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# A Technique for Fabrication of an Interim Ocular Prosthesis

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## Abstract

Several ocular and orbital disorders require surgical intervention that may result in ocular defects. Immediate intervention is required to preserve the anophthalmic socket size and prevent scar tissue contractures that may follow surgery. Unfortunately, immediate fitting of an anophthalmic socket with an artificial eye may not always be possible, and a delayed prosthesis delivery may result in settling and sinking of the prosthesis into the socket, therefore requiring orbital cavity conformation. This article presents a short review of the most commonly used techniques for processing an ocular prosthesis, while suggesting a practical transition to the application of some of them. A technique for fabricating a custom-made provisional ocular prosthesis using digital imaging technology is described. This technique may be considered in order to avoid costly procedures that might be required as a result of delayed artificial eye insertion. The technique described in this article provides a cost-effective choice for optimal orbital cavity conformation and serves as a diagnostic aid for predicting the patient's compliance to ocular prosthetic treatment. The esthetic advantages and the relative ease of fabrication of this interim prosthesis allow it to be considered a first step in the management of untreated anophthalmic sockets.

The loss of part of the face can have a physical, social, and psychological impact on those affected.[1] Maxillofacial prostheses, which restore and replace stomatognathic and associated facial structures with artificial substitutes, aim to improve the patient's esthetics, restore and maintain health of the remaining structures, and consequently provide physical and mental well-being.[2] The demand for maxillofacial prostheses has been reported to be high.[2] According to a 5-year survey conducted in the Maxillofacial Unit of the School of Oral Health Sciences at the University of The Witwatersrand, Johannesburg, South Africa, one quarter of that demand is related to ocular defects.[3]

The loss or absence of an eye may be caused by a congenital defect, irreparable trauma, tumor, a painful blind eye, sympathetic ophthalmia, or the need for histologic confirmation of a suspected diagnosis.[4] Depending on the severity of the situation, surgical management may include: evisceration, enucleation, or exenteration. Evisceration is a surgical procedure wherein the intraocular contents of the globe are removed, leaving the sclera, Tenon's capsule, conjunctiva, extraocular muscles, and optic nerve undisturbed.[4] Enucleation is the surgical removal of the globe and a portion of the optic nerve from the orbit.[4] Exenteration is the en bloc removal of the entire orbit, usually involving partial or total removal of the eyelids, and is performed primarily for eradication of malignant orbital tumors.[4]

The lost orbital volume resulting from the removal of the globe can be replaced by integrated or nonintegrated orbital implants.[5] These spherical devices are placed within the orbit, posterior to Tenon's fascia, the rectus muscles, and conjunctiva.[5] These three layers typically are closed over the implant and act as a barrier to prevent implant extrusion or migration.[5] After the surgical wound is closed, a clear concave plastic conformer is placed beneath the eyelids, onto the conjunctiva, and over the orbital implant.[5] Placement of a conformer minimizes the changes in the socket size, maintains the shape of the conjunctival fornices, and prevents scar tissue contractures from distorting the socket bed during tissue healing.[3,5] After tissue healing is complete, the conformer is replaced by a permanent ocular prosthesis.

Numerous techniques for processing an ocular prosthesis exist.[3,6–23] Mathews et al[24] classified ocular impression and fitting techniques (Table 1), and suggest using an improved technique for fabricating a custom ocular impression tray to obtain a better-fitting custom-made ocular prosthesis. They advocate the use of an existing custom ocular prosthesis or a conformer as an impression tray, modifying the technique suggested by Miller.[13] Miller's technique

 

**Table 1** Ocular impression and fitting techniques classification suggested by Mathews et al[24]

| | Technique | Authors |
|---|---|---|
| The direct impression/ external impression | An impression material is injected directly into the enucleated socket. After the material sets, additional material is applied to the external tissue, and the impression is reinforced. As a result, the anatomy of the anophthalmic socket and overlying tissue is obtained. Using the impression, a wax trial ocular prosthesis is made. Its fit, contour, and comfort are assessed. Then it is processed as done routinely. | Bartlett and Moore,[6] Brown,[7] Murphey and Schlossberg,[8] and Kennedy[9] |
| Impression with stock ocular tray | A stock ocular tray is placed in the socket. This tray has a hollow stem fastened in the middle through which an impression material is injected. Perforations in the tray aid flow and retention of the impression material. Subsequently, the impression is removed, and a wax pattern is fabricated. This wax trial prosthesis is placed in the socket, fitted, and modified as needed. Then it is processed. | Allen and Webster[10] |
| Stock ocular tray modifications | Consists of variations of the impression with stock ocular tray technique. Concentrates on the fabrication or configuration of the stock ocular tray. Everything else is as described above. | Maloney,[11] Engelmeier,[12] and Sykes et al[3] |
| Impression with custom ocular tray | This technique involves attaching a solid suction rod to the patient's existing artificial eye and investing it in an alginate mold. After the alginate sets, the prosthesis or conformer is removed and replaced with clear acrylic resin. Perforations are made in the resulting tray, and a tunnel is cut into the stem through which impression material can be delivered. The impression is made, and a wax pattern prepared. It is processed in the traditional manner. | Miller[13] |
| Impression using stock ocular prosthesis | This method uses a stock ocular prosthesis as a tray to carry impression material. The technique involves selecting an esthetic stock eye and reducing its peripheral and posterior aspects. The stock eye is then lined with an impression material and inserted for the definitive impression. Alternately, the impression material can be injected directly into the socket and then reinforced by placement of the stock eye. The resulting impression is processed, providing a customized stock prosthesis. | Rahn and Boucher,[14] Chalian,[15] Welden and Niiranen,[16] and Taicher et al[17] |
| Ocular prosthesis modification | This technique involves fitting of a stock prosthesis by trimming and polishing only. Also, relining of an existing custom or stock prosthesis using reline materials, such as dental impression waxes and tissue conditioners, rather than impression materials. Routine laboratory reline procedures are used. | Chalian,[15] Smith,[18] and Ow and Amrith[19] |
| Wax scleral blank technique | A wax scleral blank is prepared, empirically, by means of adapting wax around an object imitating the shape of an eyeball, from a socket impression or by obtaining the wax duplicate of an existing artificial eye. The resultant pattern is smoothed, tried in, relined if necessary, and adjusted. After the addition of an iris button, the pattern is invested and processed. | Benson,[20] McKinstry,[21] Schneider,[22] and Sykes[23] |

requires minimal armamentarium and relies only on the patient presenting with some type of prosthesis or conformer in place.[24]

Although early ocular prosthesis or conformer insertion has been advocated by many investigators,[3,5,25] there may be situations (e.g., economic status of the patient, poor compliance to treatment) when immediate placement of an artificial eye is avoided. If the prosthesis or conformer is delivered after healing is complete, it is likely that the artificial eye may settle and sink into the socket during the first few weeks after being fitted.[25] This may impair the eyelid support and change the right position of the palpebrae.[25] The resulting impaired esthetic facial appearance for the patient will likely require time-consuming and costly remakes,[3] especially if the delivered artificial eye is a permanent ocular prosthesis.

The purpose of this article is to describe a technique for fabricating a custom-made temporary ocular prosthesis in an attempt to avoid costly procedures that may be required after a delayed artificial eye insertion, while also making it possible to predict the patient's compliance to treatment with an ocular prosthesis.

## Technique

1. Inspect the anophthalmic socket and defect region. Measure the diameter of the iris and pupil on the intact side, preferably in daylight. Then, instruct the patient to stare at infinity, and take photographs, including frontal images of the entire face and orbital regions and images of the existing eye, using a professional or semiprofessional digital camera (Fujifilm FinePix S7000, Fuji Photo Film Co Ltd., Tokyo, Japan). It is important to obtain numerous photos with varying focal distances in different exposures, so that the most suitable images can be selected for digital remastering later.
2. Lightly lubricate the eyebrow and eyelashes on the defect side. Clean the socket by injecting cooled saline solution into it and dry with cotton pellets. Then quickly proceed to making the impression.
3. Inject a fast-setting vinylpolysiloxane impression material (Elite HD + Light Body Fast Setting, Zhermack S.p.a., Rovigo, Italy) directly into the socket and over the palpebrae of the defect region. While the material

sets, instruct the patient to stare straight ahead at a preselected object in the distance. Repeat steps 2 and 3 to make a second impression.

4. Reinforce the impressions, box them, and prepare two casts of the defect using type IV dental stone (Amberok Model Stone, ADD Ind. & Trd., Inc., Istanbul, Turkey) (Fig 1).
5. Using digital imaging software (Adobe Photoshop 7.0, Adobe Systems, Inc., San Jose, CA), remaster the previously obtained images of the existing eye, trying to reproduce an iris and pupil image and an appropriate scleral view for the artificial eye to be constructed. This procedure can be accomplished using older and later versions (e.g., Adobe Photoshop 5.0, Adobe Photoshop CS2) of the program used in this technique or versions of other similar programs (e.g., CorelDRAW Graphics Suite series, Corel Co., Ottawa, Ontario), while simpler programs (e.g., Adobe Photoshop Elements series, CorelDRAW Paint Shop series) for digital imaging will not be sufficient for this task. Although not simple, this procedure does not require the user to be well-versed in the use of such programs. After accomplishing the procedure, obtain the images of the remastered sclera and the iris in various sizes printed on good quality glossy photo-paper (Fujifilm Fujicolor Crystal Archive Paper; Fuji Photo Film, New York, NY) (Fig 2), and based on the measurements made before, decide which iris image will be used. Use the previously taken photos to assess the position of the iris and pupil for the prosthesis in relation to the eyelids.
6. Trim one of the obtained casts frontally, until reaching the vertical intersection of the socket with predictably the largest surface area. Trim the other cast to the same intersection area, but this time from the reverse direction (Fig 3A).
7. Block-out the opening of the palpebrae using modeling wax (Cavex Set Up Regular, Cavex Holland BV, Haarlem, The Netherlands) (Fig 3B), and pack orthodontic autopolymerizing clear acrylic resin (Orthocryl, Dentaurum J.P. Winkelstroeter KG, Ispringen, Germany) into the front part of the socket casts. Immediately place the assembly in a pressure pot (Polyclav Pressure Vessel, Dentaurum J.P. Winkelstroeter KG) filled with water between 40 and 46°C and maintain the initial temperature with a heating device (Heating Plate for Polyclav Pressure Vessel, Dentaurum J.P. Winkelstroeter KG) at a pressure of 30 psi for 20 minutes. Remove the cast and the polymerized acrylic resin from the pot, and according to the previously made measurements and assessments on the size and position of the pupil and the iris, adjust and mark on the acrylic resin where they should be positioned relative to the eyelids (Fig 4).
8. Section an official table tennis ball (Stiga Cup, Sweden Table Tennis AB, Eskilstuna, Sweden) in two equal parts and pour dental stone into their negatives (Fig 5A). Prepare a nearly 1.0-mm thick autopolymerizing acrylic resin (Imicryl S.C., Imicryl Dental Materials Ind. & Trd. Co. Ltd., Konya, Turkey) disk with a diameter 1.0-mm smaller than the decided iris size. Take one of the ball casts and attach the acrylic resin disk on its top using a cyanoacrylate adhesive liquid (Pattex Blitzkleber, Henkel KGaA, Düsseldorf, Germany) (Fig 5B). Then, make the impression of the altered cast using a putty vinylpolysiloxane impression material (Onetime Perfect Putty, Detax GmbH, Ettlingen, Germany) (Fig 6A). After the material sets, pack orthodontic autopolymerizing clear acrylic resin into the impression and hand-press the unaltered table tennis ball cast over it, so the acrylic resin can thin down to 2-3 mm (Fig 6B). Immediately process the assembly in a pressure pot.
9. Prepare the selected iris and scleral images by thinning the photo-paper using 400-grit silicon carbide sandpaper (P400 Wet-Dry Silicon Carbide Sandpaper, Marshall Paint and Varnish Co., Kocaeli, Turkey), so that the photo-paper gains flexibility. Perform the thinning process carefully on a smooth, flat platform by manually grinding the backside of the paper. The paper should be held still during this process, or the images may get scratched. The use of rotary instruments is not recommended, because this could damage the photographs due to the vibration occurring during the rotation. Next, adhere the prepared images carefully with a very thin layer of cyanoacrylate adhesive liquid on the polymerized acrylic resin cast (Fig 7A). After that, using a vacuum thermoforming machine (Essix EVM02, Raintree Essix, Inc, Los Angeles, CA) with full arch maximizer (Essix EMV90; Raintree Essix, Inc), tightly cover the whole surface with a 1.0-mm thick brilliant clear copolyester plastic sheet (Essix A+, Raintree Essix, Inc) that can easily accept bonding materials (Fig 7B). Do not turn off the vacuum until the plastic sheet completely cools.
10. Carefully reduce the peripheries of the formed artificial eye shell, so it can match the borders of the acrylic resin component that represents the vertically largest intersection area of the socket (Fig 8A). Care should be taken to avoid separation between the thermoformed sheet and the underlying acrylic resin. An application of cyanoacrylate cement can provide a sealed margin.
11. Superimpose the drill-marked pupil of the acrylic resin component on the backside of the trimmed shell so it can match with the pupil of the shell (Fig 8B). Stick the parts together with cyanoacrylate adhesive liquid, and after checking the position of the iris on the front part of the socket casts (Fig 9A), fill the gaps in between and seal the margins of the shell with orthodontic autopolymerizing clear acrylic resin. After processing in a pressure pot, pack orthodontic autopolymerizing clear acrylic resin into the cranial part of the socket casts and place the polymerized front part of the artificial eye so that it matches the vertical intersection of the socket with the largest surface area (Fig 9B). Remove the excess acrylic resin and polymerize the assembly in a pressure pot.
12. Trim and process the prosthesis in preparation for insertion (Fig 10). Before delivery, keep the completed

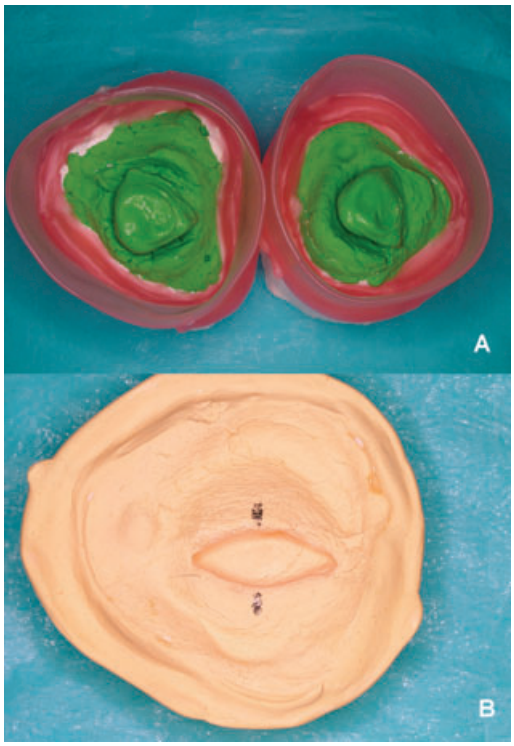


**Figure 1** Reinforced and boxed impressions (A). One of the defect region casts (B).

prosthesis in water for at least 3 days to remove a large proportion of the chemically incompletely bound residual monomers likely to be released from the acrylic resin.[26] At the delivery appointment, check the fit and contour and the patient's comfort (Fig 11). Reline with tissue conditioner (Visco-gel, Dentsply DeTrey GmbH, Konstanz, Germany) if necessary. Use the tissue conditioner as functional impression material and replace the material with orthodontic autopolymerizing clear acrylic resin within 72 hours.

13. Follow up for a few weeks until the temporary prosthesis settles, and the socket becomes dimensionally stable, repeating the relining procedure if necessary.

**Figure 2** Digitally remastered iris and scleral images printed on glossy photo-paper.

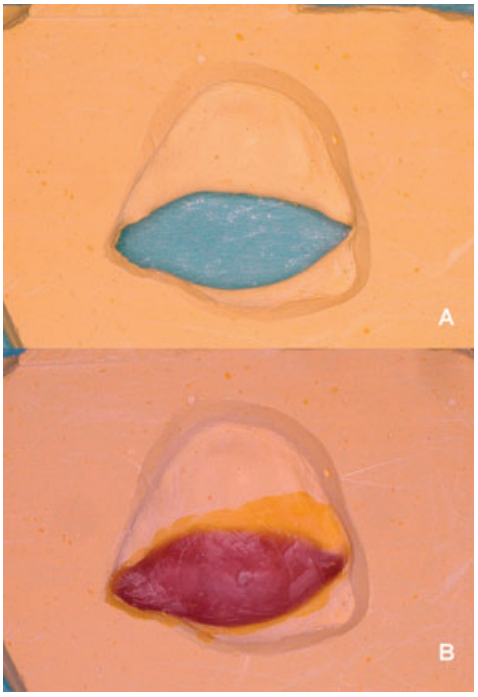


**Figure 3** Reverse view of the front part of the socket casts (A). Wax blocked-out opening of the palpebrae (B).

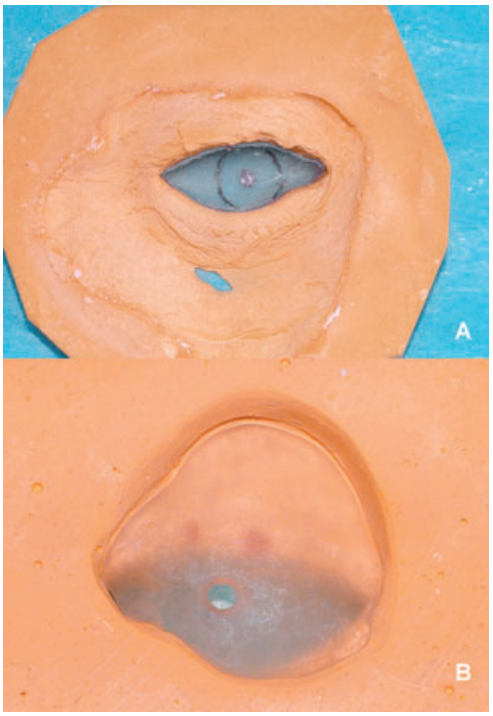


**Figure 4** The assessed position of the iris and pupil for the artificial eye (A). Reverse view of the polymerized acrylic resin component placed into the front part of the socket casts. This component represents the vertical intersection of the socket with the largest surface area. Note that the position of the pupil is drill-marked (B).

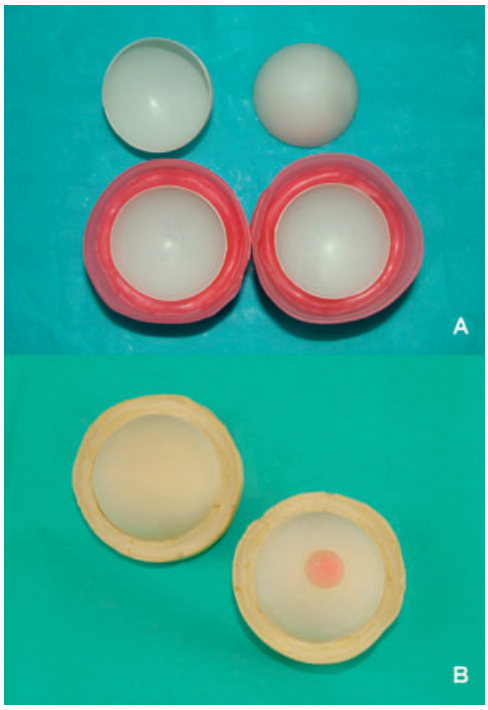


**Figure 5** Boxed table tennis hemispheres before pouring dental stone (A). View of the unaltered (left) and altered (right) table tennis ball casts (B).

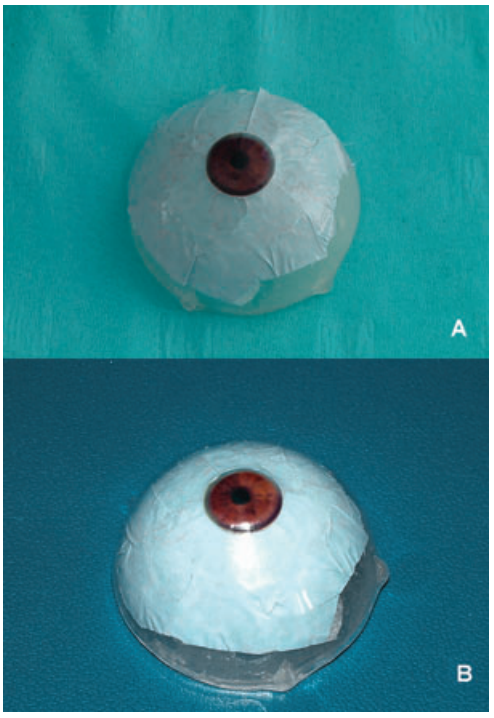


**Figure 7** Adhered iris and sclera images on the acrylic resin cast (A). Vacuum thermoformed artificial eye shell (B).

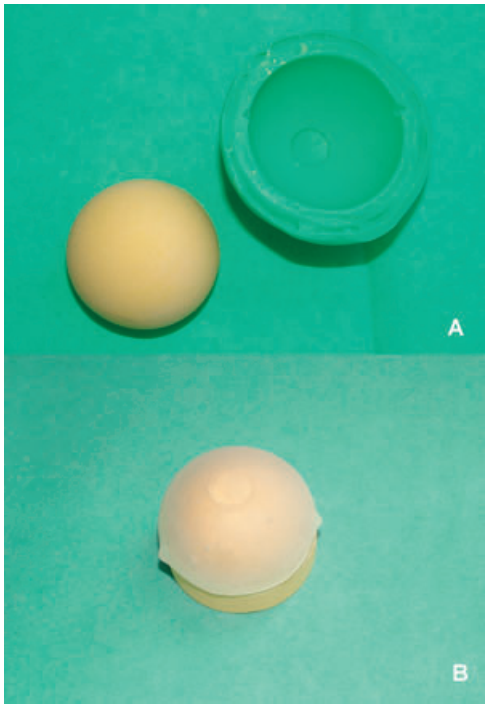


**Figure 6** The impression of the altered table tennis ball cast and the unaltered table tennis ball cast (A). The acrylic resin cast of the altered table tennis ball cast before separation from the unaltered table tennis ball cast (B).

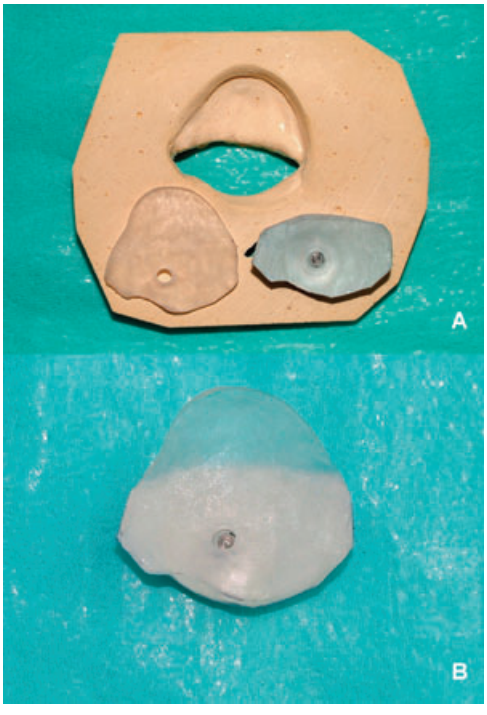


**Figure 8** View of the artificial eye shell with reduced peripheries and marked pupil position (right), and the drill-marked acrylic resin component (left) (A). Superimposed pupil positions of the acrylic resin component and the artificial eye shell (B).

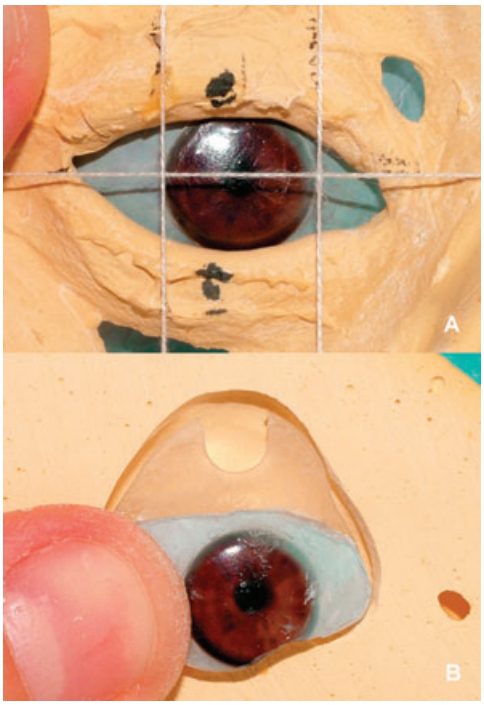


**Figure 9** Checking the relation of the palpebrae with the iris on the adhered acrylic resin component and artificial eye shell (A). Checking the position of the adhered acrylic resin component and artificial eye shell on the cranial part of the socket casts. The notch on the acrylic resin component (up) is for relieving the pressure during the runaway of the excess orthodontic autopolymerizing clear acrylic resin (B).

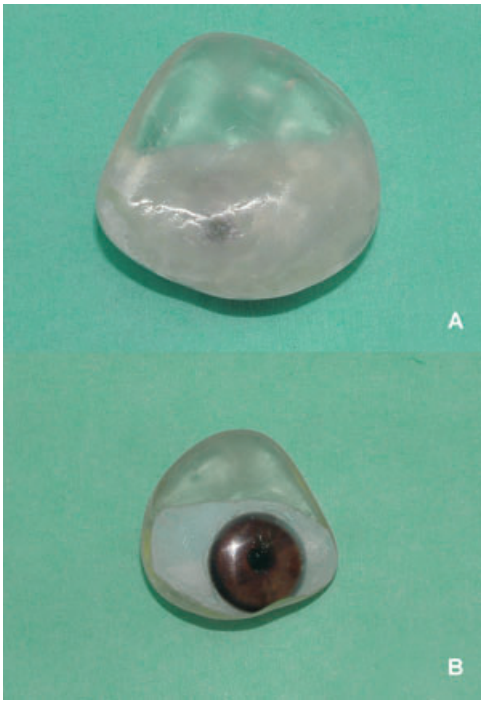


**Figure 10** Fabricated custom-made temporary ocular prosthesis before placement. Tissue surface (A) and frontal view (B).

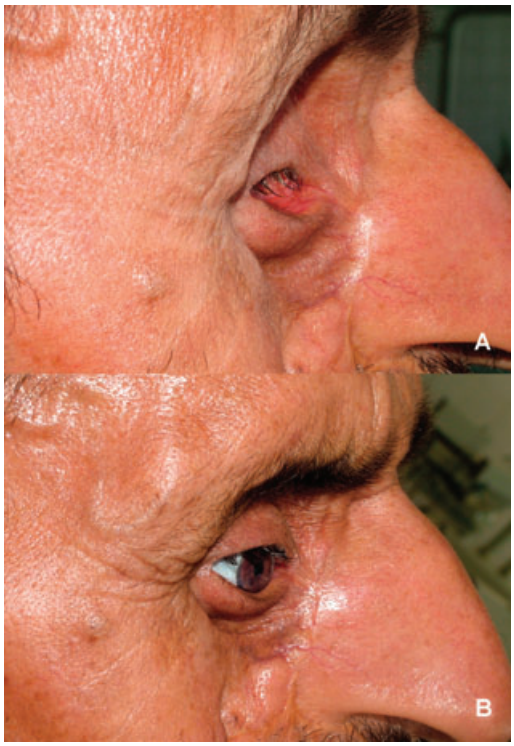


**Figure 11** Lateral view of the anophthalmic socket (A) and the prosthesis in situ (B).

Finally, proceed with the construction of the permanent custom ocular prosthesis.

## Discussion

Immediate placement of an artificial eye after enucleation may not always be possible. Delayed fitting of an ophthalmic socket with a conformer or prosthesis may result in its settling and sinking into the socket, compromising the esthetic appearance and adequate eyelid support of the defect region.[3] In such situations, delivering a temporary ocular prosthesis before a definitive one may prove time- and cost-effective for the patient.

In situations of prolonged ocular prosthesis insertion, Sykes et al[3] advocate the use of custom-made acrylic resin blank ocular conformers as an interim measure until the definitive prosthesis is made. They also suggest that if the socket depth is already reduced because of scar tissue contracture, the socket can be actively stretched by readily increasing the size of the conformer by means of adding acrylic resin on it.[3] The custom-made temporary prosthesis presented in this article can be used for the same purposes, adding the advantage of giving the patient a more natural look, which may reduce the psychological trauma associated with the loss of an eye, and increase predictability of the patient's compliance to the treatment. Although not highly esthetic, this prosthesis may prevent the demoralizing effect to the patient that can be caused by the unsatisfactory blank conformers. The construction of this prosthesis requires minimal armamentarium and is very cost-effective. It can be directly used as a custom ocular

impression tray while performing previously suggested ocular impression techniques, such as those of Mathews et al[24] and Miller,[13] prior to fabricating the definitive prosthesis. This will save time during the construction of the definitive prosthesis, allowing for a perfectly adapting custom ocular impression tray.

The acrylic resin used for the construction of this prosthesis may be a concern from the point of view of possible potential irritation effects of any residual monomer that may be released over time. It has been proved that soaking prostheses made of this kind of acrylic resin in water for 3 days before delivering to patients significantly reduces the amount of released free monomers, therefore reducing the risk of toxic and allergic reactions.[26] Rose et al[26] showed that simple precautions like this produce good results, and these kinds of plastic substances could then be graded as "noncytotoxic," corresponding to ISO-standard 10993-5 (German version DIN EN ISO 10993:1996) definitions. Although orthodontic autopolymerizing acrylic resins (particularly the one used in this technique) have also been graded as "noncytotoxic" in other investigations,[27,28] it has been emphasized that in cases of suspected possible predisposition to acute toxicity on the part of the patient, autopolymerizing acrylic resins with a barbituric acid catalyst system (e.g., Palapress, Heraeus Kulzer GmbH & Co. KG, Hanau, Germany) rather than with a benzoyl peroxide initiator system (e.g., Orthocryl, Dentaurum J.P. Winkelstroeter KG) should be preferred,[29] as the polymerization process with the amide-peroxide system progresses more slowly and less completely than the barbituric acid initiator system.[29] According to Herrmann,[30] all components of plastic materials, with the exception of polymethyl methacrylate, which represents the main structure of polymerized hot-cure acrylic resins, possess allergenic properties, although the risk of an allergic reaction can be significantly diminished by reducing the quantity of free monomers.[26]

The medical history and general examination of our patient did not reveal any suspicions for possible predisposition to allergic reactions, and no signs of toxic reactions were witnessed after the delivery of the interim prosthesis. But the potential for toxic and allergic reactions should always be taken into account, and if a possible predisposition is suspected, a patch test should be done to rule out or confirm that possibility.[31] According to the results of the patch test, a reliable plastic material can be chosen and adapted to this technique. As this is a technique for construction of a temporary prosthesis that may undergo several alterations, choosing an autopolymerizing material will be beneficial, because autopolymerizing materials are cost-effective and easier to process than heat-polymerizing acrylic resins. That is also the main reason for not choosing an acrylic resin specific for ocular prosthetic applications.

The main disadvantage of this interim ocular prosthesis is associated with the lack of a trial appointment. The color and size, and also the position of the iris relative to the eyelids are adjusted in the laboratory, according to initially made measurements and photographs. This may surely compromise the final esthetic results, but to a great extent this problem can be overcome by relining the prosthesis using appropriate relining techniques. It should be emphasized that this is a temporary prosthesis and its primary objective is not to supply superior esthetics, but to increase a patient's quality of life after loss of an eye and to prepare the socket for the definitive prosthesis to be constructed.

## Conclusion

Delayed artificial eye placement after enucleation may require multiple remakes of the delivered prosthesis because of the alterations to the size and shape of the anophthalmic socket. To prevent potential problems that may come with insertion of definitive prostheses in such conditions, provisional custom-made ocular prostheses should be considered. This will provide a cost-effective way for optimal orbital cavity conformation while serving as a diagnostic aid for predicting the patient's compliance to the treatment. The esthetic advantages and the relative ease of fabrication of the interim prosthesis presented in this article allow it to be considered a first step in the management of untreated anophthalmic sockets.

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