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Is ultra-thin Descemet stripping automated endothelial keratoplasty a viable alternative to Descemet membrane endothelial keratoplasty? A systematic review and meta-analysis

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Abstract

Background: Ultra-thin Descemet stripping automated endothelial keratoplasty (UT-DSAEK) is a recently developed surgical procedure that has shown promising results for the management of various corneal endothelial diseases.

Objectives: To evaluate the outcomes of the UT-DSAEK to the Descemet membrane endothelial keratoplasty (DMEK).

Design: A systematic analysis of the studies comparing UT-DSAEK with DMEK by evaluating one or more outcomes (vision, complications, and post-operative endothelial cell counts) was performed. The meta-analysis was done if two or more studies reported a common outcome.

Methods: We used PubMed, EMBASE, and SCOPUS databases to identify articles comparing the outcomes of UT-DSAEK with DMEK and performed a meta-analysis using RevMan, version 5.4.

Results: A total of six studies were included in this review (two randomized clinical trials and four non-randomized comparative studies). Our analysis showed the patients who underwent DMEK cases showed better visual outcomes with a mean difference of 0.06 LogMAR (95% CI: 0.04–0.09) in BCVA, albeit with i^2 of 52% (heterogenous values). The evidence was weak, with the most weightage on retrospective studies. UT-DSAEK showed significantly fewer complications such as graft dislocations, with an odds ratio of 0.25 (95% CI: 0.13–0.48). There was no significant difference in the endothelial cell counts with a mean difference of 86.34 (95%CI: −133.09 to −305.77).

Conclusion: Although the literature is limited on UT-DSAEK with post-operative visual acuity that could be practically at par with DMEK, lesser complication rates and comparable post-operative endothelial cells could be a suitable alternative to DMEK for corneal endothelial pathologies.

Keywords: Descemet membrane endothelial keratoplasty, DMEK, endothelial keratoplasty, meta-analysis, ultra-thin Descemet stripping automated endothelial keratoplasty, UT-DSAEK

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Introduction

Corneal transplantation procedures have seen a paradigm shift from the open-sky technique of full-thickness penetrating keratoplasty (PK) to recently developed technique of replacing diseased endothelium in the form of endothelial keratoplasty (EK).[1] EK has distinct advantages over PK in visual outcomes, recovery rates, and complications rates; hence, it has become the procedure of choice for managing corneal endothelial disorders like Fuchs endothelial dystrophy, pseudophakic bullous keratopathy, and failed PK.[2] The most commonly performed EK procedures include Descemet stripping endothelial keratoplasty/Descemet stripping automated endothelial keratoplasty (DSEK/DSAEK) and Descemet membrane endothelial keratoplasty (DMEK).[3]

Melles and colleagues developed DSEK that involved mechanical removal or stripping of the Descemet membrane and endothelium, followed by replacement of the layer by lamella prepared by mechanical separation of the posterior layer of the donor cornea, which essentially consisted of the endothelium, Descemet membrane, and a few posterior lamellae.[4,5] The technique was further refined by Price and colleagues and popularized for endothelial diseases and showed a good prognosis with better visual outcomes and fewer complications.[6] To overcome the issues of smooth and uniform manual dissection, the donor lamellae were prepared using a microkeratome, and this technique is known as DSAEK. It provided a smoother graft-host interface and had better vision outcomes.[7] However, this significantly adds to the cost because of additional machinery and eye bank set up for the precept tissues.

Melles and colleagues subsequently described the breakthrough technique of DMEK, where the diseased layers were replaced by only the Descemet membrane and the endothelial layer.[8] It provided exceptional visual outcomes and shorter recovery time. However, the surgical technique remains technically demanding with a steeper learning curve for donor preparation. Moreover, it has a longer surgical duration and has a higher rate of lenticular detachment compared to DSAEK.[9] Thus, DSEK/DSAEK continues to be the preferred procedure over DMEK. In a recently conducted survey, 97% of the cornea specialists responded that they perform DSEK/DSAEK regularly, while only 70% had attempted DMEK at least once in their practice.[10] Therefore, a newer surgical technique was required which could be technically comparable to DSEK but have visual outcomes at par with DMEK. Neff and coworkers attempted to elucidate a relation between the graft thickness and its effect on visual acuity.[11] They observed that thinner grafts ($<131\,\mu m$) fared better than the thicker ones, with the former achieving best spectacle-corrected visual acuity (BSCVA) of 20/25 and 71% among them had BSCVA of 20/20. This eventually led to the concept of DSAEK with thinner grafts $\leqslant 100\ \mu m$ and was named ultra-thin DSAEK (UT-DSAEK).

Busin and colleagues presented the concept and technique of lenticular preparation for UT-DSAEK.[12] The procedure involved a two-pass technique of microkeratome, where the first pass would cut the lenticule from the donor cornea, and the second pass would further refine the thickness to the tune of 100 microns. They reported that UT-DSAEK has better visual outcomes and recovery rate compared to the standard DSAEK. Furthermore, Busin and colleagues reported that UT-DSAEK vision outcomes were comparable to DMEK with fewer complications.[13] A randomized control trial compared UT-DSAEK (graft thickness $101 \pm 24\,\mu m$) with DSAEK ($209 \pm 39\,\mu m$) and showed significantly better visual outcomes at 1-year post-procedure with short recovery period in patient who underwent UT-DSAEK.[14] The rate of endothelial loss and other complications were comparable for the two procedures. Similarly, Droutas and colleagues also observed better visual outcomes with thinner corneal grafts.[15] The promising outcomes in UT-DSAEK have made it a potential surgical procedure of choice and a viable alternative to a more technically challenging procedure like DMEK. In this, systematic review, we evaluate and compare these two techniques in terms of visual outcomes and post-procedural complications.

Methods

A literature review was performed as per PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analyses) guidelines through PubMed, EMBASE, and SCOPUS, and a meta-analysis was performed to evaluate outcomes.[16] The primary search was conducted on 4 June 2021, using specific keywords (Table 1). The literature search was limited by year, language, or country of publication. A secondary search was performed from the reference sections of the identified publications. Randomized or non-randomized studies comparing UT-DSAEK with DMEK were included. Non-comparative study designs, cadaveric studies, biomechanical studies, conference abstracts, case reports, and any studies that evaluated other types of keratoplasties were excluded. The articles that were not in English were also excluded.

Table 1. The search strategy for the systematic review in PubMed, Scopus, and Embase databases.

Database	Search no.	Keywords (inception to 4 June 2021)	Results
PubMed	1	Ultra [All Fields] AND thin [All Fields] AND ("descemet stripping endothelial keratoplasty" [MeSH Terms] OR ("descemet" [All Fields] AND "stripping" [All Fields] AND "endothelial" [All Fields] AND "keratoplasty" [All Fields]) OR "descemet stripping endothelial keratoplasty" [All Fields])	94
	2	1 and versus [All Fields] AND ("descemet membrane" [MeSH Terms] OR ("descemet" [All Fields] AND "membrane" [All Fields]) OR "descemet membrane" [All Fields]) AND ("endothelium" [MeSH Terms] OR "endothelium" [All Fields] OR "endothelial" [All Fields]) AND ("corneal transplantation" [MeSH Terms] OR ("corneal" [All Fields] AND "transplantation" [All Fields]) OR "corneal transplantation" [All Fields] OR "keratoplasty" [All Fields])	48
	3	Ultra [All Fields] AND thin [All Fields] AND DSAEK [All Fields] AND DMEK [All Fields]	19
Scopus	1	TITLE-ABS-KEY (ultra AND thin AND descemet AND stripping AND endothelial AND keratoplasty AND descemet AND membrane AND endothelial AND keratoplasty)	8
	2	TITLE-ABS-KEY (ultra AND thin AND dsaek AND dmek)	6
Embase	1	'Ultra thin descemet stripping automated endothelial keratoplasty' OR [('ultra'/exp OR ultra) AND thin AND descemet AND ('stripping'/exp OR stripping) AND automated AND endothelial AND ('keratoplasty'/exp OR keratoplasty)]	15
	2	Ultra thin descemet stripping automated endothelial keratoplasty descemet membrane endothelial keratoplasty' OR [('ultra'/exp OR ultra) AND thin AND ('stripping'/exp OR stripping) AND automated AND descemet AND ('membrane'/exp OR membrane) AND endothelial AND ('keratoplasty'/exp OR keratoplasty)]	5
Total	**166**		

Data collection and analysis

The search results were independently assessed for inclusion by two authors (TS and PI). Any discrepancies were resolved by discussions and mutual consensus. The data extracted were tabulated on standardized data collection sheets, which included author names, publication year, relevant demographic parameters of patients included in the study, and outcome measures of interest, post-procedure visual acuity, complications like graft failure, rejection, or detachment, raised intraocular pressure (IOP), and endothelial cell counts (Table 2).

Outcome measures

The post-procedural best-corrected visual acuity (BCVA, in LogMAR) was the primary outcomes measure for quantitative analysis. The secondary outcome measures included complications (graft-related issues, increased intraocular pressure, re-bubbling, etc.) and post-operative endothelial cell density (cells/mm^2) and loss percentage.

Assessment of risk of bias

The risk of bias for this study was evaluated independently by two authors using the Cochrane

Table 2. A summary of the studies reporting the clinical outcomes of ultra-thin Descemet stripping automated endothelial keratoplasty and Descemet membrane endothelial keratoplasty included in the study.

Authors, year	Study	No. of patients per group	Average age (Mean age in years ± SD)	Sex (M:F)	Pre-op BSCVA (logMAR ± SD)	Pre-op spherical equivalent (D)	Pre-op lenticule thickness	Pre-op Endothelial cell count (cells/mm² ± SD)	Pre-op CCT (microns)	Surgery *N* (%)	Post-op BSCVA (logMAR)	Post-op Endothelial cell count (cells/mm²)	Post-op Pachymetry (μm)	Post-op graft complications	Post-op mean follow-up duration (months)
Chamberlain *et al.*[17]	RCT	UT-DSAEK: 25	UT-DSAEK: 68	UT-DSAEK: 9:16	UT-DSAEK: 0.27 ± 0.21	UT-DSAEK: −0.4 ± 1.9	UT-DSAEK: 73 ± 12	UT-DSAEK: 2796 ± 238	UT-DSAEK: 610 ± 44	UT-DSAEK: Pseudophakic EK: 32%, Triple EK: 68%	UT-DSAEK: 0.16 ± 0.18	UT-DSAEK: 2070 ± 292	UT-DSAEK: - 2 ± 45	UT-DSAEK: 9	12 months
		DMEK: 25	DMEK: 68	DMEK: 12:13	DMEK: 0.34 ± 0.29	DMEK: −0.8 ± 2.2	DMEK: Standard	DMEK: 2771 ± 150	DMEK: 608 ± 52	DMEK: Pseudophakic EK: 28%, Triple EK: 72%	DMEK: 0.04 ± 0.12	DMEK: 1855 ± 448	DMEK: −87 ± 46	DMEK: 16	
Dunker *et al.*[18]	RCT	UT-DSAEK: 25	UT-DSAEK: 71 ± 7	NA	UT-DSAEK: 0.31 ± 0.13	UT-DSAEK: −0.83 ± 1.54	UT-DSAEK: 101 ± 25	UT-DSAEK: 2633 ± 158	NA	UT-DSAEK: Pseudophakic EK: 100%	UT-DSAEK: 0.15 ± 0.11	UT-DSAEK: 1612 ± 645	NA	UT-DSAEK: 6	12 months
		DMEK: 29	DMEK: 72 ± 7		DMEK: 0.37 ± 0.18	DMEK: −0.09 ± 1.39	DMEK: standard	DMEK: 2679 ± 157		DMEK: Pseudophakic EK: 100%	DMEK: 0.08 ± 0.14	DMEK: 1870 ± 504		DMEK: 17	
Mencucci *et al.*[19]	Retrospective fellow-eye comparison	UT-DSAEK: 18	UT-DSAEK: 73.5 ± 7.93	UT-DSAEK: 1:8	UT-DSAEK: 0.60 ± 0.29	NA	UT-DSAEK: 80.33 ± 20.52	UT-DSAEK: 2700 ± 59.41	UT-DSAEK: 618 ± 39.41	UT-DSAEK: Pseudophakic EK: 100%	UT-DSAEK: 0.10 ± 0.04	UT-DSAEK: 1772.62 ± 185.59	UT-DSAEK: 570.38 ± 21.96	UT-DSAEK: 1	12 months
		DMEK:18	DMEK: 73.5 ± 7.93	DMEK: 1:8	DMEK: 0.51 ± 0.11		DMEK: standard	DMEK: 2625.56 ± 124.58	DMEK: 629.28 ± 38.64	DMEK: Pseudophakic EK: 100%	DMEK: 0.07 ± 0.07	DMEK: 1590.94 ± 136.87	DMEK: 516.29 ± 33.52	DMEK: 3	
Tourabaly *et al.*[20]	Retrospective	UT-DSAEK: 52	UT-DSAEK: 72 ± 7	NA	UT-DSAEK: 0.84 ± 0.38	NA	UT-DSAEK: 50 to 99	NA	UT-DSAEK: 661 ± 77	UT-DSAEK: Pseudophakic EK: 48%, Triple EK: 52%	UT-DSAEK; 0.17 ± 0.12	NA	UT-DSAEK: 597 ± 51	NA	32 months
		DMEK: 38	DMEK: 69 ± 8		DMEK: 0.48 ± 0.32		DMEK: standard		DMEK: 622 ± 58	DMEK: Pseudophakic EK: 23.7%, Triple EK: 76.30%	DMEK: 0.09 ± 0.11		DMEK: 529 ± 48		
Romano *et al.*[21]	Retrospective	UT-DSAEK: 31	UT-DSAEK: 69.3 ± 13.0	UT-DSAEK: 1:8	UT-DSAEK: 1.09 ± 0.7	NA	UT-DSAEK: 75.29 ± 15.4	UT-DSAEK: 2562 ± 111	NA	UT-DSAEK: Pseudophakic EK: 64.5%, Triple EK: 35.5%	UT-DSAEK: 0.37 ± 0.37	NA	NA	UT-DSAEK: 4	12 months
		DMEK: 25	DMEK: 77.56 ± 9.7	DMEK: 1:8	DMEK: 0.84 ± 0.58		DMEK: standard	DMEK: 2560.00 ± 100		DMEK: Pseudophakic EK: 40 %, Triple EK: 60%	DMEK: 0.17 ± 0.20			DMEK: 11	
Torras-Sanvicens *et al.*[22]	Cross sectional Comparative Observational case series	UT-DSAEK: 10	UT-DSAEK: 75.4 ± 6.69	UT-DSAEK: 2:3	UT-DSAEK: 0.49 ± 0.22	NA	UT-DSAEK: < 100 microns	UT-DSAEK: 2520 ± 257.33	UT-DSAEK: 671.12 ± 60.90	UT-DSAEK: Pseudophakic EK: 100%	UT-DSAEK: 0.16 ± 0.14	UT-DSAEK: 658.80 ± 139.33	UT-DSAEK: 621.20 ± 33.74	UT-DSAEK: 1	Not mentioned clearly
		DMEK: 10	DMEK: 75.4 ± 6.69	DMEK: 2:3	DMEK: 0.43 ± 0.17		DMEK: standard	DMEK: 2670 ± 194.65	DMEK: 656.28 ± 39.42	DMEK: Pseudophakic EK: 100 %	DMEK: 0.21 ± 0.29	DMEK: 1059 ± 421.84	DMEK: 529.70 ± 30.00	DMEK: 1	

BSCVA, best spectacle-corrected visual acuity; CCT, central corneal thickness; D, diopters; DMEK, Descemet membrane endothelial keratoplasty; EK, endothelial keratoplasty; F, female; M, male; NA, not available; SD, standard deviation; UT-DSAEK, ultra-thin Descemet stripping automated endothelial keratoplasty.

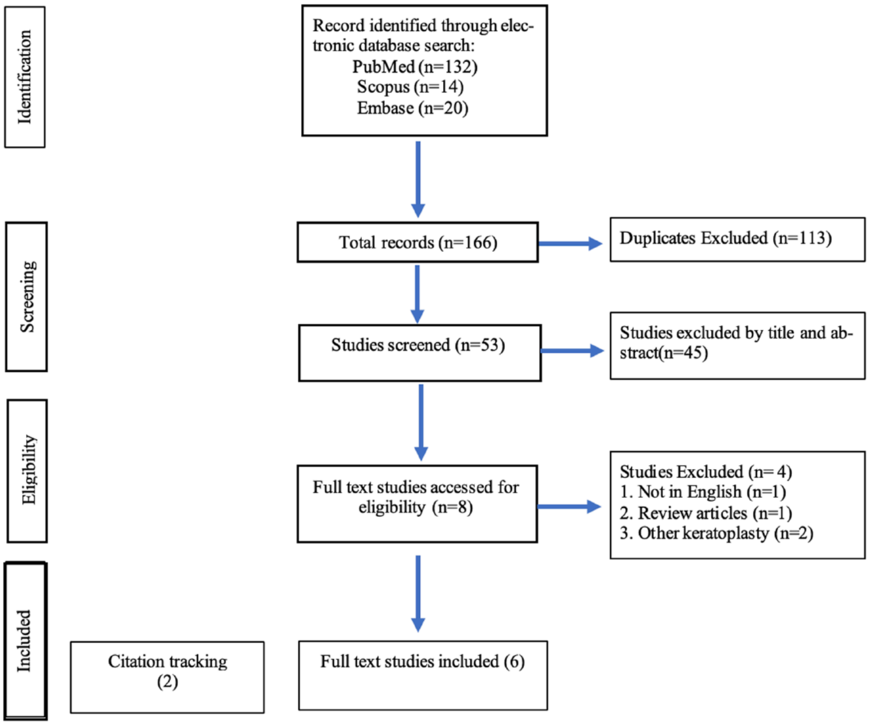

Figure 1. The PRISMA flow diagram outlining the study selection methodology.

Collaboration's risk of bias tool and MINORS tool for evaluating non-randomized comparative studies.[23,24] The figures and summary were prepared using the Review Manager Software (RevMan) version 5.4 (The Cochrane Collaboration, 2020).

Statistical analysis

We performed the meta-analysis on the outcome of interest, with statistical heterogeneity determined using the I^2 test. The underlying reasons for clinical heterogeneity were also assessed. The fixed-effects model was used to assess the outcomes if similar methods were used in all the studies, and random-effects model was used for the remaining. We used Review Manager Software (RevMan) version 5.4 (The Cochrane Collaboration, 2020) for statistical analysis.

Results

Using the aforementioned keywords, the three databases returned 166 results, out of which 53 studies were identified for further evaluation. Subsequently, the titles and abstracts were screened, and duplicates were excluded and full texts of eight studies were evaluated. For the final analysis, six studies, published between 2018 and 2020, were identified for the systematic analysis (Figure 1).

Study characteristics

The final analysis included three retrospective studies and two prospective randomized clinical trials.[17–22] The procedures were performed between 36 to 90 eyes in these studies, totaling 306 eyes (151 had UT-DSAEK and 135 had DMEK). The mean age of patients across the studies was 71.8 years. The demographics, preoperative visual parameters, and endothelial cell counts across the six studies were comparable and are outlined in Table 2.

Risk of bias

The risk of bias for the two randomized trials was low as both were level 1 studies with good quality [Figure 2(a) and (b)]. On the contrary, the MINORS tool showed moderate risk of bias [Figure 3(a) and (b)].

Primary outcomes

Among the studies included in the meta-analysis, only Chamberlain and colleagues observed a

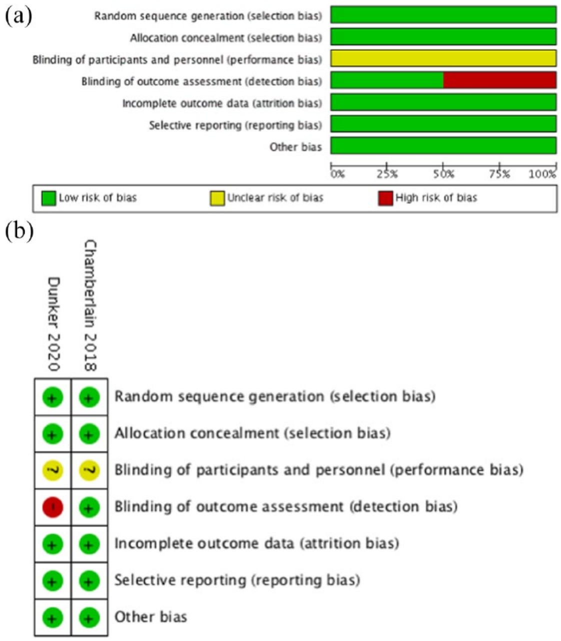

Figure 2. Risk of bias graph (a) and summary (b): A judgment of the authors' criteria about the risk of bias items presented across the two randomized trials.

significantly better post-operative VA in patients who underwent DMEK (0.04 ± 0.12) than UT-DSAEK (0.16 ± 0.18) groups.[17] In a randomized control trial, Dunker and colleagues reported a post-operative VA of 0.15 ± 0.11 in UT-DSAEK group and 0.08 ± 0.14 in DMEK group.[18] In a retrospective fellow-eye comparison study including 36 subjects, Mencucci and colleagues reported a post-operative VA of 0.10 ± 0.04 and 0.075 ± 0.07 in UT-DSAEK and DMEK groups, respectively.[19] In the two retrospective studies including in the analysis, the VA was moderately better in DMEK group compared to UT-DSAEK group; however, no statistical significance was observed. Tourabaly and colleagues reported a post-operative VA of 0.17 ± 0.12 and 0.09 ± 0.11 in the UT-DSAEK and DMEK groups, respectively.[20] Similarly, Romano and colleagues, reported a post-operative VA of 0.37 ± 0.37 and 0.17 ± 0.2 in UT-DSAEK and DMEK groups, respectively.[21] Interestingly, Torras-Sanvicens and colleagues reported moderately better VA outcomes in patients who underwent UT-DSAEK (0.16 ± 0.14) compared to DMEK (0.21 ± 0.29).[22]

The quantitative assessment of the pooled data from the studies included in the meta-analysis showed better visual outcomes in patients who underwent DMEK with a mean difference of 0.06 and a 95% confidence interval (CI) from 0.04 to 0.09. However, the data demonstrated heterogeneity with $I^2 = 52\%$, which could have been due to different designs of the included studies (Figure 4).

Secondary outcomes

The post-operative complications were only reported in five of the six studies included in the analysis and included graft failure, rejection, and

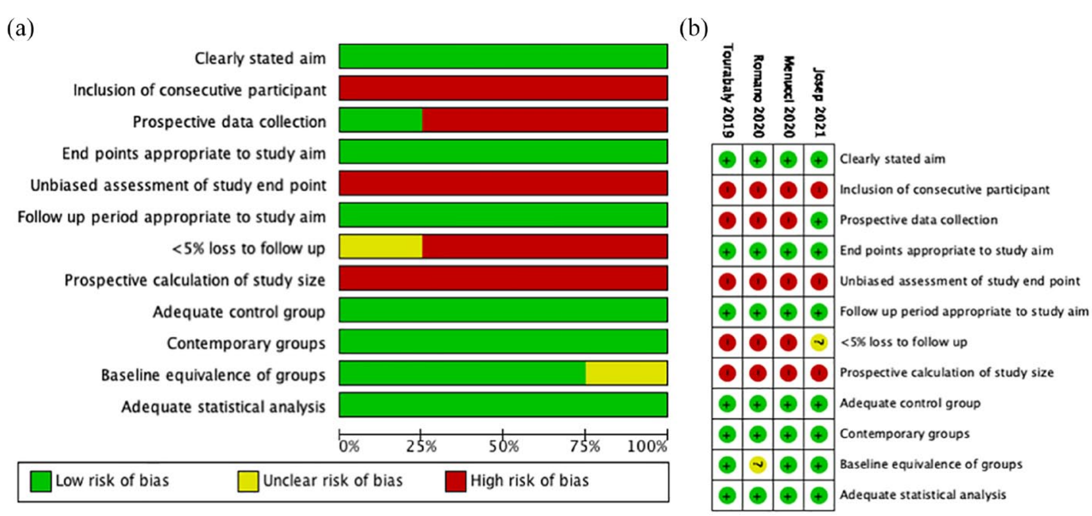

Figure 3. Risk of bias graph (a) and summary (b): A judgment of the authors' criteria about the risk of bias items presented across the four non-randomized studies.

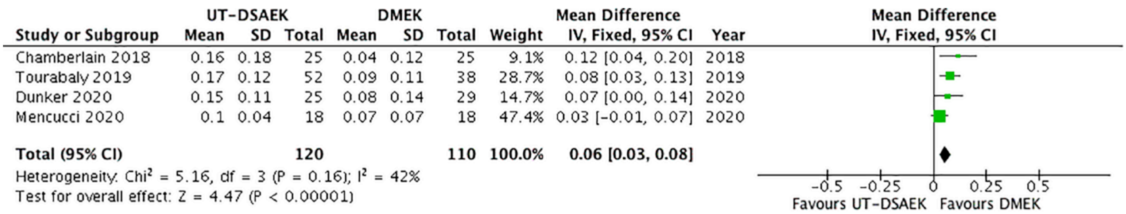

Figure 4. Forest plot comparing post-operative visual acuity (logMAR) between UT-DSAEK and DMEK groups.

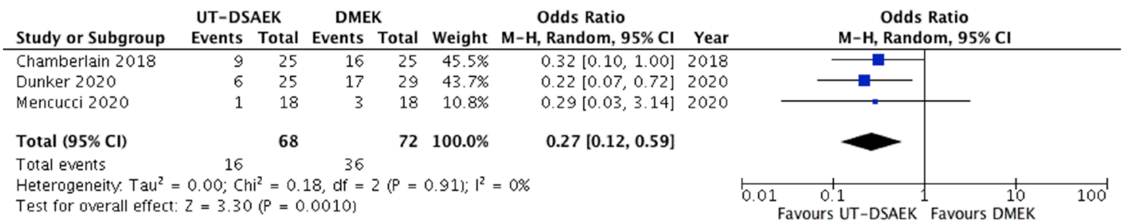

Figure 5. Forest plot comparing the rates of complication between the UT-DSAEK and DMEK groups.

displacement, re-bubbling and raised IOP. In the randomised controlled trial (RCT), Chamberlain and colleagues reported complications in 16 patients (64%) who underwent DMEK, and 9 patients (36%) had complications in the UT-DSAEK group.[17] In the other RCT included in the analysis, complications were more common post-DMEK ($n=17$, 58.6%) than UT-DSAEK ($n=6$, 24%).[18] Romano and colleagues also reported a higher frequency of complications in patients who underwent DMEK ($n=11$, 44%) compared to UT-DSAEK ($n=4$, 12.9%).[21]

In the retrospective study conducted by Mencucci and colleagues, very few complications were reported in patients who underwent DMEK ($n=3$, 16.6%) and UT-DSAEK ($n=1$, 5.5%).[19] Similarly, Torras-Sanvicens and colleagues also observed just one complication out of the 10 patients in both DMEK and UT-DSAEK groups, respectively.[22] In all the studies, re-bubbling was the most commonly reported complications and the re-bubbling rate distinctly more common in the patients who underwent DMEK compared to UT-DSAEK. The meta-analysis of the pooled data showed 21 patients who underwent UT-DSAEK and 48 patients who underwent DMEK-reported complications. These data showed a lower complication rate in UT-DSAEK with an odds ratio of 0.26 (95% CI: 0.14–0.51; Figure 5).

The meta-analysis showed higher post-operative endothelial cell counts in patients who underwent UT-DSAEK compared to DMEK. The mean difference between UT-DSAEK and DMEK groups was 96.63 and 95% CI (10.35–182.92). The analysis of endothelial cell counts in patients after both the surgical procedures is summarized in Figure 6.

Discussion

In this meta-analysis, we compare the visual outcomes and complications in patients who are managed with either UT-DSAEK or DMEK. This analysis is limited to six studies, highlighting the limited clinical data evaluating the clinical efficacy of newly adopted surgical procedure–UT-DSAEK. Although, DMEK provides optimal surgical outcomes, the complicated technique with a steep learning curve leads to higher complication rates.[10] Hence, UT-DSAEK can offer a potential alternative surgical procedure with similar visual outcomes and low complication rates.

In this study, the visual outcomes in patients who underwent DMEK were comparatively better than those who were managed with UT-DSAEK. However, the overall weightage of the retrospective studies was more in the meta-analysis, which can weaken the evidence. Moreover, Chamberlain and colleagues highlighted that the maximum effective vision difference was only 1.4 lines in patients who had either of the surgery.[17] Hence, the visual outcomes in DMEK may be statistically better, but this may not translate into clinically better outcomes than UT-DSAEK. Graffi

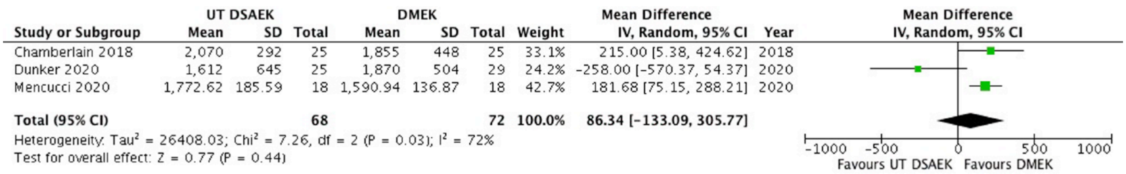

Figure 6. Forest plot comparing the post-operative endothelial cell density (cells/mm^2) between UT-DSAEK and DMEK groups.

and colleagues performed UT-DSAEK after failed primary DMEKs and showed favorable outcomes in 92% of the patients with a VA ⩾ 20/25 at 12 months and 30% of the patients with a VA ⩾ 20/20. In addition, the endothelial cell loss (ECL) was 38.9% in these patients 1 year after the surgery, thus substantiating the favorable outcomes with DSAEK.[25] The relative ease of performing UT-DSAEK, made it their procedure of choice for this salvageable method. Moreover, this report also highlights the potential of UT-DSAEK as a possible option in cases requiring revision surgeries, especially for inexperienced ophthalmic surgeons still in learning phase for DMEK.

A comparison of the safety profile of the two procedures, favored UT-DSAEK over DMEK. All the studies included in this meta-analysis reported fewer complications in patients who had UT-DSAEK compared to DMEK, which was also confirmed by the pooled analysis. The major complications reported in five of the six studies were graft dislocation and re-bubbling for both the procedures. The evaluation of each study showed that the complication rates were lower in UT-DSAEK compared to DMEK, except Torras-Sanvicens and colleagues who reported one patient each in both the groups reported post-operative complications. The endothelial cell density is a critical parameter governing the long-term survival of the transplanted graft and is considered an effective clinical measure to evaluate the long-term efficacy of the procedure. The post-operative endothelial cell density analysis was comparable for both the procedures. The ECL percentage was reported to be 25.96% in the UT-DSAEK and 33.05% in the DMEK group, by Chamberlain and colleagues.[17] Mencucci and colleagues reported 34.34% and 39.4% ECL in UT-DSAEK and DMEK groups, respectively.[19] In contrast, Dunker *et al.*[18] reported higher ECL patients who had UT-DSAEK (38.77%) compared to those who had DMEK (30.19%).

In this meta-analysis, we compared the clinical outcomes of UT-DSAEK with DMEK. The evaluation of the data from published studies shows, that the visual outcomes post-UT-DSAEK is comparable to DMEK. Furthermore, lesser complication rates, and comparable post-operative ECL makes UT-DSAEK a suitable alternative to DMEK. However, the literature on the clinical efficacy of UT-DSAEK continues to be very limited, and 60% of the included studies were retrospective. The risk of bias of the three retrospectively designed studies was moderate; therefore, more comprehensive studies are required for corroborating the current evidence about the clinical outcomes of UT-DSAEK. However, this meta-analysis has few limitations, primarily the dearth of studies comparing the outcomes of two surgical procedures because of the recent development and limit adoption of UT-DSAEK. Even among the studies included in this meta-analysis, only two out of six studies were level 1. Hence, the conclusions drawn from this review need corroboration through more large-scale level 1 studies. In addition, the risk of bias of the non-randomized studies in this review was moderate; therefore, more comprehensive studies are required to substantiate our analysis.

During the review process of this this article, another meta-analysis by Maier AB and colleagues also showed more improvement in BCVA in patients who undergo DMEK over UT-DSAEK with higher re-bubbling rate with the DMEK group.[26]

Majority of grafts in the included studies were prepared using a microkeratome, with pre-procedure corneal thickness recording done with a pachymeter, in order to decide the required microkeratome head size to achieve the targeted graft thickness of 70–130 microns.[11] In the present review, the pre-operative central corneal thickness (CCT) values were mentioned in four studies, with all of them having a corneal thickness between 600 and 700 microns. However, differences in the harvest method, graft thickness, storage and preparation methods varying among the included studies could have had impact on the final outcomes. The thickness for UT-DSAEK grafts, first laid down by Neff and co-workers was <131 microns,[11] and every included study utilized this guideline, and used similar lenticule thickness; 73 ± 12 microns,[17] 101 ± 25 microns,[18] 80.33 ± 20.5 microns,[19] in range of 50–99 microns,[20] 75.29 ± 15.4 microns[21], and <100 microns[22] (Table 2). However, even a small difference can have a potential bearing on the final visual outcomes.

Other factors which can also have a bearing on the final corneal thickness of the lenticule include the storage media used for corneal preservation, the duration of storage, adequate de-turgescence before the procedure, tissue preparation time, and the surgical experience. These factors could possibly affect the final thickness of the graft and hence the final visual outcome. The technique of graft preparation was also variable, where few authors describe a single-pass technique while few follow a double-pass technique. This also highlights the lack of standardized protocol for lenticule preparation and act as limitation to our analysis. In addition, one of the issues not addressed by the papers was that the grafts /DMEK lenticule were prepared by the surgeons or the eye banks. As regards the DMEK graft preparation all the articles have mentioned that the graft was prepared in the standardized manner, instead of furnishing a detailed method of preparation.

Conclusion

The patients who underwent UT-DSAEK have good visual outcomes, almost at par with DMEK. Moreover, fewer complications and better endothelial cell counts are reported in UT-DSAEK compared to DMEK. In addition, DMEK is technically more demanding and has a longer and steeper learning curve; therefore, UT-DSAEK is a potential alternative procedure to DMEK for endothelial corneal disorders.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Author contributions

Tanu Singh: Conceptualization; Data curation, Formal analysis; Investigation, Methodology; Project administration; Resources; Software; Supervision; Validation; Visualization; Writing – original draft; Writing – review & editing.

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Rohan Bir Singh: Conceptualization; Methodology; Writing – original draft; Writing – review & editing.

Suresh Kumar: Project administration; Supervision; Validation; Writing – review & editing.

Sudesh Arya: Project administration; Supervision; Validation.

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