Does Length, Diameter, or Bone Quality Affect Primary and Secondary Stability in Self-Tapping Dental Implants?

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Purpose: Implant stability is a clinically valuable measurement of the strength of implant anchorage in the bone during placement and in the post-osseointegration period. This study aimed to determine *1)* the effect of implant diameter and length and bone quality on measurements of primary and secondary stability (insertion torque [IT] and implant stability quotient [ISQ]), *2)* the correlation between IT and primary and secondary ISQ, and *3)* differences in ISQ in the post-osseointegration period (secondary stability) compared with immediate post-placement (primary) stability.

Patients and Methods: In this longitudinal clinical study, titanium self-tapping implants were inserted in edentulous patients. The implants were grouped according to 3 independent variables: length (10 and 11.5 mm), diameter (3.75 and 4.25 mm), and bone quality (Lekholm and Zarb classification) to analyze primary and secondary implant stability (outcome variables). Statistical analyses were performed using the Student *t* test for paired data, 1-way analysis of variance, and the Tukey procedure for multiple pairwise comparisons.

Results: Data were collected on 88 self-tapping implants inserted in 63 partially edentulous patients. IT and implant stability were affected by diameter (3.75-mm implants, 26.5-N/cm IT and 74.0 ISQ; 4.25-mm implants, 33.8-N/cm IT and 77.0 ISQ) and bone type (type 1 + 2, 34.86-N/cm IT and 77.4 ISQ; type 3, 27.09-N/cm IT and 75.6 ISQ; type 4, 20.63-N/cm IT and 70.5 ISQ; $P < .01$ for all comparisons). Secondary ISQ was affected by diameter only (77.41 for 3.75- vs 75.51 for 4.25-mm implants). IT correlated with primary ISQ ($R = 0.56$; $P < .01$), although no clear correlation with secondary stability was found.

Conclusions: IT and primary ISQ in self-tapping implants differed in patients with different bone quality and implant diameter but did not differ between the 2 implant lengths compared in this study. Secondary stability was not substantially affected by any of these factors. Although IT was closely related to primary ISQ, it was unrelated to secondary ISQ. Very high primary ISQ values tended to decrease, whereas intermediate and low values tended to increase, in the transition to secondary stability.

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Primary stability, defined as the absence of mobility in the bone bed after implant placement, depends on implant anchorage in the bone[1] and is regarded as one of the most important prerequisites for osseointegration. Although micromovements are never completely absent, osseointegration proceeds normally if they range to no more than 100 to 200 μm.[2] Beyond this threshold, such movements can harm or even break bonds between the bone and the implant, preventing osseointegration and leading to implant failure.

A distinction can be made between primary (or mechanical) implant stability, which is the result of compressive stress generated in the bone, and secondary (or biological) stability attributable to osseointegration. Primary stability is ensured by anchoring the implant in the bone at insertion and decreases as the bone around the implant remodels. Then, stability increases as new bone grows over the surface of the implant, resulting in biological fixation and what is known as secondary stability.[3]

Previous studies have described different methods for assessing implant stability.[4]

In the reverse torque test, antirotation motion is applied to determine the strength of the microscopic surface roughness formed by bone growth on the implant surface. Implant failure has been shown to occur in the 45- to 48-N/cm range, whereas a reverse torque no greater than 20 N/cm is generally accepted as reliable.[5]

The percussion test, although traditionally used because it is much less invasive, provides only nonspecific non-quantitative data.

Radiographic studies provide information on osseointegration and the loss of peri-implant bone but no measurement of implant stability.

Histologic or histomorphometric analysis yields very complete information, because it is based on tissue biopsy samples. However, it is highly invasive and thus incompatible with clinical practice.

Insertion torque (IT), which measures bone density, is noninvasive and useful in clinical practice. However, it is confined to use during insertion and thus cannot be used to determine secondary stability.

Resonance frequency analysis (RFA), one of the most popular methods, has been used in different studies. The Hertz, the basic unit (3.5 to 5.0 kHz) used in early studies,[6,7] was replaced by a more intuitive unit developed by Osstell, the implant stability quotient (ISQ).

The methods currently used most often to measure stability are IT (during surgery, for primary stability) and ISQ (during and after surgery to measure primary and secondary stability). Some studies have shown that ISQ provides information on axial stability, whereas IT measures rotational stability, concluding that the most clinically valuable information is obtained when the 2 measurements are used jointly.[8]

This study aimed to determine the effect of implant length and diameter and bone quality on implant stability measured as IT and ISQ. The null hypothesis for the factors in this study was that implant length, implant diameter, and bone type would not affect stability. The specific objectives of this research were to determine *1)* the effect of implant diameter and length and bone quality on IT and ISQ as parameters used to measure primary and secondary stability, *2)* the relation between IT values and primary and secondary ISQ, and *3)* the variation in ISQ in the transition from primary to secondary stability.

Patients and Methods

STUDY DESIGN AND SAMPLE

A clinical longitudinal study was designed and implemented to address the research objectives. The study population consisted of patients seeking treatment at the Prosthesis Department, School of Dentistry, Complutense University of Madrid (Madrid, Spain). All patients included in the survey qualified for dental implants for a single tooth or a bridge and underwent treatment from January through December 2014.

Only patients meeting the following criteria were included in the study: *1)* sufficient residual bone to accommodate an implant at least 3.75 mm wide and 10 mm long with no need for bone grafting and *2)* sites with wholly and spontaneously regenerated bone 6 months after extraction. The exclusion criteria were *1)* general contraindications for oral surgery and *2)* residual infection at implant sites.

All patients were duly informed about the aims of the study, and all provided their written consent to participate. Ethical clearance was obtained from the San Carlos Hospital (Madrid, Spain) ethics committee.

STUDY VARIABLES

The independent (predictor) variables for this study were implant length, implant diameter, and bone quality. The primary response (outcome) variables were IT and ISQ. ISQ was measured at implant placement (primary stability) and in the post-osseointegration period (secondary stability).

DATA COLLECTION METHODS

nHex implants (Mozo-Grau, Valladolid, Spain) were inserted at different sites in partially edentulous patients. The grade IV pure titanium self-tapping implants featured a 45° cylindrical shoulder with 3 mm of micro-threading at the neck, threading though the medial portion, and a conical tapered tip. Four sizes