KERATOPROSTHESIS

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Introduction

The basic idea of using an artificial cornea or performing keratoprosthesis to replace a damaged and opaque cornea is derived from the practice of placing a window in a house to be able to see out. This idea first occurred to the French doctor Guillaume Pellier de Quengsy, who published the feat in the times of the French Revolution (18th century) [1-3].

Keratoprosthesis is a surgical procedure where a diseased cornea is replaced with an artificial cornea. Traditionally, keratoprosthesis is recommended after a person has had a failure of one or more donor corneal transplants. While conventional cornea transplant uses donor tissue for transplant, an artificial cornea is used in the Keratoprosthesis procedure. The surgery is performed to restore vision in patients suffering from severely damaged cornea due to congenital birth defects, infections, injuries and burns.

Keratoprotheses are made of clear plastic with excellent tissue tolerance and optical properties. They vary in design, size and even the implantation techniques may differ across different treatment centers. The procedure is done by Ophthalmologists, often on an outpatient basis.

During the 19th century, there were scattered surgeons who attempted to follow on Quengsy's footsteps, but with equally disastrous outcomes (endophthalmitis, extrusion, and loss of the eye). Thus, it was not until the 1950's with the introduction of new materials, such as transparent non-toxic plastics, that some measure of success began to be reported[4-7]. The good results of these new designs are also attributed to the discovery of antibiotics and steroids, which have significantly improved the postoperative management.

Prosthetic corneas form the last resort for corneal blindness, especially in eyes with end-stage ocular surface disorders and in those at a high risk for conventional penetrating keratoplasty[8,9]The choice of keratoprosthesis (Kpro) depends on the underlying etiology, the anatomy of the ocular surface and the tear film status.

Types/Designs of Keratoprosthesis

Broadly speaking, keratoprostheses are categorized into the Type 1 and 2 Kpros based on the type of eye they cater to. Largely, eyes with normal lids, blink and tear meniscus without an underlying immunological etiology are considered as candidates for the Type 1 Kpro, the prototype of which is the Boston Type 1 Kpro. However, in eyes with severely dry or keratinized ocular surface with an underlying immunological disorder, associated with lid abnormalities, Type 2 Kpros are considered to be the surgical choice.

The design of a Kpro can be likened to some extent to that of an intraocular lens consisting of an optic and a haptic. The optic, which forms the central part of the Kpro responsible for viewing, in most types is a cylinder made of polymethyl methacrylate (PMMA) – creating an optically clear window. It is the haptic of the Kpro which determines the type of the prosthesis. It could be classified as:

- Biocompatible – usually a PMMA skirt with the corneal graft as in the Boston Type 1 and 2 Kpro.
- Biointegrated – as in the Dacron mesh that forms the skirt around the PMMA optic in the Pintucci Kpro.
- Biological – tooth or the bone that forms an autologous biological tissue that supports the optical cylinder in the osteoodonto and the osteo-Kpro, respectively.

The supporting cover tissue adds to the Kpro complex which is the bandage contact lens in the Type 1 Kpro that prevents the carrier graft desiccation. In Type 2 Kpros, the supporting cover is the skin in the Boston Type 2 and the buccal mucosa for the osteo and the osteo-odonto and Pintucci Kpros, respectively.

Indications

Kpros are performed for bilateral corneal blindness not amenable to conventional penetrating keratoplasty.

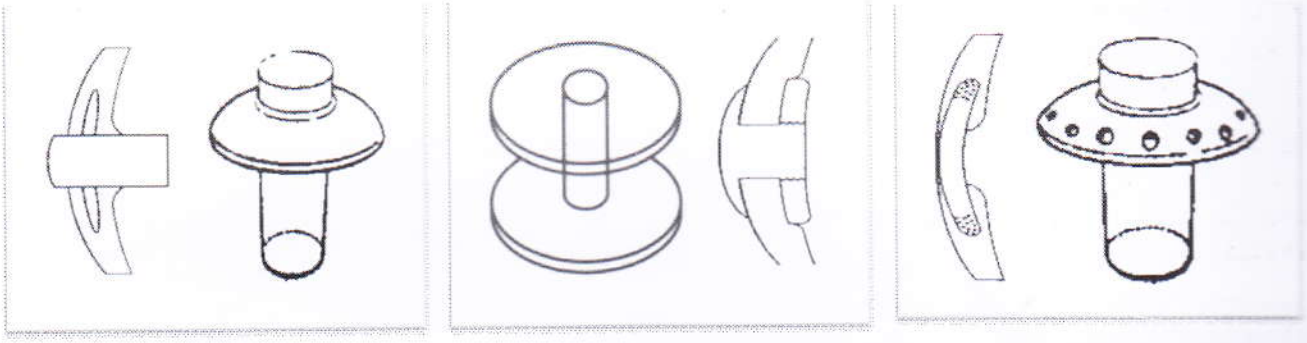
- Stevens – Johnson Syndrome
- Ocular Cicatricial Pemphigoid (Stages 3 & 4)
- Chemical Injury
- Trachoma (Stage C0 according to WHO)
- Vascularized corneas with complete stem cell loss and dryness.
- Multiple failed penetrating Keratoplasty/ Amniotic membrane or stem cell grafting.

Keratoprosthesis designs have primarily been variations of 3 main types.

First Type- PMMA stem with skirt embedded within the cornea.

Second Type- Transparent membrane with porous edges inserted into the cornea.

Third Type- PMMA 'collar button' with cornea between the plates



Boston Keratoprosthesis

The Boston Type I Keratoprosthesis is currently the most commonly used keratoprosthesis device in the US. It consists of a clear plastic polymethylmethacrylate (PMMA) optic and back plate sandwiched around a corneal graft and secured with a titanium locking ring. After the device is assembled, a partial-thickness trephination is performed on the host cornea. Full-thickness resection of the patient's cornea is then completed using curved corneal scissors. The keratoprosthesis is then secured to host tissue using interrupted or running sutures.

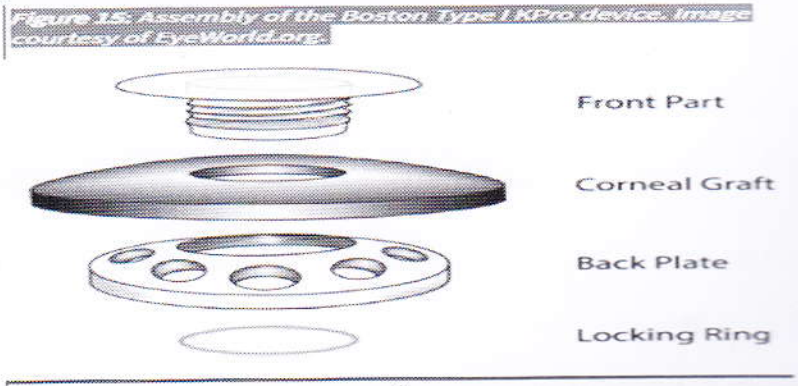
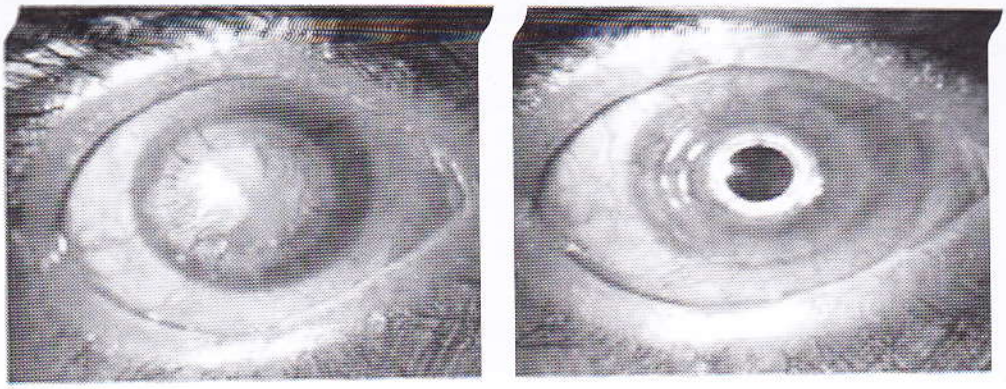


Figure 15: Assembly of the Boston type I KPro device. Image courtesy of Eyeworld.org.



Osteo-odonto Keratoprosthesis

The use of osteo-dental tissue for Keratoprosthesis was first described by Strampelli in the early 1960[10]. There is long term retention of the implant. The surgery is multi-staged and requires cross speciality experience consisting of:-

Stage I

- Preparation of globe with buccal mucous membrane graft
- Preparation of Osteoodonto acrylic lamina (OOAL)

A monocuspidate tooth is removed along with the adjacent maxillary bone and a thin section is cut from the tooth. An optical cylinder made up of PMMA is inserted through a hole made in the section. A pocket is created in the lower eyelid into which the entire prosthesis is inserted and left for 3 months. During this time soft tissue grafts to the bone to which the tooth is attached.

Stage II

Implantation of OOAL- Part of the oral mucosa is stripped off the cornea and sclera to make space for the final implantation of prosthesis. The prosthesis is detached from the eyelid pocket and implanted, with the optical cylinder protruding through a hole in the mucosa.

Chirila (AlphaCor) Prosthesis

It is the newest keratoprosthetic device. It was FDA-approved in August 2002 for patients at high risk for donor penetrating keratoplasty (PKP).

Design

The implant is a 7-mm diameter, one-piece, non-rigid synthetic cornea. It is composed of an outer skirt, that is an opaque, porous, high- water PHEMA (poly[2-hydroxyethyl methacrylate]), with a transparent central optic core of gel PHEMA.

Surgical Procedure

In Stage I, an intrastromal trephine is used to remove the central posterior corneal lamellae for insertion of the device. A corneal incision is made and dissection instruments are used to continue the corneal dissection throughout the circumference of the corneal graft, thereby creating an intralamellar pocket. An AlphaCor sizer, used to test the size and centration, is inserted into the intralamellar pocket followed by removal of the posterior disc via a 3.5 mm intrastromal trephine. After insertion of the device and closure of the limbal incision, the surface is often covered with a Gundersen conjunctival flap. If the Gundersen flap is inadequate

to cover the cornea an amniotic membrane graft may be required. In Stage II performed approximately 2 months after Stage I, the overlying conjunctiva created by the Gundersen flap is removed and trephination of the central 4 mm of the conjunctival flap and anterior corneal lamellae is done.

Pintucci Keratoprosthesis

The Pintucci KP can be implanted in thinned or perforated corneas, in corneas with stromal melting, and in eyes that have undergone several procedures including penetrating keratoplasty, other KP implantations, and glaucoma, cataract and vitreoretinal surgery.

Design

The supporting element of the Pintucci KP is made of a biointegrated Dacron fabric skirt that allows three-dimensional colonization by newly formed vascularized connective tissue. This fabric is soft and pliable, can be easily cut into the desired shape and sutured, and is chemically inert and not subject to resorption. The Dacron fabric support is fixed to the PMMA optical cylinder with a specific reliable method (international patent pending).

Keratoprosthesis still carries a somewhat greater burden post- operatively than standard keratoplasty. Successful outcome requires patient compliance, more frequent follow-up and more demands on physician time. However, in cases where further Keratoplasty appears futile, keratoprosthesis can be most rewarding.

Complications

Though the rate of success with Keratoprosthesis is high, in rare cases, certain serious complications could occur.

- Necrosis of tissue around the Keratoprosthesis (which if unchecked can lead to leak, infection, extrusion).
- Postoperative Uveitis –can lead to the following:
  - Retroprosthetic Membrane
  - Vitreous Opacities
  - Retinal Detachment
  - Macular Oedema
  - Epiretinal Membrane etc.
- Glaucoma – especially in Stevens Johnson Syndrome, pemphigoid, chemical burns.
- Infection – Endophthalmitis –now rare.

Glaucoma and extrusion of the implant are serious complications that could occur.

Sudden vitritis can cause a drastic reduction in vision. However, it is possible to treat this condition through antibiotics or by a minor laser surgery.

What next?

Keratoprosthesis is continuously evolving with newer generation materials that seek to improve treatment outcomes. The advances documented herein are only a small sample of the boiling point which the field of keratoprotheses has recently reached at. Current research is aimed at improving, on the one hand, the

anatomical results by using more biocompatible materials that provide better integration with the host tissue, and on the other hand, at providing optimal long-term and sustained visual acuity to our patients. However, post-operative complications remain the biggest challenge (mainly glaucoma, infection, and extrusion). Future designs will have to incorporate the use of newer materials that provide excellent optical properties, while at the same time become biointegrated with the ocular tissue. In short, the perfect keratoprothesis is yet to be discovered, although every day the goal gets closer and closer.

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