Assessment of the Correlation Between Insertion Torque and Resonance Frequency Analysis of Implants Placed in Bone Tissue of Different Densities

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The primary stability of dental implants is fundamental for osseointegration. Therefore, this study aimed to assess the correlation between insertion torque (IT) and resonance frequency analysis (RFA) of implants placed in mandibles and maxillas of different bone densities. Eighty dental implants were placed in maxillas and mandibles, and IT and the implant stability quotient (ISQ) were measured at the time of implant insertion. Bone density was assessed subjectively by the Lekholm and Zarb index. The type I and II densities were grouped together (group A)as were the type III and IV densities (group B). The IT in group A was higher (Student *t* test, $P = .0013$) than in group B (46.27 $\pm$ 18.51 Ncm, 33.62 $\pm$ 14.74 Ncm, respectively). The implants placed in group A showed higher ISQ (Student *t* test, $P = .0004$) than those placed in group B (70.09 $\pm$ 7.50, 63.66 $\pm$ 8.00, respectively). A significant correlation between IT and the ISQ value was observed for group A (Pearson correlation test; $r = 0.35$; $P = .0213$) and for group B ($r = 0.37$; $P = .0224$). Within the limitations of this study, it was possible to conclude that there is a correlation between IT and RFA of implants placed in mandibles and maxillas of different bone densities.

Key Words: insertion torque, dental implant, bone density, RFA

INTRODUCTION

Primary stability achieved at the time of implant insertion is considered a relevant factor for the success of the case, and it is a basic prerequisite for osseointegration. Studies have shown that factors such as bone density, length, width, type of implant, and surgical technique may interfere in primary implant stability.[1] On the other hand, secondary stability depends on the ossification obtained around the body of the implant.[2]

The clinical measurement that assesses primary implant stability is insertion torque (IT). High IT indicates that the implant is well fixed and mechanically stable within the bone tissue.[3] Although IT is important for assessing primary implant stability, resonance frequency analysis (RFA), which was developed more recently, enables improved capacity to monitor primary and secondary implant stability; this makes it possible to measure stability at the time of insertion as well as at any stage of osseointegration and prosthetic rehabilitation.[4]

A previous study sought to identify the minimum IT and ISQ values for the immediate or early loading of implants. However, because of its small sample size and unequal distribution of patients

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DOI: 10.1563/AAID-JOI-D-11-00183

among groups, the study was not able to establish these values. Furthermore, the author suggested that there is a strong correlation between high IT values and implant survival, whereas the same precision may not be related to the ISQ values, as they are subject to oscillations resulting from micro-remodeling processes that occur at the interface between the bone and implant.[6]

Atsumi et al[7] conducted a review of the methods used to assess implant stability, and they concluded that there is no definite method for this purpose. Moreover, they reported that despite RFA being a promising technology, it was not possible to establish a critical value to determine success, failure, or long-term prognosis of an implant and that further research was needed in this field.[7]

Therefore, this study aimed to assess the correlation between IT and RFA of implants placed in mandibles and maxillas of different bone densities.

Materials and Methods

The study was submitted to the Research Ethics Committee at Paulista University, and it was approved under Protocol 092/10 CEP/ICS/UNIP. All of the patients were informed individually about the nature of the study and signed a "Term of Free and Informed Consent" form.

Twenty-seven patients (20 women and 7 men) who had sought treatment at Paulista University's Dental Clinic were included in the study. A total of 80 dental implants (Revolution, SIN – Sistema de Implantes, São Paulo, SP, Brazil) were placed, with 37 placed in mandibles and 43 placed in maxillas. The minimum bone height for implant placement was 7 mm, and implants were inserted into sites where the bone repair process took more than 2 months. The classical Branemark protocol was used to place the implants in all of the surgeries.

The assessment of bone density was adapted on the Lekholm and Zarb index.[8] This index consists of a density scale that ranges from I to IV, where I corresponds to the densest and IV to the least dense bone. In the present study, during initial perforation, a single operator assessed the bone density at the time of the implant insertion and classified the sites as belonging to group A or group B. Group A included the most dense bone sites, and group B included the least dense bone sites.

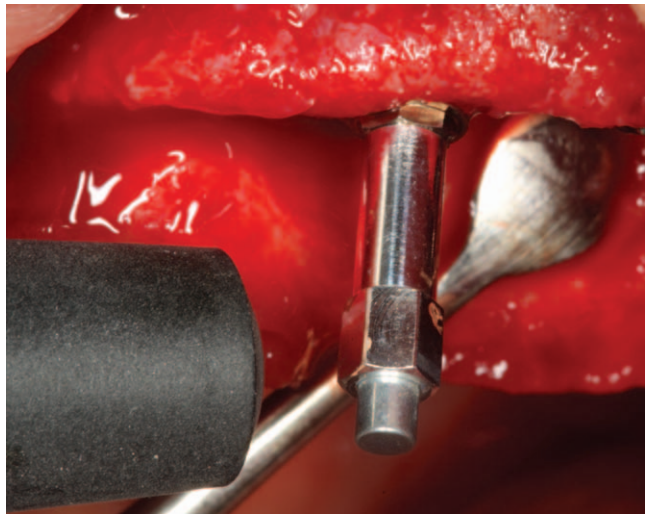

Figure. Osstell probe close to the SmartPeg.

During implant placement, IT was measured using a manual torque meter (Dérig, São Paulo, SP Brazil). Afterwards, ISQ was assessed by RFA, which was performed using an Osstell ISQ device (Osstell AB, Göteborg, Sweden) to capture an electromagnetic signal (SmartPeg, Integration Diagnostics AB, Gothenburg, Sweden) adapted to the implant with a torque of 4 to 5 Ncm. Soon afterwards, a probe emitting an electromagnetic signal was placed close to the SmartPeg (Figure) and 3 consecutive measurements were made to obtain the mean ISQ value for each inserted implant.

Statistical analysis

Initially, the Student *t* test was used to assess whether there was difference between the IT values when group A was compared with group B. The same analysis was adopted to assess the ISQ values. Afterwards, the Pearson correlation test was used to verify whether there was a correlation between IT and ISQ values. For all analyses, a level of significance of 5% was adopted.

Results

The results obtained showed that the mean (SD) IT for group A was 46.27 (18.51) Ncm, whereas for group B it was 33.62 (14.74) Ncm, and a statistically significant difference was found between the groups ($P = .0013$). A statistically significant difference ($P = .0004$) was also observed between groups A and B with regard to the ISQ (70.09 $\pm$ 7.50 and 63.66 $\pm$ 8.00, respectively) (Table).

Table

Mean (SD) of insertion torque (IT) and implant stability quotient (ISQ) according to bone density in the maxilla and mandible

	IT, Ncm	ISQ
Group A (n = 43) (maxilla = 34/mandible = 9)	46.27 (18.51)	70.09 (7.50)
Group B (n = 37) (maxilla = 33/mandible = 4)	33.62 (14.74)	63.66 (8.00)
Student *t* test (*P* value)	.0013	.0004

A statistically significant correlation was observed between IT and ISQ values for group A ($r = 0.35$; $P = .0213$), and this also occurred for group B ($r = 0.37$; $P = .0224$).

Discussion

This study showed a statistically significant correlation between IT and RFA for implants placed in mandibles and maxillas of different bone densities. Furthermore, the implants placed in denser bones (group A) showed higher IT and ISQ values.

Subjective assessments appear to have a limited value for differentiating the several types of bone density in accordance with the Lekholm and Zarb index, but these assessments allowed the extreme categories (ie, types I and IV) to be differentiated more clearly. By understanding this limitation, the present authors justified the combination of the type I and II densities into group A and type III and IV densities into group B in the present study so that there would be no conflict between close categories.

The results showed higher IT values for group A, which were statistically different when compared with the values of group B; this was in agreement with a study by Johansson et al,[9] which also presented a correlation between IT and bone density in accordance with the Lekholm and Zarb index. A series of studies have indicated that the failure rate of implants is higher in bones of type IV quality.[10–12] Furthermore, initial implant stability appears to mean a sufficient percentage of contact between the bone and implant, improving its prognosis.[13] Studies have demonstrated that the assessment of dental implant stability by means of RFA has been shown to be an efficient, noninvasive method with a high degree of reliability.[3–5] Miyamoto et al[14] found a significant correlation between ISQ and the bone cortical thickness, and Nkenke et al,[15] in a study in human cadavers, presented a correlation between the RFA values and the bone-implant contact surface. The present study showed a statistically significant correlation between IT and RFA, a condition also found in existing studies.[4,16,17]

At present, as dental implants have been more frequently used with immediate or early loading, it is clear that the biomechanical parameters may help the clinician to assess how the osseointegration process will occur. This is because implant micromovement may lead to a fibrous encapsulation instead of bone apposition; the risk increases in cases where there is less bone density.[18] The present study showed that although there are different ways of assessing dental implant stability, such as IT and RFA, these assessments are correlated and are also related to the preexistent bone density. Thus, it is up to the professional to choose the most convenient method for measuring the degree of initial dental implant stability.

Conclusion

Within the limitations of this study, it may be concluded that there is a statistically significant correlation between IT and RFA of implants placed in mandibles and maxillas of different bone densities.

Abbreviations

ISQ: instability quotient
IT: insertion torque
RFA: resonance frequency analysis

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