Use of Tilted Implants in Treatment of the Atrophic Posterior Mandible: A Preliminary Report of a Novel Approach

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Purpose: Restoration of the atrophic partially edentulous posterior mandible with implant retained prostheses has proved to be problematic, with no ideal treatment modality. The purpose of this report is to offer a novel method of treatment using tilted endosseous implants.

Materials and Methods: A total of 64 patients with edentulous spans of the mandible and less than 9.5 mm of alveolar bone overlying the inferior alveolar nerve had implants placed. The implants were placed in a bicortical manner with the porous hydroxyapatite placed subperiosteally if more than 1 mm of the apex of the implant was placed beyond the lingual cortex of the mandible. These implants were allowed to osseointegrate for 3 to 5 months and restored using custom-angled abutments.

Results: A total of 196 implants were placed in 64 patients from March 2003 through July 2008. Two implants were lost owing to a lack of osseointegration. No implants were lost because of prostodontic failure. No damage to the neurovascular structures or permanent paresthesia was noted.

Conclusions: Our initial results have shown that the use of tilted implants combined with custom abutments is a viable treatment modality for patients with atrophic edentulous mandibular spans that lack the required alveolar height for traditional dental implants.

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Prosthodontic restoration of the partially edentulous atrophic posterior mandible has proved to be problematic for the restorative dentist. For these patients, removable partial dentures were historically the only treatment option. Although endosseous dental implant placement has been shown to be a highly successful and effective treatment modality, it is subject to anatomic considerations, especially in the mandibular region. The most significant of these considerations is the available alveolar ridge above the inferior alveolar nerve. Frequently, in patients who have been edentulous for an extended period or in patients who have had periodontal disease before extraction, this alveolar ridge is not of sufficient height to allow traditional implant placement. To alleviate these anatomic limitations, a number of different treatment modalities have been attempted to allow successful dental implant placement and prosthodontic restoration.

One such method has been to increase the height of the alveolus above the inferior alveolar nerve. Reconstruction of the edentulous posterior mandible using autogenous bone grafts from the iliac crest, tibia, and rib has been described by numerous investigators.1-4 Although these methods have been shown to be marginally effective, they also are associated with a number of negative factors, including patient morbidity, treatment duration, cost, donor site morbidity, and continuous bone graft resorption.5,6 For example, Baker et al,7 using autogenous rib onlay grafting of the mandible, noted a 15% dehiscence rate with complete loss of graft material. Even in patients with graft consolidation, 50% resorption of the graft occurred within the first year, with 75% resorption by 18 months. To avoid some of the negative consequences of the more aggressive bone harvesting procedures, guided bone regeneration techniques have
been attempted using autogenous grafting from introral donor sites. Although these procedures have proved somewhat effective in increasing alveolar bone width,\(^6\) increases in alveolar height have shown similar results to those of the autogenous grafting procedures previously described. Cordaro et al\(^9\) reported a loss of vertical height during consolidation of 42% after 6 months. Attempts to stem this vertical loss with simultaneous endosseous implant placement have yielded only failure of osseointegration.\(^10\) A number of allogenic bone grafting methods have been attempted using hydroxyapatite. Although these methods have not had the negative sequela associated with donor site morbidity, they have resulted in greater amounts of graft resorption than with the previously described autogenous methods, along with increased levels of dehiscence at the surgical site.\(^11\)-\(^13\)

Because it is the position of the inferior alveolar nerve that interferes with conventional implant placement, some investigators have endeavored to simply move it out of position. Lateral nerve transposition has been attempted to lateralize the inferior alveolar nerve and allow placement of appropriate length implants. Nerve transposition is a technically demanding surgical procedure with numerous deleterious sequelae. Nearly all patients have had postoperative paresthesia in the distribution of the mental nerve. Studies have shown persistent neurosensory loss rates of more than 20% for many of these patients.\(^14\) with one incidence of postoperative mandibular fracture.\(^15\)

If one cannot go through the alveolus or move the vital structures out of the way, one can always place something that rests on the alveolus itself, such as a subperiosteal implant. Although some investigators have shown good results,\(^16\) subperiosteal implants, in general, have been shown to have significantly lower long-term survival rates and significantly greater complication rates than endosseous implants. For example, Yanese et al\(^17\) showed a 60% survival rate at 15 years for subperiosteal implants, significantly lower than the 99% survival rate at 15 years for endosseous implants reported by Lindquist et al.\(^18\) These implants are also at times very difficult to retrieve if they require removal owing to infection or fracture.

If the alveolar height is insufficient, one can place a shorter length implant. Short-length dental implants (8 mm or less) have been used effectively in regions without an adequate alveolar ridge height to accommodate traditional length implants (10 mm or greater). Griffin and Cheung\(^19\) and other investigators have shown excellent results with short implant placement in the posterior maxilla and mandible. Although effective, the clinical results from a variety of sources have shown that shorter length implants have unfavorable results compared with longer length implants within the same system, regardless of whether the implant surface was smooth or rough.\(^6\)-\(^8\),\(^20\)-\(^26\) These unfavorable results could have occurred from overload of the surrounding bone, because the shorter implants have less surface area in contact with the osseointegrated bone to distribute the resulting occlusal forces.\(^5\),\(^9\) Greater cantilever lengths have also been noted when the resulting shorter implants were restored with fixed prostheses compared with longer length implants.

In patients who are completely edentulous in the mandible, angulated implant systems have been devised that rely on placement of the endosseous implant in a mesial inclination anterior to the mental foramen in an effort to place a full-length dental implant while avoiding damage to the inferior alveolar nerve. One such method is the recently popularized all-on-four system by Nobel Biocare (Yorba Linda, CA). This method allows placement of the implant fixture at a more distal position, minimizing the resulting cantilever. Krekmanov et al\(^27\) noted a 6.5-mm increase in prosthetic support with the distal inclination of the implants placed anterior to the mental foramen at an angle of 25° to 35°. Using this distal inclination, a bilateral cantilever can be created of up to 20 mm in length for the resulting fixed prosthesis. These tilted implants and the resulting prosthesis have shown survival rates similar to those of traditional axially inclined endosseous implants.\(^28\)

Although this has been of great benefit to completely edentulous patients, it has not helped patients edentulous only distal to the mental foramen. We have proposed a novel approach using implants in a similar method to the tilted implants described in areas posterior to the mental foramen. Instead of a mesiodistal angulation with an axial placement buccolingually, we have proposed a buccolingual angulation with axial placement mesiodistally at an angulation above the inferior alveolar nerve. Using a computed tomography scan to deduce the position of the inferior alveolar nerve within the bone, Simplant (Glen Burnie, MD) software can be used to plan proper placement of an appropriate length implant. This implant will be placed at a buccolingual tilt in a direction away from the inferior alveolar nerve and will engage the lingual cortex of the mandible for additional retention and support for the implant.

**Materials and Methods**

A total of 64 qualifying patients with a partially edentulous mandibular span posterior to the mental foramen and desiring endosseous dental implant placement were entered in the present study (Fig 1). These patients had all refused traditional ridge augmentation, as described previously. All patients had a maximum of 9.5 mm and a minimum of 6 mm of bone height above the inferior alveolar nerve and a mini-
mum alveolar ridge thickness of 4 mm as determined by preoperative computed tomography imaging or i-CAT (Hatfield, PA). After imaging, the planned implant length, angulation, and placement were performed using Simplant software (Figs 2, 3). The implants that were placed were from 3 different systems: Nobel Biocare (Yorba Linda, CA), Frialit (Lakewood, CO), and Implant Direct (Calabasas Hills, CA).

SURGICAL TECHNIQUE

A full-thickness crestal incision was performed with a distal angulated release in the posterior. A full-thickness mucoperiosteal flap was then reflected in both buccal and lingual directions. The buccal flap was developed forward to allow identification and visualization of the mental nerve. The lingual flap was developed and protected with a Seldin retractor. Development and protection of the lingual flap requires advanced operator experience and diligence. Tearing or iatrogenic trauma during implant placement in this region can lead to damage to the lingual nerve or the vasculature of the floor of the mouth. Under direct visualization, the implants were intentionally placed at a tilted angulation superior to the inferior alveolar nerve in a length, direction, and inclination as di-
rected by previous planning using the Simplant pro-
gram. These implants were placed penetrating both
the superior buccal alveolus and the lingual cortex to
achieve bicortical anchorage (Fig 4). In 49 of the 194
tilted implants placed (23.7%), a few millimeters of
the apical aspect of the implant would be present
outside the lingual cortex owing to the angulation
required during placement. In these cases, hydroxy-
apatite was placed to prevent the irritation of the
lingual tissue by the extruded apical aspect of the
implant (Fig 5). An immediate postoperative i-CAT
scan was taken of the patient to confirm proper im-
plant placement and ensure no violation of the neu-
rovascular structures of the inferior alveolar nerve.
The implants were covered with watertight primary
closure for a 3- to 5-month period. The implants were
then uncovered, and custom abutments were placed.
Porcelain fused to metal restorations were then fabri-
cated for the custom abutments and splinted together
(Figs 6-8).

Results

A total of 194 implants in 64 patients were placed
in a tilted lingual manner and restored. Of the 194
implants, 43 have been in function for more than 1
year, with 15 of those in function for more than 3
years. Of the 194 total implants placed, 138 were
from Implant Direct, 50 from Nobel Biocare, and 6
from Frialit. As of July 2009, only 2 of the implants
had been lost. One Implant Direct implant failed to
osseointegrate. This implant was removed, and a new

\[\text{FIGURE 4. Crestal incision, full-thickness mucoperiostium flap}
\text{reflected. Subperiosteal reflection and retraction of the lingual}
\text{mucosa to avoid damage to the lingual nerve. Under direct visual-
ization, dental implants were placed at predetermined trajectory to}
\text{avoid inferior alveolar nerve. Implants were tilted and placed}
\text{through the buccal and lingual cortex.}
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\[\text{Pancko et al. Tilted Implants for Atrophic Posterior Mandible.}
\text{J Oral Maxillofac Surg 2010.}\]

\[\text{FIGURE 5. A, Porous hydroxyapatite placed beneath the lingual}
\text{periostium to cover the apical threads of the implants to prevent}
\text{dehiscence of the thin lingual mucosa and promote bone growth}
\text{over the exposed surface of implant. B, Postoperative panoramic}
\text{radiograph.}
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\[\text{Pancko et al. Tilted Implants for Atrophic Posterior Mandible.}
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\[\text{FIGURE 6. Custom abutments.}
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one was placed. A second implant, a Frialit, also failed to osseointegrate. This implant was removed, and a new one was placed. A total of 12 incidences of transient postoperative sensory disturbances occurred, all of which resolved after 2 weeks. No long-term neurosensory deficits have been noted, no nerve injury was reported, no gingival recession was identified, and no mechanical fractures of implants or prosthetic components were noted to date. The prosthesis survival rate for the group at 2 years (43 of 43) and for the group at 4 years (15 of 15) is 100% (Fig 9).

Discussion

The placement of lingually tilted implants as described has many distinct advantages, including obviating the need for osseous grafting, guided bone regeneration, or nerve transposition of the edentulous posterior mandible. The patient is spared the expense and morbidity of an additional surgical procedure. Another key advantage is the shortened treatment time. Autogenous cortical grafting, whether by onlay grafting or guided bone regeneration, requires anywhere from 4 to 6 months to integrate before definitive implant placement.

The tilted placement of the implants also allows for bicortical stabilization of the implants. Bicortical stabilization of the implant decreases micromotion of the implant during osseointegration and increases the success of the eventual implant. Ivanoff et al\textsuperscript{29} reported the degree of osseointegration by measuring the removal torque with monocortically and bicortically placed implants. Their experiments demonstrated bicortical implant removal torques of 2 times those of monocortically placed implants at 6 weeks and torque levels of 3 times at 12 weeks. The engagement of both cortices can also have advantages in stress distribution. Jeong et al\textsuperscript{30} showed a reduction in maximal stress in the crestal cortical bone of approximately 20% in axial and tilted implants. Bicortical stabilization has also been shown to have no ill effects on the marginal bone level around implants, with changes in height similar to those of monocortically placed implants.\textsuperscript{31}

In addition to the advantages of the placement of lingually tilted implants, some possible complications and concerns have been noted by us. Most significant was the increased strain at the coronal implant bone surface and fixture level for these off axis loaded implants. Research by Hsu et al\textsuperscript{32} have demonstrated a 3 to 4 times greater increase in strain at the cortical bone relative to similar axially loaded implants for each 30° loading angle increase. As a method to reduce the stress on the resulting tilted positioned implants, we have recommended splinting the implant prostheses together, rather than fabrication of individual...
restorations. This recommendation has originated from studies that showed better sharing of occlusal loads and distribution of stress in splinted versus individually re-
stored implant designs.3

Although not a consequence observed in the present study, nerve injury is a major concern during placement. The risk of violation of the neurovascular bundle can be minimized using a surgical guide dur-
ing placement. We also used immediate postoperative computed tomography scanning to immediately verify placement of the implants.

The placement of implants with a lingual tilt can also have the unintended consequence of emergence of the abutment into unattached gingiva. Although it was not encountered in our patient population, this result could have disastrous consequences for the periodontal health of the resulting implant. Peri-implant mucositis or peri-implantitis was not noted in any patient in the present study. The plaque index values, as measured by the gingival index of Löe and Silness observed during the follow-up visits, were comparable to those for conventionally placed endos-
seous implants.

Because of the buccal location of the abutment, it is also possible for the resulting restoration to need to be fabricated in the posterior cross bite. In the present study, 24 (12.2%) of 196 implants were re-
stored in a posterior cross bite occlusion. Patients requiring restoration in the posterior cross bite position were treated by members of the prosthodontic faculty and private practitioners with extensive experi-
ence in implant restorative techniques. Owing to the need for custom abutments for restoration of these tilted implants, these cases are difficult to restore from the prostho-
dontic aspect and should only be undertaken by advanced and experienced clinicians.

Lingually, tilted mandibular posterior implants offer an effective treatment alternative to bone grafting, guided bone regeneration, nerve lateralization, or short implants for the narrow, height deficient atro-
phic posterior mandible. Additional follow-up and long-term evaluation are needed.

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