

## Surgical techniques for corneal transplantation

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### ABSTRACT

The first successful corneal transplant was performed in 1905 by an Austrian ophthalmologist named Eduard Zirm. Penetrating keratoplasty has been the dominating procedure for almost 100 years, but in the past 15 years there has been rapid development of different surgical techniques. The aim of this paper is to provide an overview on the types of corneal transplantation commonly employed today.

**Keywords:** Transplantation, cornea, keratoplasty, lamellar, penetrating

### INTRODUCTION

Corneal blindness represents a major health challenge causing 3-4% of global blindness [1]. Corneal disease is the primary aetiology in 15% of cases of blindness in Africa, a higher proportion than in Europe or North America, and a significant number of these cases are found in children [2]. Although no recent nation-wide epidemiological studies exist, it is estimated that the prevalence of corneal blindness in Rwanda is the same as in others African countries [3].

A study from 2007 found that 12.5% of all blindness cases in Western Rwanda were due to corneal scarring. Trachoma, in this study counted as a separate identity from other reasons of corneal scarring, counted for 2.5% of the blindness cases. Combining both identities around 15% of all blindness cases were caused by corneal opacity [4].

The cornea is a transparent tissue that has an average central thickness of 550 µm and consists of 5 layers – the multilayered surface epithelium, Bowman layer, stroma, Descemet membrane and the mono-layered endothelium. The regular strati-

fication of the epithelium, the parallel orientation of the stromal lamellae and a sufficient number of healthy endothelial cells are essential for maintaining the transparency of the cornea (Figure 1). The human corneal endothelium is a non-regenerative tissue that is crucial for the fluid homeostasis of all corneal layers. Reduction in the number of functional endothelial cells below a certain threshold leads to corneal decompensation, bullous keratopathy and visual impairment that may be accompanied by pain.

### MOST COMMON CORNEAL TRANSPLANTATION TECHNIQUES

Pronounced corneal scarring or opacity requires corneal transplantation in order to restore vision. Under the umbrella term ‘corneal transplantation’ different surgical techniques are combined.

#### Penetrating keratoplasty

The transplantation of all layers of a clear donor cornea is called penetrating keratoplasty (PK). Indications for this procedure are, amongst others: stromal scarring; corneal ectasia; corneal ulcers and perforations (Figure 2).

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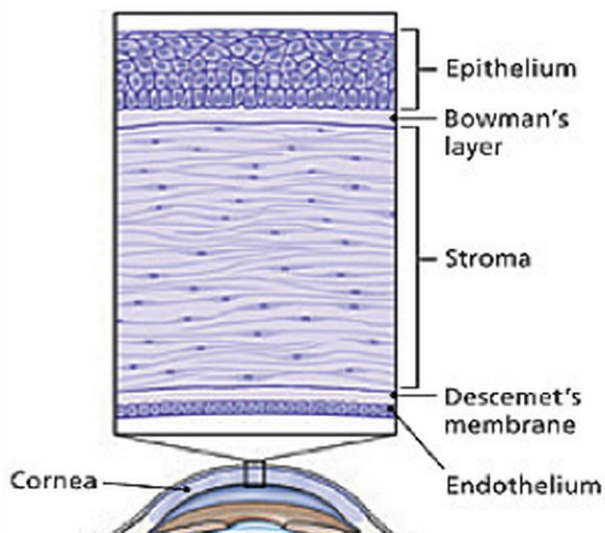
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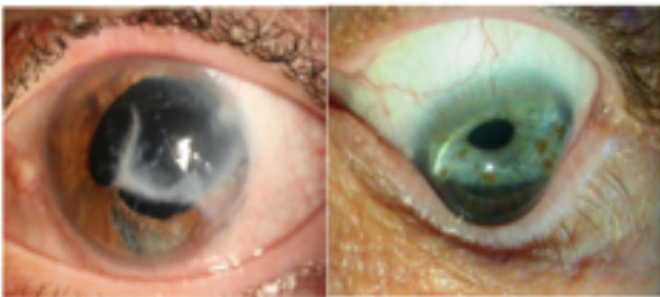
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**Figure 1: Histology of corneal layers**

Corneal scarring and keratoconus are especially prevalent in Rwanda. In PK, a full thickness trephination of the patient's cornea is performed and followed by a replacement of the diseased cornea with a full-thickness graft taken from a donor cornea. Interrupted or running sutures are placed radially (Figure 2)



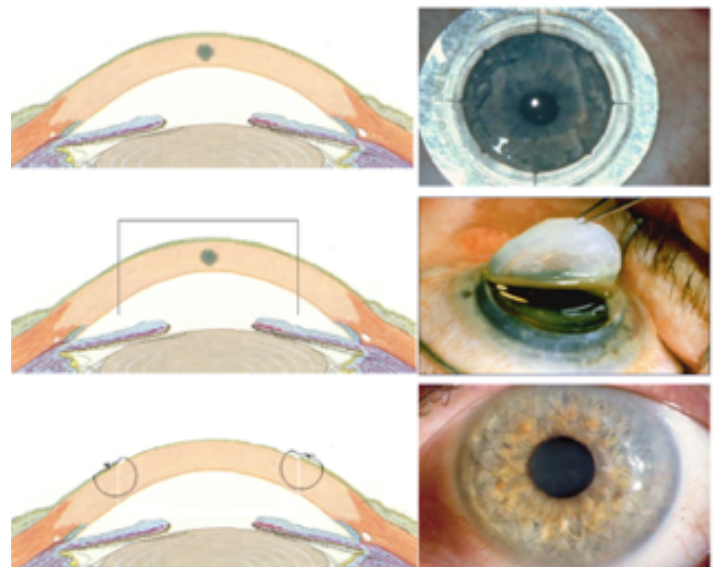
**Figure 2: Corneal scarring (left) and corneal ectasia (right)**

The operation is performed using the operating microscope, usually under general anesthesia to minimize the risk of expulsive hemorrhage. In most cases, non-resorbable nylon sutures (e.g. 10.0 nylon) are placed. Sutures have to be removed at a later date, usually after 1 year. PK is still the most commonly performed type of corneal transplantation worldwide (Figure 3).

### Lamellar techniques

Novel lamellar techniques have now been developed, which have replaced PK as the primary transplantation technique in several diseases [5]. Lamellar keratoplasty consists of a partial thickness corneal tissue replacement. These techniques have extended the indications for corneal tissue transplantation to earlier disease stages such as endothelial keratoplasty for Fuchs corneal dystrophy. Major reasons for this extension of indication are: They are less invasive procedures, lower rate of rejection and faster visual rehabilitation.

Lamellar techniques can be divided in anterior and posterior lamellar procedures.



**Figure 3: Penetrating keratoplasty**

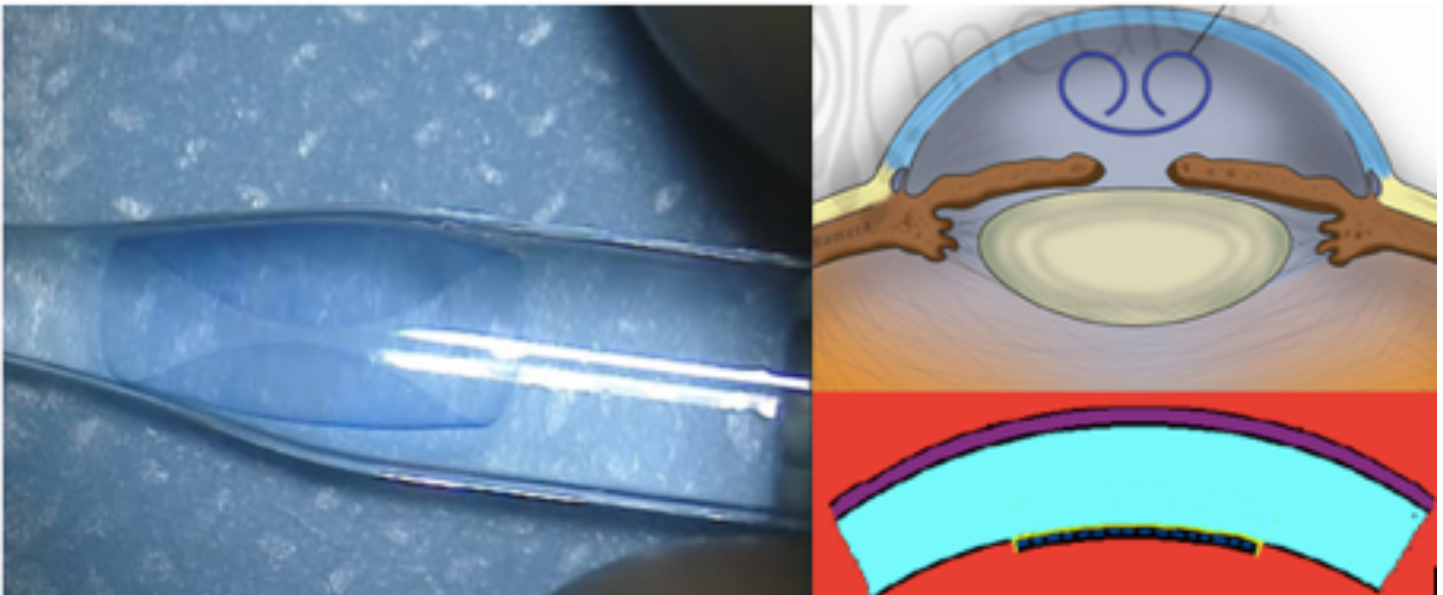
Sutures are placed in radial fashion to attach graft and host cornea together. **Left:** Schematic drawing of the essential steps of penetrating keratoplasty; **Right:** Intraoperative surgeon's view. (With courtesy from Prof. Sebastian Thaler und Regina Ebenhoch, University Eye Hospital Tübingen, Germany)

**Anterior lamellar keratoplasty (ALK)** can be deep or superficial. Superficial anterior lamellar keratoplasty (SALK) is a procedure where the dissection depth is less than one-third or 160  $\mu\text{m}$  of the cornea. In comparison in DALK more than one-third or 160  $\mu\text{m}$  of the cornea are dissected. Indications for SALK are post refractive surgery corneal opacity or anterior stromal corneal opacities after penetrating keratoplasty [6]. Advantages of this procedure are avoiding open-globe surgery and endothelial rejection associated with repeated PK [7]. As indications are limited this procedure is not commonly performed.

The most frequently performed ALK is deep anterior lamellar keratoplasty (DALK). With this procedure, the patients' Descemet membrane and endothelium are retained. Sutures, interrupted or running, need to be placed during transplantation like in PK. Indications for this procedure are ectasias such as keratoconus or corneal scars with intact Descemet membrane and endothelium.

However, 3 months-results regarding uncorrected and best corrected visual acuity, graft survival and keratometric outcomes following DALK for the indication of keratoconus, seem not to be better than PK [8]. Therefore up to today there is no sufficient evidence to prefer DALK over PK.

**Posterior lamellar procedures** are Descemet membrane endothelial keratoplasty (DMEK) and Descemet stripping automated endothelial keratoplasty (DSAEK). DMEK was introduced in 2006 by Gerrit Melles [9]. Since then it has become the standard procedure for endothelial diseases like Fuchs endothelial dystrophy or pseudophakic endothelial decompensation. Furthermore, it can be performed in eyes with endothelial decompensation after PK [10]. In DMEK (Descemet membrane endothelial keratoplasty) the Descemet membrane and endothelium are removed from the pa-



**Figure 4: Descemet membrane endothelial keratoplasty (DMEK)**

**Left:** Descemet membrane stained with trypan blue to enhance visibility during implantation. **Top right:** Situation immediately after injection of the transplant. **Bottom Right:** Schematic drawing of postoperative findings after successful DMEK with the transplanted Descemet membrane and endothelium in place. (With courtesy from Prof. Sebastian Thaler und Regina Ebenhoch, University Eye Hospital Tübingen, Germany)

tient's eye and replaced by a graft (Figure 4). Advantages are lower transplant rejection rates, faster visual recovery, and less iatrogenic astigmatism, as it is a suture-less procedure.

DSAEK is performed by a selective removal of the patient's Descemet membrane and endothelium, followed by the transplantation of a donor corneal endothelium and stroma. Thickness of the transplanted tissue is between 70-120 microns. In comparison a DMEK transplant is only 5-10 microns thick as it lacks the stromal part of the DSAEK. Indications for DSAEK are the same as for DMEK. Recent studies show that visual outcome after DMEK is better than following DSAEK, therefore DMEK is the preferred procedure [11,12].

## CONCLUSION

Penetrating keratoplasty is the most commonly performed corneal transplantation worldwide. Newer techniques especially the Descemet membrane endothelial keratoplasty (DMEK) have superseded PK for specific indications and extended its indications to earlier stages of the diseases.

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