ORIGINAL ARTICLE

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Descemet's membrane endothelial keratoplasty with a simplified technique and low complication rate: the samba technique

Ceratoplastia endotelial da membrana de Descemet com técnica simplificada e baixa taxa de complicação: a técnica de samba

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ABSTRACT | Purpose: We report a simplified Descemet's membrane endothelial keratoplasty (DMEK) technique that involves safe and effective preparation and introduction, correct orientation, and easy unfolding of the donor graft inside the recipient anterior chamber. **Methods:** In this retrospective study, we assessed the surgical outcomes of 26 eyes of 23 consecutive patients (mean age, 61.2 ± 11.4 yr; range, 39-82 yr) with Fuchs endothelial corneal dystrophy (n=19) or bullous keratopathy (n=7) who underwent the Samba technique, a simplified DMEK method, at the Sorocaba Ophthalmology Hospital, Sorocaba Eye Bank, Sorocaba, Brazil, between August 2011 and July 2012. **Results:** Of the 26 operated eyes, only two (7.7%) experienced partial graft detachment requiring rebubbling, and in those eyes, the graft was reattached successfully with one air bubble. There were no cases of primary graft failure, tissue loss, or pupillary block. All patients with good visual potential achieved a best-corrected visual acuity of 20/30 or better at 6 months, and 82.6% achieved a best-corrected visual acuity of 20/30 or better 1 month postoperatively. **Conclusion:** In this retrospective study, the Samba technique, a simplified DMEK procedure, was safe and effective, with an acceptably low rebubbling rate and no incidence of primary graft failure or pupillary block. Moreover, rapid and nearly complete visual recovery was achieved. This simplified DMEK technique can be adopted by corneal surgeons worldwide as a primary treatment for endothelial dysfunction with a less steep learning curve and low rate of postoperative complications.

Keywords: Descemet stripping endothelial keratoplasty; Corneal transplantation; Cornea/surgery

RESUMO | Objetivo: Relatar uma técnica simplificada de ceratoplastia endotelial da membrana de Descemet (DMEK) que envolve a preparação e a introdução seguras e eficazes, a orientação correta e o fácil desdobramento do enxerto doador dentro da câmara anterior receptora. **Métodos:** Neste estudo retrospectivo, foram revisados e avaliados os resultados cirúrgicos de 26 olhos de 23 pacientes consecutivos (idade média: 61,2 ± 11,4 anos, intervalo: 39 a 82 anos) com distrofia corneana endotelial de Fuchs (n=19) ou ceratopatia bolhosa (N=7) submetidos à técnica "Samba", método de DMEK simplificado, no Hospital Oftalmológico de Sorocaba, Banco de Olhos de Sorocaba, Sorocaba, Brasil, entre agosto de 2011 e julho de 2012. **Resultados:** Dos 26 olhos operados, apenas 2 olhos (7,7%) apresentaram descolamento parcial do enxerto que necessitou de nova injeção de ar na câmara anterior **"**re-bubble**"**, e nesses olhos o enxerto foi posicionado com sucesso com o procedimento de **"**re-bubble**"**. Nenhum dos 26 olhos apresentaram falência primária do enxerto ou perda de tecido, ou bloqueio pupilar. Todos os pacientes com bom potencial visual obtiveram a acuidade visual melhor corrigida de 20/30 ou melhor e 82,6% tinham acuidade visual melhor corrigida de 20/30 ou melhor com 1 mês de cirurgia. **Conclusão:** Neste estudo retrospectivo, a técnica de Samba, um procedimento de DMEK simplificado, mostrou-se segura e eficaz, com uma taxa de "re-bubble" aceitavelmente baixa e nenhuma incidência de falência primária ou complicação com bloqueio pupilar. Além disso, a recuperação visual rápida e completa foi rapidamente alcançada. Esta técnica DMEK simplificada pode ser adotada por cirurgiões de córnea em todo o mundo como um tratamento primário para disfunção endotelial com uma curva de aprendizado rápida e baixa taxa de complicações pós-operatórias.

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Descritores: Ceratoplastia endotelial com remoção da lâmina limitante; Transplante de córnea; Córnea/cirurgia

INTRODUCTION

Over the past decade, endothelial keratoplasty (EK) has evolved to become the procedure of choice for treatment of endothelial dysfunction[1-8]. EK is performed through a small incision and in a closed system and does not involve modification of the anterior surface of the recipient cornea[9]. Therefore, it allows for better and faster visual recovery, minimal refractive change, and better preservation of the ocular surface integrity compared with conventional full-thickness penetrating keratoplasty[10-12].

Worldwide, the most commonly used EK technique is Descemet's stripping endothelial keratoplasty, or Descemet's stripping automated endothelial keratoplasty (DSAEK) when the donor graft is prepared using a microkeratome[5,7]. Both surgical procedures are highly reproducible and involve removing the patient's endothelium and Descemet's membrane (DM), after which they are replaced by a donor corneal disc consisting of endothelium, DM, and posterior stroma.

Although DSAEK yields good visual recovery and reproducible results, studies have shown that only a few patients achieve best-corrected visual acuity (BCVA) better than 20/30, and that some patients require repeat EK owing to graft failure secondary to unsatisfactory postoperative BCVA[10,13].

Descemet's membrane endothelial keratoplasty (DMEK) was described first by Melles et al. in 2006[8]. This novel EK procedure enables selective transplantation of DM with its endothelium and without any associated corneal stroma[14]. Moreover, DMEK results in better restoration of the corneal anatomy and excellent visual recovery. Compared with previous EK techniques, DMEK provides better and faster visual recovery, with a lower risk of immunologic reactions to the donor graft[9,10,15]. However, it is a more challenging surgical procedure and requires a steeper learning curve to master. Primary complications associated with DMEK, especially during the surgeon learning curve, include graft detachment and primary graft failure[16-19]. Preparation of a DMEK donor graft suitable for transplantation also is more challenging, and tissue loss can occur. The availability of prestripped tissue possibly could lower, or even eliminate, the risk of tissue loss, yet only a few eye banks worldwide currently provide premade donor grafts for DMEK[16,18].

In this retrospective study, we reported postoperative outcomes of the Samba technique, a simplified DMEK procedure. This technique can be applied by most corneal surgeons in the clinical setting, without the need for an eye bank to provide prestripped tissue or a major investment in cutting-edge surgical equipment.

METHODS

In this retrospective study, we assessed the surgical outcomes of 26 eyes of the first 23 consecutive patients (mean age, 61.2 ± 11.4 yr; range, 39-82 yr) with Fuchs endothelial corneal dystrophy (FECD) or bullous keratopathy (BK) who underwent the Samba technique at the Sorocaba Ophthalmology Hospital, Sorocaba Eye Bank, Sorocaba, Brazil, between August 2011 and July 2012. Surgery was indicated for endothelial decompensation owing to FECD in 18 patients (69.2%), BK after phacoemulsification in 6 (23.1%), BK after glaucoma surgery in 1 (3.9%), and graft failure after EK in 1 FECD patient (3.9%). A triple procedure was performed in 17 patients (65.4%) with cataract associated with endothelial decompensation. One eye of one FECD patient (3.9%) was phakic with a clear lens, and that eye was left phakic. Three patients underwent bilateral DMEK. This research conforms to the tenets of the Declaration of Helsinki. Internal review board approval was obtained from the Sorocaba Ophthalmology Hospital, and all patients provided written informed consent.

All surgeries were performed by a single surgeon (N.C.P.) who had not received any training in DMEK surgery before starting to perform the procedure. On his own, he practiced DMEK donor preparation on approximately 10 corneoscleral buttons that were determined unsuitable for transplantation at Sorocaba Eye Bank before starting to perform DMEK. The surgeon had 2 yr of previous experience with approximately 30 DMEK surgeries performed via different surgical techniques, which have been described previously[19,20]. After performing those initial DMEK surgeries, he decided to standardize his own technique, termed the Samba technique, which is a modification of the original "no touch" technique[19].

Donor selection and tissue preparation

For donor tissue preparations, corneoscleral buttons stored in Optisol-GS (Bausch & Lomb, Irvine, CA, USA) at 4°C for 4 to 14 days were used. Donors between 33 and 74 yr old and with endothelial cell counts of more

than 2300 cells/mm^2 before preparation were used in these surgeries. The DMEK graft was prepared in the operating room under sterile conditions immediately preoperatively. The donor button was placed on a sterile flat surface. The rim then was stabilized with toothed forceps, and the periphery was scored using a Sinskey hook to break through the DM for 360° without compromising the stromal fibers. To allow better visualization, we used a few drops of trypan blue 0.05% to stain edges of the DM. The rim then was submerged under balanced salt solution (BSS) in a trephine system block, and the edge of the DM was grasped with nontoothed forceps to strip it away slowly from the stroma. Approximately 30% to 40% of the DM was stripped before trephinating the DM partially through the stroma with an 8.5- to 9.0-mm donor trephine. The donor cornea then was submerged again to complete the DM stripping across the trephinated area, forming a scroll with the endothelium outside. The DM roll then was stained with trypan blue 0.05% for 40 to 60 s to improve visualization while inserting and positioning it in the recipient cornea.

DMEK surgery

All patients were instructed to use a fourth-generation quinolone (moxifloxacin) four times daily, beginning 1 day preoperatively. Patients who underwent combined surgery were instructed to use a nonsteroidal anti-inflammatory drug three times daily, beginning 5 days preoperatively. All patients underwent retrobulbar anesthesia. After injection, manual ocular massage was performed for 2 to 3 min, followed by oculopressure with a Honan balloon for another 5 to 10 min to soften the eye.

Surgery began with creation of a 2.75-mm self-sealing clear corneal tunnel incision, created with a slit knife at the 10 to 12 o'clock position. Three side ports were created at approximately the 11, 1, and 8 o'clock positions for the right eye, and at approximately the 11, 1, and 4 o'clock positions for the left eye. In 17 cases, a combined routine cataract extraction with phacoemulsification and intraocular lens (IOL) implantation followed by DMEK was performed. A peripheral inferior iridotomy was performed in all cases, so that the anterior chamber could be left filled with air at the end of the procedure without causing pupillary block. The recipient DM was scored 360° and stripped using a reverse Sinskey hook, under air, from an area that was approximately the same diameter as the donor graft.

The graft was inserted with correct orientation through the main incision using a modified IOL inserter created by the surgeon preoperatively, comprised of a C- or D-cartridge (Alcon, Inc., Fort Worth, TX, USA) and a piece of intravenous tubing attached to a 1-mL syringe (Figure 1). Then, the correct orientation of the graft was confirmed with direct observation via the surgical microscope and Moutsouris sign[19]. If the graft was inverted, the anterior chamber was deepened, and tapping was performed to roll the graft into the correct orientation. Then, the graft was centered and unfolded using gentle strokes or taps onto the corneal surface, with a shallow anterior chamber maintained to help unfolding. If a double roll was achieved, gentle tapping between the rolls was performed to start unfolding, which sometimes was enough to unfold the graft completely. If a single roll with a partially unfolded graft was achieved, gentle tapping was done in the area where the graft already was unfolded so as to unfold the graft completely. A second cannula sometimes was used to minimize the depth of the anterior chamber and facilitate unfolding. To rotate, move, and center the graft, fast tapping in the periphery of the graft was performed to move the graft in the desired direction. Those indirect manipulations were used to unfold, center, rotate, or turn the graft in case of an inverted orientation. Hence, most of the graft manipulation was indirect, without the aid of air or liquid in-

Figure 1. Graft inserter

side the anterior chamber. After the graft was unfolded and centered, an air bubble was injected underneath the graft and enlarged to position the graft against the recipient posterior stroma. The anterior chamber was filled completely with air at approximately 40 mmHg, and left for 20 to 40 min to fix the graft. Thereafter, the pressure was reduced to approximately 20 mmHg, and the anterior chamber was left completely filled with air (Figure 2). The patients were placed in a supine position, facing up, for the first 24 h postoperatively. The modifications between the Samba technique and the original "no touch" technique are detailed in table 1.

RESULTS

Postoperative visual outcomes

Three eyes were excluded from the postoperative visual outcome analysis owing to preexisting comorbidities that compromised potential visual recovery. Of the 23 remaining eyes, 82.6% achieved a BCVA of ≥20/30 at 1 month postoperatively. At 6 months, BCVA was ≥20/30 in 100%, ≥20/25 in 87%, ≥20/20 in 65.2%, and 20/15 or better in 21.7%.

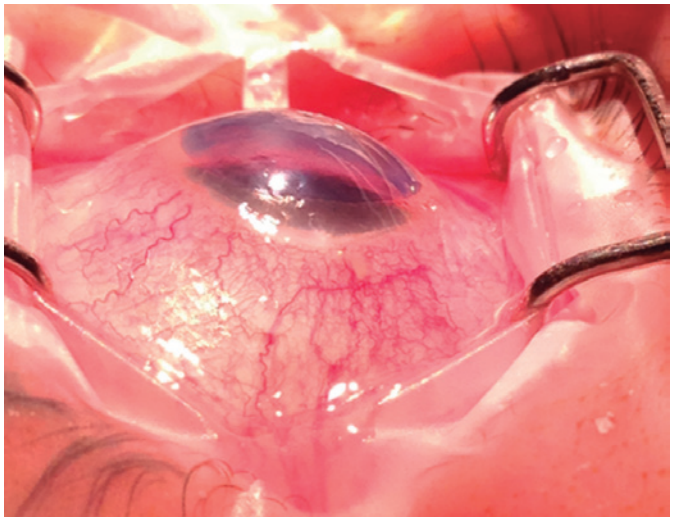

Figure 2. Complete air fill at the end of the procedure.

Endothelial cell density (ECD)

Nine eyes were excluded from the ECD analysis owing to absence of ECD data at 6 months postoperatively. Mean preoperative ECD, as measured in vitro via specular microscopy by the supplying eye bank, was 2664 ± 185 cells/mm^2. At 6 months postoperatively, the in vivo mean ECD was 1971 ± 337 cells/mm^2; that is, a mean ECD decrease of 696 ± 339 cells/mm^2 and an average loss of 26%.

Complications

With regard to surgery-related complications, no tissue loss was experienced during preparation of the DMEK grafts. Small peripheral tears were found in three prepared grafts; however, they did not interfere with graft quality or size. All surgeries were uneventful, except for case 6, in which positive pressure was found intraoperatively following peribulbar anesthesia, thus, making the DMEK operation more challenging. This and another case demonstrated partial graft detachment (7.7%). Both cases required only one intracameral air injection ("rebubbling") to achieve an attached graft with a clear cornea. There were no primary graft failures or cases of pupillary block.

DISCUSSION

Since DMEK was described first by Melles et al. in 2006[8], numerous variations on the original technique

Table 1. Modifications from the original "no touch" technique

	"No touch" technique	Samba technique
1. Tissue preparation	Predissected by an eye bank.	Prepared immediately preoperatively by the surgeon.
2. Graft insertion	Glass injector (DMEK surgical disposable set; D.O.R.C. International).	Modified plastic IOL inserter.
3. Graft unfolding	Primary with the aid of an air bubble over the graft.	Primary with indirect manipulations as gentle strokes or taps onto the corneal surface.
4. Fixating the graft	The anterior chamber is filled completely with air at approximately 20 mmHg for at least 45 to 60 min, and a partial air-BSS exchange is performed to leave the eye pressurized with a 30% to 50% air fill.	The anterior chamber is left completely filled with air at approximately 40 mmHg for 20 to 40 min. Thereafter, the pressure is reduced to approximately 20 mmHg, and the anterior chamber is left completely filled with air.
5. Avoiding pupillary block	Leave the anterior chamber with a 30% to 50% air fill.	Perform a peripheral inferior iridectomy intraoperatively.

DMEK= Descemet's membrane endothelial keratoplasty; IOL= intraocular lens; BSS= balanced salt solution.

have been reported[19-25], with those alternative techniques differing from each other in regard to preparation of the donor graft, method of graft insertion and unfolding inside the anterior chamber, and air-bubble management.

In our current clinical setting, prestripped tissue for DMEK from eye banks was not available[26,27]. Each donor sclerocorneal button could be used for only one patient, without the ease of backup tissue in cases of graft-preparation failure. In our cases, preparation was performed by the surgeon in the operating room immediately before DMEK. For this reason, it was essential to develop a preparation technique that was reproducible and easy to perform. We observed small peripheral tears in only three (11.5%) of the prepared tissues, yet they did not interfere with quality or size of the graft. Moreover, there was no tissue loss, and no procedure had to be canceled owing to failure of the prepared graft.

Initial DMEK studies reported an 8% rate of tissue loss when preparing the graft. More recent studies reported a lower graft-preparation failure rate[20,28-33]. Tenkman et al.[33] reported 1.1% tissue loss in 263 DMEK graft preparations, with tears present in 35 attempted preparations (13%). Kruse et al.[20] reported successful preparation of all 80 DMEK grafts, with small tears occurring in 26 of 80 preparations (32.5%), which always could be corrected without any tissue loss. Schlötzer-Schrehardt et al.[32] reported 2% tissue loss when preparing 350 DMEK grafts. The low graft-preparation failure rate found in our series, as well as in the most recent literature, confirmed that the graft can be prepared in the operating room immediately preoperatively and with a low risk of canceled operations due to failure of the prepared graft.

In our surgical setting, we found it easier to have a modified IOL injector created by the surgeon preoperatively using a C- or D-cartridge (Alcon, Inc.). In our cases, no complications were found during insertion of the DMEK graft, and most grafts were delivered in the correct orientation inside the anterior chamber. Previous reports have described various injectors for DMEK surgery made of plastic or glass, which showed no difference in clinical results, ECD, or complications[19,20,34].

It should be noted that it is vital to confirm orientation of the DMEK graft, as an inverted graft will lead to primary graft failure. In our cases, direct observation via the surgical microscope and Moutsouris sign[19] was used to confirm correct orientation of the graft. Two patients experienced compromised visibility of the graft during the procedure owing to advanced BK and corneal edema, and a modification of the Moutsouris sign was developed by the surgeon and used in those cases. When visibility is compromised, it becomes difficult to see the tip of the cannula turn blue when it is under the edge of the roll (Moutsouris sign). In our modified method, the cannula is slid to the side of the roll, moving the DM when the cannula touches the edge of the roll and, thus, confirming the correct orientation. Previous reports have described other techniques to assist orientation of the graft, such as marking with small peripheral tears or trephinations and ink marks[35,36], intraoperative ocular coherence tomography, handheld slit lamp, or an endoilluminator[37-39]. In our study, and even without these techniques, there were no inverted grafts and no primary graft failures. Although those techniques are useful to confirm the orientation, they are not essential to achieve a correctly oriented graft, as seen in other studies.

Several techniques have been described to unfold the graft. In the standardized "no touch" technique, an air bubble is placed between the double roll to unfold the graft.[19] Liarakos et al.[40] reviewed 100 consecutive DMEK surgical videos and found four different maneuvers used (in combination) to unfold the graft. They also found no correlation between the unfolding technique and clinical outcomes or complication rates. In our cases, indirect manipulation via gentle strokes or taps onto the corneal surface was the primary method used to open and center the graft, thus, reducing the need for a BSS flush, aid of an air bubble, or direct manipulation inside the anterior chamber to unfold and center the graft.

To avoid postoperative graft detachment, an effective technique to fix the graft is necessary and several techniques have been described. In the standard "no touch" technique[19], the anterior chamber is filled completely with air at approximately 20 mmHg for at least 45 to 60 min. Next, a partial air-BSS exchange is performed to leave the eye pressurized with a 30% to 50% air fill in the anterior chamber. Some studies have reported using 20% sulfur hexafluoride to fix the graft, as it stays in the anterior chamber for a longer interval[22,25]. In our novel Samba technique, the anterior chamber is left filled with air at approximately 40 mmHg for 20 to 40 min. Thereafter, the pressure is reduced to approximately 20 mmHg, and the anterior chamber left completely filled with air. In addition, a peripheral inferior iridectomy is performed in all cases so that the anterior chamber can be left filled with

air at the end of the procedure without causing pupillary block. In this study, there was no case of pupillary block, and the graft detachment rate was comparable with the lowest rates found in the literature, thus, confirming that the technique used to fix the graft in this series is safe and effective.

Larger reported series of DMEK cases have demonstrated postoperative results of BCVA and ECD similar to those found in our study. Gorovoy[41] described BCVA that ranged between 20/20 and 20/50, with a mean best spectacle-corrected visual acuity (BSCVA) of 20/25 at 3 months postoperatively. Mean preoperative donor cell count was 2596 cells/mm^2, which decreased to an average of 2112 cells/mm^2 for an average loss of 19% at 6 months postoperatively. Rodríguez-Calvo-de-Mora et al.[42] reported that 75% of the eyes in their series reached a BCVA of 20/25, 41% achieved 20/20, 13% achieved 20/18, and mean ECD decreased by 37% (±18%) to 1600 (±490) cells/mm^2 at 6 months postoperatively. Guerra et al.[43] described 41% of their patients achieving a BSCVA of 20/20 or better, 80% achieving 20/25 or better, and 98% achieving 20/30 or better vision. The endothelial cell loss at 1 yr postoperatively was 36% ± 20% (n=94; range, 13%-88%).

In conclusion, although DMEK is a challenging procedure, our Samba technique can allow DMEK to be adopted by most surgeons worldwide as the primary treatment for endothelial dysfunction, with a less steep learning curve and low complication rate.

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