KLINIČKI ISHOD ENDOTELNE KERATOPLASTIKE SA TRANSPLANTACIJOM DESCEMETOVE MEMBRANE (DMEK) U PRVA 52 SLUČAJA OPERISANA 2022. I 2023. GODINE

SERIJA SLUČAJEVA

CASE SERIES

DESCEMET MEMBRANE ENDOTHELIAL KERATOPLASTY (DMEK): CLINICAL OUTCOME OF THE FIRST 52 CONSECUTIVE CASES PERFORMED IN 2022 AND 2023

Vesna Jovanović[1], Zora Ignjatović[1]

[1] „Miloš klinika" specijalna bolnica za oftalmologiju, Beograd, Srbija

[1] *"Milos Clinic" Eye Hospital, Belgrade, Serbia*

SAŽETAK

Uvod/Cilj: Najčešća indikacija za keratoplastiku u zapadnim zemljama je disfunkcija endotela rožnjače. Ubrzo po svom nastanku, endotelna keratoplastika sa transplantacijom Descemetove membrane (DMEK), postala je prihvaćen metod zbog brojnih prednosti. Cilj našeg rada je da se prikaže klinički ishod DMEK-a kod pacijenata sa disfunkcijom endotela rožnjače.

Materijal i metod: Analiziran je klinički ishod operacije DMEK kod prve serije od pedeset dva oka. Sledeći parametri su korišćeni za procenu ishoda operacije: najbolje korigovana vidna oštrina (NKVO), tomografija, centralna debljina rožnjače, optička koherentna tomografija prednjeg segmenta (AS-OCT) i zadnjeg segmenta ukoliko je bilo potrebno. Svi parametri su izmereni pre operacije i do 6 meseci posle operacije.

Rezultati: Kod 46 očiju od ukupno 52, DMEK je bio uspešan. Šest meseci posle operacije od očiju sa dobrim vidnim potencijalom 100% je imalo NKVO ≥ 0,5, a 57% ≥ 0,8. Kod 8 očiju došlo je do parcijalnog odlubljivanja transplantata, što posle zbrinjavanja nije imalo uticaja na providnost rožnjače. Kod 6 očiju došlo je do primarne dekompenzacije transplantata što je zahtevalo naknadnu proceduru.

Zaključak: Naša serija je pokazala da je DMEK operacija sa odličnim ishodom u odnosu na brzinu rehabilitacije vida i potencijalnu ozbiljnost komplikacija. Glavna komplikacija, koja nije uticala na ishod operacije, bila je rano, delimično odvajanje transplantata.

Ključne reči: transplantacija rožnjače, disfunkcija endotela rožnjače, endotelna keratoplastika sa transplantacijom Descemetove membrane (DMEK)

ABSTRACT

Introduction/Objective: Corneal endothelial dysfunction is the most frequent indication for corneal transplantation in the developed countries. Shortly after its first appearance, Descemet membrane endothelial keratoplasty (DMEK) has been widely accepted due to its numerous advantages. Our aim is to report clinical outcome of DMEK in patients with dysfunction of corneal endothelium.

Material and method: We analyzed clinical outcome of DMEK of the first 52 consecutive cases. Parameters analyzed were as follows: best corrected visual acuity (BCVA), tomography, central corneal thickness, anterior segment optical coherent tomography (AS-OCT), and posterior segment OCT where needed. All parameters were measured before and up to six months after the surgery.

Results: DMEK was successful in 46 out of 52 eyes that underwent surgery. All eyes (100%) with good visual potential reached BCVA ≥ 20/40, and 57% reached ≥ 20/25. A partial graft detachment occurred in 8 eyes, which after repeated air injection into the anterior chamber resulted in graft reattachment and a clear cornea. Six eyes experienced primary graft failure which required second surgery.

Conclusion: Our series showed an excellent outcome of DMEK, concerning the rate of visual rehabilitation and potential serious complications. The main complication was an early partial graft detachment, which did not affect the final surgical outcome.

Keywords: corneal transplantation, corneal endothelial dysfunction, Descemet membrane endothelial keratoplasty (DMEK)

Autor za korespondenciju:
Vesna Jovanović
„Miloš klinika" specijalna bolnica za oftalmologiju
Vidska 24, 11000 Beograd, Srbija
Elektronska adresa: vesnajovanovic80@yahoo.com

Corresponding author:
Vesna Jovanović
"Milos Clinic" Eye Hospital
24 Vidska Street, 11000 Belgrade, Serbia
E-mail: vesnajovanovic80@yahoo.com

Primljeno • *Received*: January 29, 2026; **Revidirano • *Revised*:** June 1, 2026; **Prihvaćeno • *Accepted*:** June 2, 2026; ***Online first*:** June 25, 2026

DOI: 10.5937/smclk7-64493

UVOD

Disfunkcija endotela rožnjače predstavlja najčešću indikaciju za transplantaciju rožnjače u razvijenim zemljama [1,2]. Do pred sam kraj 20. veka, jedina terapijska opcija za lečenje disfunkcije endotela bila je perforativna keratoplastika (PKP), koja je podrazumevala transplantaciju svih slojeva rožnjače, uprkos tome što je oštećeni sloj činio svega 10% njene ukupne debljine. Pored toga, ovaj pristup star više od jednog veka bio je praćen brojnim komplikacijama, kao i sporim i često nezadovoljavajućim oporavkom vida.

Značajan iskorak načinjen je 1999. godine kada je Herit Meles (Gerrit Melles) predstavio uspešan koncept zadnje lamelarne keratoplastike (engl. *posterior lamellar keratoplasty*) (PLK) pri kome se kalem sačinjen od endotela i Descemetove membrane (DM) na tankom nosaču strome unosi u prednju očnu komoru kroz rez na limbusu i potom priljubljuje pomoću bule vazduha [3]. Ovaj tehnički zahtevan pristup omogućio je otklanjanje brojnih komplikacija povezanih sa PKP.

PLK je prošla kroz nekoliko razvojnih faza i unapređenja pre nego što je dostigla svoj konačan oblik, poznat kao endotelna keratoplastika sa transplantacijom Descemetove membrane (DMEK). Ubrzo nakon svog prvog objavljivanja u literaturi 2006. godine, DMEK je široko prihvaćena zbog svojih brojnih prednosti [4]. Mali, bešavni rez na limbusu doveo je do otklanjanja komplikacija povezanih sa prisustvom šavova na rožnjači kao i značajnog postoperativnog astigmatizma, kako pravilnog (regularnog), tako i nepravilnog (iregularnog). Pored toga, očuvana je intaktna površina rožnjače, a slobodni transplantat je manje sklon odbacivanju zbog odsustva epitela i strome. Više ne postoji bojazan od traumatske dehiscencije kružne (360˚) hirurške rane pune debljine koja je uvek prisutna kod PKP. Gotovo savršena postoperativna anatomija rožnjače i brz oporavak vida postižu se uklanjanjem samo obolelog endotela zajedno sa Descemetovom membranom (DM), nakon čega sledi transplantacija odgovarajućeg zdravog sloja [4].

Cilj ove studije bio je da se analiziraju klinički rezultati DMEK kod 52 pacijenta sa disfunkcijom endotela rožnjače. Prema našim saznanjima, ovo su prvi objavljeni rezultati DMEK, kao i prva serija slučajeva ove vrste u Srbiji.

MATERIJAL I METODE

Svi pacijenti operisani su u Očnoj bolnici „Miloš klinika“ u Beogradu, Srbija, u periodu od 2022. do 2023. godine. DMEK je izvedena na 52 oka kod 44 pacijenta (24 žene i 20 muškaraca), starosti od 47 do 88 godina (Tabela 1). Indikacije za operaciju bile su sledeće: Fuksova distrofija (38 očiju, 73%), pseudofakna bulozna keratopatija

INTRODUCTION

Corneal endothelial dysfunction is the most frequent indication for corneal transplantation in developed countries [1,2]. Until the final years of the twentieth century, the only treatment for endothelial decompensation was penetrating keratoplasty (PK), which involved transplantation of all corneal layers, despite the fact that the damaged layer accounted for only 10% of the corneal thickness. Furthermore, this 100-year-old approach was accompanied by many complications, as well as a slow and often inadequate visual recovery.

A significant step forward was made in 1999, when Gerrit Melles presented a successful concept of posterior lamellar keratoplasty (PLK), in which a graft consisting of endothelium and Descemet's membrane (DM) on a thin stromal carrier was inserted into the anterior chamber through a limbal incision and secured with an air bubble [3]. This technically demanding approach was able to eliminate various complications of PK.

PLK underwent several stages of refinement before reaching its final form, known as Descemet membrane endothelial keratoplasty (DMEK). Shortly after its first appearance in the literature in 2006, DMEK gained widespread acceptance owing to its numerous advantages [4]. A small and sutureless limbal incision has eliminated both all previous suture complications and a major postoperative astigmatism, regular or irregular, leaving an intact corneal surface and avascular graft, less prone to rejection due to the absence of epithelium and stroma. Traumatic dehiscence of the 360-degree vertical, full-thickness surgical wound, a hallmark of PK, is no longer feared. Restoration of an almost perfect postoperative corneal anatomy and rapid visual recovery are achieved by removing only the diseased endothelium together with DM, followed by transplantation of an identical healthy layer [4].

The aim of this study is to analyze clinical results of DMEK in 52 patients with a dysfunction of corneal endothelium. To our best knowledge, these are the first reported results of DMEK and the first such case series in Serbia.

MATERIALS AND METHODS

All patients underwent surgery in "Milos Clinic" Eye Hospital in Belgrade, Serbia in the period 2022–2023. DMEK was performed in 52 eyes of 44 patients (24 female and 20 male), aged 47–88 years (Table 1). The indications for surgery were as follows: Fuchs' dystrophy (38 eyes, 73%), pseudophakic bullous keratopathy (10 eyes, 19%), iridocorneal endothelial (ICE) syndrome (1 eye, 2%), complicated previous ocular surgery (2 eyes, 4%), and re-DMEK (1 eye, 2%). Preoperatively, central corneal thickness (CCT) in these patients ranged

(10 očiju, 19%), iridokornealni endotelni (ICE) sindrom (1 oko, 2%), komplikacije usled prethodne operacije oka (2 oka, 4%) i ponovljeni DMEK (1 oko, 2%). Preoperativno, centralna debljina rožnjače (CCT) kod ovih pacijenata iznosila je od 565 do 1016 mikrometara, dok se vidna oštrina u očima planiranim za operaciju kretala od mahanja rukom pred okom (engl. *hand motion*) (HM) do 20/32.

Standardna, „beskontaktna" DMEK hirurška tehnika primenjena je kod svih pacijenata. Ukratko, 23G MVR sečivo (DORC International, Zuidland, Holandija) korišćeno je za izvođenje glavne incizije od 3 mm, kao i tri bočne incizije, dok je uz pomoć šprica od 1 ml na kom se nalazila 30G kanila cela prednja očna komora ispunjena vazduhom. Uklanjanje Descemetove membrane (DM) u prečniku od 8,5 mm izvedeno je uz pomoć obrnute Sinskijeve kuke (DORC International), prilikom čega je DM svučena i uklonjena kroz glavni rez, ostavljajući ogoljen zadnji deo strome rožnjače.

Sve rožnjače donora starijih od 50 godina, sa brojem endotelnih ćelija od najmanje 2500/mm^2, dobijene su iz Lions Eye Bank International, SAD. Kalem je pripremljen od korneoskleralnog dugmeta ''no-touch" tehnikom. Korneoskleralno dugme postavljeno je na silikonski blok tako da je endotelna strana bila okrenuta nagore. DM i trabekulum pažljivo su kružno odvojeni u širini od približno 1 mm od periferije ka centru korišćenjem hokej noža. Potom je DM nežno oljuštena povlačenjem pincetom i rastegnuta preko strome, nakon čega je isečena trepanom prečnika 8,25 mm ili 8,5 mm.

Kalem pripremljen na ovaj način prenet je u staklenu posudu, ispran fiziološkim rastvorom, obojen 0,06% tripan plavom bojom (Vision Blue™, DORC International) 2 minuta, a potom ponovo ispran fiziološkim rastvorom. Pošto je usisan i postavljen u injektor, graft obojen tripan plavom bojom ubrizgan je u prednju komoru kroz glavni rez, endotelnom stranom okrenutom na dole, i pažljivo raširen preko dužice uz održavanje dubine prednje komore pomoću mešavine fiziološkog rastvora i vazduha. Zatim je mehur vazduha iskorišćen za priljubljivanje i pozicioniranje grafta uz stromu primaoca, tako da je DM grafta bila okrenuta ka stromi primaoca. Nakon 90 minuta, deo vazduha kojim je bila ispunjena prednja očna komora zamenjen je fiziološkim rastvorom i antibiotikom (Nilacef®, Hemofarm AD, Srbija), a rez je hidriran ili zatvoren jednim najlonskim šavom 10-0 (Mani, Inc., Japan) ukoliko je procenjeno da rana nije adekvatno zaptivena. Po završetku operacije, supkonjunktivalno su aplikovani gentamicin i kortikosteroid. Po završenoj operaciji, pacijentima je naloženo da naredna 24 sata provedu u ležećem položaju.

Kontrolni pregledi zakazani su prvog, trećeg i sedmog postoperativnog dana, kao i posle jednog, tri i šest

between 565 and 1016 micrometers, while visual acuity in the eyes scheduled for surgery ranged from hand motion (HM) to 20/32.

A standard, no-touch DMEK surgical technique was applied to all patients. In short, a 23-gauge MVR blade (DORC International, Zuidland, the Netherlands) was used to create a 3 mm main incision, as well as three auxiliary side-incisions, while a 30-gauge cannula attached to a 1ml syringe was used to fill the entire anterior chamber with air. An 8.5 mm Descemetorhexis was performed using an inverted Sinsky hook (DORC International), and DM was stripped and removed through the main incision, leaving a bare posterior stromal surface.

All corneas from donors older than 50, with endothelial cell count of at least 2500/mm^2, were obtained from the eye-bank Lions Eye International, USA. The graft was prepared from a corneoscleral button using a "no-touch" technique. The button was placed on a silicone block, with the endothelial side up. DM and trabeculum were carefully removed circumferentially over 1mm from the periphery towards the center, using a hockey blade. A pull exerted with forceps facilitated gentle stripping of DM, which was stretched over the stroma and then cut with an 8.25mm or 8.5mm diameter trephine.

The graft obtained in this manner was placed in a glass dish, rinsed with saline, stained with 0.06% trypan blue (Vision Blue™, DORC International) for 2 minutes, and rinsed again with saline. After being aspired into an injector, the trypan blue-stained graft was injected into the anterior chamber through the main incision, with the endothelium facing downward, and gently unfolded over the iris while maintaining anterior chamber volume with a mixture of saline and air. Then, an air bubble was used to position the graft against the recipient stroma, with its DM facing the stroma. After 90 minutes, part of the air filling the anterior chamber was exchanged for saline and an antibiotic (Nilacef®, Hemofarm AD, Serbia), and the incision was hydrated or closed with a single 10-0 nylon suture (Mani, Inc., Japan) if wound closure appeared inadequate. Finally, gentamycin and a corticosteroid injection were administered subconjunctivally. After surgery, patients were instructed to remain in the supine position for 24 hours.

Follow-up visits were scheduled on day 1, day 3, and day 7, and at one month, three and six months, when best corrected visual acuity (BCVA) was recorded, tomography (ALLEGRO Oculyzer WaveLight ® Oculyzer ™, Alcon, Novartis) and anterior segment optical coherence tomography (followed by posterior segment imaging if necessary) were performed (Zeiss

meseci. Tokom praćenja beležena je najbolje korigovana vidna oštrina (NKVO), urađena je tomografija (ALLEGRO Oculyzer WaveLight® Oculyzer™, Alcon, Novartis) i optička koherentna tomografija prednjeg segmenta (a po potrebi i zadnjeg segmenta) (Zeiss Cirrus™ 6000, Carl Zeiss Meditec), kao i merenje centralne debljine rožnjače (CCT). Studiju je odobrila Etička komisija Očne bolnice „Miloš klinike“ (30. septembra 2024. godine).

REZULTATI

DMEK je bio uspešan kod 46 od 52 operisana oka (Slika 1). Kod pet pacijenata (šest očiju) rožnjača se nije razbistrila i nije došlo do obnavljanja njene providnosti u roku od tri meseca posle operacije, uprkos potpunom naleganju transplantata i pravilnoj orijentaciji od prvog postoperativnog dana (Oči br. 1, 8, 11, 18, 21 i 50). Pacijent 11/50 (Tabela 1; oba oka su pripadala istom pacijentu) nije se pridržavao postoperativnog uputstva o ostajanju u ležećem položaju.

U proseku, CCT se smanjila sa 790 µm (raspon 565–1016 µm) na 543 µm (raspon 437–936 µm).

Funkcionalni rezultati DMEK analizirani su kod 35 od 52 operisana oka sa očuvanim preoperativnim vidnim potencijalom. Iako je operacija protekla bez komplikacija, oči broj 1, 6, 8, 11, 14, 15, 16, 18, 21, 26, 36, 37, 43, 47, 48 i 50 isključene su iz analize zbog ograničenog vidnog potencijala. Kod svih 35 očiju (100%) postignuta je NKVO od 20/40 ili bolja do trećeg postoperativnog meseca, a ovaj nivo vidne oštrine održan je tokom šestomesečnog perioda praćenja. NKVO od 20/25 ili bolju ostvarilo je 20 od 35 pacijenata (57%).

Cirrus™ 6000, Carl Zeiss Meditec), and CCT was measured. The study was approved by the Ethics Committee of “Milos Clinic” Eye Hospital (30 September, 2024).

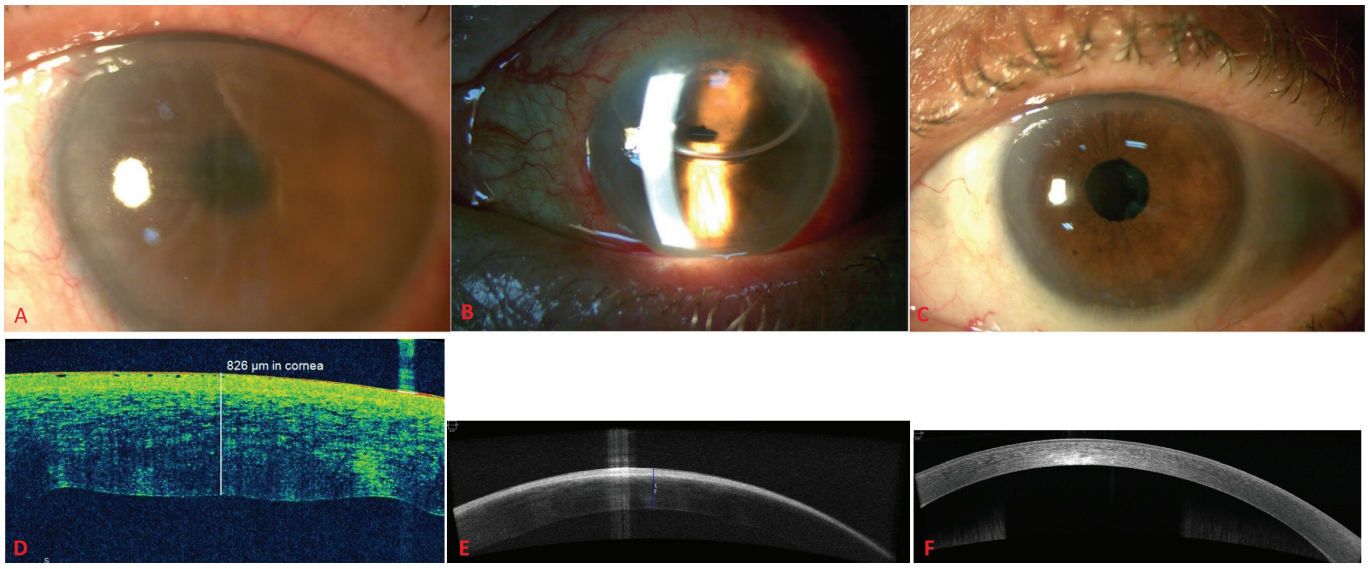
RESULTS

DMEK was successful in 46 out of 52 eyes that underwent surgery (Figure 1). In five patients (six eyes), the corneas failed to clear and regain transparency within three months postoperatively, despite complete graft attachment and proper graft orientation from postoperative day 1 (Eyes 1, 8, 11, 18, 21, and 50). Patient 11/50 (Table 1, both eyes belonged to the same patient) did not comply with the postoperative instruction to remain in the supine position.

On average, CCT decreased from 790 µm (range 565–1016 µm) to 543 µm (range 437–936 µm).

DMEK functional results were analyzed in 35 eyes (of the 52 that underwent surgery) with good preoperative visual potential. Despite uneventful surgery, Eyes 1, 6, 8, 11, 14, 15, 16, 18, 21, 26, 36, 37, 43, 47, 48, and 50 were excluded from the analysis because of limited visual potential. All 35 eyes (100%) achieved a BCVA of 20/40 by three months postoperatively and maintained this level of visual acuity throughout the six-month follow-up period. Twenty of the 35 patients (57%) achieved a BCVA of 20/25 or better.

Total postoperative graft detachment did not occur in any of the treated eyes. Early partial graft detachment was observed in eight eyes between postoperative days 3 and 7. All affected eyes (19, 23, 24, 27, 37, 39, 40, and 41) were successfully managed



Slika 1. Fotografija Oka br. 5 dobijena pregledom špalt lampom. A) Edem rožnjače na pseudofaknom oku pre DMEK, B) Prvi postoperativni dan posle DMEK-a – mehur vazduha u prednjoj komori, rožnjača providna C) Tri meseca posle DMEK-a, D) Preoperativni AS-OCT, E) AS-OCT prvog postoperativnog dana, transplantat potpuno priljubljen, F) AS-OCT tri meseca posle operacije

Figure 1. Slit lamp photograph of an Eye 5. A) Corneal edema in pseudophakic eye before DMEK, B) first day following DMEK – air bubble in the anterior chamber, cornea is clear, C) three months following DMEK, D) Preoperative AS-OCT, E) AS-OCT on postoperative day 1, transplant completely attached, F) AS-OCT 3 months postoperatively

Tabela 2. Podaci o pacijentima sa endotelnom dekompenzacijom lešenih DMEK tehnikom

Table 2. Patients' data on DMEK for endothelial decompensation

	Pol / Gender	Starost / Age (Years)	Oko (OD/OS) Dijagnoza / Eye (OD/OS) Diagnosis	po NKVO / po BCVA	po pah. (µm) / po pach (µm)	NKVO 1 d po / BCVA 1 d pop	NKVO 1m pop / BCVA 1m pop	1m pah. (µm) / 1m pach (µm)	NKVO 1m pop / BCVA 3m pop	3m pah. (µm) / pach (µm)	NKVO 6m pop / BCVA 6m pop	6 m pah. (µm) / 6 m pach (µm)
1	F	61	OD Fuchs, PC IOL, ERM	0.2	700	0.1	0.3	611	0.3	597	0.3	585
2	M	67	OS BK, PC IOL	0.1	959	2/60	0.7	553	1	519	1	522
3	M	65	OD Fuchs, PCIOL	0.2	717	0.1	0.8	550	0.9	530	0.9	528
4	M	76	OS BK, PC IOL, TTR, VPP	0.2/60	950	3 60	0.7	522	0.7	520	0.7	517
5	M	67	OS BK, PC IOL, antiVEGF	HM	826	3/60	0.3	479	0.7	488	0.7	510
6	F	73	OD PC IOL, BK, ERM	0.05	734	2/60	0.3	580	0.3	556	0.3	534
7	F	72	OS BK, PC IOL, anti VEGF	0.5/60	608	1/60					0.1	550
8	M	88	OS BK, PC IOL , gl	HM	750	1/60					0.15	474
9	F	62	OS Fuchs	0.2	903	0.3	0.9	532	0.9	534	0.9	532
10	F	62	OD Fuchs, PC IOL	0.1	650	0.2					0.8	546
11	M	69	OS Fuchs,PC IOL, Ambl, Alb, Nyst, Gl	HM	947	0.5/60					HM	936
12	M	59	OD Fuchs, PC IOL	0.1	819	0.4	0.7	512	0.8	535	0.9	535
13	M	59	OS Fuchs, PC IOL	0.4++	708	0.1	0.7	537			0.7	569
14	F	67	OD PPV, lensect, IOL retro, glauc	4/60	1000	0.05	0.05	546			0.05	540
15	F	67	OS Fuchs, PC IOL, ambl, Nyst	3/60	1016	0.05	0.16		0.2		0.2	537
16	F	67	OD Fuchs, PC IOL ambl, Nyst	0.1	730	2/60	0.1		0.2		0.2	534
17	M	53	OD Fuchs, PC IOL	0.5	670	0.7	1	540	1	537	1	527
18	F	84	OD PC IOL, BK, antiVEGF	0.5/60	980	0.3/60			0.3/60	844	0.3/60	850
19	F	56	OD Fuchs, PC IOL	0.2	565	0.1	0.8	427			0.8	467
20	F	76	OS Fuchs, PC IOL	0.2/60	1000	0.5/60					0.05	530
21	F	56	OS ICE sy, PC IOL	0.05	850	0.2	0.4	493	2/60	649	2 60	650
22	F	71	OD Fuchs, PC IOL	0.1	827	0.2					0.8	467
23	F	70	OD Fuchs, PC IOL	0.4	720	1/60	0.7	525	0.7	524	0.8	530
24	F	87	OS Fuchs, PC IOL	0.5/60	800	1/60	0.2	637	0.8	645	0.8	558
25	M	65	OS Fuchs, PC IOL	0.1	653	0.5	0.7	454			0.7	460
26	F	72	OD Fuchs, PC IOL, ERM	0.1	810	2/60	0.3	463	0.3	450	0.3	480
27	F	73	OS Fuchs, PC IOL	0.1	608	4/60	0.6	511			0.8	506
28	F	59	OD postDMEK, PC IOL	0.5	627	0.5/60	0.7	526			0.7	540
29	F	68	OS Fuchs, PC IOL	0.1	851	1/60	0.2	478	0.7	481	0.7	491
30	M	81	OD Fuchs, PC IOL, AMD	0.4	692	0.3	0.7	530	0.8	524	0.8	504
31	M	60	OD BK, PC IOL	0.4	703	3/60	0.7	530	0.7	501	0.9	498
32	F	56	OS Fuchs, PC IOL	0.2	911	0.05	0.6	471	0.6	479	0.6	468
33	M	71	OD Fuchs, PC IOL	1/60	804	1/60	0.8	480			0.8	529
34	M	47	OD Fuchs, PC IOL	0.5	637	0.5/60	0.8	511	1	498	1	500
35	M	76	OD Fuchs, PC IOL	1/60	917	1/60	0.6	539	0.6	539	0.6	559
36	M	77	OD Fuchs, PC IOL, AMD	0.2	825	4/60	0.4	524	0.2	535	0.4	536
37	M	67	OS BK, PC IOL, TASS, DM makul	0.1	717	1/60	0.4	573	0.4	570	0.4	569
38	F	82	OS Fuchs, PC IOL	0.1	730	0.05	0.5	532	0.5	495	0.5	538
39	F	70	OD Fuchs, PC IOL	0.2	783	3/60	0.6				0.8	523
40	M	72	OS Fuchs, PC IOL	0.05	984	3/60	0.4				0.4	524
41	F	59	OS Fuchs, PC IOL	0.6	683	0.3	0.7				0.7	474
42	M	68	OS Fuchs, PC IOL	0.1	747	0.3	0.7	532	0.8	502	0.8	482
43	F	79	OD Fuchs, PC IOL, gl	1/ 60	850	2/60	0.2		0.2		0.2	437
44	F	72	OD Fuchs, PC IOL	0.1	753	0.1	0.4	650	0.7	520	0.8	500

45	F	59	OD Fuchs, PC IOL	0.4	799	0.2	0.7	544	0.7	549	0.8	569
46	F	67	OS Fuchs, PC IOL	3/60	911	2/60	0.8	560	0.8		0.8	560
47	M	78	OD BK, PC IOL, TTR	0.4	700	0.5/60	0.4	689	0.4	620	0.6	567
48	M	79	OS BK, PC IOL, gl, AMD	3/60	844	0.05	0.6	595	0.6	567	0.6	567
49	M	61	OD Fuchs, PC IOL	0.4	715	3/60	0.9	529			0.9	521
50	M	71	OD Fuchs, PC IOL, nyst, ambl, alb, gl	HM	980	1/60	4/60	750			4/60	700
51	M	71	OS Fuchs, PC IOL	0.2	709	0.05	0.8	560			0.8	565
52	M	65	OS Fuchs, PC IOL	0.2	689	0.05			0.9	546	0.9	556

Skraćenice: po NKVO = preoperativna najbolje korigovana vidna oštrina, po PAH. = preoperativna pahimetrija, NKVO 1 d pop = najbolje korigovana vidna oštrina prvog postoperativnog dana, NKVO 1 m pop = najbolje korigovana vidna oštrina mesec dana postoperativno, NKVO 3 m pop = najbolje korigovana vidna oštrina 3 meseca postoperativno, 3 m pah. = pahometrija 3 meseca postoperativno, NKVO 6 m pop = najbolje korigovana vidna oštrina 6 meseci postoperativno, 6 m pah. = pahimetrija 6 meseci postoperativno, Fuks = Fuksova endotelna distrofija, PC IOL = intraokularna sočiva prednje komore (pseudofakična), ERM = epiretinalna membrana, BK = bulozna keratopatija, TTR = operacija glaukoma (trabekulektomija), VPP = pars plana vitrektomija, antiVEGF = pacijent je prethodno primio intravitrealnu injekciju anti–vaskularnog endotelnog faktora rasta, Gl = glaukom, Ambl = ambliopija, Alb = albinizam, Nyst = nistagmus, IOL retro = retropupilarno intraokularno sočivo, SMD = senilna degenracija makule, TASS = toksični sindrom prednjeg segmenta oka, DM macul = dijabetička makulopatija, ICE Sy = iridokornealni endotelni sindrom

Abbreviations: po BCVA = pre operative best corrected visual acuity, po PACH = pre operative pachymetry, BCVA 1 d pop = Best corrected visual acuity at postoperative day 1, BCVA 1 m pop = Best corrected visual acuity at one month postoperatively, BCVA 3 m pop = Best corrected visual acuity at 3 months postoperatively, 3 m pach = pachymetry 3 months postoperatively, BCVA 6 m pop = Best corrected visual acuity at 6 months postoperatively, 6 m pach = pachymetry 6 months postoperatively Fuchs = Fuchs endothelial dystrophy, PC IOL = posterior chamber intraocular lens (pseudophakic), ERM = epiretinal membrane, BK = bullous keratopathy, TTR = glaucoma surgery (trabeculectomy), VPP = pars plana vitrectomy, antiVEGF = patient previously got intravitreal injection of anti-vascular endothelial growth factor, Gl = glaucoma, Ambl = amblyopia, Alb = albinism, Nyst = nystagmus, IOL retro = IOL retropupillaris, AMD = age-related macular degeneration, TASS = toxic anterior segment syndrome, DM macul = diabetic maculopathy, ICE Sy = Iridocorneal endothelial Syndrome

Potpuno postoperativno odvajanje grafta nije zabeleženo ni kod jednog od lečenih očiju. Rano delimično odvajanje grafta uočeno je kod osam očiju između trećeg i sedmog postoperativnog dana. Sve zahvaćene oči (19, 23, 24, 27, 37, 39, 40 i 41) uspešno su zbrinute ponovnom vazdušnom tamponadom. Većina ovih pacijenata (Oči br. 19, 24, 37, 39 i 41) nije se pridržavala preporučenih uputstava o postoperativnom pozicioniranju, uključujući i prvih nekoliko sati posle operacije, što je od suštinskog značaja za stabilnost grafta. Nakon ponovnog prianjanja grafta, sama ponovljena vazdušna tamponada nije uticala na providnost rožnjače.

Odbacivanje grafta nije zabeleženo ni kod jednog od operisanih očiju.

DISKUSIJA

DMEK je stekla popularnost od kada je prvi put opisana u literaturi [4]. Mali broj hirurga rožnjače bilo je uvereno da je svrsishodno uložiti napor u savladavanju ove prilično zahtevne tehnike, s obzirom na to da su rani rezultati pokazali brz oporavak vida, pri čemu je šest od deset pacijenata dostiglo NKVO od 20/40, a još tri pacijenta 20/20 već mesec dana nakon operacije [5]. Ovi obećavajući rezultati ubrzo su potvrđeni u većim serijama, zahvaljujući sve širem prihvatanju tehnike. Potpuni oporavak vidne oštrine nakon DMEK postiže se za približno mesec dana, u poređenju sa periodom do godinu dana nakon PKP, što predstavlja značajnu prednost naročito kod starijih pacijenata sa endotelnom disfunkcijom [6]. Gotovo savršena postoperativna anatomija, karakteristična za koncept zamene isključ-

with rebubbling. Most of these patients (Eyes 19, 24, 37, 39, 41) failed to comply with the recommended postoperative positioning instructions, including during the first few hours after surgery, which are vital for maintaining graft stability. From the moment of graft re-attachment, rebubbling itself did not affect corneal transparence.

None of the eyes suffered from graft rejection.

DISCUSSION

DMEK has gained popularity since its first description in the literature [4]. Quite a few corneal surgeons have been convinced that the effort required to learn this rather demanding technique is worthwhile, as early results demonstrated rapid visual recovery, with six of ten patients achieving a BCVA of 20/40, and another three reaching 20/20 just one month after surgery [5]. These promising results were soon confirmed in larger series, made possible by the growing acceptance of the technique. A complete recovery of visual acuity after DMEK required approximately one month, compared with up to one year after PK, representing a key advantage for predominantly elderly patients with endothelial dysfunction [6]. The almost perfect postoperative anatomy inherent to the concept of replacing only the diseased corneal layer with a healthy one through a small, peripheral sutureless incision was an additional factor that accelerated the introduction of DMEK into clinical practice. Transplantation registers in all developed countries began to show a steep trend toward replacing PK for DMEK in the treatment of corneal endothelial diseases [7].

čivo obolelog sloja rožnjače zdravim tkivom kroz mali bešavni rez, predstavljala je dodatni faktor koji je doprineo bržem uvođenju DMEK-a u kliničku praksu. Državni transplantacioni registri u razvijenim zemljama pokazali su jasan trend zamene tehnike PKP tehnikom DMEK u terapiji endotelnih bolesti rožnjače [7].

Analizirali smo rezultate kod 52 oka sa različitim bolestima endotela rožnjače i utvrdili da je većina pacijenata imala Fuksovu distrofiju rožnjače (73%). Ovaj nalaz je u skladu sa činjenicom da je Fuksova distrofija glavna indikacija za transplantaciju rožnjače u razvijenim zemljama.

Naši rezultati pokazuju da je veliki broj očiju sa svim uzrocima oštećenja vida (27/52) postigao NKVO od 20/40 ili bolju mesec dana nakon DMEK, što predstavlja donji prag za dobijanje vozačke dozvole. Uspeh je još izraženiji u podgrupi pacijenata sa dobrim preoperativnim vidnim potencijalom (35 očiju): 100% je postiglo NKVO od 20/40 ili bolju, dok je 57% dostiglo NKVO od 20/25 ili bolju mesec dana nakon operacije. Međutim, dobar preoperativni vidni potencijal sam po sebi nije jedina garancija optimalnih funkcionalnih ishoda nakon operacije. Zaista, šest naših pacijenata postiglo je NKVO od 20/20 ili bolju, a dodatna tri pacijenta dostigla su 20/20 šest meseci nakon DMEK. Smanjenje vidne oštrine za jednu do dve linije, čak i kod očiju sa subepitelnom fibrozom, kod nekomplikovanog DMEK, može biti posledica dugotrajnog preoperativnog edema rožnjače. U literaturi nisu dostupni dokazi koji ukazuju da se ishodi NKVO kod pacijenata sa endotelnim bolestima rožnjače nakon PKP mogu izjednačiti ili približiti rezultatima postignutim DMEK tehnikom. Istorijski gledano, potrebno je oko godinu dana da 40–50% pacijenata sa Fuksovom distrofijom postigne NKVO od 20/40 ili bolju nakon PKP [4]. Štaviše, za postizanje ovog nivoa vidne oštrine često je neophodna korekcija kontaktnim sočivima, što je zadatak koji većina starijih pacijenata nije u stanju da ispuni.

Kao što se i očekivalo, visok i/ili iregularni astigmatizam, komplikacije povezane sa šavovima, kasna dehiscencija rane i odbacivanje grafta nisu uočeni u našoj seriji, budući da su ove komplikacije karakteristične za PKP. Umesto toga, kao i drugi autori pre nas, najčešće smo se susretali sa glavnom komplikacijom DMEK – delimičnim ili potpunim odvajanjem grafta [8].

Nijedan od pacijenata u našoj seriji nije imao potpuno odvajanje grafta. Međutim, delimično odvajanje grafta koje je zahvatalo optičku zonu uočeno je kod osam očiju između trećeg i sedmog postoperativnog dana. Ponovno pričvršćivanje grafta uspešno je postignuto ponovnim ubrizgavanjem vazduha u prednju komoru kroz postojeći rez, što je rezultiralo potpunim prianjanjem grafta i providnom rožnjačom u svim slučajevima već narednog dana.

We analyzed our results in 52 eyes with various diseases of corneal endothelium and found that most patients suffered from Fuchs's corneal dystrophy (73%). This finding is consistent with the fact that Fuchs' dystrophy is the main indication for corneal transplantation in countries with advanced economies.

Our results show that a large number of eyes with all causes of vision impairment included (27/52) achieved a BCVA of 20/40 or better one month after DMEK, which represents the lower threshold for eligibility for a driver's license. The success is even more evident in the subgroup of patients with good preoperative visual potential (35 eyes): 100% achieved a BCVA of 20/40 or better, while 57% reached 20/25 or better one month after surgery. Good preoperative visual potential is not the sole guarantee of optimal functional outcomes after surgery. Indeed, six of our patients achieved a BCVA of 20/20 or better, and an additional three reached 20/20 by six months after DMEK. The reason for a reduction of one to two lines of visual acuity even in eyes with uneventful DMEK subepithelial fibrosis caused by long-standing preoperative corneal edema. It is not possible to find evidence showing that BCVA outcomes in patients with corneal endothelial diseases undergoing PK can match, or even closely approach, those achieved with DMEK. Historically, it takes a year for 40–50% patients with Fuchs' dystrophy to achieve a BCVA of 20/40 or better following PK [4]. Moreover, contact lens correction is often required to achieve this level of vision, a task that most elderly patients are unable to perform.

As expected, high and/or irregular astigmatism, suture-related problems, late wound dehiscence, and graft rejection were not observed in our cases, as these complications are inherent to PK. Instead, we, as others before us, encountered the main complication of DMEK – partial or total graft detachment [8].

None of the patients in our series had a complete graft detachment. However, partial graft detachment involving the optical zone was observed in eight eyes between postoperative days 3 and 7. Graft reattachment was successfully achieved by repeated air injection into the anterior chamber through the existing side incision, resulting in complete graft attachment and a clear cornea in all cases on the following day.

On the other hand, six corneas (11.5%) succumbed to the primary graft decompensation and failed to clear in spite of complete graft attachment from the time of surgery through the six- month follow-up. According to the literature, the percentage of primary graft decompensation is between 2.2% and 8% [9]. Possible causes range from inadequate endothelial cell function to trauma before and during surgery. Severe corneal

S druge strane, šest rožnjača (11,5%) je razvilo primarnu dekompenzaciju grafta i nisu se razbistrile uprkos potpunom prianjanju grafta od trenutka operacije do šestomesečnog praćenja. Prema dostupnoj literaturi, učestalost primarne dekompenzacije grafta iznosi između 2,2% i 8% [9]. Mogući uzroci kreću se od neadekvatne funkcije endotelnih ćelija do traume pre i tokom operacije. Težak edem rožnjače, uz lošu vidljivost zadnjeg segmenta rožnjače i prednje komore, povećao je verovatnoću hirurške traume u svim našim slučajevima. Pored toga, kod dva pacijenta (Oči br. 8 i 11) postojala je velika verovatnoća nepoštovanja propisane terapije. Svim pacijentima sa primarnim otkazivanjem grafta zakazan je ponovni DMEK ili PKP. Nisu uočene druge komplikacije.

ZAKLJUČAK

Naša serija je pokazala odlične ishode DMEK u pogledu brzine rehabilitacije vida i učestalosti ozbiljnih komplikacija. Kao i u prethodnim izveštajima hirurga sa velikim brojem transplantacija, ovi rezultati ukazuju na to da DMEK ima potencijal da postane zlatni standard u lečenju pacijenata sa endotelnom disfunkcijom rožnjače u našoj praksi. Ovaj potencijal dodatno potkrepljuju naši neobjavljeni podaci o transplantacijama izvedenim 2024. godine.

Sukob interesa: Nije prijavljen.

edema with poor visibility of the posterior cornea and anterior chamber increased the likelihood of surgical trauma in all our cases. Additionally, a high likelihood of non-compliance with the prescribed therapy was present in two patients, Eyes 8 and 11. All patients with primary graft failure were scheduled for either repeat DMEK or PK. No other complications were observed.

CONCLUSION

In conclusion, our series demonstrated excellent outcomes of DMEK in terms of the rate of visual rehabilitation and occurrence of serious complications. Like previous reports from high-volume transplant surgeons, it holds promise for establishing DMEK as a gold standard treatment for patients with corneal endothelial dysfunction in our practice. This potential is further supported by our unpublished data on transplantations performed in 2024.

Conflict of interest: None declared.

LITERATURA / *REFERENCES*

1. Huertas-Bello M, Sabater AL, Koo EH. The Evolving Therapeutics of Endothelial Disease. Eye Bank Corneal Transpl. 2023 Sep;2(3):e0015. doi: 10.1097/ebct.0000000000000015.
2. Tourabaly M, Knoeri J, Georgeon C, Borderie V. Review of the Literature: Surgery Indications for Fuchs' Endothelial Corneal Dystrophy. J Clin Med. 2025 Mar 29;14(7):2365. doi: 10.3390/jcm14072365.
3. Melles GR, Lander F, Beekhuis WH, Remeijer L, Binder PS. Posterior lamellar keratoplasty for a case of pseudophakic bullous keratopathy. Am J Ophthalmol. 1999 Mar;127(3):340-1. doi: 10.1016/s0002-9394(98)00324-9.
4. Melles GR, Ong TS, Ververs B, van der Wees J. Descemet membrane endothelial keratoplasty (DMEK). Cornea. 2006 Sep;25(8):987-90. doi: 10.1097/01.ico.0000248385.16896.34.
5. Melles GR, Ong TS, Ververs B, van der Wees J. Preliminary clinical results of Descemet membrane endothelial keratoplasty. Am J Ophthalmol. 2008 Feb;145(2):222-7. doi: 10.1016/j.ajo.2007.09.021.
6. van Dijk K, Ham L, Tse WH, Liarakos VS, Quilendrino R, Yeh RY, et al. Near complete visual recovery and refractive stability in modern corneal transplantation: Descemet membrane endothelial keratoplasty (DMEK). Cont Lens Anterior Eye. 2013 Feb;36(1):13-21. doi: 10.1016/j.clae.2012.10.066.
7. Flockerzi E, Turner C, Seitz B, Collaborators GSG; GeKeR Study Group. Descemet's membrane endothelial keratoplasty is the predominant keratoplasty procedure in Germany since 2016: a report of the DOG-section cornea and its keratoplasty registry. Br J Ophthalmol. 2024 May 21;108(5):646-53. doi: 10.1136/bjo-2022-323162.
8. Fu L, Hollick EJ. Rebubbling and graft detachment in Descemet membrane endothelial keratoplasty using a standardised protocol. Eye (Lond). 2023 Aug;37(12):2494-8. doi: 10.1038/s41433-022-02362-2.
9. Droutsas K, Giallouros E, Melles GR, Chatzistefanou K, Sekundo W. Descemet membrane endothelial keratoplasty: learning curve of a single surgeon. Cornea. 2013 Aug;32(8):1075-9. doi: 10.1097/ICO.0b013e31828f0e3c.