Resonance Frequency Analysis of Dental Implant Stability During the Healing Period (A Clinical Study)

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Aim: The aim of this clinical study was to measure the implant stability quotient using a method called resonance frequency analysis of dental implants during the healing period.
Material and methods: A number of 27 patients received 50 internal hexagon implants (Biohorizons) either in the maxillary or in the mandibular arch. Implant stability was measured with an Osstell Mentor device (Osstel, AB, Sweden) using the resonance frequency analysis at the time of implant placement, 15, 30, 60 and 90 days post insertion.
Results: The mean implant stability quotient for all implants placed was 67.06. The lowest value of the implant stability quotient was at 30 days post insertion measuring 62.
Conclusions: In relation to the gender the implants placed in female patients showed a higher mean value of the implant stability quotient. In relation to the location within the dental arch the implants placed in the anterior areas had a higher implant stability quotient than the ones places in the posterior areas of the arch.

Keywords: dental implants, resonance frequency analysis, implant stability quotient

Introduction

Titanium implants are now increasingly used to provide support for the prosthesis replacing missing teeth in complete or partially dentate patients. Implant stability plays a critical in the long term success of dental implants. Without it long term success cannot be achieved. There are different methods used to measure the implant stability such as the Percusion test, the Periotest (Gulden, Bensheim, Germany) the Dynamic Model Analysis, the Reverse Torque technique. Meredith et al in 1996 [1] designed a new technique whereby the bone formation around the implant and the rigidity of the interface between the bone and the implant could be monitored using resonance frequency analysis – RFA. Resonance frequency analysis offers the clinician a noninvasive method to asses the implant stability during healing and even after loading the implants [2,3].

The result of the measurement is presented as a parameter called implant stability quotient – ISQ – and is measured with the OssTell Mentor (OssTell AB Sweden) The ISQ unit is based on the underlying resonance frequency and ranges from 1 (lowest stability) to 100 (highest stability).

Transducers are available for different implant systems and abutments making the RFA measurements comparable, irrespective of the type of the implant used [4]. Clinically the values of the ISQ change during the osseointegration period and are affected by a series of factors such as location of the implants, gender, supracrestal dimension of the implants, and by the implants characteristics [1,4].

The objective of this clinical study was to measure the ISQ value of the implants during the osseointegration period and to determine the factors that influence the IQS and therefore the stability if the dental implants.

Material and methods

Twenty seven patients that received one ore more internal hex implants (Biohorizons) participated in this prospective study. A total number of 50 implants were placed in both maxillary and in the mandibular arch. The implants used, had a diameter ranging between 3.8 and 4.6 mm and a length varying from 9–12 mm. The insertion torque was equal or greater than 35 Ncm for all the implants.

The inclusion criteria were as follows: healthy patients (ASA Clasification II – one systemic condition but controlled), male or females age 30–50, nonsmokers. Implants that are placed in immediate extraction sites, or implants that required additional procedures such guided bone regeneration were not included in the study.

All implants were placed according to the manufacturer recommendations in a non submerged technique .A healing abutment was placed at the time of surgery to facilitate the reading of the implant stability during the healing period. Surgical information was recorded at the time of the surgery such as age, gender, implant characteristics and bone quality. Implant stability quotient – ISQ – was measured using the OssTell Mentor device (OssTell AB Sweden) at 0, 15, 30, 60 and 90 days post surgery. The transducer was connected to the implant according to the manufacturer instructions. Statistical analyses were performed.

Results

The primary or raw data was collected from a sample of 27 patients, 13 woman and 14 men. The number of 50 implants was divided in 25 anterior and 25 posterior. The sample is a random stratified one and it was obtained by separating the population into mutually exclusive sets of data, and then drawing simple random samples from each stratum.

Table I. The calculated mean values of ISQ measurements

Days after surgery	Total	ISQ MEAN			
		Gender		Dental arch	
		Woman	Men	Posterior	Anterior
0	71.68	73.10	70.26	74.80	68.56
15	65.36	73.80	56.92	58.00	72.72
30	62.00	65.50	58.50	59.70	64.30
60	69.20	72.60	65.80	65.30	73.10
90	72.95	76.30	69.60	71.10	74.80

Utilizing a stratified sampling method leads to more efficient statistical estimates, providing that strata are selected based upon relevance to the criteria in question.

A sample size calculator, accessible on line, has been used to establish how many ISQ values are needed in order to get results that reflect the target population. The size of the sample has been determined considering a confidence level of 95%, a confidence interval of 19.5, and a population of 2000.

Based on the sampling frame and the sample dimension, 50 values of the ISQ measurements were recorded in table for each case.

The arithmetic mean was used to describe the centre of the data, for this study. The raw data was summarized and reorganized using the following formula:

Sample mean: $$\bar{\chi} = \frac{1}{N}\sum_{i=1}^{N} X_i$$

Where: N = 50 represents the number of implants; Xi = ISQ values (Table I).

The three scattered diagrams build to show the ISQ values throughout the study undivided and divided by gender and dental arch were made using Microsoft Office Excel 2007.

In these diagrams the ISQ mean values are the dependent variables, which depend to some degree on the other variable, also called the independent variable, in this case "Number of days after surgery".

The mean ISQ of all the implants was 71.68 on the day of the surgery. The lowest ISQ value of the implants was at 30 days after the surgery in both bone types with a mean value of 62. After that the implant stability increased up to 90 days post surgery, reaching a value of 72.95 (Figure 1).

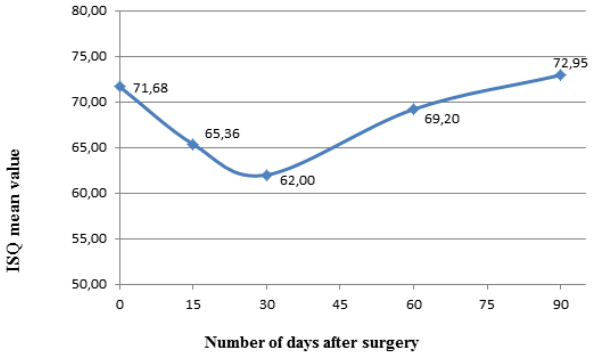

Fig. 1. Relationship between ISQ and time during study

The ISQ value of the implants placed in female patients were higher than the ISQ values of the ones placed in male patients (Figure 2).

With respect to the location of the implants the IQS was lower in the maxillary arch than in the mandibular arch, it was also higher in the anterior areas of the arch than in the posterior areas, which corresponds with different bone types found in the different locations of the maxillary and mandibular arch (Figure 3).

No statistically significant relationship was found between the diameter, length and the insertion torque and the resonance frequency analysis.

Discussions

During the process of the osseointegration of the implants the value of the ISQ varies with time. At the surgical phase the average ISQ for all the implants was 71.68, indicating a high primary stability, higher than the results obtained by different clinicians using different type of implants Bishoff at all [5] found an average of 60.3, Boronat Lopez et al 62.6 [6]. In our study the value of the ISQ decreased to 62 at 30 days post insertion. However all the clinicians cited above found a decrease in the ISQ during week 3 and four of healing. After that there was a steady increase in the ISQ value up to 90 days post insertion when it reached a mean ISQ value of 69.2. It may be speculated that the decrease of the ISQ values may be due to the loss of mechanical stability identified during the early phase of healing and bone remodeling [7,8].

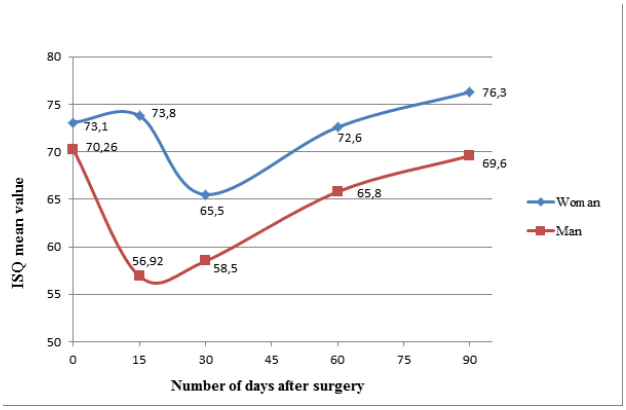

Fig 2. Relationship between ISQ and gender

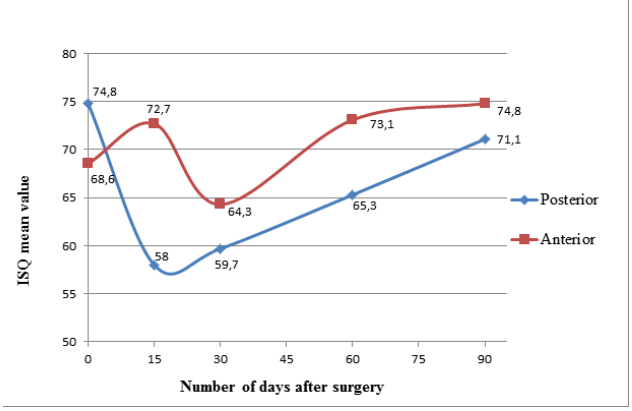

Fig. 3. Relationship between ISQ and dental arch position

A significant relationship was found between the bone type and the ISQ [9,10,11,12,13]. The more compact the bone type the greater the ISQ values and the insertion force. Regarding the location of the implant, the ISQ values were greater in the mandible than in the maxilla. The mean value of the ISQ for the mandible being > 60, while in the maxilla < 60. Furthermore the implants placed the anterior part of the mouth either in the maxilla or in the mandible showed higher values than those placed in the posterior areas of the mouth. In the anterior part of the mouth the bone has a thick cortical plate and a dense trabecular bone compared to the posterior areas of the mouth and therefore the primary stability is higher in these regions of the mouth.

With respect to the gender of the patients our clinical study showed a higher ISQ value for the female patients compared to the male patients. These results were also confirmed by different other clinicians [14,15,16].

All cited above also found a statistically significant difference of the ISQ value of implants placed in male and in female patients , the values always being lower in men than in women. However for Zix et al [17] men showed a higher implant stability than women; which these authors attributed to older age and postmenopause of the patients (worse bone density), these findings not being transferable to the women in general.

As the length and the diameter of the implant increases, the total total bone implant interface increases and that results ina higher primary stability of the dental implants [14,18]. However, Ballery et al (2004) [9], in a pilot study reported a short implant could as stable as a long one – the length of the implant does not affect the primary stability of the implants. Horovitz et al (2003) [19] and Linish et al (2004) [10] in two different clinical studies, using implants between 10 and 12 mm in lenghts, reported no correlation between the length of the implant and the RFA values while Balleri et al (2002) [9] recorded greater RFA values with short implants, upon measuring after one year of loading. The present study similar to the studies of Balleri et al, Zix et al and Lopez et al [9,17,16] demonstrated that there was no statistically significant differences in regard top the length and the diameter of the implants in relation to the ISQ.

Conclusions

The resonance frequency analysis technique can supply the clinician with relevant information about the state of the bone-implant interface at any stage during the treatment and at the follow-up examinations. It evaluates the implant stability as a function of the stiffness of the bone-implant interface and is influenced by factors such as bone density, jaw healing and the exposed implant height above the alveolar crest. Studies indicate that implants with a high ISQ value are successfully integrated while implants with a low and declining ISQ value may be a sign of ongoing implant failure and/or a marginal bone loss.

The data obtained from this study showed that the implant stability varies from the time of the surgery up to 90 days post insertion. The lowest value of all the implant placed was at 30 days post surgery. The mean ISQ value was higher in female than in male patients. With respect to the location of the implants the ISQ value was higher in the mandibular arch than in the maxilla. Furthermore the ISQ was higher in the anterior areas of the mouth than in the posterior areas. However, more clinical studies and reports are needed to formulate clear guidelines for clinical use of the resonance frequency analysis technique.

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