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Digital Rehabilitation of a Post-Mucormycosis Maxillectomy Defect Using a 3D-Printed Obturator with Objective Speech Analysis: A Case Report

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Case Report

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Abstract

Maxillectomy following mucormycosis results in severe functional and aesthetic impairments, including midfacial collapse, compromised speech, and impaired mastication, necessitating comprehensive prosthetic rehabilitation. This case report presents a fully digital workflow for rehabilitating a patient with a post-mucormycosis maxillectomy and sunken midface. Conventional impressions were digitised using a laboratory scanner to design and fabricate a definitive obturator and a three-dimensional (3D) printed maxillary denture. The integration of CAD/CAM technology and 3D printing enhanced precision, reduced processing time, and minimised manual errors. Objective speech analysis using PRAAT software was conducted before and after prosthesis delivery, demonstrating significant improvements in intensity and formant frequency alignment across key vowels, indicating restored articulatory efficiency and vocal resonance. In addition to aesthetics and masticatory improvements, the prosthesis contributed to better speech intelligibility and an overall enhancement in the patient's quality of life. This report highlights the effectiveness of digital prosthodontic techniques in delivering precise, efficient, and functionally optimised rehabilitation in maxillectomy patients, with measurable improvements in speech outcomes.

Introduction

Mucormycosis is an aggressive, angio-invasive fungal disease whose incidence has risen markedly in the past decade, particularly among individuals with uncontrolled diabetes, prolonged corticosteroid therapy, or other immunocompromising conditions [1]. In the craniofacial region, rapid vascular invasion necessitates extensive surgical debridement; partial or total maxillectomy is often unavoidable, leaving patients with oro-nasal communication, altered resonance, and pronounced midfacial collapse [2]. The resultant loss of bony and soft-tissue scaffolding impairs mastication, deglutition, and speech while producing a characteristic “sunken” facial profile that profoundly affects psychosocial well-being [3].

When microvascular free-flap reconstruction is contraindicated by systemic status, defect magnitude, or patient preference, an obturator-based prosthetic approach remains the mainstay of care. Conventional analogue protocols, however, depend on multiple sequential impression, wax-pattern, and flasking stages that can introduce dimensional error and lengthen clinical and laboratory timelines [4]. Contemporary digital prosthodontics, integrating high-resolution intra- and extra-oral scanning, computer-aided design/computer-aided manufacturing (CAD/CAM), and additive manufacturing, overcomes these limitations by enabling precise, reproducible, and patient-specific fabrication of obturators and midfacial prostheses [5]. Three-dimensional (3D) printing, in particular, permits rapid prototyping of lightweight obturator frameworks and silicone substructures that optimise fit, retention, and biomechanical performance.

Beyond morphological restoration, functional validation is essential. Objective acoustic assessment with PRAAT software provides quantifiable metrics, such as intensity and formant alignment, that correlate with speech intelligibility and resonance, offering a robust complement to patient-reported outcome measures [6]. This clinical report details a digitally driven workflow for rehabilitating a post-

mucormycosis maxillectomy patient with midfacial deficiency, emphasising the synergy of laboratory scanning, CAD-guided design, 3D printing, and serial PRAAT-based speech analysis to achieve efficient, precise, and clinically verifiable restoration of both function and facial aesthetics.

Case report

A 48-year-old female patient reported to the Department of Prosthodontics with a chief complaint of missing upper anterior teeth, leading to difficulty in mastication, impaired speech, and a notable change in facial appearance. The patient had a significant medical history of COVID-associated mucormycosis, which necessitated a segmental maxillectomy on the right side of the maxilla approximately three years prior. Her post-surgical course was uneventful, and there was no history of adjunctive radiotherapy or chemotherapy. However, no interim prosthetic rehabilitation was provided following surgery. She denied any familial or genetic disorders, but psycho-socially, she expressed considerable emotional distress and loss of self-confidence due to the midfacial collapse and inability to engage socially with comfort.

Extraoral examination revealed a midfacial deformity characterised by a sunken upper lip and flattening of the right nasolabial region, contributing to asymmetry and loss of facial projection. (Fig. 1a-c).

Intraoral examination revealed an Aramany Class VI maxillary defect with missing maxillary anterior teeth (11, 12,13, 21, 22,23), right posterior premolars (14, 15), and left posterior teeth (24, 26) (Fig. 1d, e). The mandibular arch exhibited the absence of both first molars (36 and 46) (Fig. 1f). However, the patient declined replacement of the missing mandibular teeth and specifically requested prosthetic rehabilitation for the maxillary defect with a definitive obturator.

Following a comprehensive clinical and radiographic evaluation, a fully digital workflow was planned for the fabrication of a definitive obturator to optimise precision, retention, stability, and functional performance. The treatment process included intraoral digital scanning for precise mapping of the maxillary defect and computer-aided design (CAD) for accurate prosthetic planning and individual customisation. An extended labial flange was incorporated into the design to address the sunken upper lip and midfacial collapse, aiming to enhance facial aesthetics, improve phonetics, and restore masticatory efficiency.

In this case, speech analysis was also integrated into the treatment protocol using the PRAAT software to evaluate pre- and post-rehabilitation phonetic outcomes. This helped in assessing the functional improvement achieved through the obturator prosthesis. The patient was thoroughly informed about the digital workflow and speech assessment tools, and written informed consent was obtained before initiation of the treatment.

A primary impression of the maxillary and mandibular arch was made using irreversible hydrocolloid (Zelgan 2002, Dentsply, India) to record the anatomical landmarks and defect area. The primary cast was obtained by pouring the impression with a die stone (Kalident, Kalabhai Dental Pvt. Ltd., India) (Fig. 2a). The custom tray was fabricated with autopolymerizing acrylic resin (Self-Cure Acrylic Repair Material,

Dentsply, India) (Fig. 2b). Border moulding was performed using a low-fusing impression compound (Pinnacle, DPI, India) to ensure accurate adaptation, including the defect area. The definitive impression was made using light-viscosity condensation silicone (Oranwash, Zhermack, Italy), and the master cast was poured using die stone (Kalstone, Kalabhai, India) (Fig. 2c,d).

2d) Master cast, 2e) STL file of the master cast, 2f) digitally designed cusil denture base.

The master cast was scanned using a laboratory scanner (E3; 3Shape A/S) to capture undercuts for optimal retention. The obtained standard tessellation language (STL) file was then imported into CAD software (Meshmixer; Autodesk Inc.) for digital processing and design modifications (Fig. 2e). A trial denture base was digitally designed using CAD software, and the STL file was exported for fabrication (Fig. 2f).

A 3D-printed Cusil denture was created, onto which an occlusal rim was constructed. Maxillomandibular jaw relation was then recorded (Fig. 3a). Following the acquisition of the jaw relation via scanning, the tooth arrangement was digitally designed, incorporating extended anterior flanges to enhance fit and function (Fig. 3b,c). Upon verification of the accuracy and aesthetic alignment of the tooth arrangement, the trial denture design was exported to the CHITUBOX v2.1.0 slicing software (CHITUBOX). The final design was then fabricated using a Digital Light Processing (DLP) 3D printer (Max X; Asiga), ensuring precise reproduction of the trial denture with optimal resolution (Fig. 3d-f).

The clinical evaluation demonstrated a significant enhancement in prosthesis stability and retention, along with marked improvement in midface contour and alleviation of the sunken lip appearance (Fig. 4a-d).

Following the try-in procedure, the trial denture was scanned, and the definitive obturator was digitally designed with precision (Fig. 5a,b). The definitive obturator was fabricated through 3D printing utilising biocompatible resins: CURO ProDenture (Ackuretta) for the base and CROWNTEC (Saremco Dental AG) for the teeth (Fig. 5c-e). A long-term soft liner (Mollosil; Detax GmbH) was applied to optimise retention and enhance patient comfort (Fig. 5f).

Post-insertion evaluation revealed substantial improvements in patient-reported satisfaction, phonetic articulation, masticatory function, and overall prosthetic performance. Baseline speech evaluation using PRAAT software before prosthesis delivery revealed a mean vocal intensity of 65.2 dB and altered vowel formant patterns /a/: F1 593 Hz, F2 1125 Hz; /e/: F1 451 Hz, F2 1702 Hz; /u/: F1 351 Hz, F2 866 Hz—reflecting acoustic distortion secondary to loss of anterior maxillary structures. At the 1-week post-insertion follow-up, the patient reported improved comfort, masticatory efficiency, and phonetic clarity. These subjective improvements were objectively supported by acoustic data showing an increase in mean intensity to 71.4 dB and normalisation trends in vowel formants, particularly for /a/ (F1 459 Hz, F2 1196 Hz). A structured post-prosthetic care regimen was initiated, including saline rinses, soft-brush cleaning of the obturator, and progressive dietary advancement to facilitate tissue adaptation. At the 1-month review, mean intensity further increased to 73.5 dB, with continued realignment of /e/ vowel

formants (F1 420 Hz, F2 1881 Hz) and improved speech intelligibility. By 3 months, the prosthesis demonstrated excellent positional stability and restored facial contour, with acoustic values indicating further gains, mean intensity 75.2 dB; /u/: F2 1042 Hz, enabling unrestricted oral function. At the 6-month evaluation, the prosthesis remained well-adapted and mucosally compatible, with sustained improvement in speech parameters (mean intensity 76.8 dB; /a/: F1 506 Hz, F2 1280 Hz; /e/: F2 1951 Hz), confirming long-term phonetic restoration. No complications such as tissue irritation, mechanical wear, or prosthetic instability were observed, highlighting the structural integrity, biocompatibility, and clinical success of the fully digital, 3D-printed maxillofacial rehabilitation in anterior maxillectomy cases.

Furthermore, the rehabilitation effectively restored midfacial contour, mitigating the sunken midface deformity, as evidenced by pre- and post-operative comparative analysis (Fig. 6a-f). The patient received detailed post-prosthetic care instructions, emphasising stringent hygiene protocols and a structured adaptation period to promote long-term prosthetic success and oral tissue health. The six-month follow-up demonstrated exceptional prosthesis stability, with sustained enhancements in speech articulation, masticatory function, and overall esthetic outcomes.

Discussion

Maxillectomy occasioned by mucormycosis obliterates critical anterior palatal and midfacial support, precipitating oronasal communication, loss of facial contour, and multidimensional functional compromise. Conventional obturators partially restore these deficits but often fall short in precision fit, weight optimisation, and esthetic integration, particularly when extensive soft-tissue collapse demands customised three-dimensional scaffolding [6]. In the present case, a hybrid workflow capitalised on the fidelity of a conventional mucostatic impression for capturing intricate defect margins, then leveraged CAD-based modelling and Digital Light Processing (DLP) printing to design a lattice-filled, hollow obturator and a Cusil-type maxillary denture with an extended flange.

This approach conferred several notable advantages in the rehabilitation of anterior maxillectomy defects. The lightweight construction of the digitally designed, hollow obturator significantly minimised rotational forces acting on the residual palate, thereby enhancing prosthesis stability during function. Virtual relief design and pressure mapping allowed for precise control over areas of tissue contact, effectively reducing the risk of mucosal trauma and improving overall patient comfort. Furthermore, additive manufacturing enabled rapid prototyping and accurate reproduction of the patient's facial contour, contributing to improved aesthetic outcomes and higher patient satisfaction. These clinical observations align with recent in vivo studies demonstrating that digitally fabricated hollow obturators can reduce overall prosthesis weight by 25–40% while providing superior retention and comfort compared to conventionally processed acrylic alternatives [7,8].

A silicone soft liner was incorporated along the peripheral seal to absorb functional micromovements and augment adhesion to mobile mucosa. Systematic reviews affirm that resilient liners, when bonded to CAD-milled or printed frameworks, lower peak mucosal stress and extend tissue tolerance, especially in

defects devoid of bony undercuts [9]. Moreover, the digitally articulated occlusal scheme reduced premature contacts, limiting post-insertion adjustments to minor polishing.

Baseline recordings revealed reduced vocal intensity (65.2 dB) and dispersed formant patterns, reflecting impaired resonance due to anterior maxillary loss. Over time, speech parameters improved significantly, with intensity rising to 71.4 dB at one week, 73.5 dB at one month, 75.2 dB at three months, and 76.8 dB at six months. Concurrently, F1–F2 values for vowels /a/, /e/, and /u/ approached normative ranges, indicating restored articulatory control. These improvements paralleled enhanced speech intelligibility and the resolution of hypernasality, confirming the prosthesis's effectiveness.

PRAAT is a valuable, free acoustic analysis tool widely used in maxillofacial rehabilitation to objectively assess speech outcomes. It offers high-resolution data, customisable scripts, and a broad range of phonetic parameters, making it ideal for tracking changes after prosthetic interventions like obturator placement. Its advantages include accessibility, precision, and the ability to monitor progress over time. However, it requires technical expertise, is sensitive to recording conditions, and lacks normative data for post-maxillectomy cases. Indicated for evaluating speech restoration and therapy outcomes, its use is limited in patients with cognitive impairments, trismus, or acute oral pain. Despite these limitations, PRAAT enhances clinical documentation and research reliability in prosthodontic care [11].

The integration of PRAAT-based analytics into a digital fabrication pathway provided quantifiable evidence of speech restoration, complementing esthetic and masticatory gains. Although capital investment in scanners, design software, and certified resins remains a barrier, cost analyses suggest that reduced chairside time and fewer remakes offset initial expenditures within three to five complex cases. Limitations include the difficulty of intraoral optical capture in expansive defects and the necessity for operator training in acoustic analysis. Ongoing advances in artificial-intelligence-assisted scanning and automated speech-feature extraction promise to streamline both processes.

This case confirms that a hybrid conventional–digital strategy, augmented by objective acoustic monitoring, can deliver predictable esthetic, biomechanical, and phonetic rehabilitation for anterior maxillectomy defects. Future multicentre studies should correlate PRAAT-derived metrics with long-term prosthesis survivorship, patient-reported oral-health–related quality of life, and three-dimensional biomechanical modelling to validate these findings across broader clinical settings.

The long-term prognosis for this digitally fabricated prosthesis is favourable, with sustained retention, phonetic restoration, and aesthetic satisfaction confirmed up to six months. Continued follow-up is advised to assess mucosal compatibility and midfacial contour maintenance.

The patient shared that the post-surgical facial collapse and speech difficulty had a profound impact on her confidence and daily functioning. She described the digitally fabricated prosthesis as life-changing, restoring her appearance, enabling clear speech and comfortable eating, and doing so efficiently with minimal clinical visits.

Conclusion

The integration of digital prosthetic design with conventional impression techniques presents a highly effective approach for rehabilitating patients with anterior maxillary defects following mucormycosis. This case demonstrates that combining a hollow definitive obturator with a 3D-printed Cusil-type denture not only improves prosthesis fit, retention, and aesthetics but also significantly restores speech, mastication, and midfacial contour. The use of PRAAT software for serial speech analysis provided objective evidence of functional recovery, reinforcing the clinical value of incorporating acoustic assessment into rehabilitation protocols. While digital workflows require specialised equipment and technical expertise, they enable precise, patient-specific solutions with reduced manual errors and enhanced efficiency. As digital technologies and AI-assisted prosthetic design continue to evolve, their application in maxillofacial prosthodontics is poised to further optimise both functional outcomes and quality of life for patients with post-mucormycosis maxillectomy defects.

Declarations

Informed Consent

Written informed consent was obtained from the patient for publication of this case report and accompanying clinical images.

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Figures

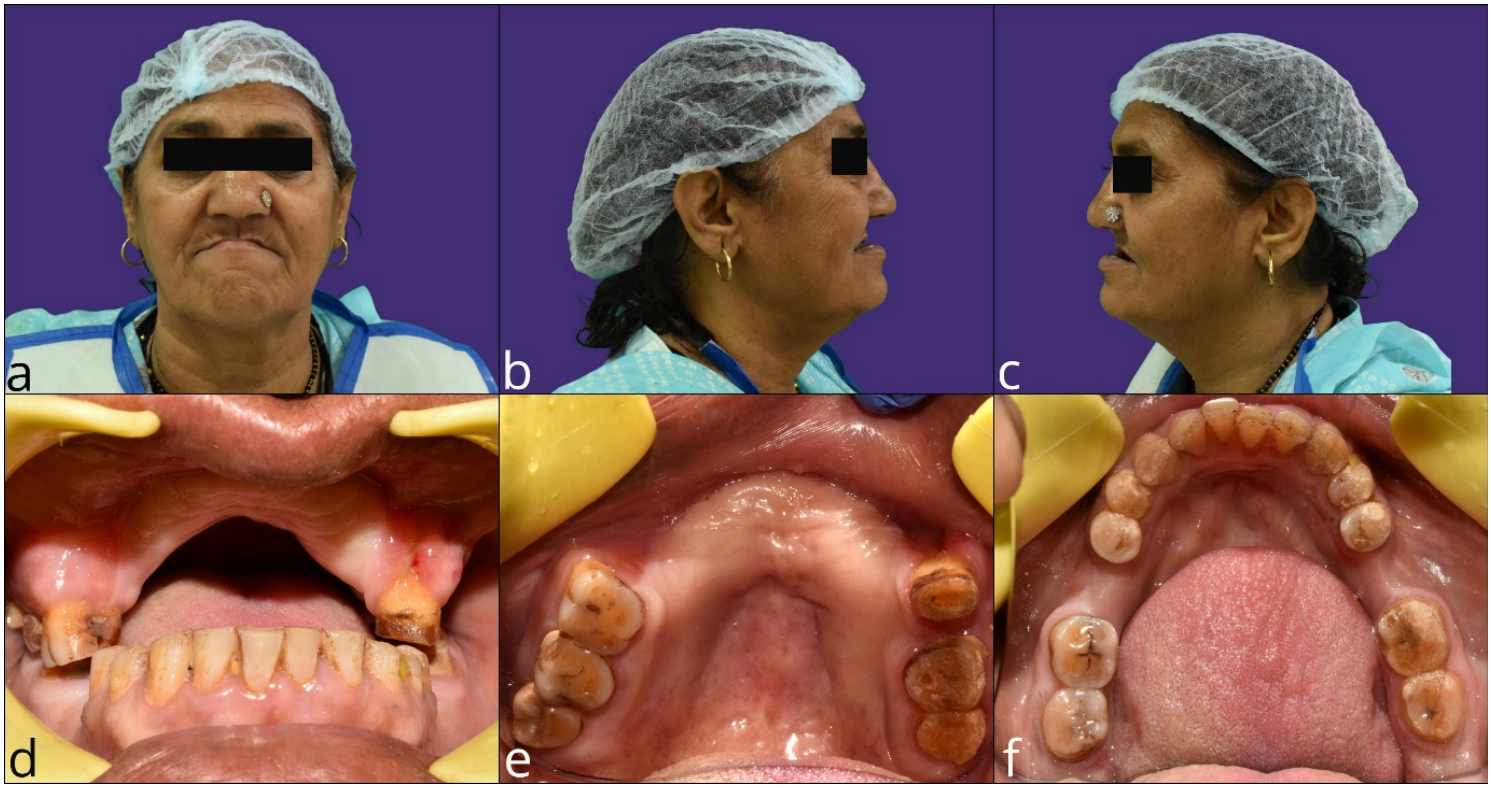


Figure 1

1a) Extraoral frontal view, 1b,c) Extraoral right and left lateral view, 1d) Frontal occlusal view, 1e) Maxillary arch view, 1f) Mandibular arch view.

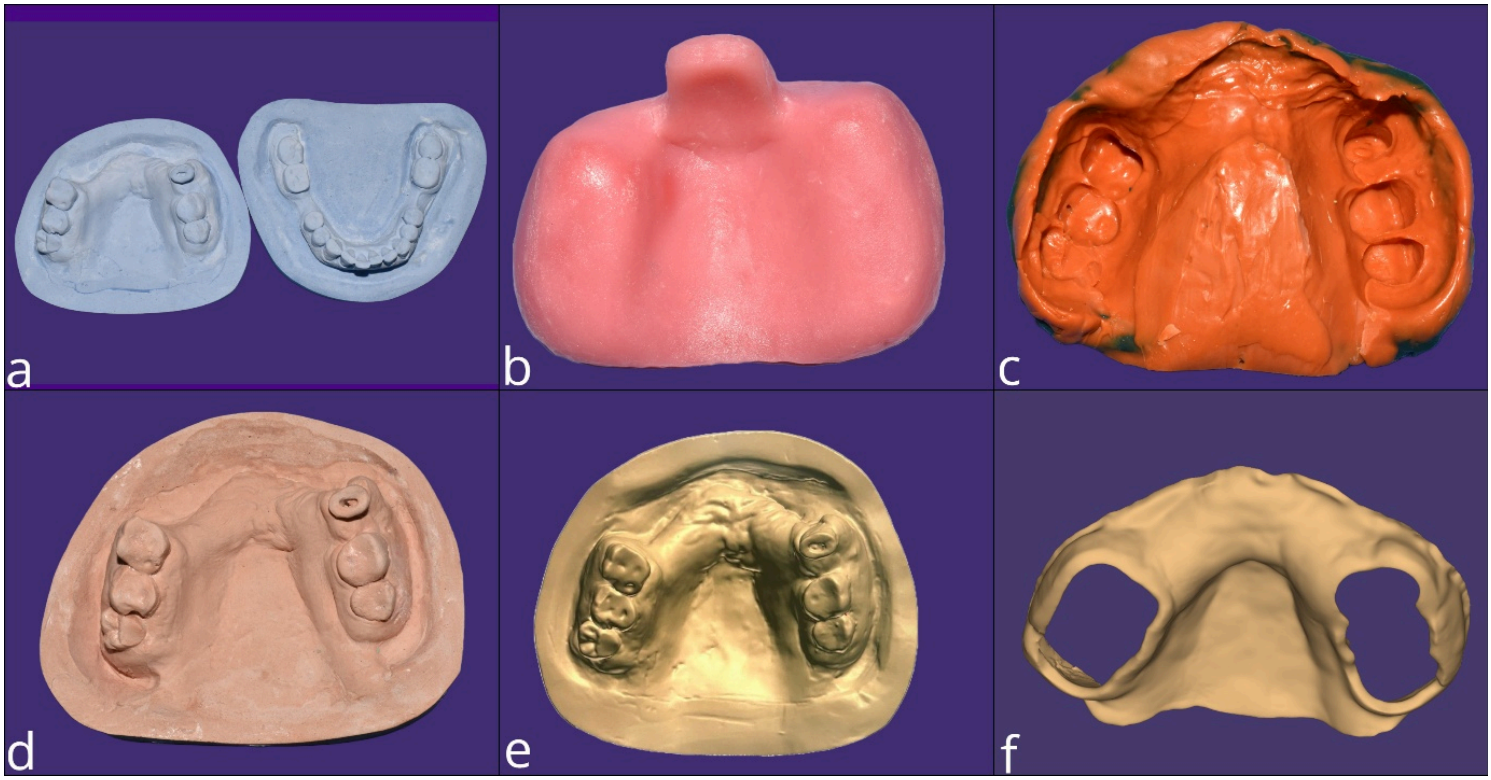


Figure 2

2a) Maxillary and mandibular primary cast, 2b) Custom tray, 2c) Final impression,

2d) Master cast, 2e) STL file of the master cast, 2f) digitally designed cusil denture base.

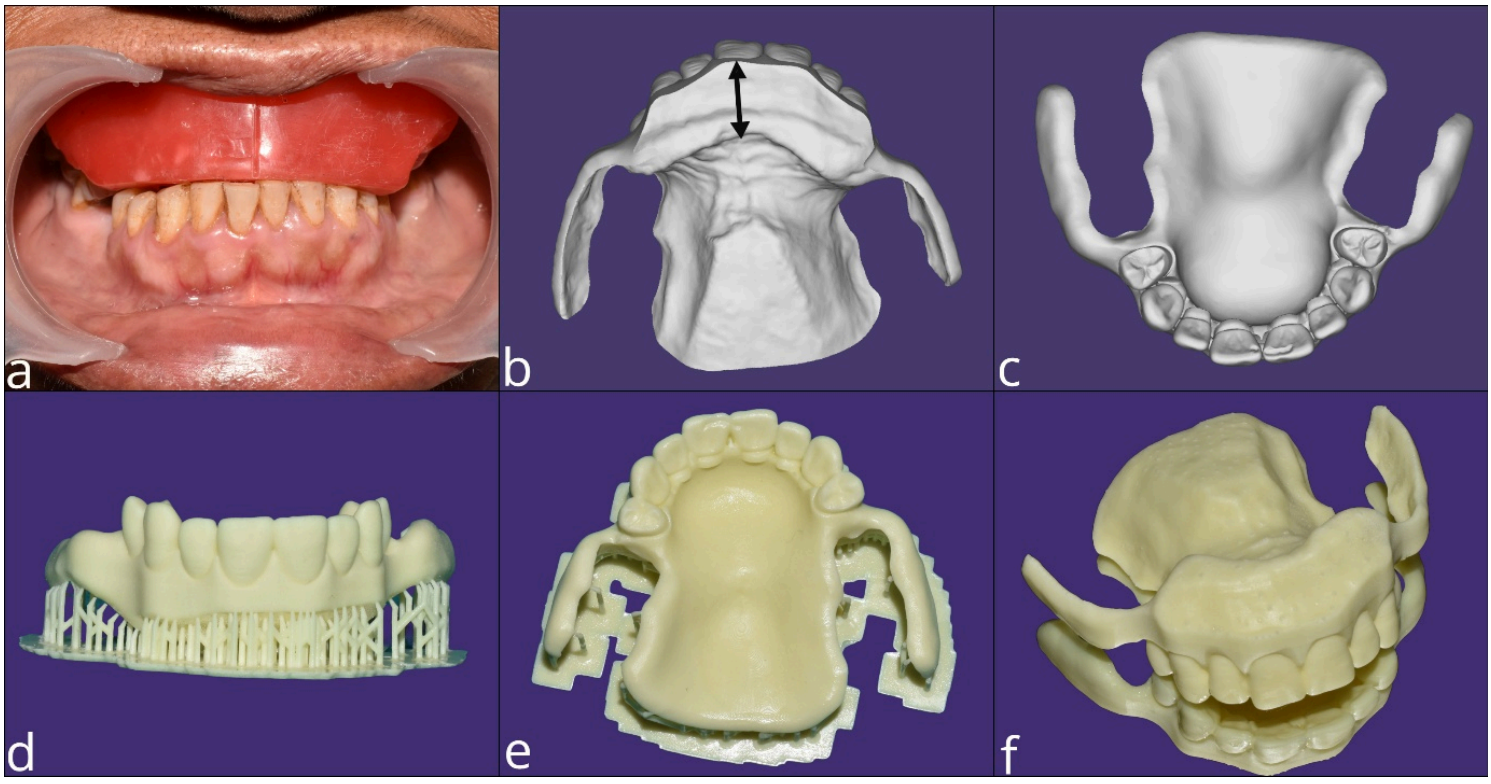


Figure 3

3a) Jaw relation. 3b,c) digitally designed trial denture with extended flange. 3d-f) 3D-printed trial denture.



Figure 4

4a) Intraoral try-in view. 4 b-d) Extraoral try-in view.

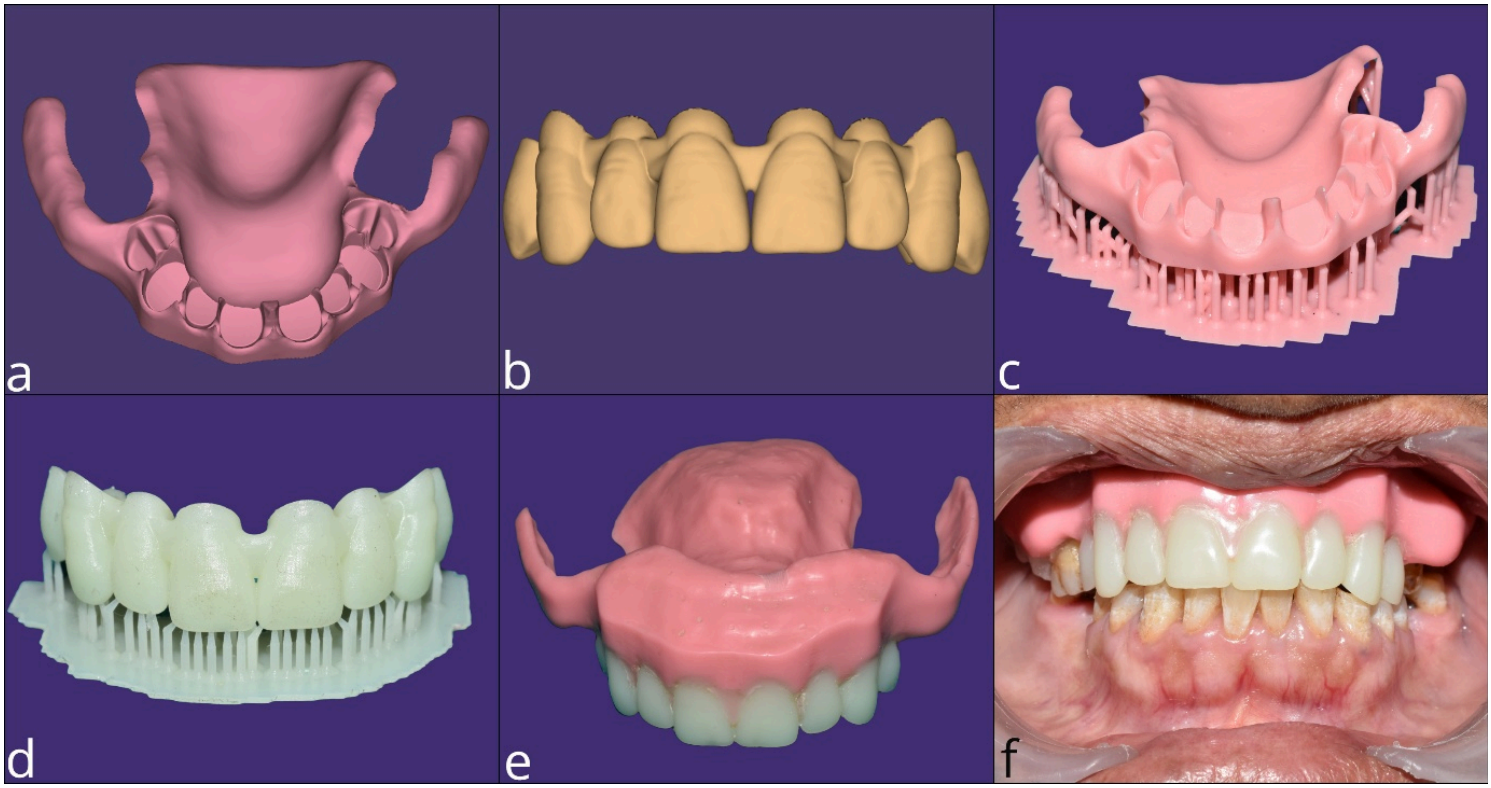


Figure 5

5a,b) CAD design denture and teeth, 5c,d) 3D printed denture base and teeth, 5e) Final prosthesis, 5f) Definitive prosthesis intraoral view.

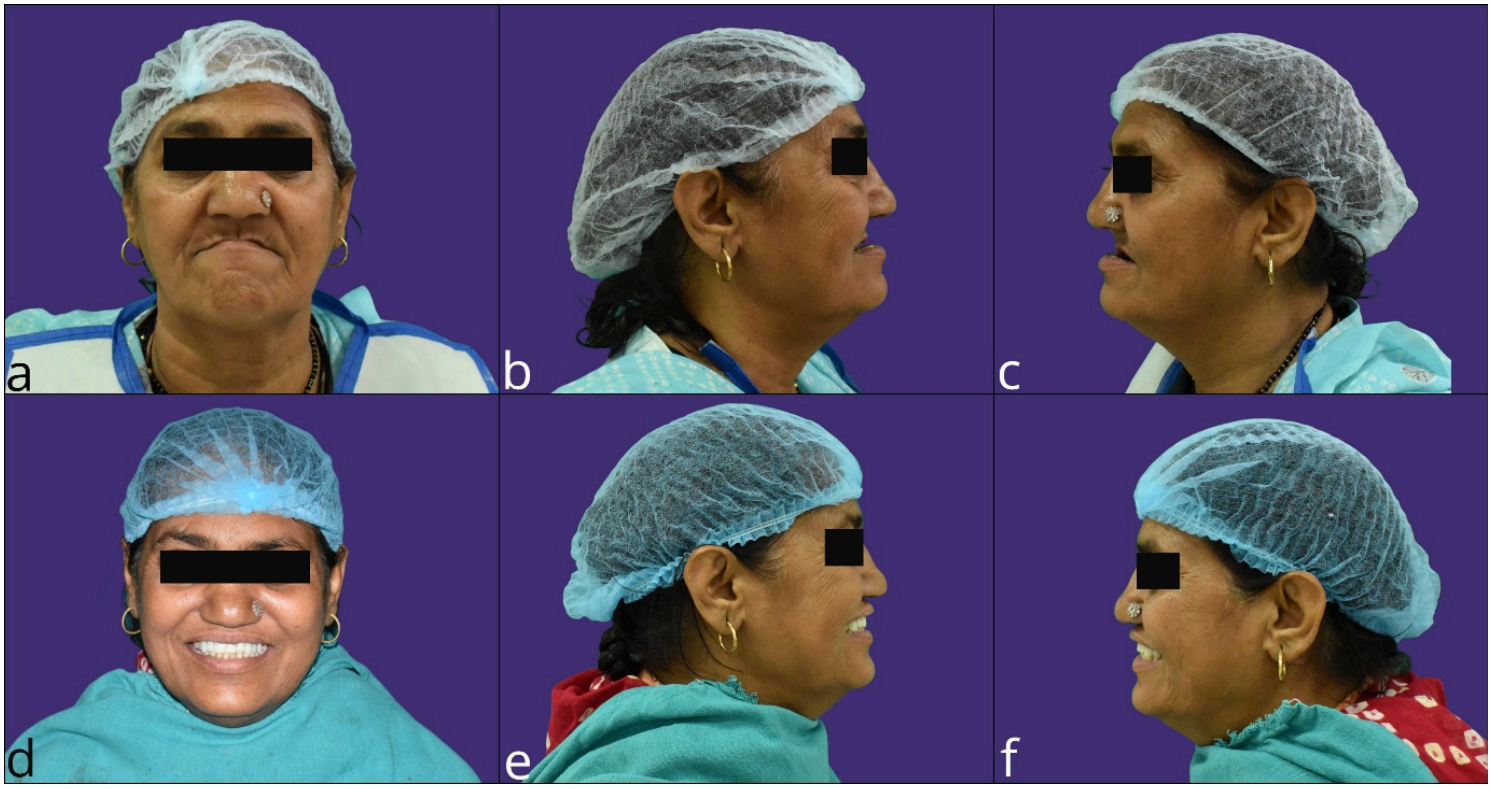


Figure 6

6a-6c) Pre-rehabilitative extraoral frontal and lateral view. 6d-f) Post-rehabilitative extraoral frontal and lateral view.