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CLINICAL REPORT

Three-dimensional printed definitive cast for a silicone obturator prosthesis: A clinical report

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ABSTRACT

For patients with head and neck cancer requiring a maxillectomy, obturator prostheses help with quality of life. These patients routinely require adjuvant oncologic treatments with significant adverse effects. Treatment sequelae can leave patients with difficulty speaking and swallowing, reduced salivary function, reduction in maximal incisal opening, and at risk of osteoradionecrosis. A 55-year-old African-American woman presented with significant trismus and reduction in maximal incisal opening after treatment for squamous cell carcinoma of the left maxillary sinus. She had received a left total maxillectomy with adjuvant chemotherapy and radiation treatments. With her reduced opening, she was no longer able to insert her interim obturator prosthesis, which caused difficulty speaking and nasal regurgitation. A cone beam computed tomography scan was made of the patient's maxillectomy defect. From the Digital Imaging and Communications in Medicine file, a definitive cast was 3-dimensionally printed to fabricate a flexible silicone obturator prosthesis. This treatment has allowed the patient to return to a functional quality of life and could help other patients in similar situations. (J Prosthet Dent 2019;121:353-7)

Head and neck cancer can be a devastating disease that often negatively affects a patient's quality of life.[1,2] Treatment of head and neck cancer involves multiple modalities, including head and neck surgery, radiation therapy, and chemotherapy. Selection of treatment involves careful consideration of histology, location, and size of the primary tumor along with the status of cervical lymph nodes.[3] For maxillary and nasal sinus malignancies, this could involve a maxillectomy with a varying size and shape of resection.

Patients with malignant neoplasms of the maxillary gingiva or hard and soft palate often require extensive rehabilitation to return to a normal quality of life. The adverse sequelae from oncologic treatments have negative quality of life effects, including oronasal communication, hyposalivation, mucositis, tissue fibrosis, trismus, and osteoradionecrosis.[1,2,4] Rehabilitation of these patients can be accomplished through standard maxillofacial prosthetics and/or free tissue transfer, depending on the physicians' preference and patient presentation.[5-7] When severe, adverse treatment sequelae make rehabilitation difficult, ingenuity and creativity are required to treat the patient's needs. Silicone obturator bulbs have been shown to be a creative flexible prosthesis that can obturate a maxillectomy defect and be self-retentive.[8-10]

Recently, the use of computer-aided design (CAD) and 3-dimensional (3D) printing have been used in prosthodontics.[11-14] Various techniques have been shown using cone beam computed tomography (CBCT), intraoral scanners, and 3D printing to aid in maxillofacial prosthesis fabrication. Surgical obturators have been designed digitally and printed.[15] Preliminary casts have been made to fabricate accurate custom trays.[16] 3D printed definitive casts can be incorporated into a conventional workflow to fabricate obturator prostheses.[17-19] Using CAD, definitive prostheses could be designed and printed.[20] This clinical report

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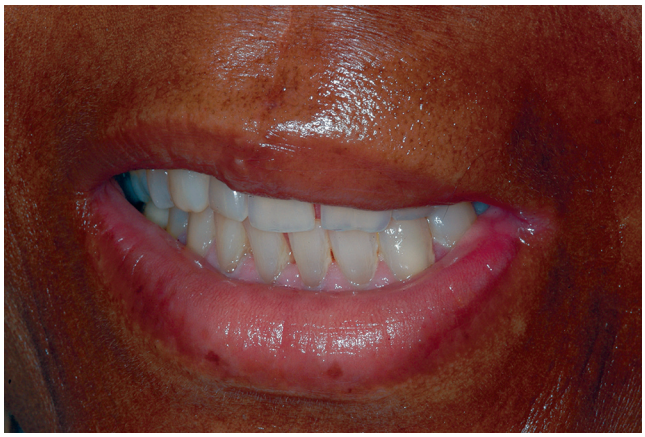

Figure 1. Initial presentation frontal view, patient smiling.

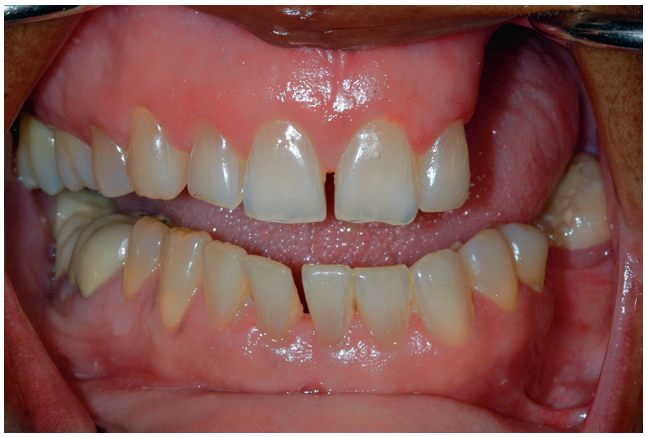

Figure 2. Initial presentation intraoral view, patient at maximal incisal opening of 4.5 mm.

demonstrates a creative use of CAD and 3D printing technology to fabricate a self-retentive silicone obturator prosthesis for a patient with a maxillectomy defect and severe trismus.

CLINICAL REPORT

A 55-year-old African-American woman presented to the Memorial Sloan Kettering Cancer Center Dental Service for evaluation of her interim obturator prosthesis (Fig. 1). She reported being unable to insert her obturator prosthesis due to a limited maximal incisal opening (MIO). The patient had been treated for a left maxillary sinus squamous cell carcinoma 10 months earlier. Her treatment involved a left total maxillectomy preserving the orbit with a rectus free flap reconstruction. The free flap subsequently dehisced and required the Dental Service to fabricate an interim obturator prosthesis. The final pathology report revealed a T4aN0M0 invasive squamous cell carcinoma with bone and perineural invasion.[21] The patient subsequently underwent and completed adjuvant chemotherapy and intensity-modulated radiation therapy to the tumor in the amount of 6100 cGy. She initially had an MIO of over 20 mm and due to the adverse effects of her oncologic treatment, her MIO collapsed to 4.5 mm (Fig. 2) even after multiple physical therapy treatments and use of a jaw motion rehabilitation system (TheraBite; Atos Medical AB). She could no longer use her interim obturator prosthesis and required a new prosthesis to obturate her maxillectomy defect.

Multiple attempts were made without success to make an impression of the maxillectomy defect using modified impression trays. A CBCT (Orthopantomograph OP300; Kavos Dental) scan was made of the midface to include the entire maxillectomy defect (Fig. 3). The Digital Imaging and Communications in Medicine (DICOM) file was uploaded into image processing software (Mimics; Materialize NV), and segmentation was

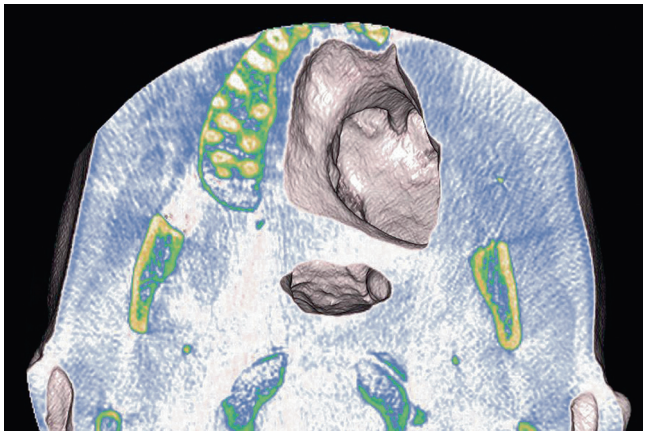

Figure 3. Cone beam computerized tomography rendering, inferior view of maxillectomy defect.

performed. The segmentation was uploaded into CAD software (SpaceClaim; SpaceClaim Corp) to further manipulate and prepare for 3D printing (Fig. 4). The definitive cast was printed in acrylonitrile butadiene styrene (RGD 515 Digital ABS; Stratasys Ltd) in a 3D printer (Objet260 Connex3; Stratasys Ltd) (Fig. 5). After removal of the printing support material, the maxillectomy anatomy was evaluated, and unwanted features were blocked out. The 3D printed definitive cast was duplicated using pourable polyvinyl siloxane duplicating material (PolyPour; GC America Inc) and cast with Type III dental stone (Denstone Golden; Kulzer GmbH) to fabricate a duplicated definitive cast.

On this cast, a wax pattern of the flexible obturator prosthesis was made with a thick border around the maxillectomy orifice to prevent over insertion and provide a handle to insert and remove the prosthesis. A mold of the wax pattern was fabricated with dental stone and sectioned into 3 pieces to account for anatomy undercuts and obturator design. The mold was packed

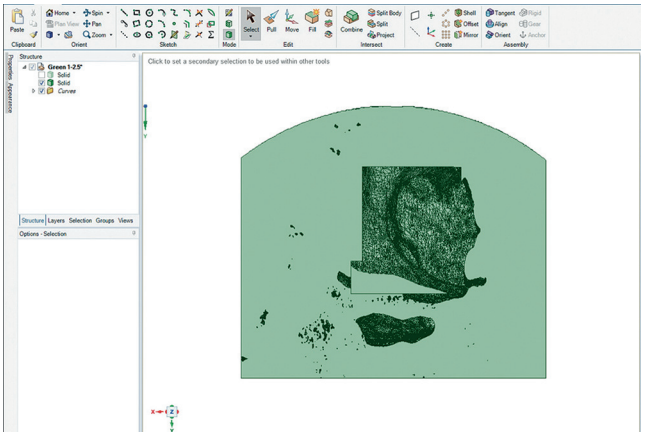

Figure 4. Inferior view of CAD segmentation in SpaceClaim software. CAD, computer-aided design.

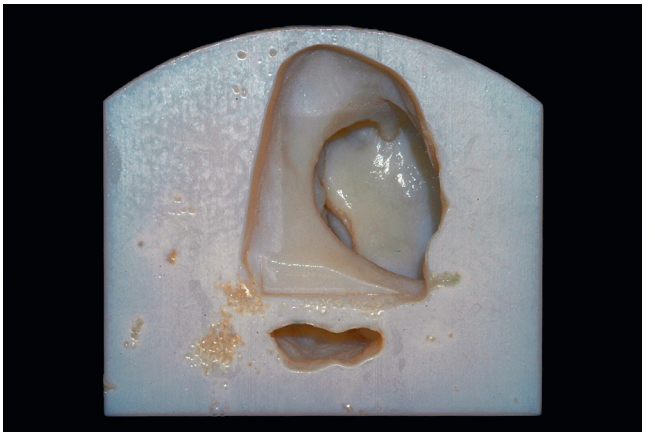

Figure 5. Trimmed 3D-printed definitive cast.

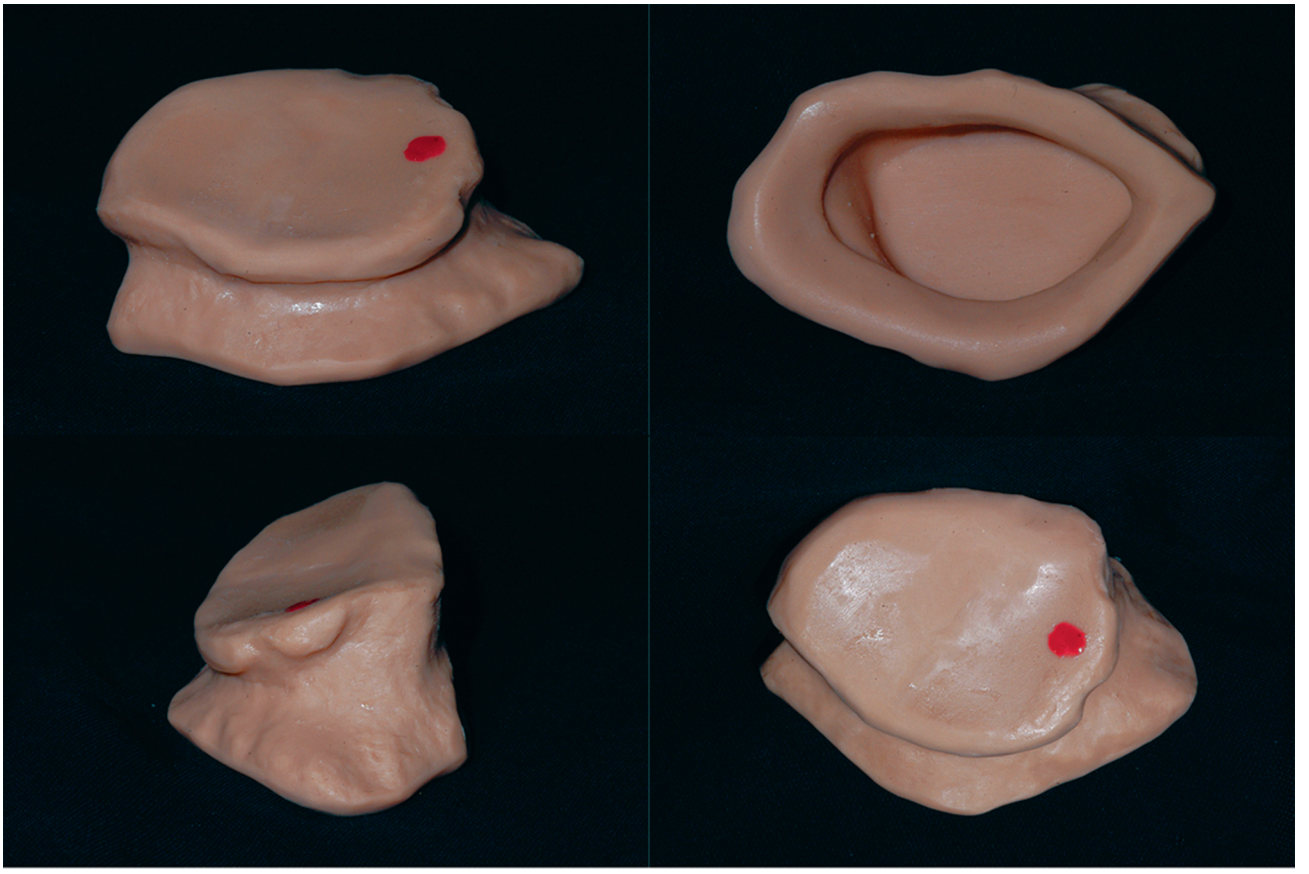

Figure 6. Multiple views of silicone definitive obturator prosthesis. *Red marking* signifies front of prosthesis to aid in orientation.

following the manufacturers' recommended protocol with platinum silicone elastomer (A-RTV-40; Factor II Inc) that was colored to a flesh tone with rose silk intrinsic silicone coloring. After polymerization, the mold was deflasked, and the flexible silicone obturator prosthesis was trimmed and contoured (Fig. 6).

The patient returned for delivery of the flexible silicone obturator prosthesis. The prosthesis was compressed laterally and inserted through the missing teeth and maxillectomy defect on the left side and pushed vertically into place until the retentive features engaged (Fig. 7). With the prosthesis inserted, the patient was able to produce intelligible speech and did not produce nasal regurgitation while drinking or eating (Fig. 8). The patient was followed up for a period of 6 months without complications.

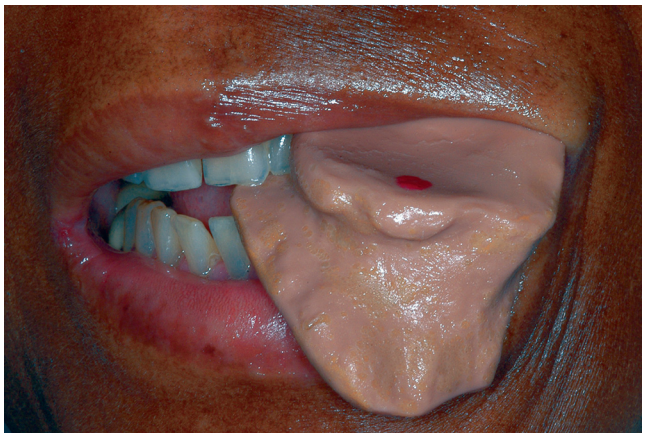

Figure 7. Insertion of silicone definitive obturator prosthesis.

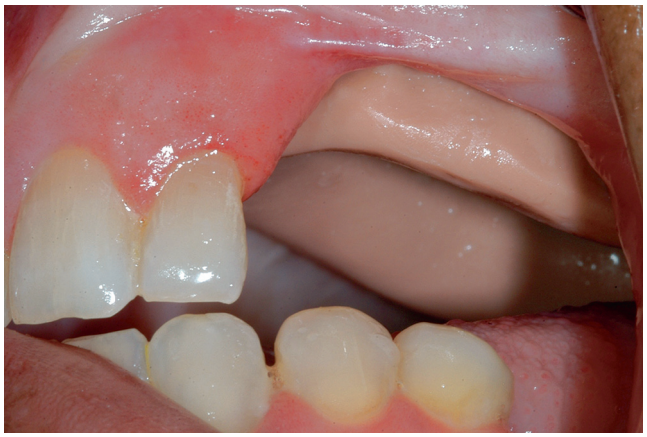

Figure 8. Intraoral lateral view of inserted definitive silicone obturator prosthesis.

DISCUSSION

This clinical report demonstrated a new use of CAD and 3D printing technology in a clinical setting for the fabrication of a challenging obturator prosthesis. The inability to use classic techniques to fabricate the obturator prosthesis necessitated this treatment approach. With this approach, a flexible prosthesis was fabricated that a patient with severe trismus and limited MIO could insert and then function normally. The cameo surface was hollow to allow maximum compression for insertion and removal. The patient adapted well to the prosthesis and never complained of it acting as a food trap because she could reach the entire cameo surface with her tongue. After completing this prosthesis, additional possibilities of these technologies were considered. Other treatment options could include fabrication of custom impression trays or printing wax patterns to be processed into definitive prostheses.

The advantages of this technique include the ability to capture craniofacial and oral anatomy without impression materials, easy duplication and manipulation of casts before printing, and a positive patient treatment experience. The disadvantages include the cost of the materials and printer, the availability of software and a 3D printer, radiation to the patient from the CBCT, and artifacts, distortion, and inaccuracies from the CBCT. The cost of this cast was estimated to be $500 for the cost of materials and use of the printer. The expenditure will be reduced with the availability of less expensive printers and materials. Contraindications include allergies to silicone, patients with multiple metallic dental restorations, and general CBCT contraindications.[22] The future direction of treatment for these patients would be to further modify the obturator for improved speech and mastication, improve materials and methods, and use a complete digital workflow to create molds or prostheses. Research is needed to streamline the treatment protocol and use of dental materials.

SUMMARY

The selective use of newer technologies such as CAD and 3D printing can help the clinician fabricate prostheses for difficult clinical presentations. For this patient, we were able to fabricate a flexible silicone obturator prosthesis that could insert despite her severe trismus. The prosthesis has performed well over a 6-month follow-up period with no complications. This is an early example of how this technology can benefit patients.

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