Determination of Primary Stability: A Comparison of the Surgeon's Perception and Objective Measurements

Marco Degidi, MD, DDS[1]/Giuseppe Daprile, DMD[1]/Adriano Piattelli, MD, DDS[2]

Purpose: *To evaluate the difference between the dental surgeon's perception of implant stability and the actual insertion torque and actual values obtained through resonance frequency analysis (RFA) during implant insertion surgery.* ***Materials and Methods:*** *One hundred fifty-two patients who needed one or more dental implants were selected. A total of 514 Xive implants was inserted. For all 514 implants, after insertion, the oral surgeon was asked to indicate the probable RFA values (implant stability quotient [ISQ]). For 483 implants, the surgeon was also asked to indicate the probable insertion torque values (N/cm). The actual values were then measured. The RFA and insertion torque values were grouped into low, medium, and high groups.* ***Results:*** *The mean perceived RFA was 72.2 ± 9.8 ISQ. The mean actual RFA was 73.5 ± 10.2 ISQ. This difference was statistically significant ($P = .01$). The mean perceived insertion torque was 39.1 ± 20.1 Ncm. The mean actual insertion torque was 39.9 ± 20.7 Ncm. The mean difference between actual and perceived ISQ values was −1 ± 14.9, with a range from −60 to 59; the mean difference between actual and perceived insertion torque values was −1.3 ± 9.9, with a range from −38 to 45.* ***Conclusions:*** *Xive implants obtained good primary stability in many different clinical situations with a standard protocol. Primary stability is generally underestimated, especially in the presence of low or medium ISQ and torque values. The accuracy of primary stability prediction is not good enough to prevent mistakes when using an immediate loading technique; therefore, a more systematic use of objective measurements is encouraged.* INT J ORAL MAXILLOFAC IMPLANTS 2010;25:558–561

Key words: *dental implants, immediate loading, implant stability, insertion torque, resonance frequency analysis*

Primary stability was always considered a fundamental prerequisite to osseointegration. In the original Brånemark protocol, this objective was obtained chiefly through the engagement of the implant with the cortical bone.[1] More recently, implant geometry was changed to achieve the same result, even in sites with poor bone quality. Primary stability is even more important when clinicians wish to use immediate loading protocols; the reliability of this technique has been demonstrated by many studies, but the stiffness of the bone/implant/crown system must be ensured to provide a good result.[2]

Different methods to objectively evaluate primary stability have been proposed[3]; insertion torque and resonance frequency analysis (RFA) seem to be the most trusted. The determination of the first is done by a torque gauge incorporated within the drilling unit; on the other hand, RFA is measured by an electronic device and a transducer that is tightened to the implant by a screw. Before these devices were available, the surgeon was requested to evaluate the primary stability by percussion testing or by subjective perception during implant insertion; unfortunately, these are still the most widely used methods in daily practice.

The aim of the present study is to evaluate the difference between the dental surgeon's perception and the actual values of RFA and insertion torque in the determination of implant stability during implant insertion surgery.

MATERIALS AND METHODS

In the period between February and October 2007, 152 patients (70 men, 82 women; age ranging from 23 to 83) who needed one or more dental implants were selected. Informed written consent to use their data

[1]Private Practice, Bologna, Italy.
[2]Professor of Oral Pathology, Dental School, University of Chieti, Italy.

Correspondence to: Prof Adriano Piattelli, Via F. Sciucchi 63, 66100 Chieti, Italy. Fax: +39-0871-3554076. Email: apiattelli@unich.it

Table 1 Mean Values and Percentages for Perceived and Actual ISQ and IT, Divided Into Groups

	RFA		IT	
Group	Perceived	Actual	Perceived	Actual
Low	47.4 ± 5.1 (4.2%)	42.3 ± 5.2 (3.1%)	16.8 ± 4.8 (32.3%)	17.6 ± 6.3 (32.9%)
Medium	65.1 ± 5.1 (41.8%)	63.3 ± 5.4 (28.6%)	38.2 ± 7.5 (40%)	36.6 ± 7.1 (34.2%)
High	79.6 ± 3.7 (54%)	79.2 ± 4.5 (68.3%)	66.1 ± 6.1 (27.7%)	65.6 ± 6.6 (32.9%)

for research purposes, approved by the Ethics Committee of the University of Chieti, Italy, was obtained from patients. Exclusion criteria were as follows: a high degree of bruxism, smoking more than 20 cigarettes per day and excessive consumption of alcohol, localized radiation therapy of the oral cavity, antitumor chemotherapy, liver pathologies, hematic nephropathies, immunosuppressed status, current corticosteroid therapy, current pregnancy, inflammatory and autoimmune diseases of the oral cavity, and poor oral hygiene.

A total of 514 Xive implants (Dentsply Friadent) was inserted. The implants were distributed as follows: 81 in the anterior maxilla, 180 in the posterior maxilla, 44 in the anterior mandible, and 209 in the posterior mandible. As a consequence, during surgery all four different bone densities, as classified by Lekholm and Zarb,[4] were encountered. Implant length and diameter were chosen to obtain maximum primary stability; therefore, all available lengths (8, 9.5, 11, 13, 15, and 18 mm) and diameters (3.0, 3.4, 3.8, 4.5, and 5.5 mm) were used. All the implants were inserted by a single oral surgeon who had considerable experience in implant surgery and immediate loading techniques.

Antimicrobial prophylaxis was obtained with 500 mg of amoxicillin twice daily for 5 days starting 1 hour before surgery. Local anesthesia was induced by infiltration with articaine/epinephrine, and postsurgical analgesic treatment was performed using 100 mg of nimesulide twice daily for 3 days. Oral hygiene instructions were provided.

After a crestal incision was made, a mucoperiosteal flap was elevated. All implants were inserted according to a strict protocol that followed the manufacturer's instructions. Sutures were removed 14 days after surgery.

For all 514 implants, after they were inserted, the oral surgeon was asked to indicate the probable RFA values (implant stability quotients [ISQs]) according to his perception of primary stability. For 483 implants, the surgeon was also asked to indicate the probable insertion torque values (in Ncm). After that, the actual ISQs were collected by means of a transducer attached to the implant via a screw and a frequency response analyzer (Osstell Mentor, Integration Diagnostics). The actual maximum insertion torque values were recorded by an electronic instrument (Frios Unit E, W&H Dentalwerk) during low-speed insertion.

The RFA records were grouped as follows: low ISQ values (0 to 50), medium ISQ values (51 to 70), and high ISQ values (71 to 100). The insertion torque records were grouped as follows: low insertion torque (0 to 25 Ncm), medium insertion torque (26 to 50 Ncm), and high insertion torque (51 to 70 Ncm).

Following descriptive data analysis, the Kolmogorov-Smirnov test was used to test the distributive normality. Mann-Whitney and Kruskal-Wallis tests were used to compare mean values. Chi-squared and Pearson R tests were used to explore possible associations between the studied variables. A P value < .05 was considered significant.

RESULTS

The mean perceived RFA (pRFA) was 72.2 ± 9.8 ISQ, with a range from 26 to 90. The mean actual RFA (aRFA) was 73.5 ± 10.2 ISQ, with a range from 35 to 94. This difference was statistically significant (P = .01). The mean perceived insertion torque (pIT) was 39.1 ± 20.1 Ncm, with a range from 5 to 90. The mean actual insertion torque (aIT) was 39.9 ± 20.7 Ncm, with a range from 4 to 71. The difference was not statistically significant.

The mean values and frequency distribution for pRFA and aRFA and for pIT and aIT, divided into low, medium, and high groups, are presented in Table 1. The mean difference between aRFA and pRFA was –1 ± 14.9, with a range from –60 to 59; the mean difference between aIT and pIT was –1.3 ± 9.9, with a range from –38 to 45. The mean differences between pRFA and aRFA and between pIT and aIT, divided into low, medium, and high groups, are presented in Table 2.

Tables 3 and 4 show the correlations between pRFA and aRFA and between pIT and aIT. The Spearman correlation value is also reported. Tables 5 and 6 show the correlations between pIT and pRFA and between aIT and aRFA. The Spearman correlation value is also reported.

Table 2 Mean Differences Between Perceived and Actual ISQ and IT, Divided Into Groups

Group	aRFA/pRFA (range)	aIT/pIT (range)
Low	−6.1 ± 12.9 (−60 to 15)	−12.2 ± 11.9 (−38 to 4)
Medium	−1.4 ± 15.3 (−40 to 42)	−5.0 ± 9.9 (−29 to 34)
High	5.5 ± 14.3 (−18 to 59)	2.2 ± 8.0 (−15 to 45)

aISQ = actual ISQ; pISQ = perceived ISQ; aIT = actual IT; pIT = perceived IT.

Table 3 Correlation Between pISQ and aISQ

	Low aRFA	Medium aRFA	High aRFA
Low pISQ	4	13	4
Medium pISQ	8	92	115
High pISQ	3	39	236

aISQ = actual ISQ; pISQ = perceived ISQ. Spearman correlation = 0.394.

Table 4 Correlation Between pIT and aIT

	Low aIT	Medium aIT	High aIT
Low pIT	106	46	6
Medium pIT	45	98	51
High pIT	5	24	102

aIT = actual IT; pIT = perceived IT. Spearman correlation = 0.655.

Table 5 Correlation Between pIT and pISQ

	Low pRFA	Medium pRFA	High pRFA
Low pIT	19	100	40
Medium pIT	1	73	113
High pIT	2	27	108

pIT = perceived IT; pISQ = perceived ISQ. Spearman correlation = 0.441.

DISCUSSION

Immediate loading of implants can provide reliable results only if primary stability of the implants is achieved. The use of an immediate loading technique with implants that do not present good primary stability can result in micromovements and jeopardize osseointegration. Different methods have been proposed for the precise determination of primary stability. Currently, insertion torque and RFA seem to be the most indicative, but these techniques require dedicated electronic devices. Because of the cost of these devices and the time required to obtain the torque and ISQ values for each implant inserted, the use of percussion testing or surgical perception to determine primary stability is still common in dental practice. The use of these "perceptive" techniques is considered less accurate than an objective measurement of precise parameters. This study tried to determine whether an experienced clinician could precisely predict insertion torque and RFA values and, consequently, the primary stability of an implant during the insertion procedure by means of his own perception.

The actual values measured for insertion torque and RFA in this study showed that Xive implants generally obtained good primary stability in different clinical situations using a standard surgical protocol. Even in the presence of a wide range of bone quality and volume, Tables 3 and 4 show that the majority of the implants inserted presented with medium to high values of insertion torque, and nearly all obtained medium or high ISQ values.

The mean IT found in the present study is very similar to values reported by a series of studies conducted by Turkyilmaz et al[5–7]: the authors reported mean values between 39.4 Ncm and 41.5 Ncm in three different clinical trials of 142, 158, and 60 Brånemark System implants, respectively. In the same studies, the authors presented mean ISQ values consistent with those measured in the present study (RFA values between 70.5 and 74.1 ISQ). On the other hand, a study of 905 Brånemark dental implants[8] reported a mean RFA value of 67.4 ISQ. All these studies proposed a modified surgical protocol to achieve a higher primary stability.

Table 6 Correlation Between aIT and aISQ

	Low aRFA	Medium aRFA	High aRFA
Low aIT	10	66	85
Medium aIT	6	46	114
High aIT	1	29	126

aIT = actual IT; aISQ = actual ISQ. Spearman correlation = 0.247.

When the actual mean RFA and IT values were divided into three different groups (see Table 1), it became clear that ISQ values were generally high or medium, while low ISQ values were quite rare. On the other hand, the distribution of actual mean IT values was much more uniform between the three groups. These data seem to confirm that RFA and IT represent two different features of primary stability, with the first indicating the resistance to bending load and the latter indicating the resistance to shear forces.[9] This difference is also apparent when analyzing Table 6; the correlation between RFA and IT was very low, showing that the two variables are practically independent. Data presented by Turkyilmaz et al[6] are in contrast with the results of the present study; among 142 Brånemark implants, the authors reported a Spearman correlation of 0.583, which is very far from the 0.247 reported here. The reason for this difference appears unclear, but it could be explained by the different design of the implants studied, as well as the smaller sample.

Considering the mean perceived values, it is evident from the data that, in general, primary stability was underestimated, and, particularly for RFA, the difference between perceived and actual ISQ values was statistically significant. Nevertheless, the analysis of Table 2 shows that the underestimation of both ISQ and IT values was particularly evident when implant primary stability was low or medium, whereas there tended to be an overestimation when primary stability was actually high. From the same table it is clear that the range of error can be extremely variable (up to 60 ISQ or 38 Ncm).

To better understand the clinical importance of mistakes in perception of stability, Tables 3 and 4 show correlations between actual and perceived parameters. The Spearman correlation demonstrated a good surgical capability to predict IT, but, at the same time, poor accuracy in prediction of RFA values. This is probably a result of the surgeon's familiarity with the first parameter, which is more easily perceivable by means of handpiece and manual instruments during implant insertion.

In the same tables, it can be seen how frequently an implant with perceived high/medium ISQ or IT actually showed low ISQ or IT, and vice versa. The data show that it is quite common to perceive high primary stability for implants with actual low/medium stability, especially considering RFA values. If 65 ISQ were used as the RFA threshold for immediate loading,[9] the accuracy of prediction would not have been good enough to prevent mistakes.

Table 5 shows the correlation between perceived RFA value and perceived IT. Spearman correlation demonstrated that the two variables considered were practically independent. This suggests that, even when primary stability was predicted as a single phenomenon, clinicians tend to differentiate between the two components represented by RFA and IT values.

Unfortunately, no other data are available to compare the results of the present study; therefore, further studies could be useful to fully understand the importance of objective measurements of primary stability. Nevertheless, the present study suggests that, even in the presence of good clinical experience, the surgeon's capability to predict primary stability is not always sufficient, especially with low values of IT and RFA; therefore, a more systematic use of objective measurements must be encouraged, in particular when following an immediate loading protocol. The additional costs and time required for these measurements have to be considered, but an objective determination of primary stability would be a clear improvement over daily clinical practice.

CONCLUSIONS

Within the limitations of the present study, the results show that Xive implants can obtain good primary stability in many different clinical situations with a standard protocol. Primary stability is generally underestimated, especially in the presence of low to medium implant stability quotients and insertion torque. The accuracy of primary stability prediction is not good enough to prevent mistakes when using an immediate loading technique; therefore, a more systematic use of objective measurements is encouraged.

REFERENCES

1. Adell R, Lekholm U, Brånemark P-I. Surgical procedures. In: Brånemark P-I, Zarb GA, Albrektsson T. Tissue-Integrated Prostheses: Osseointegration in Clinical Dentistry. Chicago: Quintessence, 1985:211–232.
2. Östman PO. Immediate/early loading of dental implants: Clinical documentation and presentation of a treatment concept. Periodontol 2000 2008;47:90–112.
3. Atsumi M, Park SH, Wang HL. Methods used to assess implant stability: Current status. Int J Oral Maxillofac Implants 2007;22: 743–754.
4. Lekholm U, Zarb GA. Patient selection and preparation. In: Brånemark P-I, Zarb GA, Albrektsson T. Tissue-Integrated Prostheses: Osseointegration in Clinical Dentistry. Chicago: Quintessence, 1985:199–209.
5. Turkyilmaz I, Tumer C, Ozbek EN, Tözüm TF. Relations between the bone density values from computerized tomography and implant stability parameters: A clinical study of 230 regular platform implants. J Clin Periodontol 2007;34:716–722.
6. Turkyilmaz I, Tözüm TF, Tumer C, Ozbek EN. Assessment of correlation between computerized tomography values of the bone, and maximum torque and resonance frequency values at dental implant placement. J Oral Rehabil 2006;33:881–888.
7. Turkyilmaz I. A comparison between insertion torque and resonance frequency in the assessment of torque capacity and primary stability of Brånemark system implants. J Oral Rehabil 2006;33:754–759.
8. Östman PO, Hellman M, Wendelhag I, Sennerby L. Resonace frequency analysis measurements of implants at placement surgery. Int J Prosthodont 2006;19:77–83.
9. Sennerby L, Meredith N. Implant stability measurements using resonance frequency analysis: Biological and biomechanical aspects and clinical implications. Periodontol 2000 2008;47: 51–66.