCD	High IOP	0.78	0.3	2,992	2,812	2,456	4.2	4
MCD		1.47	0.3	2,782	2,571		2.8	3.25
Advanced PMD	Double AC	1.77	0.48	2,465	2,314	2,110	5.1	4.5
Advanced KC		1	0.18	2,444	2,213		1.92	2.25
Advanced KC		1.17	0.3	2,572	2,341	2,144	4.6	2
KC with DM scar (posthydrops)		1.07	0.3	2,824	2,666	2,422	3.3	2.5
Advanced KC	High IOP	0.78	0.18	2,881	2,598	2,491	6	2
KC with Bowman's scar		0.78	0.18	2,923	2,725	2,411	6.1	2.5
Advanced KC		0.6	0.3	2,991	2,770	2,317	3.4	1.5
Advanced KC		1	0.18	2,412	2,318	2,192	3.9	2.25
Advanced KC		1	0.18	2,642	2,512	2,183	4.2	2.75
KC with Bowman's scar		1.3	0.48	2,433	2,242		2.7	3
Advanced KC		1.07	0.3	2,811	2,611		1.9	1.25

sl no, serial number; BCVA, best corrected visual acuity in LogMAR; EC, endothelial count in cells/mm^2; astig, astigmatism in diopter; KC, keratoconus; PMD, pellucid marginal degeneration; MCD, macular corneal dystrophy; AC, anterior chamber; IOP, intraocular pressure in mmHg; refr, refraction value; topo, topography value)

Graph 1 shows the decrease in EC count over different periods of time postoperatively. Percentage decrease noted from preoperative period to sixth postoperative week was 7.48%. At sixth month postoperative and at 1 year postoperative, the percentage drop in count was found to be around 15.1%. Further follow-up may be necessary to assess the count at a later postoperative period.

Discussion

All patients in the study had a good postoperative functional outcome (visual acuity) and anatomical outcome (graft take and EC count). Though few patients developed immediate postoperative complications, adequate and prompt management helped in a good outcome.

Big bubble as described by Anwar and Teichmann[13] has come a long way and helps in a good lamellar dissection during DALK.[16,17] Many modifications of the technique have also been described and have been useful for DALK.[18–20] In case of a failed big bubble, manual dissection may be required to carry out the stromal dissection.[21] In our study, we found that DM perforation can occur at any stage of the surgery and the surgeon ought to be extremely careful for the same.

Two patients with DM scar posthydrops (paracentral) were operated with a good postoperative outcome. Contrary to the popular belief that performing DALK in patients with preoperative hydrops with DM scar can compromise the outcome postoperative, studies have shown that following hydrops, ECs migrate over the ruptured site.[22,23] Posthydrops, there is generally some scarring of the Descemet's membrane at the margins of the tear and thus extension of the tear intraoperatively at the same site following DM perforation is lesser. Also, posthydrops with DM rupture endothelial rejection is higher with PK, and thus DALK is preferred[24] if central cornea is not involved. This study successfully demonstrates DALK even in patients with posthydrops.

This study showed that most DM perforation could be managed without a need to convert to PK. Previous studies

have shown that conversion to PK is required in case of DM perforations.[10,25] To our knowledge, this is the only study wherein large number of macroperforation cases, DALK was successfully done. We had four patients (25%) with macroperforation of DM. Identification and proper management of the perforation led to an excellent visual outcome.

EC count of patients showed initial decrease, but on subsequent follow-up from 6 months onward the decrease was relatively stable (15.1% 6 months onward up to 1 year). Though there was a decrease in count on follow-up which is expected in patients following DM perforation with air bubble injection,[9] the percentage decrease needs to be further evaluated for a larger sample size and for a longer duration follow-up. This paves way for future research in determining the amount or percentage of ECs decease post-DALK with and without intraoperative DM perforation. Further research aimed at determining the postoperative outcome on longer follow-up period is required. Previous studies comparing outcome of DALK versus PK showed that the decline in EC count was less with DALK compared with PK[1,2,12,24,26-29] and thus better outcome. However, one can expect a higher EC count drop in patients who had an intraoperative DM perforation compared with DALK with no intraoperative perforation as shown in other studies.[26] Percentage decrease noted from preoperative period to sixth postoperative week was 7.48% in our study, and at sixth month postoperative and at 1 year postoperative, the percentage drop in count was found to be around 15.1%. This is comparative to the study conducted by Leccisotti *et al*.[9]

Limitations faced in this study are the small sample size and a short period of follow-up. Also, many may not find it technically comfortable to continue with DALK in cases of macroperforation. Also, the exact titrated size of macroperforation up to which DALK can be done is difficult to predict and is subjective based on the surgeon and the location of the perforation. The long-term outcomes of these patients are also not known and may be required to follow-up for better understanding.

Conclusion

This study emphasizes on certain points for a successful DALK even in macroperforation, and only few studies have mentioned successful DALK in macroperforation.[9,10] It is important to maintain a well-formed chamber with air tamponade and not panic and identify the exact site of perforation and progress with gentle and careful dissection: first, away from the site of perforation and then finally toward it to prevent further extension of perforation. There are certain complications pertaining to intraoperative DM perforation,[9,30,31] and adequate management of these complications can lead to an excellent postoperative outcome. Also in patients with a history of hydrops, starting with layer-by-layer dissection from the beginning is advisable as done in this study. In scarred corneas, most cases had a type 2 bubble, and in these cases, it is better to proceed with manual layer-by-layer dissection as these bubbles are thinner and have higher risk of rupture. Thus, this study shows that not all DM perforation cases need to be converted to PK if adequate chamber formation can be attained and also a careful gentle dissection with right method of lamellar dissection even in scarred corneas can attain a good visual outcome. Though this study has a small number of patients with successful DALK postintraoperative DM perforation, it paves way for future research with a larger sample size comparing the postoperative outcomes in patients of DALK with macroperforation compared with microperforation.

Table 2: Effect of DALK on BCVA

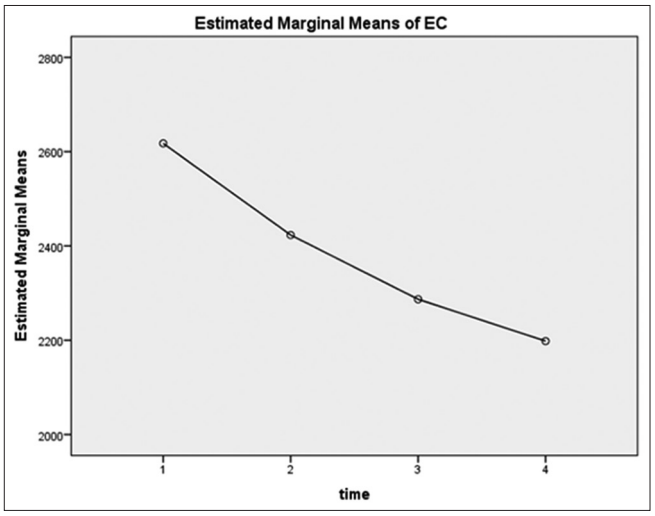
BCVA (*n*=16)	Preoperative	Postoperative	Difference	*P*
Values	1.07±0.3 (logMAR)	0.28±0.09. (logMAR)	0.8±0.25 (logMAR)	0.00

DALK, deep anterior lamellar keratoplasty; BCVA, best corrected visual acuity in LogMAR

Table 3: Effect of DALK on astigmatism

Astigmatism (*n*=16)	Preoperative	Postoperative	Difference	*P*
Values	4.14±1.5 D	2.7±0.97 D	(1.45±1.6 D)	0.003

DALK, deep anterior lamellar keratoplasty



Graph 1: Decrease in endothelial cell (EC) count over different periods of time postoperatively. *X*-axis represents time period of follow-up in our study. (1 = preoperative period, 2 = 6 weeks postoperative period, 3 = 6 months postoperative period, and 4 = 1 year postoperative period). *Y*-axis shows the estimated marginal means in cells/mm^2

Table 4: Effect of DALK on endothelial cell count

Endothelial cell count (*n*=7)	Preoperative	Postoperative at 6 wk	Postoperative at 6 mo	Postoperative at 1 y	*P*
Values (cells/mm^2)	2,674±221	2,477±213	2,270±202	2,267±160	0.0

DALK, deep anterior lamellar keratoplasty

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Nil.

Conflicts of interest

There are no conflicts of interest.

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