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### RESEARCH ARTICLE

#### OSTEO-ODONTO-KERATOPROSTHESIS-A GROUNDBREAKING PROSTHESIS

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#### Abstract

Corneal Blindness is a leading cause of blindness globally. Various conditions like Stevens–Johnson’s syndrome, severe chemical burns, cicatricial pemphigoid, end-stage trachoma, multiple failed grafts and graft versus host disease lead to end stage corneal disease. Advanced corneal disease leads to blindness. When traditional treatment modes fail, it occurs, a keratoprosthesis named osteo odonto keratoprosthesis developed by Strampelli in Italy is a life-changing prosthesis. This technique comprises of biological components like tooth–bone complex which is used as a skirt to mount an optical cylinder and the buccal mucous membrane is used to cover it. Osteo-odonto-keratoprosthesis surgery comprises of 2 stages. In stage 1, the defective eye is prepared and buccal mucosa is sutured over the sclera. The osteo-odonto lamina is prepared to support an optical cylinder and placed under the contralateral eye. After 24 months, in stage 2, the lamina is retrieved and implanted in the defective eye and the buccal mucosal graft is reflected back and sutured. This surgery requires a multidisciplinary approach of ophthalmologists, dentists, radiologists. This review paper highlights the background, history, indications, contraindications, pre operative patient assessment, surgical procedure, post operative care with follow up, prosthetic rehabilitation, complications.

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#### Introduction:-

The worldwide prevalence of blindness as recorded in 2020 was 0.62% of the global population that is around 43.3 million people. Corneal disease is one of the leading common cause of blindness affecting around 8 million

population worldwide.<sup>2</sup> Different eye disorders alter the transparency of the cornea, leading to corneal scarring and blindness. In the most severe cases, the scarring is accompanied by extreme dryness and keratinization of the ocular surface.<sup>3</sup> Conditions like Stevens–Johnson’s syndrome, severe chemical burns, cicatricial pemphigoid, end-stage trachoma, multiple failed grafts and graft-versus-host disease lead to advanced end-stage corneal disease. Corneal grafts, corneal transplantation, other forms of ocular surface reconstruction surgery are the modes of treatments for damaged cornea. In severe compromised cases when these treatment modes prove to be a doomed failure comes the role of keratoprosthesis. Amongst the keratoprosthesis, the osteo-odonto-keratoprosthesis (OOKP) is a groundbreaking prosthesis. The osteo-odonto-keratoprosthesis is a keratoprosthesis technique in which an autologous tooth–bone complex is used to mount an optical cylinder, as an artificial cornea, stabilized by an overlying autologous buccal mucosal graft.<sup>4</sup>

### Background And History

History of keratoprosthesis dates back more than 200 years when a French ophthalmologist, Pellier de Quengsy proposed implanting a glass plate into an opaque cornea. In 1855 Nussbaum performed the first surgical case in a human with a quartz crystal implant. Different keratoprotheses (KPros) and techniques (von Hippel 1877, Dimmer 1889, and Salzer 1895) were developed over the next half-century.<sup>5</sup> In 1963 the osteo-odonto-keratoprosthesis (OOKP), was first developed in Italy by Strampelli and later modified by Falcinell. Strampelli had noted that gutta-percha will remain in root canal of the tooth indefinitely but will be rejected if it is implanted into the soft tissues. Hence, it is most likely that if an optical cylinder is implanted in the tooth-bone complex and then placed in a corneal envelope, the whole complex will form an autograft and prevent the extrusion of the optical cylinder.<sup>3,6</sup>

### Indications

Bilateral blindness from severe, end-stage corneal and ocular surface diseases, such as severe dry eye conditions, and eyes with intact retinal and optic nerve function whose conjunctival and lid abnormalities are incompatible with standard corneal grafting or ocular surface transplantation procedures.<sup>7</sup> Common conditions include-

1. Severe end-stage Stevens–Johnson syndrome
2. Mucous membrane pemphigoid
3. Chemical injury
4. Thermal injury
5. Trachoma

### Contraindications

The following are the contraindications<sup>7</sup>-

1. Age under 18 years
2. Eyes having no perception to light
3. Pthisis bulbi
4. Persons having advanced glaucoma
5. Retinal detachment cases
6. Psychologically unstable patients

### Pre-Operative Patient Assessment

Proper pre-operative assessment is very essential before undergoing the surgical procedures. These include<sup>8</sup>-

1. **Ophthalmological investigations**-VA (intact light perception), digital estimation of Intraocular pressure are necessary.
2. **Intraoral assessment**- Proper clinical evaluation of the tooth and buccal mucosa health is very essential.
3. **Radiological Investigations**- Ultrasonography (A-scan and B-scan) for eye, Orthopantomography IOPA Xray
4. **Psychological Assessment**- Patient needed to be mentally stable as this procedure needs multiple surgeries and life-long follow-ups.

### Surgical Procedure

The OOKP surgical procedure consists of 2 stages. These are:

**Stage 1**- A single-rooted tooth usually a healthy canine is osteotomized (Figure-1) with attached periosteum and osteo-odonto lamina is prepared. In order to expose the pulp chamber to the axial middle of the root, the other side of the tooth is hemishaved and the bone is smoothed parallel to the tooth's mid-sagittal plane using a diamond disk (Figure-2). This process is accompanied by constant saline irrigation. Then complete removal of the pulp is done.

A hole is drilled perpendicular in the centre of the lamina.<sup>4</sup> An optical cylinder (Figure-3) of appropriate power (based on A-scan biometry) is cemented into the osteo-odonto lamina.<sup>8</sup> The entire keratoprosthesis measures around 12 mm x 6 mm x 3 mm, which is having an optical cylinder with a minimum 1 mm dentine margin around. The optical cylinder is available in two different diameters (3.5 and 4.0 mm) and standard 8.75 mm length. The entire keratoprosthesis is implanted in the submuscular pouch below the contralateral eye so that a fibrovascular coating can form over the lamina.<sup>4</sup>

A 3 cm-diameter full-thickness buccal mucosal graft is harvested below the parotid duct avoiding the parotid duct orifice (Figure-4). Excess fat and muscle are removed from the graft. Before the mucosal graft is sutured over the corneal and scleral surfaces of the eye, it is soaked in an antibiotic solution, such as cefuroxime.<sup>4</sup> On the suggested eye, a 360-degree limbal peritonectomy is performed. In order to remove the epithelium and scar tissues over the cornea, superficial keratectomy is done. Bridle sutures are used to isolate the rectus muscles. The buccal mucosal graft is transferred and sutured over the sclera (Figure-5) bounded by the insertion sites of rectus muscles.<sup>8,9</sup>



**Figure 1:-** Raising of the flap and the osteotomized tooth is removed.  
(Courtesy- Tay et Al)



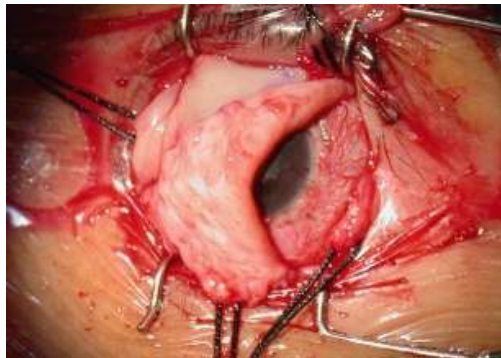
**Figure 2:-** Use of a diamond disk to smoothen the bone parallel to the mid-sagittal plane (Courtesy-Tay et Al)



**Figure3:-** Optical cylinder and drilled hole in the osteo-odonto lamina  
(Courtesy- Tay et Al)



**Figure4:-** Harvesting of a buccal mucosal graft  
(Courtesy- Tay et Al)

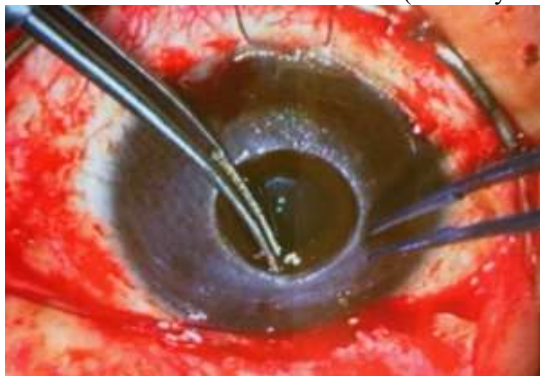


**Figure 5:-** The buccal mucosal graft is transferred and sutured over the sclera.  
(Courtesy- Tay et Al)

**Stage 2-** The stage 2 surgery is undergone 2-4 months after the stage 1. The lamina is retrieved (Figure-6) and is kept in heparinized venous blood of the patient till the time of implantation.<sup>8</sup> The fibrovascular capsule is examined and trimmed away from the anterior and posterior surfaces of the optical cylinder. The buccal mucosal graft is reflected superiorly, eye to be restored is prepared (Figure-7). The cornea is exposed. Corneal trephination of 5mm in diameter is done to create a central opening in the eye.<sup>4</sup> Cryoextraction of the lens is done, iris is removed from its root, a core vitrectomy is carried out. The lamina is then positioned into the corneal opening. The lamina is anchored tightly with vicryl sutures to the globe and to reform the globe air is injected. The optical cylinder's centering is verified by intraoperative indirect ophthalmoscopy.<sup>8</sup> The BM graft is reflected back and sutured. A trephination (Figure-8) of 3mm in diameter is done over the centre of the graft so that the anterior portion of the optical cylinder can protrude. This allows clear visual axis and light to be transmitted and focussed on retina for clear vision (Figure-8,9)<sup>4</sup>



**Figure6:-** Retrieval of the osteo-odonto lamina (Courtesy- Tay et Al).



**Figure 7:-** Preparation of the eye which is to be restored (Courtesy- Tay et Al).



**Figure8:-** A trephination is done over the centre of the graft so that the anterior portion of the optical cylinder can protrude (Courtesy- Tay et Al).



**Figure9:-**Completed OOKP in a patient with ocular blindness(Courtesy- Tay et Al).

#### **Post Operative Care And Follow Up Visits**

Analgesics, antibiotics, prednisolone 20 mg and lansoprazole 30 mg are prescribed for 5 days post-operatively. Following stage 1, glass rodding is done to keep the fornices open. Different mouthwashes like chlorhexidine, nystatin are used. After stage 2, diamox, steroids and antibiotics are prescribed. Buccal mucous membrane is monitored and the optical cylinder is cleaned using a fresh sliced lemon's juice on a sterile cotton-tipped applicator.<sup>5,8</sup> Lifelong follow-up is required. During follow-ups vision is checked, digital estimation of intraocular pressure, assessment of the buccal mucous membrane, examination of the optical cylinder, assessment of resorption of the bone is done.<sup>5</sup>

### **Prosthetic Rehabilitation**

Patients are then referred to a prosthodontist for replacement of the missing tooth along with adjacent tissues. The esthetically correct treatment of a localized alveolar ridge defect is a common prosthetic challenge. Andrew's bridge is the best option available. It combines advantages of removable and fixed prosthesis. Other options include ridge augmentation followed by fixed prosthesis or implant retained prosthesis.

### **Complications**

Oromaxillary fistula formation and damage to the adjacent teeth during preparation of the osteo-odontolamina may occur. If inadvertent perforation of the cornea occurs then a full-thickness graft may be required. Resorption of the lamina, bone infection if occurs implanted keratoprosthesis should be explanted and treated prior to continuation of the procedure. Intravitreal haemorrhage from the iris, expulsive suprachoroidal hemorrhage which is devastating and rare may occur. Early postoperative complications include choroidal detachment, decentration of the optical cylinder. Late postoperative complications include buccal membrane overgrowth or melting, endophthalmitis, glaucoma, and retinal detachment.<sup>7</sup>

### **Discussion:-**

This innovative prosthesis osteo-odonto-keratoprosthesis remains the keratoprosthesis of choice for end-stage corneal blindness.

The optical cylinder transmits light onto the fovea of the retina in the central axis of the eyeball. The autogenous hard tissue skirting keeps the optical cylinder steady in the eye. Various keratoprosthesis surgeries have utilized to support the optical cylinder. e.g., PMMA (Cardon keratoprosthesis), polytetrafluoroethylene (Legeais keratoprosthesis), aluminium oxide ceramic (Polack keratoprosthesis), Dacron (Pintucci keratoprosthesis). The extrusion rates of these keratoprostheses are significantly higher than those of OOKP, ranging from 10% (Pintucci) to 21% (Cardona).<sup>10,11</sup> It is seen that the stability and longevity of the osteo-odontolamina in osteo-odonto-keratoprosthesis surgery is much better than other keratoprosthesis.

Bioceramics can also be used for supporting the optical cylinder. But at pH 6.5–5.0, associated with infectious and inflamed tissues, bioceramics degrade more rapidly as compared to tooth and bone.<sup>12</sup>

Tan A et al conducted a systemic review upon surgical outcomes and found that the anatomical survival rate in all the studies was 87.8% (range 67–100%) at 5 years. Visual acuity was more than 6/18 in 52% (range 46–72%) in this surgery.<sup>7</sup>

R Michael et al in 2008 conducted a study to assess the long-term anatomical and functional survival rates between osteo-odonto-keratoprosthesis and osteokeratoprosthesis. Based on Kaplan-Meier analyses, 10-year anatomical survival was 66% for OOKP and 47% for OKP. and 10-year functional survival was 38% for OOKP and 17% for OKP.<sup>13</sup>

Iyer et al., [20] reported a 96% anatomical success of OOKP laminae in 50 cases with a mean follow-up of 15.38 months (range: 1–54 months).<sup>14</sup>

Among all the available biological and synthetic keratoprostheses, the OOKP have a higher success rate.

### **Conclusion:-**

This innovative Osteo Odonto Keratoprosthesis success is attributed to the biological constitution of its components. It provides the best long term anatomical and visual outcomes even in the most challenging cases of ocular surface disease, ultimately increasing the quality of the life.



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None.

**Conflict of Interest**

None.

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