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REVIEW ARTICLE

MODIFIED OSTEO-ODONTO-KERATOPROSTHESIS": A NOVEL DENTAL AND OPHTHALMIC AMALGAMATION

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Abstract

The modified osteo-odonto-keratoprosthesis (MOOKP) is a biologic keratoprosthesis aimed to treat patients with corneal blindness caused by end-stage ocular surface diseases. MOOKP, also well known as- 'Tooth-in-eye surgery', has proven to be the most effective therapeutic modality based on the number of patients who have undergone the procedure and the duration of documented follow-up. The original technique was described by Benedetto Strampelli and Prof.Giancarlo. Falcinelli has refined and improved this procedure, in a step wise manner. The procedure involves multiple stages, including the transplantation of buccal mucosa to the damaged ocular surface and the implantation of an osteo-odonto lamina with a mounted polymethylmethacrylate lens. Upon successful biointegration of the osteo-odonto lamina, the keratoprosthesis is able to resist resorption, provide stability, and prevent bacterial invasion and epithelial ingrowth. MOOKP surgery demands multidisciplinary team approach involving dentists and ophthalmologists. Possible complications of this procedure include ulceration of the implant buccal mucosa, ocular infection and secondary glaucoma. Nevertheless it has to be admitted that MOOKP surgery is extremely technique- sensitive and time consuming but however the results will be very satisfying and the patient may regain a quality of life that makes every effort for follow-up and treatment of unavoidable complications well worthwhile. This review article highlights the Modified Osteo-Odonto-Keratoprosthesis (MOOKP) indications, surgical Techniques, advantages and associated limitations

Introduction:-

Corneal opacification is the second most common cause in the world for blindness affecting an estimated 10 million people, in which corneal blindness is far more prevalent, as a result of ocular surface disease leading to corneal neo-vascularisation and scarring[1]. A damaged cornea can be the result of severe chemical burns, trachoma, ocular cicatricial pemphigoids, Steven-Johnson Syndrome, or several corneal graft failures. Corneal transplantation is not feasible in these cases since the dry surface is not conducive to the healing and nourishment of the transplanted biological tissue, unlike in a normal eye and an artificial cornea or keratoprosthesis is used to restore the vision.

HISTORY:-

The concept of placement of an artificial cornea dates back to1789 during the French Revolution when first keratoprosthesis was described by Guillaume Pellier de Quengsy.[2] In recent times, multiple synthetic corneas have been pioneered and among them, three types are most sought after in clinical practice- The Boston

Keratoprosthesis (Massachusetts Eye & Ear Infirmary, Boston, MA), The AlphaCor (Addition Technology Inc., Des Plaines, IL) [3] and the osteo-odonto-keratoprosthesis (OOKP) which was originally described by Benedetto Strampelli and later on modified in a stepwise fashion by Falcinelli G . The modified osteo-odontokeratoprosthesis (MOOKP) is used in many countries, including Italy, the United Kingdom, Austria, Germany, Singapore, and Japan.[4,5]

Ideal keratoprosthesis:-

The ideal Kerato-Prosthesis (KPro) device should be able to replace and surpass the natural cornea with an improved optical quality, decreased aberrations and a specifiable power. It should possess excellent bio-integration, provide resistance against infection and long-lasting. It should also mimic some of the inherent qualities of the cornea such as drug penetration and feasibility of intraocular pressure measurement.[6,7]

KPros with biological skirts were developed with a motive to resemble the corneal tissues with improved bio-intergration and Bio-compatibility properties, such as the Strampelli OOKP using autologous tooth root and alveolar bone as a supportfor a PMMA (polymethyl methacrylate) optical cylinder, cartilage (Casey) and tibial bone (Temprano)[8]

The Modified Osteo- Odonto -Keratoprosthesis (MOOKP) also known as **'Tooth In Eye Surgery'** is combination of a synthetic optic with a biological haptic where the cornea is replaced by a polymethyl methacrylate (PMMA) optical cylinder glued to a biological support (haptic) made by human living tissue[9]. The rationale behind MOOKP is the use of an autologous single rooted tooth with the surrounding alveolar bone fashioned as a plate for carrying the PMMA optical cylinder. The cylinder is cemented to the dentine. The dentine is coupled to the alveolar bone by the dento-alveolar ligament thus simulating the oral environment.[5] (Fig-1)

Indications for mookp:-

Bilateral corneal blindness in severe cases of:

1. Stevens-Johnson syndrome
2. Lyell syndrome
3. Trachomatous chronic conjunctivitis
4. Erythema multiforme
5. Vascular corneal surgeries
6. severe Pemphigoid
7. Physical injuries
8. Chemical injuries
9. Epidermolysisbullosaacquisita
10. Loss of the lids (eg: Crouzon disease)
11. Aniridia with severe corneal changes
12. Multiple failed penetrating keratoplasty
13. Corneal failure after vitrectomy with silicone oil filling that cannot be removed safely.

Contraindications:

Absolute:

- ✓ patients with repeated graft rejections
- ✓ children under the age of 17 [10]
- ✓ eyes that have no perception of light
- ✓ evidence of phthisis
- ✓ advanced glaucoma
- ✓ irreparable retinal detachment [13]

Relative:

- ✓ Patients content with their level of vision[8]
- ✓ Mentally unstable patients
- ✓ Patients with habits like smoking ,betel nut chewing etc
- ✓ Defective light perception[10]

Psychological assessment prior to MOOKP surgery:-
As is the case for any surgical procedure, the potential patient must appreciate the risks involved and have a realistic appreciation of the potential benefits. Candidates for MOOKP surgery must also understand that the formation of an osteo-odonto-keratoprosthesis involves multiple operations, usually over a period of months and sometimes years involving multiple hospital admissions and follow-up visits. The patient must also appreciate the significant financial, time and emotional stresses that will be encountered.[8]

Pre-operative ophthalmological assessment:-

VA (intact light perception)- Essential
Entoptic phenomena- Not mandatory
Electrodiagnosis (eg, positive flash-VEP) -Not mandatory
Ultrasonography (no pathologic findings)- Essential
A-scan biometry- Essential
Digital estimation of intraocular pressure -Essential
Examination for dry eye- Not mandatory

Pre-operative oral assessment:-

Orthopantomography - Essential
X-ray of tooth- Essential
Spiral CT- Not mandatory

Oral mucosal assessment:-
The condition of the buccal and labial mucous membrane should be evaluated. The oral mucosa may be damaged due to muco-cutaneous diseases in patients indicated for MOOKP and severe scarring of the oral mucosa may compromise the successful harvest. Smokers should be advised to stop smoking to improve the graft revascularization[8]. Oral hygiene regimen is mandatory to diminish the risk of infection. Chlorhexidine or nystatin mouthwash should be advised two days prior to the surgery.[10]

Dental Assessment:-
The assessment aims to select a healthy tooth (root) with the best shape and size with adequate encasement of alveolar bone for harvesting along with the fashioning a "lamina".The ideal tooth in size and shape with the best surrounding bone is usually the canine (upper/lower). All other things being equal, the choice of upper or lower canine depends on the proximity of the maxillary sinus in the upper and, although rarely a problem with the proximity of the mental foramen in the lower. Other single-rooted teeth can be used in the absence of a canine. The assessment of suitability of the tooth depends on clinical and radiological assessment

The surrounding anatomy is assessed to avoid possible complications and to reduce the aesthetic compromise to a minimum. During the harvesting of the tooth, adequate space between the adjacent teeth should be maintained to prevent any damage. The periodontal bone loss must be assessed. Clinical assessment of bone loss can be useful but radiographs are essential.

Surgical technique:-
The MOOKP procedure involves 2 stages performed over a period of 6-9 months.

Stage 1:
It involves ocular surface reconstruction and fashioning of an osteo-odonto lamina and its optical cylinder.

In the first stage, a canine tooth is harvested from the selected quadrant of the patient's oral cavity after the radiographic assessment to determine that the tooth has a healthy and viable root structure. A surgical motorized saw is used to excise the canine root encased in alveolar bone from the jaw (Fig-2). The lamina is fashioned by sawing through the root of the tooth in a longitudinal fashion to expose the dentine and the root canal (Fig-3)[10]. The pulp in the root canal is scraped off and a hole is drilled in the widest part of the root – to a size of 3 to 4 mm depending on the width of the root at that point. An appropriately sized plastic cylinder of suitable power (determined from the axial length of the eye) is then glued to the hole using dental cement. A subcutaneous pouch is created in the tissues of the cheek and the lamina-cylinder complex is placed in it and the pocket is sutured closed after instilling

antibiotic powder.[14] The implant has to be inserted into a subcutaneous pouch for about 3 months to enhance revascularization of the implant, to promote growth of connective tissue and remaining periosteum.

PMMA Cylinder:-
A PMMA optical cylinder is cemented in the root with PMMA cement and the pulp chamber is obliterated with PMMA cement as well[15]. The completed keratoprosthesis consists of one sagittal half of the canine root with bone, ideally measuring 12 mm × 6 mm× 3 mm, carrying an optical cylinder with a margin of dentine of at least 1 mm all round. The MOOKP optical cylinder comes in two different diameter sizes (3.5 and 4.0 mm) and a standard length of 8.75 mm; a wider diameter offers the benefit of a wider osteo-odontolamina. The ideal lamina should be of a size measuring 12 mm × 6 mm × 3 mm. A hole of an average diameter of 3.70 mm (range, 3.3-4.0mm) is prepared leaving an edge of dentine.

The optical characteristics of the PMMA optical cylinder are-mean intraocular diameter: 4.1 mm (range, 3.6-4.6 mm); mean extra-ocular diameter: 3.65 mm (range: 3.3-4.0 mm); mean length: 7.75 mm (range: 7.25-8.25 mm); mean radius of the convex extra-ocular surface:16 mm; mean radius of the convex intraocular Surface:6.5 mm; refractive index: 1.49; and equivalent power:50.8 diopters .[16]

Preparation of the Globe:-

Before the eye is covered with buccal mucous membrane:-
All corneal epithelium (including all remaining limbal stem cells) has to be thoroughly removed, and an intact Bowman membrane, if still present, also has to be removed. The conjunctiva has to be recessed with the superficial Tendon up to the recti muscles. Cautery should be reduced to a minimum so as not to destroy the episcleral vessels that will provide blood supply and drainage of aqueous humor. If the cornea is not vascularized, the eye should be covered with Tenon capsule because the mucous membrane would be too fragile to survive without vascularization and would become necrotic. Whenever a very thin cornea is present, a lamellar keratoplasty should be performed.[10]

Stage 2
Stage II surgery is performed 2 to 3 months later to allow time for a connective tissue cover to develop around the lamina implanted in the cheek. If required, the integrity of the lamina can be checked by performing a spiral computed tomographic evaluation [17].

It starts with retrieval of the osteo-odonto lamina from its sub-muscular pocket and excess soft tissue is removed from the bone surface. On the dentine surface, no soft tissue is allowed to remain. Excess connective tissue is removed from the two ends of the optic cylinder, and carefully trimmed over the rest of the lamina. The lamina is reinserted into its pocket until the eye is ready to receive it. The buccal mucosal graft is reflected to allow access to the cornea. A Flieringa ring is sutured in place. The centre of the cornea is marked, and a small hole is trephined, the diameter of which corresponds to that of posterior part of the optical cylinder[18].

Relieving incisions are made and total iridodialysis, lens extraction and anterior vitrectomy are performed. The posterior part of the lamina is inserted through the central corneal hole and the lamina is sutured onto the cornea and sclera. The eye is re-inflated with filtered air. The mucosal flap is replaced after drilling a hole to allow the protrusion of the anterior part of the optical cylinder .

The mucosal graft on the ocular surface is incised superiorly and reflected from the superior sclera and cornea, in a downward direction. The inferior attachment of the mucosal graft is left undisturbed to ensure that the blood supply is retained. A Flieringa ring is sutured in place and a 3 mm opening is created in the center of the cornea. Three radial incisions are made in the cornea extending till the limbus. The iris is disinserted at the root and removed by gently pulling on the tissue and hypotensive anesthesia is used to control the ooze.

Constant irrigation with balanced salt solution helps to wash the blood away and prevents a large clot forming in the anterior chamber. The lens is then cryo -extracted and the radial corneal cuts are sutured [19.] A limited anterior vitrectomy is performed and the lamina isthen placed over the cornea, such that the posterior part of theoptic cylinder is in the anterior chamber – entering through thecentral corneal opening. The lamina is sutured into position usingthe connective tissue covering and episcleral bites. Air injection through the pars plana using a 30-gauge needle is used to maintain the intraocular pressure and avoid severe hypotony.

At the conclusion of suturing, indirect ophthalmoscopy is performed to ensure that there is a good view of the disc and posterior pole, with the eye in the primary position. If this is not seen, a cylinder tilt may be responsible and the sutures are adjusted to straighten the cylinder position. Any bleeding into the vitreous cavity can also interfere with the visualization. After the cylinder and lamina are in satisfactory position, the mucosal flap is replaced and a small opening is created over the optic cylinder to allow the anterior portion of the cylinder to protrude through the mucosa. The superior edge of the mucosal flap is sutured in place and this completes the operation.[16,19]

Infection is a major concern since oral tissues are used and extensive ocular surgery is performed. Intravenous antibiotics are used for the first week after surgery and oral antibiotics are continued for another week. After the first stage the patient should receive systemic and local antibiotic therapy. Sometimes a scleral shield should be inserted to avoid shrinkage of the fornices for a few days. After the second stage systemic and local antibiotics should be administered. Additional systemic corticosteroids are recommended to avoid intraocular inflammation and mannitol with or without acetazolamide has to be administered as long as the intraocular pressure seems to be elevated.[10]

The presence of the lamina and the large mucosal graft preclude measurement of intraocular pressure using the current instrumentation. Intraocular pressure is estimated digitally and the health of the optic nerve is monitored using regular automated field measurements and visualization of the optic disc. The visual field provided by current cylinder designs is about 30 to 350 and allows good ambulant vision to the patient. [16]

Complications:-

Intra-operative complications at stage 1(A) (Preparation Of the Mucous Membrane)

- Damage to the parotid duct

Intra-operative complications at stage 1(B) (Preparation Of the Globe)

- Corneal perforation
- Scleral rupture

Intra-operative complications at stage 1 (C) (Preparation Of the Tooth)

- Oronasal fistula (into maxillary sinus)
- Fracture of the mandible
- Damage to adjacent teeth and the oral structures
- Postoperative complications after stage 1 (B)
- Trophic alteration of the mucosa
- Rise in IOP
- Choroidal detachment
- Retinal detachment

Postoperative complications after stage 1:-

- Infection of lamina in pocket
- Absorption of lamina
- Perioperative complications at stage
- Expulsive hemorrhage
- Choroidal detachment
- Hemorrhage into the vitreous

Late postoperative complications after stage 2:-

- Buccal mucosa alteration
- Glaucoma
- Choroidal detachment
- Retinal detachment
- Endovitrealhemorrhages
- Endophthalmitis
- Uveitis/retroprosthetic membrane
- Retroprosthetic fistula
- Optic cylinder instability

- Expulsion of the optic cylinder
- Expulsion of the prosthesis

Figures:-

Figure-1 : Schematic illustration of the MOOKP architecture

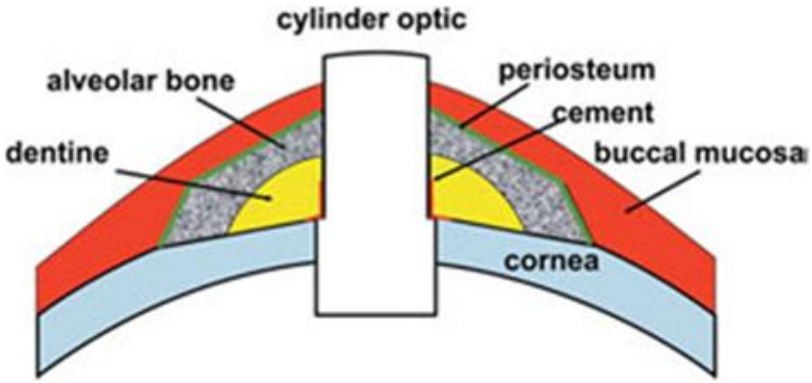


Figure- 2: Harvesting a canine tooth with a bone saw.

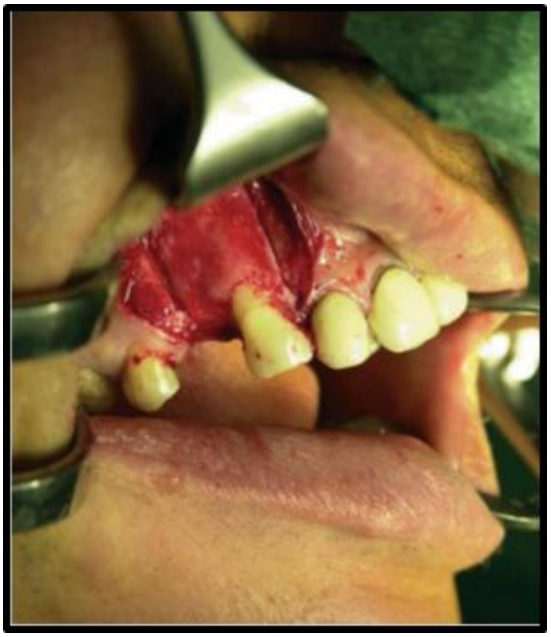


FIGURE-3 Modification of lamina for exposure of pulp canal

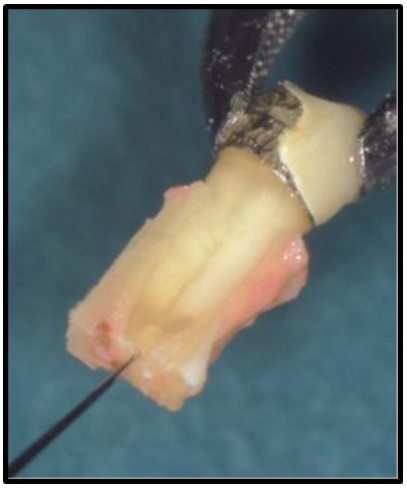
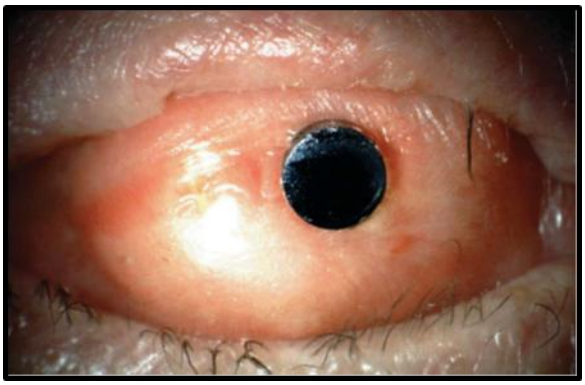


FIGURE 4- The dentoalveolar lamina and the optic cylinder.

Figure 5- Eye with OOKP



Conclusion:-

The Modified osteo-odonto-keratoprosthesis depicts an excellent multi-disciplinary approach involving ophthalmology and dentistry. MOOKP surgery is an invaluable treatment modality for restoring sight in the cases of corneal blindness not amenable to conventional corneal surgery. However, the MOOKP procedure still is a very time consuming, complicated procedure with associated morbidity, including ocular complications and dental defects. Formal training is mandatory for the concerned entire team since process of patient selection, counselling, pre-operative evaluation, surgical technique and management of post-operative complications is complex. The future of the keratoprosthesis will be intricately related with the further advances in tissue engineering.

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