COMPARATIVE STUDY
— of implant placement torque and resonance frequency analysis on the implant and abutment

Introduction

The long-term clinical success of dental implants is dependent upon osseointegration, which is defined as a direct functional and structural connection between the bone and implant surface. Primary stability is, therefore, paramount. Several methods have been used to determine implant stability; however, resonance frequency analysis (RFA) is considered the most accurate. Despite RFA having been used since 1980 in orthopedics, it has only been used in implantology since the 1990s, when it was described by Meredith and has been widely used ever since.

When evaluating the stability of implants, quantitative methods such as RFA can yield valuable information that could contribute to long-term treatment success. RFA allows measurements of stability on a numerical scale ranging from 0 to 100, and such measurements can be obtained soon after implant placement or at any time during healing. According to Nedir et al., RFA may aid in the decision-making process regarding the best time for seating of the prosthesis on the implant during the healing period.

Currently, the demand for esthetic dentistry is increasing; therefore, immediate loading approaches, in which the prosthesis is seated on the implant in the same session, have been widely used. Nevertheless, load can only be applied if the implant presents sound primary stability. Further torque will be applied when seating the abutment on the implant, which may prevent future RFA measurements directly on the implant, since removal of torqued abutments may impair osseointegration during the healing period.

In order for an implant to be able to receive immediate loading, it is necessary for the final placement torque to be high. However, studies comparing RFA with measurements obtained directly from the implant and abutment combined are scarce. Therefore, the objectives of the present study were to analyze the resonance frequency of the implant and abutment set immediately after placement and to compare them with the final placement torque.

Patient selection

Nine patients, five males and four females, were evaluated in this study, with 17 implants being placed in different areas of both arches. The patients were attended to by undergraduate students of the São Leopoldo Mandic dental school (Campinas, Brazil) throughout 2014. The patients were assessed and those found not to have any systemic diseases that would affect the healing process of the implant were included. Patients with a systemic disease or insufficient bone quality were excluded.

Preoperative procedures

Each patient underwent computed tomography scans in order to survey the area where the implant would be placed, as well as to classify the type of bone, including height and width measurements in order to select the most suitable implant design for each situation. A full blood count and coagulation screen were performed for each patient.
Intraoperative procedures

The surgical procedures followed asepsis guidelines and were performed under local anesthetic. A #15c scalpel blade was used to make an incision along the bone crest and, subsequently, a full mucoperiosteal flap was raised. The surgical guide was inserted and bone drilling performed following the manufacturer’s recommendations.

After preparation of the surgical socket, a Neodent Morse taper connection implant was placed. It was initially placed using an electric motor and finalized with a manual torque wrench. The final placement torque was recorded for subsequent comparative analysis. Upon completion of implant placement, a specific transducer was fixed inside the implant (Fig. 1a) and, subsequently, the implant resonance frequency was measured (Fig. 1b) using the Osstell device. The implant was then torqued to a screwed abutment and, in turn, a specific transducer was set inside the abutment (Fig. 2a). At this point, the resonant frequency of the abutments was measured using the same equipment (Fig. 2b).

Statistical analysis

The resonance frequencies, both from the implant and the abutment, were taken from the buccal, mesial, distal and lingual aspects, and a mean value was obtained for each region. After the last measurement, an abutment protection cylinder or temporary restoration was placed and the flap sutured.
abutment using nonparametric tests. Data were analyzed comparatively using the Wilcoxon and Pearson correlation tests, at a significance level of 5%.

Results

The mean values and standard deviations for implant and abutment placement torques (in N cm) and RFA (in ISQ) were 53.5 ± 19.7, 67.6 ± 8.4 and 52.8 ± 2.8, respectively (Table 1; Figs. 3–5).

Statistical analysis did not find a linear pattern between the measurements of placement torque and ISQ, either on the implant (–0.24) or the abutment (–0.18). Regarding the comparison between ISQ for the implant and abutment, despite a significant numerical difference (p < 0.05), a linear pattern was observed (0.68).

Discussion

RFA is a reliable method for measuring the stability of dental implants and this finding has recently been reported by several authors.7, 9, 10, 12–15 It is commonly measured using an Osstell device immediately after implant placement or at any time during the healing process, as well as after loading of the implants.4 Park et al. demonstrated that two different directional measurements are needed for RFA, since this allows the detection of ISQ change patterns that would not be identified if only unidirectional measurement was used.16 This information influenced the decision-making process in the present study, since two RFA measurements were taken for each implant, one from the buccal and the other from the lingual aspect, and the average was then calculated.

In the present study, mean values and standard deviations for placement torque (in N cm) and RFA (in ISQ) on both the implant and abutment on the day of implant placement (53.5 ± 19.7, 67.6 ± 8.4 and 52.8 ± 2.8, respectively) were analyzed. No obvious linear pattern was observed. When the measurements of ISQ on the implant compared with placement torque were compared, the linear correlation coefficient was –0.24. This corroborates the findings of Schliephake et al.17 and Akça et al.,18 yet contradicts the results of Friberg et al.19 and Turkyilmaz et al.20 When comparing the ISQ values on the abutment with placement torque, no linear pattern was observed; the linear correlation coefficient was –0.18. Therefore, if RFA is accepted as the most suitable method for determining the best time for implant loading, it can be speculated that the placement torque measurement would be unnecessary. However, Esposito et al.,11 in a literature review, argued that if an immediate loading approach is considered among the treatment options, then the implant must be placed with a high torque, which usually exceeds 30 N cm21 or 40 N cm.22 Therefore, RFA and torque are two distinct methods for analyzing implant stability and both should be considered. The main difference between them is that ISQ can be measured months after implant placement, whereas torque can only be measured on the day of surgery, which makes the latter a weak method for

<table>
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<th>Measurement</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Median</th>
<th>Lower</th>
<th>Upper</th>
<th>N</th>
</tr>
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<tbody>
<tr>
<td>Torque (N cm)</td>
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<td>45</td>
<td>25</td>
<td>100</td>
<td>17</td>
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<tr>
<td>RFA on implant (ISQ)</td>
<td>67.6</td>
<td>8.4</td>
<td>68</td>
<td>47</td>
<td>78</td>
<td>17</td>
</tr>
<tr>
<td>RFA on abutment (ISQ)</td>
<td>52.8</td>
<td>2.8</td>
<td>52</td>
<td>47</td>
<td>57</td>
<td>17</td>
</tr>
</tbody>
</table>

Table 1

Main descriptive statistics of the groups for each studied measurement.
analyzing secondary or biological stability. ISQ is a reliable method for implant follow-up and the initial base value should be recorded in order for the clinician to have a reference for maintenance purposes. Implant failures are occasionally difficult to diagnose and the comparison against the initial ISQ value can be a useful approach to assessing risk of implant failure.

Analysis of the association between the ISQ values on the implant and on the abutment indicated a linear pattern in the data, as the linear correlation coefficient was $0.68$. However, a significant difference was observed in terms of the mean ISQ value measured on the implant and on the abutment ($p < 0.05$), with the highest values observed on the implant. Many studies have demonstrated that implants with a high initial ISQ value ($> 60$) are often successfully osseointegrated$^{22, 23}$ and tend to perform well clinically in the long term. Sennerby and Meredith state that low initial ISQ values that continue to decrease as healing progresses may be a sign of implant failure.$^{23}$ Glauser et al. report an implant failure rate of $11.2\%$. The implants with an initial ISQ value of higher than $69$ had a $100\%$ success rate, while those with an initial ISQ value of between $48$ and $59$ had an average failure rate of $19\%$, and $100\%$ of the implants with an initial ISQ value of lower than $39$ failed.

No studies were found that compared ISQ on the implant and the abutment at the same surgical intervention, which was the approach chosen in this study. The ISQ values for each implant and abutment were very far apart, despite the results showing a linear pattern between them. This finding complicates the use of RFA on implants where an abutment is torqued in the same session as the implant, since removal of the abutments torqued during the osseointegration period is not indicated. Therefore, when the ISQ value for an implant at the time of placement is less than $60$, an abutment should not be torqued during the same session,$^{9}$ since such a scenario contraindicates immediate loading. Measurements at the implant level are regarded as the most accurate approaches to defining the loading protocol for any particular prosthesis; however, measurements at the abutment level could be the safest way to follow up on dental implants, since premature abutment removal could result in implant failure. Because of the linear correlation identified between both measurements, abutment ISQ or implant ISQ values could be used equally.

Based on the results presented in this study, less accuracy was observed in the measurement of ISQ when the abutment was seated in the same surgical session, which is essential for immediate loading. Owing to the lack of studies using the same methodology, further investigation is needed in order to develop methods that are more accurate for evaluation of ISQ on abutments. In addition, studies comparing RFA on implants and abutments of different implant systems would be desirable. Therefore, it can be concluded in the present study that no association was found between the measurements of placement torque and RFA. Additionally, a statistically significant difference was identified between the implant and abutment ISQ measurements.

Editorial note: A list of references is available from the publisher.