Clinical Factors Related To Implant Stability With Tapered Implants
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Additional Content:
Reddy M, Geurs N. A Prospective, Randomized-Controlled Study of BIOMET 3i Tapered Implants Placed by Students in Graduate Programs.
Stach R, Kenealy J. Outcomes from a Retrospective Study of 626 Sequential Cases of BIOMET 3i Tapered Implants.
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Clinical factors related to implant stability with tapered implants

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Immediate occlusal loading of dental implants offers benefits to both patients and clinicians. Although excellent results have been reported for both early and immediately loaded implants, these protocols are technique sensitive. Success depends upon many factors, including the achievement of high primary implant stability. This article reviews some recent studies relating to initial implant stability and presents a protocol to obtain high primary stability for immediately loaded implants. A clinical case illustrating the protocol is presented.

Key Words: primary stability, immediate loading, tapered implants, implant stability

Introduction

Many factors explain the growing popularity of immediate loading protocols. Patients appreciate being able to shorten the overall length of implant treatment and reduce the number of procedures they must undergo in order to obtain fixed implant prostheses. Full-arch immediate loading enables patients to function with non-removable implant prostheses within one to two days of tooth extraction, eliminating the need to experience any period of edentulism with complete dentures. For the implant team, immediate occlusal loading offers multiple benefits including greater cost-effectiveness, fewer post-operative patient visits, and higher referral rates for surgeons.

The original Brånemark protocol called for relatively long (three to six months) unloaded healing intervals because it was thought that placing occlusal loads onto implants prior to osseointegration could lead to fibrous tissue encapsulation rather than direct bone apposition. Support for lengthy unloaded post-surgical periods also was bolstered by the belief that necrotic bone in implant osteotomies needed to be replaced by new bone before any loads could be tolerated.

In 1979 Ledermann published results associated with successful healing for immediately loaded endosseous implants; multiple researchers and clinicians subsequently reported similar results. In 2007, a systematic Cochrane review of 11 randomized controlled trials that compared outcomes for early or immediately loaded implants to outcomes for conventionally loaded implants found no statistically significant differences for any of the meta-analyses. Histomorphometric analyses of retrieved, immediately loaded endosseous implants have
demonstrated that immediate loading does not impede osteogenesis and bone remodeling.\textsuperscript{15-18} Peri-implant bone and soft-tissue levels around healed, immediately loaded implants also do not appear to differ from those found around traditionally loaded implants.\textsuperscript{19}

Despite the broad body of evidence validating the predictability of immediate loading in carefully selected patients, some studies have reported higher failure rates with an immediate-loading approach, as compared to a staged approach for implant placement.\textsuperscript{10,20-22} However, it should be noted that some of these findings related to machine-surfaced implants\textsuperscript{10,20} and others related to single implants.\textsuperscript{21,22} This suggests that immediate loading is technique sensitive and should be applied to patients with caution.

### Achieving High Primary Stability

Crucially important to immediate occlusal loading is achieving high primary implant stability. Primary stability must be sufficient to allow implants to resist micromovement until adequate biologic stability has been established.\textsuperscript{23} For roughened implant surfaces, research has demonstrated that the tolerable range of micromovement is between 50 and 150 \(\mu m\).\textsuperscript{24}

A number of recent studies have shed light on various aspects of initial implant stability. In 2009 Rozé et al.,\textsuperscript{25} investigating a possible correlation between bone micro-architecture and primary implant stability, placed 22 implants in human cadaver maxillae and mandibles for which the bone structure had been determined pre-operatively by computed tomography (CT). Primary implant stability was measured by resonance frequency analysis; Osstell ISQ values ranged from 50 to 70. No correlation was found between the ISQ values and the trabecular bone histomorphometrical parameters. Instead, the authors concluded that primary implant stability is correlated to the cortical thickness around implants, which can be assessed with standard clinical CT scans.

O’Sullivan et al\textsuperscript{26} compared the primary implant stability of five implants: Nobel Biocare’s Standard threaded, Mark II self-tapping, and Mark IV tapered self-tapping implants (Nobel Biocare AB, Gothenburg, Sweden), the Astra Tioblast (AstraTech AB, Mölndahl, Sweden), and the BIOMET 3I OSSEOTITE\textsuperscript{®} (BIOMET 3I) Implant. Fifty-two implants were placed into maxillary bones of nine unembalmed human cadavers; peak-insertion-torque, resonance-frequency, and removal-torque values were recorded at each implant-placement site. Qualitative assessments of bone quality at each site were also made. The authors found that all implants demonstrated good primary stability in Type II and III bone, but the Standard, Mark II, OSSEOTITE, and Tioblast implants were less stable when placed into Type IV bone. The authors concluded that tapered implants exhibited higher insertion torques than cylindrical implants, as well as significantly higher resonance-frequency values, which indicated a higher interfacial stiffness at the implant-bone interface.

Turkyilmaz et al\textsuperscript{27} using smaller-diameter drills to enhance primary implant stability, placed 60 implants into the posterior maxillae of 22 patients and recorded bone
densities (as determined with computerized tomography), maximum insertion torque, and resonance-frequency-analysis results. Strong correlations were observed between bone density, insertion torque, and implant stability values at implant placement. The authors concluded that using smaller-diameter drills for implant placement in posterior maxillae, where bone quality is generally poor, may improve primary implant stability.

Ottoni et al. placed 46 Frialit-2 implants into 23 patients and restored these within a 24-hour period with provisional crowns designed to receive occlusal masticatory loads. A minimum insertion torque of 20Ncm was achieved. This approach was compared to a control group of implants restored after a healing period. After a 24-month data-collection period, the experimental group included 10 failed implants, nine of which had been placed with an insertion torque of 20Ncm. Only one implant from the control group failed during the same period. The survival rate was independent of implant length, site position, and bone quality and quantity. Relative risk for implant failure was associated with insertion torque in the experimental group but was not significant for the control group. To achieve osseointegration, it was found that an insertion torque above 32Ncm was necessary. The authors’ low insertion torque (20Ncm) was associated with increased potential for loss, which could be decreased by 20% per every additional 9.8Ncm of insertion torque.

In 2009, Neugebauer et al. investigated seven different surgical motors, measuring torque during typical surgical and prosthetic procedures using a special load-transfer mechanism for a torque gauge. For each setting, 30 measurements were made and means were calculated. The authors concluded that the highest percentage shortfall was 20.5% at a set torque of 11.4Ncm (absolute deviation, 2.4Ncm). The highest percentage by which a torque was exceeded was 54.6% (absolute deviation, 5.5Ncm). The lowest value for absolute shortfall was found to be -5.6Ncm at a set torque of 45Ncm. The highest absolute value exceeded was 15Ncm at a set torque of 40Ncm. Potentially problematic torque values were identified in the low-torque-value setting, as the implant position may be changed if a drilling unit applies excessive torque to a healing abutment or cover screw. In addition, torque values above the critical value of 50Ncm may be applied unwittingly while working with a set torque of 40Ncm. The authors concluded that although surgical motors for implant treatment demonstrated acceptable torque measurements for implant procedures, annual or chairside calibration with a standard handpiece is recommended in order to apply consistent quantities of torque and reduce implant failure rates.

Trisi et al. in 2009 designed a study to determine whether micromotion at the implant/bone interface was related to primary implant stability achieved with increasing insertion-torque values. A total of 120 Ti-Bone implants were placed into three categories of fresh bovine bone samples: hard, normal, and soft. Five groups of peak insertion torque values (20, 35, 45, 70 and 100Ncm) were evaluated in each bone-density category. A loading device consisting of a digital force
gauge and a digital micrometer was used to measure the implants' micromovement during the application of 20, 25, and 30Ncm lateral forces. The authors found a statistically significant difference between implant micro-mobility placed with different levels of torque and in different bone densities. In soft bone, it was not possible to achieve more than 35Ncm of peak insertion torque. The authors concluded that increasing peak insertion-torque values reduced implant micromotion within the osteotomies. In addition, micromotion in soft bone was found to be consistently high, which could lead to failures relative to osseointegration.

In light of such research and the author's 21 years of clinical experience in implantology and 30 years in practice, the author has developed a protocol for achieving high primary stability for immediately loaded implants.

The protocol includes:
- Identifying the quality and quantity of available bone
- Using an implant with optimal macro- and micro-geometry
- Paying attention to biology and biomechanics
- Undersizing osteotomies and preparing these precisely for placement of tapered implants
- Matching the drilling sequence to the bone type
- Understanding the surgical instrumentation
- Understanding the instruments available for determining primary stability at the time of implant placement
- Performing the surgical procedure accurately; paying attention to details

Additionally, the author considers two-handed guidance of the handpiece to be critical for successful implant osteotomy preparation and implant placement in difficult cases. One hand should be maintained on the head of the handpiece and significant apical force should be used to maintain control of the drills. The angulation of the handpiece and drill should be monitored continually during both guided and non-guided surgeries. The author always uses a bone tap in dense bone prior to placing an implant into an osteotomy.

**Clinical Case Presentation**

The following case illustrates an application of this protocol. The patient, a 35-year-old male, presented with a failing maxillary anterior fixed partial denture that had replaced his central incisors in the wake of their traumatic evulsion (Fig. 1). Clinical examination of the two lateral incisors, which supported the prosthesis, found that the right one had a vertical root fracture, while the left one had suffered a major endodontic failure (Fig. 2). Intraoral radiographs (insets) and a CT scan of the edentulous ridge revealed that the bone quality was Type II, and the vertical and buccolingual dimensions were adequate to accommodate placement of implants. Moreover, approximately 33mm of intercuspid prosthetic space was available – more than enough to allow for an optimal inter-implant distance.

The patient provided informed consent for a treatment plan that called for immediate loading of two implants to be placed in the central incisor positions and delayed loading for two implants placed in the lateral incisor positions.
Impressions were made, and a wax-up was obtained for fabrication of a fixed provisional restoration and a surgical template.

The two lateral incisors were atraumatically extracted, and a full-thickness mucoperiosteal flap was elevated. Osteotomies were created in the positions indicated by the surgical guide. At the two extraction sites, instead of following the long axis of each socket, the bur was positioned against the palatal wall and aligned with the cingulum of the future restoration. Following these directions, the initial osteotomy began 5mm to 7mm more apically from the soft-tissue contour on the palatal side (Figs. 3a and 3b).

Four 4.0mm x 11.5mm OSSEOTITE® Natural Tapered Implants (BIOMET 3i) were placed, and cover screws were placed on the two lateral implants (Fig. 4). Positioning the two lateral incisor implants into the bone on the palatal wall of the extraction sites resulted in a small gap between each implant and the labial plate. In order to establish a thicker, more stable labial wall that would better resist bone resorption, the gaps were filled with autogenous bone collected from the flutes of the shaping drills.

Transfer assemblies were connected to the two central incisor implants. After temporarily suturing the flap, an impression was made. The sutures were then removed around the two central incisor implants, and a bone dehiscence on the buccal plate of the right implant was grafted. A resorbable collagen membrane was placed on that implant, and a connective tissue graft harvested from the palatal area was also used to cover the expanded buccal contours.

To prevent collapse of the soft tissue until delivery of the provisional prosthesis the following day, wide healing abutments were placed on the two central incisor implants and tightened to 10Ncm. These were removed the next day, and a metal-reinforced provisional restoration with cantilevered lateral incisors was screw-retained to the two central incisor implants and checked to ensure the absence of centric and eccentric contacts (Fig. 5). The patient was instructed not to masticate on the provisional restoration for at least eight weeks.

Six months later, the two lateral incisor implants were exposed in a flapless procedure. Measurement of the implant-stability quotient by resonance frequency analysis confirmed secondary osseointegration of all four implants. After a gingivoplasty procedure was carried out to smooth the soft-tissue contours, the provisional restoration was re-connected to the two central incisor implants.

The soft tissue was allowed to heal for an additional eight weeks, and then the patient presented for implant-level impressions (Fig. 6). The soft-tissue contours were established by the contours established in the provisional restoration. Implant-level impressions were made (Fig. 7); the diagnostic cast of the provisional restoration was to be used as a reference in fabricating the definitive restoration (Fig. 8). A master cast was created and mounted in the
correct jaw relationship (Fig. 9). Teeth were waxed, and ZiReal® Posts (BIOMET 3i) were placed onto the master cast (Figs. 10a and b) and modified to conform to the shape of the desired restoration emergence profiles (Fig. 11). The prepared modified posts were placed onto the implants and secured with retaining screws tightened to 32Ncm (Fig. 12), and the provisional restoration was cemented to the posts. Six months later, after maturation of the soft tissues, the second provisional restoration was removed, and four definitive all-ceramic crowns (IPS Empress 2, Ivoclar Vivadent, Amherst, New York, USA) were cemented in place (Fig. 13). Periapical radiographs taken during this visit, more than a year after implant placement, showed minimal peri-implant bone remodeling (Fig. 14).

After more than eight years of follow-up, the peri-implant soft tissues and the bone levels remain stable (Figs. 15 and 16a-c).

Clinical Relevance
Among the conditions necessary to enable successful immediate occlusal loading, one of the most crucial is high primary stability for newly placed implants. Adherence to the following recommendations is suggested:

- Identify the quality and quantity of available bone for each implant site.
- Use an implant with optimal macro- and micro-geometry.
- Pay attention to biology and biomechanics.
- Undersize osteotomies and prepare these precisely for placement of tapered implants.
- Match the drilling sequence to the bone type.
- Understand the surgical instrumentation.
- Understand the instruments available for determining primary stability at the time of implant placement.
- Perform the surgical procedure accurately; pay attention to details.
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A Prospective, Randomized-Controlled Study of BIOMET 3i Tapered Implants Placed by Students in Graduate Programs*

Abstract

BACKGROUND: The success rate for implants placed by dental students early in their implant residency programs has been suggested to be lower than for experienced clinicians. The objective of this prospective study was to document the success rates of NanoTite™ and OSSEOTITE®-surfaced Certain® Tapered Implants in graduate-training programs.

MATERIALS AND METHODS: All study implants are the Certain® Tapered Implant System (BIOMET 3i, Palm Beach Gardens, FL) made from titanium alloy Ti6Al4V, having an internal connection and either the OSSEOTITE® or NanoTite™ Surface. An Internet database was used to randomly assign one of the two surface types to each site where an implant would be placed. The implant-placement surgeries were conducted at several university periodontal and maxillofacial oral surgery graduate programs in the United States. All patients qualified to receive dental implants provided informed consent to be included in the study. The specific placement techniques were those directed by the teaching staff at the individual study centers. Restorative designs and procedures were also at the discretion of the treating clinicians.

RESULTS: At the time of this interim report, 453 implants had been placed in 423 patients (mean age 55.5 ± 17.0 years) over a period of 29 months. Prior to the study, most students had not yet placed their first dental implant. Over a 30-month follow-up period, 10 implant failures were declared. Failures were not clustered but rather were distributed among 9 patients treated by 8 students and were evenly divided between the implant-surface groups. The overall cumulative survival rate for these Tapered implants is 97.8% (97.9% for NanoTite™ Tapered and 97.7% for OSSEOTITE® Tapered).

CONCLUSION: Considering that most students had never before placed a dental implant, the relatively high cumulative survival rates in this study suggest that contemporary teaching programs are effective in training new operators in dental implantology.

*For complete study information, please visit the BIOMET 3i Website: www.biomet3i.com
Outcomes from a Retrospective Study of 626 Sequential Cases of BIOMET 3i Tapered Implants*


Abstract

BACKGROUND: The placement of tapered-apex dental implants requires specific osteotomy-preparation instrumentation. Drills for tapered implants establish a finite osteotomy depth for which care is needed to ensure the proper implant descent and seating. Implant design and the instruments provided for osteotomy preparation contribute to the elements needed for successful use of tapered implants. The aim of this evaluation was to document the success of a new tapered implant in a large population.

METHODS: A protocol for conducting a retrospective study was submitted to high-volume users of the BIOMET 3i Certain® Tapered Implant System to solicit participation and contribution of data. Participants gathered information from their first 20 patients receiving tapered implants between June 2008 and December 2009. No exclusion criteria were applied. Data collection was done on standardized forms and processed in one database management system. Baseline variables included: demographics (gender, age at implant placement), diabetes, smoking behavior, implant site assessment (bone density), placement approach (2-stage, single stage, immediate provisionalization), and restorative type (single unit, fixed multiple unit, overdenture). Outcome variables included the implant's functional status and survival on the date of the patient’s last evaluation.

RESULTS: A total of 46 clinicians were approached for participation in the study, and 25 provided completed data records (54% compliance). The total number of patients represented in the data set is 473 with 626 prosthetic cases supported by 836 BIOMET 3i Certain® Tapered implants. Implant diameters ranged from 3.25 to 6mm and lengths ranged from 8.5 to 13mm. Implant locations were 63% posterior and 37% anterior, with 56% in maxillae and 44% in mandibles. A total of 13 implant failures were reported for a cumulative survival rate of 98.4%. Of the failures, 12 were in the maxillae, and one was in the mandible. Failures were evenly divided across implant dimensions.

CONCLUSION: Tapered implants in this retrospective analysis, placed in a variety of cases and locations, were found to have clinically acceptable success rates.

*For complete study information, please visit the BIOMET 3i Website: www.biomet3i.com
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