Case Report

# The Tripodal Mandibular Subperiosteal Implant: A Case Report

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## Abstract

*The subperiosteal implant is a modality that has been used for several decades, although its popularity has declined due to the increasing use of endosseous dental implants. Nonetheless, it remains a treatment option in some situations, especially for cases of atrophic mandible. This article reports the case of a patient rehabilitated using a simplified surgical protocol involving CAD/CAM technology and a screw-retained denture supported by a tripodal subperiosteal implant.*

**Keywords: Subperiosteal implant, CAD/CAM, stereolithography, screw-retained denture**

## Introduction

For patients with a severely resorbed mandible, wearing a denture may be uncomfortable. In such patients, the bony structure and musculature, such as the mentalis muscle, that would otherwise support the denture may be lost, and without a broad base of bone and the musculature necessary to maintain the denture in place, the denture may move constantly when utilized for various functions[1].

A subperiosteal implant consists of a custom-fabricated titanium framework that is designed to rest on top of the mandibular bone, under the periosteum, and be stabilized by a combination of fibrous tissue and bone support. Permucosal extensions provide for support and attachment of the prosthesis[2]. Dahl placed the first subperiosteal implants in 1940. However, criticism of his implant technique by the Swedish government caused him to abandon his efforts[3]. In 1947, the first American subperiosteal implants were developed, and in 1948, Gershkoff and Goldberg placed the first subperiosteal complete denture implant manufactured from Vitallium[4].

Previous subperiosteal frameworks were designed to rest directly on the alveolar crest[3,5]. In 1982, however, a new design called the tripodal mandibular subperiosteal implant was devised by Linkow[5] and his laboratory technician. This type of implant rests on the thick cortical bone present at the external oblique ridge and the symphysis of the mandible at the genial tubercles[6].

The use of subperiosteal implants has declined in recent

1(a) 1(b)

Fig. 1 Extra-oral views with complete dentures, (a) frontal view, (b) lateral view

years due to the increasing use of endosseous dental implants. However, in some extreme cases, the use of endosseous implants may not be suitable because of increased cost, the time required for treatment, postoperative pain, and the need for multiple invasive procedures (e.g., iliac grafting). Such hardships may seem likely to cause too much suffering in some patients to make a simple gain in the stability and masticatory function of a lower denture worthwhile.

In the old days, the surgical protocol for a tripodal mandibular subperiosteal implant was comprised of a two-stage surgery, the first for taking a direct bone impression and the second for placing the custom-made implant. More recently, however, techniques have been developed for making subperiosteal titanium frameworks based on models of jaws made via computerized tomography (CT) scans and CAD/CAM technology[7].

This article describes the case of a patient with a severely resorbed mandible treated with a tripodal mandibular subperiosteal implant designed with the assistance of CAD/CAM technology.

## Case report

A 74-year-old woman came to Tzu-Chi Hospital in September 2011, complaining about the poor chewing function of her dentures. She had been wearing the dentures, which were ill-fitted and loosened easily during function, for more than 10 years. She received a new set of complete dentures after the extraction of a retained root from the maxilla. She was satisfied with the maxillary denture, but she still complained about the instability of the mandibular denture when chewing and also had recurrent ulcerations on the mandibular ridges. She also disliked her dentofacial appearance (Fig. 1). Therefore, she asked for an evaluation regarding implantation and fixed prostheses.

The patient's medical condition included osteoporosis controlled by a dose of 60 mg of Prolia every half year. She also had other systemic diseases and health issues including rotator cuff syndrome, lumbosacral spondylosis, kyphosis, and a closed fracture of the dorsal thigh, all of which were under regular follow-up by her physician at Tzu-Chi hospital. Otherwise, the patient was generally healthy and did not have any drug or food allergies. In discussing the subject with her physician, she stated that dental surgery under general anesthesia was acceptable to her.

Clinical examination showed that even with the new set of complete dentures, she still had a reduced facial height in the lower part of her face and a drooping appearance at the corners of her mouth, which was due to the severely resorbed mandible. Intra-orally, the ridge of the maxilla was flat and rounded with an undeveloped tuberosity. Even though the ridge was severely resorbed, especially in the posterior area, the retention of the maxillary denture was well achieved by border seal. However, the mandibular denture was not stable on the flat ridge of the mandible, which made her uncomfortable when chewing and

2(a) 2(b) 2(c)

Fig. 2 Intra-oral views. (a) Maxillary occlusal view, (b) mandibular occlusal view, (c) frontal view

Fig. 3 Panorex film

caused ulceration easily (Fig. 2). No temporal mandibular disorder (TMD) problems were noticed. The muscles of mastication were not tender to palpation, and no soreness was noted by the patient upon opening or closing her mouth.

Panorex film (Fig. 3) indicated that the alveolar ridges were severely resorbed, especially in the mandible, and almost only basal bone remained. She had approximately 12 mm of bone height in the anterior symposis and 10 mm of bone height at the mental foramen. Using the newly made complete dentures as a reference, a CT scan (Lightspeed VCT 64-Slice CT Scanner, General Electric, USA) was performed.

According to the radiographic examination, there was insufficient bone height for root form implants unless the patient plans to receive extensive bone grafting from the iliac or tibia. The other treatment option was a tripodal subperiosteal implant made of cast titanium and fabricated with the assistance of CAD/CAM technology, with a overlay prosthesis screw-retained on the implant framework.

After being informed about all the treatment options, the patient and her family chose a mandibular denture supported by a subperiosteal implant and an opposing maxillary denture.

The CT scan files were sent to a milling center (TDS Biotech, Taiwan) to create a 3D computer model using medical imaging software (Designer, TDS Biotech, Taiwan). Rapid prototyping by 3D printer was then used to fabricate precise anatomical resin models of the patient's jaw. Since the patient was still not satisfied with her extra-oral profile with the newly made dentures, and since the space was not sufficient for overdenture either, the vertical dimension had to be increased. With the

4(a)

4(b)

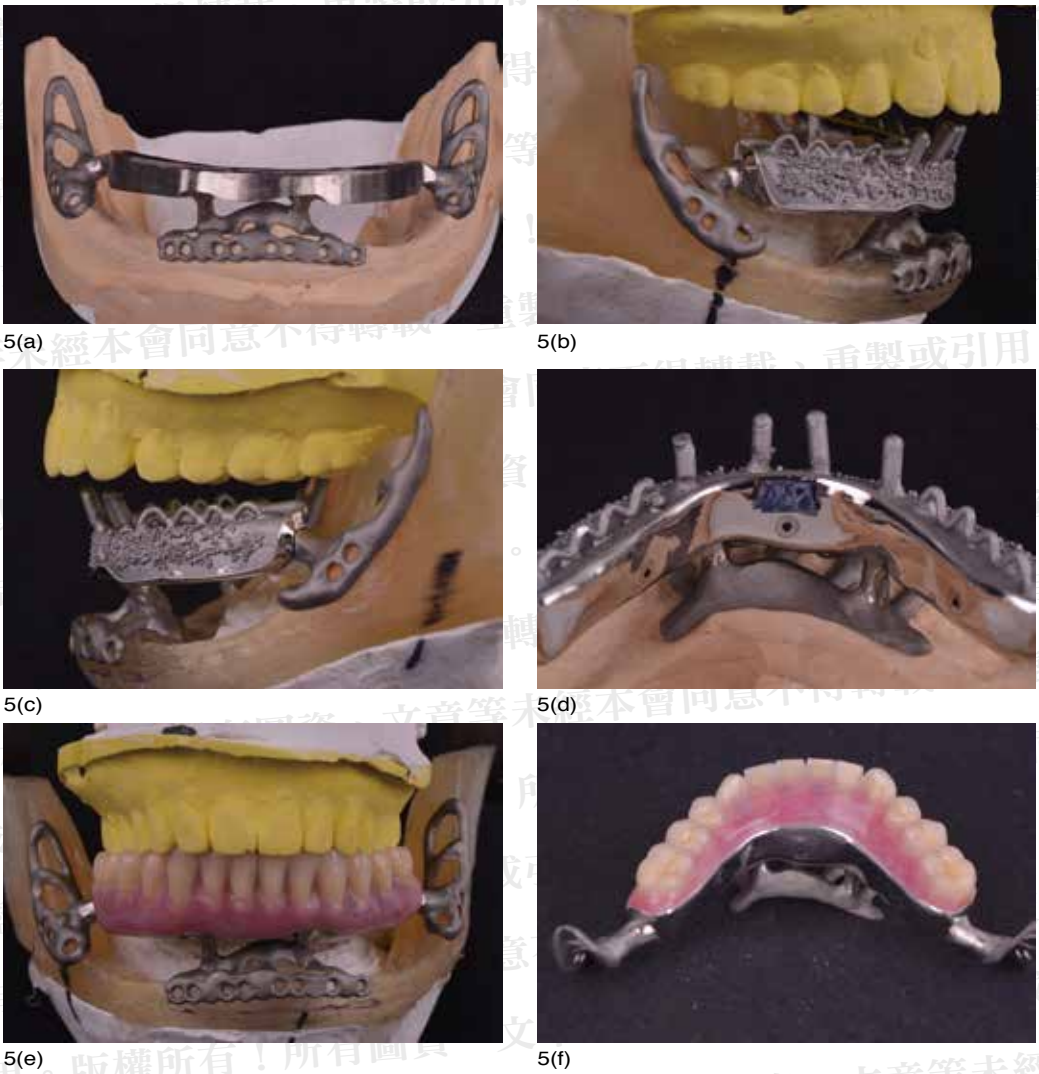
4(c)

4(d)

4(e)

4(f)

Fig. 4 Clinical procedures: (a) Mandibular model, (b) wax dentures try-in — frontal view, (c) wax dentures try-in — right buccal view, (d) wax dentures try-in — left buccal view, (e) verify vertical dimension — frontal view, (f) verify vertical dimension — lateral view



5(a) 5(b) 5(c) 5(d) 5(e) 5(f)

Fig. 5 Lab procedures. (a) TSI titanium framework, (b) overdenture framework — right view, (c) overdenture framework — left view, (d) overdenture framework — lingual view, (e) overdenture — frontal, (f) overdenture — lingual view

mandibular model, a record base was made to verify the vertical dimension and the jaw relationship for further teeth arrangement (Fig. 4). The CAD/CAM-made model eliminated the need to conduct a preliminary surgery simply to make a model of the patient's mandible. The framework of the tripodal subperiosteal implant was easily designed from the resin model, and the relevant communication between the clinician and the technician was also easier.

Once the design of the subperiosteal implant was completed, it was delivered to a dental laboratory (Gija Dental Lab, Taipei, Taiwan) for fabrication of the titanium framework (Biotan Titan Grad 1, Schutz, Germany) of the implant and of the mandibular denture. The denture was screw-retained to the implant framework with titanium screws (Bredent, Germany) inserted through screw holes on the lingual side. The mandibular denture was packed at the same time. The casting framework of the implant was polished, sandblasted, passivated, and sterilized before being delivered (Fig. 5).

At the surgical appointment, the patient was sedated via general anesthesia and intubated by nasal approach, and the oral cavity was swabbed with chlorhexidine gluconate 12% for 30 seconds. An oral pack was then placed, after which flap reflection from the retromolar pad at about 5 cm along the bilateral sides was accomplished. Another flap incision about 6 cm long was made at the anterior of the mandible. A 1.5 cm vertical releasing incision was made in the center of the symphysis, and the soft tissues were reflected by elevators. The tripodal

6(a) 6(b) 6(c)

Fig. 6 Surgical procedures. (a) TSI insertion — frontal, (b) TSI insertion — maxillary, (c) Panorex after TSI insertion

subperiosteal implant (TSI) was then seated on the patient's jaw and a titanium screw was used to establish a firm initial fixation. The soft tissues were approximated, and primary closure was achieved with 5.0 vicryl. The mandibular denture was also delivered during the surgery (Fig.6). To decrease postoperative swelling, the patient was administered 8 mg of dexamethasone. The patient withstood the whole procedure well and was discharged the day after the surgery.

Soft and liquid diets were suggested after the surgery. The wound healing was even, and the sutures were removed two weeks later. The maxillary denture was made following with final impression, jaw relationship verification, and wax denture try-in. The tripodal subperiosteal implant was loaded 8 weeks after the surgery. The patient was satisfied with the profile and the function of the new dentures (Fig.7). Regular follow-ups were arranged for every 2 months after delivery, and no complications were noticed during a 2-year follow-up period (Fig.8).

## Discussion

Implant treatment can be simple and highly predictable nowadays. Owing to implants, the increase in comfort in recent years for patients who wear dentures has been striking, especially for those who suffer from a lack of stability and retention. At the same time, advanced surgical techniques, such as alveolar augmentations or sinus grafting, or even grafting from the iliac, are required for some conditions. Relatedly, treatment with some types of implants may occasionally be compromised due to limited bone height. Therefore, subperiosteal implants, although declining in use overall, have been shown to be a successful treatment option for patients who are not suitable for extensive graft surgery.

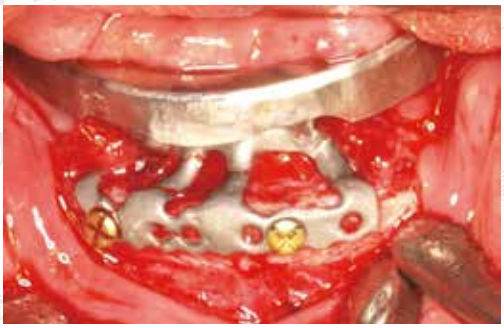
The reasons that subperiosteal implants sometimes fail have previously been discussed. Some subperiosteal implants have shown poor biocompatibility, resulting in inflammatory responses and rejection when alloys such as chrome-cobalt were used. However, the utilization of titanium has greatly improved biocompatibility and reduced the rate of rejection issues common with chrome-cobalt alloys[8,9]. Corrosion resulting from the instability of this oxide-metal interface has previously been reported to cause foreign body reactions leading to chronic inflammation and eventual implant rejection and failure[10]. In the case described herein, the framework of the subperiosteal implant was made of commercially pure titanium. After the casting process was completed, the titanium surface was sandblasted to remove the oxidation layer. Except for those parts of the framework with rough surfaces, such as the meshes and parts of the posts, that were intended to stay beneath the soft tissues, the other parts of the framework were highly polished.

The second reason for the failure of subperiosteal implants is a lack of osseointegration due to the nature of the surgical techniques and loading protocol traditionally used for such implants. Traditionally, chrome-cobalt subperiosteal implants would be placed on top of the bone and loaded with prostheses either immediately or soon after placement. However, a lack of direct bone contact and an immediate loading protocol often lead to fibrous integration11. In the case described herein, the tripodal subperiosteal implant was seated directly on the bone and had a firm initial fixation provided by titanium screws. Furthermore, the mandibular denture was not loaded until 8 weeks after the surgery to allow time for bone remodeling.

The tripod design of the implant used in this case is different from the design of the original subperiosteal implants from the early 1940s. It uses the mandibular symphysis and the angle of the mandible as locations for

7(a)

7(b)



7(c)

7(d)

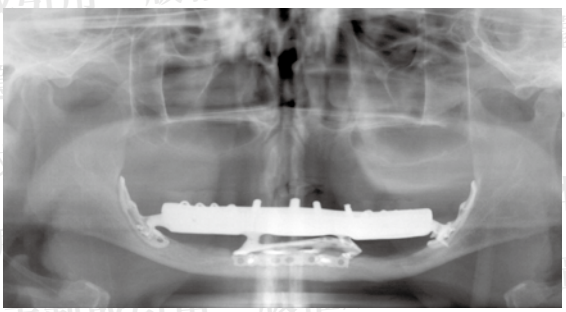
7(e)

7(f)

7(g)

Fig. 7 Overdenture delivered. (a) Extra-oral frontal view, (b) extra-oral lateral view, (c) intra-oral frontal view, (d) intra-oral maxillary occlusal view, (e) intra-oral mandibular occlusal view, (f) intra-oral right buccal view, (g) intra-oral left buccal view

8(a)



8(b)

Fig. 8 Follow-up. (a) Hygiene care instruction, (b) Panorex after 2 years

the framework to rest upon. The area of the mandibular symphysis, where the genioglossus muscle and the geniohyoid muscle attach, forming the genial tubercle, is resistant to resorption over time. The angle of the mandible, meanwhile, is the attachment for the internal pterygoid muscle and the masseter muscle. Due to the functional attachments for these muscles, the angle also resists resorption over time. These two locations, the symphysis and the angle of the mandible, are thus better areas for the location of the feet or mesh of a subperiosteal implant[5,12]. The current design effectively transfers force to the substructure through the permucosal posts, which are anterior to the mental nerve, in the retromolar pad area, and connected to a continuous mesobar[2,7].

In the old days, patients had to undergo two surgical phases of treatment involved in fabricating and inserting a TSI. Nowadays, it is possible to print out models of jaws via computerized tomography (CT) scans and CAD/CAM technology. With this approach, there is no need for another surgery simply to obtain a model of a patient's jaw[2,7,12]. This is of substantial benefit to patients, especially elderly patients. Nonetheless, the subperiosteal titanium framework still has to be made by casting since the curvatures and the minor structures of mesobars cannot be milled by the CAD/CAM machine.

In the case described herein, after completing the surgical phase of the implant insertion, the mandible overlay prosthesis was seated on the mesostructure. The maxillary denture was fabricated 8 weeks later, after which the occlusion was checked and balanced to eliminate unilateral and protrusive interferences. The buccal cusps of the mandibular posterior teeth occluded with the flat occlusal surfaces of the maxillary teeth, and the mandibular lingual cusp contacts were relieved. For the most part, the implant denture for a TSI is implant-borne and retained on the framework by O-rings[1,2,5,13] or ERA attachments[8]. In this case, the implant prosthesis was fixed to the TSI by three screws on the lingual side in order to prevent lifting forces when the prosthesis is removed or transfered to the framework repeatedly, thus eliminating mandibular tissue irritation. Hygiene care can be accomplished, meanwhile, by using interdental brushes.

## Conclusion

The previously unpredictable tripodal subperiosteal implants have in recent years become more predictable and less invasive, while also requiring fewer surgical procedures and being less technique-sensitive than in the past. CAD/CAM technology has effectively simplified the lab procedures involved in the fabrication of these implants, although this technology still has some limitations. Moreover, screw-retained dentures may effectively lower the repeated lifting forces associated with TSIs. At the same time, a periodic recall, just as with all other implant programs, is an important part of successful tripodal subperiosteal implant treatment.

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