

Descemet Membrane Endothelial Keratoplasty: Update on Endothelial Transplantation Techniques

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Abstract

The cornea remains in a state of deturgescence, maintained by the endothelial cell Na⁺/K⁺ ATPase and by tight junctions between endothelial cells that limit the entrance of fluid into the stroma. By maintaining an optimum level of corneal hydration, endothelial cells preserve the ordered arrangement of collagen fibers, which is crucial for corneal transparency. Fuchs' endothelial corneal dystrophy (FECD) was initially described by Fuchs in 1910 as a combination of epithelial and stromal edema in older patients. It manifests itself as bilateral, albeit asymmetric, central corneal guttae, corneal edema, and reduced vision. The Descemet membrane thickens and develops excrescences known histopathologically as guttae. Stromal edema develops, and the corneal thickness may increase to over 1,000 μm. When the edema is severe, the corneal epithelium can detach from its basement membrane, creating painful bullae on the anterior surface of the cornea. FECD is the most common endothelial dystrophy and is usually seen beyond the fifth decade of life, although not all cases are in the elderly. Pseudophakic bullous keratopathy is a term used to describe endothelial cell loss caused by surgical manipulations in the anterior chamber (usually due to pseudophakic intraocular lens (IOL) implantation, but it may

be related to any other intraocular surgical procedure, obviously including phakic IOL implantation). If the corneal endothelium is damaged during surgery (as often occurs during cataract extraction, phakic IOL implantation and other procedures), the same spectrum of symptoms as found in FECD can develop, although the histological phenotype of both diseases is different and, usually, there is no guttata in pseudophakic bullous keratopathy. Full-thickness grafts have been the standard of care for treating medically uncontrollable endothelial disease for a significant number of years worldwide. However, although the success rate is 90% in low-risk patients, it is only 30–50% in more complex, higher-risk cases, and overall, 30% of cases have a rejection episode. Moreover, regrafting has become the most common indication for corneal transplantation in the US and in some places in Europe. The more recently developed lamellar keratoplasty techniques are designed to overcome some of the problems of corneal transplantation by leaving as much of the healthy cornea in place as possible. For example, endothelial keratoplasty procedures replace only the endothelium but leave the patient's cornea's refraction as well as most of its biomechanical properties fairly intact. In this chapter, we will review the actual techniques for endothelial transplantation and

provide an update on the surgical strategy (mostly for Descemet membrane endothelial keratoplasty) and its clinical results and complications.

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Introduction

The adult human cornea averages 540 μm in thickness [1], with the following classical layers, from anterior to posterior: epithelium, epithelial basement membrane, Bowman's layer, stroma, Descemet membrane (DM), and endothelium (fig. 1).

The cornea remains in a state of deturgescence, maintained by the endothelial cell Na^+/K^+ ATPase and by tight junctions between endothelial cells that limit the entrance of fluid into the stroma. By maintaining an optimum level of corneal hydration, endothelial cells preserve the ordered arrangement of collagen fibers, which is crucial for corneal transparency [2]. When the endothelial cell density is low or the cells are malfunctioning, the associated loss of tight junctions between cells allows more fluid to enter the stroma. The endothelial cells that remain may present a higher concentration of the Na^+/K^+ ATPase in an effort to compensate for the loss [1].

The average human cornea has an endothelial cell density of 5,000–6,000 cells/ mm^2 at birth, decreasing to 2,500–3,000 cells/ mm^2 by adulthood. There is an average physiological cell loss of 0.6% per year [1]. Corneal edema appears at 700–400 cells/ mm^2 [1, 3]. Adult human corneal endothelial cells are arrested in the G phase of the cell cycle and do not undergo mitosis [4]. Therefore, lost cells cannot be replaced physiologically, although, as we will see throughout this chapter, significant research is focused on this subject.

Fuchs' endothelial corneal dystrophy (FECD) was initially described by Fuchs in 1910 as a combination of epithelial and stromal edema in older patients [5]. It manifests itself as bilateral, albeit asymmetric, central corneal guttae, corneal edema, and reduced vision [6, 7]. The DM thickens

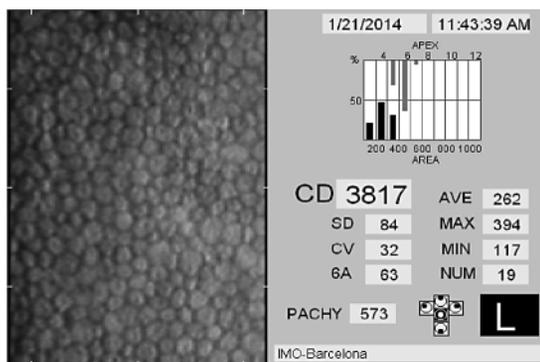


Fig. 1. Microscopy view of a young healthy endothelium.

and develops excrescences known histopathologically as guttae. Stromal edema develops, and the corneal thickness may increase to over 1,000 μm . When the edema is severe, the corneal epithelium can detach from its basement membrane, creating painful bullae on the anterior surface of the cornea [2, 8]. FECD is the most common endothelial dystrophy (the others have the same indications for surgery but, from the perspective of statistical incidence, are almost insignificant) and is usually seen beyond the fifth decade of life, although not all cases are in the elderly; Biswas et al. reported several families with early onset of this dystrophy in the third and fourth decades of life [9]. FECD is, despite its dominant inheritance form, more common and progressive in women [10]. It may also present in a sporadic form and is thought to be a primary disorder of the endothelium, although other hypotheses have been postulated, including some secondary options. The total number of endothelial cells is low, and existing cells may not function properly. The course of this dystrophy can be further accelerated after intraocular surgery, and most commonly cataract extraction. A cell count of less than 1,000 cells/ mm^2 and a corneal thickness greater than 640 μm have been classically considered major risk factors for corneal decompensation after cataract surgery [11–13].

Pseudophakic bullous keratopathy (PBK) is a term used to describe endothelial cell loss caused

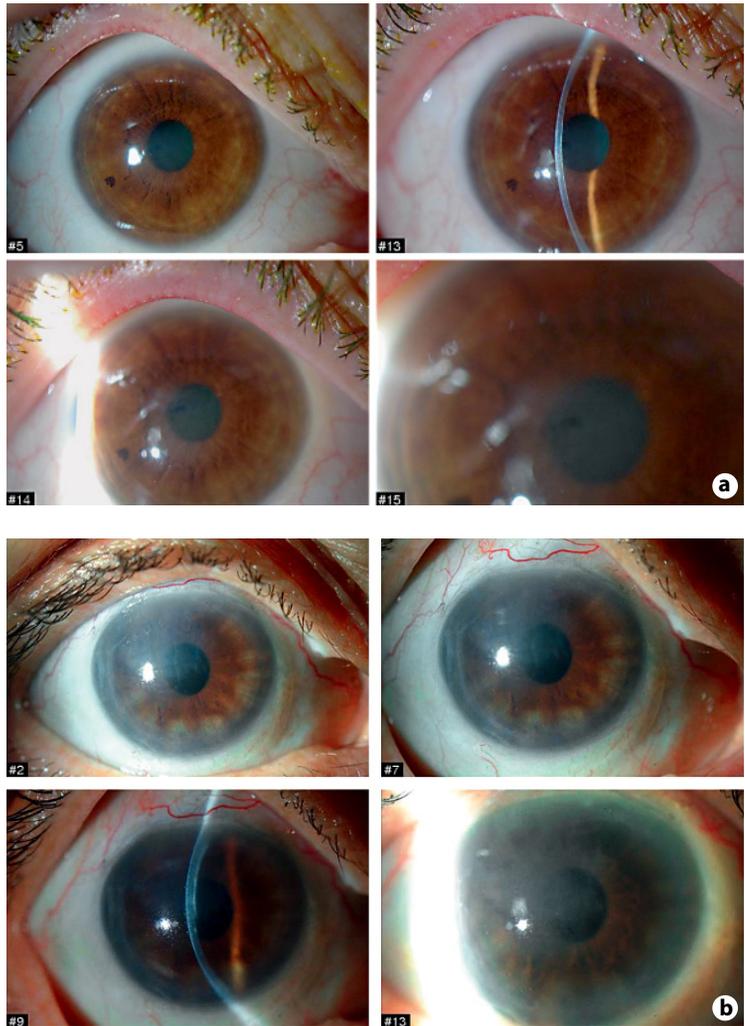


Fig. 2. a Slit-lamp images of an eye with stromal corneal edema and Fuchs' dystrophy and **b** an eye with pseudophakic non-Fuchs' irreversible corneal edema postoperatively.

by surgical manipulations in the anterior chamber (AC). If the corneal endothelium is damaged during surgery (as often occurs during cataract extraction, phakic intraocular lens implantation and other procedures) [3], the same spectrum of symptoms as found in FECD can develop, although the histological phenotype of both diseases is different and, usually, there is no guttata in PBK (fig. 2).

Toxic anterior segment syndrome is a rare complication of intraocular surgery that has only recently been recognized [14]. It is characterized by acute sterile inflammation in the anterior seg-

ment caused by noxious agents such as medications, residual viscoelastic agents, or preservatives or by an altered osmolarity or pH of the irrigating solution [15–17]. Permanent corneal endothelial damage can occur in severe cases of toxic anterior segment syndrome.

Full-thickness grafts (PK) have been the standard of care for treating medically uncontrollable endothelial disease for a significant number of years worldwide. Lamellar keratoplasty (LKP) techniques are continuing to gain wider acceptance, although there will likely remain a place for