

Case Report

Ocular Prosthesis in Dentistry-A Review

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Abstract

The management of an anophthalmic socket requires the combined effort of ophthalmologist and maxillofacial Prosthodontist. The surgeon provides the basis for successful rehabilitation. The maxillofacial Prosthodontist provides prosthetic treatment to the best of his ability. A thorough knowledge of the anatomy is necessary for successful treatment. The goal of any prosthetic treatment is to return the patient to society with a normal appearance. The aim of this review article was to show the fabrication of Ocular prosthesis which can be used to provide a cosmetic replacement for enucleated or eviscerated eyes.

Introduction

Ocular prosthesis has been used since a long time in Dentistry and treatment modalities have been evolving daily. Inter disciplinary treatment approach is required to correct the ocular defects. Great knowledge of the anatomy of the orbital region is required. The eyeball is the origin of sight. It closely resembles a camera in its structure. It is almost spherical in shape and has a diameter of about 2.5 cm. Dating from very early times in Egypt (i.e., the Presynaptic Period, before 3000 B.C.), simple inlaid eyes, consisting usually of white shell beads, have been found, and human figures bearing such eyes are to be seen in the Cairo museum [1,2]. These early artificial eyes were very good imitations of the natural organ, with such essential features as eyelids, sclera, cornea, iris, pupil, and even the caruncle and plica semilunaris. The margin of the eyelid consisted of a narrow of copper, and the wedge-shaped eyeball was cut out of opaque white quartz or white crystalline limestone. The anterior surface was beautifully polished and shaped to correspond with the natural curvature of the sclera. Amboise Pare (1510-1590), a Frenchman, was the first to use both glass and porcelain eyes [3]. At first Venice had the monopoly, then the art spread to France and Bohemia. By 1,835 artificial glass eyes were being produced on a large scale in Germany, which continued as the center of production. The glass eye has the disadvantage of being extremely fragile. Glass prosthesis will sometimes explode spontaneously in the eye socket and will require painstaking removal of the sharp fragments by an ophthalmologist surface glass is affected when the fluids of the socket cause an itching which may be extremely

irritating to the socket membranes. Glass restorations are also difficult to fit properly in relation to defects and variations, so that very often the prosthesis is far too small, giving the wearer the appearance of enophthalmos [4]. Now day's glass has been replaced by acrylic material to make the ocular prosthesis. This ocular restorative process has been explained in the review article.

Fabrication of Ocular Prosthesis

When the surgical site is well healed and dimensionally stable, fabrication of an ocular prosthesis can begin. Before beginning, a thorough examination of the enucleated socket must be made to ensure proper healing and the absence of infection [5,6]. The location of the implant, movement of the tissue bed, and size and extent of the socket should be noted (Figure 1).

Impressions

An impression of the socket can be made with irreversible hydrocolloid. An impression tray can be fabricated from hard baseplate wax by warming it over a flame and adapting it to the contour of the area around the eye. A wax handle is attached to aid manipulation. The tissue side is scored with a hot spatula to afford retention for the impression material [7]. The patient is seated erect, requested to stare at a distant spot, and instructed to hold his gaze in a straightforward position with eyes open while the impression is being made. This procedure will ensure that the posterior aspect



Figure 1: Ocular Prosthesis.

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of the enucleated socket and its rectus muscles will be in the same relative position as those of the remaining eye. The irreversible hydrocolloid is mixed using an extra half measure of warm water, providing a smooth, runny mix that will set quickly. The impression material is placed into a large syringe. Enlarging the opening of the tip of the syringe will facilitate expression of the impression material. With the patient's eyelids open, the irreversible hydrocolloid mixture is injected into the socket, being careful to completely fill the socket without trapping tiny air pockets. The lids are then released and some of the impression material is expressed over the lids [8]. The tray, which has been coated with the impression material, is placed over the eye and allowed to set. When set the material in the socket and over the lids can be removed as one piece. The patient is instructed to open his eye as wide as possible, and the impression is gently removed. Care must be taken not to tear the impression from the tray at the thin section that represents the lid opening. Prior to pouring the cast, this section of the impression can be reinforced by placing a straight pin through it from the posterior aspect. The impression is inspected and the socket is checked for any residual irreversible hydrocolloid [9].

Stock tray impression technique

An impression is made of the ocular defect using a disposable syringe, stock ocular trays and irreversible hydrocolloid. During the procedure, the patient should be seated in an upright position with the head supported by the headrest. This position allows the natural positioning of the palpebrae and surrounding tissue relative to the force of gravity. The tray should be placed into the defect to determine the proper orientation and fit without overextension (Figure 2). The tray is then removed and the impression material is loaded in the syringe and sufficient material is ejected to fill the concavity of the tray [10]. The tray is reinserted and sufficient material is injected to elevate the lid contours similar to the normal side. Once filled the patient is directed to move their eyes both up and down. After the impression sets the assembly is removed and examined for defects and voids.

Formulation of the cast

The impression is poured in two sections. A box is formed around the tray with 3-inch masking tape. The first half of the cast is poured with a mix of dental stone using "slurry water" to accelerate the setting time. This procedure will prevent excessive water loss from the impression. The mix is vibrated onto the boxed impression up to and around the widest part of the socket impression. The impression is then placed in a humidifier while the stone sets. At least two keyways are cut into the surface of the first pour using a large, round vulcanite bur. The stone is then lubricated with a separating medium and the second half of the impression is poured and returned to the humidifier [11].

Custom ocular prosthesis fabrication

Wax pattern: The melted wax is poured through the funnel shaped hole and into the assembled mold. Soaking the mold in water for a few minutes prior to filling it with molten wax will prevent the wax from adhering to the stone. After the wax has cooled, the wax pattern is recovered. Once the wax pattern has been smoothed and polished, it is ready to be tried in the eye socket [12]. To insert the wax pattern, the upper lid is lifted, and the superior edge of the pattern is placed behind the lid and gently pushed upward. While drawing the lower lid down, the inferior border of the pattern is seated in the inferior fornix, and then the lower lid is released. The eye contours are checked. When the wax pattern is determined to be appropriate,

it is flaked and processed in scleral resin. The scleral blank is then finished, and it is polished using pumice and acrylic resin polish (Figure 3).

Iris location: The Scleral blank is tried in and the middle of the pupil is marked while the patient gazes directly at the clinician [13]. The size of the iris is measured using a millimeter measurement gauge or optical scale. The outline of the iris is then marked on the scleral blank using Carmen red ink. This ink will transfer to the investing stone, facilitating the appropriate placement of the corneal prominence. The blank is tried in again to verify the location and size of the iris. The location of the iris will transfer to the investment and a scraper can then be used to create the corneal prominence of the prosthesis in the investment.

Black iris disk technique: The natural eye is observed closely and the diameter of the iris is estimated using a millimeter measurement gauge or optical scale [14]. Ocular discs, which are used in the iris painting, are available in half mm sized increments, ranging from 11 mm to 13 mm. They come in black or clear, and either with or without pupil apertures. Clear corneal buttons are available in the same sizes as the discs. The buttons can also be purchased with pupils of various sizes already in place. The technique employed in painting the disk produces a three-dimensional effect. Oil pigments are employed in this technique but are mixed with monomer-polymer syrup during the painting process. This mixing procedure provides some degree of translucency in the iris painting and permits rapid drying of the pigments. The basic eye color or background color is observed along with the limbus color. The background color is applied to the disk first, using brush strokes from the center toward the periphery.

After the background color is applied and dried, a coat of the clear syrup is applied and allowed to dry. Characteristic striations are applied over the clear layer and allowed to dry. A second clear layer is then applied and further characterization accomplished. After the second layer is dried, the limbus color is matched around the periphery of the disk and a third clear layer applied. The color around the pupil is applied over the last clear layer and the final color



Figure 2: Stock tray impression.



Figure 3: Wax Pattern.

evaluated with the water interface. After a satisfactory color match has been obtained, a final clear layer is applied and allowed to stand for 15 minutes. A single droplet of the monomer-polymer syrup is then placed in the center of the iris disk and the lens button is gently placed and centered. The positioning of the iris-lens assembly on the wax scleral pattern is the most important phase in fabrication of the prosthesis. Fix the lens button to the Scleral pattern in a manner such that the apparent gaze of both natural and artificial eyes is on the same object, or parallel to one another and in the same plane [15]. The position and gaze of the artificial eye is again observed. The sclera is slightly roughened using sandpaper disks in preparation for adding the simulated vasculature. Rayon-thread fibrils are placed onto the surface of the sclera using the monomer polymer syrup. The pattern and type of vessels (tortuous, straight, and branched) of the opposite eye are reproduced. The colors found in the sclera are usually yellow and blue, or combinations of these. Greens and browns can also be present. The scleral painting begins with the application of a wash of yellow comparable to that found on the patient's natural eye. Next, blue is added, which is usually located inferior and superior to the iris. Finally, any characteristic details present in the natural eye are added. Once complete, a coat of monomer and polymer is applied to the sclera. The eye is now ready for the final processing; the application of a layer of clear acrylic resin is done. The prosthesis is cleaned and placed in socket. The fit of the artificial eye are evaluated and adjustments are made as necessary.

Patient instruction: The method of inserting and removing the prosthesis and its care are demonstrated to the patient. The prosthesis should be removed at least once a day for cleaning. The prosthesis should not be allowed to come into contact with alcohol or solvents of any kind as this could cause crazing of the acrylic resin. If the eye should become scratched it must be returned for polishing [16].

Retentive aids

Anatomic retention: This necessitates the use of both hard and soft tissues of the head and neck area. Retention of the dynamic extraoral area depends on many factors for a successful end result [17]. These factors are related to the location and size of the defect, tissue mobility or lack thereof, undercuts, and the material weight of the final prosthesis. Hard tissues act as a base against which to seat the prosthesis and to provide a better seal of the prosthesis with the use of an adhesive. Soft tissues prove to be more troublesome because of their flexibility, mobility, lack of a bony basal support, lower resistance to displacement when a force is applied, deficiencies as a base for firmly securing the surgical adhesive during cementation and the physiologic nature of Squamous ectodermal tissues.

Mechanical retention: It is advisable to use eye glasses as an indirect mechanical retention which act the same time hides the margins of the prosthesis. The eye glasses should be free of and not a part of the prosthesis. In addition to eye glasses, an elastic strap may be used to hold the glasses on and help retain the prosthesis.

Magnets: These may be embedded in an orbital prosthesis to help secure it to a maxillary obturator which may be in contact with an above prosthesis.

Snap buttons and straps

Adhesives: Retention can be enhanced and may rely entirely on the use of a surgical grade extra-oral adhesive. In general, each material provides its own adhesive because of its own because of its inherent physical and chemical properties. The adhesives aid

retention, marginal seal, and border adaptation. This secures the prosthesis against accidental dislodgement [18].

Ocular implants: Most ocular defects result from trauma, although occasionally tumors require removal of the eye [19]. Frequently an implant is placed in the tissue bed to facilitate construction of the ocular prosthesis (Figure 4). If no material is used to help fill the space the orbit will exhibit a sunken appearance as the size of a prosthetic eye is limited by the opening between the superior and inferior Palpebra. If no implant is placed to which the ocular muscles can be connected, there will be no movement of the overlying prosthetic eye. An implant that is attached to the ocular muscles will move as the muscles move in their normal course. Consequently, a prosthetic eye in contact with the tissue that covers a moving implant will move as the muscles move in the eye in contact with the tissue that covers a moving implant will have some degree of movement. The result will be a more realistic prosthesis. The restored muscle function creates tension on the orbital walls and ensures a more normal pattern of orbital growth (Figure 4).

Materials and types of ocular implants

There are three basic types of ocular implants: the buried; the semi-buried, integrated; and the buried, semi-integrated [20]. The buried implant may be a simple ball or other shape that sits in the cone of muscles of the orbit, partially filling the area previously occupied by the eyeball. The implant creates movement of the prosthesis by moving the tissue bed on which the prosthetic eye rests. The buried, semi-integrated implant theoretically results in more movement of the prosthesis. The principal complication associated with buried implants is erosion of the overlying tissue, resulting in exposure of the implant. Erosions can be secondary to an oversized implant, an oversized conformer, or contamination of the implant at the time of insertion. A semi buried, integrated implant was introduced by Ruedemann in the early 1940's. This type of implant consisted of a ball or similar shape that sat in the cone formed by the ocular muscles.

The semi buried, integrated implant resulted in increased mobility for the prosthetic eye and more lifelike action, but most became infected and were lost within 2 to 5 years [21]. The buried, semi-integrated ocular implant consists of a body to which the muscles are attached or overlapped and sutured. The entire implant is buried, but the anterior surface has a configuration that makes a protuberance in the anterior surface of the encapsulating tissue. When a custom prosthesis is fabricated, a counter contour to the implant is formed on the posterior surface of the prosthetic eye. There is always tissue separating the artificial eye from the implant, so although movement is limited, it is improved by this semi-integrated arrangement.

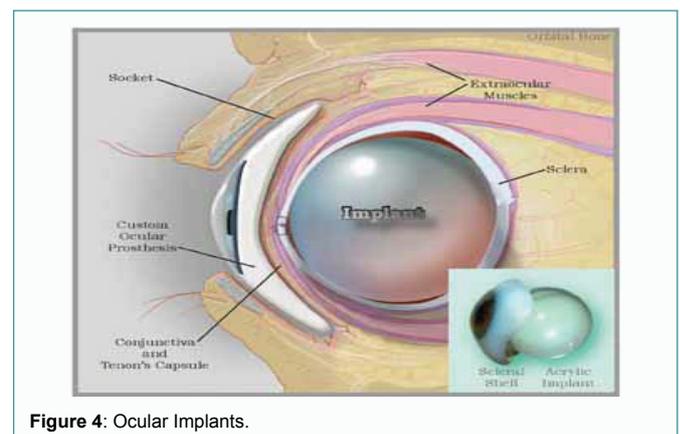


Figure 4: Ocular Implants.

Computer aided design of facial prosthesis using a three-dimensional optical data acquisition system

The conventional impression technique for manufacturing facial prosthesis with an elastic material, which is used in the treatment of patients with facial defects caused by tumor resections, means further discomfort and a delayed treatment and re-socialization for the patient, who is already burdened with the surgical operation and possible radiotherapy [22,23]. A better solution could be the use of computer assisted design and fabrication of facial prosthesis (Rapid Prototyping). The prerequisite for this technique is the provision of usable readings of the exact form of the defect which is to be treated. In regard to these requirements, the optical 3D co-ordinate measurement technique on the basis of the phase measuring profilometry (fringe projection technique) is a promising instrument for the precise, non-tactile and painless recording of surface structures. A non-tactile "optical impression taking" is possible on the patient and that the CAD/CAM-production of a facial prosthesis is possible with the data taken. The advantage of this kind of measurement of the facial surface is that, in comparison to classical impression techniques with an elastic substance-which may be painful and burdening for the patient and which carries a risk of intrusion of impression material into the nasal cavities (e.g. "paranasal sinuses")-the procedure is painless and very precise. Additionally, no pressure is exposed on the tissue, so that the measurements reflect the natural facial surface.

Steps involved

Collection of 3D anatomic data using scanning techniques-

1. Computerized Tomography (CT scanning)
 - a) Magnetic Resonance Imaging (MRI Scanning)
 - b) 3D Optical Scanning
2. Generation of 3D Computer Model (Blue print) of the extra oral defect
3. Manufacture of a physical prototype:
 - a) Computer Numerically Controlled (CNC) milling
 - b) Rapid Prototyping

Computer-Aided Design and manufacture techniques have shown some promising applications in the fabrication of facial prosthesis but it is limited to the production of an intermediate wax pattern from which the definitive prosthesis is subsequently obtained through conventional procedures. In addition problems relating to the color compatibility of the facial prosthesis with surrounding tissues remain to be overcome [16,20]. The development and evaluation of these advances continue. It can be anticipated that future developments may include direct fabrication of high precision computer designed definitive facial prosthesis without the need to produce an intermediate wax pattern and a color map of the definitive prosthesis by means of a spectrophotometer-assisted color calibration of the surface. With advancements in computer, electronics, and biomedical engineering technology, it may someday be possible to have an artificial eye that can provide sight as well. Work is already in progress to achieve this goal, based on advanced microelectronics and sophisticated image recognition techniques. Though it may take several more years before prosthesis will both look and see just like a natural eye, a Canadian company is developing an artificial eye that will be connected either to the optical nerve or directly to the visual cortex. This eye consists of a rubbery lens that can change focus, a high-precision color processing

system, and microscopic photo-receptors that sense the presence of objects and pick up motion [8,9,11].

Researchers at MIT and Harvard University are also developing what will be the first artificial retina. This is based on a biochip that is glued to the ganglion cells, which act as the eye's data concentrators. The chip is composed of a tiny array of etched-metal electrodes on the retina side and a single sensor with integrated logic on the pupil side. The sensor responds to a small infrared laser that shines onto it from a pair of glasses that would be worn by the artificial-retinal recipient.

Complication in fitting anophthalmic socket

Ptosis: Superior eyelid ptosis is a frequent problem in the restoration of an anophthalmic patient [15,16,18].

Pseudoptosis: Due to the loss of volume between the implant and the lids after removal of the eye. If the physiological function of the eyelids is intact, correction of Pseudoptosis is achieved by increasing the volume of the prosthesis in the socket. This condition usually occurs whenever a small, poorly fitted prosthesis is used. A simple technique of correcting Pseudoptosis is to make a larger prosthesis that will thrust forward and separate the eyelids.

Persistent ptosis: requires modification of the ocular prosthesis to correct for a deficient levator muscle, which causes the upper eyelid to droop. Attempts aimed at increasing the size of the ocular prosthesis, as seen in Pseudoptosis, will not correct the problem in persistent ptosis. The tension on the superior lid forces the larger prosthesis downward, thus depressing the lower eyelid, deflecting the gaze downward and creating patient discomfort. A thin transparent shelf can be made across the front surface of the eye to hold the upper eyelid at the desired open position. The shelf is 3 mm to 4 mm wide and is placed along the upper limbus. This modification of the prosthesis works well for ptosis caused by a superiorly migrated, large, spherical implant with limited socket space between the implant and the upper eyelid. The major drawback to the shelf is that eye cannot blink or close. The weight of the upper eyelid and the action of the orbicularis muscle may press the eye downward. This may be corrected by adding material to the inferior tissue surface of the prosthesis to contour it backward and upward. The surface above the shelf can be reduced to decrease the weight of the prosthesis and to create space for a tight upper eyelid.

Ectropion: Inferior displacement of the implant can lead to the loss of the inferior fornix and cause ectropion of the lower lid. Patients have difficulty with retention of the prosthesis, since it has a tendency to slip down and out over the everted lower lid. This is rectified by extending a thin lower edge that will press downward upon the tarsus, and rotate it into a more vertical plane, thus creating a lower fornix. The lower edge should be rounded and at least 1 mm in thickness so it will not cut into the socket. The lower fornix will deepen within minutes of modification, and insertion of the prosthesis and retention will improve.

Sagging lower eyelid: The weight of the prosthesis and the contraction force of the upper eyelid on the prosthesis can cause a downward displacement of the lower eyelid, causing it to droop.

Degenerative disease may also weaken the lower eyelid, causing it to droop. By removing resin from the mid inferior margin of the prosthesis, downward pressure against the middle of the lower fornix is relieved. Wax is added to extend the nasal and temporal aspects of the inferior margin to create pressure in the medial and lateral areas

of the lid. This directs the weight of the prosthesis where the lower eyelid is strongest, near the palpebral ligaments. These modifications tilt the tarsus of the lower eyelid favorably so that the eyelid margin is elevated.

Conclusion

The goal of any prosthetic treatment is to return the patient to society with a normal appearance and reasonable motility of the prosthetic eye. The disfigurement resulting from loss of eye can cause significant psychological, as well as social consequences. However with the advancement in ophthalmic surgery and ocular prosthesis, patient can be rehabilitated very effectively. The maxillofacial Prosthodontist should provide prosthetic treatment to the best of his ability and should also consider psychological aspects and if necessary the help of other specialist should be taken into consideration.

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