

Perceived difficulties and barriers to uptake of Descemet's membrane endothelial keratoplasty among surgeons

This article was published in the following Dove Press journal:
Clinical Ophthalmology

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Purpose: To determine barriers related to implementation of Descemet's membrane endothelial keratoplasty (DMEK) among corneal surgeons.

Methods: This was a multicenter survey study of all corneal surgeons who participated in a DMEK wet lab organized by the Netherlands Institute for Innovative Ocular Surgery. Data related to barriers limiting uptake of DMEK surgery, self-perceived levels of competence, and difficulty with different steps of DMEK surgery were analyzed.

Results: The survey response rate was 31% (22 of 72). The most common barrier to uptake of DMEK surgery identified was anxiety related to incorrect insertion of the tissue and the need to regraft (64%, 14 of 22), followed by anxiety related to tissue preparation (50%, eleven of 22). Surgeons also felt anxious regarding the possibility of rebubbling with initial DMEK (41%, nine of 22). Steps related to DMEK graft (76%) preparation, tissue insertion (41%), and graft unfolding (72%) were identified as the most difficult steps to learn by the respondents.

Conclusion: The DMEK learning curve, especially for the novice surgeon, may be shortened by seeking educational resources, including wet labs and surgical videos. Eye banks may facilitate adoption of DMEK by making validated DMEK tissue more accessible to surgeons globally.

Keywords: DMEK, uptake, barriers, difficulties

Introduction

Endothelial keratoplasty (EK) techniques have evolved rapidly in recent years. They have largely replaced penetrating keratoplasty as the standard of care for treatment of endothelial disease. Descemet's membrane EK (DMEK), which involves replacing only the diseased Descemet's membrane and endothelium, is the latest anatomical iteration of EK.¹ However, despite being associated with better postoperative visual outcomes, faster visual recovery, and lower rates of endothelial rejection,²⁻⁴ widespread implementation of DMEK has been limited.

Furthermore, a wide variation currently exists in DMEK-uptake rates among countries. For instance, German surgeons were performing DMEK 12 times as often as Descemet's stripping EK (DSEK) in 2016.⁵ In contrast, DMEK accounted for only 11% of the EKs performed in the US in 2015, while DSEK accounted for approximately 50% of all corneal transplants during the same period.⁶ The purpose of this study was thus to identify barriers associated with physician uptake of DMEK.

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Methods

This was a global, survey-based, cross-sectional study performed between March 27, 2018 and September 28, 2018. A 17-item questionnaire (Qualtrics, Provo, UT, USA) developed at the Wilmer Eye Institute was sent to all corneal surgeons who participated in a DMEK wet lab organized by the Netherlands Institute for Innovative Ocular Surgery (<https://www.niios.com/niios-academy/dmek-wetlab-courses-for-beginners-and-early-starters/course-description>).

Data collected from the survey included information related to the surgeons' practice (place and region) and their surgical volume for different procedures (penetrating keratoplasty, DSEK/Descemet's stripping automated (DSAEK), DMEK, and cataract). Participants were also asked whether they had received any formal DMEK training, potential barriers to uptake of DMEK in their practice, self-perceived levels of preparedness and competence, and difficulty with the different steps of DMEK surgery. Since no identifying data were requested through the survey, the study was reviewed and deemed exempt by the Johns Hopkins institutional review board. A consent script was included with the surveys to inform respondents of their participation being voluntary. All statistical analysis was performed using SPSS version 23 (IBM, Armonk, NY, USA). Means with SD were computed to describe continuous data. Frequencies and percentages were calculated to describe categorical data.

Results

Participant characteristics

The survey response rate was 31% (22 of 72). All respondents were surgeons in practice, and a majority (46%, ten of 22) had participated in the DMEK wet-lab within 1–2 years of this survey. Almost 82% (18 of 22) were from outside the US, and most (91%, 20 of 22) had not received any formal surgical training in DMEK (Table 1). Within the study cohort, 50% (eleven of 22) had performed >50 DSEK/DSAEK procedures. In comparison, 77% (17 of 22) had done <50 DMEK surgeries, with the majority in the 1–10 category (Table 2).

Barriers to DMEK surgery

The most common barrier identified to uptake of DMEK surgery was anxiety related to incorrect insertion of the tissue and having to regraft (64%, 14 of 22), followed by

Table 1 Characteristics of corneal surgeons who participated in the survey

DMEK participants (n=22)	n (%)
Time since formal DMEK wet-lab course	
Within 6 months	1 (4.6)
Between 6 months and 1 year	2 (9.1)
Between 1 and 2 years	10 (45.5)
Between 2 and 3 years	3 (13.6)
Between 3 and 4 years	2 (9.1)
Between 4 and 5 years	1 (4.6)
>5 years	3 (13.6)
Current level of practice	
Surgeon in practice	22 (100)
Place of practice	
Academic/university setting	9 (40.9)
Private practice	8 (36.4)
Combination of academic and private	3 (13.6)
Other	2 (9.1)
Public hospital	
Region of practice	
Within the US	4 (18.2)
Outside the US	18 (81.8)
Formal surgical training in DMEK	
Yes	0
No	20 (90.9)
Other ^a	2 (9.1)

Note: ^aAnother day course.

Abbreviation: DMEK, Descemet's membrane endothelial keratoplasty.

anxiety related to tissue preparation (50%, eleven of 22). Surgeons also felt anxious about the possibility of rebubbling with initial DMEK (41%, nine of 22). Cost (36%, eight of 22) was also identified as a barrier (Table 3).

Steps of DMEK surgery

Steps related to DMEK graft (76%) preparation, tissue insertion (41%), and unfolding (72%) were identified as the most difficult steps to learn by the respondents. More than half (52%) the participants also indicated difficulty managing complications (Table 4). Most respondents reported feeling only moderately prepared during their initial DMEK surgery. We found that 46% of the participants currently felt competent in performing DMEK surgery and did not require input from more experienced surgeons. Approximately a third, however, still required more than minimal input for certain steps of the surgery, including preparing and unfolding the DMEK graft, while 18% required such help for graft insertion (Table 5).

Table 2 Surgical case volume of participants

Surgeries performed, n (%)	0	1–10	11–50	51–100	101–500	≥501
Penetrating keratoplasty	0	1 (4.6)	3 (13.6)	3 (13.6)	7 (31.8)	8 (36.4)
DSAEK/DSEK	5 (22.7)	1 (4.6)	5 (22.7)	2 (9.1)	6 (27.3)	3 (13.6)
DMEK	3 (13.6)	10 (45.5)	4 (18.2)	2 (9.1)	3 (13.6)	0

Abbreviations: DSAEK, Descemet's stripping automated endothelial keratoplasty; DSEK, Descemet's stripping endothelial keratoplasty; DMEK, Descemet's membrane endothelial keratoplasty.

Table 3 Barriers limiting surgeon adoption of DMEK

If you have started DMEK surgery, what has been a barrier? ^a	n (%)
Finding the right patient	5 (22.7)
Cost associated with DMEK tissue	8 (36.4)
Anxiety about tissue preparation, if preparing yourself	11 (50.0)
Anxiety about tissue quality, if using an eye bank	2 (9.1)
Concern about needing backup DSAEK tissue	8 (36.4)
Anxiety about increased possibility of rebubbling with initial DMEK	9 (40.9)
Anxiety about inserting the tissue incorrectly and needing to regraft	14 (63.6)
Do not believe the challenges associated with DMEK are worth switching from DSAEK	2 (9.1)

Note: ^aPercentages may not add up to 100%, since some participants had multiple responses.

Abbreviations: DMEK, Descemet's membrane endothelial keratoplasty; DSAEK, Descemet's stripping automated endothelial keratoplasty.

Educational resources

Faculty interaction in either the operating room or the practice lab, watching surgical videos, review of post-operative surgical outcomes, and attending wet-lab training courses were reported as the most helpful resources by participants in helping strengthen their surgical skills (Table 6).

Discussion

The first successful DMEK surgery was performed more than a decade ago,⁷ and while the number of DMEK procedures being performed rose every year between 2012 and 2016, as per data provided by the Eye Bank Association of America, widespread adoption of the technique by corneal surgeons has been slow, because of the perceived difficulty of the procedure.^{1,8} In our study, we found steps related to graft preparation, graft insertion, and unfolding as being the most difficult to learn by corneal surgeons. Graft preparation and graft insertion were also identified as important barriers to the uptake of DMEK surgery, in addition to procedure-related complications and cost.

Manual preparation of donor tissue has frequently been cited as a cause of concern by corneal surgeons. Indeed, graft-preparation failure can often result in certain unacceptable risks related to donor-tissue loss, cancellation of the surgery, and associated financial loss.⁹ Recently, however, several eye banks in the US and abroad have begun prestripping donor tissue. Terry et al⁹ and Deng et al¹⁰ demonstrated successful DMEK surgeries in series of 80 eyes and 40 eyes, respectively, using technician-prepared prestripped donor tissue. None of the donor tissue in either series was damaged by tearing when finishing the final 10% of the stripping maneuver. Moreover, certain eye banks now provide preloaded tissue grafts, thereby further decreasing burden on the surgeon and reducing surgical time and tissue wastage.¹¹ A recent multicenter study involving 55 surgeons, however, found that most surgeons were still preparing grafts themselves.¹² The authors suggested that this may have partly resulted from a lack of local eye banks equipped to prepare DMEK grafts surgically.¹² As such, this highlights the important role that eye banks may need to play to make validated DMEK donor tissue more widely available, since only by eliminating this tissue-preparation and -insertion risk will DMEK ever become commonplace. Future studies to determine safety of using preloaded DMEK tissue, as well as studies to evaluate methods by which DMEK tissue can be analyzed after preloading, are however needed.

Excessive graft manipulation during preparation and implantation can damage endothelial cells. Therefore, quantifying endothelial cell loss that occurs during graft preparation would be a strong indicator of long-term endothelial cell loss and indirectly of graft-failure rates. In their study involving 31 DMEK grafts, Tran et al reported that tissue preloading incurred more endothelial cell loss than simply prestripping tissue.¹³ Studies have also found greater cell loss in the S-stamp area in preloaded DMEK grafts, often with complete loss of all cells in the stamped area.¹⁴ DMEK presents a steep learning

Table 4 Self-perceived difficulty with learning different steps of DMEK surgery

How difficult did you find it to learn the following steps of DMEK surgery?					
	Not at all difficult	A little difficult	Moderately difficult	Very difficult	Total
Selecting the right patient	13 61.90%	7 33.33%	1 4.76%	0 0	21
Selecting the right tissue source if pre-prepared	11 57.89%	4 21.05%	3 15.79%	1 5.26%	19
Preparing the DMEK graft	1 4.76%	4 19.05%	8 38.10%	8 38.10%	21
Performing descemetorhexis	10 45.45%	7 31.82%	4 18.18%	1 4.55%	22
Preparing the DMEK tissue for insertion	5 22.73%	7 31.82%	10 45.45%	0 0	22
Inserting the DMEK tissue	7 31.82%	6 27.27%	8 36.36%	1 4.55%	22
Unfolding the DMEK tissue	3 13.64%	3 13.64%	7 31.82%	9 40.91%	22
Counselling the patient postoperatively	11 50	7 31.82%	4 18.18%	0 0	22
Managing complications	3 14.29%	7 33.33%	8 38.10%	3 14.29%	21

Abbreviation: DMEK, Descemet's membrane endothelial keratoplasty.

curve and surgical skills that are entirely different from DSEK.⁸ Experienced DSEK surgeons may not be as compelled to learn DMEK, especially when they might be achieving satisfactory results with their current technique. Furthermore, unlike certain procedures, such as cataract surgery, which has well-defined algorithms for every step of the surgery, a similar “if this, then that” algorithm does not currently exist for DMEK.⁸ Therefore, the steep learning curve combined with surgeons not knowing the specific “next steps” of surgery and the higher rate of complications experienced initially currently limit the amount of DMEK surgery performed today.¹⁵ However, instead of perceiving the learning curve as a barrier, surgeons should focus on methods to optimize the learning curve to ensure progress. Education and surgical practice can play a particularly crucial role in this, while ensuring a smooth transition from DSEK to DMEK.

One such surgical training resource is wet labs. Surgeons can perform and practice essential surgical maneuvers in wet-lab sessions, which are required to confirm the orientation of the endothelium and unfold and position the DMEK graft in a repeatable and reproducible manner.

Furthermore, the resources needed to set up DMEK-oriented practice labs are readily available and cheap.¹⁶ Sessions supervised by well-experienced trainers may be especially helpful. In fact, one-on-one interactions with experienced faculty were found to be among the most helpful educational resources in our study sample. While formal training has its advantages, the growing platform of video-sharing websites now allows for rapid dissemination of surgical techniques, something not previously possible. Indeed, surgical videos have been shown to be a valuable tool for demonstrating and teaching surgical technique at a minimal cost. In a recent study by McKee et al involving 40 eyes, DMEK surgery was successfully performed in 97% of cases by a corneal surgeon who had learnt the procedure primarily by watching YouTube videos of standardized DMEK techniques.¹⁷

Surgeon anxiety regarding postoperative complications was also identified as an important barrier to uptake of DMEK. It is noteworthy that prior studies have shown a decreasing trend in complication rates as the individual surgeon's learning curve is completed.^{12,18,19} Therefore, it is important that the higher complication rate early on does

Table 5 Self-reported surgeon competence regarding different steps of DMEK surgery

How competent do you currently feel about performing each of the following steps of surgery?					
	Level 1: Not competent	Level 2: Able to do with moderate coaching from a more experienced surgeon	Level 3: Able to do with minimal input from a more experienced surgeon	Level 4: Able to do without input from a more experienced surgeon	Total
Selecting the right patient	0	0	6 27.27%	16 72.73%	22
Selecting the right tissue source if prepared	0	4 18.18%	4 18.18%	14 63.64%	22
Preparing the DMEK graft	3 13.64%	4 18.18%	8 36.36%	7 31.82%	22
Performing descemetorhexis	1 4.55%	2 9.09%	5 22.73%	14 63.64%	22
Preparing the DMEK tissue for insertion	1 4.55%	2 9.09%	7 31.82%	12 54.55%	22
Inserting the DMEK tissue	2 9.09%	2 9.09%	6 27.27%	12 54.55%	22
Unfolding the DMEK tissue	3 13.64%	5 22.73%	4 18.18%	10 45.45%	22
How competent do you feel in DMEK surgery overall?	2 9.1%	2 9.1%	8 36.4%	10 45.5%	22
In order to reach level 4 competence for DMEK surgery overall, how many procedures did you need?					n (%)
0-5					5 (22.7)
6-10					3 (13.6)
11-20					9 (40.9)
21-30					3 (13.6)
31-50					2 (9.1)
50+					0

Abbreviation: DMEK, Descemet's membrane endothelial keratoplasty.

Acknowledgments

The authors would like to acknowledge Xinyi Chen for her help with the study survey and the Mitchell Trust for their continued support of our work.

Disclosure

The authors report no conflicts of interest in this work.

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