Exploring the Debate: DMEK and DSEK in Corneal Transplantation

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Scientific progress is rarely a linear process. This notion is especially true as it pertains to the development of surgical techniques that have the potential to shape future clinical landscapes. Corneal transplantation is no exception. From the very first iterations of full corneal transplants performed in the 19th century to the highly nuanced endothelial procedures available today, corneal medicine has served — and continues to foster — an academic arena where research discoveries and surgical innovations come together to advance the field.

Corneal transplantation, or "keratoplasty" as it was termed by Dr. Franz Reisinger in 1824,[1] aims to restore cornea-related visual deficiencies by replacing opaque tissue from disease or trauma with transparent tissue from a healthy donor eye.[2] In the pre-modern era (1813-1905), pioneers in the field debated whether animals (xenograft) or same-species donors (allograft) would be the optimal source of donor tissue with the highest chances of success.[1] Initial attempts at developing xenografts from rabbits and chickens were unsuccessful, but the first successful allograft was performed between two gazelles in 1837. In 1905, the first successful human-to-human allograft was performed by Dr. Eduard Zirm, creating the foundations for and paving a clear direction for the development of grafts used in modern practice.[1] The ambitious environment of keratoplasty surgeons has persisted, inviting current corneal specialists to engage in the constructive exchange of ideas in the spirit of optimizing clinical practices.

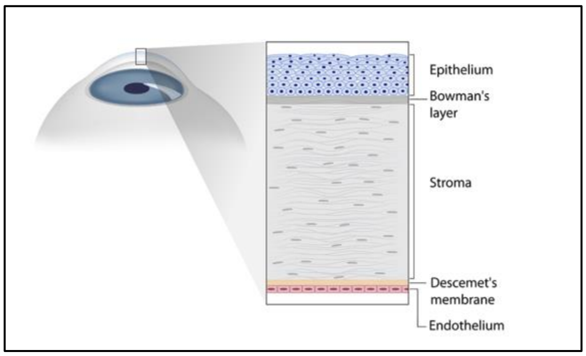

Figure 1. *Anatomy of the cornea.*[3]

In the modern era (1905-present), selection of surgical technique lies at the center of corneal transplant discussions. Anatomically, the cornea constitutes the anterior-most part of the eye and consists of five major layers (**Figure 1**).[3] Starting anteriorly, these include an epithelium, Bowman's membrane, stroma, Descemet's layer, and endothelium. The stroma constitutes a large part of the corneal structure and consists of keratocytes and collagen lamellae.[4] Penetrating keratoplasty (PK) describes surgical replacement of all five layers of the cornea (**Figure 2**).[5,6] PK offered the best visual quality throughout the pre-modern era and continued to be the predominant surgical technique until 2005. As the field progressed, however, lamellar keratoplasty (LK), which targets select diseased layers, has grown in popularity. LKs are separated into anterior (ALK) or posterior (PLK) based on the location of the opacity it aims to resolve and endothelial integrity of the receipt.[5] For example, deep anterior lamellar keratoplasty (DALK) is often performed to replace deep stromal scars from healed infectious keratitis by removing the anterior layers of the cornea up to and excluding Descemet's membrane. Since the posterior layers (Descemet's layer and endothelium) remain untouched, DALK is indicated in patients with normal endothelial functioning.[7] Although DALK has shown to provide faster visual recovery and lower rejection rates compared to PK, both carry the risk of postoperative astigmatism and ametropia.[5]

On the other hand, PLK, specifically endothelial keratoplasty (EK), is preferred in conditions that only affect the endothelial layer. EK avoids anterior dissection, a shortcoming of early PLK procedures, in order to limit refractive changes, long-term suture-related complications, and wound dehiscence.[7,8] The introduction of Descemet stripping endothelial keratoplasty (DSEK) and Descemet's membrane endothelial keratoplasty (DMEK) by Dr. Gerrit Melles in 2004 and 2006, respectively, sparked yet another ongoing investigation to determine the optimal procedure.[9,10] DSEK utilizes a 4.0-5.0 mm clear cornea or scleral tunnel incision to access Descement's membrane and associated endothelium (**Figure 3**).[11] These layers are stripped in a circular fashion and removed in order to create a stromal bed to accommodate the inserted donor graft, which includes an endothelium, Descemet's membrane, and a thin layer of posterior stroma.[10] The donor tissue is then tamponaded against the cornea using air. The preparation of donor lamellae, which typically ranges in thickness from 70-135 μm, can be performed by manual dissection, laser, or through use of a microkeratome.[12] This contribution earned adoption of the term DSAEK to reflect the microkeratome's automated properties that made the preparation more simple and precise.[8] Importantly, this standardization allowed eye banks to provide precut donor tissue for DSEK procedures which facilitated rapid adoption by surgeons.[8] By 2014, DSEK accounted for 50% of corneal transplants in the United States.[13]

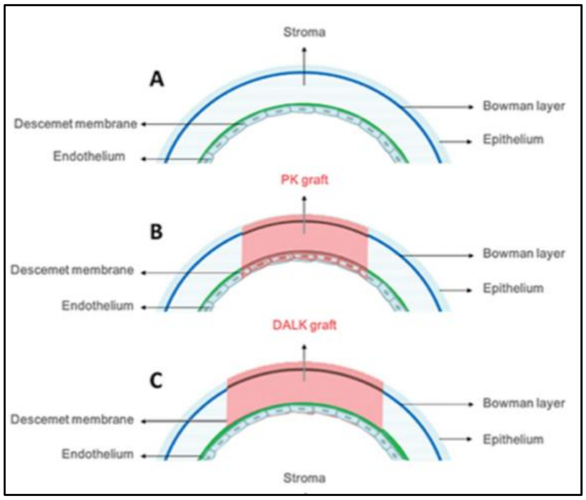

Figure 2. *Schematic diagram of healthy* (A) *cornea,* (B) *PK, and* (C) *DALK.*[6]

DMEK similarly involves stripping the Descemet membrane and endothelium from the recipient, but a donor graft containing counterparts to these layers is inserted.[9] The donor tissue is similarly fixated using air or a gas formulation in the anterior chamber to tamponade the graft against the host cornea, but the lack of a donor posterior stroma in DMEK results in the use of a much thinner graft (15-20 µm).[14] This presents many challenges in donor graft preparation, which relies on manual peeling techniques in the operating room at the time of surgery or by eye banks. The thin graft may require complex surgical maneuvers for proper orientation in the eye. Furthermore, without a portion of the posterior stroma, DMEK grafts often do not adhere easily to the rim of the host Descemet membrane, resulting in a more postoperative detachments.[15] Given these challenges associated with DMEK, many surgeons prefer to use DSEK in "complex eyes" including those with prior vitrectomy, glaucoma tubes, or iris defects.

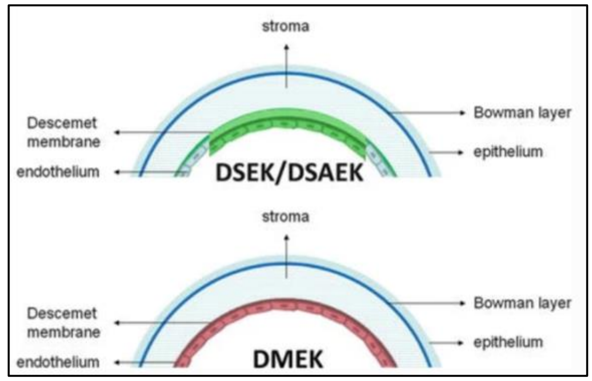

Figure 3. *Schematic diagram of DSEK/DSAEK and DMEK procedures.*[11]

The deliberation surrounding DSEK versus DMEK comes down to considering risks and rewards on an individual patient basis. DMEK has been shown to result in better visual acuity, evidenced by higher best-corrected distance visual acuity (BCDVA) after 12 months postoperatively (20/23) compared to DSEK (20/32) in a retrospective case series with patients receiving both procedures, one in each eye.[16] Additional studies have shown 20/20 visual acuity rates of 25% at three months and 48% at six months, further supporting DMEK's promising visual acuity advantage.[17] DSEK may be associated with less visual improvement due to astigmatism from a larger incision, subepithelial haze, and hyperopic shift cause by transplanted stroma with mismatch between the donor and host corneal curvatures in thicker grafts.[18] Nonetheless, the average visual acuity reported in DSEK is 20/40 after six months for either pre-cut tissue or manual dissection preparation.[19] As newer ultrathin methods are developing (UT-DSEK), which have shown 20/20 performance in 12.3% of patients after three months and 26.3% after six months,[20] the visual acuity gap between the two procedures may be closing.

DMEK has been associated with higher rates of graft detachment, with reports of 26.1% of patients having partial graft detachment.[15] Consequently, significantly higher re-bubbling rates are reported in DMEK (24%) compared to UT-DSEK (4%).[21] Although the higher learning curve in DMEK led to higher rates of graft failure initially, recent evidence suggests that this value has declined from 7.69% to 0.68% from 2013 to 2018.[22] This figure is comparable to reported DSEK graft failure reports (0.86%).[22] As surgeons continue to become more familiar with DMEK and tissue preparation methods further improve, the safety profile may continue to improve.

These two notable trends — improved visual acuity in UT-DSEK procedures and reduced complication rates after DMEK — have further muddled the debate of which approach is superior. Although both procedures are indicated for Fuchs's endothelial dystrophy and pseudophakic bullous keratoplasty, which presents as corneal edema as a complication after cataract surgery or other intraocular surgery, variation in patient populations and pathology may present opportunities for each to play a role in a surgeon's keratoplasty repertoire.

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