Clinical Case Report

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Natural teeth-retained splint based on a patient-specific 3D-printed mandible used for implant surgery and vestibuloplasty

A case report

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Abstract

Rationale: With respect to improving the quality of oral rehabilitation, the management of keratinized mucosa is as important as bone condition for implant success. To enhance this management, a natural teeth-retained splint based on a patient-specific 3-dimensional (3D) printed mandible was used in vestibuloplasty to provide sufficient keratinized mucosa around dental implants to support long-term implant maintenance.

Patient concerns: A 28-year-old male patient had a fracture of the anterior andible 1 year ago, and the fracture was treated with titanium.

Diagnoses: The patient had lost mandibular incisors on both the sides and had a shallow vestibule and little keratinized mucosa.

Interventions: In the first-stage implant surgery, 2 implants were inserted and the titanium fracture fixation plates and screws were removed at the same time. During second-stage implant surgery, vestibuloplasty was performed, and the natural teeth-retained splint was applied. The splint was made based upon a patient-specific 3D-printed mandible. At 30-day follow-up, the splint was modified and reset. The modified splint was removed after an additional 60 days, and the patient received prosthetic treatment.

Outcomes: After prosthetic treatment, successful oral rehabilitation was achieved. Within 1 year and 3 years after implant prosthesis finished, the patient exhibited a good quantity of keratinized gingiva.

Lessons subsections: The proposed splint is a simple and time-effective technique for correcting soft tissue defects in implant dentistry that ensures a good quantity of keratinized mucosa.

Abbreviations: 3D = three-dimensional, CT = computed tomography.

Keywords: 3-dimensional (3D) printing mandible, dental implants, keratinized mucosa, natural teeth-retained splint, vestibuloplasty

1. Introduction

In recent decades, implant prostheses have played a large role in oral rehabilitation and have been accepted by both clinicians and patients.[1,2] To achieve successful rehabilitation, the maintenance of implants in a healthy state with appropriate function and esthetics has emerged as a novel challenge. Many studies have focused on bone grafting and future implant placement; however, for implant installation, soft tissue management is as important as bone condition.[3–5]

A healthy keratinized mucosa has long been recognized as the preferred peri-implant soft tissue,[6] and it has been suggested that it is essential for decreasing the susceptibility of the peri-implant mucosa to inflammation, and results in less bone loss and healthier soft tissue.[7–10] A lack of keratinized mucosa can contribute to vestibular groove shallowing in combination with soft tissue defects caused by trauma or sneak separation to close wounds. The oral vestibule can be deepened by the surgical procedure of vestibuloplasty, which changes the soft tissue attachment. Thus, for oral rehabilitation, vestibuloplasty is often required with or without bone grafting procedures.[11,12] In the past, vestibuloplasty was conducted using various methods or modifications in combination with secondary epithelization or the use of different grafts.[13,14] However, secondary epithelization often leads to future complications, including shrinkage, scarring, contracture, and/or fibrosis.[15] The use of autogenous grafts such as full-thickness skin, dermal, meshed skin, or palatal mucosa also has limitations, including restrictions on the quantity and size of available donor tissue, damage of the donor area, and patient discomfort 16. Moreover, postoperative muscle attachment from the lingual side is a potential obstacle to vestibule reconstruction.[16]

Three-dimensional (3D) printing is revolutionizing manufacturing and is becoming an important technology for dentistry. As dentistry already uses advanced imaging techniques 3D printing can complement this to allow customized manufacture of a wide range of products. These include drill guides for

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dental implants and the implants themselves, surgical models, and copings and frameworks for implant and dental restorations.[17] The uses for 3D printing in dentistry are likely to expand in part due to the variety of materials and biomaterials that can be used.[18] However, at present, there have been no case reports of vestibuloplasty with a 3D-printed mandible.

Here, we report a case where vestibuloplasty was performed, and a natural teeth-retained splint was used based on a patient-specific 3D-printed mandible to provide an appropriate method for maintaining adequate vestibular morphology and achieving stability of the peri-implant keratinized mucosa.

2. Case report

This study was approved by the ethic committee of Chinese People's Liberation Army General Hospital. Informed consent was obtained from all individual participants included in the study. All the procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

A 28-year-old male patient visited our hospital for oral rehabilitation in January 2014. He had a fracture of the anterior mandible 1 year ago, and the fracture was treated with titanium fracture fixation plates and screws. Clinical examination revealed that the patient had lost mandibular incisors on both the sides and had a shallow vestibule and little keratinized mucosa (Fig. 1A). Computed tomography (CT) images generally indicated that there was sufficient vertical bone for implant insertion but that titanium fracture fixation plates and screws might first need to be removed (Fig. 1B). After surgical indications and treatment modalities were carefully explained, the patient agreed to an implant approach with vestibuloplasty.

For the first stage of surgery, undertaken in January 2014, under local anesthesia (4×1.7 mL articaine hydrochloride and epinephrine tartrate injections; Produits Dentaires Pierre Rolland, Merignac, France), a No. 15 scalpel was used to make an alveolar crest incision in the mandibular region from canine to canine. A full-thickness mucoperiosteal flap was then raised just superior to the inferior border of the mandible, allowing for the removal of the previously placed titanium plates and screws (Fig. 1C). The Astra Tech implant system (Dentsply Implants Manufacturing GmbH, Mannheim, Germany) was employed, and a pilot drill was used to mark the implant areas at the mandibular lateral incisors. These areas were sequentially drilled to fit 2 OsseoSpeed TX 3.5S implants of 11 mm in length. The hand piece was used to achieve a torque of 35 Nm for these 2 implants. Subsequently, 3.5/4.5-type cover screws were placed (Fig. 1D). To improve osseointegration, 1 bottle of bone powder (0.25 g Bio-Oss, Geistlich Pharma AG, Wolhusen, Switzerland) was used on the labial side (Fig. 1E). The full-thickness mucoperiosteal flap was sutured with 3-0 wires.

After 30 days, with gingival loop resection, the cover screws were replaced with healing abutments (with a height of 4 mm and a diameter of 4.5 mm). After an additional 30 days, in March 2014, the patient was admitted for vestibuloplasty, the second-stage operation. Oral examination revealed no problems with the implants and bone contact; however, the peri-implant keratinized mucosa was insufficient (Fig. 2A and B).

Vestibuloplasty was performed with the patient under local anesthesia (4×1.7 mL articaine hydrochloride and epinephrine tartrate injections). A No. 15 scalpel was used to make an incision on the ridge crest, with 2 extra incisions parallel to the long axis of the tooth created below the 2 mandibular lateral incisors to carefully expose the periosteum, ensuring that periosteum remained on the sides of the implants (Fig. 2C). Using 4-0 wires, the superior portions of the lingual flaps were sutured to the inferior portions of the sides of the implants (Fig. 2D). Periodontal dressings were cut to fit the vestibular defect in the anterior mandibular region (Fig. 2E).

The natural teeth-retained splint was settled onto the anterior mandibular defect region by ligature fixation to the first mandibular premolars to create the vestibule (Fig. 2F). The improved natural teeth-retained splint was fabricated in the laboratory prior to the surgery, and details regarding this splint are presented in Fig. 2G. The patient's CT image was used to get a patient-specific 3D-printed mandible for making a precision splint. At the 30-day follow-up, the natural teeth-retained splint was modified to adapt to the vestibular configuration (Fig. 3).

Within 60 days, an appropriate vestibular depth (about 1 cm) had been achieved in the lower anterior region (Fig. 4A). The prostheses were designed as a 4-unit fixed bridge supported by the 2 implants (Fig. 4B and C).

After receiving the prostheses, the patient had regular follow-up for denture adjustment and the maintenance of oral hygiene.

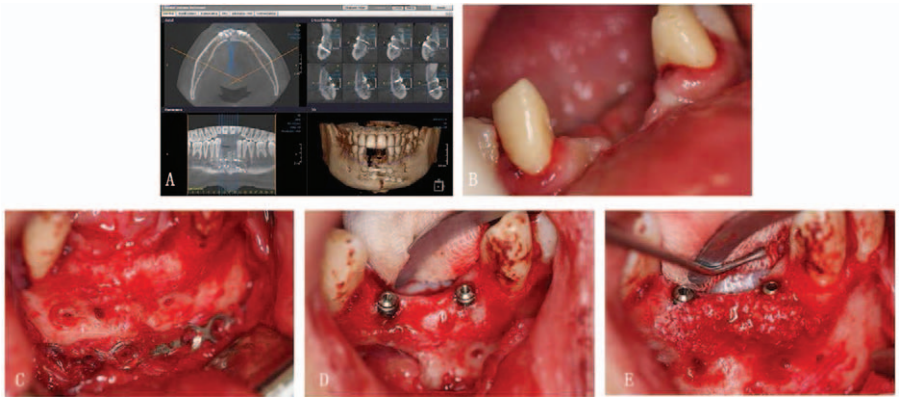

Figure 1. Preoperative examination results. A, Computed tomography (CT) images. B, Clinical examination findings. C, The previously placed titanium plates and screws. D, The 2 inserted implants with 3.5/4.5-type cover screws. E, One bottle of bone powder was used on the labial side. Note: in (B), there was no alveolar ridge crest from the anterior view because of scar tissue barrier, so we got the inclination view.

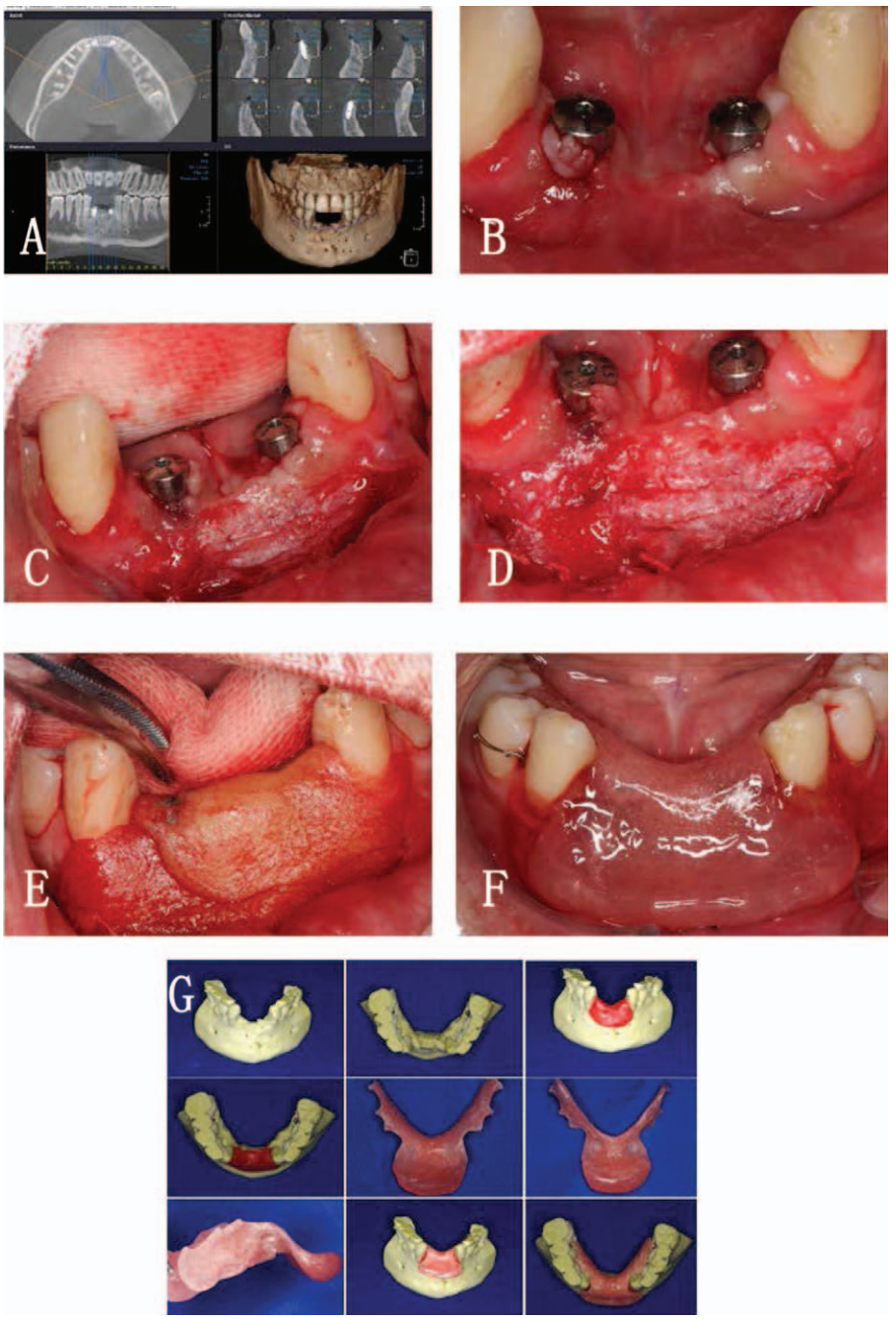

Figure 2. Vestibuloplasty undertaken in March, 2014, 60 days after the first surgery. A and B, Preoperative examination results from CT and clinical examination. C, An incision on the ridge crest with 2 extra incisions parallel to the long axis of the tooth below the 2 mandibular lateral incisors to carefully expose the periosteum. D, The superior portions of the lingual flaps were sutured to the inferior portions of the sides of the implants. E, Periodontal dressings. F, Settling the improved natural teeth-retained splint. G, Details regarding the natural teeth-retained splint. CT = computed tomography.

Within 1 year and 3 years of follow-up, the patient exhibited a good quantity of keratinized gingiva as 2 mm of masticatory gingiva. Although minor insufficiencies were observed due to recession caused by the patient's unhealthy oral habits, the keratinized gingiva was getting better over time (Fig. 5A–D).

3. Discussion

This patient presented with lost mandibular incisors on both the sides and severely inadequate soft tissue vestibule in the anterior lingual mandibular region. After the insertion of 2 implants and the concurrent removal of titanium fracture fixation plates and screws, second-stage implant surgery, vestibuloplasty was performed, and a natural teeth-retained splint was applied, based upon a patient-specific 3D-printed mandible. This method provided adequate healthy keratinized mucosa around the dental implants and after prosthetic treatment, successful oral rehabilitation was achieved. Within 1 year the patient exhibited a good quantity of keratinized gingiva and this improved after 3 years.

Although the clinician's main goal is to ensure adequate function for the patient, bone grafting and implant placement attract the most attention. However, one of the most important

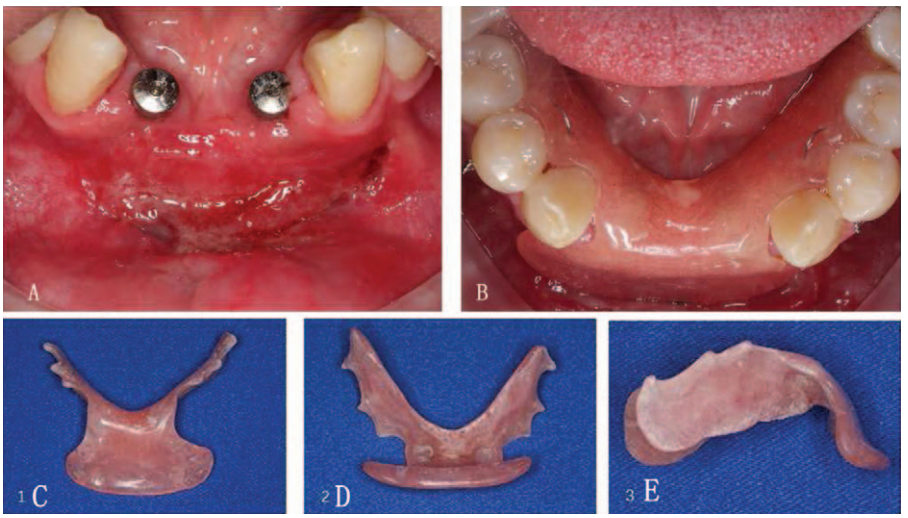

Figure 3. Follow-up in April 2014, 30 days after vestibuloplasty. A, Clinical examination without the splint. B, Clinical examination of the splint in place. C–E, The improved natural teeth-retained splint was modified to adapt to the vestibular configuration.

determinants of the success of an implant is the quality of keratinized mucosa.[6] Recent clinical studies have concluded that an increased width of keratinized mucosa around implants could result in less bone loss and healthier soft tissue.[10] Consequently, various surgical techniques have been developed to reconstruct keratinized mucosa around implants. At these sites, patients have been treated with vestibuloplasty conducted using various methods or modifications in combination with secondary epithelization or the use of different grafts.[13,14] However, these techniques for correcting soft tissue vestibular defects also have many limitations, such as restrictions on the quantity and size of available donor tissue, damage of the donor area, and patient discomfort.[19] In certain cases, it has been reported that the patient presented with a prominent postoperative insertion of muscles in the mental region of the mandible.[20] Other studies have also revealed the postoperative shrinkage or contraction of augmented tissue.[15] To avoid muscle reinsertion and tissue shrinkage, in the present case, the natural teeth-retained splint based on patient-specific 3D-printed mandible was used during vestibuloplasty to ensure the presence of sufficient keratinized mucosa around the dental implants.

This case report highlights how a natural teeth-retained splint based on a patient-specific 3D-printed mandible can be regarded as a predictable and valuable approach in vestibuloplasty for promoting the reconstruction of keratinized mucosa.

We propose this method of performing vestibuloplasty in combination with a natural teeth-retained splint for correcting soft tissue defects in implant dentistry. This method provides the

Figure 4. Follow-up in May 2014, 60 days after vestibuloplasty. A, An appropriate vestibular depth had been achieved in the lower anterior region. B and C, The prostheses were designed as a 4-unit fixed bridge supported by the 2 implants.

Figure 5. Follow-up in July 2015 and July 2017 1 and 3 years after vestibuloplasty. A and B, Clinical examination in July 2015 showed the patient had a good quantity of keratinized gingiva with minor insufficiencies caused by recession. C and D, Clinical examination in July 2017 showed the patient had a better quantity of keratinized gingiva than 1-year follow-up observation and the minor recession had been improved.

following advantages: a natural teeth-retained splint using a patient-specific 3D-printed mandible as the base can improve the precision; it eliminates the need for another round of surgery for soft tissue management, thereby decreasing damage to the donor area; can achieve the desired results without connective tissue or full-thickness gingival flap graft, which reduces the possibility of treatment failure induced by soft tissue grafting; and it avoids muscle reinsertion and tissue shrinkage. This approach provides for a sufficient quantity of keratinized mucosa and improves the retention and stability of the final prosthesis.

4. Conclusions

This case report demonstrates the use of an improved natural teeth-retained splint in vestibuloplasty to achieve healthy keratinized mucosa around implants. The proposed method is a simple and time-effective technique for the correction of soft tissue defects in implant dentistry.

Acknowledgments

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