• Review •

Ocular prosthesis incorporating IPS e-max press scleral veneer and a literature review on non-integrated ocular prosthesis

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Abstract

• The article highlights a new method for the fabrication of an ocular prosthesis by the incorporation of a ceramic scleral veneer. The steps of fabrication include impression making, wax try-in, performing a "cut-back" on a selected stock eye, insertion of the IPS e-max press scleral veneer, finishing and insertion. It also includes a detailed review on non-integrated ocular prostheses.

• **KEYWORDS:** IPS e-max press; ceramic eye prosthesis; ocular prosthesis

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INTRODUCTION

An ocular prosthesis creates an illusion of a normal eye and its surrounding tissues, and maintains the volume of its socket[1]. The accurate duplication of color, contour, size and orientation, similar to that of a natural eye, is important in order to obtain realism and symmetry[2]. The methods of fabricating ocular prostheses have progressed over the years to provide superior cosmetic replacement of the enucleated or eviscerated eye[1]. The procedure that constitutes the removal of the contents of the globe, leaving the sclera, extraocular muscles and optic nerve intact, is called evisceration. The defect is usually corrected using a sclera cover shell prosthesis[3]. The removal of the entire globe after severing the muscles and the optic nerve is called enucleation. The rehabilitation of such defects is by using an ocular prosthesis after an impression of the socket is made. The natural undercut of the eyelids can hold a scleral shell or a prosthesis after evisceration and enucleation, respectively[4]. Exenteration is a procedure involving removal of all tissues within the socket and the entire orbit, including the conjunctiva, globe, orbital fat and a part or all of the eye lids[4-14]. In exenterated cases, the prosthesis can only be retained with the help of a spectacle, magnetic buttons, adhesive, pin and sockets[15].

CASE REPORT

A male patient aged 52y reported to the Department of Prosthodontics. He had suffered from trauma to his left eye two years ago, which had to undergo surgical enucleation (Figure 1). The width of the palpebral fissure in open and closed conditions; depth of the superior and inferior fornices; palpebral muscle control; internal anatomy in resting and in full excursion; anterior-posterior depth; and the support from the superior and inferior tarsal plates, were evaluated. All conditions were found to be favorable for the retention of a prosthesis. It was decided to replace the ocular defect with a custom-made prosthesis. After ethical committee approval, consistent with the Declaration of Helsinki, an informed consent was obtained from the patient after explanation of the treatment plan and its outcomes. Topical anesthesia was given to provide comfort to the patient while making the impression. The moulded shell/stock tray impression technique was used to record the impression in the socket. An impression was made using a moulded shell of acrylic resin with perforations to favour the flow and retention of the impression material. The auto mix tips of the impression gun were attached to the moulded shell. Medium body addition silicone (monophase) was injected into the socket using the automix impression gun (Figure 2). The set impression was removed by applying outward pressure near the inferior palpebral fissure. The impression was removed, boxed and poured using the two pour technique using type III dental stone. After setting, separating media was applied and the remaining impression was poured with type III dental stone. The cast was retrieved from the impression and prepared for wax pattern fabrication by coating a layer of separating media on to the defective surface before the molten modeling wax was poured. After the wax was solidified, the upper half of the cast was separated along the medial and lateral canthus. The wax pattern was retrieved and smoothened to remove

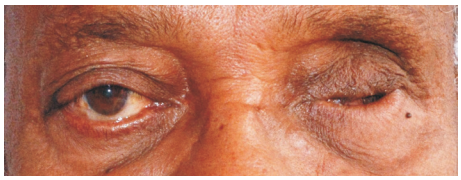

Figure 1 Pretreatment photograph.

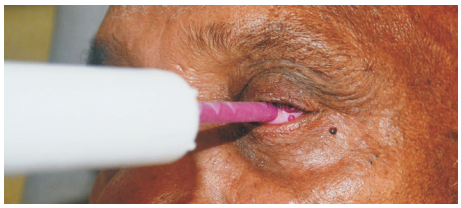

Figure 2 Impression of the ocular defect.

any irregularities and then polished. The precision of the pattern was checked in the patient by observing the extension of the wax pattern into the fornices (Figure 3). The extended areas were adjusted by trimming the wax. The retention and the lid support provided by the wax pattern were checked during open and closed eye positions. After adjustments were made, the wax pattern was flasked and processed with tooth molding powder and clear heat cured acrylic. After deflasking, the scleral blank thus obtained was polished using pumice. After the scleral blank was inserted in the socket, the patient was asked to look distantly and fix the contralateral eye. The location of the iris of the normal eye with respect to the inner and outer canthus, and the upper and lower lids, was marked using a graph paper transparent guide (Figure 4). Similar markings were transferred to the side of the defect (Figure 5). The iris was then cut off from the stock eye and fixed using cyanoacrylate on the scleral blank. The visible area of the sclera was then marked, and a cut back of 2 mm using the wheel shaped diamond point (WR 13 Mani burs India) was made to accommodate a wax pattern for the IPS e-max press (Ivoclar Vivadent AG, Schaan, Liechtenstein) scleral veneer (Figure 6). Shade matching was done using the VITA classical A1-D4 shade guide (VITA Zahnfabrik Essen, Germany). The wax pattern was tried and necessary adjustments were made. The IPS e-max press scleral veneer was prepared using the lost wax technique. Intrinsic stains were also added to match with the colours of the contralateral eye (Figure 7). The porcelain sclera was then cemented using resin adhesive cement RelyX U200 translucent shade Self-Adhesive Resin Cement (3M India) onto the acrylic scleral blank. Prior to insertion, the prosthesis was disinfected using 70% isopropyl alcohol and 0.5% chlorhexidine solution. After thoroughly cleaning the prosthesis with saline solution to prevent chemical irritation, it was inserted and checked for fit, contour, and movements (Figures 8 and 9).

DISCUSSION

Modification of Stock Eye A stock ocular prosthesis of appropriate size and color, after selective grinding or addition of

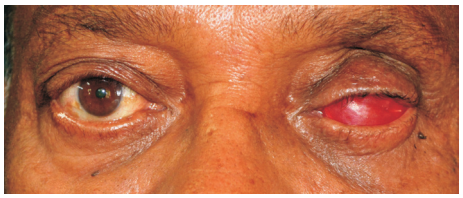

Figure 3 Wax pattern trial.

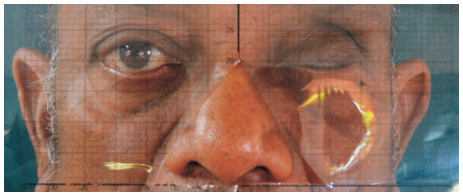

Figure 4 Iris positioning.

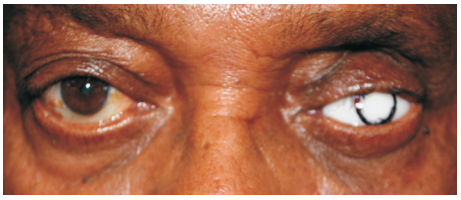

Figure 5 Confirmation of the transferred iris position.

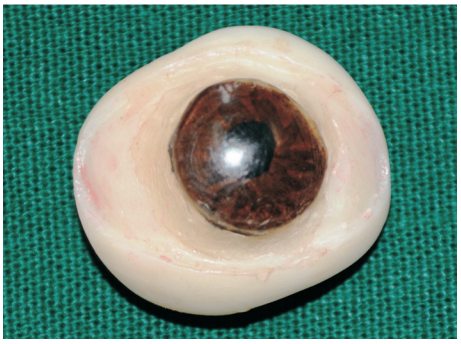

Figure 6 Cut-back on the sclera for porcelain insert.

Figure 7 IPS e-max scleral veneer.

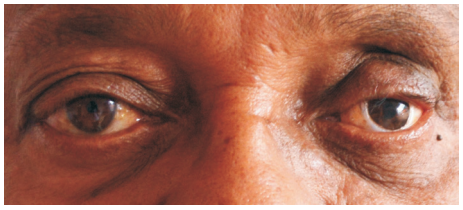

Figure 8 Post-treatment photograph.

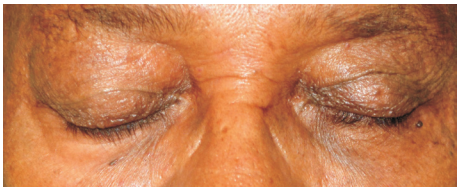

Figure 9 Post-treatment photograph on closure of eyelid.

acrylic resin has been suggested[16]. The use of a viscoelastic tissue conditioner as an impression material on the stock prosthesis, in order to obtain better adaptation of the defect, has also been suggested[17]. Moreover, the iris alone may be removed from the stock eye and incorporated with the custom fabricated eye[15]. A modified custom eye approach was used in this case, wherein the iris alone was removed from the stock eye and incorporated with the custom fabricated eye[15].

Impression Technique The stock tray impression technique that was used in this case report is the most commonly used technique. It was first described by Allen and Webster who termed it as the "modified impression method". An impression is made using a stock ocular tray[15,18-19]. These acrylic resin trays, have perforations that help in the flow and retention of the impression material. The tray has a hollow handle which fits a plastic disposable syringe. The impression material is injected into the socket *via* the syringe, through the impression tray. After setting, the impression is removed by applying an oblique outward force near the inferior palpebral fissure, or by holding the impression material flash on the outer surface with tweezers[20]. The impression is then invested in dental stone. A wax pattern is prepared from the mold produced from the impression, following which, the wax prosthesis is placed in the socket for trial and adjustments[21].

A modified impression tray can be obtained by perforating a hole of diameter between three to four millimeters through the resin tray at the pupillary location, through which a five milliliter plastic syringe can be attached for supporting the tray and for carrying the impression material. Light bodied impression material can then be mixed and delivered into the socket through the syringe[22]. However, in this case report, instead of using a five milliliter syringe tip, an auto mix tip along with the impression gun was used. The tip could be disengaged from the impression gun, serving as a tray handle to retrieve the impression.

Location of Iris Position The measurements were made while the patient looked ahead and the contralateral eye was relatively fixed[14,22-24]. The midline of the patients face and another line passing through the center of the iris of the contralateral eye were marked. The distance between two lines was measured using a digital caliper[23]. However, an additional measurement may be made from the inner canthus of the eye till the nasal bridge[24]. These values may be transferred on to the cast for locating the ocular part of the orbital prosthesis.

The dimensions of the cornea are obtained by using an Intra Pupillary Distance scale[14]. The distance between the medial canthus and the corneal periphery of the normal eye is obtained. This value is then transferred to the scleral pattern. A horizontal line is then drawn in order to indicate the lower border of cornea. The resulting "L" shaped lines (green and yellow) determines the approximate dimensions of the cornea[22].

In this case, the position of the iris of the natural eye in relation to the inner and outer canthus, and the upper and lower lids, were marked using a graph paper transparent guide. These markings were then transferred to the side of the defect.

Iris Selection When bilateral ocular prosthesis have to be fabricated, the choice of iris diameter and scleral colour depend on patients age and race. However, in this case, an iris of similar size and colour as the normal eye was selected and cut off from the stock prosthesis and placed on a predetermined position on the wax pattern, such that the borders of the iris were flush with the wax pattern, and try in was done[23].

IPS E-max Press Scleral Veneer The lithium-disilicate or lithium-orthophosphate ($Li_2Si_2O_5$, Li_3PO_4)[25-27] content in modern glass based ceramics provides flexural strength, two to three times greater than that of conventional glass-ceramics[25-26,28-33], enabling them to be used as dental restorative materials in the molar region[29,33-34]. These ceramics have high transclusency[26,29,35] and excellent mechanical properties[25-26,33]. A durability of 94.8% after 8y has been reported for lithium-disilicate crowns[35-37]. Glass based ceramics such as feldspathic porcelain, HS10PC (estetic ceram), IPS Empress I and II (Ivoclar Vivadent AG, Schaan, Liechtenstein) and IPS e-max press have been used[38].

IPS e-max press was introduced in 2005 as a superior press-ceramic material. Its crystalline volume and reactive index provide it with superior translucency and physical properties as compared with IPS Empress ceramics[39-41]. The fracture resistance of IPS e-max Press crowns has been reported to be greater than that of HS10PC crowns[42], and similar to that of natural teeth[39]. IPS e-max Press crowns were found to have better wear resistance and resistance to crack propagation than Procera AllCeram crowns (Nobel Biocare)[43-44], probably due to the presence of rod-shaped crystals[44]. They also showed greater resistance to crack formation than IPS Empress II crowns, making them ideal for stress-bearing areas[27].

Our technique incorporated the use of ceramic stains on a scleral veneer fabricated using IPS e-max press. The sclera was customized using IPS e-max press, since the sclera constitutes a large portion of the visible eye and there is wide variation in the appearance of the normal sclera from person to person. An ocular prosthesis fabricated with IPS e-max press ceramic would never have to undergo forces or wear as compared with those during mastication. This makes the ocular prosthesis almost completely resistant to damage. Although, surface degradation, wear, and material loss are common problems associated with ceramic[27,43], they are unlikely to occur in an ocular prosthesis because it would only have mucosal contact. Moreover, it was recently found that accelerated aging of dental ceramic under artificial conditions, did not produce any change in color stability[45]. After three years of follow up, the patient is satisfied, and there has been no change in the form or appearance of the prosthesis.

LITERATURE REVIEW

History The earliest ocular prosthesis ever found was from Shahr-I Sokhta (Iran), from a woman dating back to 2900-2800 BC. The prosthesis was hemispherical with a diameter of about 2.5 cm. It was composed of a very light material, possibly bitumen paste. Its surface had a thin cover made of gold, within which was engraved a circle in the center (representing the iris), from which patterns of gold lines emerged like sun rays. There were tiny holes on both sides of the eye prosthesis, from which a golden thread could be drawn to maintain the prosthesis in its defect[46-48]. In the fifth century BC, Roman and Egyptian priests fabricated artificial eyes from painted clay, that were attached to cloth outside the socket[49-50]. The use of ART eyes had also been found in statues of Egyptians 1613-2494 BC[51]. Eyes made of glass were fabricated by the Venetians during the late 16th century. However, eyes made of glass were crude, fragile and uncomfortable, and their fabrication procedure was known only to the Venetians. By the end of the 18th century, Parisians began artificial eye-making. French surgeon, Ambrose Pare (1510-1590), described the method for fitting artificial eyes within the socket. They were made from gold and silver pieces, and were classified into two types: Ekblephara (worn in front of the eyelid) and Hypoblephara (worn under the eyelid). The hypoblephara eye was meant to be placed above an atrophic eye, as enucleation was not in practise until mid 1800's. Later on, Pare fabricated eyes made of glass and porcelain[52-54].

Germany eventually became the center for artificial eye fabrication after they invented the glass blowing technique. Ludwig Muller-Uri, a German glass blower, fabricated fine artificial eyes made of glass[54]. The export of German glass made eyes to the USA declined during the second world war, following which, the Naval Dental School (USA) in 1943 started the production of acrylic ocular prostheses[10,49,51,53,55-57]. Acrylic eyes were found to be superior, since they did not have the limitations of glass made eyes such as fragility, brittleness, lack of adjustability, and their susceptibility to socket fluid and spontaneous explosions. Moreover, acrylic eyes were not very fragile, adjustments were easy and various features could be incorporated to suit esthetic requirements, such as determining corneal and pupillary dimensions and painting conjunctival vessels[14,58].

Etiology Various congenital factors may result in the absence of eyes[4,6-8,59-60]. However, the loss of an eye could result from sharp objects like pencils, glass, nails or needles[61]. It may also result from a surgical procedure required due to irreparable trauma[4,6-8,59-60,62], painful blind eye[4,6,8,60,63], sympathetic ophthalmia resulting from 0.001% to 2.0% of all traumatized eyes[4,6,8,60,62-63], tumours [4,6-8,59-60] and the need for a histological confirmation[4,6,8,60,63]. The various tumours affecting the eye, that may require ocular removal include basal cell carcinoma[64-70], squamous cell carcinoma[68-70], retinoblastoma[62,71-74], malignant melanoma[62,64-67,72-74] and rhabdomyosarcoma[64-67].

Implications Traumatic loss or congenital absence of an eye often result in emotional or physical problems[75], hypoplasia and facial asymmetry[76], functional disability[10,75], impaired esthetics[10,76], psychological misbalance[75-76] and societal reactions[10,75]. The replacement of the defect with an ocular prosthesis depends on the joint efforts of an ophthalmologist, surgeon and a prosthodontist[7-10]. Correction of the defect with an ocular prosthesis results in physical and psychological healing[1,10], rehabilitation[17], social acceptance[1,10], improved quality of life[77] and growth and development[76].

Classification Non-integrated ocular prosthesis may be classified based on shape (spherical *vs* oval) or the method of fabrication (stock *vs* custom). Nonintegrated prostheses do not contain any device for attachment with extraocular muscles, and neither do they permit the in-growth of organic tissue into the prosthesis[78]. Non-integrated prostheses may be made with acrylic[72,78], glass, and silicone spheres[72,79].

EVALUATION

Evaluation of the socket must be done at resting position, during complete excursive movement of the musculature of the eye[14]. The Anaopthalmic socket has a "Triangular" outline. The nasal aspect forms the most acute apex of the triangle which resolves into the medial canthus. A reddish elevation in the lacrimal caruncle is found in this region. The superior border forms the next most acute apex. The inferior lateral region forms the most rounded apex of the triangle[14]. Sufficient superior and inferior fornices, sufficient palpebral fissure that can accommodate the tissues of the normal eye, sufficient anterior-posterior depth, sufficient support from superior and inferior tarsal plates, minimum adhesions of scar tissue, sufficient mobility of the eyelids and some irregularities in tissues in the depth of the socket, are required for adequate adaptation of the ocular prosthesis[1]. The socket must also consist of healthy conjunctival epithelium[14,51]. The quantity of orbital adipose tissue, the extent of muscular atrophy, and the tonus and contour of the eyelids, must be carefully inspected[52]. A constricted socket with insufficient superior and inferior fornices, palpebral fissure and anterior-posterior socket depth, might pose various problems with regard to retention and cosmetics. In case of constricted sockets, prior treatment with step by step fabrication of large pressure conformers for expanding and shaping the socket is necessary[1]. Post-enucleation increase in socket dimensions may result in abnormalities such as lateral canthus, deep superior fornix, superior lid ptosis and sagging of the inferior lid. These conditions may result in posterior and inferior migration of the ocular prosthesis or an implant[80].

STOCK EYE

Stock prostheses are relatively less expensive and can be inserted quickly[81-84]. Patients with stock eyes need to remove their prosthesis several times in a day, in order to clean the socket of its discharge resulting from inflammation due to improper fit of the prosthesis in its socket. The inadequate fit also results in failure to stimulate eyelid movement[83,85-86]. These factors result in changes in lid anatomy, leading to a contracted socket[87]. Moreover, the irregularities in a stock prosthesis may collect debris and mucus and be a source of infection for the mucosa[83,88]. The following stock eyes have been suggested for use as interim prosthesis, conformer or stent, in order to help in the regrowth and adaptation of tissues in the socket, after surgical enucleation[84].

1) Conventional shell type: indicated when the remaining orbital tissues are prominent, with minimal space for an ocular prosthesis. The thickness of its scleral portion is about 1-1.5 mm.

2) Hook or shelf type: indicated in ocular defects with shallow lower fornix and lax lower lid, where there is a tendency for the prosthesis to slip out from the inferior border. A right angled hook resting over the stump, supports the prosthesis by reducing the weight on the lower lid.

3) Curled back shell: indicated in cases where the inferior fornix is insufficient or shallow. The upper portion of the prosthesis extends backwards at a right angle to the vertical fold of the eye.

4) Forty five degree bent eye: indicated in situations when an ordinary reform eye would turn back at 45° from the horizontal. The band prevents the temporal portion of the upper eyelid from drooping.

5) Peanut eye: these eyes are indicated when the reform eye tends to sink backwards and pulls away from the inner canthus. They are shortened in vertical direction and elongated horizontally with a temporal curve.

6) Reversed shape: it is indicated when the prosthesis is vulnerable to rotation within the socket. Its vertical dimension is larger nasally and temporally.

CUSTOM EYE

Compared with stock eyes, custom-made ocular prosthesis provide superior compatibility with ocular tissues due to improved adaptation, resulting in less irritation, infection or accumulation of fluid at the tissue-prosthesis interface[17,51,89]. Due to their close proximity with the tissue bed[17,21,51,82-83,86,89-90], there is better mobility of prosthesis[22,51,82-83,90], uniform distribution of pressure[17,22,51,89-90] and decrease in the incidence of conjunctival abrasion and ulceration[17,51,89-90] as compared with stock prostheses. Control over the orientation, colour, contour and size of various parts of the eye, brings about superior facial symmetry and esthetics[21-22,82-83,90]. However, custom fabricated eyes have the disadvantage of increased fabrication time and cost[90] due to the complex painting skills required by the operator[88,91].

IMPRESSION TECHNIQUE AND TRAY

A good impression technique is necessary to obtain a precise fitting prosthesis that would be free of voids at the tissue-prosthesis interface. An ideal impression must reproduce the superior and inferior fornices, the palpebral position in relation to the posterior wall and the posterior wall itself. Prior to impression making, the patient must be seated upright and the head must be positioned on the head rest. This posture ensures optimal positioning of the palpebrae and other surrounding tissues with regard to gravitational force[14].

The fabrication of a custom tray to make an impression had been recommended by various authors[10,57,60,92-95]. An important benefit of the impression tray is that the anterior surface gets contoured optimally, since the tray ensures a spherical contour for the prosthesis without any excess bulge or protrusion. It also accurately duplicates the superior and inferior fornices, and the medial and lateral canthi. Prefabricated impression trays come in various sizes and are side (left or right) specific. A tube attached to the impression tray functions by delivering the impression material into the socket[96].

The tray must be positioned such that it supports the lids. The stem of the tray must be positioned parallel to an imaginary line drawn perpendicular to the pupils. For evaluating lid contour, the patient must be asked to rotate the eyes in all directions without head movement. If the tray is placed accurately, the movement of its stem would correspond with that of the pupil of the natural eye[14].

The various impression techniques used for the fabrication of a custom ocular prosthesis are: 1) external tray impression technique; 2) moulded shell/ stock tray impression technique; 3) modifications of the stock tray impression technique; 4) custom ocular tray technique; 5) stock ocular prosthesis impression technique; 6) modifications of the stock ocular prosthesis impression technique; 7) empirical impression technique; 8) using polyvinyl siloxane (PVS).

MATERIAL OF PROSTHESIS

An ideal ocular prosthesis must possess optimal durability, flexibility, weight, color, hygiene, thermal conductivity, ease of use, biocompatibility, texture and availability. There is no such prosthetic material that possesses all of the above mentioned properties[97-99].

Polymethyl methacrylate (PMMA) is considered better than most other ocular prosthetic materials with regard to its durability, biocompatibility, light weight, adjustability, strength, translucency, ease of fabrication, coloring capabilities, availability and cost[1]. The production of acrylic made ocular prosthesis was pioneered by the the United States Navy[83]. However, acrylic can result in allergy leading to irritation, redness, excessive secretions, swelling *etc*[51]. Ocular prosthesis made of PMMA has been used widely by various authors[23,78,87,100]. Some authors have used heat polymerizing

acrylic resin[15,86]. Tooth coloured acrylic resin has been used to match with the sclera[22,71]. Room Temperature Vulcanizing (RTV) medical-graded silicone (factor II) has been recommended for making ocular prostheses, since they provide better esthetics compared with acrylic due to their flexibility and less weight[24].

Glass made eyes comprise of a scleral portion made of fusible opaque glass, and a corneal portion composed of transparent glass. Opaque glass is composed of silicone (30%), potassium (20%), lead oxide (30%) and tin oxides (10%), while transparent glass is fabricated by excluding the metal oxide content. But glass has the disadvantage of difficulty in handling and adjustment. However, they may be used in cases of allergy to PMMA[1].

IRIS SELECTION

The portion of the iris may be painted on to the prosthesis with oil paints using the "paper iris disk technique" and the "black iris disk technique"[52]. Replication of the iris may also be done using digital photography, wherein the image is edited using Adobe Photoshop and the print out is obtained on photo paper[10]. The part of the photo that contains the iris is cut out and a layer of cyanoacrylate is applied over it to make it water resistant. In order to obtain a convex shape for the cornea, clear self-cure acrylic can be applied over the paper containing the iris and attached to the scleral blank after finishing and polishing[86]. However, an image of diameter 1 mm smaller than the measured contralateral iris, can be cut and placed to account for the magnification produced by the acrylic layer that would cover the prosthesis[71].

EYE COLOUR

Fibers Red silk fibers[22-23] are added to obtain different hues to mimic blood vessels or other associated colors of the eye. Red fibers in self-cure acrylic polymer have also been used for the same[15].

Paints Ferrous pigments, acrylic paints and oil paint with acrylic monomer as diluting agent have been used. These paints were aimed at reproducing the accurate color of skin, blemishes, freckles or scars. A study that compared the longevity of different types of paints concluded that oil paints had the highest resistance to aging[55].

MOBILITY OF THE PROSTHESIS

Friction between the posterior surface of the prosthesis and the conjunctiva, or movement of the conjunctival fornices, may result in movement of the prosthesis[3,49].

INSERTION AND INSTRUCTIONS

Disinfection of the prosthesis can be done by immersing the prosthesis for five minutes in 0.5% chlorhexidine and 70% isopropyl alcohol, followed by a saline rinse before insertion[96]. While inserting the prosthesis, the patient must look in the mirror, evert the lower eyelid and place the inferior part the prosthesis into the fornices, followed by placing the upper part of the prosthesis after lifting the upper eyelid. After placing the prosthesis, the patient must blink the eyes gently to ensure seating of the prosthesis. The prosthesis must be removed by first everting the lower lid[14]. Drying of the eyes and subsequent irritation may be resolved by the use artificial tears (ophthalmic lubricant) prior to insertion of the prosthesis. The lubricant maintains a tear film over the prosthesis and helps in eye movement[14,94]. The prosthesis must be evaluated for any irregularities, in which case, it must be repolished. Subtractive adjustments are contraindicated for a few days, unless the patient complains of irritations. The patient must be recalled after one day, three days and one week for follow up[14]. The prosthesis can be cleaned with water and soap, baby shampoo, or contact lens cleaner[51]. The frequency for cleaning has been suggested every day[51] and at weekly intervals[14]. The patient must visit the doctor every six months for polishing and adjustments[14]. However, a life span of six months to one year has also been suggested[51]. In children, the size of the prosthesis would need periodic enlargement to match with the expansion of the enophthalmic cavity[1,76,88]. A prosthesis with an accurate fit must maintain normal eye opening, provide support for the eyelids, allow certain movement, have sufficient retention and provide adequate esthetics[1].

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