Resonance frequency analysis of dental implant stability during the healing period

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Abstract

Purpose: The objective of the present study was to measure the implant stability quotient (ISQ) values during the osseointegration period, and determine the factors that affect implant stability. Materials and Methods: To measure implant stability, resonance frequency analysis (RFA) was performed in 24 patients (12 women, 12 men) with a total 64 Defcon® implants (10 anterior maxilla, 12 posterior maxilla, 18 anterior mandible, 24 posterior mandible). Bone type was classified according to the Lekholm and Zarb index (52 type II bone, 12 type III). RFA was used for direct measurement of implant stability on the day of implant placement and consecutively once a week for 8 weeks and at week 10. Results: The mean ISQ of all measured implants was 62.6. The lowest mean stability measurement was at 4 weeks for all bone types (60.9). Gender was found to be significant ($p<0.05$); women showed higher implant stability than men. In relation to location within the dental arch, statistical analysis showed higher ISQ values for anterior implants than posterior fixtures ($p<0.05$).

Key words: *Resonance frequency analysis, dental implant, implant stability quotient (ISQ).*

Introduction

Dental implant stability is a prerequisite for osseointegration. There are different ways of measuring implant stability, such as the Periotest® (Gulden, Bensheim, Germany) or the Dental Fine Tester® (Kyocera, Kyoto, Japan), however they have been criticized for their lack of resolution, poor sensitivity and their susceptibility to being influenced by the operator (1). Resonance frequency analysis (RFA) offers a clinical, noninvasive measure of stability and presumed osseointegration of implants (2,3), being a useful tool to establish implant loading time (4). The RFA values are represented by a quantitative unit called the Implant Stability Quotient (ISQ) on a scale from 1 to 100, and are measured with the Osstell® (Integration Diagnostics AB, Gothenburg, Sweden); an increased ISQ value indicates increased stability (2).

Clinically, RFA values have been correlated with changes in implant stability during osseous healing, failure of implants to integrate and the supracrestal dimensions of the implant (1,5).

The objective of the present study was to measure the primary stability of dental implants during the healing period and determine the factors that affect the Implant Stability Quotient (ISQ).

Material and Methods

Thirty healthy subjects who had received one or more Defcon® implants at the Department of Oral Surgery, participated in this clinical prospective study. The inclusion criteria were as follows: healthy patients who agreed to take part in the study of implant stability by resonance frequency analysis for a period of ten weeks. Patients who

did not attend the follow up examinations or implants without primary stability were excluded.

All implants were placed using a conventional, mechanized, non-submerged technique, and abundant irrigation with saline solution. Surgical information was collected: age, sex, implant location, implant length and width, bone quality (at the time of surgery) following the anatomic criteria proposed by Lekholm and Zarb (1985), and insertion torque (obtained by the Osseocare® physiodispenser).

Implant stability was measured in duplicate for each patient and the RFA was taken at weeks 0 (day of the surgery), 1, 2, 3, 4, 5, 6, 7, 8 and 10 by the same clinician or under his supervision. The value was measured by Osstell® equipment (Integration Diagnostics AB, Gothenburg, Sweden). The transducer was directly connected perpendicular to the implant as recommended by the manufacturer. The investigation protocol of Barewal et al. (3) and Bischof et al. (6) was followed.

Statistical analyses were performed with a mixed effects model using S-Plus 6.0 Professional for Windows. The pertinent mathematical hypotheses were verified in all analyses – statistical significance being considered for $p \leq 0.05$.

Results

Twenty-four patients were included, 12 females and 12 males, with a mean age of 46.9 years (range 21 to 68); 6 patients were excluded for lack of follow-up. A total of 64 Defcon® Avantblast® TSA surface implants (Impladent, Sentmenat, Barcelona, Spain), 22 maxilla and 42 mandible, were placed. Ten implants were located in the anterior maxilla, twelve in the posterior maxilla, eighteen in the anterior mandible and twenty-four in the posterior mandible. The implant used ranged from 8.5 to 14.5 mm in length with diameters of 3.6 and 4.2 mm. With respect to bone type, 52 implants were placed in type II and 12 in type III bone. The insertion torque was equal to or greater than 45 Ncm in 50 implants and lower in 14 implants.

The mean ISQ of the implants, on the day of surgery, was 62.6 (range 60.9 to 63.4). Statistical analyses revealed that the lowest mean stability measurement was at 4 weeks for bone types II and III. Subsequently, stability increased up to the 10th week (Figure 1).

With regard to gender, statistically significant differences were found ($F=2.02$, $p<0.05$), values being always lower in men than in women (Figure 2).

The ISQ of the mandibular and maxillary implants showed no statistically significant differences, although lower ISQ values were always found in the maxilla. Implant arch location significantly affected implant stability, being higher in the anterior than the posterior area ($F=2.71$, $p<0.05$) (Figure 3).

No statistically significant relationship was found between the resonance frequency analysis and the variables of diameter, length, and insertion torque. Some lower ISQ values were obtained for type III bone, although with no statistically significant relationship (Table 1).

Discussion

Bischof et al. (6) found an average ISQ value of 60.3 following surgery, Boronat et al. (7) of 60.1 and in the present study a value of 62.6 was obtained. In this study, the lowest average value was found at the fourth week, however, for Barewal et al. (3), and Ersanli et al. (8), the third week was the most critical. The stability reduction corresponds with the bone remodeling stage, for Brånemark et al. (9) this stage varies between the second and the fourth week. Martínez et al. (10), found 11 failures during the healing period, having placed 290 implants in 56 patients (success rate before implants loading of 96.21%).

In agreement with Brochu et al. (11), a higher stability quotient was found in females than in males (there was a significant relationship between sex and Osstell value). However, for Zix et al. (12), men showed higher implant stability than women; which these authors attributed to the older age and postmenopause of the patients (worse bone density), these findings not being transferable to women in general. Ostman et al. (13) in a long-term study, established that the differences found between RFA, with respect to sex, were not clinically relevant as there were no differences in the failure rates between men and women.

The quantity and location of cortical and trabecular bone surrounding the implant are an important factor in stability as they contribute to bone-implant contact (3); Nedir et al. (14), observed that the majority of implants in the maxilla had an ISQ of < 60 and those in the mandible of > 60. Corresponding with the results obtained in our study, Barewal et al. (3) and Bischof et al. (6) also found higher values in the mandible, being statistically significant in the latter (6). Likewise, Peñarrocha et al. (15) reported more failures in the maxilla, placing 642 Defcon® implants with early loading; 12 fixtures failed, of which 10 were placed in the upper maxilla.

The bone quality and implant stability is lower in the posterior area; for this reason the posterior implant success rate is less than the anterior (16). In the anterior area, the thick cortical and the dense trabecular bone will increase primary stability; in this study, ISQ was higher in this area than the posterior region.

Some authors (13,17,18), suggest that using longer and wider implants increases primary stability due to the increased bone-implant contact surface area. In the present study, in that of Balleri et al. (19) and that of Zix et al. (12), the RFA does not confirm this clinical supposition, since no statistically significant differences were found with regard to length or diameter in relation to the ISQ.

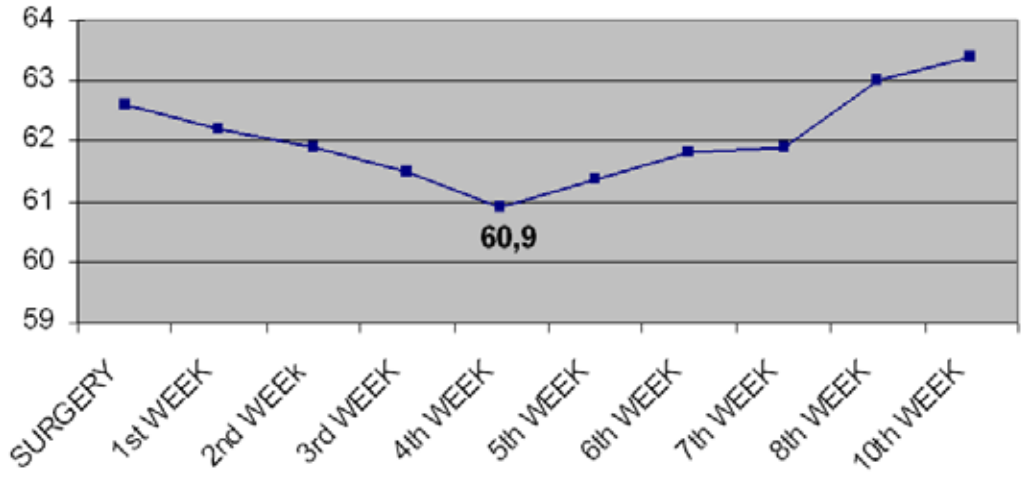

Fig. 1. ISQ values throughout the study. Note fourth week.

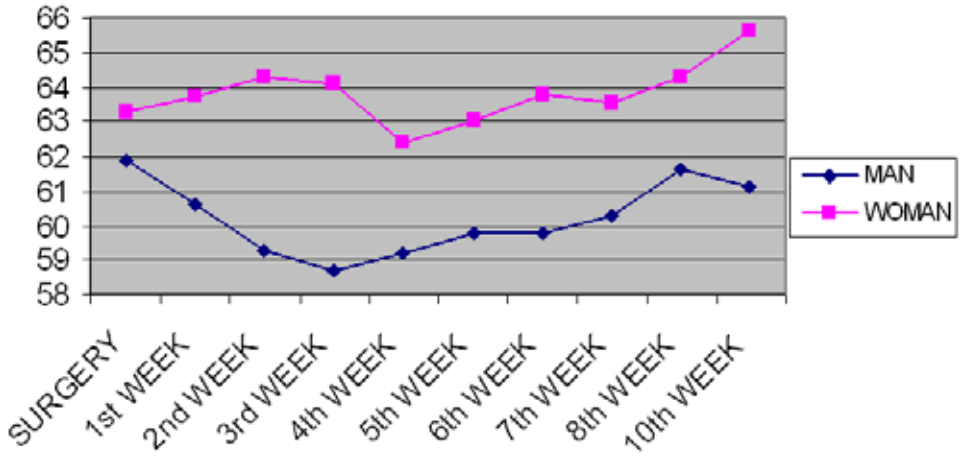

Fig. 2. Relationship between ISQ and gender.

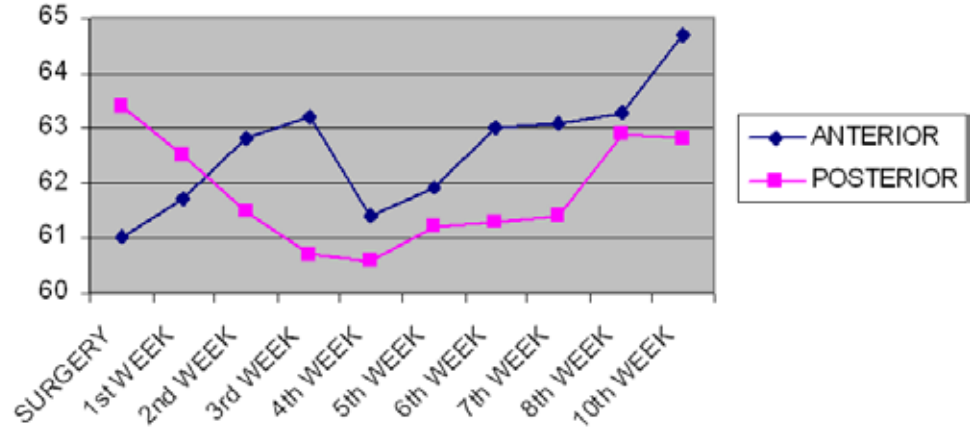

Fig. 3. ISQ and dental arch.

Table 1. Statistical data for ISQ values for different variables.

	Valor ISQ		
	Statistic used	**Valor P**	
Age	r_{xy} = *0,027*	*p=0,10*	*p> 0,05*
Sex	F=2,02	**p=0,03**	**p≤ 0,05**
Maxilla/Mandible	F= 1,698	*p=0,90*	*p> 0,05*
Anterior/Posterior	F= 2,71	**p=0,05**	**p≤ 0,05**
Diameter	F= 0,862	*p=0,56*	*p> 0,05*
Length	F= 1,219	*p=0,21*	*p> 0,05*
Torque	F= 0,662	*p=0,84*	*p> 0,05*
Bone type	F= 16,819	*p=0,78*	*p> 0,05*

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