Mastering Endothelial Keratoplasty

DSAEK, DMEK, E-DMEK, PDEK, Air pump-assisted PDEK and others
Volume II

Soosan Jacob
Editor

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For Dad and Mom

“No matter how far we come, our parents are always in us.”

-Brad Meltzer

Foreword

It is my pleasure really to write a few words as a foreword for this two-volume book on endothelial keratoplasty led by Dr. Soosan Jacob. As a cornea surgeon for the last 20 years, I have personally experienced the evolution of surgical visual rehabilitation of patients with corneal endothelial disease and/or trauma. My training and early practice was focused on penetrating keratoplasty. It was through the work of great innovators in our field of cornea transplantation surgery that endothelial keratoplasty techniques were introduced and popularized. Endothelial keratoplasty techniques currently account for the majority of cornea transplantation procedures performed in the USA and many other countries around the world. The advantages in safety and accelerated efficacy with endothelial keratoplasty techniques are enormous. It only takes one intraoperative suprachoroidal hemorrhage during an open-sky graft, or an inadvertent trauma in a successful penetrating keratoplasty, resulting in a wound dehiscence and catastrophic intraocular structure(s) expulsion to appreciate this.

The journey in the development of these techniques has been colorful and rapid!

DLEK was probably the earliest innovation, with DSAEK next, and later, DMEK, PDEK and DMET. Dr. Jacob has been one of those pivotal innovators and early adaptors, as a keen surgeon and passionate clinician enriching the current status quo of cornea surgery with many innovative concepts and techniques. Her commitment not only to patient care but also to academic medicine has brought to fruition this cornea transplantation “encyclopedia”.

Dr. Jacob has generously recruited the significant contributions of many other leading experts and innovators from all around the globe, generating a complete journey for the anterior segment surgeon reader through anatomy, history, technique, technology, complications and their management. I think the ophthalmic community is indebted to her for this brilliant text, and I am personally grateful to use it as a reference guide myself!

Enjoy the knowledge, passion and brilliance of our colleagues in action.

A. John Kanellopoulos, MD
Clinical Professor of Ophthalmology, NYU Medical School
New York, NY

Medical Director: The Laservision Clinical
and Research Institute, Athens, Greece

President: The International Society of Refractive Surgery-Partner
of the American Academy of Ophthalmology

Preface

The landscape of cornea as a sub-speciality has changed significantly from the past. Technology has improved by leaps and bounds and new techniques are constantly evolving. Interlinking of technology, newer surgical techniques, and basic research has brought about rapid shifts in our approach to corneal surgery, especially keratoplasty. Lamellar keratoplasty, both anterior and posterior, have shown such improved results that they have become the standard of care. The last two decades have seen the introduction of posterior lamellar keratoplasty as well as many changes in the way it has been performed. Endothelial keratoplasty has today become the most popular of choices for endothelial dysfunction requiring surgery. In 2011, about half the corneal transplants performed in the USA were Descemet stripping automated endothelial keratoplasty (DSAEK), and in 2012 it overtook penetrating keratoplasty in terms of the number of corneas being used. The acceptance is similar in many other parts of the world. The reason DSAEK is finding favor with both surgeons and patients is because of the improved recovery times and visual outcomes as well as the numerous intra-operative advantages. However, despite the even greater perceived advantages of the two more recent forms of endothelial keratoplasty – Descemet membrane endothelial keratoplasty (DMEK) and Pre-Descemet endothelial keratoplasty (PDEK) – there is still hesitancy on the part of many corneal surgeons to the inclusion of these into their surgical armamentarium. This is because these are perceived as more challenging techniques with a greater learning curve.

This two-volume book on endothelial keratoplasty (EK) serves to fill up a vacuum in this space as there is at present no book that covers all kinds of EK including DSAEK, ultra-thin DSAEK (UT-DSAEK), DMEK, and PDEK. It has been aimed to serve as an excellent guide for DSAEK to both the beginning surgeon as well as those who need a refresher to sharpen their skills further. It also at the same time serves as a stepping stone for successfully, and with minimal heartburn, mastering the more challenging newer endothelial keratoplasties, viz., DMEK and PDEK. The various minute steps that are essential for these as well as for newer ancillary techniques which help make surgery easy such as endoilluminator assisted DMEK (E-DMEK) and the air-pump assisted PDEK have been described in detail. The original pioneers for the various techniques as well as eminent specialists in this area have contributed their knowledge as well as given their tips and tricks for increasing surgical success. The two volumes have been designed to comprehensively cover the pre-, intra-, and post-operative period. The presence of numerous high-quality photographs, illustrations, and linked videos help make understanding easier and make this two volume book a must-have for all corneal surgeons. Despite the amount of educational material in it, the size and format has been kept to allow easy reading. The electronic format of the book helps carry it around for easy and quick reference at any place or time.

I would like to thank many people for making this labor of love possible. My co-authors who have contributed so much of their valuable time and effort to writing excellent chapters and have become dear friends; my friends and colleagues for their constant support in innumerable ways, and Saijimol AI for helping me with everyday work that otherwise would have overwhelmed me. I would also like to thank Naren Aggarwal and Teena Bedi from Springer for encouraging me to take on this task, for being immensely helpful at every step and for keeping this book to such high standards. I would like to thank all my patients from whom I have learnt so much and all the teachers in my life who have taught me so much. I would like to especially thank my two mentors, Drs. Amar and Athiya Agarwal who have pushed me ever forwards and always encouraged me to keep raising the bar further and further, always more than I would think possible for myself. I would also like to thank my parents – Mary Jacob and Lt. Col Jacob Mathai – for guiding me and molding me into what I am and my brother Alex Jacob and my sister Asha Jacob for always being there for me. Finally, I would like to thank Dr. Abraham Oomman, my husband, my best friend, my confidante, and my sounding board for his unflinching support and constant love, for making me keep at it and complete it, and lastly my children, Ashwin and Riya, who tolerated me throughout and kept me smiling through all the long hours spent.

Finally, as Oliver Wendell Holmes said, “Great things in this world depends not so much on where we stand but which direction we are moving.” This book is an attempt to throw a light to illuminate the path and make it easier to travel. I hope you the reader will enjoy this book and glean from it pearls that you will be able to incorporate into your practice.

Chennai, India Soosan Jacob

About the Editor

Dr. Soosan Jacob, MS, FRCS, DNB, MNAMS is Director & Chief; Dr. Agarwal's Refractive and Cornea Foundation (DARCF) and Senior Consultant, Cataract and Glaucoma Services, Dr. Agarwal's Group of Eye Hospitals, Chennai, India. She is a noted speaker widely respected for her innovative techniques and management of complex surgical scenarios. She conducts courses and delivers lectures in numerous national and international conferences; has been the recipient of IIRSI Special Gold medal, Innovator's award (Connecticut Society of Eye Physicians), ESCRS John Henahan award for Young Ophthalmologist, AAO Achievement award and two time recipient of ASCRS Golden Apple award.

She has special interest in cutting-edge cataract, cornea, glaucoma, and refractive surgery and has won more than 40 international awards for videos on her surgeries, innovations and challenging cases at prestigious international conferences in United States and Europe. Her innovations, many of which have won international awards, include **anterior segment transplantation**, where cornea, sclera, artifical iris, pupil and IOL are transplanted enbloc for anterior staphyloma; **suprabrow single stab incision ptosis surgery** to enhance postoperative cosmesis; **turnaround techniques** for false channel dissection during Intacs implantation; **Glued Endo-Capsular Ring** and **Glued Capsular Hook** for subluxated cataracts; **Stab Incision Glaucoma Surgery (SIGS)** as a guarded filtration surgery technique; **Contact lens assisted crosslinking (CACXL)** for safely cross-linking thin keratoconic corneas; **Endo-illuminator assisted DMEK (E-DMEK)** and **Air Pump Assisted PDEK** for easier and better surgical results; and the **PrEsbyopic Allogenic Refractive Lenticule (PEARL) Inlay** for treating presbyopia. She has proposed a new classification of **Descemet's membrane detachments** into **rhegmatogenous, tractional, bullous and complex detachments** with a suitable **treatment algorithm** and a new technique of **relaxing descemetotomy** for tractional Descemet's detachment. Her surgeries and surgical techniques have often been Editor's Choice in prestigious International Ophthalmic websites (AAO/ ONE network, ISRS, Eyetube etc). Her **video blog** "Journey into the Eye - A surgeon's Video blog" in the prestigious Ocular Surgery News, USA features her surgical videos. She also has her own surgical educational **YouTube channel: Dr. Soosan Jacob** with more than 2500 subscribers.

Dr. Jacob is senior faculty for training postgraduate, fellowship and overseas doctors. She has authored more than 80 peer reviewed articles, numerous chapters in more than 30 textbooks by international publishers, is editor for 15 textbooks in ophthalmology and reviewer for many prestigious journals. She has two popular columns, **"Eye on Technology"** and **"Everything you want to know about"** in the prestigious **Eurotimes** magazine published by ESCRS.

She is a committee member of ISRS/AAO Multimedia Library and is on the editorial board of the Ocular Surgery News–Asia Pacific Edition, Cataract and Refractive Surgery Today- Europe, Glaucoma Today and the EuroTimes Magazines. Her life and work have been featured on the **Ocular Surgery News cover page, "5Q" interview** (prestigious Cataract and Refractive Surgery Today), **"Sound off"** column (CRST) and is the first researcher internationally to be interviewed in the prestigious CRST **"Researcher's Column."** She can be contacted at dr_soosanj@hotmail.com

Contents

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Chapter 1
Endothelial Keratoplasty Combined with Cataract Extraction

J.H. Woo and J.S. Mehta

Contents

1.1 Introduction

Endothelial keratoplasty is the current standard of care for diseases of corneal endothelial dysfunction, having surpassed conventional penetrating keratoplasty in terms of safety, speed and predictability of visual recovery, tectonic integrity of the globe, stability of ocular surface and refractive outcomes [1–4]. As the field of endothelial keratoplasty continues to advance and evolve, the role of combined procedures to address endothelial dysfunction with coexisting cataract has been studied. Heralded as 'the new triple procedure', endothelial keratoplasty combined with cataract

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extraction offers the promise of rapid visual rehabilitation, predictable refractive outcomes, convenience and cost-effectiveness of a one-stage procedure, without the purported risks of increased postoperative complications [5–8]. The decision to proceed with the triple procedure and surgical planning can be complex and necessitates careful consideration of the patient's visual function and requirements, underlying cause of endothelial dysfunction, the presence of any concurrent ocular disease and target refraction. Specific modifications to surgical techniques in phacoemulsification and endothelial keratoplasty are often required to further optimize visual outcomes and minimize complications.

1.2 Considerations for Surgery

1.2.1 Indications

The definite indication for endothelial keratoplasty combined with cataract extraction is the presence of corneal decompensation, without stromal scarring, and visually significant cataract (Fig. 1.1). It is important to determine the extent to which the underlying cornea condition and cataract contributes to the patient's symptoms and reduced vision as well as the longer term effects of cataract surgery on the cornea (or vice versa, that of endothelial keratoplasty on the lens clarity).

Any visually significant lens opacity will necessitate cataract extraction, which may be undertaken as a single procedure, if the corneal endothelial reserves are deemed sufficient; as part of a sequential or staged procedure before or after keratoplasty; or as part of a triple procedure. The main risk of performing cataract extraction alone in such a scenario is that of future endothelial cell loss and resultant corneal decompensation. It has been shown that endothelial cell loss occurs at a rate of 2.5 % per year 10 years after cataract surgery, 2.5–8.0 times the rate in healthy unoperated eyes [9]. Patients with diabetes mellitus [10], eyes with shorter axial length [11, 12] and hard cataracts [13] are predisposed to increased endothelial

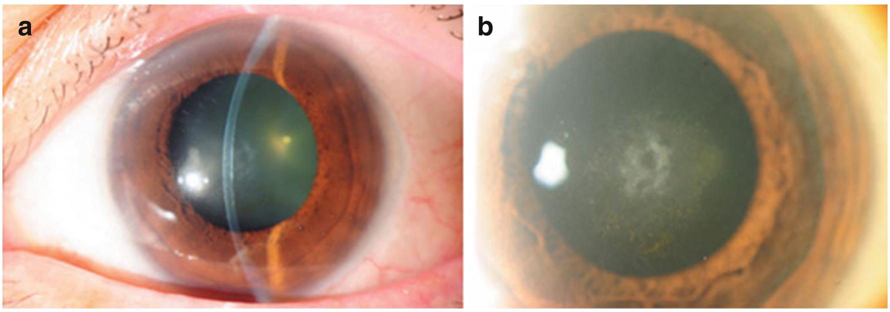

Fig. 1.1 A patient with corneal decompensation secondary to Fuchs endothelial dystrophy and visually significant nuclear sclerotic cataract. (**a**) Photograph showing corneal edema and nuclear sclerotic cataract (**b**) Magnified view of cornea showing guttata and endothelial pigments

damage during surgery. Surgical variables and complications such as prolonged phacoemulsification time [11], posterior capsule rupture [14] and postoperative intraocular pressure spike [12] may further deplete corneal endothelial reserve in an already compromised eye. As such, identification of patients at risk of significant endothelial cell loss after cataract surgery alone may aid surgical decision-making. Careful counselling of such patients regarding the potential need for endothelial keratoplasty in the event of corneal decompensation in the future cannot be overemphasized.

Conversely, for eyes with marked endothelial dysfunction but only incipient lenticular opacification, the options include endothelial keratoplasty alone or the triple procedure. The main concern with proceeding with endothelial keratoplasty alone is the acceleration of cataract formation [15–18], not unlike that seen in penetrating keratoplasty [19, 20]. Price et al., in a retrospective review of 60 phakic eyes which had undergone Descemet stripping endothelial keratoplasty (DSEK), reported a rate of cataract formation of 43 % after 3 years of follow-up, significantly higher than that of unoperated normal eyes in the same age group [16]. Burkhart et al. also reported a 76 % rate of cataract progression in 49 eyes which had undergone Descemet membrane endothelial keratoplasty (DMEK) at the end of 1 year [20]. Both studies identified age as a significant risk factor for cataract formation and cataract extraction after endothelial keratoplasty, with the likelihood of cataract extraction within 3 years increased from 7 % in patients who were 50 years or younger at the time of surgery to 55 % in those over 50 years of age [16]. In a small case review of 12 eyes after phakic Descemet membrane stripping endothelial keratoplasty (DSAEK), Tsui et al. also found a significant difference in the mean anterior chamber depth between eyes that developed cataracts and those that did not, with cataract development being associated with a preoperative anterior chamber depth of less than 2.80 mm [17]. Therefore, for younger patients, in whom the preservation of a clear crystalline lens with its accommodative amplitude is favoured, endothelial keratoplasty alone may suffice. Older patients without visually significant cataract will need to be counselled regarding the risk of cataract formation and progression after endothelial keratoplasty before an informed choice between proceeding with cataract surgery after keratoplasty or as part of a combined procedure. Notably, various groups have reported good clinical outcomes with cataract surgery after endothelial keratoplasty. Price et al. reported no intraoperative and postoperative complications or significant decline in central endothelial cell density in 22 eyes in which cataract extraction was successfully performed after DSEK [16]. Similarly, the feasibility of standard technique phacoemulsification after DMEK has been supported by Dapena et al. [21].

Traditionally, slit-lamp biomicroscopic evidence of microcystic oedema or stromal thickening, a central corneal thickness (CCT) measurement of more than 600 μm and low central endothelial cell count by specular microscopy have been accepted as predictors of endothelial failure after cataract surgery [22]. Seitzman et al., in a large retrospective non-comparative case series of 136 patients with Fuchs endothelial dystrophy who underwent phacoemulsification, recommended increasing the CCT measurement cut-off to 640 μm and even beyond, in view of advancements in cataract surgery techniques which allowed for improved visual rehabilitation in patients [23]. These factors, together with higher age, presence of morning blur, reduced best-corrected visual acuity (BCVA), decreased contrast sensitivity, glare and failure of endothelial cell measurement should sway the corneal surgeon towards offering a triple procedure. The limitations of CCT as a sole determinant of future need for endothelial keratoplasty, taking into account the normal distribution within the population and diurnal variations, have prompted the search for other novel objective predictors. Van Cleynenbreugel et al. proposed the use of in vivo confocal microscopic basal epithelial cell layer backscatter measurement, as an indicator of corneal hydration status, to predict the need for endothelial keratoplasty after cataract surgery in patients with Fuchs endothelial dystrophy [24].

1.2.2 Planned Sequential Surgery or Triple Procedure

Proponents of planned sequential cataract extraction and endothelial keratoplasty are chiefly concerned with the theoretical risks of increased graft dislocation [25], instability of newly implanted intraocular lens (IOL) [26] causing graft damage and the increased inflammatory response associated with the combined procedure [27]. Similarly, poor visualization of anterior chamber and lens details from bullous keratopathy have prompted others to recommend performing endothelial keratoplasty first followed by cataract extraction several months later when corneal clarity has been substantially restored [28].

However, various groups have since shown that with modifications in surgical technique, combined surgery has a good safety profile with regards to graft dislocation and primary graft failure [5], with no higher risk than performing endothelial keratoplasty alone [6]. In a prospective, non-comparative, interventional case series of 315 eyes with Fuchs endothelial dystrophy which had undergone either DSAEK alone or triple procedure, Terry et al. reported a dislocation rate of 1.8 % for combined surgery group compared to 4 % in the DSAEK only group and no case of primary graft failure [5]. Similarly, Chaurasia et al., in a case series of 492 eyes which had undergone DMEK alone or with concurrent cataract surgery, did not find any significant difference in rates of graft failure, air reinjection and endothelial cell loss within 3–6 months between the two groups [6].

1.2.3 Refractive Targets

In contrast to penetrating keratoplasty, which induces changes in both the anterior and posterior corneal curvature, modern endothelial keratoplasty techniques do not alter the corneal topography significantly [29, 30] and hence induce minimal changes to the cylinder or spherical equivalent. However, a hyperopic shift of 0.7–1.5 D (median 1.2 D) has been described in DSAEK [1, 7, 27, 31, 32]. A similar, but smaller, shift of up to 0.9 D can also be expected in DMEK [8, 33, 34]. This effect is commonly attributed to a more negatively powered posterior corneal curvature secondary to the non-uniform thickness profile of the donor lenticule which may be thin centrally but thick in the periphery [35–37].

Therefore, it may be prudent to empirically target a more myopic postoperative refraction between −1.00 and −2.00 D in eyes undergoing combined endothelial keratoplasty and cataract extraction, in order to avoid unintended hyperopic results. This principle should also be applied in patients with endothelial dysfunction who are undergoing cataract surgery alone in anticipation of the hyperopic shift associated with endothelial keratoplasty, if required in the future. In addition, it is important to take into account a possible reduction in hyperopic shift over time after endothelial keratoplasty. Scorcia et al. [37] reported the average postoperative spherical equivalent changed from −0.31 ± 2.35 D before surgery to 1.03 ± 2.21 D 1 month after surgery, 0.61 ± 2.07 D 3 months after surgery, and 0.31 ± 2.03 D 12 months in 34 eyes after standard DSAEK. This progressive change in hyperopic shift was correlated with the overall reduction of corneal thickness, and in particular, with the difference in thickness between central and peripheral cornea. Similarly, in a retrospective observational study of nine eyes post-DSEK, Holz et al. [38] also reported a change in monthly postoperative spherical equivalent of −0.25 D over the initial 100–200 days, secondary to differential donor graft thinning over time. Patients should therefore be counselled regarding this possible change in postoperative refraction and may need future changes in spectacle correction.

Separate strategies in improving refractive outcomes in the new triple procedure have since emerged. Bonfadini et al. proposed the optimization of IOL constant in which prediction errors were retrospectively calculated for 30 consecutive triple DSAEK procedures performed by a single surgeon and used to calculate the IOL constant for the cohort. He reported a reduction of the mean absolute error from 1.09 ± 0.63 D (range, 0.12–2.41 D) to 0.61 ± 0.4 D (range, 0–1.58 D; $P = 0.004$) and a significant improvement of refractive accuracy compared to the manufacturer's IOL constant with such optimization [39]. In response to the expected hyperopic shift from reduced corneal power seen in post-DSAEK eyes, De Sanctis et al. adjusted the K readings by −1.19 D before the IOL calculation. They reported a mean absolute prediction error was 0.59 ± 0.42 D (range, 0.05 to −1.52 D) from this approach, compared to 0.86 ± 0.62 D; $P = 0.04$ unadjusted. The postoperative spherical equivalent fell within ±0.50 D, ±1.00 D and ±2.00 D of the predicted refraction in 55.5 %, 83.3 % and 100 % of cases, respectively. They concluded that this led to more accurate IOL calculation and predictable refractive error after combined surgery [40].

1.2.4 Intraocular Lens (IOL) Implant

The effect of IOL design on the outcomes of combined endothelial keratoplasty and cataract surgery has not been well studied. There have been concerns regarding the stability of the implanted IOL during combined procedures, in particular, the risks of lens decentration and dislocation during donor graft insertion and air bubble placement, which may lead to endothelial cell loss. This may be further compounded by intraoperative factors such as an oversized capsulorrhexis, fluctuations in anterior chamber dynamics, iris prolapse and a large dilated pupil. Notably, Laaser et al. [8], in a retrospective case series of 61 consecutive eyes which had undergone simultaneous DMEK and cataract surgery, compared the use of a spherical single-piece acrylic intraocular lens and a multi-piece acrylic intraocular lens, but found no significant difference in BCVA, spherical equivalent, endothelial cell density, central corneal thickness, refractive and topographic cylinder, target refraction as well as the rebubbling rate between the two designs.

The use of toric IOL may be feasible, given the stability of refractive astigmatism after endothelial keratoplasty [41]. Scorcia et al. [42] reported a case in which simultaneous DSAEK and cataract surgery with implantation of a customized hydrophilic acrylic bitoric IOL was performed in a patient with a failed penetrating keratoplasty graft, secondary cataract and high astigmatism. A BCVA of 20/20 was achieved at 6 months, with improvement in refraction from −3.00/−8.50 × 12 preoperatively to +0.25/−1.00 × 10 postoperatively. Wavefront analysis and internal topography map showed only 4° of IOL rotation from the intended axis while there was 15 % endothelial cell loss from the baseline value. However, such an approach may be limited by difficulty in obtaining precise biometric measurements in the presence of corneal oedema, in addition to any surgically induced astigmatism.

Higher order aberrations and back scatter associated with endothelial keratoplasty [43–45] essentially precludes the implantation of multifocal IOLs. Similarly, the relative lack of refractive predictability (still, at present stage) in endothelial keratoplasty makes accommodative IOLs, for which achieving postoperative emmetropia is crucial, a poor option when considering combined surgery.

Opacification of the IOL is a potential complication after endothelial keratoplasty [46, 47].

Patryn et al. first reported three cases of membranous opacification over the anterior surface of previously implanted foldable acrylic IOL 7–18 months after DSEK [46]. Fellman et al. [47] went further to examine the ultrastructure and histology of the deposits found on a hydrophilic acrylic IOL 9 months after DSEK. Light microscopy revealed the presence of granular deposits densely distributed in a round pattern within the margins of the anterior capsulorrhexis. These lesions also stained positive for calcium using alizarin red and von Kossa methods. The aetiology of IOL opacification is unknown but has been postulated to be the result of calcification caused by IOL-air contact as well as metabolic and/or inflammatory changes associated with air injection and surgical manipulation. Nevertheless, any opacification of the IOL is likely to be visually significant, with high degree of light scattering [47]. These lesions may not be amenable to medical treatment, and often require an exchange of the IOL.

1.3 Surgical Approach: Specific Modifications to Standard Techniques in Combined Surgery

We routinely perform combined endothelial keratoplasty and cataract surgery under general or local (peribulbar) anaesthesia. This is to ensure patients' comfort and cooperation due to the anticipated longer duration of surgery and precise intraocular manipulation involved. Although, topical anaesthesia has been advocated by some authors [48–50], this may not be ideal for surgeons on the learning curve or patients who may be anxious or are unlikely to cooperate fully during the course of surgery.

The cataract surgery component of the operation takes precedence over endothelial keratoplasty, to avoid unnecessary trauma to the cornea graft. Visualization in eyes with severe corneal oedema and bullous keratopathy can be improved by performing epithelial debridement (Fig. 1.2). A standard 4.5 mm scleral tunnel and paracentesis incision wound are created, with emphasis on making the paracentesis shorter and more vertically orientated. This is done to prevent the graft from occluding the paracentesis and allow easier injection of air in the later stages of surgery. Visualization of anterior chamber and lens may be further enhanced with the use of trypan blue dye.

Cohesive ophthalmic viscoelastics (OVDs), such as Healon (Abbott Medical Optics Inc., Santa Ana, California, USA), are recommended during cataract surgery. Although dispersive OVDs are used in standard cataract surgery, the risk of viscoelastic retention may cause subsequent problems in combined surgeries. Major concerns about retained viscoelastics impeding graft adhesion (with resultant dislocation) and interfering with interface clarity have been voiced by several authors [6, 25, 51–53].

To date, there is no large prospective randomized study aimed at evaluating the role of viscoelastic in graft adherence and dislocation. However, Terry et al. have suggested the safety of Healon in combined surgeries after reporting a lower rate of graft dislocation than all other published data in which Healon was not used before donor insertion. This was further substantiated by full graft attachment without any viscoelastic in the interface immediately after surgery, amongst the eyes in which graft dislocation occurred subsequently [5]. As such, meticulous and thorough removal of viscoelastics (including behind the IOL) at the end of cataract surgery

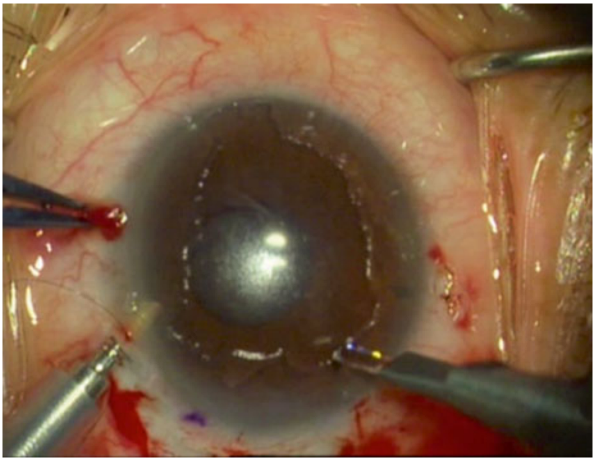

Fig. 1.2 Epithelial debridement to improve visualization in severe bullous keratopathy

remains a crucial step in the new triple procedure. However, we prefer to perform the descemetorhexis under air following Healon removal (Fig. 1.3).

This allows excellent visualization and better control of the continuous curvilinear tear of the Descemet membrane, due to the enhanced surface tension, from the air-tissue interface on the posterior corneal surface. Also a complete air fill in the anterior chamber confirms the complete removal of viscoelastic following IOL insertion [54].

In order to prevent IOL prolapse from the capsular bag and into the anterior chamber, especially after the donor lenticule has already been inserted (Fig. 1.4), we typi-

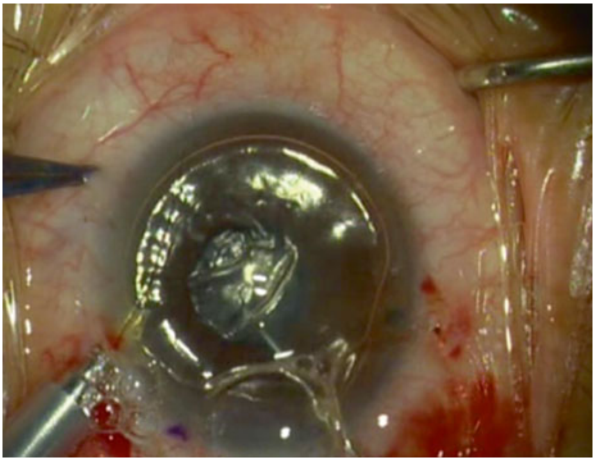

Fig. 1.3 Descemetorhexis performed under air provides excellent visualization and surgical control. A complete air fill confirms the removal of all viscoelastic

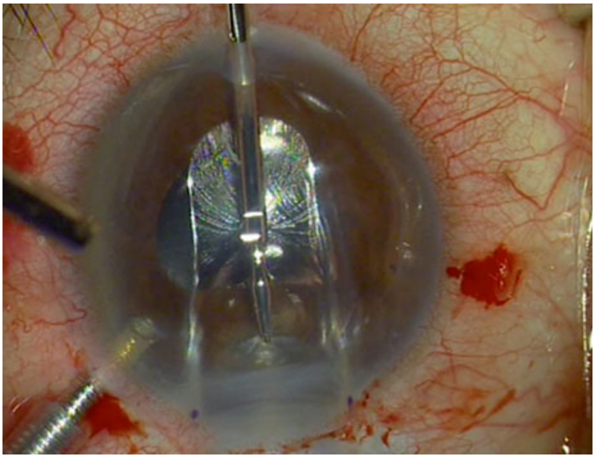

Fig. 1.4 Insertion of the donor lenticule using the Endoglide Ultrathin

cally undersize our capsulorrhexis to 4–5 mm or smaller (Fig. 1.5). To ensure additional stability of the IOL in preparation for graft insertion, a miotic agent such as carbachol 0.01 % is injected intracamerally to constrict the pupil. This manoeuvre also serves to prevent iris prolapse and inadvertent insertion of the graft into the posterior chamber. We routinely perform an inferior peripheral iridectomy in all cases to avoid the risk of pupil block (Fig. 1.6). Lastly, all wounds are sutured to ensure air and water tightness, to avoid problems of air leakage and hypotony (Fig. 1.7).

1.4 Outcomes

Current literature on the outcomes of combined endothelial keratoplasty and cataract surgery is promising but limited. Covert et al. [7], in prospective non-comparative case series of 21 eyes of 21 consecutive patients with Fuchs endothelial

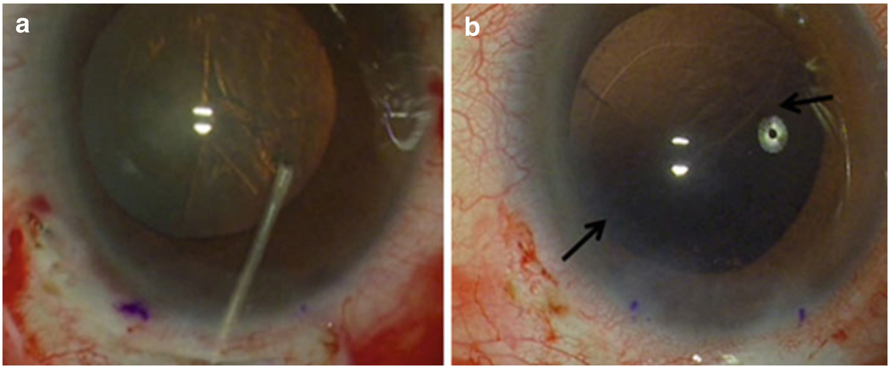

Fig. 1.5 (**a**) The capsulorrhexis is undersized to prevent IOL prolapse out of the capsular bag. (**b**) The *arrows* indicate the margins of the capsulorrhexis

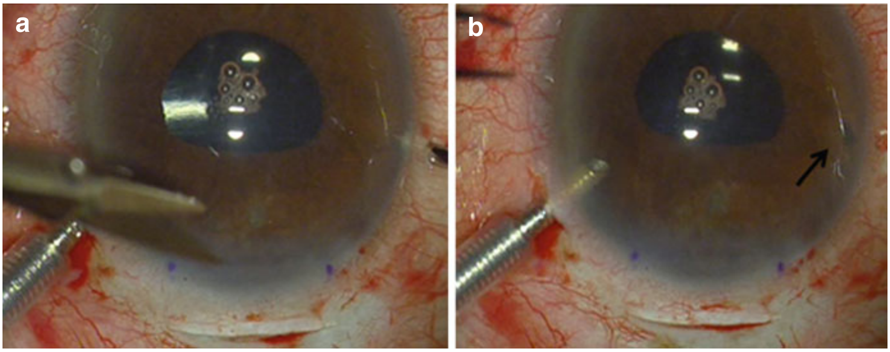

Fig. 1.6 (**a**) Creation of an inferior peripheral iridectomy to prevent pupil block. (**b**) Inferior surgical iridectomy as indicated by the *arrow*

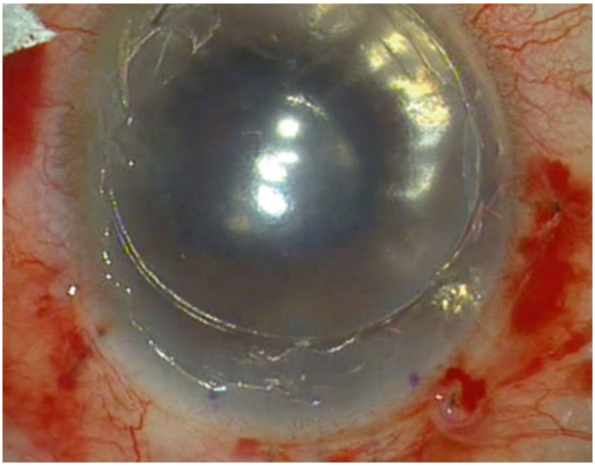

Fig. 1.7 Full air tamponade after donor lenticule insertion. All wounds have been sutured to prevent air leakage and hypotony

dystrophy and coexisting senile cataract who underwent combined DSAEK and phacoemulsification with 6 months of follow-up, concluded that the procedure provides rapid visual rehabilitation with predictable refractive outcomes. The average preoperative and 6-month postoperative BCVA was 20/68 ± 1.7 lines (mean ± standard deviation) and 20/34 ± 1.1 lines, respectively, with over 90 % of eyes (19 out of 21) having achieved a BCVA of 20/40 or better. They reported three eyes with donor corneal lenticule dislocation on the first postoperative day, while two of these went on to have recurrent dislocation which necessitated a repeat DSAEK. The authors attributed the observed dislocation rate to the learning curve associated with the procedure and have recommended further refinement of surgical techniques, such as corneal venting incisions, peripheral corneal scraping and longer air tamponade, to improve lenticule adherence. Other complications in the series included acute graft rejection (three eyes) and pupillary block glaucoma (two eyes).

Terry et al. [5], who performed combined DSAEK and phacoemulsification on 225 eyes with Fuchs endothelial dystrophy and cataract, reported a dislocation rate of 1.8 % (four eyes) with no case of iatrogenic primary graft failure. In terms of visual outcomes, the BCVA improved from an average of 20/52 preoperatively to 20/31 at 6 months after surgery, representing an average gain of 2 Snellen lines ($P < 0.001$). Of these, 93 % of eyes achieved a BCVA of 20/40 or better. The group went further to evaluate the rate of donor endothelial cell loss and reported a mean loss of 32 ± 14 % and 32 ± 15 % at 6 and 12 months, respectively. There was no significant cell loss between the 6- and 12-month period and between combined surgery and DSAEK only groups.

Combined DMEK and cataract surgery (coined ‘triple-DMEK’) represents another step forward in the evolution of the triple procedure, as the replacement of diseased host endothelium without additional donor stromal tissue provides more rapid visual recovery and lower risks of graft rejections [55, 56]. Chaurasia et al.

[6] reported an improvement in median BCVA from 20/40 to 20/20 in 180 eyes with Fuchs endothelial dystrophy which had undergone triple-DMEK, after excluding eyes with pre-existing retinal and optic nerve pathology. The group also found an air reinjection rate of 29 %, in addition to a median endothelial cell loss of 25 % at 6 months, with 3.5 % of eyes having primary graft failure. Similarly, Laaser et al. [8] reported satisfying results in terms of visual outcomes for 61 eyes which had undergone triple-DMEK. In their series, the BCVA improved from 0.6 ± 0.23 logMAR preoperatively to 0.19 ± 0.22 logMAR at 6 months after surgery, with 81.4 % of eyes reaching a BCVA of 20/40 or better. Notably, the mean endothelial cell loss was 40 % after 6 months while 73.8 % of eyes required at least one air injection postoperatively, comparable to reinjection rates reported for DMEK alone [33]

1.5 Conclusion

Endothelial keratoplasty combined with cataract surgery clearly offers better visual outcomes and safety profile compared to the traditional triple procedure. The rates of graft survival and complications are also comparable to sequential or staged surgery. We expect combined surgery to be the mainstay of treatment for patients with endothelial dysfunction and visually significant cataract in the future. However, careful patient selection and counselling, coupled with modifications in operative techniques, are still imperative in the overall surgical planning to optimize outcomes and prevent complications.

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