Research Article

Reliability of the multipeg™ transducer in measuring dental implant stability by using a resonance frequency analysis device (Osstell®): An observational clinical study

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Abstract: Background: Measuring implant stability is an important issue in predicting treatment success. Dental implant stability is usually measured through resonance frequency analysis (RFA). Osstell® RFA devices can be used with transducers (Smartpeg™) that correspond to the implants used as well as with transducers designed for application with Penguin® RFA devices (Multipeg™). Aims: This study aims to assess the reliability of a MultiPeg™ transducer with an Osstell® device in measuring dental implant stability. Materials and Methods: Sixteen healthy participants who required dental implant treatment were enrolled in this study. Implant stability was measured by using an Osstell® device with two transducers, namely, Smartpeg™ and Multipeg™. Insertion torque was also measured and recorded as >50 and ≤50 N • cm. Unpaired t-test and Mann–Whitney U test were conducted to assess the relationships of the implant stability values obtained by the two transducers with insertion torque, whereas Pearson and Spearman's correlations were utilized to investigate correlations between the two transducers. Interclass correlation coefficients were applied to assess the reliability between the two transducers. Results: Implant stability measurements (primary and secondary) showed strong positive correlations between Smartpeg™ and Multipeg™. The reliability values between both transducers in primary and secondary implant stability measurements were 0.922 and 0.981, respectively. The use of both transducers revealed higher implant stability measurements for implants inserted with insertion torque > 50 N • cm than those inserted with insertion torque ≤ 50 N • cm. Conclusions: This study demonstrated that the Multipeg™ transducer is reliable in measuring the stability of dental implants using an Osstell® device.

Keywords: resonance frequency analysis, osstell, smartpeg, multipeg

Introduction

Implant stability can be described as a lack of clinical movement under a particular load and is regarded as an essential criterion for achieving and maintaining the osseointegration of dental implants [(1)]. The continuous objective and qualitative monitoring of dental implant stability is a useful approach for assessing the state of healing in peri-implant bone [(2)]. Implant stability is measured by using one of two methods: invasive/destructive procedures, which include histologic/histomorphometric analysis, and noninvasive/nondestructive procedures, such as resonance frequency analysis (RFA) (3). Invasive procedures are incompatible clinically (4). RFA aids in determining how deeply an implant has embedded into the bone and the rigidity of the bone–implant interface. It is a nondestructive analytical method that measures dental implant stability and bone density at different phases by using structural analysis and vibration (5). No other technique has been shown to be more accurate than RFA in assessing osseointegration (6).

The Osstell® apparatus (Integration Diagnostics, Gothenburg, Sweden) determines the RFA. This device utilizes transducers linked to implants; these transducers, called Smartpegs™ (Integration Diagnostics, Gothenburg, Sweden), record the shift of implant fixtures by printing lateral force on the transducer to evaluate implant–bone interface rigidity and deflection (7). Its method involves attaching transducers to implant fixtures and transmitting an undetectable current with a low voltage across pegs; electromagnetic pulses are used to stimulate the pegs to determine the pegs' resonance frequency. Then, the resonance frequency is measured and converted into the implant stability quotient (ISQ) on a scale of 1–100 ISQ units (8).

Penguin® (Integration Diagnostics Ltd., Goteborgsvagen, Sweden) is a new-generation RFA device created by the same company that is now available in the dentistry market. The Penguin® RFA device features a compact pen-like shape and a multiuse Titanium transducer (Multipeg™), facilitating its use (9). Titanium multipegs are sterilizable and therefore can be used multiple times for up to 20 times (10).

Some in vitro studies and only a few clinical studies have investigated the reliability of the Multipeg™ transducer in measuring implant stability with an Osstell® device. Therefore, this study aimed to assess the reliability of using the Multipeg™ transducer with the Osstell® device in measuring dental implant stability compared with that of Smartpeg™, which is the corresponding transducer of the Osstell® device. The authors hypothesized that using Multipeg™ to measure implant stability may be cost-effective because, unlike the single-use Smartpeg™, it is a multiuse transducer and is sterilizable up to 20 times.

Materials and methods

Study design

This study was designed and implemented as an observational study guided by the "Strengthening the Reporting of Observational Studies in Epidemiology" guidelines (11). It was conducted at the Department of Oral and Maxillofacial Surgery, College of Dentistry, University of Baghdad, from December 2021 to December 2022. It was performed in accordance with the principles of the Declaration of Helsinki (12) and was approved by the institutional research ethics committee (Project No. 412121). All patients understood the treatment protocol and possible complications and signed the informed consent sheet. The study involved patients who required dental implant therapy to rehabilitate partially edentulous areas by using the delayed implantation protocol.

Patient selection

The patients included in the study were healthy adults without any systemic diseases. They belonged to category one of the physical status classification of the American Society of Anesthesiologists and had the ability to comply with the treatment protocol.

Any patient with systemic diseases, a history of radiotherapy to the head and neck region; acute infection at the proposed implant site; or requiring complicated surgical procedures, such as bone grafts, was excluded from the study.

Radiographic assessment

All patients were asked for a preoperative cone beam computed tomogram (Kavo OP 3D PRO, Germany), which was necessary for the assessment of the buccolingual and apicoocclusal dimensions of the alveolar bone in the proposed implant site. Such an assessment allowed for the selection of the appropriate dental implant by using the OnDemand3D program (Cybermed Inc., Seoul, Korea).

Surgical procedure

The surgical procedure involved the reflection of the full-thickness mucoperiosteal flap under local anesthesia followed by osteotomy preparation by using a NucleOSS™ surgical kit (Izmir, Turkey). The preparation began with a pilot drill and was continued through sequential drilling at a speed of 800 rpm under copious normal saline irrigation.

Dental implants (NucleOSS™ T6, Izmir, Turkey) were inserted through the motorized method with the engine set at 50 rpm and 50 N·cm torque. When the insertion torque exceeded 50 N·cm, a hand ratchet was used to insert an implant into its final position approximately 0.5 mm below the alveolar bone crest.

Stability measurements

After implant insertion, primary stability was measured by using an Osstell® device. The single-use transducer Smartpeg™ (type 21) was attached to the implant fixture, and primary stability was measured by placing the probe tip of the Osstell® device 2 mm away from the Smartpeg™. Two readings were taken: the first along a buccolingual direction and the second along a mesiodistal direction. The mean value of the two readings by the Smartpeg™ transducer was registered as ISQ1-SP. The measurement was then repeated by using the multiuse Multipeg™ (type 66) in a similar manner, and the mean value was recorded as ISQ1-MP. A cover screw was placed after primary stability measurement, and the flap was closed by suturing.

After 3 months, secondary stability measurements were performed similarly, and the mean values of measurements for Smartpeg™ and Multipeg™ were recorded as ISQ2-SP and ISQ2-MP, respectively. Finally, the patients were referred to the prosthodontics department for the fabrication of the final prosthesis.

Statistical analysis

Statistical analysis was performed by using GraphPad Prism version 6 for Windows (GraphPad Software, La Jolla, CA, USA) and Statistical Package for Social Science version 21 (IBM™, New York, US). The Shapiro–Wilk normality test was used to assess the distribution of numerical variables. Descriptive statistics comprised the mean, standard deviation (SD), and median of numerical variables and the numbers and percentages of categorical variables. Unpaired t-test, Mann–Whitney U test, interclass correlation coefficient (ICC), and Pearson and Spearman correlations were used for inferential statistical analysis. The level of significance was related to probability value ≤ 0.05.

Results

The study included 16 consecutive patients, of whom 11 (68%) were females and 5 (32%) were males. The patients had an age range of 21–60 years and a mean (SD) age of 46.4 (10.8) years. The patients received 35 dental implants. The mean number of dental implants per patient was 2.2. Of these 35 dental implants, 7 (20%) were 8 mm in length and 28 (80%) were 10 mm in length. In terms of diameter, 10 (28.5%) implants were 3.5 mm in diameter and the remaining 25 (71.5%) implants were 4.1 mm in diameter.

The mean (SD) and median of the primary stability measurement obtained when using Smartpeg™ were 75.09 (4.17) and 74, respectively, and those when using Multipeg™ were 74.20 (3.12), and 75, respectively. The mean (SD) and median of the secondary stability measurement acquired with Smartpeg™ were 73.47 (6.98) and 75.5, respectively, and those with Multipeg™ were 72.67 (5.72) and 74.50, respectively.

Strong positive correlations were found between ISQ1-SP and ISQ1-MP as well as between ISQ2-SP and ISQ2-MP as illustrated in Table (1), Figure 1, and Figure 2. As illustrated in Table (2), the ICCs for the primary and secondary stability measurements using the two transducers exceeded 0.9, indicating excellent reliability.

Table 1: Correlations between Smartpeg™ and Multipeg™.

ISQ	Correlations (r, p-value)
ISQ1-SP vs. ISQ1-MP	0.91, <0.0001 * [S]
ISQ2-SP vs. ISQ2-MP	0.95, <0.0001 † [S]

ISQ1 = Primary stability, ISQ2 = Secondary stability, SP = Smartpeg™, MP = Multipeg™, * = Pearson correlation, † = Spearman correlation, S = Significant

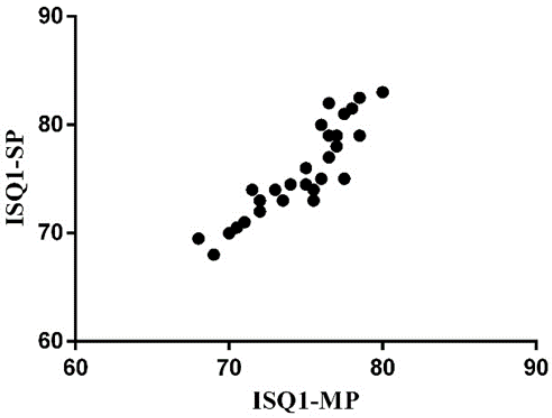

Figure 1: Correlation between the primary stabilities measured by the two transducers (ISQ: Implant stability quotient, SP: Smartpeg™, MP: Multipeg™).

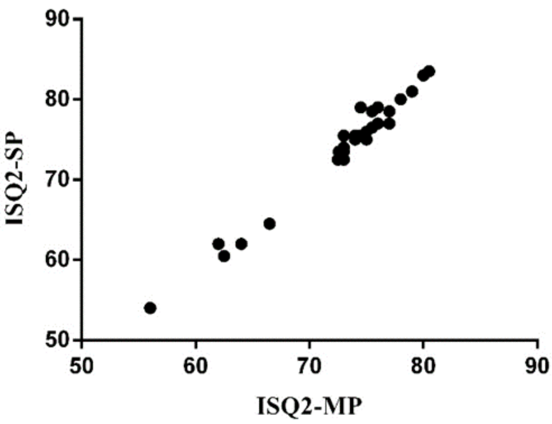

Figure 2: Correlation between the secondary stabilities measured by the two transducers (ISQ: Implant stability quotient, SP: Smartpeg™, MP: Multipeg™).

Table 2: ICCs of the stability measurements acquired with each transducer.

Stability measurements	ICC	95% Confidence Interval	
		Lower Bound	Upper Bound
ISQ1 SP–ISQ1 MP	0.922	0.818	0.963
ISQ2 SP–ISQ2 MP	0.981	0.951	0.991

ICC = Interclass correlation coefficient, ISQ1 = Primary stability, ISQ2 = Secondary stability, SP = Smartpeg™, MP = Multipeg™.

Nineteen dental implants (54.3%) were installed with insertion torque > 50 N·cm (17 in the mandible and 2 in the maxilla). The remaining 16 dental implants (45.7%) were installed with insertion torque ≤ 50 N·cm (6 in the mandible and 10 in the maxilla). Dental implants inserted with insertion torque > 50 N·cm showed higher primary and secondary stability measurements with Smartpeg™ and Multipeg™ than those inserted with insertion torque ≤ 50 N·cm as shown in Table (3).

Table 3: Relationship of Smartpeg™ and Multipeg™ with insertion torque

Insertion torque (N·cm)	**ISQ1-SP**			**ISQ1-MP**		
	Mean	SD	Median	Mean	SD	Median
≤50	72.91	3.60	72.00	72.38	2.91	71.75
>50	76.92	3.77	77.00	75.74	2.43	76.50
p-value	0.002 * [S}			0.0007 † [S]		
	ISQ2-SP			**ISQ2-MP**		
	Mean	SD	Median	Mean	SD	Median
≤50	70.16	7.87	74.25	69.94	6.38	72.80
>50	76.29	4.71	76.50	74.96	3.97	75.50
p-value	0.02 * [S]			0.01 * [S]		

ISQ1 = Primary stability, ISQ2 = Secondary stability, SP: Smartpeg™, MP: Multipeg™, * = Mann–Whitney U test, † = Unpaired t-test, S = Significant

Discussion

Implant stability can be evaluated by using several techniques, including histomorphometry; although this technique is the gold standard, it is extremely invasive because it destroys the bone–implant interface [9]. RFA is a reliable, nondestructive, and facile technique for assessing implant stability [10]. The present study focused on measuring implant stability by using an Osstell® device with two transducers, Smartpeg™ and Multipeg™, and comparing the reliability of Multipeg™ with that of Smartpeg™, which is the corresponding transducer of Osstell® devices.

ISQ value measurement by Osstell® devices offers an objective, dependable, reproducible, and noninvasive approach for evaluating implant stability; as a result, it is often used to monitor the development of osseointegration during the healing period [13]. However, Huwiler et al. concluded that the ISQ value used in monitoring implant stability over time should be questioned because RFA does not provide a predictive value for the stability loss of dental implants during the healing period [14]. The primary and secondary stability values recorded in this study by using Osstell® are considered high in accordance with the standards of the devices that consider ISQ value > 70 [15]. High primary implant stability is a prerequisite for the success of osseointegration by decreasing the chance of implant micromotion [16]. Secondary stability values increase over time during healing depending on primary implant stability, bone formation and remodeling, and implant surface characteristics [2].

The present study found a strong positive correlation between Smartpeg™ and Multipeg™ at two points of time (ISQ1 and ISQ2). This result is in agreement with the finding of Bural et al., who found a nonsignificant difference between Smartpeg™ and Multipeg™ during measurements with an Osstell® device and showed that although Multipeg™ is originally fabricated for Penguin® devices, it can be used with Osstell® devices for measuring implant stability [10]. Chávarri-Prado et al. measured implant stability by using Osstell® and Penguin® devices and observed a strong correlation between the stability measurements that Smartpeg™ and Multipeg™ acquired with the two devices and different accessories and concluded that no significant difference existed despite the small variations in the readings of Osstell® and Penguin® devices [17]. In addition, Herrero-Climent et al. suggested that Osstell® and Pinguin® devices can obtain reliable implant stability measurements and recommended using the specific transducer for each device [18]. The statistical analysis performed in the present study found high consistency and excellent reliability between Smartpeg™ and Multipeg™ transducers given that the ICC between ISQ1-SP and ISQ1-MP was 0.922 and that between ISQ2-SP and ISQ2-MP was 0.981, which coincided with the standard ICC values listed by Koo et al., who maintained that ICCs exceeding 0.9 indicate excellent reliability [19].

In this study, dental implants installed with insertion torque > 50 N·cm showed higher ISQ values with Smartpeg™ and Multipeg™ than those installed with insertion torque ≤ 50 N·cm. This result is in line with the observations of Zita et al., who observed a linear correlation between insertion torque and the implant stability measured by Osstell®/ISQ at insertion and during the healing phase [20], and of Chávarri-Prado et al., who found that the presence of cortical bone increases insertion torque, resulting in high stability measurements obtained using Osstell® with Smartpeg™ and Multipeg™ [17].

Conclusion

Although this study has some limitations that are mainly related to its limited sample size and observational nature, it demonstrated that the Multipeg™ transducer is reliable in the measurement of the stability of dental implants with an Osstell® device.

Conflict of interest

The authors have no conflicts of interest to declare.

Author contributions

All authors contributed to the study conception and design. Materials preparation and data collection and analysis were performed by AYD, SYB, and HK. The first draft of the manuscript was written by AYD, and all authors commented on the previous versions of the manuscript. All authors read and approved the final manuscript.

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Informed consent

Informed consent was obtained from all individuals included in this study or their guardians.

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العنوان: موثوقية محول الطاقة (Multipeg ™) في قياس استقرار زرعة الاسنان باستخدام جهاز تحليل تردد الرنين (Osstell®): دراسة سريرية ملاحظة.

الباحثون: الامين ياسين ضاحي , سلوان يوسف حنا, هايك خاشادوريان

المستخلص:

الخلفية: يعد قياس استقرار زرعة الاسنان مسألة مهمة في توقع نجاح العلاج. عادة ما يتم قياس ثبات زرعة الاسنان باستخدام مبدأ تحليل تردد الرنين (RFA). جهاز (Osstell®) الذي يعمل بمبدأ (RFA) يمكن استخدامه مع محول الطاقة الخاص به (Smartpeg™) الذي يستجيب لنوع الزرعة المستخدمة, كذلك يمكن استخدامه مع محول الطاقة (Multipeg™) الخاص بجهاز (Pinguin®) الذي يعمل ايضا بمبدأ (RFA).

الاهداف: هدفت هذه الدراسة لتقييم موثوقية محول الطاقة (Multipeg ™) مع جهاز (Osstell®) في قياس استقرار زرعة الاسنان.

المواد و طرق العمل: شملت الدراسة ستة عشر مشارك سليم من الامراض ممن يحتاج علاج زراعة الاسنان. استقرار الزرق تم قياسه باستخدام جهاز (Osstell®) مع محولين للطاقة (Smartpeg™, Multipeg™), تم قياس عزم ادخال الزرعة ايضا و تسجيله على انه اكبر من 50 او اصغر او يساوي 50 نيوتن.سم. تم استخدام اختبار t غير المرتبط و اختبار (Mann Whitney U) لتقييم العلاقات بين استقرار الزرعة الذي تم الحصول عليه بواسطة محولين الطاقة و عزم ادخال الزرعة, بينما تم استخدام علاقة بيرسون و علاقة سبيرمان لقياس العلاقة بين محولين الطاقة. تم استخدام معامل العلاقة بين الطبقات (ICC) لتقييم الموثوقية بين محولين الطاقة.

النتائج: اظهرت نتائج قياس استقرار زرعة الاسنان ارتباط ايجابي قوي بين محولين الطاقة (Smartpeg, Multipeg), و كانت الموثوقية بين كلا المحولين في قياسات استقرار الزرع الاولي و الثانوي 0.922 و 0.981 على التوالي. باستخدام كلا المحولين ، لوحظ ارتفاع قياسات ثبات الزرعة بالنسبة للزرعات التي تم إدخالها بعزم ادخال أكبر من 50 نيوتن.سم من تلك التي تم إدخالها بعزم دوران أصغر او يساوي 50 نيوتن.سم.

الاستنتاجات: أظهرت هذه الدراسة أن محول الطاقة (Multipeg ™) كان موثوقًا به في قياس ثبات غرسات الأسنان باستخدام جهاز (Osstell®).