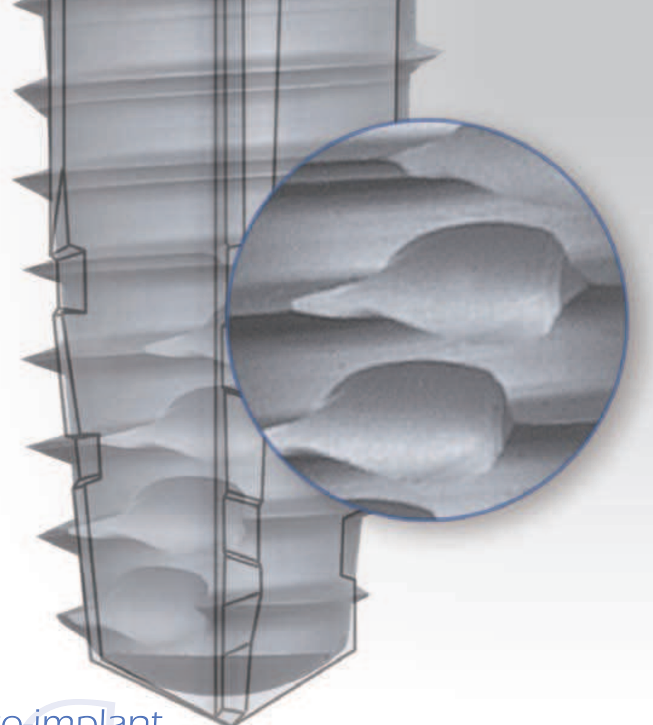
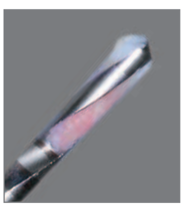


planning

Primary stability and initial bone-to-implant contact: The effects on immediate placement and restoration of dental implants

Alan M. Meltzer, DMD, MScD



With the growing popularity of immediate implant placement and provisionalization, the achievement of primary implant stability has become more important than ever. An intimate contact between the implant and the bone at the placement site provides the mechanical support that makes primary implant stability possible. Moreover, if the greatest possible surface area of the implant is in contact with bone, osseointegration may occur more rapidly and completely.

A variety of measures can enable clinicians to improve initial bone-to-implant contact (IBIC). These include the use of implants with improved designs, both macrogeometric and topographical. New drilling protocols also help to create an intimate implant-to-osteotomy fit.

Key Words: primary stability, IBIC, immediate placement

Introduction

Implant dentistry has evolved rapidly over the past 40 years, and technological advancements have been so dramatic that it is sometimes possible to lose sight of the remarkable ways in which patient expectations regarding implant dentistry have also changed. In fact, the latter often have been the primary driver of the former.

The earliest implant patients were grateful simply to recover something approaching normal masticatory function and speech. But as implants began to move into the clinical mainstream, patients understandably expressed a desire for more natural-looking restorations. In response, implant practitioners developed a remarkable arsenal of knowledge and technology for delivering highly aesthetic implant-supported prosthetic solutions. As this has occurred, the speed with which those restorations can be delivered has moved to the forefront of patient concerns.

Patients with failing dentition understandably want teeth that look like the ones with which they were born. Yet for a long time, potential implant recipients had been told that the only way to achieve this was to wear removable teeth for an extended period. This protocol furthermore required a complex series of surgical and restorative visits during which the removable provisional restorations were relined and adjusted and refined–only to ultimately be discarded.


Fig. 1

Increasingly, prospective implant patients have been demanding treatment protocols that:

- Take less time
- Require fewer surgeries and office visits
- Eliminate the need for any removable prosthesis
- Deliver superior function and aesthetics

In response, clinicians have accelerated the implant treatment process, provisionalizing implants earlier and in some cases providing early or immediate restoration for implants placed in fresh extraction sites.[1] While the pool of patients who are candidates for such accelerated treatment continues to expand, not all cases fulfill the biomechanical requirements necessary to achieve high levels of success. To this end, the principles of wound healing must still be respected and not violated. At the same time, heightened patient demands have posed this question for implant practitioners: Are there innovative biomechanical approaches to immediate implant placement and provisionalization that may expand the number of suitable cases, even in immediate extraction sites and poorer quality bone?

Improving Implant Stability

For any immediately placed implant to succeed, primary (mechanical) stability must be sufficient to enable the implant to resist micromovement until sufficient biologic stability (secondary stability) is adequately established.[2] In a review of the literature focusing on early wound healing adjacent to endosseous dental implants, Raghavendra et al[3] point out that a critical period occurs after implant placement, when osteoclastic activity has decreased the initial mechanical stability of the implant, but not enough new bone has been produced to provide an equivalent or greater amount of compensatory biological stability.

During this period of transition between primary and secondary stability, the implant faces the greatest risk of micromotion and potential consequent failure. Extrapolating from research in dogs, it is estimated that this period in humans occurs roughly two to three weeks after implant placement.

This work suggests that a pathway to increasing the number of cases suitable for immediate placement and provisionalization is to improve both the initial mechanical stability and the rate and speed of osseointegration. Hypothetically, if the level of primary stability can be increased and the rate of osseointegration at the same time can be accelerated, then the dip in total stability described by Raghavendra et al can be reduced, and the implant is made less susceptible to micromovement and potential failure.

Historically, numerous researchers have documented high success rates with the immediate loading of implants placed in the edentulous mandible.[4-10] These high success rates have been achieved even with machined surface implants. Retrospective analysis has led the author to believe that these high success rates are related to high primary stability. The level of primary stability may be maintained for longer periods due to the fact that these cases represent the placement of multiple implants in dense bone with the concomitant splinting of the implants around a curve. This approach represents a pure mechanical solution to the findings of Raghavendra et al.

Histomorphometric studies conducted by Mendes and Davies[11] shed light on how the rate of osseointegration may be increased. By implanting T-shaped bone in-growth chambers in rat femora (Fig. 1), they found that osteoconduction occurs earlier when the bone and implant surface start out in close proximity. Conversely, the further away from the surface the bone is, the longer it takes the implant to achieve biologic stability regardless of the surface topography.

Mendes et al also found that osteoconduction on both etched and commercially pure titanium surfaces was significantly increased when the surfaces were modified with nano-scale deposits of calcium phosphate crystals.[11, 12]

IBIC

The concept of initially placing more bone within the immediate vicinity of the implant surface has been termed Initial Bone-to-Implant Contact (IBIC) by the author. Maximizing IBIC has two major benefits: 1) the greater the IBIC, the greater the mechanical stability, thus enhancing the implant's ability to withstand micromovement while secondary stability develops. 2) Reducing the osteogenic migration distance decreases the time for osteoconduction to occur.

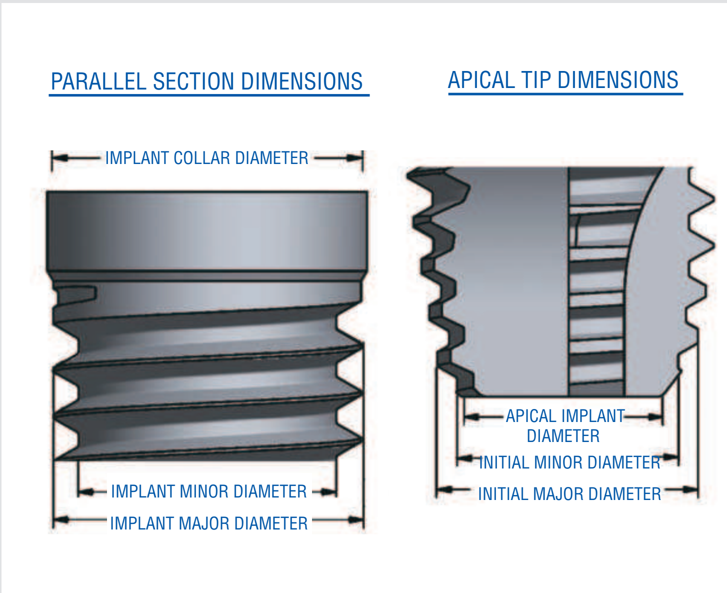


Fig. 2

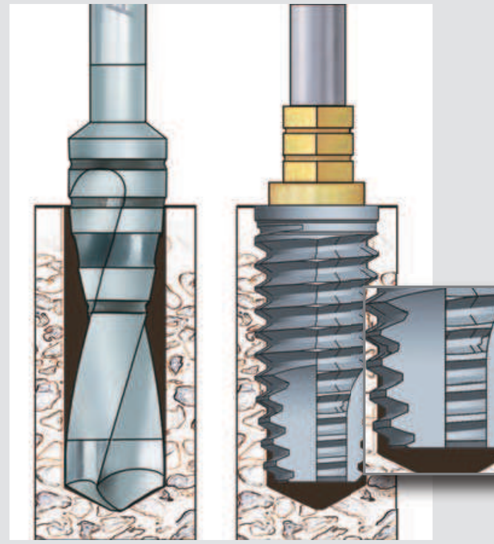


Fig. 3

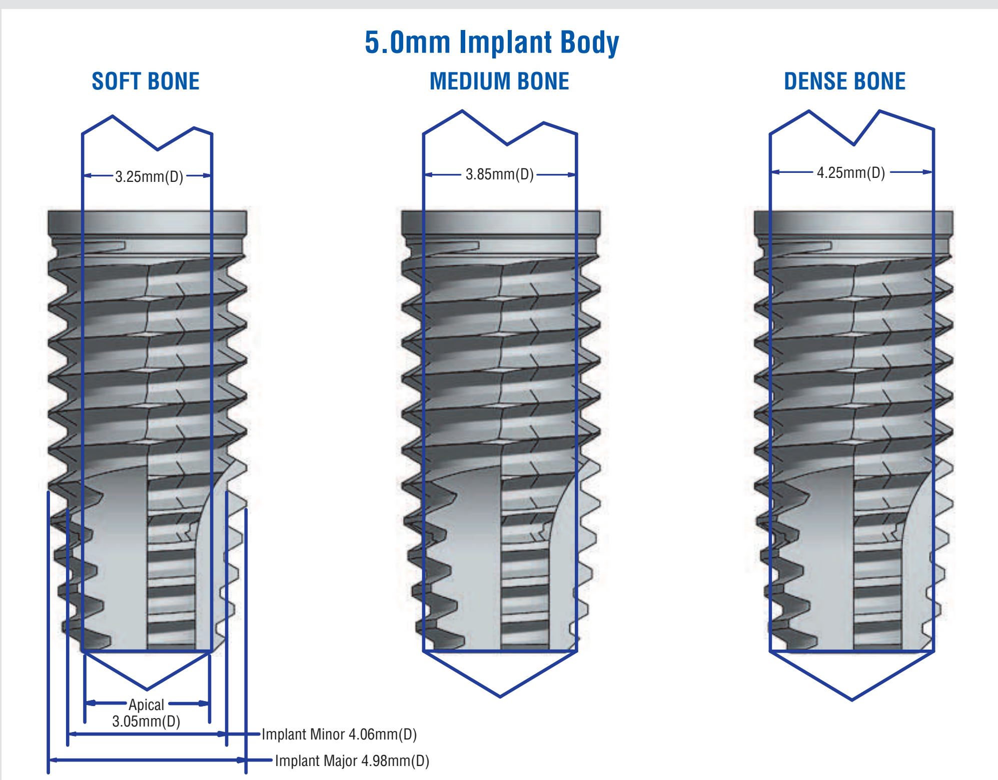


Fig. 4

Fig. 1 Back-scattered electron image of one plane of a t-shaped implant chamber. Such studies have shown that the closer the bone is to the surface of the implant, the faster BIC is established.[11]

Fig. 2 Parallel-walled implants are not truly parallel, as these have various diameters throughout the length of the implant including: the implant collar, from thread base to thread base (minor diameter), from thread tip to thread tip (major diameter), and at the apical self-tapping region.

Fig. 3 Use of a straight drill may reduce IBIC in the apical third of the implant because of the narrower diameter and self-tapping incremental cutting edge of the implant.

Fig. 4 Revised drilling guidelines may improve IBIC. The blue overlays suggest guidelines based on soft, medium, and dense bone scenarios. For example, when placing a 5mm implant in soft bone, creation of a 3.25mm osteotomy may compensate for the implant's tapered apex. In denser bone, less undersizing of the osteotomy may be necessary.

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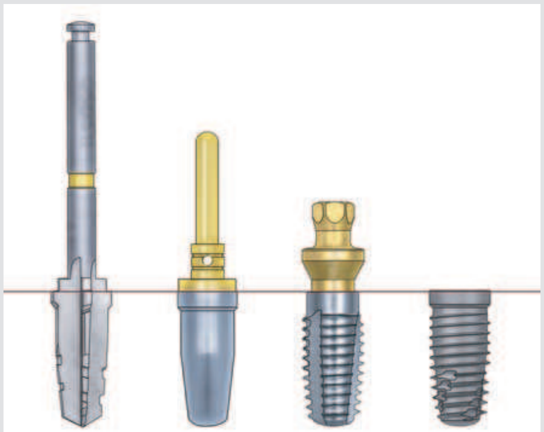

Fig. 5

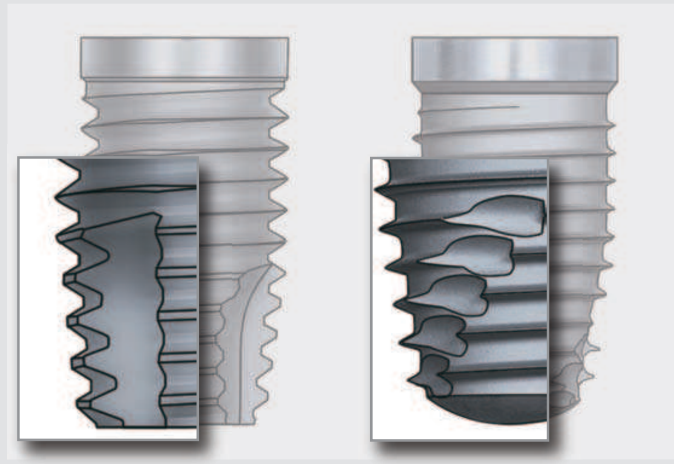

Fig. 6

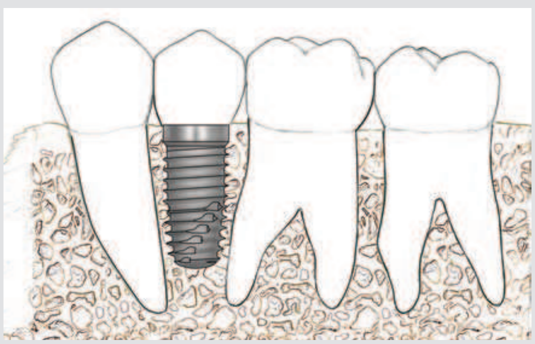

Fig. 7

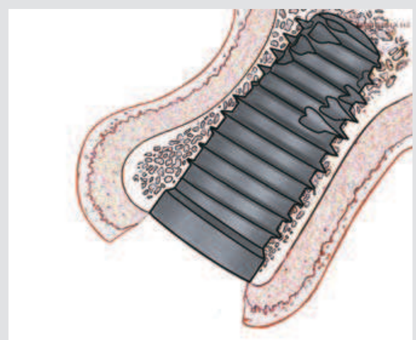

Fig. 8

A variety of measures can increase IBIC. These include:

Altering Drilling Guidelines

The drilling protocol determines the fit of the implant within the osteotomy and the extent of IBIC. Although osteotomies for parallel-walled implants traditionally have utilized a final drill that is smaller than the diameter of the implant, closer consideration of the complex geometry of parallel-walled implants reveals that they typically have many diameters: one at the prosthetic platform, another at the collar, still more when measuring along the major and apical portions of the implant body. As Fig. 2 illustrates, a typical so-called 4mm diameter implant only truly measures 4mm from thread tip to thread tip along the major parallel portion of the implant body. Self-tapping features at the apex of parallel-walled implants introduce another dimension for consideration in bone-to-implant contact.

When classic drilling protocols are utilized for such implants, the result may be overpreparation of the osteotomy, particularly in the apical third (Fig. 3). To improve IBIC, some modification of the classic protocols is justified (Fig. 4). Revised Drilling Guidelines from BIOMET ***3i*** for the parallel-walled implants call for creation of a slightly undersized osteotomy, resulting in greater IBIC. In areas of softer bone quality, the osteotomy site may also be stepped, in order to further improve IBIC.

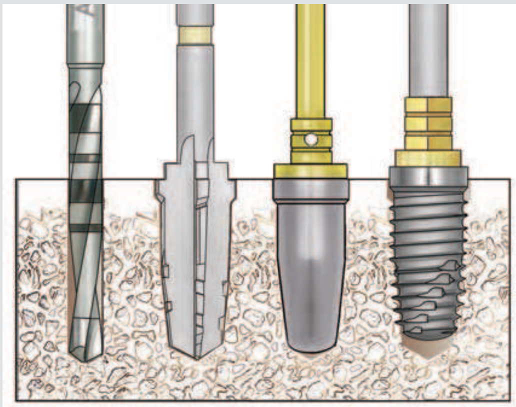

Fig. 9

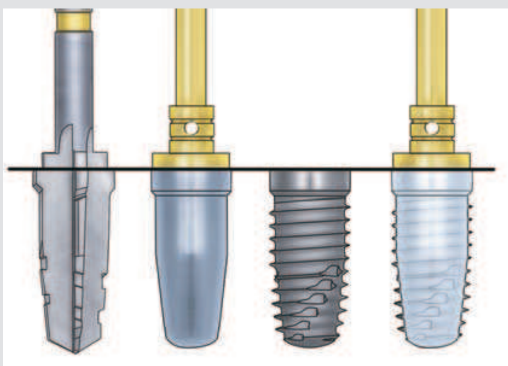

Fig. 10

Fig. 5 Osteotomies that intimately conform to the depth and diameter of specific-sized tapered implants can be created by using depth- and diameter-specific drills.

Fig. 6 The Spiral ICE™ (Incremental Cutting Edge) design of the BIOMET ***3i*** Tapered Implant may allow more IBIC than the self-tapping features of traditional parallel-walled implants.

Fig. 7 A tapered implant may better accommodate the surgical space when converging roots are present.

Fig. 8 Tapered implants may be ideally suited in those clinical situations where facial concavities are present.

Fig. 9 Illustration depicts a tapered implant (far right) that is incompletely seated within the prepared osteotomy. When this occurs, the result may be reduced IBIC and initial primary stability.

Fig. 10 In order to maximize IBIC, tapered implants should be completely seated within the prepared osteotomy. Use of the corresponding Depth/Direction Indicator (NTDI) (second from the left) prior to implant placement may confirm the proper apical-occlusal positioning of the implant. The corresponding NTDI is equal to the minor diameter of the specific implant, as depicted on the far right.

Using Tapered Implants

IBIC can also be improved by altering the implant macrogeometry. When tapered implants are placed using depth and diameter specific drills, the osteotomy can be more precisely matched to the depth and diameter of the implant (Fig. 5). The BIOMET ***3i*** Tapered Implant also incorporates taller and thinner threads that penetrate laterally into the bone, further increasing mechanical stability. The self-tapping feature of the tapered implant has been modified into a spiral incremental cutting edge design (Fig. 6). While this new self-tapping modification provides ease of insertional torque, this cutting edge has been shortened to further improve IBIC at the implant apex. Revised drilling guidelines for BIOMET ***3i*** Tapered Implants may improve the IBIC still further. For example, in cases presenting with soft bone, undersizing the osteotomy by one drill diameter is recommended.

Tapered implants may offer additional benefits when used in the presence of converging roots or large facial concavities (Figs. 7 and 8). However, the tapered design also imposes greater demands upon the clinician for precision in terms of vertical positioning. Failure to seat a tapered implant completely within a tapered osteotomy may result in less IBIC and hence reduced primary stability (Fig. 9). To avoid such underseating, BIOMET ***3i*** Tapered Implants come with Depth/Direction Indicators (NTDIs) (Fig. 10). Once the osteotomy has been prepared with the Shaping Drill, a NTDI makes it clear where the implant-abutment junction should be positioned. The implant itself must then be driven to the vertical position that was visualized with the directional indicator. The step-by-step protocol for placement of tapered implants in dense bone is demonstrated in (Figs. 11.1-11.12).

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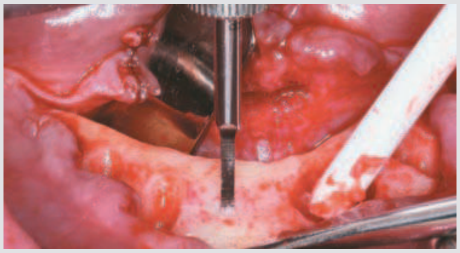


Fig. 11.1

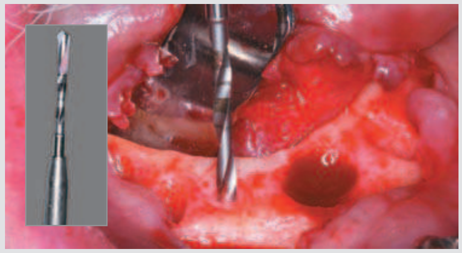
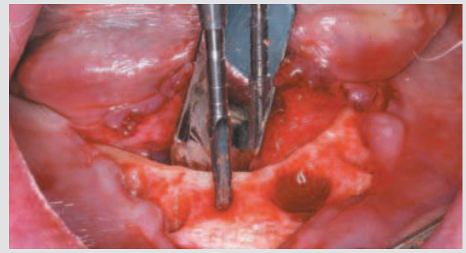


Fig. 11.2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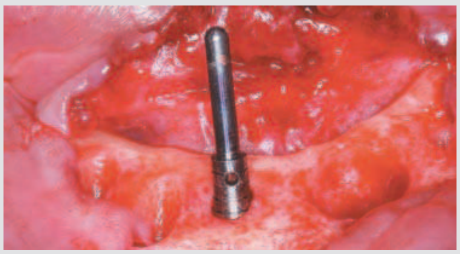
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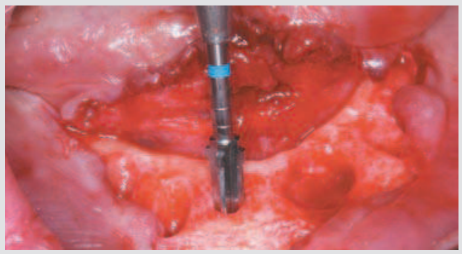
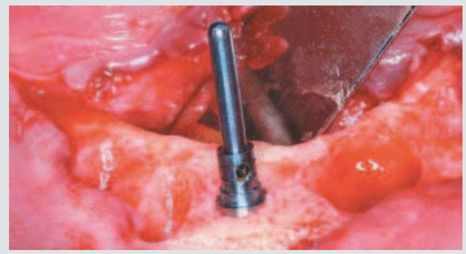


Fig. 11.5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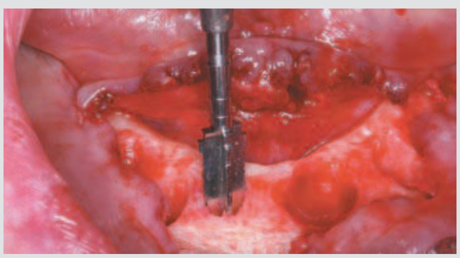
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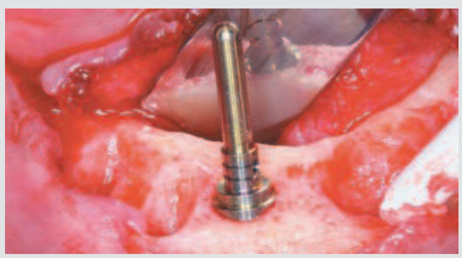
Fig. 11.8

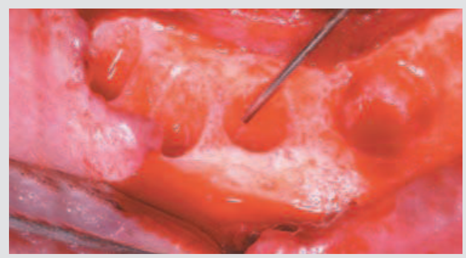
Fig. 11.9

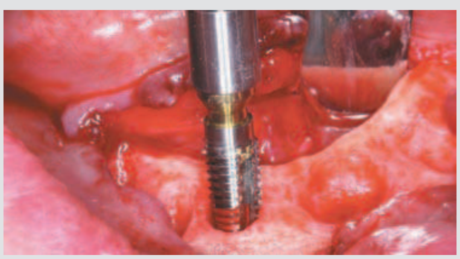
Fig. 11.10

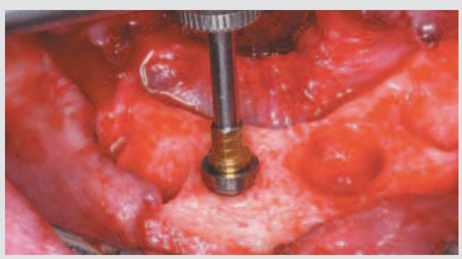
Fig. 11.11

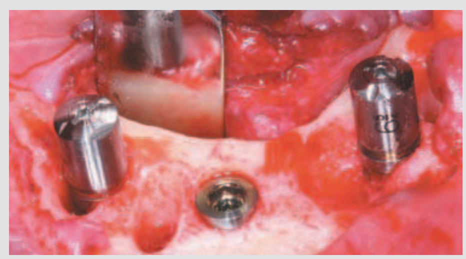
Fig. 11.12

Fig. 11.1 An ACT® Pointed Starter Drill was used to pierce the cortical plate and initiate the drilling sequence.

Fig. 11.2 Osteotomy creation continued with a 2mm diameter Twist Drill.

Fig. 11.3 A 3.25mm (D) x 13mm (L) Quad Shaping Drill (QSD) was advanced into the osteotomy.

Fig. 11.4 A 3.25mm (D) x 13mm (L) Natural Tapered Depth and Direction Indicator (NTDI) was placed to verify the osteotomy positioning and orientation.

Fig. 11.5 A 4mm (D) x 13mm (L) QSD was then advanced into the osteotomy.

Fig. 11.6 A 4mm (D) x 13mm (L) NTDI was placed for verification.

Fig. 11.7 A 5mm (D) x 13mm (L) QSD was advanced into the osteotomy.

Fig. 11.8 A 5mm (D) x 13mm (L) NTDI was placed for verification.

Fig. 11.9 The osteotomy was irrigated with saline and suctioned to remove any debris.

Fig. 11.10 Because of the dense nature of the bone at this site, a 5mm (D) x 13mm (L) Tapered Implant Bone Tap was used to full depth.

Fig. 11.11 A 5mm (D) x 13mm (L) NanoTite™ Tapered Implant was seated into the prepared osteotomy with the drilling unit set on 40rpm.

Fig. 11.12 Final seating of the implant was accomplished with a hand ratchet to approximately 80Ncm.

After insertion of the implant using a handpiece, a hand ratchet must also be employed to apply a sufficient torque (up to 100Ncm) to achieve the final apico-occlusal positioning. Higher insertion torque values have been found to correlate with high resonance frequency analysis (RFA) values,[13] and low RFA values have been associated with increased risk for implant failure after immediate loading.[14] In the author's opinion, the tapered implant body design is associated with higher insertion torque values and high implant stability quotients, therefore creating a synergy which may promote osseointegration.

Clinical Relevance

Patients increasingly are demanding implant-placement protocols that deliver functional and aesthetic implant-supported restorations quickly and economically, without requiring use of a removable prosthesis. In order to meet these expectations, clinicians must find ways to place implants that have a high level of primary stability as well as rapid osseointegration. Achieving a high degree of IBIC by means of optimized implant macrogeometries and drilling protocols can help to achieve both of these requirements.

More information including an interview entitled "Why Tapered Implants?" will be coming soon to www.JIRD-online.com.

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Dr. Meltzer received his dental degree from the University of Pennsylvania and his Masters in Periodontics and Oral Medicine from Boston University, School of Graduate Dentistry. He is a Diplomate of the American Board of Periodontology and a Fellow of the Academy of Osseointegration, where he serves on its Research and Education Committees. He is a featured speaker for the New Jersey Society of Periodontists, The University of Milan, Milan, Italy and is Former Director of Graduate Periodontology at Temple University. Dr. Meltzer maintains a private practice in Voorhees, New Jersey.

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For more information, refer to the BIOMET 3i Surgical Manual.