International Journal of Dental Sciences
www.dentaljournal.in
E-ISSN: 2663-4708
Received: 25-05-2026, Accepted: 24-06-2026, Published: 09-07-2026
Volume 8, Issue 3, 2026, Page No. 21-26

Rehabilitation of an Anophthalmic socket using a custom hollow ocular prosthesis with an integrated lubricant reservoir and Augmented Reality-guided iris positioning: A case report

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Abstract

Background: Loss of an eye, whether secondary to trauma, infection, or malignancy, produces significant functional and psychosocial consequences. While conventional stock prostheses offer a basic rehabilitative option, custom-made ocular prostheses provide superior esthetics, fit, and patient satisfaction. A recurring clinical problem in anophthalmic patients is socket dryness arising from disrupted tear dynamics, which causes discomfort and may accelerate conjunctival deterioration. This report describes a case in which both challenges—socket dryness and imprecise iris positioning—were simultaneously addressed through a purpose-built prosthetic design and a digital alignment technique.

Case Report: A 32-year-old male presented fifteen years after traumatic evisceration of the left eye. He had never been fitted with a prosthesis. A custom hollow acrylic ocular prosthesis was fabricated incorporating an internal lubricant reservoir, sealed by an adapted insulin syringe plunger cap and connected to the socket surface via a precision exit hole. Iris positioning was accomplished by overlaying a graph-grid on an eyewear frame and cross-referencing the iris coordinates in real time using an augmented reality (AR) Golden Ratio facial filter. The prosthesis was evaluated across all planes of ocular movement and found to meet clinical and esthetic criteria.

Conclusion: Integration of a passive self-lubricating mechanism with digital iris mapping produced an ocular prosthesis that satisfied both functional and cosmetic goals. The techniques reported here are reproducible, cost-effective, and applicable in settings without access to sophisticated fabrication equipment.

Keywords: Ocular prosthesis, anophthalmic socket, lubricant reservoir, Augmented Reality, iris positioning, maxillofacial prosthodontics

Introduction

The eye occupies a unique position in human anatomy, serving simultaneously as the primary sensory organ for vision and as a critical determinant of facial appearance and personal identity. Unilateral enucleation or evisceration—performed for trauma, end-stage glaucoma, intraocular tumour, or painful blind eye—leaves the patient with not only permanent visual loss in the affected side but also a profound esthetic and psychological deficit.

Epidemiological data suggest that trauma remains the leading cause of unilateral eye loss among working-age adults, with the majority of cases occurring in men between the second and fourth decades of life [1]. The psychological sequelae are well documented and include depression, social withdrawal, occupational impairment, and diminished self-esteem [2]. Ocular prosthetic rehabilitation mitigates these effects by restoring facial symmetry, maintaining the orbital volume, and providing eyelid support.

Two persistent clinical problems complicate the long-term success of ocular prostheses. First, the anophthalmic socket invariably exhibits altered tear dynamics: the loss of the globe disrupts the lacrimal pump mechanism, reduces goblet cell density, and diminishes the mucin component of the tear film, resulting in progressive socket dryness, irritation, and discharge [3, 4]. Second, achieving precise alignment of the prosthetic iris with the fellow eye—particularly across the vertical and horizontal meridians—remains technically demanding and heavily operator-dependent.

Various strategies have been reported to address socket dryness, ranging from frequent topical lubrication to implant-assisted socket reconstruction [5]. For iris positioning, conventional techniques rely on anatomical landmarks and the clinician's visual judgment, which introduces reproducibility concerns [6, 7]. The advent of digital imaging and augmented reality (AR) technology has opened new avenues for objective, quantifiable facial measurements that can inform prosthetic design.

This case report describes the fabrication of a custom hollow ocular prosthesis that integrates a passive internal lubricant reservoir with an AR-guided iris positioning method. Each component of the technique is described in sufficient detail to permit independent replication. The report follows the CARE (CAse REport) guidelines for clinical case reporting.

Case Report

Patient History and Presentation

A 32-year-old male agricultural worker presented to the Department of Prosthodontics requesting ocular rehabilitation of the left eye. Fifteen years earlier, he had sustained penetrating ocular trauma from a wooden stick, for which he underwent evisceration at a regional hospital. No ocular conformer had been fitted postoperatively, and

the patient had never worn a prosthesis in the intervening period.
On examination, the left socket appeared deep and well-formed. The eyelid margins showed mild retraction, and mild ptosis of the upper lid was noted. The conjunctival lining was erythematous and dry, with incomplete eversion of the lower lid—consistent with long-standing neglect of the anophthalmic socket. There was no evidence of active infection, cyst formation, or contracted socket. The contralateral right eye was normal with regular iris pigmentation, which served as the reference for prosthetic matching.
Systemic history was unremarkable. The patient was motivated for rehabilitation and expressed particular concern about achieving a natural appearance. After detailed discussion of the planned treatment, written informed consent was obtained.

Treatment Planning
Given the history of socket dryness and the absence of prior prosthetic wear, a custom hollow acrylic ocular prosthesis was planned rather than a stock prosthesis. The hollow design reduces prosthetic weight, decreases conjunctival pressure, and, critically, provides an internal cavity that can function as a lubricant reservoir [8]. An integrated reservoir was incorporated to deliver passive lubrication during the blink cycle. Augmented reality technology was employed to achieve precise iris positioning.

Clinical and Laboratory Procedures
Primary Impression and Cast
A primary impression of the anophthalmic socket was obtained using the external tray technique with zinc oxide eugenol impression paste. Care was taken to adequately capture the fornices and the superior sulcus without distorting the soft tissue. A primary cast was poured in dental stone.

Custom Conformer Fabrication and Trial
A heat-cured acrylic conformer was fabricated on the primary cast and tried in the patient's socket. Pressure areas were relieved, and the conformer was adjusted to achieve comfortable seating with adequate retention. The conformer served a dual purpose: conditioning the socket tissues and providing the form for the definitive impression.

Definitive Impression
The definitive impression was recorded using light-body addition silicone elastomer, which accurately captured the fine surface detail of the socket. A rigid putty index was fabricated over the light-body impression to maintain its spatial configuration and allow accurate cast pouring. The definitive cast was poured in Type IV dental stone.

Wax Pattern and Trial Insertion
A wax ocular conformer was sculpted on the definitive cast, replicating the shape, curvature, and volume of the planned prosthesis. The wax pattern was tried in the patient's socket and evaluated for lid closure, gaze symmetry, and comfort. Adjustments were made to ensure symmetric lid contour and natural movement.

Iris Positioning Using Augmented Reality
Accurate iris positioning is one of the most demanding steps in ocular prosthesis fabrication. In this case, a two-stage approach was employed. First, a transparent graph grid was fixed to the lens of a plain eyewear frame and placed on the patient's face. The centre of the natural iris in the fellow eye was identified on the grid, and the corresponding co-ordinates were transferred to the wax pattern, anchoring the iris button at the identical position [9].
In the second stage, the Snapchat Golden Ratio facial filter—which overlays a mathematically derived grid based on proportional facial symmetry—was used to verify iris placement in real time. The filter provided a dynamic, three-dimensional cross-reference that accounted for slight asymmetries introduced by facial movement and soft tissue displacement. Both the patient and the operator could simultaneously visualise the esthetic outcome on a smartphone screen. This approach is consistent with emerging literature supporting digital facial mapping as an adjunct to conventional prosthetic techniques [10, 11].
After confirming alignment, a customised iris button was painted to match the pigmentation, limbal ring, and radial stria of the fellow iris. The button was attached to the wax pattern, and its position was verified once more using both the graph-grid and the AR filter.

Reservoir and Lubricant Mechanism
A hollow space was incorporated into the posterosuperior aspect of the wax pattern to serve as the lubricant reservoir. Access to the reservoir was provided by a removable cap fashioned from the rubber stopper of an insulin syringe plunger—a material chosen for its biocompatibility, low cost, and ease of fabrication. The cap was stabilised with a stainless steel wire loop to prevent unintended displacement. A gutta-percha cone was positioned behind the iris button to maintain the spatial form of the wax pattern during the dewaxing stage and to prevent collapse of the hollow cavity.

Acrylization Using the Lost Salt Technique
The wax pattern, complete with iris button and reservoir mechanism, was invested in a split flask using dental plaster. Dewaxing was performed by boiling water immersion. To create the hollow prosthetic shell, the lost salt technique was employed: sodium chloride crystals were packed into the hollow cavity before acrylic packing. The heat-cured acrylic was processed in the conventional manner. After deflasking, the salt crystals were dissolved in warm water, yielding a hollow prosthesis of even wall thickness [12].
A 0.5 mm exit hole was created on the superolateral surface of the prosthesis, oriented toward the limbal region of the socket. The trajectory of this channel was designed so that the negative pressure generated during each blink would draw lubricant from the reservoir and deposit it on the conjunctival surface, providing passive, blink-synchronised hydration throughout the day.

Characterisation and Finishing
Surface characterisation was performed chairside using acrylic pigments and fine red rayon fibres to simulate the scleral vasculature. Colour matching was performed under natural and artificial lighting with the patient present, comparing the prosthetic sclera to the fellow eye. A thin layer of poly-methyl methacrylate monolayer (Monopoly) was applied over the painted surface to seal and protect the characterisation layer, prevent pigment leaching, and reduce

surface roughness, which is associated with reduced biofilm accumulation.

Loading and Function of the Lubricant Reservoir

Preservative-free artificial tear solution was drawn into a dropper and introduced through the removable cap into the reservoir. Approximately 0.1–0.15 mL was found sufficient for a full working day in clinical trials. On blinking, the negative pressure generated within the socket draws lubricant through the exit channel and distributes it across the conjunctival surface, mimicking the action of the lacrimal gland. The patient was instructed to refill the reservoir each morning before insertion.

Final Evaluation and Delivery

The finished prosthesis was inserted and evaluated across all cardinal positions of gaze—superior, inferior, medial, and lateral. Eyelid closure, symmetry of palpebral aperture, and prosthetic mobility were assessed. Iris alignment was re-confirmed using the AR filter, confirming congruence with the preoperative plan. The patient reported immediate improvement in comfort relative to the unprotected socket, and expressed high satisfaction with the esthetic result. Post-operative instructions regarding hygiene, nightly removal, and reservoir refilling were provided. A recall appointment was scheduled at two weeks and three months.

Discussion

This case illustrates two complementary advances in ocular prosthetic technique: a passive internal hydration system and a digitally assisted iris positioning method. Each is considered separately before examining their combined clinical significance.

Socket dryness is the most frequently reported complaint among long-term ocular prosthesis wearers and contributes to conjunctival hypertrophy, socket inflammation, and eventual prosthetic intolerance [3, 13]. Standard management involves topical lubricant drops or ointments applied multiple times daily, which is inconvenient and poorly sustained in occupational settings. Kavlekar and colleagues described an early prototype of a self-lubricating hollow prosthesis with a functional reservoir, demonstrating proof-of-concept for the passive hydration approach [8]. The present case refines this design by using a readily available, sterile-grade rubber stopper as the closure mechanism, reducing the need for custom machined components. The blink-activated delivery system is physiologically rational, as the orbicularis oculi contraction that closes the lids simultaneously compresses the socket slightly, creating the pressure differential that drives lubricant flow.

Precise iris positioning determines whether an ocular prosthesis reads as natural or obviously artificial in social interaction. Several methods have been described, including pupilometer measurements, transparent templates, and digital photography overlays [6, 7, 9]. Zilpilwar and colleagues described an eye-mapping technique using graph grids and anatomical reference lines, demonstrating that simple low-cost tools can achieve acceptable alignment when applied systematically [9]. The present case extends this approach by adding a real-time AR layer. The Golden Ratio filter, originally developed for social media, coincidentally encodes the same proportional relationships that prosthodontists rely on for facial symmetry assessment. Its use as a clinical adjunct has not, to the authors' knowledge, been formally reported in prosthetics literature, though digital overlay methods are gaining acceptance in maxillofacial rehabilitation [10, 11].

Several practical considerations merit discussion. The insulin syringe rubber stopper is a novel material adaptation that should be used as supplied (pre-sterilised), and clinicians should confirm biocompatibility with the specific brand used. The 0.5 mm exit hole diameter was selected empirically; future work could examine the relationship between hole diameter, reservoir volume, and lubricant delivery rate. The Snapchat filter used here is a commercially available application and may change with software updates; clinicians should verify that the Golden Ratio overlay remains accurate in successive versions or identify equivalent alternatives.

The lost salt technique for hollow ocular prosthesis fabrication is well established in the literature and presents no additional complexity compared with conventional heat-cured acrylic processing [12]. Clinicians comfortable with standard ocular prosthetic fabrication should be able to incorporate the hollow design with minimal additional training.

Limitations of this report include its single-case design, absence of objective outcome measures, and a follow-up period insufficient to assess long-term socket health. Controlled studies comparing socket moisture levels, patient-reported comfort, and conjunctival histology between conventional and reservoir-equipped prostheses are needed to establish evidence-based clinical recommendations.

Fig 1: Occular Defect

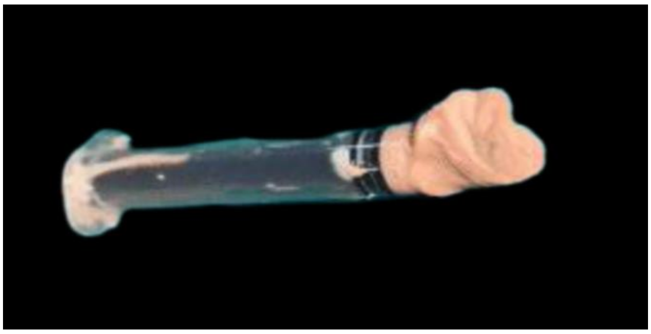

Fig 2: Primary impression

Fig 3: Custom Conformer, Figure 4b- Tryin Of Custom Conformer

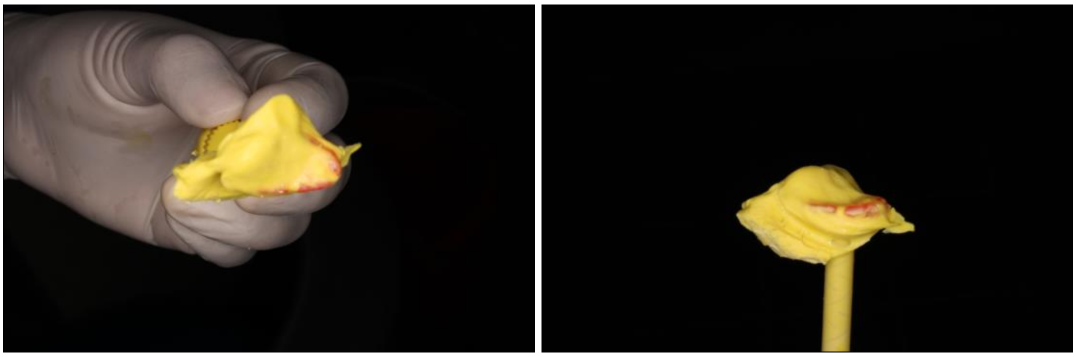

Fig 4: Definitive Impression

Fig 5: Wax Pattern and Tryin

Fig 6: Iris Orientation-6A- Graph Grid on Eyewear, Figure 6b- Augmented Reality Filter, Figure

Fig 7: Reservoir attachment

Fig 8A: Prosthesis after characterisation,

Fig 8B: Chairside Colour Matching

Fig 9: Dropper, Artificial Tear, Loading Of Artificial Tear

Fig 10: Pre and Post-Operative Image

Conclusion

Rehabilitation of the anophthalmic socket presents challenges that extend beyond simple prosthetic replacement of the lost globe. This case demonstrates that a custom hollow acrylic ocular prosthesis incorporating a passive internal lubricant reservoir, together with augmented reality-guided iris positioning, can simultaneously address socket dryness and achieve superior esthetic alignment. The materials and methods described are accessible, cost-effective, and reproducible in routine prosthodontic practice. Such integrative approaches have meaningful potential to improve comfort, esthetics, and quality of life for patients requiring ocular prosthetic rehabilitation.

Acknowledgements

The authors thank the patient for providing written consent for publication of this case. No external funding was received for this work.

Conflict of Interest: The authors declare no conflicts of interest.

Ethical Approval: Written informed consent was obtained from the patient prior to treatment and for publication of clinical details and images.

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