

Small-Diameter Implants

A Treatment Consideration for the Maxillary Edentulous Patient



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Figure 1. Small-diameter implant (SDI) 2.4 mm x 13 mm.



Figure 2. Initial clinical view—centric occlusion.

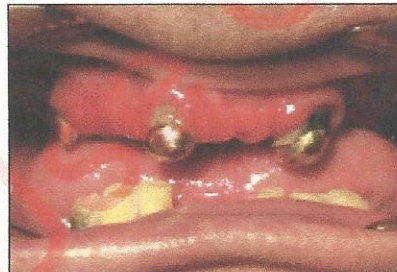


Figure 3. Initial clinical view of maxilla.

Small-diameter implants (SDIs) appeared in the discipline of implant dentistry as retainers for a transitional prosthesis while conventional sized endosseous implants osseointegrated. Recent FDA approval of SDIs for long-term use has broadened their indications. The incorporation of SDIs for the treatment of the maxillary edentulous patient with atrophic alveolar bone and large pneumatized sinuses has demonstrated successful outcomes. The SDI protocol for the edentulous maxilla is implant placement anterior to the sinus with delayed loading of the complete maxillary overdenture. This article and the case report presented demonstrate the use of SDIs to assist in the retention and stability of a maxillary complete overdenture.

Implant dentistry has become a major aspect of clinical dental practice due to the biological concept of osseointegration. Although conventional size endosseous implants received FDA approval in 1970, SDIs have recently gained similar approval.¹ In 2004, the FDA approved SDIs for long-term use for full and partial denture stabilization as well as fixed multiunit prostheses. This approval applies to implants less than 3 mm in diameter, and more specifically, 1.8 mm, 2.1 mm, and 2.4 mm, and corresponding lengths greater than 10 mm. The applications of SDIs for increased stability and retention of overdentures have demonstrated successful clinical outcomes. As a result, the indications for SDIs for long-term use have gained wider acceptance and interest.

Although the mandibular complete denture patient has experienced the majority of clinical limitations, the maxillary edentulous condition demonstrates a similar compro-

mised state in regards to form and function. The demand for complete removable dentures will continue to increase as the United States edentulous population approaches 40 million.² The incorporation of SDIs to aid in stability and retention for the maxillary complete denture patient can enhance speech, function, aesthetics, and comfort.³ Most importantly, dental implants retard the rate of alveolar bone resorption in the maxilla.^{4,5} As a result, the SDI-retained maxillary overdenture can achieve patient expectations and demonstrate excellent treatment outcomes.

The SDI design, as well as the surgical and prosthetic protocol, possesses various characteristics for a successful treatment plan for the edentulous maxilla. The one-piece, small-diameter (2.4 mm) design possesses strength while engaging the atrophic cortical alveolar ridge and underlying cancellous bone (Figure 1). The strength of the SDI is associated with the one-piece design and the material nature of the titanium alloy (Ti-6Al-4V) structure. The surgical protocol consisting of a flapless, partial osteotomy approach simplifies the procedure and risks for the general or medically compromised patient. The prosthetic stage can be initiated as an immediate load or under traditional stage protocols, depending on biomechanics as it relates to the quality and quantity of bone. This minimally invasive approach unique with SDIs parallels other such trends in healthcare services.⁶

The case presented in this paper demonstrates the utilization of SDIs to retain a maxillary complete overdenture. The treatment plan was approached in a staged manner, including initial extraction with site preservation followed by subsequent implant place-

ment and prosthetic reconstruction. The mandibular arch was treated with conventional, nonimplant dental approaches. The treatment was completed in 13 months with a resultant ideal clinical outcome while achieving patient expectations.

CASE REPORT

A 73-year-old male presented to the office with a chief complaint of "my upper denture rocks all over the place when I eat." The clinical evaluation of the patient exhibited an existing complete maxillary denture with severely worn and fractured prosthetic teeth (Figure 2).

The maxilla contained 3 remaining teeth with extracoronary gold copings serving as tooth retained overdenture retainers (Figure 3). The maxillary teeth exhibited recurrent caries and severe horizontal bone loss. The mandibular arch demonstrated a chronic periapical abscess associated with the mandibular left second molar (No. 18) and several mobile teeth including the mandibular lateral incisors (Nos. 23 and 26) and mandibular right first premolar (No. 28) due to severe bone loss. The mandibular canines (Nos. 22 and 27) and mandibular left first premolar (No. 21) demonstrated moderate bone loss without pathological mobility (Figure 4). A diagnosis for the patient consisted of dental caries, moderate to severe periodontitis, and a collapsed vertical dimension of occlusion (VDO).

Treatment plans were presented and the agreed upon final prosthesis was the following:

- Maxilla: 6 SDI overdenture
- Mandible: mandibular removable partial denture (RPD).

continued on page 88

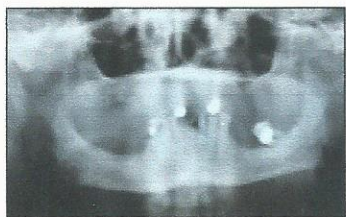


Figure 4. Initial PANOREX.



Figure 5. Presurgical view—edentulous maxilla.



Figure 6. Tissue punch.



Figure 7. Two-mm diameter bleeding sites.

Small-Diameter Implants...

continued from page 86

The treatment plan was approached in a staged manner consisting of extractions with bone grafting followed by implant placement and prosthetic reconstruction. The medical history was unremarkable except that the patient took a multivitamin daily. Surgical consent was reviewed and signed, and the patient was scheduled for the initial procedure.

The initiation of treatment was the extraction of all remaining maxillary teeth (Nos. 3, 5, 8, and 11) with concurrent socket grafting. Tooth removal was accomplished using 301, 34S elevators and a universal 151 forceps. After complete debridement of the socket with a double-ended curette, a mineralized irradiated bone Allograph (Mineross/Puros) in a 1:1 ratio was packed into the socket. A dense polytetrafluoroethylene barrier (Cytoplast) and 4.0 vicryl sutures were used to secure the Allograph material. The existing complete denture was relined with a soft reline material (COE-SOFT [GC America]). The mandibular arch preprosthetic treatment consisted of the extractions of teeth Nos. 18, 23, 26, and 28 without site preservation techniques.

The complete denture stage of treatment was initiated 6 weeks postextraction. Maxillary denture fabrication was approached in a conventional manner with secondary impressions, shade (A2 VITA Shade Guide [Vident]), and mold (P8 BlueLine [Ivoclar Vivadent]) selection. A maxillary-mandibular relationship was established, and at prosthetic try-in, the maxillary complete denture and mandibular RPD were evaluated for occlusion, aesthetics, phonetics, and vertical dimension. After patient acceptance, the final prosthesis was processed, polished, and placed.

The SDI surgical procedure was initiated 6 months postextraction (Figure 5). The patient was prepped, draped, and asked to rinse with a chlorhexidine mouthwash for 30 seconds. Platelet rich plasma (PRP) was obtained after a 20-cc draw from the right median cubital vein utilizing

standard phlebotomy techniques. A single-spin centrifuge was utilized for PRP processing. A local anesthetic was administered, consisting of 4 carpules (72 mg) of 2% Lidocaine with 1:100,000 epinephrine using a buccal and palatal infiltration approach. A surgical guide was placed over the soft tissue and 3 bleeding points were established with an endodontic explorer. The surgical guide was fabricated from .020x-wide coping and temporary crown and bridge material size 5-1/8-in square (Buffalo Dental Manufacturing), which was adapted to a diagnostic stone model. The purpose of the template was to delineate mesial-distal spacing of individual implants. This type of template is not utilized during osteotomy preparation but establishes the position of the most distal implant as it relates to the anterior aspect of the maxillary sinus.

A 2-mm diameter tissue punch was utilized to create access to the crest of the ridge with the bleeding points serving as its center (Figures 6 and 7). A long shank No. 2 round surgical bur was used to create a dimple in the crest of the maxillary alveolar ridge. A 5-mm partial osteotomy was made with a 1.1-mm stainless steel drill. The implant placement protocol included the use of a finger driver and thumb wrench to fully seat three 2.4 x 13 mm titanium alloy SDIs (3M ESPE) (Figure 8). The same protocol was performed on the contralateral side to complete a total of six 2.4 x 13 mm SDIs (Figure 9). Relief was made in the undersurface of the complete maxillary denture with the aid of pressure indicating paste to prevent physical trauma to the SDIs and to ensure maintenance of the VDO. The soft tissue was soaked with PRP, and PRP was also placed into the relief "reservoirs" in the undersurface of the denture (Figures 10 and 11). The incorporation of PRP was to expedite hard- and soft-tissue healing through enhanced growth factor concentrations such as platelet derived growth factor, transforming growth factor

beta-1 and epithelial growth factors.⁷⁻⁹ The patient was given postoperative instructions, ice was applied to the upper lip of the face, and the patient was discharged.

The SDI prosthetic stage was initiated after a 6-month osseointegration period. The undersurface of the complete denture consisted of 6 relieved areas where the SDI prosthetic o-balls were positioned. The direct (intraoral) prosthetic attachment technique consisted of placing shims, the o-ring housing complex onto the o-ball, and verification of centric relation (Figure 12). A hard reline material was expressed into the denture reservoirs and around the o-ring housings. The patient was guided into centric relation and the chin was supported to maintain VDO. After a 7-minute autocuring period, the denture was removed from the mouth, trimmed, and polished (Figures 13 to 15). If shims were present intraorally or in the denture, they were removed. The complete denture was seated onto the SDIs and retention, aesthetics, phonetics, and vertical dimension were confirmed.

DISCUSSION

Minimally invasive surgical approaches to healthcare services continue to evolve, and SDI protocols paralleled this trend.¹⁰ Although the edentulous mandibular denture patient demonstrates limitations in form and function, the maxillary edentulous patient is not free of concerns. The utilization of SDIs in the edentulous maxilla can enhance stability, retention, and comfort for the complete denture patient. More importantly, this minimally invasive procedure can meet patient expectations while obtaining successful long-term outcomes.¹¹

The success rates of SDIs in the maxilla for retaining overdentures are enhanced when they mimic conventional implant osseointegration protocols.¹² The success of SDIs is based on the critical need for rigid osseous fixation at placement and mature bone when placed into function.¹³ Maxillary bone is composed of a thin cortical layer and a robust cancellous component

(Type III). Therefore, SDIs are placed into partial and undersized osteotomies to ensure rigid fixation. The retentive features cured into the maxillary denture are engaged after the implants have integrated for a 6-month period. This protocol ensures that biomechanical loading of the maxillary overdenture is initiated in mature bone.

The physical composition of an SDI demonstrates a stable implant system. The SDI material is designed and manufactured as a one-piece titanium alloy material. This design eliminates the microgap and small retaining screw, thereby eliminating the potential for loose or broken screws. The physical properties of titanium alloy (Ti-A16-V4) exhibit greater tensile and shear strength in comparison to commercial pure medical grade titanium.¹⁴ The thread design is grit-blasted and acid-etched, enhancing surface area and roughness, which encourages bone apposition.¹⁵ The smooth collar and microthreads encourage soft-tissue adhesion via a hemidesmosomal adherence.¹⁶

A proper diagnosis based on a sound radiographic and clinical evaluation is critical in gaining data that facilitates proper implant placement.¹⁷ A radiographic-surgical template facilitates a flapless approach by delineating the location of the maxillary sinus and potential individual implant sites. A radiopaque material incorporated into the template can approximate the anterior aspect of the sinus, thereby preventing the placement of implants into the maxillary sinus or associated Type IV bone quality. A clinical exam with manual palpation of the alveolar ridge aids in site selection for implant placement. This examination involves tracing the buccal and palatal bony walls with an index finger and thumb to confirm irregularities in bone (ie, undercuts). In addition, ridge mapping can be performed under local anesthesia with surgical calipers to determine buccal-palatal thickness. These diagnostic procedures aid in the ability to perform implant placement via a flapless approach.

continued on page 90



Figure 8. Three 2.4 x 13 mm titanium alloy SDIs.



Figure 9. Six 2.4 x 13 mm titanium alloy SDIs.



Figure 10. Platelet rich plasma application—extraorally.



Figure 11. Platelet rich plasma—under surface of denture.

Small-Diameter Implants...

continued from page 88

It should be noted that cone beam computed tomography (CBCT) technology provides 3-dimensional (3-D) views of soft tissue and osseous architecture. The incorporation of a 3-D generated surgical guide can assist in implant placement, prosthetic design, and safety. The utilization of a mucoperiosteal flap to visualize the ridge and critical structures prior to osteotomy preparation combined with a CBCT can further enhance surgical outcomes. However, in the specific case presented in this article, the author's decision to prepare the partial osteotomy flapless was based on previous site preservation (socket

grafting) at the time of tooth extraction, and an adequate zone of keratinized tissue. Although in many cases CBCT technology can be advantageous prior to flapless implant surgery, in this specific case the diagnostic procedures described and clinical experience delivered safe and predictable results.

The treatment plan in the case presented focused on increasing the retention, support, and comfort of the previous prosthesis, which consisted of a maxillary overdenture retained with 3 cemented gold copings on residual roots. The new prosthesis was designed with the concept that retention was a critical key for a successful outcome. A maxillary overdenture consists of a minimum of 6 SDIs located anterior to

the maxillary sinus. The rationale for 6 implants is based on the quality of bone and biomechanical loads. The Type III bone associated with the maxilla is soft in comparison to the bone quality of the mandible (Type I and II). The biomechanical loads applied to the implants follow the equation: stress is equal to force divided by area. By increasing the number of implants in the maxilla, stress is reduced, thereby increasing longevity of the SDIs and prosthesis.¹⁸ The incorporation of additional implants (greater than 6) is determined by the available space, opposing occlusion, and quality of bone.

The success of the SDI maxillary overdenture relies on the fundamental principles of complete denture construction.¹⁹ The SDIs serve as retentive

components, but support, stability, and additional retention are derived from basic anatomical structures. A border molded custom tray is used to capture border extension and post dam within the secondary impression. The post dam is a critical aspect for overdenture retention with the use of SDIs. The aesthetic component of the denture starts with the width of the teeth. The width of the nose is equivalent to the width of the 4 maxillary incisors, and their length is determined by the distance from the incisal papilla to the upper lip at rest.²⁰ The maxillary posterior teeth should not be positioned coronal to the anterior teeth. The creation of a "reverse smile-line" deviates from the aesthetic ideal with regards to the plane of occlusion.

The occlusal design in this case report was developed in accordance with orthopedic and orthodontic relationships. The jaw relationship was pseudo Class III due to a severely atrophied maxilla in relationship to the mandible. The anterior tooth setup demonstrated 2 mm in overbite and overjet with the posterior maxillary teeth set in crossbite. The maxillary buccal cusps were placed in the central fossa of the mandibular posterior teeth. The implant occlusal scheme was developed in a bilateral balanced occlusion with 20° anatomical teeth for the maxillary denture.²¹⁻²³ The mandibular RPD teeth were set up in accordance with standard occlusal principles with zero degree monocline teeth. This approach centered the force over the alveolar ridge of both arches, thereby preserving the alveolar bone.

The surgical phase of SDIs is minimally invasive due to the flapless approach, partial osteotomy preparation, and implant placement protocol. The flapless approach allows for an implant placement procedure without excessive bleeding, ideal for all patients and more specifically, the medically compromised. A tissue punch can be used to gain access to the osseous crest when sufficient keratinized tissue is present. The partial osteotomy procedure lends itself to rigid fixation of the implant while increasing bone quality via compression. The maxillary osteotomy is created with a 1.1-mm diameter drill that is significantly smaller than the 2.4-mm diameter implant. This protocol establishes the needed rigid fixation in soft, Type III bone. The implant is auto-advanced, creating the complete osteotomy while compressing the bone as it proceeds apically. In effect, the implant is acting like an osteotome. It is critical when using the finger driver and thumb wrench to be cognizant of the direction and angulation of the implant, therefore avoiding critical vital structures and maintaining parallelism to adjacent implants. It is critical to follow stringent

surgical protocols to prevent early and late stage implant failure.²⁴

The prosthetic stage is initiated after a conventional osseointegration period of 6 months. The maturation of bone is crucial for long-term success of the max-

illary SDI overdenture. The retentive o-ring housings can be incorporated via an indirect (laboratory) or direct (intraoral) technique. The direct (intraoral) approach was utilized in this case due to parallel implants and because a new

maxillary denture was completed prior to implant placement. An autocuring composite resin material is efficient in "picking up" the o-ring housing complex. The o-ball prosthetic design has exhibited a long history of retention suc-



Figure 12. O-ring housings.

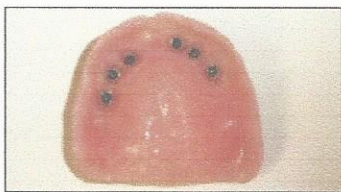


Figure 13. Maxillary overdenture—under surface.



Figure 14. Final PANOREX.



Figure 15. Final clinical view, centric relation.

cess while being simple in design. The O-ring housing complex allows for easy retrieval and replacement, making maintenance a simple process. The palatal aspect of the denture should not be removed because it aids in stability, support, and retention of the denture. The removal of the palatal vault of the

denture may increase crestal bone loss due to enhanced load on the implants.

CONCLUSION

The utilization of SDIs has grown in clinical practice since FDA approval for long-term use. The minimally invasive protocol, and reduced treat-

ment times and cost favor the incorporation of this alternative to conventional implants. The usage of SDIs to aid in retention of the overdenture patient should be a treatment consideration for the edentulous maxilla. Although the current body of evidence is promising, the need for long-term studies is essential for widespread acceptance by the dental profession. ♦

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Disclosure: Dr. Jackson is a paid lecturer and key opinion leader for 3M ESPE.