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Review Article

Ocular Prosthesis: A Next Generation Cosmetic Management by an Eye for an Eye

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Abstract

An ocular prosthesis is an artificial eye that replaces an absent natural eye following an enucleation, evisceration or orbital exenteration. The prosthesis fits over an orbital implant and under the eyelids that covers the structures in the eye socket. It is a non-optical device designed only to improve the cosmesis of an individual with anophthalmic socket or disfigured eye. A normal facial appearance is one of the inherent human traits, if any changed or lost challenges physical, social, mental well-being, self-confidence and psychological influence on the affected people. The loss of an eye is a severe psychological trauma with negative impact on the quality of life of the patient. It is quite challenging to restore the normal look of the patient for bringing him to normality in society. In this view, an ocular prosthetic eye helps to improve the quality of life, satisfaction and appearance of affected eye to any injury or disease of the patient. It is given to uplift the patient's behavioral, mental status and improve the confidence especially in children.

Today, most artificial eyes are made of medical grade plastic acrylate (polymethyl methacrylate material) with an average life of about 2-3years depending upon the way that people use it. It is commonly known as "Device or Scleral Shell or Glass Eye or Fake Eye". The children require more frequent replacement of the prosthetic eye due to rapid growth changes in the eye. The construction of an ocular prosthesis in the case of congenital and acquired anophthalmia differs in etiology but many concepts of management for a child are the same as for an adult. An early intervention with ocular prosthesis can stimulate orbital growth and prevent facial asymmetry.

Objectives:

- To describe a custom fitting, clinical characteristics of ocular prosthesis and their incidence over the years.
- To analyze the basic &types of ocular prosthesis, treatment, complications, post-rehabilitation care as well as the emphasizing on their impact on quality of life.

Keywords: Ocular prosthesis; Prosthetic eye; Artificial eye anophthalmia; Malformation; Polymethyl methacrylate; Enucleation; Evisceration; Conformer

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Introduction

The sensory organs play a significant role in our daily lives, specifically eyes help for communication, movement, perception and physical attraction [1]. The any disfigurement associated with absence of an eye can cause significant physical and emotional problems [2]. The loss of an eye may be caused due to congenital defect, severe trauma, tumor, painful blind eye, sympathetic ophthalmia (granulomatous uveitis) or the need for histological confirmation of a suspected diagnosis [3]. The surgical procedures in the removal of an eye can be broadly classified as an evisceration (the contents of the globe are removed leaving the sclera intact), enucleation (the entire eyeball is removed after severing the muscles and the optic nerve) and exenteration (the entire contents of the orbit including the eyelids & the surrounding tissues are removed [4]. The rehabilitation of the patient who has suffered the psychological trauma of an ocular loss requires a prosthesis that will provide the optimum cosmetic and functional result [2]. The etiology of inherent ocular deformities could be because of hereditary changes, maternal nourishment deficiency mainly vitamin A, and maternal contamination during pregnancy [5-7]. Among all the eye defects, the condition called phthisis bulbi, demands a major place in and around the world. It is a condition where the eye becomes unsightly, small, shrunken and non-functional but has not deteriorated to a condition that requires evisceration or enucleation. Artificial prostheses should be provided as soon as possible to improve the spirit and ease of mind of the afflicted patients and re-instate them to acceptable normality [8].

Today, the majority of ocular prosthesis worn by the patients is made out of acrylic materials. Several approaches, techniques & innovative research have been used for fabrication and well-fitting of the prostheses. The empirical fitting stock eye & its modifications by making the impression of the defected eye socket and custom eye technique are the most commonly used techniques worldwide [9,10]. In addition, the an ophthalmic individuals have concern associated with the general well-being, issues associated with employment, maintenance of the prosthesis and concerns associated with monocular implications such as depth perception and reduced visual field [11-13]. These elements can potentially influence the patient's satisfaction. The frequent complications faced by ocular prosthetic users are lagophthalmos, watering, mucous discharge and reduced motility of prosthesis [14,15].

Materials & Method

The literature search was performed using following these headings & sub-headings such as Ocular Prosthesis, Artifical Eye, Ocular Implant, Bionic Eye, Orbital Prosthesis and its combinations. The literature search include 56-publications from Pubmed, Google Scholar, Research Gate, J-Gate, Crossref, Academia, world Cat, Publons, Scilit, ICMJE & CORE search engines have been reviewed.

History of Ocular Prostheses

In 2613-2494 B.C

The evolution of ocular prostheses in accordance with popular belief, the first artificial eyes were made by the Egyptians "A golden age of the Old Kingdom of Egypt Dynasty IV" lasted from c. 2613-2494 B.C. These ancient civilizations such as the Babylonians and the Samarians most likely have also used the art of artificial eyes in their statues and mummification practices using precious stones, silver or metal [16-19].

In 2900-2800 BC

The world's oldest prosthetic eye was discovered in Iran's "Burnt City" in 2006. Archaeologists determined that this eye is from approximately 2900-2800 BC and was found still embedded in the eye socket of a woman's skull of 28-32 years [20,21]. It has a hemispherical form and a diameter of just over 2.5 cm, it consists of very light material, probably bitumen paste [22]. This prosthetic eye should be considered as the first ocular prosthesis in the medical history. At first, it seems that designing the eye was associated with aesthetic aspects [23].

Ocular Prostheses: The Future of Looking Back

The Dawn of Modern Prostheses (1561)

Ambrose Pare of Paris published a book describing two types of ocular prostheses; one that was placed under the eyelid, named hyplepharon and the other situated on the outside celepharon [24]. Ambrose Pare, a French dentist is considered to be the pioneer of modern artificial eyes. A hypoblephara eye was designed to be used above an atrophic (shrinkage) eye, as enucleation was not a common practice until the middle of the 1800s. He used glass and porcelain to fabricate artificial eyes [25].

In the 19th Century

A German craftsmen (later coined Ocularists) began to tour the United States and other parts of the world, setting up for several days at a time in one city after another where they fabricated eyes and fit them to patients. In the United States, eyes continued to be made of glass until the onset of World War II, when German goods were limited and German glass blowers no longer toured the United States. The United States military, along with a few private practitioners, developed a technique of fabricating prostheses using oil pigments and plastics. Since World War II, plastic has become the preferred material for the artificial eye in the United States [26-28].

In 1849

At the beginning of 19th century, France became the center for the fabrication of ocular prostheses. It was only in 1849, thanks to Boissonneau, that the term ocularist came to be. Boissonneau was producing glass eyes that were quite popular in Europe and America [29].

In 1853: Peter Gouglemann, Boisonneau's student, founded a studio dedicated to ocular prostheses in 1851, in New York. During the Second World War, the glass shortage brought on the use of acrylic, used most typically in dentistry and methyl methacrylate [1].

In 1853: Ludwig Muller Uri used a new material and a new method to make glass eyes for human patients. These doll eyes had a human appearance. He developed a unique method that could colour the iris. His nephew, Friedrich A. Muller is credited for developing the double glass prosthesis [1].

In the 20th Century

The American Society of Ocularists was formed in 1957; the refinements of ocular implants and surgical procedures have greatly improved the end results that ocularists can achieve. Many breakthroughs and improvements have been made in the last five decades, both in terms of material and technique. Present day ocularistry has evolved through the invention and technique of many individuals. The absence of ocular content may

be congenital or acquired due to surgical removal which can be indicated in several cases such as traumas, cancer, microphthalmos, endophthalmitis and suprachoroidal hemorrhage [30-33]. The ocular defects can be corrected by prostheses which have many functions such as restore the esthetic, prevent eyelid deformation, protect the anophthalmic cavity, orientate the lacrimal flux; and avoid its accumulation in this cavity [34]. Furthermore, the ocular prosthetic rehabilitation is associated to psychosocial improvement, once the prostheses are able to influence positively the interpersonal relations, which leads to a positive impact on the quality of life.

In the 21st century: The Next Generation Artificial Eyes

Most ocular prostheses made today are in the shape of a half shell and are placed on top of an ocular muscle implant. Towards the end of the 1940s and early 1950s, many types of implants were developed. Despite the demonstration of excellent mobility in these implants, the majority would lead to necrosis, an infection or exposure, which ultimately would lead to their removal [35]. The first materials used in order to make these implants were glass, plastic, cartilage and silicone [36-38]. This material is biocompatible, non-toxic and contains pores that are of 500µm in diameter. This structure would allow tissues to grow within the implant, which would substantially diminish the possibility of migration [39,40]. These days, spherical and porous implants are gaining popularity. The several techniques have been used in the fabrication and fitting of the artificial eyes such as fitting a stock eye, modifying a stock eye by making an impression of an ocular defect, and the custom eye technique. Custom eye prosthesis provides more esthetic blending and precise match of the sclera and iris of the contralateral eye. Although the procedure for fabricating a custom eye prosthesis is a time consuming trial and error approach, the esthetic and functional results justify the extra effort [16,41-43]. Various techniques such as grid attached to spectacles, grid graph, pupillometer; and Benson visual judgment were used in the past for pupil alignment [44]. However, these pupil locator techniques are difficult to stabilize well and subjective.

The custom-made eye prosthesis is fabricated using a digital image using digital statutory liquidity ratio camera and iris positioning was done using pupil alignment technique to enhance the natural esthetics and accuracy of the ocular prosthesis [45]. The literature reported various artificial eyes based on the material used for fabrication and variations in the reform eye [46].

A Digital Prosthetic Eye

Today's prosthetic eyes look very realistic. The healthy eye moves naturally, the prosthetic eye has no or limited movement, creating a misalignment that many wearers find disfiguring. A digital prosthetic eye serves as a sense organ of sight and adds to the beauty of the face. The prosthesis, made from a plastic acrylic, is digitally matched in size and color to the patient's remaining natural eye [47]. There are several conditions such as congenital defects, irreparable trauma or tumors leading to surgical intervention and unfortunate loss or absence of the eye [48]. A multidisciplinary team approach & management are essential in providing accurate and effective rehabilitation of the ocular defect [49]. The eye is a vital organ not only enabling sight but also because it is indispensable element of facial expression. The loss of an eye has an important impact on an individual's self-esteem, equally affecting social and professional interactions [50]. Cosmetic rehabilitation with custom made ocular prostheses gives such individuals social and professional acceptance and mitigates problems of re-integration in society. For centuries, ocularists and eye surgeons have worked together to try to create an artificial eye as close to a realistic one as possible. Several researchers have proposed ideas to solve this problem. However, none of these inventions has shown real success so far.

Dr. Jeremiah Tao, a professor of ophthalmology and Ian G. Harris, a professor of computer science help to design a new type of prosthetic. They hypothesized that digital micro-screen technology, widely used in smart phones and smart watches could be coupled with algorithms that track pupil movements. In this way, they could achieve a more dynamic ocular prosthetic, one that moves in synchrony with the healthy eye. Moreover, Organic Light-Emitting Diode (OLED) technology allows for single-layer screens that are thin, flexible and lightweight enough to be trimmed and shaped on an ocular shell. They found that the neural network captured pupil location with high accuracy and allowed the prosthetic eye to move with the same amplitude and velocity as the natural, tracked eye. The work still needs to be done to make the digital eye look more realistic, but Tao and Harris believe their real-time image processing in tandem with the neural network may lead to viable next-generation eye prosthesis for patients [51].

Retinal Prosthesis: Bionic Eye

The U.S. Food and Drug Administration approved the bionic eye in (February, 2013) for use by individuals with end-stage retinitis pigmentosa. The artificial retina, dubbed the Argus II Retinal Prosthesis System (developed and manufactured by Second Sight Medical Products Inc., Sylmar, Calif.) may prove to be an aid to those blinded by the disease retinitis pigmentosa. The Argus II can partially restore the sight of blind individuals after surgical implantation. It operates by using a miniature camera mounted in eyeglasses that captures images and wirelessly sends the information to a microprocessor (worn on a belt) that converts the data to an electronic signal and transmits it to a receiver on the eye. The pulses travel to the optic nerve and, ultimately, to the brain, which perceives patterns of light and dark spots corresponding to the electrodes stimulated. Blind individuals can learn to interpret these visual patterns [52].

World's First Spherical Artificial Eye has 3D Retina

Scientists have developed the world's first 3D artificial eye with capabilities better than existing bionic eyes and in some cases, even exceed those of the human eyes, bringing vision to humanoid robots and new hope to patients with visual impairment. The key feature allowing such breakthroughs is a 3D artificial retina made of an array of nanowire light sensors which mimic the photoreceptors in human retinas. Prof. FAN Zhiyong and Dr. GU Leileihave developed a connected the nanowire light sensors to a bundle of liquid-metal wires serving as nerves behind the human-made hemispherical retina during the experiment, and successfully replicated the visual signal transmission to reflect what the eye sees onto the computer screen.

In the future, those nanowire light sensors could be directly connected to the nerves of the visually impaired patients [53].

Eye Print Prosthetic (EyePrintPRO): Prosthetic Scleral device

The EyePrintPRO is an optically clear, prosthetic scleral device designed to match the exact scleral contours of a patient's individual eye which is unique like a fingerprint. Developed to address the most significant of elevation differences on an ocu-

lar surface, the EyePrintPRO accommodates patients with the most severe ocular disease, trauma, and/or ocular elevation differences. Through the rotational stability, enabled by this custom fit, the EyePrintPRO also features advanced optics, like optical prism in any direction, a fully customizable multifocal and decentered optics. For most patients, this results in superior vision, a more comfortable fit, and translates into longer wear time [54].

Application of Ocular Prosthesis

Ocular prosthesis is an artificial eye, which is implanted in patients who have lost their eye due to various causes such as Trauma, Surgery, Cancer or in patients with shrunken damaged eyes (Pthisical Eyes), congenital absence (Anophthalmos), corneal scar or abnormally small sized eyes (Microphthalmos) with no visual potential. Prosthetic eye implant is recommended after an eye is surgically removed due to damage or disease. This implant supports proper eyelid functioning.

There are Three Main Surgical Methods used for Partial or Complete Removal of the Eye

Evisceration: The jelly-like material inside of the eye is suctioned out. But the procedure preserves tissues in the outer eye & eye socket (orbit) including sclera, extraocular muscles and optic nerve.

Indications:

- Chronic Uveitis
- Neovascular Glaucoma
- Corneal Perforation
- Endophthalmitis

Enucleation: The entire eye (the globe-like eyeball) is cut away along with portion of optic nerve and removed from the eye socket while maintaining the surrounding orbital tissues.

Indications:

- Intraocular Malignancy e.g. Retinoblastoma, Uveal Melanomas
- Phthisical Eye
- Ruptured Globe/Orbit/Eyeball

Exenteration: It is a procedure involving removal of all the tissues within the entire globe and its surrounding structures including the extraocular muscles, orbital fat, optic nerves, conjuctiva and eyelids.

Indications:

- Malignant Cancer (e.g. Eyelids, Conjuctiva, Intraocular Structures)
- Orbital Tumor

Basics of Ocular Prosthesis

There are several methods of fitting an artificial eye. Many years ago stock eyes or ready-made eyes were fit by trying different shapes into the socket until a satisfactory lid opening was achieved. This method required the fitter to have a large selection of stock eyes on hand to simulate the patient's iris color and fill the shape requirements with the iris in the right position [55].

Procedure

The bio-eye ocular implant is surgically placed within the orbit at the time the eye is removed and the tissues are closed over the implant. A temporary conformer is then placed over the implant and under the eyelids to maintain the space for the artificial eye. The artificial eye fits over the implant and under the eyelids and will move as the implant moves or "tracks" along with the natural eye. If further movement is desired, your eye care specialist can perform a simple procedure to connect the artificial eye to the implant by means of a peg. In this optional procedure, a hole is placed in the implant and a peg is inserted into the hole. The final results in each case will vary depending on the condition of the orbit, muscles, surrounding tissues and the skill of the ophthalmologist, optometrist and ocularist.

Materials

The material used is similar to that used for taking dental impressions and the process takes only a few minutes. This procedure is not painful although some patients experience slight discomfort from the pressure of the material filling the socket. The hydroxyapatite and human bone are the main material and the natural choice. A remarkable similarity is noticed between the porous structure of certain coral species and human bone. The mineral in coral is match to that of human bone known as hydroxyapatite. This is new natural derived material has both the porous structure & the chemical structure of bone. Thus, the tissues of the body will accept even grow into this naturally derived hydroxyapatite implants, stability, decrease rejection risk and essentially become a living part of the body.

Common Used Materials

a. Porous e.g., Polyethylene, Hydroxyapatite, Aluminum Oxide

b. Non-Porous e.g. Silicon & Polymethyl Methacrylate (PMMA)

Types of Ocular Prosthesis

Artificial eye (Reform Eye)

The artificial eye is a curved disc of plastics having a centre thickness of 2 mm or greater. It is fitted to replace the lost volume of the socket and to restore natural appearance and movement.

Shell Eye

The shell eye is a curved disc of plastic having a centre thickness of less than 2 mm. It is similar in nature and appearance to a scleral contact lens. It usually covers a disfigured or cosmetically undesirable eye. The device is worn over the eye tissue and extends over the sclera as well.

Cosmetic Shell

The Cosmetic shell is case of disfigured eye only, if there is no danger to the patient in the retention of the sightless eye. It is extensively used after evisceration. It is made of acrylic and it is lighter and thinner than the artificial eye.

Corneal Prosthetic Lens

The corneal prosthetic lens is a rigid contact lens the approximate size of the iris of the natural eye. This lens is colored to match the iris of the natural eye. Its purpose is to cover a deformity of the iris, cornea or anterior segment of the eye. The

application can incorporate optics and a clear pupil as needed.

Scleral Shells

A scleral shell is an ocular prosthesis that is worn over an existing eye. Typically, one who is a candidate for a scleral shell has a blind phthisical eye. The shell fits like a large contact lens, covering the whole front surface of the eye globe. It moves along with the existing eye and is fit so that the eyelid openings are symmetrical.

Hydrophilic Prosthetic Lens

The hydrophilic prosthetic lens is a soft contact lens that is fit to mask disfigurement, undesirable conditions and or handle visual issues. The cosmetic outcome is to match or change the patient's natural appearance. Pupil and or iris cosmesis as well as optical prescriptions are possible.

Self-Lubricating Prosthesis

The Self-Lubricating Prosthesis (SLP) is a patented modification to a new or existing ocular prosthesis. It provides a continual release of lubricant, eliminating dry eye syndrome as well as burning and itching. These conditions are more commonly associated with prosthetic eye wearers who do not have the ability to close their eyelids over the prosthesis. The SLP has a chamber built into the prosthesis in which lubricant is stored. It slowly released on to the front surface of the prosthesis, providing moisture and comfort to the inner lining of the eyelids.

Facial Prosthesis

A facial prosthesis is an artificial device used to replace a missing or malformed facial feature. A person in need of a prosthesis may have lost a part of his or her face due to cancer, trauma, or as a result of a congenital birth anomaly.

Therapeutic Prosthesis

If a child is born with either anophthalmia (no eyes) or microphthalmia the eye socket needs to be expanded to ensure that there is no facial distortion as the child grows up. The socket is expanded by various in house means over a period of days and weeks, depending on the individual case to a point where a cosmetic prosthesis can be provided. This process needs repeating frequently to match the growth and simulate socket expansion.

Conformer

Conformers are used after enucleation to conform to the conjuctival sac formices. They should adhere closely to the socket contour and fill the depths of the formics without stretching them. Easy closure of the eyelids after the conformer is slipped into place usually indicates proper fit. Most of the conformers have 1, 3 & 5 drainage holes to allow mucoid discharge to escape and to facilitate the insertion of postoperative medication.

Processing

In the custom-made prosthesis, no one method is used for every patient & the approach will vary with the circumstances and the ocularist doing the work. From the impression of the socket, a wax model is made for the fitting of the final shape.

Fabrication

Impression: An impression of the socket is taken with an alginate material to provide the posterior (back) dimensions of the prosthesis.

Modeling: A wax model is fabricated from the impression and is sculpted to achieve the best symmetry with lid opening and direction of the remaining eye.

Painting: The prosthesis is hand painted while observing the patients companion eye. This involves matching the iris color, limbal blend, scleral tinting and veining.

Polishing and Fitting: The prosthesis is polished and fit to determine if any adjusting is necessary.

Complications

- Discharge, Dry Eye, Discomfort & Implant Exposure
- Pain, Ptosis, Lid Laxity
- Expulsion
- Adhesion
- Problem associated with peg

Discussion

The fabrication of ocular prosthesis has been known to human being since times immemorial. The application of ocular prosthesis helps to overcome many psychosocial problems; however, there are various consequences and concerns connected to the use of ocular prosthesis [12]. Multiple techniques have been developed, often transferring in fabricating and fitting artificial eyes. The ocular prosthetic rehabilitation fulfills aesthetic as well as psychological requirement of the patients. A correctly placed prosthesis should restore the normal opening of the eye, support the eyelid, restore the degree of movement and be beautiful pleasing. The ocular prostheses are either ready-made or custom-made and are produced from either glass or methyl methacrylate resin. However digital reproduction is possible now with advanced photographic methods. The close adaptation of the custom-made ocular prosthesis to the tissue bed provides maximum comfort and restores full physiologic function to the accessory organs of the eye [56].

Conclusion

An ocular prosthesis is a device put in place of a natural eye that has been destroyed as a result of injury or disease. This specialty aims to provide fellow human beings who have lost of an eye with emotional and mental assistance. While current technology doesn't allow the eye to see, it can help one-eyed patients to feel better emotional, psychological, physical and social well-being. The customized ocular prosthesis demonstrated excellent fit, mobility and comfort. The common prevalent prosthetic related issues are mild watering and discharge, which seems to be concurrent with previous studies. The excess watering and discharge can be caused if the surfaces of the prosthesis are rough and the edges are sharp. Therefore, the patients should have a yearly check-up of the prosthesis and polish the shell if needed.

Key Message

Satisfaction and comfort of one-eyed patients depends on the improvement in the quality of life and activities of daily living among prosthetic shell wearers.

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References

1. Raizada K, Rani D. Ocular prosthesis. Cont Lens Anterior Eye. 2007; 30:152-162.
2. Bartlett SO, Moore DJ. Ocular prosthesis: A physiologic system. J Prosthet Dent. 1973; 29: 450-9.
3. Nafij BJ, Theerathavaj S, Mohammad KA. A Complete Procedure of Ocular Prosthesis: A Case Report. International Medical Journal. 2013; 20:729 -730.
4. Kaur A, Pavaiya A, Singh SV, Singh RD, Chand P. A simplified approach to fabrication of an ocular prosthesis: a case series. Indian J Dent Res. 2010; 21: 615-617.
5. Verma AS, FitzPatrick DR. Anophthalmia and microphthalmia. Orphanet J Rare Dis. 2007; 2: 47.
6. Weber KA, Yang W, Carmichael SL, Shaw GM. Nutrient intake in women before conception and risks of anophthalmia and microphthalmia in their offspring. Birth Defects Res. 2018; 110: 863-70.
7. Dolk H, Busby A, Armstrong BG, Walls PH. Geographical variation in anophthalmia and microphthalmia in England, 1988-94. Br Med J. 1998; 317: 905-10.
8. Shah V, Yadav L, Singh M, Kharbanda S. Custom ocular prosthesis in rehabilitation of a child operated for retinoblastoma. Natl J Maxillofac Surg. 2015; 6: 232-6.
9. Cain JR. Custom ocular prosthetics. J Prosthet Dent. 1982; 48: 690-4.
10. Allen L, Webster HE. Modified impression method of artificial eye fitting. Am J Ophthalmol. 1969; 67: 189-218.
11. Rokohl AC, Koch KR, Trester M, Trester W, Pine KR, et al. Concerns of anophthalmic patients wearing cryolite glass prosthetic eyes. Ophthal Plast Reconstr Surg. 2018; 34: 369-74.
12. Pine NS, de Terte I, Pine KR. An investigation into discharge, visual perception and appearance concerns of prosthetic eye wearers. Orbit. 2017; 36: 401-6.
13. Pine K, Sloan B, Stewart J, Jacobs RJ. Concerns of anophthalmic patients wearing artificial eyes. Clin Exp Ophthalmol. 2010; 39: 47-52.
14. Ahn JM, Lee SY, Yoon JS. Health-related quality of life and emotional status of anophthalmic patients in Korea. Am J Ophthalmol. 2010; 149: 1005-11. e1.
15. Hatamleh MM, Abbariki M, Alqudah N, Cook AE. Survey of ocular prosthetics ehabilitation in the United Kingdom, Part 1: Anophthalmic patients' aetiology, opinions, and attitudes. J Craniofac Surg. 2017; 28: 1293-6.
16. Artopoulou II, Montgomery PC, Wesley PJ, Lemon JC. Digital imaging in the fabrication of ocular prostheses. J Prosthet Dent. 2006; 95: 327-30.
17. Gordon B. The ancient origins of artificial eyes, 3rd ed. Annuals of medical history: New York, USA. 1940.
18. Gray PH. Radiography of ancient Egyptian mummies. Med Radiogr Photogr. 1967; 43: 34-44.
19. Martin O, Clodius L. The history of the artificial eye. Ann Plast Surg. 1979; 3: 168-171.
20. Seyed Sajjadi SM, Costantini L. An artificial eye, Shahr-I Sokhta. Cultural Heritage, Tourism, and Handicrafts Organization of Sistan & Balouchestan. 2009.
21. 3rd Millennium BC. Artificial Eyeball Discovered in Burnt City Archived 2012-04-11 at the Way back Machine.
22. London Times. 5,000-Year-Old Artificial Eye Found on Iran-Afghan Border. Fox news. 2007.
23. Moghadasi AN. Artificial Eye in Burnt City and Theoretical Understanding of How Vision Works. Iran J Public Health. 2014; 43: 1595-6.
24. Pare A. Cimbrosie. Oruveres: Paris. 1561.
25. Taylor TD. Clinical maxillofacial prosthetics. 3rd ed. Chicago: Quintessence Publishing Co. Inc.; 2000; 233-76.
26. Galeski J. The Plastic Eye Comes of Age, Artificial Eye Fitting, Optical Journal Review. 1949; 36-37.
27. Hughes M. The Galeski Prosthesis. Journal of Ophthalmic Prosthetics. 1989; 1: 27-32.
28. Clyde Andrews. Journal of Ophthalmic Prosthetics Fall. 2005; 8: 37-39.
29. Boissonneau M. Yeux, artificial mobiles. Ritterich: Paris. 1849.
30. Bermejo E, Martínez-Frías ML. Congenital eye malformations: clinical-epidemiological analysis of 1,124,654 consecutive births in Spain. Am J Med Genet. 1998; 75: 497–504.
31. Goiato MC, Mancuso DN, Sundefeld MLMM, et al. Aesthetic and functional ocular rehabilitation. Oral Oncology Extra. 2005; 41: 162–164.
32. Nakra T, Simon GJ, Douglas RS, Schwarcz RM, McCann JD, et al. Comparing outcomes of enucleation and evisceration. Ophthalmology. 2006; 113: 2270–2275.
33. Zheng C, Wu AY. Enucleation versus evisceration in ocular trauma: a retrospective review and study of current literature. Orbit. 2013; 32: 356–361.
34. Perrone A, Bercini F, Azambuja TWF. Prótese ocular, revisão da literatura e apresentação de caso clínico. Rev Fac Odont Porto Alegre. 1996; 37: 13–14.
35. Johnson WJ. The perfect socket: the ocularist's view. In: S Bosniak (Ed.), Principles and practice of ophthalmic plastic and reconstructive surgery. Saunders: Philadelphia. 1996; 1127-1133.
36. Helms HA, Zeiger HEJ, Callahan A. Complications following enucleation and implantation of multiple glass spheres in the orbit. Ophthalmic Plastic Reconstr Surg. 1987; 3: 87-89.
37. Hornblass A, Herschorn BJ. Double sphere orbital implantation in enucleation and evisceration. Ophthal Plast Reconstr Surg. 1985; 1: 65-68.
38. Tyers AG, Collin JR. Baseball orbital implants: a review of 39 patients. Br J Ophthalmol. 1985; 69: 438-442.
39. Perry AC. Integrated orbital implants. Adv Ophthalmic Plast Reconstr Surg. 1990; 8: 75-81.
40. Perry AC. Advances in enucleation. Ophthalmol. Clin North Am. 1991; 4: 173-182.
41. Taicher S, Steinberg HM, Tubiana I, Sela M. Modified stock-eye ocular prosthesis. J Prosthet Dent. 1985; 54: 95-8.
42. Rao SB, Akki S, Kumar D, Mishra SK. A Novel method for the management of anophthalmic socket. Adv Biomed Res. 2017; 6: 72.
43. Benson P. The fitting and fabrication of a custom resin artificial eye. J Prosthet Dent. 1977; 38: 532-8.

44. Pai UY, Ansari NA, Gandage DS. A Technique to achieve predictable iris positioning and symmetry in ocular and orbital prostheses. J Prosthodont. 2011; 20: 244-6.

45. Shetty PP, Chowdhary R, Yadav RK, Gangaiah M. An iris positioning device and centering approach: A technique. J Prosthet Dent. 2018; 119: 175-7.

46. Sajjad A. Ocular prosthesis-a simulation of human anatomy: Assesses literature review. Cureus. 2012; 4: e74.

47. Lapointe J, Jean-Sébastien B, Kashyap R. Next Generation Artificial Eyes with Dynamic Iris. Int J Ophthalmol Clin Res. 2016; 3: 062.

48. Soares ÍP, França VP. Evisceration and enucleation. Semin Ophthalmol. 2010; 25: 94-7.

49. Mishra SK, Ramesh C. Reproduction of custom-made eye prosthesis maneuver: A case report. J Dent Oral Hygiene. 2009; 1: 59-63.

50. Doshi PJ, Aruna B. Prosthetic management of patient with ocular defect. J Indian prosthodont soc. 2005; 5: 37-38.

51. Dr. Jeremiah Tao and Ian G. Harris, Tag: https://www.ucihealth.org/blog/2021/03/digital-prosthetic-eye-for-21st-century.

52. Tag: https://science.osti.gov/Science-Features/News-Archive/Featured-Articles/2013/02-14-13

53. Leilei Gu, Swapnadeep Poddar, Yuanjing Lin, Zhenghao Long, Daquan Zhang, et al. A biomimetic eye with a hemispherical perovskite nanowire array retina. Nature. 2020; 581: 278.

54. Sah R, Pathak H. Ocular Prosthetis: Part-I. DOS Times April 2005; 10: 392-398.

55. Chattopadhyay SK, Shetty P, Sinha S. Ocular Prosthesis in Phthisis Bulbi: Patient Rehabilitation. Adv Hum Biol. 2016; 6: 108-10.