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CLINICAL REPORT

Digitally designed and milled implant-retained maxillofacial prosthesis for velopharyngeal closure in a patient with a nonsurgically treated cleft palate: A clinical report

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ABSTRACT

An implant-retained maxillofacial overdenture with a pharyngeal speech aid prosthesis was fabricated for a patient with a nonsurgically treated cleft palate who was unable to achieve velopharyngeal closure. Computer-aided design and computer-aided manufacturing were used to fabricate a metal-reinforced prosthesis using the Ivotion Denture System and subtractive manufacturing with geographic guides. Magnetic attachments were incorporated to improve the retention and stability of the prosthesis. Masticatory function, deglutition, and esthetics were found to be improved at the 6-month follow-up. (J Prosthet Dent 2025;133:908-914)

A cleft palate is a common congenital malformation resulting from the failed fusion of the lateral palatine processes. Symptoms after growth completion include distorted articulation, decreased oral pressure, and increased nasal resonance.[1–3] Surgical methods aim for velopharyngeal closure within the first 2 years of life[4,5]; however, some patients cannot undergo surgery because of delayed diagnosis or financial constraints.

Beumer et al reported the successful nonsurgical treatment of a patient with a cleft across the entire soft palate with a maxillofacial prosthesis.[6] Diagnostic tools such as nasal endoscopy, articulation tests, and oral pressure tests aid in the fabrication of effective prostheses.[7–9] Soft-palatal and pharyngeal tissue movement negatively affects prosthesis retention and stability, which can be addressed by using precisely positioned implants to retain and stabilize the prosthesis.[10–13]

Advances in digital dentistry facilitate the fabrication of complete dentures for edentulous patients with various workflows, including complete denture-associated maxillofacial prostheses.[14–19] These advances offer benefits over traditional methods, such as volumetric stability, esthetic appeal, precision fit, and improved strength.[20–24] However, reports of patients receiving digitally fabricated maxillofacial prostheses with these advantages are lacking. This report describes the nonsurgical treatment of a patient with a soft palate cleft using a digitally fabricated maxillofacial prosthesis; the workflow is illustrated in Figure 1.

CLINICAL REPORT

A 66-year-old man visited the department of prosthodontics, Seoul National University Dental Hospital, seeking complete dentures. He had been completely edentulous for 20 years and had no previous denture experience. Clinical evaluation revealed incorrect pronunciation with poor articulation. Intraoral examination revealed a cleft in the central portion of the soft palate with collapse of the palatoglossal and palatopharyngeal arches (Fig. 2). Computed tomography showed fusion failure of the posterior hard palate, absence of the soft-palatal aponeurosis and uvular muscles, abnormal soft-palatal muscle insertion, and atrophy of the lower posterior nasal structures near the pharynx (Fig. 3).

An interim maxillofacial prosthesis and mandibular complete denture were fabricated conventionally to

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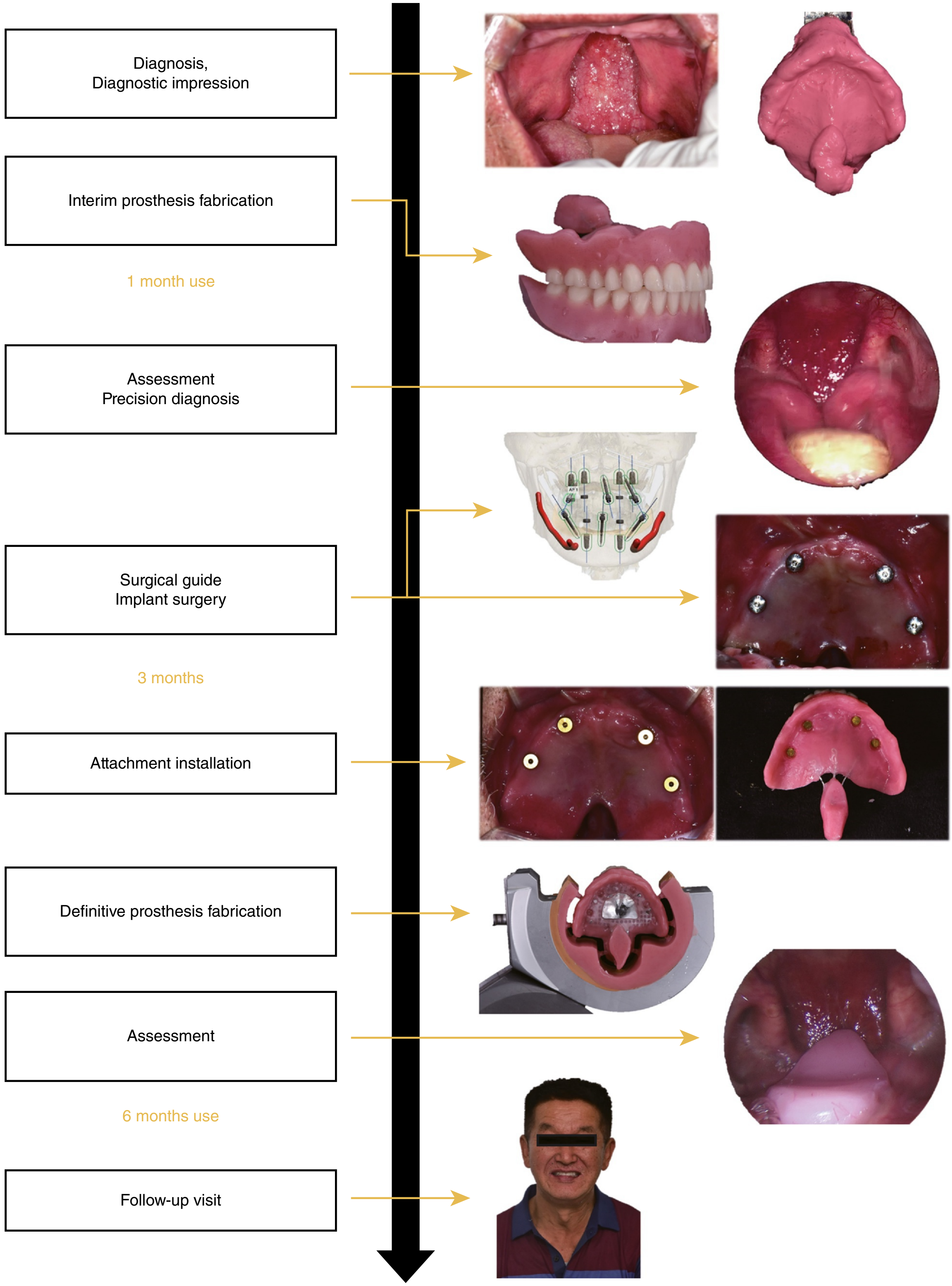

Figure 1. Treatment timeline.

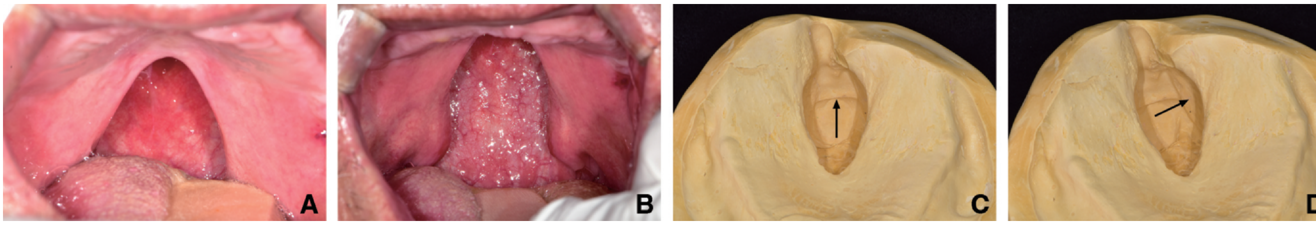

Figure 2. Intraoral photographs and diagnostic casts. A, Divided soft palate. B, Collapsed palatoglossal and palatopharyngeal arches. C, Passavant ridge (*black arrow*). D, Lateral tissue movement (*black arrow*).

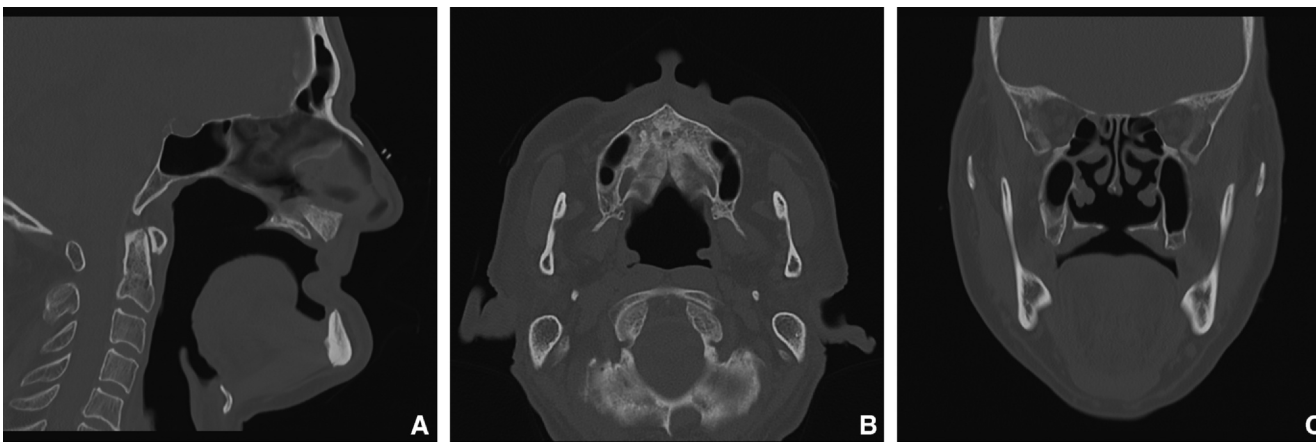

Figure 3. Computed topography images. Fusion of posterior hard palate, soft-palatal aponeurosis and missing uvular muscles. A, Sagittal view. B, Horizontal view. C, Frontal view.

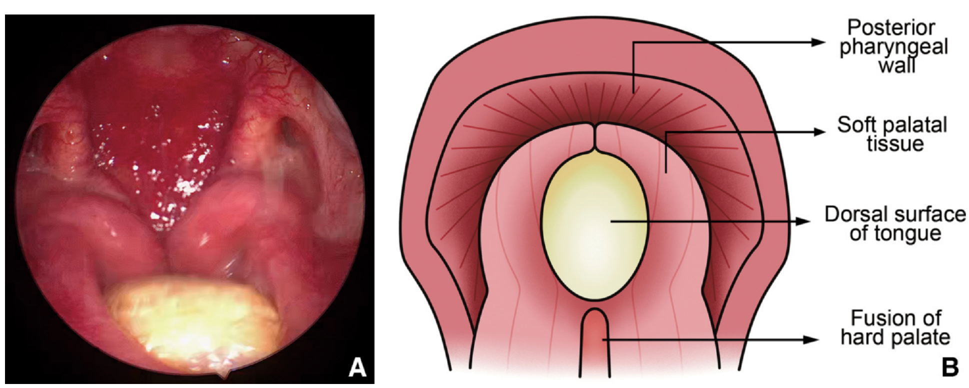

Figure 4. Velopharyngeal closure compensation of patient. A, Nasal endoscopy. B, Diagram of patient's functional anatomy.

Table 1. Pronunciation accuracy without and with maxillofacial prosthesis

Without/with Prosthesis	Consonants	Vowels
Words	23/43	8/10
Accuracy (%)	53.49	80

assess retention and stability against the displacement forces exerted by the soft-palatal and pharyngeal movements. Functional impressions of the soft palate and pharyngeal regions were made while the patient articulated glottal and soft-palatal consonants, recording maximal soft-palatal muscle movement during dry deglutition and head and neck tilting. The diagnostic cast revealed the Passavant ridge and lateral soft-tissue movement associated with velopharyngeal closure (Fig. 2). The obturating area of the interim prosthesis, 10 mm in height, was designed with 1- to 2-mm clearance around the Passavant ridge and the lateral soft-tissue wall to maintain air flow and compensate for velopharyngeal closure.

During the second visit, the patient reported minimal prosthesis use because of unbearable discomfort and insufficient retention and stability. Nasal endoscopy (HOPKINS telescope; Karl Storz) revealed a compensatory mechanism for velopharyngeal closure (Fig. 4). During deglutition, the soft palate muscles showed

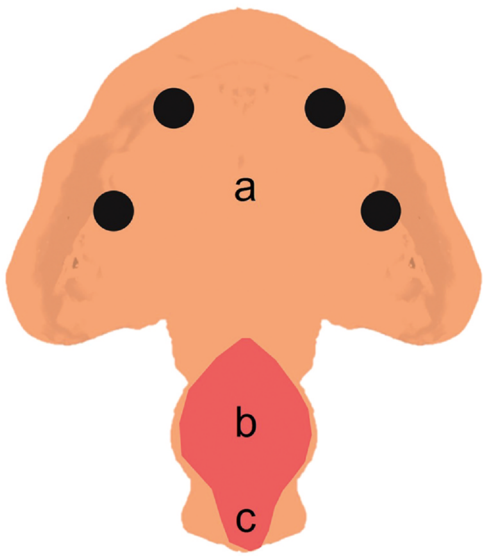

Figure 5. Definitive prosthesis design. a, Implant-supported overdenture with magnet attachments. b, Resin plate to make unconstrained movement of tongue. c, High resin wall to achieve soft-palate closure.

extensive but weak movement, converging around the posterior pharyngeal wall, whereas the central oval-shaped cleft was obturated by the midsection of the tongue. However, the soft palate movement was insufficient to displace the heavy-bodied impression materials, resulting in an overextended posterior obturation area and consequent discomfort.

Pronunciation assessment revealed compensatory tonal errors resulting from air escaping into the nasal cavity caused by the extensive defect. Articulation omissions of soft-palatal consonants and articulation substitutions because of the tongue's inability to block the defect were noted (Table 1). Importantly, the patient had not acquired tongue-articulation skills. These factors collectively contributed to his unintelligible pronunciation.

After diagnosis, a definitive prosthesis was designed (Fig. 5). A surgical template was fabricated, and 6 dental implants (Osstem TS III; Osstem Implant) were placed in the bilateral maxillary canine, first molar, and mandibular canine regions. Sinus augmentation was simultaneously performed using an osseodensification bur (Densah bur; Versah) and xenograft bone (Bio-Oss; Geistlich Pharma) to address low insertion torque associated with limited maxillary alveolar bone height. Considering the patient's limited dexterity, magnet keepers (Magden SA; Shinwon Dental) were attached to the implants 3 months postoperatively, and magnets were embedded in the interim prosthesis to improve retention and stability.

During the initial visit for fabricating definitive prostheses with the Ivotion Denture System (Ivoclar AG), duplicate dentures served as trays for the preliminary impressions. A centric tray handle was affixed to the maxillary duplicate denture to obtain a preliminary occlusal record. Minor occlusal-plane errors were rectified using the Universal Transfer Bow System (UTS 3D; Ivoclar AG). Facial scans in both resting and smiling states were acquired with a facial scanner (Bellus3D; TMD Technologies) and a facial-scan device. During the second visit, a definitive impression (Imprint II Garant Light body; 3M ESPE) of the oral area was obtained using a gnathometer tray fabricated based on the acquired data. Gothic arch tracing (Gnathometer CAD; Ivoclar AG) established the interocclusal relationship. A tissue conditioner (COE-SOFT; GC America) was applied to the posterior area, and an impression of the pharyngeal area was recorded under functional conditions for 20 minutes. Digital facebow transfer and mandibular-movement tracking (Zebris for Ceramill; Amann Girrbach AG) were performed. The acquired data were transmitted to the laboratory and overlaid to create a virtual patient. After tooth arrangement, occlusal adjustments were made using the tracking data (Fig. 6). During the third visit, trial dentures were evaluated for function and esthetics. A subtractive manufacturing method with a geographic guide was used to fabricate a metal-reinforced denture. The designed teeth and metal framework with the geographic guide were assembled onto the brownstone intaglio of the milling holder, which matched the occlusal structures of the milled teeth and the 3 hemispheres of the geographic guide. Polymethyl methacrylate resin (Press LT; Retec) was injected into the milling plate, and the definitive prosthesis was milled and polished (Fig. 7). During the fourth visit, the prosthesis was delivered with magnets embedded using pattern resin (Pattern Resin LS; GC America). Nasal endoscopy confirmed a precise seal between the soft palate and pharyngeal speech aid prosthesis (Fig. 8).

At the 6-month follow-up, the patient reported satisfactory mastication, comfortable swallowing, and a natural appearance. However, the articulation test showed no pronunciation improvement (Table 1). Therefore, speech therapy was scheduled, and pharyngeal area augmentation was planned to enhance oral pressure and reduce nasality.[6]

DISCUSSION

The treatment approach for this patient used digital workflows to fabricate a maxillofacial prosthesis. Digital facebow transfer allowed the superimposition of the imaged definitive cast and the virtual articulator, solving the mounting problem caused by spatial interference between the real posteriorly extended definitive

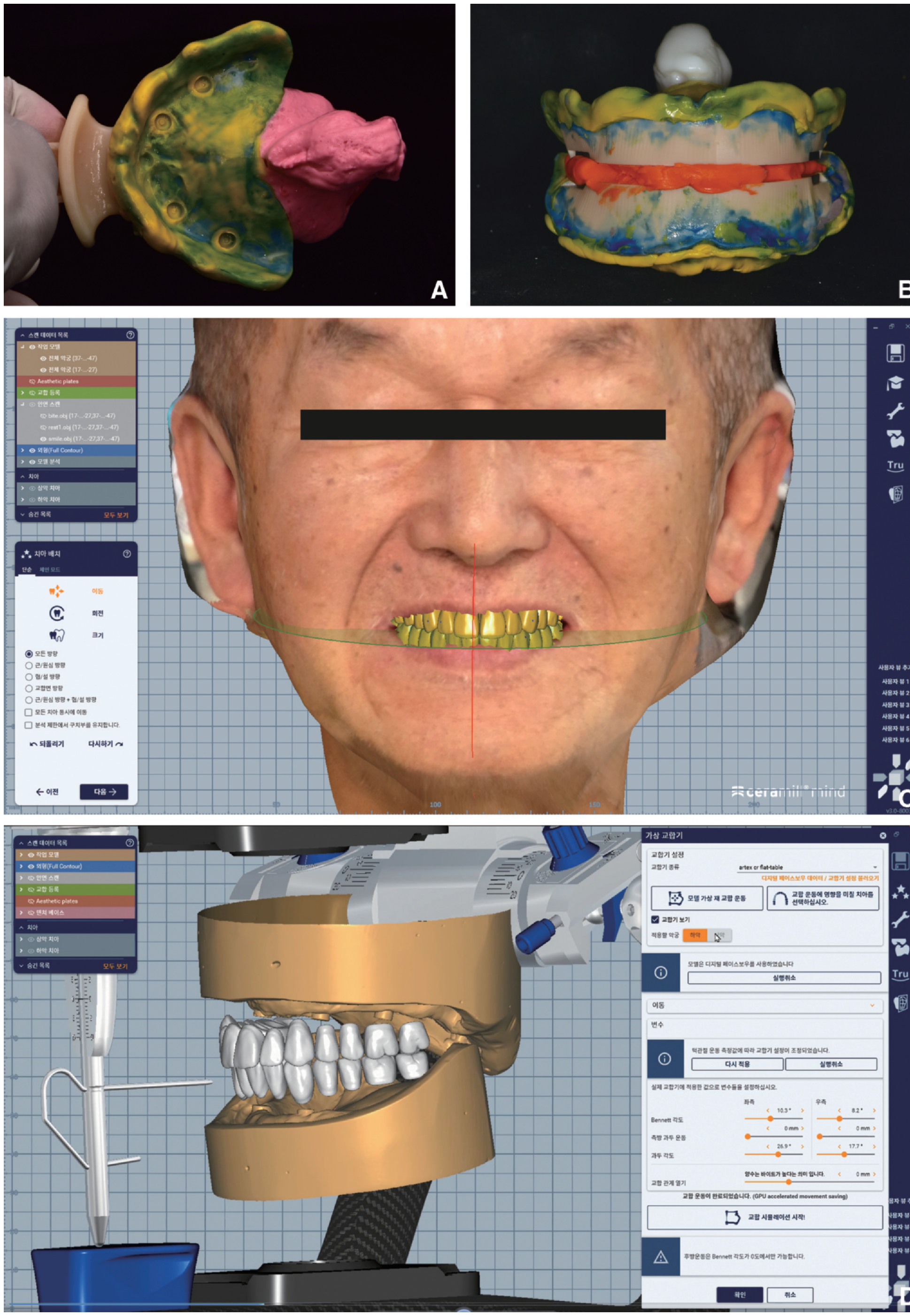

Figure 6. Computer-assisted designing process for definitive prosthesis. A, Preliminary impression by using duplicate denture with centric tray handle. B, Functional impression and centric-relation record by using gnathometer tray. C, Tooth arrangement on virtual patient. D, Occlusal adjustment on virtual articulator by using Zebris for Ceramill data. Bilateral balanced occlusion applied for retention and stability of prosthesis.

maxillary cast and the upper frame of the semi-adjustable articulator. The virtual patient model accounted for facial asymmetry. CAD-CAM addressed deep undercuts in the pharyngeal area, preventing wax-denture removal issues and cast destruction. Subtractive manufacturing of the metal-reinforced denture mitigated resin polymerization shrinkage and volumetric changes in the prosthesis.

In this clinical report, magnet attachments were used to retain and to stabilize the prosthesis. Boven et al[25] reported less marginal bone loss with bar-type attachments than LOCATOR-type in 4-implant overdentures.

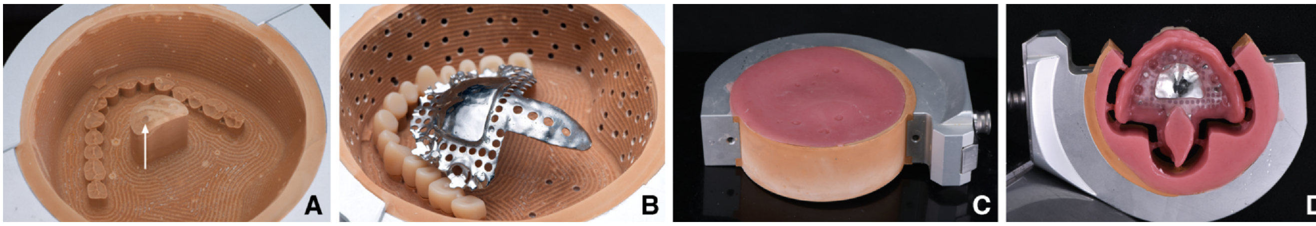

Figure 7. Preparation of milling plate. A, Milled stone base with three dimples for geographic guide (*white arrow*). B, Assembly of milled teeth, framework with geographic guide, and milled stone base. Three hemispheres on metal framework matched to each dimple. C, Denture resin injected and polymerized after assembly. D, Milled definitive prosthesis.

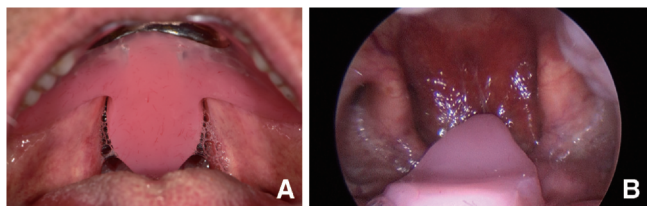

Figure 8. After delivery of definitive prosthesis. A, Intraoral photograph at rest. B, Nasal endoscopy during deglutition with definitive prosthesis.

While bar-type attachments were initially considered, bulky devices were unsuitable for a patient with low dexterity. To facilitate use of the prosthesis and to reduce lateral force on the implants, solitary-type magnet attachments were selected.[26]

At the 6-month follow-up, the patient showed no improvement in pronunciation. A previous study[27] indicated that unresolved phonetic issues in patients with a cleft palate may lead to persistent phonologic errors, not easily corrected by surgery or prosthetics. Therefore, long-term, strategic speech therapy may be warranted as part of prosthodontic management for older adults with cleft palates.[28]

The presented digitalized fabrication technique for maxillofacial prostheses may be contraindicated for prostheses larger than the milling plate size. The short 6-month follow-up period is a limitation of this report. A long-term follow-up, at least 2 years, is necessary to assess implant survival, hard and soft tissue reaction, and the effectiveness of the speech aid prosthesis.

SUMMARY

This clinical report illustrates the fabrication of a maxillofacial prosthesis for the nonsurgical management of a patient with a cleft palate. Digital technology was used to design and manufacture an implant-assisted overdenture with magnetic attachments. Configuration of the pharyngeal speech aid prosthesis was determined with data from nasal endoscopy and pronunciation assessments.

PATIENT CONSENT

Written informed consent for using the treatment information and clinical photographs has been obtained.

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