Endothelial Keratoplasty: Case Selection in the Learning Curve

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Purpose: Many corneal surgeons are making the transition from penetrating keratoplasty to endothelial keratoplasty techniques such as Descemet's stripping endothelial keratoplasty and Descemet's stripping automated endothelial keratoplasty in the routine treatment of corneal endothelial failure. Donor dislocation is the commonest complication of these newer techniques. We set out to determine whether preoperative lens/iris diaphragm integrity might influence the rate of donor dislocation and whether donor endothelial failure was more common after surgical intervention for donor dislocation.

Design: A retrospective multisurgeon comparative case series from a large teaching and referral center.

Participants: Ninety-three eyes of 85 patients: consecutive cases of Descemet's stripping endothelial keratoplasty (n = 77) or Descemet's stripping automated endothelial keratoplasty (n = 16) performed between March 2004 and January 2007.

Methods: A retrospective review of case notes.

Main Outcome Measures: The number of eyes with an open communication between the anterior and posterior chambers (an iridectomy or lens capsular defect not covered by a posterior chamber intraocular lens), the number of eyes requiring surgical intervention to correct donor dislocation, and the number of eyes with donor endothelial failure within the follow-up period.

Results: Complete data sets were available for analysis in 89 eyes. The median follow-up interval at the time of the audit was 7 months (range 1–34 months). Donor dislocation was significantly more common ($P = 0.017$) in eyes with an open communication between the anterior and posterior chambers, occurring in 11 of 25 cases (44%) versus 12 of 64 cases (19%) with an intact iris/lens diaphragm. Early endothelial failure was significantly more common ($P = 0.011$) in cases requiring additional surgical intervention for donor dislocation, occurring in 6 of 21 cases (29%) after successful surgical reattachment of a dislocated donor disc versus 4 of 67 cases (6%) in which no additional intervention was required.

Conclusions: Donor dislocation after endothelial keratoplasty is more common in cases with an open communication between the anterior and posterior chambers. The risk of donor endothelial failure is increased in cases of donor dislocation. Trainee surgeons and surgeons in making the transition from penetrating keratoplasty should initially select cases with an intact lens/iris diaphragm.

Key Words: endothelial keratoplasty, dislocation, case selection

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INTRODUCTION

Descemet's stripping endothelial keratoplasty (DSEK) and, more recently, Descemet's stripping automated endothelial keratoplasty (DSAEK) have rapidly gained in popularity superseding deep lamellar endothelial keratoplasty (DLEK) as the preferred endothelial keratoplasty (EK) technique.[1–3] Many corneal surgeons have already switched over to these minimally invasive alternatives to penetrating keratoplasty (PK) as their procedure of choice in the surgical treatment of corneal endothelial failure, and many more are either early in the transition or considering starting.

DSEK and DSAEK both rely on a complete anterior chamber air fill to encourage donor adhesion during surgery.[4–6] This may be harder to achieve in cases with an open communication between the anterior and posterior chambers—typically cases of pseudophakic bullous keratopathy (PBK) without a posterior chamber intraocular lens (IOL). A partial or complete air fill is usually left in the anterior chamber at the end of surgery,[5,6] and patients are encouraged to posture faceup for 30 minutes or longer in the immediate postoperative period. Faceup positioning is commonly interrupted during patient transfer from the operating room, particularly in an ambulatory surgery setting, allowing air to escape into the posterior chamber in cases where an open communication exists. Early postoperative donor tissue tamponade is then less efficient, and this may influence donor adherence.

Several authors report relatively high donor dislocation rates in the early stages of their EK learning curve.[6–8] But previous reports have not considered factors in case selection, such as integrity of the lens/iris diaphragm, that may be relevant to the rate of donor dislocation. Additional surgical manipulation is usually successful in repositioning donor tissue after dislocation, but this intervention comes at a price: some additional donor endothelial cell loss is inevitable.[3] Primary graft failures are also relatively common in early case series,[7,8] indicating that an association between donor dislocation and donor endothelial failure may exist.

Using data from a multisurgeon audit of the transition to DSEK and DSAEK at Moorfields Eye Hospital, we set out to

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examine whether donor dislocation was more common in cases of corneal endothelial failure with an open communication between the anterior and posterior chambers. We also examined the association between donor dislocation and primary or early graft failure.

METHODS

A retrospective review of case notes was performed for consecutive cases of DSEK or DSAEK listed for surgery between March 2004 and January 2007 at Moorfields Eye Hospital. Cases performed by experienced corneal transplant surgeons and corneal trainees were included. All operating surgeons had performed less than 50 cases of EK (including DLEK) at the time of the audit, and 4 of 7 surgeons had performed less than 10 cases in total.

In addition to demographic and follow-up interval data, details of diagnosis, comorbidity, previous surgery, pre- and postoperative visual status, surgical technique, complications, and additional surgical interventions were collated on a Microsoft Excel (Microsoft Corporation, Seattle, WA) spreadsheet. Main outcome measures for this study were the number of donor dislocations and the number of cases of primary or early endothelial failure—defined, respectively, as initial failure of the cornea to clear (primary endothelial failure) or recurrence of corneal edema within the follow-up period (early endothelial failure).

Two key comparisons were assessed statistically using a one-sided Fisher exact test (www.quantitativeskills.com/sisa/statistics/fisher.htm): the rate of donor dislocation in cases with and without an open communication between the anterior and posterior chambers and the rate of primary or early endothelial failure in cases with and without additional surgical interventions to correct donor dislocation. Cases with a peripheral iridectomy or a posterior capsule defect with no posterior chamber IOL at the end of surgery were categorized as having an open communication between the anterior and posterior chambers.

DSEK and DSAEK techniques used for the majority of patients were as previously described.[4–7] Briefly, thin posterior corneal lenticules (80%–90% depth) were prepared by either manual (DSEK) or automated (DSAEK) dissection. Automated dissection was performed using a Moria CB microkeratome (Moria, Doylestown, PA) using either a 300-μm (if donor corneal central pachymetry <570 μm after epithelial removal) or a 350-μm head.[5] In total, 7.5–9 mm diameter donor lenticules were then punched out and left covered in storage medium ready for insertion before the patient entering the operating room. The recipient corneal surface was marked at the same diameter or, in earlier cases, 0.5 mm greater than the diameter of the donor lenticule to guide sizing of the descemetorhexis. After completion of any additional surgery, the descemetorhexis, and careful removal of any ocular viscosurgical device, a thin layer of cohesive ocular viscosurgical device (sodium hyaluronate—ProVisc, Alcon, Fort Worth, TX) was applied to the central endothelial aspect of the donor lenticule which was folded taco style and introduced to the anterior chamber through a 5-mm scleral or corneal pocket using single-point fixation forceps (71 cases) or a suture drag technique[9] (18 cases). The donor lenticule was then unfolded over a filtered air bubble or unfolded during anterior chamber reformation with balanced salt solution, endothelial side down. Donor lenticules were centered using a 30-gauge needle to fixate and reposition the stromal aspect of the donor lenticule over a small air bubble or simply by massage over the corneal surface after a complete anterior chamber air fill. After a period of at least 8 minutes with a complete anterior chamber air fill, and, in some cases, ancillary measures to encourage donor adhesion including roughening of the peripheral host stroma[10] (5 cases), and external corneal massage (84 cases) and/or stab drainage incisions[5] (15 cases) to remove interface fluid, a partial air/balanced salt solution exchange to leave an air bubble approximately the same diameter as the donor lenticule at completion of surgery was performed through a small peripheral paracentesis incision. Patients were then postured face-up-to-the-ceiling for 1–2 hours postoperatively before postoperative review to exclude pupillary block and discharge.

In total, 20% perfluoropropane or 20% sulfur hexafluoride gas tamponade was used in a subgroup (20 cases) by one surgeon with variations in surgical technique, and results were described in detail elsewhere.[11] We also compared the donor dislocation rate in this subgroup with that for patients in whom filtered air alone was used for donor disc apposition. A two-sided Fisher exact test was used for statistical examination of this comparison.

Finally, 1- and 6-month visual results in cases where the indication for surgery was endothelial failure associated with Fuchs' corneal endothelial dystrophy or PBK with no comorbidity other than cataract were examined for comparison with other case series.

RESULTS

Ninety-three eyes of 85 patients (female/male = 50/35, average age 68 years, SD = 14) had DSEK (n = 77) or DSAEK (n = 16) performed by 7 surgeons (including 3 corneal trainees) in the audit period. Case notes could not be retrieved in 3 cases. One case was abandoned before donor insertion (see below), leaving 89 complete data sets for analysis. The median follow-up interval at the time of the audit was 7 months (range 1–34 months). Indications for surgery included a relatively high proportion of cases with PBK (34%) and endothelial failure after previous PK (14%) (Fig. 1). Twenty-five (57%) cases performed for indications other than Fuchs' corneal endothelial dystrophy had an open communication between the anterior and posterior chambers. Preoperative factors increasing technical difficulty in this group included aniridia (n = 2), broad iridectomy (n = 9), the presence of a glaucoma drainage tube (n = 5), aphakia (n = 6), an anterior chamber IOL (n = 11), and previous pars plana vitrectomy (n = 7). All iridectomies in this series were surgical; none of the eyes had a Yttruim Aluminum Garnate (YAG) laser peripheral iridotomy alone. Additional surgical procedures combined with DSEK or DSAEK included phacoemulsification and IOL implantation (n = 24), anterior vitrectomy with IOL removal or exchange (n = 4), and glaucoma drainage tube trimming/repositioning (n = 2). All the cases in which Fuchs' corneal

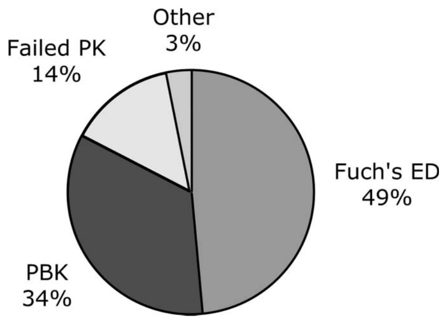

FIGURE 1. Indications for EK in this case series included a relatively high proportion of cases of PBK and endothelial failure after PK. Other indications included posttraumatic endothelial failure (1 case) and aniridia (2 cases). In just under half the cases, the indication for surgery was Fuchs' corneal endothelial dystrophy (Fuchs' ED). Twenty-five of the PBK or failed PK cases had an open communication between the anterior and posterior chambers (a peripheral iridectomy or lens capsular defect with no posterior chamber IOL). The lens/iris diaphragm was intact in all cases of Fuchs' ED.

endothelial dystrophy was the primary indication for surgery had an intact iris diaphragm and a posterior chamber IOL in situ.

Donor dislocation (Fig. 2A) was significantly more common ($P = 0.017$) in cases with an open communication between the anterior and posterior chambers, occurring in 11 of 25 completed cases (44%) versus 12 of 64 cases (19%) with an intact iris/lens diaphragm. In total, 23 cases (26%) required repeat surgical intervention for graft dislocation. These comprised 22 cases of dislocation into the anterior chamber treated by graft relocation and repeat air tamponade and 1 case of dislocation into the posterior chamber (Fig. 2B). In all but 2 cases, donor dislocation was clinically evident within 24 hours of surgery. Revision surgery, as previously decribed,[12] was effective in reattaching 19 of 22 cases (86%) of dislocation into the anterior chamber. Graft repositioning was repeated in 2 cases of failed reattachment, and a PK was performed to revise the remaining case.

Donor dislocation was more common in cases in which 20% sulfur hexafluoride or 20% perfluoropropane was used to encourage donor apposition ($P = 0.006$), occurring in 9 of 20 cases (45%) versus 12 of 69 cases (17%) in which filtered air alone was used. Donor lenticule diameters were similar in the cases with (mean $\pm$ SD: 8.3 ± 0.6 mm) and without (mean $\pm$ SD: 8.2 ± 0.3 mm) donor dislocation.

Donor endothelial failure was significantly more common ($P = 0.011$) in cases requiring additional surgical intervention for donor dislocation, occurring in 6 of 21 cases (29%) after successful surgical reattachment of a dislocated donor disc versus 4 of 67 cases (6%) in which no additional intervention was required. Successful repeat DSEK was performed in 2 of the 10 cases of corneal endothelial failure and 2 cases were revised by PK. Revision surgery had not been completed in 6 cases of corneal endothelial failure at the time of the audit. In all cases, donor endothelial failure was characterized by failure of the graft to clear after surgery (primary graft failure) rather than recurrence of corneal edema during the follow-up period (early graft failure).

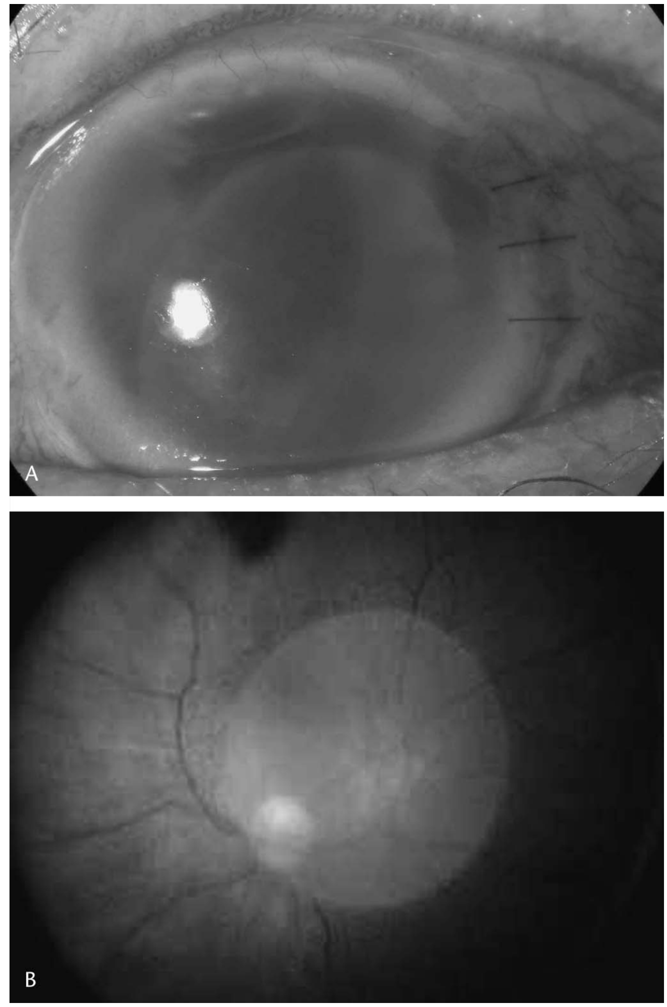

FIGURE 2. Donor dislocation (A) was significantly more common in cases with an open communication between the anterior and posterior chambers. Our series included 1 case of dislocation into the posterior chamber (B). This was a case of traumatic aniridia with a ciliary sulcus sutured iris diaphragm posterior chamber IOL (Morcher GmBH, Stuttgart, Germany) in situ preoperatively and a history of total retinal detachment treated by pars plana vitrectomy. The indication for EK was PBK. The posterior dislocation was revised by donor hemisection with intraocular scissors, retrieval of the divided donor disc through a 3.2-mm pars plana incision, and PK.

Other complications included failed preparation of donor disc (perforation during manual dissection 2 cases, button hole during microkeratome dissection 1 case), significant interface haze (Fig. 3) present at last review (4 cases—all DSEK), and choroidal hemorrhage before donor insertion (1 case—aphakic bullous keratopathy—PK performed without recurrent bleeding 4 months later). Difficulty in inserting, unfolding, or positioning donor tissue was recorded in the operating notes in 10 cases. Exploratory analysis, again using a one-sided Fisher exact test, revealed a strong association with early donor endothelial failure (6 of 10 cases; $P < 0.0001$) that was independent of donor dislocation (3 of 10 cases). Specific problems recorded included intrasurgical

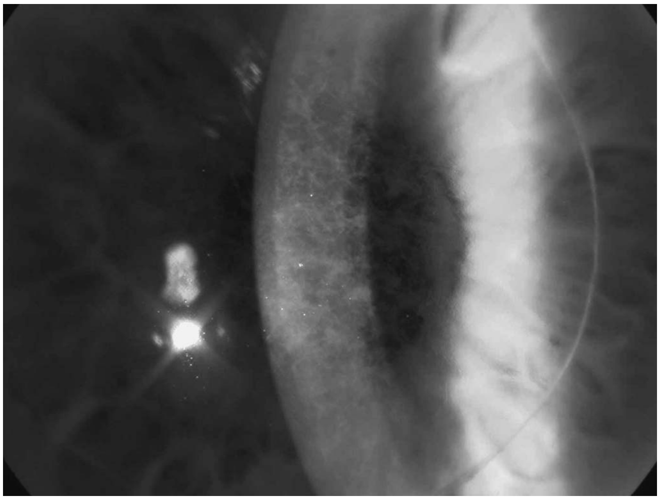

FIGURE 3. Significant interface haze was evident in 4 cases at the last recorded review.

fibrinous adhesion between iris and donor corneal stroma impeding donor unfolding (1 case) and initial unfolding of the donor tissue, endothelial side up (1 case).

In cases not complicated by donor corneal endothelial failure, visual results were generally encouraging. Eighty-nine percent of cases of Fuchs' corneal endothelial dystrophy or PBK with no preexisting visually significant co-pathology other than cataract had a 6-month postoperative best spectacle-corrected visual acuity of 6/12 or better (Table 1).

DISCUSSION

Data presented here confirm that donor dislocation after EK is less common in eyes with an intact lens/iris diaphragm and that additional tissue manipulation, either during the initial operation or at revision surgery in cases of donor dislocation, increases the likelihood of donor endothelial failure. These findings are unsurprising but have important implications for case selection and surgical technique.

The study design has several limitations. As a retrospective review of the transition to a new technique with limited follow-up, it was not possible to provide meaningful comment on endothelial cell counts or the effect of modifications in surgical technique, such as stab drainage incisions, which were introduced in later cases only. We had a high rate of data retrieval however (>95%), and the relatively gross outcome measures examined here (donor dislocation and donor endothelial failure) should have been recorded accurately in case notes. The general applicability of the main findings is also strengthened by the inclusion of data from both experienced and inexperienced surgeons at varying stages in their transition from PK to EK techniques.

TABLE 1. Visual Acuity Results in Uncomplicated Cases of Fuchs' Corneal Endothelial Dystrophy or PBK With No Preexisting Visual Co-Pathology Other Than Cataract

Time Point	Median BSCVA	Range BSCVA	%BSCVA ≥ 20/40
Preoperatively (n = 36)	20/120	20/30–CF	14
>1 mo postoperatively (n = 36)	20/40	20/20–20/120	78
>6 mo postoperatively (n = 26)	20/40	20/16–20/80	89

BSCVA, best spectacle-corrected visual acuity; CF, counting fingers.

Our overall rates of dislocation (26%) and early graft failure (11%) were high compared with previously published figures. Rates of dislocation in larger case series reported elsewhere range from 1% to 25%, with donor endothelial failure rates varying from 0% to 18%.[6–8,12–15] Our results reflect the combined experience of 7 surgeons making the transition from PK to EK techniques; other factors contributing to the high rates of dislocation and donor endothelial failure we observed may have included the relatively high proportion of cases performed for PBK or failed previous PK (Fig. 1) and poor results in a subgroup of cases operated on using unsuccessful variations in surgical technique.[11]

The association of an open communication between the anterior and posterior chambers with an increased likelihood of donor dislocation is a matter of common experience for EK surgeons worldwide. Data presented here confirm the strength of this association. Air and viscoelastic can move freely between the anterior and posterior chambers where the lens/iris diaphragm is not intact. In addition to problems maintaining adequate air tamponade both at surgery and postoperatively in the presence of an open communication, it may be harder to ensure that viscoelastic has been cleared from the eye before donor material insertion. Most such cases are already aphakic or pseudophakic and can be performed using an anterior chamber maintainer throughout without viscoelastic. Other measures that may help reduce donor dislocation include intrasurgical air compression at controlled higher pressures,[16] surface massage during intrasurgical air compression and stab incisions to expel retained interface fluid,[7] and peripheral host stromal roughening to encourage tissue adhesion.[10] Collaborative research that systematically examines the contribution of these and other developments in surgical technique designed to enhance donor adhesion should help to improve future results.

One other case of dislocation of donor material into the posterior chamber (Fig. 2B) has been reported in a similar multisurgeon EK series.[14] The use of a retaining suture in aniridic cases has recently been described[17] and should avoid this complication in cases where posterior dislocation is a possibility. We used this additional safety measure in 2 aniridic cases. In both these cases, the retaining suture was removed 1 day after surgery and no subsequent dislocation.

Our data highlight the association between additional donor manipulation at surgery or in donor repositioning after dislocation and endothelial failure after EK. Price and Price have previously commented on the association between donor dislocation, donor endothelial cell loss,[18] and donor failure[7]; a recent comparison of longer term endothelial integrity in cases of 5-mm wound (donor folded) and 9-mm wound (donor unfolded) DLEK by Terry et al[19] showing significantly higher endothelial cell loss at 1 and 2 years after small incision (folded donor) DLEK underlines the imperative of minimizing donor tissue manipulation. Further research is required to quantify the extent to which new techniques of tissue insertion[9,20] and unfolding[21] will mitigate cell loss in small incision EK.

Early visual recovery and improved wound strength after EK are widely documented and continue to drive the transition from PK to DSEK or DSAEK as the treatment of choice in corneal endothelial failure.[1] Our encouraging visual results in uncomplicated cases (Table 1) confirm that early visual rehabilitation is achieved in most cases.

Increasingly, corneal surgeons in training will be orientated toward EK techniques rather than PK. Terry et al have recently demonstrated a 1.5% donor dislocation rate with no primary graft failures in a 200 case series of DSAEK which included 60 cases performed by surgeons in training.[22] These good results may reflect adherence to a specific surgical technique and close supervision by a highly experienced EK surgeon. But integrity of the lens/iris diaphragm in a high proportion of cases may have been a factor—only 15% of the cases were performed for PBK in Terry's series.

The key conclusion of this study is that the risk of donor dislocation and subsequent endothelial failure is higher in cases without an intact lens/iris diaphragm. Case selection for surgeons who are at an early stage in the EK learning curve should be informed by these findings.

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