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Research Article

An In-Vitro Assessment of the Reproducibility of Periotest Value and Implant Stability Quotient

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Abstract

Background: This in-vitro study investigated the reproducibility of Periotest values (PTVs) and Implant Stability Quotients (ISQs) among evaluators with different training and clinical experience.

Methods: Two endosseous implants (Implants I and II) were placed in each of 2 different densities of wood blocks (soft Balsa and hard Euro-Beech) to provide Standardized Test Specimens. The PTVs and ISQs of each implant were measured 9 times by each of 5 evaluators using the Periotest and Ostell. The repeated PTVs and ISQs were analyzed statistically by using a paired *t* test ($P = .05$), 1-way ANOVA ($P = .05$), and post hoc Tukey multiple comparison test ($\alpha = .05$).

Results: The means of PTVs were similar for Implants I and II in both Balsa and Euro-Beech ($P > .05$); while the ISQs were found to be significantly different ($P < .05$). The ANOVA and Tukey test ($\alpha = .05$) demonstrated a consistency in the means of PTVs among the evaluators. The differences in the means of ISQs were small among the evaluators and narrow in the distribution of repeated data for each evaluator.

Conclusion: The PTVs and ISQs both may indicate a clinically reliable assessment of implant stability. Although the ISQs were not consistent among the evaluators, the differences were small with a narrow distribution of repeated data.

Keywords: Implant stability, Periotest Value, Implant Stability Quotient

Introduction

Implant stability depends on both the geometry of implant and density of peri-implant bone [1,2]. It may also be an indicator of the long-term prognosis for the success of implant-supported prostheses. The commonly used clinical methods include sound/percussion, mobility, reverse-torque, and radiographic assessment to test the status of bone-implant interface [3]. However, these methods provide little more than highly subjective estimates of the status of integration and are of limited clinical value.

The Periotest (Medizintechnik Gluden, Modauta, Germany) was initially designed to assess the mobility of natural dentition. However, this device met with only limited acceptance because of the variations in measurement values at different evaluation periods [4]. It produced transient vibrations and was one of the first instruments to provide a reasonably quantifiable measure of the bone-implant complex [5-9].

The Ostell (Osstell AB, Gotenberg, Sweden), is a dynamic vibration resonance frequency analysis (RFA) testing device that uses wireless technology to assess implant stability. "Osstell Mentor" assesses the stability of bone-implant complex and provides measures as an Implant Stability Quotient (ISQs) [10-12]. It involves a "smart peg" that is screwed into the implant, which then subjected to magnetic pulsing creating a vibration within the smart peg that is detected by a "pick-up coil". The principle behind this approach is similar to that of the vibrations associated with a "tuning fork".

The Periotest values (PTVs) are more positive with implants placed in the maxilla than mandible, and are higher in the early stage of osseointegration than late stage [13-15]. The PTVs and ISQs may differ depending on the time of measurements in the treatment sequence. Furthermore, the PTVs and ISQs are not universal in indicating the quality of bone around implants because of the different mechanisms of measurement and clinical conditions. Thus, the reproducibility of PTVs and ISQs has yet to be investigated in a standardized manner [16-19].

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The purpose of this *in-vitro* study was to investigate the reproducibility of the PTVs and ISQs measured by different evaluators with various training and experience backgrounds, where the implants were placed in different densities of wood blocks to provide standardized test specimens. The repeatability of measures using different instruments and evaluators were therefore controlled and represented the primary focus of this study.

Materials and Methods

Five evaluators with different backgrounds of clinical training and experiences were selected to investigate the reproducibility of the PTVs and ISQs using the standardized test specimens. The evaluators were provided with the instructions supplied by the manufacturers of the each device for the test procedures to be followed using the Periotest and Osstell instruments.

Pre-study Standardization

For the Periotest, the ends of several aluminum cylinders were carefully machined to provide a 2 mm recessed area which was covered by thin metal disks of different thicknesses using different materials (Figure 1). When the disk was struck in the middle, it produced a reproducible PTV. The investigators completed testing until a reproducible/repeatable value was recorded. This value was adopted as the "standard" for that test specimen and was used for this study. For the Osstell resonance frequency analysis instrument, the calibration device included with the instrument was used to produce a reproducible ISQ (Figure 1). Each potential evaluator underwent a calibration test that required producing the same value for at least 2 out of 3 tests during a 3-test sequence, using each standardized instrument for the Periotest and Osstell. Once these conditions were met, each evaluator started the instrument reproducibility data collection phase of this study.

In-Vitro Instrument Reproducibility Study

The test specimens consisted of Implants I and II (Astra-Tech EV, 4.2 mm in diameter and 11 mm in length; Dentsply Implants, Waltham, MA) placed into each wood block of different densities (less dense Balsa and more dense Euro-Beech). The implant sites were drilled to simulate the osteotomy site as recommended by the manufacturer. To investigate the sensitivity of each test device, the implants were placed and secured by self-tapping in Balsa and Euro-Beech wood blocks.

The implants were placed to extend 2 mm above the wood block to allow contact with the test instruments. After having completed the training, the 5 each evaluator measured 9 times the implant stability by using each instrument of Periotest and Osstell against each implant placed in the each wood block of Balsa and Euro-Beech. Thus, the stability of each implant was measured 45 times by means of each test instrument of Periotest and Ostell.

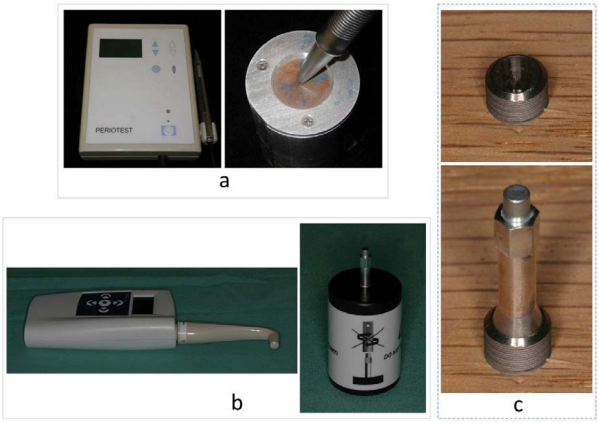

Figure 1: Standardization devices: **a.** Periotest devices: test specimen (right), **b.** Osstell devices: calibration device (right), **c.** Implants embedded in wood without "smart peg" (top) and with "smart peg" for Osstell (bottom).

Statistical Analyses

The paired *t* test was used to determine significant differences ($P < .05$) in the mean values of PTVs and ISQs between Implants I and II in each wood block of Balsa and Euro-Beech. A one-way analysis of variance (ANOVA; $P < .05$) and Tukey's multiple comparisons ($\alpha = .05$) post hoc analysis were also conducted, using a computer software (SPSS version 22.0, IBM), to reveal any significant differences among the mean values of PTVs and ISQs obtained by each evaluator.

Results

The means and standard deviations of PTVs and ISQs for Implants I and II in each wood block of Balsa and Euro-Beech are summarized in Tables 1 and 2. The means of PTVs were significantly higher in Balsa wood block than in Euro-Beech; and the means of ISQs the opposite (*t* test; $P < .05$).

The means of PTVs were similar between Implants I and II in each wood block of Balsa and Euro-Beech (*t* test; $P > .05$); while, the means of ISQs were significantly different (*t* test; $P < .05$). The means of ISQs for Implant I in both wood blocks had significantly higher values than Implant II ($P = .03$).

Evaluator	PTV		ISQ	
	Implant I	Implant II	Implant I*	Implant II
1	19.4 (0.5)^{a}	21.0 (0.0)^{a}	31.2 (0.8)^{a}	31.9 (0.3)^{a}
2	19.7 (0.7)^{a}	20.0 (1.5)^{a}	37.0 (0.5)^{b}	35.0 (0.0)^{b}
3	19.0 (0.7)^{a}	23.4 (0.7)^{a}	35.0 (0.0)^{d}	30.2 (0.4)^{c}
4	19.7 (0.7)^{a}	21.6 (0.5)^{a}	38.8 (0.4)^{c}	32.0 (0.0)^{a}
5	19.8 (0.7)^{a}	19.8 (0.7)^{a}	34.9 (0.3)^{d}	31.0 (1.0)^{d}
Mean	19.5 (0.7)	21.2 (1.6)	35.4 (2.6)*	32.0 (1.7)

*Implant I had significantly (*t* test; $P = .03$) higher ISQ value than Implant II.

For each implant, PTVs with same lowercase letters were not statistically different (ANOVA and post hoc Tukey test; $\alpha = .05$).

Table 1: The means (standard deviations) of PTVs and ISQs for implants placed in Balsa wood block.

	PTV		ISQ	
Evaluator	Implant I	Implant II	Implant I*	Implant II
1	-6.4 (0.5)^{a}	-6.7 (0.5)^{a}	72.3 (0.7)^{a}	70.3 (0.7)^{a}
2	-6.4 (0.5)^{a}	-6.7 (0.5)^{a}	69.9 (0.3)^{b}	64.7 (0.7)^{b}
3	-6.8 (0.4)^{a}	-5.9 (0.3)^{a}	70.3 (0.7)^{c}	68.9 (0.6)^{a}
4	-6.3 (0.9)^{a}	-6.4 (0.7)^{a}	69.9 (0.3)^{b}	63.9 (2.6)^{b}
5	-6.9 (0.3)^{a}	-6.3 (0.5)^{a}	73.2 (1.0)^{d}	73.1 (0.3)^{c}
Mean	-6.6 (0.6)	-6.4 (0.6)	71.1 (1.5)*	68.2 (3.7)

*Implant I had significantly (*t* test; $P = .03$) higher ISQ value than Implant II.

For each implant, PTVs with same lowercase letters were not statistically different (ANOVA and post hoc Tukey test; $\alpha = .05$).

Table 2: The means (standard deviations) of PTVs and ISQs for implants placed in Euro-Beech wood block.

The means of PTVs were similar among the 5 evaluators for Implants I and II in each wood block of Balsa and Euro-Beech (ANOVA; $P > .05$); whereas, the means of ISQs were significantly different among the evaluators (ANOVA; $P < .05$). The pairwise comparisons (post hoc Tukey test; $\alpha = .05$) among the mean scores of each evaluator are also summarized in Tables 1 and 2. While the actual difference was quite small in the mean scores obtained by each evaluator, and the distribution of data within each evaluator as indicated by small ranges of standard deviations was relatively narrow.

Discussion

Any instrument used to quantitatively assess the implant stability should be non-invasive and easy to use by clinicians [3]. According to Naert, et al. [6], the PTVs were not significantly influenced by splinting with fixed restorations. If this concept could be applied to dental implants, it may not be necessary clinically to remove the restorations and abutments to monitor the implant-bone complex over extended periods of time. Assuming the validity of this concept, avoiding the removal of the dental prosthesis and placing a "smart peg" to check the status of bone-implant complex may represent a distinct advantage of the Periotest over the Osstell for monitoring the health status of bone-implant complex.

The Periotest instrument appears to be highly reproducible and capable of detecting minor changes in the bone-implant complex within a specific range of rigidity. Clinically integrated implants were shown to demonstrate a range of -8 to +9 PTVs that approximates the Miller Mobility Index used for natural teeth [6]. Other studies have found a much narrower range of PTVs (-6 to +2) for integrated implants and recorded small changes in pooled PTVs for implants in each bone density over time [3,8,9]. The range of PTVs recorded in this study was even narrower with small standard deviation for both implants (0.6 to 1.6) placed in Balsa and Euro-Beech wood block. This may partly relate to the standardization method of test specimens being placed in wood blocks with a homogeneous density.

The RFA may provide valuable insight into the health status of bone-implant complex and future prognosis of dental implants because clinically firm implants with poor stability are more likely to fail when loaded [11]. Chang, et al. [12] compared a new instrument that was based on RFA with that of the commercially available Osstell instrument. Their results suggested that RFA devices could be useful in evaluating the status of bone-implant healing process associated with a recently placed implant.

The Osstell appears to be sensitive in detecting differences in implant stability. It detected the difference between Implants I and II in each wood block of Balsa and Euro-Beech. The means of ISQs were also significantly different among evaluators in this study. This may relate to the wider range of the Osstell scale (0-100) than Periotest (-8 to +29) [13,17,19]. In fact, the actual difference of the means was quite small and the test scores of repeated measure were found to produce a narrow range of data distribution within each evaluator. Thus, both the Periotest and Osstell instruments can provide clinically useful and comparably reliable information and exhibit an association with each other in assessing the status of the bone-implant complex.

Numerous variables must be controlled in gathering clinical data [16-19]. Both the reproducibility of instruments used to collect data and the manner in which the instruments are used by clinicians can influence the results. This problem is even more significant in clinical studies, where different dentists with different levels of clinical experience utilize a different instrument from the same manufacturer to evaluate the implant stability. These variations, when not controlled, may result in widely differing data that is often reported in the dental literature. The pre-study training and calibration of evaluators in this pilot study represented an attempt to significantly reduce the variables of these clinically uncontrollable factors.

Conclusion

Within the limits of this study, the PTVs were found to be more consistent than ISQs among the evaluators. However, both the PTVs and ISQs may indicate reliable assessments of implant stability because of small differences in the means among evaluators and narrow distributions of repeated data within each evaluator.

Disclosure

The authors declare no conflict of interest related to this manuscript.

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