Custom made polymeric artificial eye: Appearance and characteristics of wear and care

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Abstract. A prosthetic eye may enhance the appearance of individuals who have lost sight due to injury or illness. Implanting a polymeric ocular prosthesis (POP) after an eye is surgically removed following an enucleation, evisceration, or orbital exenteration is always advised. This implant supports proper eyelid functioning as well as increasing patient confidence by restoring natural appearance. From February 2013 to January 2019, an experimental study was done on five hundred cases. The included patients experienced enucleation or evisceration procedure and had ocular prosthesis fitting. Data were entered, coded, cleaned, and analyzed using IBM SPSS statistics. A total of 500 cases completed the questionnaire. Of these, 55.8% were male, and 44.2% were female, with 50.2% of the patients lost their eyes because of injuries. In terms of operation variety, evisceration was done in 61.4% of the patients, enucleation in 37.6%, and others are in only five congenital cases (1%). According to this study, 28.8% of patients suffered from deposits formed on the prosthetic eye, while the absence of deposits was 71.2%. Significant psychological, as well as social consequences can result from the disfigurement associated with eye loss. Despite using the available materials and techniques to treat such patients, one needs to be a little creative and very inventive. Ocular prostheses act as a tool for restoring patients’ self-confidence and facilitating changes in their social convenience. Precise attention is essential to preserve the prosthesis and reminiscent of tissue health.

Key words: Polymeric ocular prosthesis, Artificial eye, Polymethyl methacrylate, Enucleation, Evisceration, Orbital exenteration.

1. Introduction

Eyes are the organ of vision, a way to the soul, the center of facial expressions, and an epitome of cosmetic appearance in human beings also play a significant role in nonverbal communication. Any sudden trauma, pathology, or congenital anomalies of the eye may require a surgical intervention, leading to eyeball loss [1]; this can negatively affect the patient physically and psychologically. The rehabilitation of a lost eye with an ocular prosthesis is a method that has a place in the field of maxillofacial prosthetics [2]. The Ocular prosthesis can trace back to the Egyptian and Roman civilizations, where artificial eyes were manufactured from noble metals and precious stones. The stock glass eyes gained popularity in Germany and other European nations in the 18 century. During the Second World War, the severe shortage of glass eyes led to dental acrylic resin as an alternative for ocular prosthesis fabrication, which was popularized by the United States Naval schools [3]. The surgical management to cure any of the conditions mentioned above may involve the following methods depending on the severity [4]. There are three types of surgical intervention; the evisceration method, where the globe's contents are removed, leaving the sclera preserved. The enucleation method, where the entire eyeball severed from the muscles and optic nerve, is more invasive. Exenteration, where the
orbit's exclusive contents removed, eyelids and the surrounding tissues may or may not be involved [5].

Surgeries can cause defects to the eye that has functional as okay aesthetical challenges to the patient. These defects can be treated by custom-made ocular prostheses, which would enhance the self-confidence, mental status, and acceptance of the patient. One of the ocularist challenges is to manufacture a prosthetic eye similar to the natural eye by size, color, orientation, and contour [6]. An ocular prosthesis is either readymade (stock) or custom made. This prosthesis can make either from glass or methyl methacrylate resin PMMA. Glass is not the material of choice because it is brittle and delicate. Interaction with orbital fluids deteriorates the surface, resulting in a life expectancy of 18 to 24 months. [7]. The methyl methacrylate resin usage is considered superior for ocular prosthetic materials: tissue compatibility, lightweight, better fracture-resistant resistance, transparency, easy fabrication, easy adjustability, and capability for intrinsic and extrinsic coloring [8]. Some of the essential benefits of PMMA ocular prosthesis are that they precisely meet the patient's needs. The possibility of making infinite modifications, exceptionally impact-resistant material, is comfortable to wear due to their low thermal conductivity. They are suitable for individuals with an active lifestyle or patients with affected eyelids. There have been reported some side effects arising from PMMA, but its use has far overcome its negative features, therefore study and examine 500 polymeric, artificial eye wearers in Iraq. The results show the effect of fabrication precision of the custom-made polymeric, artificial eye on patient's psychological well-being. The custom-made polymeric ocular prosthesis gives a life-like appearance hence help the wearer to better integrate with society.

2. Materials and Methods

2.1. Materials

We select five hundred cases from the following institutions: (Ibn AL Haytham optical clinic, Majeed Raheem Jaber AL-shuwaili; specialist in animated artificial eyes (UK) optician (UK), Association of British dispensing opticians, Baghdad- Al-Karrada.)

From February 2013 to January 2019, an experimental study at Ibn Al-Haytham hospital holds five hundred cases. The patients under consideration experienced enucleation or evisceration procedure had ocular prosthesis fitting. A simple anonymous questionnaire completed confirming a 100% completion rate. The questionnaire contained necessary information such as age, gender, and marital status. The questionnaire also evaluated patient attributes like the cause of eye loss (injury, tumor, congenital anomalies, others), duration of wearing an ocular prosthesis, cleaning frequency (once every 2 months, once every 3 months, once every 6 months), and other people's response.

We divide the variables into three groups: Personal variables such as age, gender, and marital status included in the first. Surgical variables included in the second such as the type of operation. The latter included prosthetic variables, including a period of wearing an ocular prosthesis, symptoms that the patient may suffer from (ocular discharge, foreign body sensation, tearing, and pain), and patient satisfaction.

The following steps can fabricate the custom-made polymeric ocular prosthesis (POP): Primary impression made with irreversible hydrocolloid material. The syringe was attached to the special tray by a hole at the center of the tray. The impression material then injects into the socket. As the material is injected, the patient is informed to make different eye movements to get the available form impression. After setting the material, the impression is taken from the eye socket and tested to check all the details. The lower part of the impression dipped by pouring a two-piece dental stone cast. After setting of the stone, the surface cover with separating media. Then a second layer ran. Next, the molten wax was poured into the impression to form the wax pattern to replicate the missing eye; the wax pattern was correctly contoured and carved. The wax pattern was examined and checked into the patient's socket. Iris position was determined by contralateral iris as a reference using modified eyeglass with makings. The patient asked to sit upright and look straightforward. The prefabricated stock eye is used to select the size and color of the iris portion. Iris portion cut from the chosen stock eye. One can do a second try using a wax pattern with an iris desired button. The iris portion's final wax pattern was flaked, dewaxed,
and packed using heat cure acrylic resin—curing and polishing scleral with iris button done. Fine red fabric threads are mounted on the scleral painting to resemble the natural eye's blood vessels; however, to retain the blood vessel fibers in place, the entire scleral section is coated with monomer polymer syrup and allowed to set up. Over the sclera's surface, a thin wax layer was applied to produce a clear acrylic place, which gave a realistic appearance. Flacking, dewaxing, packing and curing the scleral body carried out using heat cure acrylic resin. When healing is done, the prosthesis is finished, polished, and inserted into the patient's eye [9] (Fig.1).

Figure 1. a) Impression of the socket; b) Fabricated wax pattern; c) Wax patterns with iris buttons; d) Dewaxing and packing with acrylic; e) Final finished polymeric prosthesis.

2.2. Data management

Results are entered into a Microsoft Excel spreadsheet (Microsoft office 2013) on a personal computer. Data were entered, coded, cleaned, and analyzed using the IBM SPSS statistic (version 20). Frequency and percentages were used for qualitative variables.

3. Results & Discussion

Lack of eye content can be congenital or acquired [10] because of surgical intervention, which can indicate in several different cases, like cancer, trauma, endophthalmitis, and a blind eye. Although reports suggest inherited and environmental causes, such as genetic mutations [11], it is still unclear about congenital eye defects' etiology. Maternal inadequacy of nutrition, primarily vitamin A, see [12]. Infections during pregnancy [13] are the most common forms. However, anophthalmia and microphthalmia characterized the absence of ocular tissue inside the orbit, and smaller than the general population's average size [11], they can affect one or both eyes [14]. Three forms of surgery can cause acquired ocular defects. Evisceration is a surgical procedure that removes all intraocular contents. Simultaneously, keeping the scleral shell, extraocular muscle attachments, and orbital adnexa surrounding it. Enucleation, which is the removal of the entire eyeball keeping the nearby structures within the orbit. Finally, Exenteration is a surgical operation that involves removing the whole globe and its surrounding structures, which includes muscles, fat, nerves, and eyelids (outer parts dependent on the pathological causes) [15]. A total of 500 patients included in this work consisted of 78 children (15.6%), 78 adolescents (15.6%), and 344 adults and elderly (68.8%), with 279 (55.8%) male and 221 (44.2%) female. The subjects' mean age was 32; among the personal variables' marital status, 232 (46.4%) were single, and 268 (53.6%) were married, as detailed in Table 1.

Table 1. Classification of study participants concerning personal variables.
Regarding the causes of anophthalmos, the injury was the highest, 251 (50.2%) of the patients lost their eyes because of injury, tumor 22 (4.4%), congenital anomalies 31 (6.2%), other causes 196 (39.2%) (Fig 2).

| General information | No. | %     |
|---------------------|-----|-------|
| Gender              |     |       |
| Male                | 279 | 55.8  |
| Female              | 221 | 44.2  |
| Marital status      |     |       |
| Single              | 232 | 46.4  |
| Married             | 268 | 53.6  |
| Mean age            |     |       |
|                     | 32  |       |
| Age group           |     |       |
|                     | 3-13| 15.6  |
|                     | 14-20| 15.6 |
|                     | 21-88| 68.8 |

**Fig. 2.** Classification of study participants for the cause of eye removal

In terms of operation variables, the types of operation were:
- Evisceration in 307 patients (61.4%).
- Enucleation in 188 patients (37.6%).
- Others are in only five congenital cases (1%).

241 (48.2%) of the patients had the operation on the right eye. In comparison, 254 (50.8%) had operated the left eye, and only 5 (1%) had the procedure in both eyes; only 167 (33.4%) of patients had the process in their dominant eye, as shown in Table 2.
Table 2 Classification of study participants concerning their operation properties.

| Operation properties       | No. | %    |
|---------------------------|-----|------|
| Injury                    | 251 | 50.2 |
| Tumor                     | 22  | 4.4  |
| Cause of eye removal      |     |      |
| Injury                    | 251 | 50.2 |
| Tumor                     | 22  | 4.4  |
| Congenital anomalies      | 31  | 6.2  |
| Others                    | 196 | 39.2 |
| Evisceration              | 307 | 61.4 |
| Type of operation         |     |      |
| Enucleation               | 188 | 37.6 |
| Others                    | 5   | 1    |
| Right                     | 241 | 48.2 |
| The enucleated eye        |     |      |
| Left                      | 254 | 50.8 |
| Both                      | 5   | 1    |
| Was it the dominant eye   |     |      |
| Yes                       | 167 | 33.4 |
| No                        | 333 | 66.6 |

Some studies have shown that evisceration surgery is favorite in severe trauma cases. While in advanced stages of intraocular malignancy, enucleation is used [18]. Besides, psychosocial improvement is associated with ocular prosthetic restoration because it positively impacts life quality [16, 17].

The study found out that 496 (99.2%) patients depend on themselves for movement, while only 4 (0.8%) don’t. Less than half of the participants in this study (43%) are using protective glasses, as shown in Fig.2 and 329 (65.8%) of the patients mention that they use lubricant eye drops, as shown in Fig.3

Figure 3. Classification of study participants with respect to wearing protective glasses.
Just (24.6%) of patients were prepared to adapt with eye loss, while 75.4% did not. Regarding the period of wearing an ocular prosthesis, three patients (0.6%) have been wearing it for less than six months, 68 patients (13.6%) between 6 and 12 months, five patients (1%) between 1 and 2 years, and 424 patients (84.4%) for longer than two years as shown in Fig.5

All 500 patients stated that during sleep, they generally kept their ocular prosthesis in their eyes. As to the managing of the ocular prosthesis, 422 (84.4%) of the patients clean their ocular prosthesis every six months, 49 (9.8%) clean their ocular prosthesis every three months, and 29 (5.8%) clean their ocular prosthesis every two months. 144 (28.8%) of the patients said deposits formed on the prosthetic eye and absent of deposits formation in 356 (71.2%). Considering the satisfaction of surgical outcomes, the percentage of "satisfied" was the highest inpatient satisfaction, as detailed in Table 3. Results satisfactory in POP need manufactured to meet an individual patient needs [19-20]. Using heat-polymerizing acrylic resin materials with good dimensional stability will help achieve adequate retention, the safety of the remaining tissues, and excellent esthetics during use to enhance the patient's psychological and social acceptance [21-22]. The patient's acceptance of eye prosthesis can improve by improving the prosthesis movement and the eye prosthesis development [23-24]. Custom POP has many benefits comprising an excellent indication of the eyelids, better fit and comfort, and improved esthetics obtained from regulating the size of the iris, pupil, and color of the iris and sclera [27,28]. On the other hand, the stock prosthesis is available in regular sizes, forms, and shades; they have the potential drawbacks of poor fit, poor esthetics, and downward eye movements [25, 26,29].
Table 3. Classification of study participants for general results (n=500).

| General results                                  | No. | %    |
|-------------------------------------------------|-----|------|
| Patient depend on him/herself in movement       |     |      |
| Yes                                             | 496 | 99.2 |
| No                                              | 4   | 0.8  |
| Received training to adapt with eye            |     |      |
| Yes                                             | 123 | 24.6 |
| No                                              | 377 | 75.4 |
| Wearing O.P during sleep                        |     |      |
| No                                              | 0   | 0    |
| Small                                           | 0   | 0    |
| Large                                           | 0   | 0    |
| Size of artificial eye used                     |     |      |
| Suitable                                        | 500 | 100  |
| Do not use                                      | 0   | 0    |
| Stopped to use                                  | 0   | 0    |
| Color matching of artificial eye with original eye |     |      |
| Suitable                                        | 500 | 100  |
| Not suitable                                    | 0   | 0    |
| Deposits build up on the eye                    |     |      |
| Present                                         | 144 | 28.8 |
| Absent                                          | 356 | 71.2 |
| Ocular discharge                                | 500 | 100  |
| Symptoms                                        |     |      |
| sensation                                       | 0   | 0    |
| Tearing                                         | 0   | 0    |
| Pain                                            | 0   | 0    |
| Very satisfied                                  | 0   | 0    |
| Satisfied                                       | 494 | 98.8 |
| Dissatisfied                                    | 6   | 1.2  |
| Very dissatisfied                               | 0   | 0    |

Discharge is the second most important concern of the patient. Discharge frequency is considered the most crucial feature of eye prosthesis comfort wearing [30, 31]. 47% of the ocularists indicated that mucoid discharge might cause by surface deposits that build upon the prosthetic eye, 29% by excessive prosthesis handling, and 24% by other factors, such as dust and dirt in the socket [31]. Nearly all patients complained of ocular discharge in this study, and it was the most frequent symptom.

It is necessary to realize that the needs for effective ocular prosthesis treatment are multifaceted. The clinician must consider clinical performance metrics from the care staff's point of view and be attentive to patients' psychological reactions to treatment. Patients' expectations of eye prosthesis in esthetics, comfort, and fit affect their level of compliance with wearing the prosthesis [32, 33].

4. Conclusion

The polymeric ocular prosthesis has many benefits for individuals who lose one or both eyes, such as proper facial function and physical appearance. The loss of any part of the face inflicts both physical and psychological trauma to the patient. Ocular disorders can be congenital or developed and may cause an undesirable psychological effect that reflects right on the quality of life. Significant psychological and social consequences can result from the disfigurement associated with the loss of an eye. Ocular prostheses act as a tool for restoring patients' self-confidence and facilitating changes in their social convenience. This study recruited five hundred participants from a single eye clinic (Ibn AL Haytham Optical). The study found that 279 of the study participants were males, and 221 were females. However, the injury was the most common cause of eye removal; more than half of the patients had evisceration, 241 had enucleated the right eye, while 254 had enucleated the left eye. Only 5 of them had the patients who had enucleated both eyes. Four hundred ninety-six of the patients stated that they depend on themselves in movement. Only 144 patients notice deposits buildup on the artificial eye.
References

[1] Khungar PN, Mistry RA, Pisulkar SK, Dahane TM, Borle AB, Godbole SD, (2020) Prosthetic rehabilitation of an ocular defect—a case report. Medical Science. 24(103):1061-6.

[2] Taylor TD, (2000). Clinical maxillofacial prosthetics. Quintessence Publication Co. Inc, Illinois.

[3] Barman J, Rahman R, Bhattacherjee S, (2020). Prosthetic rehabilitation of an ocular defect with custom made ocular prosthesis: A case report. IP Int J Maxillofac Imaging. 6(1):20-3.

[4] Kaur A, Pavaiya A, Singh S, Singh R, Chand P, (2010) A simplified approach to fabrication of an ocular prosthesis: A case series. Indian J Dent Res. 21(4):615-36.

[5] Beumer J, Zlotolow I, (1996). Restoration of facial defects. In: Beumer J, editor. Maxillofacial Rehabilitation—Prosthetic and Surgical Considerations. St. Louis, Mo, USA: Mosby; pp. 350–364.

[6] Lanzara R, Thakur A, Viswambaran M, Khattak A, (2019). Fabrication of ocular prosthesis with a digital customization technique – A case report. J Fam Med Prim Care. 8(3):1239.

[7] Verma N, Saxena A, (2016). Rehabilitation of eye defect with customized ocular prosthesis: A Case Report. Int J Oral Health Med Res. 3(2):38-41.

[8] M.Krishna, Abhijita Mohapatra, Gopal Krishna Choudhury, (2019). Prosthetic Rehabilitation of Ocular Defect: A Case Report 10.5958/0976-5506.02690.1

[9] A Meenakshi, TS Pradeepa and Shruti Agarwal, (2019). Prosthetic rehabilitation of an ocular defect: A case report, Int. J. Appl. Dent. Sci. 5(1):188-190.

[10] Bermejo E, Martínez-Frias ML. Congenital eye malformations: clinical-epidemiological analysis of 1,124,654 consecutive births in Spain. Am J Med Genet. 1998 Feb 17;75(5):497–504.

[11] Verma AS, Fitzpatrick DR, (2007 Nov). Anophthalmia and microphthalmia. Orphanet J Rare Dis. 26; 2:47.

[12] Weber KA, Yang W, Carmichael SL, et al (2018). Nutrient intake in women before conception and risks of anophthalmia and microphthalmia in their offspring. Birth Defects Res. 110(10):863-870.

[13] Dolk H, Busby A, Armstrong BG, et al (1998 Oct). Geographical variation in anophthalmia and microphthalmia in England, 1988-94. BMJ. 317(763):905–909.

[14] Ludwig PE, Czyz CN, Embryology E. Malformations SourceStatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2018–2017 Dec 28.

[15] Coas VR, Neves CC, Rode SM, (2005). Evaluation of the etiology of ocular globe atrophy or loss. Braz Dent J. 16(3):243–246.

[16] Fernandes AUR, Goiato MC, Batista MAJ, et al. Color alteration of the paint used for iris painting in ocular prostheses. Braz Oral Res. 2009 Oct-Dec;23(4):386–92386.

[17] Goiato MC, dos Santos DM, Bannwart LC, et al, 2013 Jan. Psychosocial impact on anophthalmic patients wearing ocular prosthesis. Int J Oral Maxillofac Surg.;42(1):113–119.

[18] Koyle MT, Gokce G, Uysal Y, Ceylan OM, Akincioğlu D, et al, (2015). Indications for eye removal surgeries. A 15-year experience at a tertiary military hospital. Saudi Med J 36: 1205-1209.

[19] Ow RK, Amrith S. (1997) Ocular prosthetics: use of a tissue conditioner material to modify a stock ocular prosthesis. J Prosthet Dent. Aug;78(2):218–222.

[20] Somkuwar K, Mathai R, Jose P, December 2015. Ocular prosthesis: Patient rehabilitation - A Case Reprot Journal of the royal medical services ,Vol. 22 ,No. 4 Rev Clin Pesq Odontol 2010; 6(3): 287-292.

[21] Pesqueira AA, Goiato MC, dos Santos DM, et al (2012). Effect of disinfection and accelerated ageing on dimensional stability and detail reproduction of a facial silicone with nanoparticles. J Med Eng Technol.;36(4):217–221.

[22] Syrians D, Leles CR, Mendonca EF, (2013). A 12 - year retrospective survey of management neoplasm in the orbital cavity in a Brazilian cancer hospital. Open Dent J 7: 140-145.

[23] Bhat S, (2010). Ocular prosthesis: art meets science, Rev Clin Pesq Odontol 6(3):287- 292.
[24] Song J, Oh J, Baek SH, (2006). A survey of satisfaction in anophthalmic patients wearing ocular prosthesis. *Graefes Arch. Clin. Exp. Ophthalmol* 244(3): 330-335.

[25] Goel BS, Kumar D, (1969). Evaluation of ocular prosthesis. *Journal of the All-India Ophthalmological Society*. 17(6):266–269.

[26] Smith RM, (1995). Relining an ocular prosthesis: a case report. *J. Prosthdont*.4(3):160–163.

[27] Beumer J, Zlotolow I, (1996). Restoration of facial defects. In: Beumer J, editor. Maxillofacial Rehabilitation—Prosthodontic and Surgical Considerations. St. Louis, Mo, USA: Mosby; pp. 350–364.

[28] Ow RKK, Amrith S, (1997). Ocular prosthetics: use of a tissue conditioner material to modify a stock ocular prosthesis. *J. Prosthet. Dent*. 78(2):218–222.

[29] Cain JR, (1982). Custom ocular prosthetics. *J Prosthet Dent* 48:690-4.

[30] Pine K, Sloan B, Stewart J, Jacobs RJ, (2011). Concerns of anophthalmic patients wearing prosthetic eyes. *Clin Experiment Ophthalmol* 39(1): 47–52.

[31] Pine K, Sloan B, Stewart J, Jacobs R, (2012). A survey of prosthetic eye wearers to investigate mucoid discharge. *Clin Ophthalmol* 6: 707-714.

[32] Chang TL, Garrett N, Roumanas E, Beumer J, (2005). Treatment satisfaction with facial prostheses. *J Prosthet Dent* 94:275-80.

[33] Kaira LS, Bhayana RN, Asopa V, et al (2014). Management of ocular defects: A case series. *Eur. J. Prosthodont. 2* (1): 33-36.