Influence of Drilling Speed on Stability of Tapered Dental Implants: An Ex Vivo Experimental Study

Karen P. Almeida, DDS1/Rafael Delgado-Ruiz, DDS, MSc, PhD2/Leandro G. Carneiro, DDS, DSc1/Alberto Bordonaba Leiva, DDS, MS1/Jose Luis Calvo-Guirado, DDS, MS, PhD3/Gerardo Gómez-Moreno, DDS, PhD4/Hans Malmström, DDS, MS5/Georgios E. Romanos, DDS, PhD, Prof Dr Med Dent6

Purpose: The aim of this study was to evaluate whether the drilling speed used during implant site preparation influences primary stability. Materials and Methods: Eighty tapered designed implants (3.8 × 10 mm) were inserted following osteotomies created in solid rigid polyurethane foam (simulating bone type II) and cellular rigid polyurethane foam (simulating bone type IV). Half were prepared using drilling speeds of 800 rpm (low speed), and the other half were prepared using speeds of 1,500 rpm (high speed). Following insertion, implant primary stability was measured using Periotest and Osstell (resonance frequency analysis [RFA]) devices. Results: Two-way analysis of variance (ANOVA) used for this study found that the drilling speed used to create the osteotomies appeared to have no significant impact on primary stability. Conclusion: The bone quality and not the osteotomy drilling speed seems to influence the implant primary stability. Int J Oral Maxillofac Implants 2016;31:795–798. doi: 10.11607/jomi.4485

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Primary stability (PS) may be defined as the mechanical anchorage of the implant in the surrounding bone achieved immediately after implant insertion resulting from the implant fixation inside the bone. Successful dental implant outcomes depend on the PS achieved following implant placement. The absence of mobility is a clinical prerequisite.

Several factors may affect PS, such as the implant geometry, length, and diameter, the surgical technique, the bone quality and quantity, and the implant surface characteristics. PS plays an important role in successful osseointegration and is a prerequisite for early or immediate implant loading.

During creation of implant osteotomies in healed bone, drilling forces and friction cause two different types of damage to the bone: thermal and microstructural. Drilling techniques have thus evolved in an attempt to reduce both. For instance, expanding the osteotomy site gradually by using sequential increments of the drill diameter in conjunction with profuse irrigation can reduce the thermal changes and keep the bone temperature below the critical threshold of 47°C. Reducing the drilling speed to between 50 and 100 rpm has been demonstrated to preserve vital osteocytes, thus maintaining the bone’s regenerative potential. Conversely, increasing the drilling speed to 1,000 rpm results in less bone-to-implant contact (BIC) and lower bone area fraction occupancy (BAFO) in the early stages of bone healing in dogs.

Simplified drilling protocols using two (a pilot and final) drills or single (four-bladed) drill protocols also have been demonstrated to result in thermal changes and implant survival rates similar to those achieved using sequential protocols.

The bone quality and quantity at the implant placement site is a major concern when planning treatment and includes physiologic and structural aspects, such as the degree of bone mineralization. Especially when advanced clinical protocols such as immediate or early loading are planned, achieving adequate PS is crucial and is often difficult in low-density bone.
A lack of PS in type IV bone has been shown to result in lower success rates. Clinical studies show greater implant survival rates in the mandible than in the maxilla, due to the good mandibular bone quality (ie, its greater density).

Although previous studies have suggested that differences in drilling speed may be beneficial for early implant integration, none have examined the influence of drilling speed on implant PS. Yet the question arises of whether changes in the drilling speed go beyond the thermal ones. Could microstructural changes at osteotomy sites induced while drilling at different speeds affect the PS of implants placed in those sites? The objective of the present study was to evaluate the influence of drilling speed on the PS of tapered dental implants placed in simulated type II and type IV bone.

**MATERIALS AND METHODS**

**Material for Drilling Procedure**

A total of 80 osteotomies were created 4 mm apart from one another in biomedical test blocks—40 in solid rigid polyurethane foam that simulates type II bone and 40 in cellular rigid polyurethane foam that simulates type IV bone (Sawbones, Pacific Research Laboratories). The American Society for Testing Materials has found that polyurethane blocks have mechanical properties comparable to human cancellous bone. Specifically, the density was 0.24 vs 0.16 g/cm³, with a compressive strength of 4.1 vs 2.3 MPa, and compressive modulus of 68.4 vs 23 MPa, respectively. The cell size was 0.5 to 1.0 mm for both of the used solid foams.

**Experimental Drilling Protocol**

In each of the two types of blocks, half the osteotomies (according to the manufacturer’s drilling sequence guidelines) were created using a maximum drilling speed of 800 rpm, and half were created using a maximum drilling speed of 1,500 rpm. A total of 80 internally hexed 10-mm-long, 3.5-mm-diameter tapered implants (Strong SW HI, Sistema de Implante Nacional) were inserted in the osteotomies, as follows: 20 in the artificial type II bone drilled at 800 rpm, 20 in the artificial type II bone drilled at 1,500 rpm, 20 in the artificial type IV bone drilled at 800 rpm, and 20 in the artificial type IV bone drilled at 1,500 rpm.Copious irrigation with saline solution was used during the entire drilling procedure.

Following their insertion, all implants were stable mechanically.

**Evaluation of Primary Stability**

The PS of each implant was assessed using two distinct noninvasive diagnostic methods: the Periotest and resonance frequency analysis (RFA) using the Osstell device. Both of these methods provide an objective, although indirect, assessment of implant stability. The Periotest was originally designed to assess the damping characteristics of the periodontium and its relationship with natural teeth. In 1990, Olivé and Aparicio proposed the use of Periotest values for clinical follow-up of the stability of bone-implant anchorage, due to the test’s quantitative and reproducible attributes. The Periotest can be used at the time of implant insertion to measure the PS and later on for complementary assessment during the osseointegration period. The testing scale extends from −8 to +50, with the lowest values signifying the greatest stability/damping effect of the measured implant or tooth. According to Noguerol et al, the Periotest performs better than radiography as a prognostic method at stage-one surgeries, and it assesses implant stability as a complementary diagnostic technique for osseointegration at stage-two surgery, given that subclinical implant mobility appears before signs of inflammation can be detected in radiographs.

RFA was introduced by Meredith et al. This method requires placement of an electronic transducer onto the implant head or prosthetic abutment. A low-voltage current, undetectable by the patient, is passed through the transducer. Original measurements were made in hertz and then converted into implant stability quotient (ISQ) units through the use of an Osstell RF analyzer. ISQ values range from 1 to 100. A high ISQ value indicates high stability, and a low ISQ value represents low stability. Thus, a decrease in the RF value is related to a decrease in stability, with an increased risk of implant failure. Studies documenting ISQ values during implant healing have shown a correlation between clinical stability, as assessed by ISQ values, and the biologic events pertinent to the documented phase. However, the association between RFA values and the clinical perception of implant stability remains unclear. The operator was calibrated prior to the drillings. A blinded examiner performed the Periotest and Osstell readings.

**Statistical Analysis**

Two-way analysis of variance (ANOVA) was used to study the effects of drill speed on the implant design, as assessed by Periotest and Osstell RFA testing. Differences were considered significant when \( P < .05 \).

**RESULTS**

As would be expected, the Periotest and RFA assessments found higher PS for implants placed in the type II bone compared with type IV bone (Table 1). In the
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clinical consideration when preparing osteotomies in soft bone where higher implant stability must be achieved. Undersizing the osteotomy is generally recommended, especially when implants will be loaded immediately, or the bone has been augmented, and remodeling and maturation of the grafting material has not yet been established.

The consistency of the data for both bone densities would seem to prove that the PS is independent of the drilling speed. The external validity of the drilling protocol is limited by the fact that a single operator performed all the procedures. However, the operator was previously calibrated.

It has been shown that PT and ISQ cannot be compared between implants, but rather, they are to be used as a comparison for the same implant at different timeframes (longitudinal), and PT and RFA are not expected to be able to demonstrate exact differences but only trends. Maybe the use of insertion torque during implant placement would have been more appropriate in this respect.

Without doubt, more data regarding drilling speed variations and using other implant designs (thread geometries) and operators should be considered for future studies. Although the presented study is an ex vivo evaluation of the PS, it is of clinical interest to demonstrate the effect of the speed of drilling to improve the clinical outcomes, especially in compromised bone qualities.

**CONCLUSIONS**

Within the limitations of this study, the PS achieved for the used tapered dental implant design placed in material simulating type II and type IV bone did not depend significantly on whether a lower or higher drilling speed (800 rpm or 1,500 rpm) was used to create the osteotomies. In soft bone, there is a trend toward better mechanical stability and higher drilling speed during osteotomy preparation.

**ACKNOWLEDGMENTS**

The authors disclose no conflicts of interest related to this study.

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**DISCUSSION**

Given that optimization of implant osteotomy drilling parameters has focused mainly on reducing thermal changes (to keep them below the critical threshold of 47°C), the present experimental work was performed to clarify whether two different drilling speeds could influence the PS achieved in normal and soft bone.

In general, drilling procedures for inserting dental implants are performed with a handpiece. However, manual drilling in cortical bone recently was demonstrated to result in high vibration rates, compared with automated methods.43 This can have an extraordinary impact on the surgical precision achieved (the relation between the implant and osteotomy diameters).

This agrees with the results of the present work, which showed similar implant mechanical stability for osteotomies performed with lower or higher drilling speeds in the soft (type IV) bone. This may be due to the shape (configuration) of the drills for the individual implant design. Drilling at lower speed requires more time to achieve the final osteotomy and thus exposes the site to drilling and vibration for a longer time, possibly leading to an enlarged osteotomy site and consequently lower mechanical anchorage of the implants placed in soft bone. This may be an important

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**Table 1  Primary Stability Evaluation for Tapered Dental Implants (Mean ± SD)**

<table>
<thead>
<tr>
<th></th>
<th>800 rpm</th>
<th>1,500 rpm</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Periotest</td>
<td>RFA</td>
</tr>
<tr>
<td>Type II bone</td>
<td>3.05 ± 1.431782</td>
<td>60 ± 3</td>
</tr>
<tr>
<td>Type IV bone</td>
<td>9.2 ± 2.83957</td>
<td>48 ± 5</td>
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</tbody>
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