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Endothelial keratoplasty: indications and outcomes in a tertiary care center in Lebanon

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Abstract

Objective This study aims to assess the indications and outcomes of Descemet membrane endothelial keratoplasty (DMEK) surgeries in Lebanon, where tissues are imported. Focusing on visual acuity (VA) and central corneal thickness (CCT).

Methods This retrospective chart review analyzed 86 DMEK surgeries performed on 78 patients between 2016 and 2023, examining CCT and VA measured preoperatively and up to one-year post-DMEK. Variables of interest included the rate of rebubbling, intraocular pressure (IOP), tissue preparation methods (preloaded, surgeon-prepared, or pre-stripped/precut tissue), donor age, donor endothelial cell count, time from death to preservation, time from preservation to surgery, and time from death to transplant. The goal was to explore the relationships between these variables and the clinical outcomes.

Results The most common indication for DMEK was pseudophakic or aphakic bullous keratopathy (PBK), followed by graft failure and Fuchs' endothelial corneal dystrophy (FECD). Significant improvements in VA and CCT were observed postoperatively ($p < 0.001$ and $p \leq 0.015$ respectively). The mean IOP was 16.8 mmHg at baseline and 17.2 mmHg at 1 year post-operatively. The mean LogMAR score was 1.46 ± 0.16 at baseline, improving to 0.87 ± 0.21 at the 1-year follow-up. The rebubbling rate was 28.7%. Patients who required rebubbling had significantly higher central corneal thickness (CCT) during the first month ($p = 0.027$), but this difference was not observed over the course of the entire year. However, a notable incidence of postoperative new onset elevation in IOP was documented, affecting approximately 36.5% of patients.

Conclusion Despite challenges posed by limited resources and economic constraints in Lebanon, DMEK surgery has shown promising outcomes in improving VA and CCT. Vigilant monitoring and management of postoperative complications, particularly elevated IOP, is essential. Addressing systemic barriers to healthcare access and enhancing corneal transplantation infrastructure are crucial for ensuring equitable delivery of advanced ophthalmic care in resource-limited settings.

Keywords Descemet membrane endothelial keratoplasty, Corneal surgery, Corneal transplant, Endothelial keratoplasty

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Introduction

Corneal endothelial cells (CEC) play a crucial role in maintaining corneal transparency by regulating aqueous humor outflow [1]. However, they have limited regenerative capacity [1]. Damage to these cells leads to compensatory mechanisms like cell migration and size increase to restore the monolayer, resulting in decreased endothelial cell density (ECD) [1]. Conditions like Fuchs' endothelial corneal dystrophy (FECD) and pseudophakic bullous keratopathy (PBK) cause progressive CEC loss, often leading to the need for corneal transplantation [1]. Over the past years, the approach to treating corneal endothelial failure has evolved significantly, shifting from penetrating keratoplasty (PK) to more selective lamellar procedures [1]. Endothelial keratoplasty (EK), a major advancement in corneal transplant surgery, allows for partial-thickness replacement of diseased endothelium and has become the preferred treatment. Its high success rate, along with lower complication risks and faster visual recovery compared to PK, has led surgeons to favor EK over traditional full-thickness transplants [1–7]. However, despite its advantages, Descemet membrane endothelial keratoplasty (DMEK) remains technically challenging, particularly in graft preparation and unfolding, which can affect surgical efficiency and endothelial cell survival [7]. The method used for graft preparation is a key determinant of surgical success, with even the stripping speed influencing outcomes [8].

Although DMEK has a widespread application, it is associated with a certain level of inequality. Qualified surgeons and a functioning eye bank infrastructure are required to gain access to it. In addition, these surgeries can be expensive. Patients with a low socioeconomic status tend to live far from corneal care centers, have lower rates of compliance with postoperative care, and have decreased access to essential medications, such as corticosteroid drops, that are necessary to prevent graft rejection [9]. For these reasons, patients with corneal blindness secondary to endothelial dysfunction living in third-world countries may remain blind, despite the curability of their condition with EK [9].

Our medical center, situated in Lebanon, is a tertiary facility where obtaining tissue is not immediate; instead, it may take days for the tissue, harvested from deceased donors, to reach the patient after ordering it from abroad. Hence, our study is the first to look at DMEK within the context of a third-world country. This setting adds unique challenges to the already complex procedure. In particular, Lebanon suffers from severe financial burdens which may further delay the process of endothelial keratoplasty. Patients may have difficulty attending follow-up appointments, potentially compromising the success of the surgery and long-term outcomes. Furthermore, our study includes a comparison of the results of DMEK based on the surgical technique: prepared by the surgeon. pre-stripped but requiring cutting during the operation and precut, preloaded tissue.

Finally, given the reported rarity of FECD in the Middle East region, this observation prompts further investigation into the most common indications for DMEK in our center, specifically in Lebanon [10, 11].

Materials and methods

Study design and participants

The DMEK technique was adopted at American University of Beirut Medical Center (AUBMC) in 2016. This study is a retrospective chart review of DMEK surgeries performed on 78 patients at a tertiary care center (AUBMC) between January 2016 and January 2023. The surgeries were performed by three cornea specialists, all trained in DMEK surgery. The data included measurements of corneal thickness, logarithm of the minimum angle of resolution (LogMAR) visual acuity, and intraocular pressure (IOP) both preoperatively and up to one year post-surgery. Analysis was performed to correlate surgical complications with these parameters, as well as factors such as tissue preparation method and donor characteristics. The study received approval from the institutional review board (IRB).

Follow-up

Patients were monitored monthly for one year, though the number of patients attending each follow-up visit varied.

Surgical technique

The DMEK surgical technique involved the use of a 7 mm graft size. A temporal approach was consistently used, except in cases where a superior approach was required for cataract surgery, which limited the graft size. A cannula with 20% SF6 gas was then instilled underneath the DMEK graft to aid positioning. Full gas tamponade was achieved by injecting 20% SF6 through a 32-gauge needle at the limbus.

Covariates

The predictors of interest included the following:

Rebubbling was treated as a binary variable (Yes/No) indicating whether patients underwent rebubbling.

The Surgical technique was grouped into three categories: preloaded, prepared by surgeon, and pre-stripped/precut.

Donor age and endothelial cell count were treated as continuous variables.

The time intervals including time from death to preservation, time from preservation to surgery, and time from death to transplant were measured in days and reported as continuous variables. Time from death to transplant

was further dichotomized into less than 10 days and ≥ 10 days.

Statistical analysis

Sample characteristics were described, using frequency with percentages for categorical variables and mean with standard deviation for continuous variables.

Our primary analysis assessed the variation in corneal thickness and visual acuity (LogMAR) over a one-year follow-up after DMEK surgery. Given that the two continuous outcomes were repeated across time for each patient, we used mixed-effect models with the subject as a random effect to account for repeated measures per patient and with time as monthly intervals (from month 1 to month 12).

We then used linear mixed models (LMM) to examine the relationships over time between the two continuous outcomes with specific indicators of interest (rebubbling, surgical technique, donor age, donor endothelial cell count, time from death to preservation, time from preservation to surgery, and time from death to transplant). Estimated marginal means (EMM) were reported and pairwise comparisons were performed to assess changes between different time points in order to identify specific time points where significant variations in the outcomes occurred. In an additional analysis, we tested for interactions between indicators of interest and time (e.g., rebubbling*month) to identify whether relationships between clinical indicators and outcomes change across time; we note the limited sample size and that results showed no consistent patterns of interactions for both outcomes.

All analyses were conducted using STATA version 16. P-values < 0.05 were considered statistically significant.

Table 1 Sample characteristics

Characteristics	*n* (%) or mean ± SD
Age, in years	**60.9 ± 18.8**
Gender	
Male	**39 (45.3%.)**
Female	**47 (54.7%)**
Country of origin	
Lebanon	**78 (90.7%)**
Palestine	**4 (4.7%)**
Iraq	**3 (3.5%)**
Egypt	**1 (1.2%)**
Number of visits	
Excluding baseline Pre-op visit up to 12 months	**4.56 ± 2.58**
With baseline Pre-op visit up to12 months	**5.5 ± 2.60**

SD: standard deviation

Results

Demographics

Our study analysed **86 surgeries performed on 78 eyes of 77 patients undergoing DMEK surgery**. Among these procedures, 8 DMEK surgeries were performed on one eye twice (4 DMEK repeats), and one patient had both eyes operated on. The demographic data revealed a nearly equal distribution between genders, with females comprising 54.7% of the cohort and males accounting for 45.3%. The patients enrolled in the study exhibited a mean age of 60.9 years with a standard deviation of ± 18.8 years. Additionally, the majority of our patients were Lebanese (90.7%), with other origins including Palestinian (4.7%), Iraqi (3.5%), and Egyptian (1.2%, Table 1).

Pre-existing comorbidities

In our patient population, a significant portion presented with various comorbidities. Notably, 52% of individuals were diagnosed with hypertension, 39% exhibited dyslipidemia, 28% were identified as having diabetes mellitus, 98% of patients had a preexisting ophthalmologic disease.

Intraocular pressure (IOP)

The mean IOP was 16.8mmHg at baseline, 16.4mmHg at 1 month, 18.4mmHg at 3 months, 17.9mmHg at 6 months, and 17.2mmHg at 1 year. Almost more than half of the patients (57.6%) were already on glaucoma medications prior to DMEK surgery, while only 36.5% experienced a new onset post-procedure increase in IOP and required initiation of IOP-lowering medications. The rebubbling rate among patients who developed new onset elevated IOP was (25.9%, $p = 0.69$).

Indications for DMEK

Among 86 DMEK surgeries that were done, the most common indication was PBK (53.5%) followed by graft failure (19.8%), FECD (19.8%), herpes keratitis (2.3%), corneal decompensation secondary to glaucoma valve placement in the anterior chamber (1.2%),Peters anomaly (1.2%), post Bright Ocular Cosmetic iris implantation (BrightOcular®, 1.2%) and Descemet membrane detachment post cataract surgery(1.2%).

Corneal thickness

The mean Corneal Thickness score at baseline was 747.16 µm (713.4 µm 1-780.91 µm), which decreased to 590.82 µm (553.46–628.17 µm) at the 1-month follow-up and increased to 602.8 µm 1 (550.55–655.07 µm) at the 1-year follow-up.

Figure 1 presents the changes in corneal thickness over the first-year post-operation (these are marginal means estimated from linear mixed models accounting for repeated assessments per subject; the marginal means are also presented in Supplementary Table S1). We observed

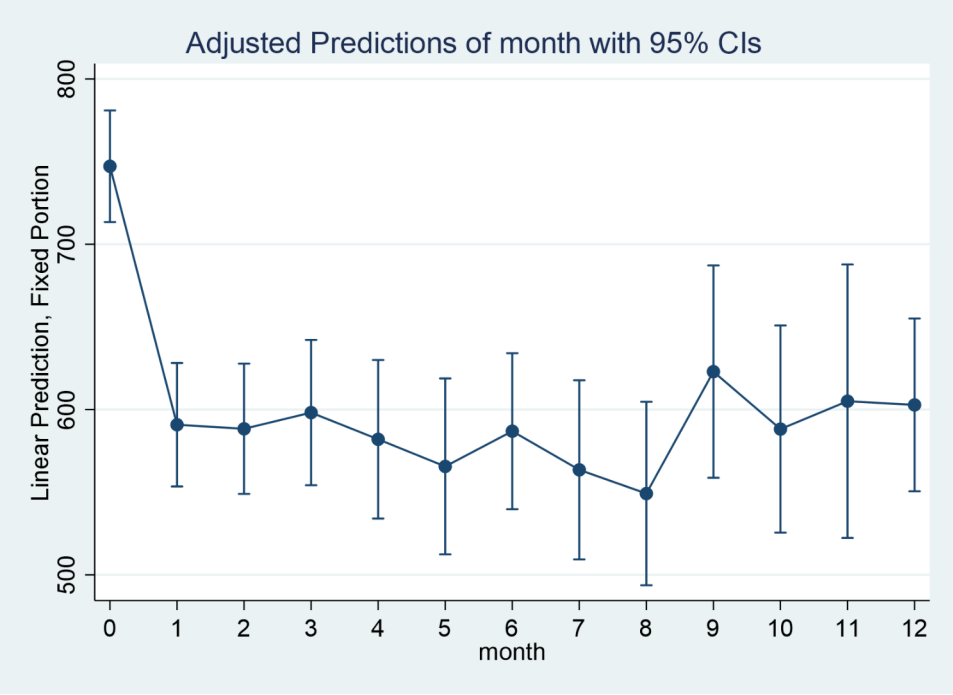

Fig. 1 Changes in corneal thickness over the first year after DMEK surgery. Figure 1: *Pairwise comparisons revealed statistically significant differences between time points Months 1–12 and Baseline ($p < 0.001$), as well as between Month 9 and Month 8 ($p = 0.048$). However, no statistically significant differences were found for pairwise comparisons between all the other time points ($p > 0.05$)*

that corneal thickness significantly decreased across all time points as compared to baseline (pre-operation), with a clear trend of the decrease occurring in the first month followed by a plateau until the 12th month. There were some variations such as an increase in corneal thickness at the 9-month versus the 8-month follow-up ($p = 0.048$) but this trend was not sustained in later follow-ups (no indication of higher thickness across 10, 11, or 12-month follow-up).

Our rebubbling rate was around 28.7% (23 eyes required rebubbling). With regards to factors related to corneal thickness over time, rebubbling was associated with a higher corneal thickness over the year post-operation but this result did not reach statistical significance ($B = 56.96$, 95% CI: -6.68 120.61, $p = 0.079$; Table 2).

While the risk of pupillary block is highest within the first 24 h postoperatively, we observed no cases following DMEK in our study [12].

The percentage of rebubbling for each method is as follows: preloaded: 37.5%, prepared by the surgeon: 27.9%, and precut: 30.0%. No significant association was found between the surgical technique and the rebubbling rate, as indicated by a p-value of 0.851.

There were no significant associations between surgical technique ($p = 0.320$ and $p = 0.221$), donor age ($p = 0.948$), donor endothelial cell count ($p = 0.723$), time from death to preservation ($p = 0.129$), time from preservation to surgery ($p = 0.126$), time from death to transplant ($p = 0.288$) and corneal thickness progression over the year post-operation (Table 2).

Visual acuity (LogMAR)

Figure 2 presents the changes in visual acuity over the first year post-operation (marginal means are also presented in Supplementary Table S1). The mean LogMAR score at baseline was 1.46 (1.30–1.62), which improved to 1.15 (0.93–1.37)at the 1-month follow-up and further decreased to 0.87(0.66–1.08) at the 1-year follow-up.

We observed that LogMAR significantly decreased from baseline (pre-operation) to month 5. This was followed by a trend for an oscillating plateau reaching its minimum at month 12. There were some variations such as an increase in visual acuity after the 11-month follow-up (pairwise comparisons between time points 4, 5, 7, 8, 12 versus Month 11 were statistically significant).

As for factors related to visual acuity over time, rebubbling was not associated with significant changes in visual acuity over the year post-operation ($p = 0.450$, Table 2).

The mean donor cell count was 2803.5 +/- 272.6 cells/mm^2.Higher donor endothelial cell count was not associated with significant changes in visual acuity over the year post-operation ($p = 0.212$; Table 2).

There were no significant associations between visual acuity and surgical technique ($p = 0.829$ and $p = 0.794$), donor age ($p = 0.907$), time from death to preservation ($p = 0.390$), time from preservation to surgery ($p = 0.094$),

Table 2 Factors related to changes in corneal thickness and visual acuity over 12 months and 4 weeks period following surgery

	Beta coefficient for change over 12 months*		Beta coefficient for change over 4 weeks*	
	Beta (95% CI)	***p*-value**	**Beta (95% CI)**	***p*-value**
Corneal thickness				
Rebubbling (Yes vs. No**)	56.96 (-6.68 120.61)	0.079	73.74 (8.40 139.08)	**0.027**
Surgical technique (prepared by surgeon, pre-stripped/cut vs. preloaded**)				
Prepared by surgeon	46.13 (-46.53 134.79)	0.320	41.81 (-51.99 135.62)	0.382
Pre-stripped/precut	73.44 (-43.76 190.32)	0.221	72.28 (-49.99 194.54)	0.247
Donor age	0.09 (-2.78 2.97)	0.948	1.22 (-1.75 4.19)	0.421
Endothelial cell count(cells/mm^2)	-0.02 (-0.13 0.09)	0.723	0.002 (-0.12 0.12)	0.970
Time from death to preservation	-49.45 (-113.27 14.36)	0.129	-33.09 (-99.42 33.24)	0.328
Time from preservation to surgery	18.25 (-5.16 41.67)	0.126	10.98 (-13.53 35.51)	0.380
Time from death to transplant	12.80 (-10.81 36.41)	0.288	6.77 (-17.82 31.36)	0.589
Time from death to transplant (10 ≥ days vs. < 10**)	53.90 (-16.15 123.95)	0.132	38.82 (-34.73 112.36)	0.301
Visual Acuity (LogMAR)				
Rebubbling (Yes vs. No**)	0.13 (-0.20 0.45)	0.450	0.35 (0.04 0.66)	**0.028**
Surgical technique (prepared by surgeon, pre-stripped/cut vs. preloaded**)				
Prepared by surgeon	0.05 (-0.41 0.52)	0.829	-0.02 (-0.47 0.43)	0.936
Pre-stripped/precut	-0.08 (-0.68 0.52)	0.794	-0.17 (-0.76 0.41)	0.559
Donor age	0.001 (-0.01 0.02)	0.907	-0.009 (-0.023 0.005)	0.197
Endothelial cell count	0.0004 (-0.0002 0.0009)	0.212	0.0007 (0.0002 0.001)	**0.008**
Time from death to preservation	-0.14 (-0.46 0.18)	0.390	-0.15 (-0.46 0.17)	0.359
Time from preservation to surgery	0.098 (-0.02 0.21)	0.094	0.08 (-0.03 0.20)	0.148
Time from death to transplant	0.07 (-0.05 0.18)	0.259	0.05 (-0.06 0.17)	0.355
Time from death to transplant (10 ≥ days vs. < 10**)	0.26 (-0.08 0.61)	0.135	0.15 (-0.19 0.49)	0.395

*Beta coefficients are estimated from separate linear mixed models for each predictor-outcome relationship accounting for repeated assessments per subject

** indicates reference group

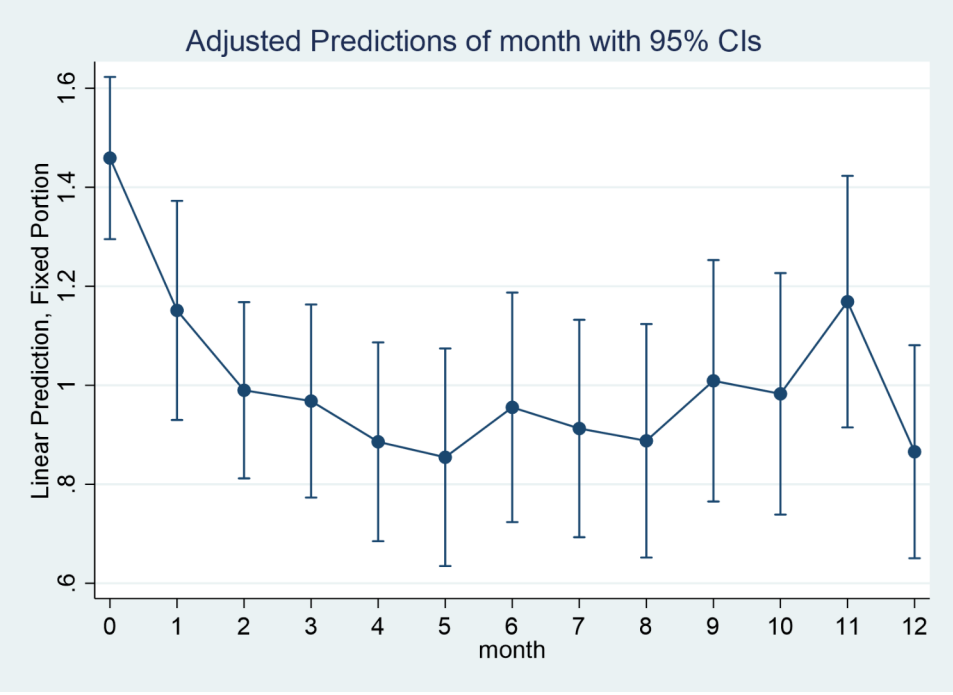

Fig. 2 Changes in visual acuity (LogMAR) over the first year after DMEK surgery. Figure 2: *Pairwise comparisons revealed statistically significant differences between time points Months 1 to 12 versus baseline (p ≤ 0.015). Additionally, statistically significant differences were observed between Months 4, 5, 8, and 12 compared to Month 1 (Italic). Furthermore, all pairwise comparisons between Months 4, 5, 7, 8, and 12 versus Month 11 were statistically significant (p < 0.05)*

time from death to transplant ($p = 0.259$) over the year post-operation (Table 2).

Time from death until preservation

The mean time from death till preservation ranged from 0 to 1 day. No significant association was found between the time elapsed from death until preservation and corneal thickness progression over one year ($p = 0.129$). Similarly, there was no significant correlation between this time interval and LogMAR progression ($p = 0.390$).

Time from preservation until surgery

The mean time from preservation until surgery was 9.6 +/- 1.4 days. Regarding the duration from preservation until surgery, no significant association was observed between this interval and corneal thickness progression over one year ($p = 0.126$). Although an increase in this time period was associated with higher LogMAR values, the relationship did not reach statistical significance ($p = 0.094$).

Time from death until transplant

The mean time from death until transplant was 10.2+/- 1.4 days. Analysis of the time elapsed from death until transplant revealed no significant association with corneal thickness progression over one year ($p = 0.288$) and LogMAR progression ($p = 0.259$).

Discussion

Our study demonstrated a significant decrease in corneal thickness during the first year after surgery compared to baseline, accompanied by a significant improvement in LogMAR. This finding aligns with several published studies [13–15]. For instance, a recent study conducted in the Netherlands by Dunker et al. looked at 752 eyes that underwent DMEK and found a significant improvement in LogMAR progression up to two years post-transplant The average LogMAR decreased from 0.45 logarithm preoperatively to 0.08 logarithms two years after DMEK [16]. Additionally, a study done by Schlögl et al., looking at 310 DMEK procedures has also shown significant improvement in LogMAR and corneal thickness up to 5 years post procedure [15]. Corrected distance visual acuity (CDVA) significantly increased from 0.62 ± 0.42 LogMAR before DMEK to 0.13 ± 0.12 LogMAR ($P < 0.001$) following DMEK [15]. Corneal thickness decreased from 644 ± 67 µm before DMEK to 557 ± 49 µm at 5 years postopeartively [12, 15].

In the literature, graft detachment requiring rebubbling represents a significant challenge in DMEK surgery [12]. The prevalence of eyes requiring rebubbling varies widely, ranging from 2 to 84%, with the majority of studies reporting percentages between 10% and 30% [17–19]. In this study our rebubbling rate (28.7%) was comparable to that reported by Chaurasia et al.(2014). This study examined the outcomes of 492 DMEK procedures between April 2011 and August 2012 and reported a rebubbling rate of 30% [20]. However, our rebubbling rate was higher than that reported in other studies [14, 21]. This difference can be attributed to our smaller sample size, as well as the fact that two out of the patients who required rebubbling also underwent vitrectomies in addition to DMEK surgery [22]. Consequently, the gas bubble was less effective in pressing the graft tissue into the cornea.

In our study, the primary indication for DMEK was found to be PBK, which contrasts with the predominant indication of FECD reported in most existing literature [23–26]. This deviation can be attributed to the fact that the majority of published studies originated from regions such as Asia, America, and Europe. However, our study represents the first investigation of DMEK surgery indications in Lebanon, a Mediterranean country. Interestingly, our findings align closely with studies conducted in neighboring countries, such as Greece, Qatar, and Turkey. In Greece, for example, bullous keratopathy (BK) was the most common indication for corneal transplant (37.5%), with only a minority presenting with FECD (8.8%) [27]. Similarly, in Qatar, corneal scarring (52.0%) and aphakic/pseudophakic bullous keratopathy (13.5%) were the leading indications for corneal transplant compared to FECD(2.4%) [28]. Likewise, in Turkey, keratoconus (34.1%) and bullous keratopathy (17%) were the primary indications for corneal transplant compared to FECD (16%) [29].

Recent studies have shown that endothelial graft preparation techniques vary widely, each with its own advantages and limitations [30]. While numerous methods have been proposed, no single standardized approach has been universally accepted [30]. Our findings revealed no statistically significant correlation between the type of preparation method (preloaded, prepared by surgeon, or pre-stripped precut) and the progression of corneal thickness over the course of one year ($p = 0.340$ and $p = 0.219$) [30, 31]. Similarly, there were no significant associations observed between the preparation type and the progression of LogMAR visual acuity ($p = 0.829$ and $p = 0.794$) [30, 31].

The literature suggests that graft preparation method plays a critical role in DMEK outcomes, with surgeon-prepared grafts demonstrating superior adhesion properties compared to pre-stripped and preloaded tissues [30, 31]. Variability in adhesion force and elasticity due to preparation techniques may influence rebubbling rates and postoperative outcomes [31]. Additionally, the time from graft preparation to surgery is a key factor, as prolonged intervals, especially in preloaded tissues, have been linked to reduced endothelial viability and lower

adhesion potential, potentially increasing detachment risk [31]. This contrasts with our findings, where neither the surgical technique nor the time from preparation to surgery had a significant impact on any outcome [31].

The documented occurrence of increased intraocular pressure (IOP) within 12 months post-DMEK surgery varies between 6.1% and 21.9% [32–34]. However, our data reveal a notably higher incidence of post-DMEK elevation in IOP, affecting approximately 36.5% of patients. This elevated rate could be attributed to the fact that over half of our patients (57.6%) already had increased IOP before undergoing DMEK. Additionally, most of our patients had a diagnosis other than FECD. It's important to note that preexisting glaucoma and receiving an initial diagnosis other than FECD can significantly increase the risk of elevated IOP and the development of glaucoma following DMEK surgery [35]. Moreover, conducting a DMEK procedure is more complex in eyes that have undergone prior glaucoma surgery. Factors such as corneal edema, a tube shunt, anterior synechiae, a history of trabeculectomy, or abnormalities in the anterior segment can increase the surgical difficulty [36].

Being situated in a third-world country poses numerous obstacles to the effective execution of DMEK procedures. In Lebanon, a significant impediment arises from the limited availability of eye banks and corneal donors, thus impeding timely access to corneal tissue for recipients. Moreover, the recent economic downturn has aggravated these challenges. Many patients face financial constraints, rendering them unable to afford essential follow-up appointments and medications, including vital eye drops for postoperative care. These economic limitations not only undermine the patients' ability to adhere to treatment regimens but also diminish the overall accessibility of healthcare resources. Furthermore, the economic crisis has introduced additional hurdles at the governmental level, leading to the suspension of many government functions for months, thereby obstructing the process of acquiring tissue for needy recipients.

While this study provides valuable insights into the outcomes of DMEK surgery in Lebanon, several limitations must be considered. The relatively small sample size of 83 surgeries with follow-up data limits the statistical power and generalizability of the findings. Additionally, the study's single-center design may introduce institutional biases, and the sample may not be representative of broader populations. The short follow-up period of one year also limits our ability to assess the long-term sustainability of improvements in corneal thickness and visual acuity, as well as the development of complications. Moreover, economic constraints in Lebanon, due to the ongoing economic crisis, have affected patients' ability to afford essential follow-up visits, medications, and postoperative care, which may have influenced outcomes. Furthermore, inconsistent follow-up due to financial and logistical challenges may have led to an underreporting of complications or incomplete data on long-term effectiveness.

This study's findings offer several key insights that could enhance clinical practice, particularly in resource-limited settings like Lebanon. First, the significant improvements in VA and CCT observed after DMEK surgery align with the growing body of evidence supporting its efficacy for treating endothelial diseases such as PBK and graft failure. These results emphasize the value of DMEK as an effective surgical option, with outcomes comparable to those seen in larger international studies. In addition, the high rate of rebubbling observed in this study highlights the need for clinicians to carefully monitor graft stability, especially in cases involving additional procedures like vitrectomy, which may affect the success of the gas bubble in pressing the graft into place [22]. The study also reveals a higher-than-expected incidence of increased IOP following surgery, which underscores the importance of preoperative IOP assessment and vigilant post-surgical monitoring for elevated IOP, particularly in patients with a history of glaucoma or other preexisting ocular conditions [22]. Additionally, the lack of a significant correlation between tissue preparation methods and surgical outcomes (such as CCT and VA) suggests that factors beyond preparation method may influence postoperative results, allowing for more flexibility in surgical practice [30, 31]. The study also provides valuable insights into regional trends, highlighting that PBK is a more common indication for DMEK surgery in Lebanon compared to FECD, a trend that mirrors patterns seen in neighboring countries [29]. These findings can guide clinicians in tailoring DMEK surgery protocols based on local patient populations and conditions. Overall, this study emphasizes the need for ongoing research and improvements in healthcare infrastructure, such as better access to donor tissues and enhanced management of postoperative complications, to optimize outcomes for patients undergoing DMEK surgery, especially in settings with limited resources.

Conclusion

In conclusion, our study sheds light on the outcomes of DMEK surgery in Lebanon, providing valuable insights into the challenges and successes of implementing this advanced procedure in a third-world country. Despite the unique obstacles posed by limited resources and economic constraints, DMEK surgery has demonstrated promising results in improving visual acuity and corneal thickness among our patient population. Moving forward, efforts to address the systemic barriers to healthcare access and improve the infrastructure for corneal transplantation are essential to ensure equitable

and sustainable delivery of advanced ophthalmic care in resource-limited settings like Lebanon.

Abbreviations

AUBMC	American University of Beirut Medical Center
CCT	Central Corneal Thickness
DMEK	Descemet membrane endothelial keratoplasty
EK	Endothelial keratoplasty
EMM	Estimated marginal means
FECD	Fuchs' endothelial corneal dystrophy
IRB	Institutional review board
IOP	Intraocular pressure
LMM	Linear mixed models
PBK	Pseudophakic or aphakic bullous keratopathy
VA	Visual Acuity

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12886-025-04015-w.

Supplementary Material 1

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Author contributions
Sally Al Hassan, M.D.: Contributed to the study conception and design, analyzed and interpreted the clinical data, and wrote the manuscript. Martine Elbejjani, Ph.D.: Provided expertise in statistical analysis, contributed to the data analysis and interpretation, and critically reviewed and edited the manuscript. Sara Mansour: Assisted with data collection, performed preliminary data analysis, and contributed to the drafting and revision of the manuscript. Joseph Khalil, M.D.: contributed to the study design, assisted in the clinical data analysis and collection, and contributed in the manuscript writing. Shady Awad, M.D.: Assisted with the surgical procedures, contributed to data collection, and reviewed the manuscript. Joanna S. Sadde, M.D.: Supervised the entire research project, performed surgeries, provided guidance on the study design and methodology, contributed to data interpretation, and critically revised the manuscript for important intellectual content. All authors have read and approved the final manuscript.

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Data availability
Data is provided within the manuscript or supplementary information files. additional data is available upon reasonable request from the corresponding author.

Declarations

Ethics approval and consent to participate
This study was approved by the Institutional Review Board (IRB) at AUBMC. The need for informed consent to participate was waived by the Institutional Review Board (IRB) at the American University of Beirut Medical Center (AUBMC), as this study is a retrospective chart review and all data were anonymized prior to analysis. This study adhered to the tenets of the Declaration of Helsinki and was conducted in accordance with relevant national guidelines.

Competing interests
The authors declare no competing interests.

Data availability
All data used is available upon reasonable request from the corresponding author Dr Joanna S.Saade by email (js62@aub.edu.lb).

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