RESEARCH PAPER

Blending Digital Precision with Conventional Craft: A Hollow Bulb Definitive Obturator with a Direct Metal Laser-Sintered Framework Using Threaded Putty Hollowing Technique – A Case Report

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ABSTRACT

Background:
Loss of the maxilla leaves an opening between the mouth and the nasal cavity or antrum. Patients then struggle with nasal leakage of food and fluids, hypernasal speech, poor chewing and a sunken facial profile. A definitive obturator is expected to seal this communication, stay in place under function and remain light enough for the residual teeth and tissues to carry.

Case Description:

A 69-year-old man who had undergone a right partial maxillectomy for chronic osteomyelitis about 13 months earlier presented with an ill-fitting interim obturator, nasal regurgitation of liquids, unclear speech and difficulty in chewing. The defect involved the right hard palate, alveolar ridge and a portion of the soft palate (Aramany Class I).

Treatment Approach:

A definitive closed hollow bulb obturator was fabricated through a mixed workflow. The defect and the dental arch were recorded conventionally with a sequential impression protocol (alginate primary impression, functional border moulding with low-fusing impression compound, light-body addition silicone wash and an alginate pick-up impression). The master cast was scanned, the cobalt–chromium framework was designed in exocad with digital survey and block-out, and the framework was produced by direct metal laser sintering (DMLS). The bulb was hollowed at the packing stage with the threaded putty method, in which a putty spacer tied to a thread is sandwiched between two layers of heat-cured resin and pulled out through a small window after processing.

Outcome:
The framework seated passively at try-in without adjustment of the rests or clasps. The hollowed prosthesis weighed 31.25 g compared with 25 g for the same bulb filled solid, a reduction of 20%. At the one-week review the patient reported no nasal leakage during the water-drinking test, and a perceptual speech assessment showed improved production of sibilant and plosive sounds with reduced nasal resonance. The patient was able to insert and remove the prosthesis without help.

Conclusion:
Combining a conventional impression sequence with digital framework design, DMLS manufacture and threaded putty hollowing produced a well-adapted, light obturator in this patient. The approach uses equipment and materials that most postgraduate departments already possess.

Keywords: Maxillofacial prosthesis; Obturator; Maxillectomy; Computer-aided design; Direct metal laser sintering; Denture, partial, removable

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INTRODUCTION

Removal of part or all of the maxilla, whether for a tumour, a fungal infection, trauma or chronic osteomyelitis, leaves the oral cavity open to the nose and the maxillary sinus. The consequences follow quickly. Liquids escape through the nose during swallowing, air leaks into the nasal cavity during speech so that words lose their consonants and acquire a nasal tone, chewing on the resected side becomes impossible, and the loss of bony support lets the cheek and upper lip collapse inward. Patients withdraw from eating in company and from conversation. Aramany's classification of partial maxillectomy defects in dentate patients, first published in 1978, still frames how prosthodontists describe these defects and plan the prosthesis; a Class I defect is a resection along the midline with the remaining teeth on one side of the arch[1].

Two routes exist for closing the defect: surgical reconstruction with free or pedicled flaps, and prosthetic obturation. A recent systematic review and meta-analysis that pooled 466 patients found no meaningful difference in quality-of-life scores, speech or masticatory measures between the two approaches, and concluded that both remain acceptable choices depending on the patient's fitness, the size of the defect and the need to inspect the cavity for recurrence[2]. Obturation keeps the surgical site visible, avoids a second operation and can be adjusted as the defect changes; in India it is also the more affordable option.

The obturator itself passes through three stages. A surgical obturator is placed at the time of resection, an interim obturator is worn during healing, and a definitive obturator is fabricated once the defect has stabilised, which usually takes three to six months, or longer after radiotherapy. Dholam and colleagues followed 30 patients through these phases and showed that quality of life and acoustic speech parameters improved stepwise, with the definitive prosthesis bringing the patient closest to the preoperative state[3]. Comparable improvements in the Oral Health Impact Profile and the Obturator Functioning Scale have been documented in Indian patients rehabilitated after mucormycosis-related maxillectomy[4], and a 2026 study of older adults reported rising bite force and better swallowing of liquids over the first six months of obturator use[5].

A definitive obturator must do several things at once: seal the communication, resist displacement under gravity and the pull of the cheek, distribute load between the residual teeth and the defect margins, and remain comfortable enough for daily wear. Weight sits at the centre of all four. A solid acrylic bulb that fills a hemi-maxillectomy cavity is heavy, and gravity acts on it constantly. The abutment teeth bear the leverage, the mucosa along the defect margin is rubbed, and the patient learns to hold the prosthesis in place with the tongue. Hollowing the bulb reduces the weight substantially. Nanda and co-workers reviewed the available methods and observed that hollow obturators improve retention and stability and reduce the load on

the supporting structures[6]. The bulb can be left open toward the nasal side or closed. Open bulbs are easy to make and adjust but trap food and secretions; closed bulbs are hygienic and lighter, at the cost of a more complicated laboratory procedure.

Many materials have been used as a temporary spacer to create the closed hollow space: dental stone, salt, sugar, modelling clay, thermocol, glycerine soap, wax, ice and silicone putty, among others[7]. Each has drawbacks: soluble spacers must be dissolved out slowly through an opening, stone must be broken out, sugar and salt may contaminate the resin, and ice must be frozen immediately before packing. Nanda and colleagues recently described a rope of gauze coated with silicone that is pulled out after curing[8], and several Indian groups have reported flasking modifications that trap a hollow space between resin layers[9,10]. Other authors have formed the bulb from thermoplastic sheet in a single flask[11]. Fluid leakage into the hollow space through joints or through porous walls remains the main long-term worry with closed bulbs; a laboratory study of printed hollow specimens showed that walls thinner than 2 mm absorbed water and eventually failed[12].

Digital technology has entered obturator fabrication over the past decade, though not uniformly. A systematic review of 33 studies found that in most reports the digital component was confined to one or two steps, and only four described a fully digital process[13]. Jain's review of 13 studies reached a similar conclusion, noting reductions in working time and material use but a persistent reliance on conventional impressions for the defect[14]. Boffano and colleagues, reviewing 72 patients rehabilitated after head and neck cancer, found that only three had received a completely digital treatment[15]. Intraoral scanning of a maxillectomy cavity is hampered by the depth of the defect, by mobile soft tissue, by trismus and by blood and mucus, and many authors still prefer a physical impression for the defect while using scanning and design software for the rest[16]. The hybrid workflow is therefore not a compromise but the current state of practice.

Within this hybrid approach, the metal framework is the component that has benefited most from digitisation. Conventional lost-wax casting of a cobalt–chromium framework involves duplicating the cast in refractory material, waxing the pattern by hand, investing, burning out, casting and finishing. Each step introduces small dimensional errors, and a framework that rocks on the cast is not unusual. Computer-aided design allows the cast to be surveyed on screen, the path of insertion to be tested from any angle, undercuts to be blocked out to a precise depth, and the components to be positioned with consistent dimensions. The framework can then be manufactured directly from the design file by selective laser melting or direct metal laser sintering, in which a laser fuses successive layers of metal powder to build the part[17]. In vitro studies have shown that laser-sintered frameworks fit more truly than cast frameworks, regardless of the depth of the palatal vault[18,19]. A 2025 cross-over clinical trial in 26 arches found that DMLS frameworks needed fewer laboratory repetitions than cast ones and fitted better at the reciprocal arms, although they needed more chairside adjustment at some components[20]. A two-year clinical follow-up of a DMLS partial denture reported patient satisfaction equal to that of a cast prosthesis[21], and a cross-over study of 2025 recorded mean framework deviations of about 0.1 mm for both fully digital and mixed workflows, well within the accepted clinical tolerance[22].

For hollow obturators, most published digital reports have used three-dimensional printing of the bulb in resin[23-26], sometimes combined with a printed titanium or cobalt–chromium framework. These reports come from centres with in-house printers and hollowing software. Many teaching hospitals in India lack this capability but can send a scanned cast to a commercial laboratory for DMLS framework production while processing the bulb in heat-cured acrylic resin in a conventional flask. There is little in the literature describing how to integrate a laser-sintered framework with a conventionally processed closed hollow bulb in a way that is reproducible in such a department. The present report describes one such workflow. Its contribution is the sequence rather than any single step: a conventional sectional impression of the defect, digital survey and design of the framework, DMLS manufacture, and a threaded putty method of hollowing that is performed at the packing stage and needs no additional equipment.

CASE PRESENTATION

Patient history

A 69-year-old man was referred to the Department of Prosthodontics, Mahatma Gandhi Post Graduate Institute of Dental Sciences, Puducherry, India, for definitive prosthetic rehabilitation of a right maxillary defect. He had undergone a right partial maxillectomy approximately [13] months earlier for chronic osteomyelitis of the maxilla. There was no history of radiotherapy or chemotherapy. He was not a smoker and did not chew tobacco or betel quid. Dental history: the patient had lost few mandibular posterior teeth on both sides several years earlier because of caries and had never worn a mandibular prosthesis.

He had been wearing an interim acrylic obturator with wrought-wire clasps for the previous 12 months. The obturator had become loose, and his chief complaints were leakage of water and thin liquids through the nose, speech that his family found difficult to

understand, and an inability to chew on the right side. The prosthesis dropped when he spoke for long periods and he had to press it up with his tongue.

Extraoral examination

The face was asymmetrical, with a visible depression over the right malar region and loss of support of the right upper lip. Mouth opening was adequate at 43 mm. There was no facial scar, and there was no palpable lymphadenopathy. The temporomandibular joints were free of tenderness or clicking.

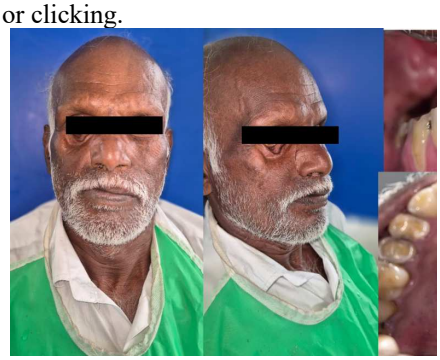


Fig no:01 -Preoperative extraoral frontal and profile views, intraoral frontal view showing generalized tooth wear and discoloration, and maxillary occlusal view demonstrating the existing dentition and palatal anatomy.

Intraoral examination

A well-healed defect occupied the right side of the maxilla. It extended from the midline of the hard palate laterally to the buccal vestibule and from the region of the right central incisor posteriorly to include the tuberosity and the anterior third of the soft palate. The margins were covered by mature, non-tender mucosa with no sign of persisting infection or sequestrum. The nasal side of the defect was lined by respiratory epithelium and was moist. The medial wall of the defect was the residual palatal shelf; the lateral wall was formed by the scarred cheek mucosa, and a shallow lateral scar band was present at the junction of the two. According to Aramany's scheme the defect was classified as Class I[1].

The remaining maxillary teeth were the left central incisor, left lateral incisor, left canine, left first and second premolars and left first and second molars. All were firm, with no mobility, and were caries-free. Generalised erosion of the occlusal and incisal surfaces was noted, without sensitivity. Periodontal probing depths were within 3 mm, and there was no bleeding on probing after scaling. The left canine, left second premolar and left second molar were judged suitable as abutments. The left canine had adequate crown height and a favourable distal undercut; the left second premolar offered a mesial rest seat and a buccal undercut; the left second molar had a sound crown with a mesial rest seat and a buccal retentive area. The mandibular arch was partially edentulous, with the anterior teeth and premolars present and the molars missing bilaterally (Kennedy Class I). The residual ridges were well rounded. An intraoral periapical radiograph of the abutment teeth showed adequate bone support without periapical pathology.

Diagnosis and treatment plan

The diagnosis was an acquired right maxillary defect, Aramany Class I, with a partially edentulous maxillary and mandibular arch. Treatment options discussed with the patient included surgical reconstruction with a free flap, an implant-retained obturator, and a conventional tooth-supported definitive obturator. He declined further surgery. In view of the favourable abutment teeth and the patient's preference for a prosthesis he could remove and clean himself, a definitive closed hollow bulb obturator supported by a cobalt–chromium framework was planned. Written informed consent was obtained for treatment and for publication of clinical photographs.

TREATMENT PROCEDURE

Preliminary impression

The undercuts within the defect, particularly the region under the lateral scar band and the nasal aspect of the residual palatal shelf, were blocked out with petroleum-jelly-coated gauze folded into a roll and tied with dental floss so that it could be retrieved easily. A stock perforated metal tray was selected and its right posterior flange was extended with modelling wax to reach the defect. The primary impression was made with irreversible hydrocolloid (Prime Dental, India) mixed slightly thicker than usual so that it would not flow into the nose. The impression was removed after setting, checked for tears, disinfected and poured in Type III dental stone (Gold Stone) .

Custom tray and functional moulding of the defect

A custom tray was fabricated on the primary cast in autopolymerising acrylic resin with a 2 mm wax spacer over the dental arch and with a solid extension into the defect, kept about 3 mm short of the recorded walls. The extension was tapered to allow withdrawal from the cavity, and the tray was checked in the mouth for stability.

The walls of the defect were then recorded functionally. Type I low-fusing impression compound (green stick; DPI, Mumbai, India) was softened in a water bath, added to the defect extension in increments, tempered and seated. The patient was asked to swallow, to say "ah" to lift the soft palate, to move the mandible from side to side and to turn the head to either side so that the pterygomandibular raphe and the coronoid process would shape the lateral and posterior extent. Compound was added until the extension engaged the depth and the lateral scar band without displacing the tissues.

Secondary impression

Tray adhesive was painted on the compound and the intaglio of the tray and allowed to dry for five minutes. A wash impression of the entire arch and the defect was made with light-body addition silicone (Aquasil; Dentsply, India). The material was injected first into the defect region and around the abutment teeth, then loaded into the tray, and the tray was seated with light finger pressure while the patient repeated the functional movements. After the silicone had set, the impression was removed along the path of withdrawal determined by the tray extension, inspected for voids and disinfected.

Pick-up impression

The secondary impression recorded the defect and the dental arch in fine detail but, being made in a rigid custom tray with a defect extension, it was not ideal for recording the full extent of the buccal vestibule on the intact side, and there was a small risk that the compound-lined extension would distort during pouring. A pick-up impression was therefore made. The set secondary impression, still in its tray, was reseated in the mouth. A stock tray of a larger size was loaded with alginate and seated over it so that the alginate covered the custom tray, the residual arch and the vestibular sulci on the intact side. On removal, the custom tray with its silicone impression came away embedded in the alginate as a single unit. This "pick-up" ensures that the defect impression, the arch impression and the vestibular extensions are related to one another in a single pour and that the delicate silicone borders are supported during boxing. The combined impression was beaded, boxed and poured in Type III dental stone (Gold Stone) to produce the master cast.



Fig.no :02 Border moulding using green stick compound, followed by a definitive impression using light-body addition silicone and a pickup impression technique.

Digital survey and framework design

Rest seats were prepared on the mesial marginal ridges of the left second premolar and left second molar and on the cingulum of the left canine, and a guiding plane was prepared on the distal surface of the left canine. These preparations were made in the mouth before the secondary impression so that the master cast carried the definitive rest seats. The master cast was surveyed briefly with a conventional surveyor to confirm a workable path of insertion before scanning.

The master cast was scanned with a laboratory model scanner (accuracy under 10 µm as specified by the manufacturer) and exported as a standard tessellation language (STL) file. The file was imported into exocad DentalCAD (exocad GmbH, Darmstadt, Germany). In the partial-framework module, the cast was surveyed on screen with the path of insertion adjusted in small increments until the guiding planes on the abutment teeth were parallel and the undercuts on the left canine, left second premolar and left second molar were retentive to a depth of 0.25 mm at the intended clasp tip positions. Undesirable undercuts along the defect margin and beneath the residual palatal shelf were blocked out digitally, and relief was added over the palatal mucosa where a major connector would otherwise impinge on the tissue.

The framework was designed with the following components: an anteroposterior palatal strap major connector on the intact side, extending to the margin of the defect and incorporating a lattice-type mesh over the defect to retain the acrylic bulb; occlusal rests on the left second premolar and left second molar and a cingulum rest on the left canine; a circumferential Akers clasp on the left second molar engaging the buccal undercut; an I-bar on the left second premolar with a mesial rest and distal proximal plate; and a combination clasp on the left canine with a cast reciprocal element and a wrought-wire retentive arm to reduce torque on the tooth nearest the defect. Finishing lines were placed so that acrylic alone would contact the defect margin. The major connector was set at a uniform 0.5 mm thickness and the design was exported for manufacture (Figure 4).

Framework manufacture by direct metal laser sintering

The design file was sent to a commercial laboratory for DMLS production in a cobalt–chromium alloy.A laser fuses successive layers of alloy powder, each about 20–40 µm thick, according to the sliced design; the supports are removed after the build, and the part is heat-treated to relieve residual stress, sandblasted and polished. The finished framework was checked on the master cast for complete seating of the rests and for passive contact of the major connector with the palate before it was returned to the department.

Framework try-in

The framework was tried in the mouth. Fit was assessed visually and with a disclosing medium (pressure-indicating paste) under the rests and the major connector. All three rests seated fully, the clasp tips engaged the planned undercuts, and the major connector contacted the palatal mucosa without blanching. No adjustment of the rests or reciprocal elements was required; a single high spot on the intaglio of the I-bar proximal plate was relieved.

Retention and occlusal clearance of the rests were confirmed.



Fig.no:03 Digital framework design using Exocad software, direct metal laser sintering (DMLS) fabrication of the metal framework, and intraoral framework try-in to evaluate fit and adaptation.

Record base, occlusal rim and jaw relations

A record base was made in autopolymerising acrylic resin (DPI RR Cold Cure, India) by the dough technique over the mesh and the defect region of the master cast, so that it was attached to the framework through the retentive lattice. The defect extension of the record base was contoured to the master cast surface. An occlusal rim was built in modelling wax on the record base and adjusted in the mouth for lip support, occlusal plane and vertical dimension. Labial and buccal fullness were assessed with the patient in profile; the rim on the defect side was thickened to restore the collapsed cheek contour. The vertical dimension of occlusion was set with the aid of the remaining anterior teeth. Centric relation was recorded against the mandibular record base and occlusal rim made on the mandibular cast, and the casts were mounted on a mean-value articulator (Figure 6).



Fig.no:04 Bite registration, teeth arrangement and trial evaluation, followed by dewaxing in preparation for the final prosthesis processing.

Teeth arrangement and trial

Acrylic resin teeth were selected to match the shade and mould of the remaining maxillary teeth. The teeth on the defect side were set slightly buccal to the ridge crest to restore lip and cheek support, and a lingualised occlusal scheme was used to reduce lateral loads on the defect side. At trial insertion the aesthetics, phonetics and occlusion were verified and the patient approved the appearance. The polished surface on the defect side was contoured convex so that the cheek would not trap the prosthesis.

Flasking, dewaxing and mould preparation

The waxed prosthesis with the framework was flasked in a conventional brass flask using Type II dental plaster in the lower half and a dental stone cap over the teeth. After the plaster had set, the flask was placed in boiling water for five minutes, opened and the wax flushed out with boiling water. The autopolymerising record base was now removed from within the mould so that the entire denture base and bulb would be processed in heat-cured resin: the record base was sectioned with a high-speed tungsten carbide straight fissure bur under water spray and lifted off the mesh and the cast, taking care not to abrade the master cast surface or the framework. Two coats of cold-mould seal (sodium alginate separating medium) were applied to the cast and to the plaster surfaces and allowed to dry.

Threaded putty hollowing and packing

The hollowing was carried out at the packing stage, using silicone putty as the spacer. Addition silicone putty (Aquasil Soft Putty; Dentsply) was mixed and shaped into a form that matched the internal contour of the defect on the master cast but was uniformly about 2 mm smaller in every dimension. Before the putty set, a length of thick thread was pressed into its centre and looped so that one end of the thread emerged from the putty on the side that would face the superior (nasal) surface of the bulb. The putty was allowed to set and its dimensions were checked against the defect on the cast (Figure 7).

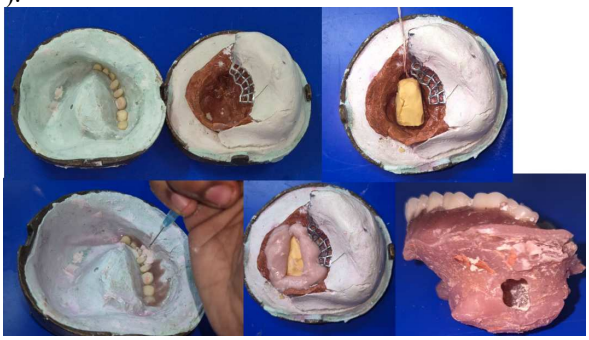


Fig.no:05 Following dewaxing, removal of the acrylic baseplate and placement of thread-infused putty within the obturator space to facilitate hollow bulb fabrication.

Heat-cured polymethyl methacrylate (DPI Heat Cure, India) was mixed at the recommended powder-to-liquid ratio and allowed to reach the dough stage. The dough was divided into two portions. The first portion was adapted into the defect region of the mould and over the mesh, forming a layer about 2 mm thick against the cast. The set putty spacer was positioned on

this layer with the thread directed upward, and the second portion of dough was packed over the putty and over the remainder of the mould so that the spacer was fully enclosed. The thread was left lying between the two halves of the flask so that its position could be located later. Trial closure was performed with a polyethylene sheet, the flash was trimmed, and the flask was finally closed under a bench press and clamped. Bench curing was allowed for 30 minutes to reduce porosity, and the prosthesis was then processed by the long curing cycle (74 °C for 8 hours followed by 100 °C for 1 hour) in a water bath.

Retrieval of the spacer and sealing

After bench cooling the flask was opened and the prosthesis was deflasked carefully to preserve the framework. The position of the thread marked the point at which the spacer lay closest to the superior surface of the bulb. A small access window, about 4 mm in diameter, was cut on the superior surface at this point with a No. 704 tungsten carbide bur. The thread was grasped with an artery forceps and the putty spacer was pulled out through the window in one piece, aided by gentle rotation. Because the spacer was elastic it deformed readily and left the interior cavity clean, with no residue to dissolve or scrape. Transillumination showed uniform walls of about 2 mm. The window was then sealed with autopolymerising acrylic resin (DPI RR Cold Cure) applied in increments, cured under pressure at 2 bar in warm water for 20 minutes to minimise porosity, and finished flush with the surface. The prosthesis was placed in water for 24 hours and the seal was tested by immersion in coloured water and by weighing before and after, confirming that no fluid had entered the hollow space.

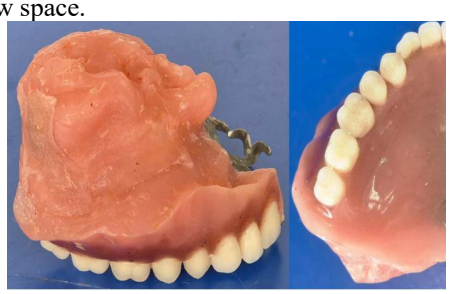


Fig.no:06 Finished and polished definitive hollow bulb obturator prosthesis.

Finishing, polishing and weight measurement

The prosthesis was trimmed, finished and polished in the usual way. The prosthesis was weighed on a digital balance (accuracy 0.01 g). The finished hollow obturator weighed 31.25g. For comparison, the weight of the same design filled solid was estimated by weighing the putty spacer and converting its volume to resin mass giving a calculated solid weight of 25 g and a reduction of 20%.



Fig.no:07 Evaluation of occlusion following definitive obturator insertion.

Insertion and post-insertion care

The prosthesis was inserted along the planned path, pressure spots on the intaglio of the bulb along the lateral scar band and the posterior margin were relieved, and the occlusion was refined. The patient was taught to insert, remove and clean the prosthesis, to leave it out at night in water and to avoid hot water. A written instruction sheet was provided.



Fig.no:08 Postoperative extraoral view following definitive obturator rehabilitation.

Follow-up and functional assessment

The patient was reviewed after 24 hours, one week and one month. At the 24-hour visit, a small sore spot at the posterior margin of the bulb was relieved. At the one-week visit the prosthesis was retentive; it did not drop on opening or speaking, and the patient did not need to hold it with his tongue. Nasal leakage was assessed by asking the patient to drink 100 mL of water while seated upright; no water escaped through the nose, and the swallowing time was 3 seconds. Speech was assessed perceptually by the clinician using informal conversation, reading of a standard passage in the patient's language and counting from one to twenty, with attention to the sibilant /s/, the plosives /p/, /b/, /t/ and /d/, and the nasal sounds /m/ and /n/. Nasal resonance was rated on a seven-point scale from normal to severe hypernasality, and intelligibility was rated by two listeners on a six-point scale. The patient reported that his family could understand him on the telephone, that he had resumed eating with others and that he could chew soft foods on the right side. The

buccal flange visibly improved the right facial contour.

DISCUSSION

This report describes the rehabilitation of an Aramany Class I maxillectomy defect with a definitive closed hollow bulb obturator in which the framework was designed digitally and produced by DMLS, while the impression, the record stage and the processing of the bulb followed conventional laboratory methods. Each element of the workflow has been described separately in the literature; the value of the present case lies in showing how they can be combined in a department that has access to a model scanner and a commercial DMLS service but not to an in-house resin printer or to software for hollowing a bulb.

The impression sequence

The success of any obturator is decided at the impression stage. The bulb must engage the walls of the defect closely enough to seal and to gain some retention from the lateral scar band and the nasal side of the residual palate, yet it must not extend into undercuts that will make insertion painful. The sequence used here, an alginate primary impression with gauze block-out, functional moulding of the defect walls with low-fusing compound, a light-body silicone wash and a pick-up impression in alginate, is a development of the sectional and two-stage impression methods that have been reported for large defects[9,10]. Compound was preferred for border moulding because it can be added incrementally and is stiff enough to record the defect walls under functional movement without slumping. A custom tray with a rigid extension into the defect gives an accurate record of the cavity, but the buccal vestibule on the intact side and the relationship of the defect to the arch are better recorded with a flexible material in a larger tray. Picking up the set secondary impression in alginate produces one cast on which the defect, the teeth and the vestibule are all recorded in correct relation, and the alginate supports the silicone borders during boxing so that they do not distort. Chouksey and colleagues, comparing conventional and digital impressions in 20 maxillectomy patients, found no difference in speech outcomes after three months, which supports the view that a carefully executed conventional impression remains an acceptable basis for a definitive obturator[27]. Where mouth opening is restricted, a hybrid of cone-beam computed tomography and a conventional impression has been described[28]; this was not needed here.

Digital design of the framework

Framework design for an obturator differs from that for an ordinary partial denture in three respects: the arch is discontinuous, the lever arm from the fulcrum line to the defect is long, and the teeth nearest the defect are the most vulnerable to torque. Aramany's principles for Class I defects call for a tripodal arrangement of rests, a rigid major connector along the residual palate, indirect retention as far anterior as possible, and stress-releasing retention on the tooth adjacent to the defect[1]. Designing on screen made these principles easier to satisfy: the path of insertion could be tilted and re-evaluated in seconds, the undercut depth at each clasp tip read directly, block-out applied to a stated depth and palatal relief made uniform. The stored design also allows the framework to be reproduced without a new impression if it is lost or fractured. Ali and colleagues have gone further and shown that a case-based reasoning system trained on 209 maxillectomy cases can propose an obturator framework design for a new patient with a precision of 0.8 in the top five retrieved designs, which suggests that digital design will become more, not less, automated over the next few years[29]. Selukar and co-workers described the practical difficulties of designing a hollow bulb cast partial denture for a mucormycosis defect, including the problem of extending the mesh into the defect without compromising rigidity[30]; in the present case the lattice was designed to stop 2 mm short of the defect margin so that acrylic alone contacts the healing tissue and can be relined if needed.

Advantages of DMLS for the framework

The choice of DMLS over lost-wax casting was made for accuracy and for predictability. Conventional casting involves duplication of the cast, manual waxing, burn-out and casting, each of which can introduce distortion, and the accumulated error is why cast frameworks so often need adjustment at try-in. Peng and colleagues showed in a typodont study that selective-laser-melted cobalt–chromium and titanium frameworks had significantly better trueness than frameworks cast from printed patterns[18], and Abd El Hamed and co-workers found the same advantage regardless of palatal vault depth[19]. The clinical evidence is more recent. Conceição and colleagues, in a cross-over trial in 26 arches, reported fewer laboratory repetitions and better fit of the reciprocal arms with DMLS, though DMLS frameworks needed adjustment at more components chairside[20]. Muehlemann and co-workers, comparing DMLS and cast frameworks in the same patient over two years, found the DMLS maxillary framework fitted better in all areas except the rests and the major connector, and patient satisfaction was equal[21]. Elgamal and colleagues reported mean framework deviations of 0.10–0.11 mm for laser-melted frameworks made by fully digital and mixed workflows, both well below the 0.31 mm threshold generally accepted for clinical fit[22]. In the present case the framework seated at try-in with a single spot of relief, which is consistent with these reports.

Two further points favour DMLS in obturator work. The mesh over the defect can be built as a lattice of uniform strut thickness that would be difficult to wax by hand and that locks the acrylic bulb without adding bulk, and the layered build avoids the internal porosity that sometimes affects cast cobalt–chromium. The disadvantages are cost, which in India is still somewhat higher than casting for a single framework, and dependence on an outside laboratory, which adds a few days to the schedule. Tissue-surface adaptation and retention of digitally fabricated obturators have been shown in a laboratory model to decrease after simulated loading equivalent to a year of use[31], which reinforces the need for periodic review and relining regardless of how the framework is made. Soltanzadeh and colleagues described an early combination of CAD design, selective laser sintering of the framework and conventional acrylic processing of the obturator in 2019[17]; the present case follows the same principle but adds a functional impression sequence and a defined hollowing step.

The threaded putty hollowing technique

Every method of making a closed hollow bulb faces the same two problems: how to hold a space open inside the resin during packing, and how to get the spacer out afterwards without leaving anything behind. Nimonkar and colleagues reviewed the materials that have been used and listed their disadvantages: salt and sugar must be dissolved out and may contaminate the resin; dental stone must be broken and picked out; thermocol may partly dissolve in monomer; wax may be absorbed into the resin; and ice, which they favoured, must be prepared immediately before packing and handled quickly[7]. Nanda and colleagues recently used a gauze rope coated with silicone that is pulled out after processing, reasoning that a flexible spacer withdrawn through a small opening leaves a clean cavity[8]. Mani and co-workers extended hollowing to the tooth-bearing part of a complete obturator to reduce the weight of a bilateral prosthesis[32].

The threaded putty method used here belongs to the same family of retrievable spacers but has particular advantages. Addition silicone putty is available in every prosthodontic department, is dimensionally stable during the curing cycle, does not react with monomer and does not absorb water. Because it is elastic, a putty block considerably larger than the access window can be pulled through the window by the thread, deforming as it comes and returning to shape outside; no material is left behind and nothing needs to be dissolved. The thread also tells the operator exactly where to cut the window, so that the opening is small and placed on the superior surface of the bulb, away from the polished and occlusal surfaces and away from the tissue-bearing margins. The spacer is made 2 mm smaller than the defect in every dimension, which gives a predictable wall thickness; a laboratory study of printed hollow specimens showed that 1.5 mm walls absorbed more water and eventually failed while 2.0 mm walls remained sealed[12], and the same thickness has been adopted here. The step adds perhaps ten minutes to packing and needs no extra equipment. The weakness of any closed bulb is the sealed window, which is a joint between heat-cured and autopolymerising resin; the seal was tested here by immersion in coloured water and by weighing, but the long-term integrity of the seal cannot be judged from a single case, and the patient has been asked to report any change in the weight or smell of the prosthesis.

Jamayet and colleagues hollowed a printed obturator in software and recorded a 22.2% reduction in weight and a 24.7% reduction in volume for the bulb[23]; Alfaraj and co-workers used an open-source program to hollow a solid design in a single step with precise control of wall thickness[24]; Ma and colleagues and Liu and colleagues described cast-free workflows in which the framework, the hollow bulb and the teeth are all designed and printed separately and then assembled[25,26]; Tasopoulos and colleagues replaced an existing obturator by scanning the old prosthesis and printing a new closed hollow bulb[33]; and Towithelertkul and co-workers used the patient's existing denture to position an open hollow framework[34]. Gomes and colleagues printed a two-piece hollow bulb obturator retained by magnets for a patient with trismus[35]. Printed denture base resins for closed hollow bulbs are still being evaluated, however; a 2026 study found that fluid ingress into printed hollow specimens varied with the resin and the printing orientation and increased with thermocycling[36]. Heat-cured polymethyl methacrylate has a long track record in obturators, and the threaded putty technique lets the clinician keep that material while still obtaining a hollow bulb of predictable wall thickness.

Functional outcome

The outcomes recorded in this patient were a passively seating framework, a hollow prosthesis weighing 25 g, absence of nasal leakage on a water-drinking test, improved perceptual speech ratings and independent insertion and removal. These are modest measures but they match the outcomes reported in larger series. Grover and colleagues found that speech intelligibility, nasal resonance and swallowing ability all improved significantly with a customised obturator compared with a conventional one in 48 maxillectomy patients[37]; Bhushan and co-workers documented a rise in speech intelligibility scores from about 19 to about 29 over two months with a definitive obturator[38]; and Negi and colleagues reported patient-rated intelligibility rising from 2.0 to 4.2 on a five-point scale over six months in 30 patients[39]. Ta and colleagues, describing digitally planned immediate

obturators in 20 patients, noted that speech problems were the most persistent complaint even when mastication and aesthetics were satisfactory[40], which is a reminder that the bulb contour and the posterior extension matter as much as the framework. A finite element study of Aramany Class I defects found no meaningful difference in displacement between one-piece and two-piece hollow bulb designs, supporting the use of a one-piece prosthesis when the patient can insert it[41]. Punjabi and colleagues combined a laser-welded titanium framework with a silicone cap for patients in whom retention is difficult[42]; this was not needed here because the abutment teeth were sound.

Novelty and clinical significance

The novelty claimed for this report is limited and specific. Sectional impressions, digital framework design, DMLS frameworks and retrievable spacers have each been reported. What has not been described in detail is a single workflow that (a) uses a conventional functional impression and pick-up for the defect, (b) surveys and designs the framework digitally with a lattice retention area engineered for a bulb, (c) manufactures the framework by DMLS through a commercial service, and (d) hollows the bulb during conventional heat-cure packing with a thread-retrieved putty spacer. The workflow adds no equipment beyond a model scanner and keeps the clinical stages familiar to postgraduate students, which makes it a practical route to a digitally designed framework for a teaching institution that is not yet equipped for fully digital fabrication.

Limitations

This is a single case with short follow-up, and no conclusion about longevity, fracture resistance or the durability of the sealed window can be drawn from it. The speech assessment was perceptual and clinician-rated; acoustic analysis with software such as Praat, nasometry or a validated intelligibility test would have provided stronger evidence[3,27]. The weight reduction was calculated from the spacer volume rather than measured against a solid duplicate processed under identical conditions. Quality of life was not assessed with a validated instrument such as the Obturator Functioning Scale or OHIP-14, which have been used in comparable Indian patients[4]. The framework fit was judged clinically rather than by superimposition of a scan of the framework on the design file, which is now the accepted method for quantifying trueness[20,22]. Finally, the patient had not received radiotherapy and had healthy abutment teeth; the workflow may need modification in irradiated patients or in those with compromised abutments, where implant retention or a two-piece design may be preferable.

CONCLUSION

In this patient with an Aramany Class I maxillectomy defect, a definitive closed hollow bulb obturator was fabricated by combining a conventional functional impression sequence with digital survey and design of the framework, DMLS manufacture in cobalt–chromium and threaded putty hollowing of the bulb during conventional heat-cure processing. The framework seated passively with minimal adjustment, the hollow bulb reduced the weight of the prosthesis, the oronasal communication was sealed on a water-drinking test, and the patient's speech and comfort improved on short-term perceptual assessment. The threaded putty method produced a closed hollow space of predictable wall thickness with materials already present in the laboratory and without residue. The workflow is reproducible in a teaching department that has a model scanner and access to a commercial DMLS service, and it may be a useful intermediate step for centres that are not yet equipped for fully digital obturator fabrication. Longer follow-up and objective measurement of speech, weight and framework fit in a larger group of patients are needed before wider claims can be made.

DECLARATIONS

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