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Original Research Article

Evaluating dental implant stability using three devices Osstell®, Periotest®, and AnyCheck®: a clinical study

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Abstract – Introduction: Implant stability is usually measured with resonance frequency analysis (RFA) and damping capacity assessment (DCA). This study aimed to measure primary and secondary stabilities using 3 devices that are based on these methods, namely; RFA (Osstell®) and DCA (Periotest® and AnyCheck®) to assess the correlations of the measurements obtained by these devices and the correlations between implant stability and insertion torque. **Material and Methods:** This observational prospective study included 35 dental implants. The implant stability was measured using the 3 devices. Mann–Whitney *U* test and unpaired *t*-test assessed the relationship between implant stability and insertion torque, while the Spearman and Pearson correlations measured the correlation between readings collected via the 3 devices for the primary and secondary stabilities. **Results:** For the primary stability, there was a strong positive correlation between Osstell® and AnyCheck® and moderate negative correlations between Periotest® and both Osstell® and AnyCheck®. While for the secondary stability, strong correlations with similar patterns were observed among the 3 devices. The stability measurements showed significant relationships with the insertion torque. **Conclusions:** The 3 devices are reliable in measuring implant stability; also, high insertion torque can lead to improved implant stabilities (primary and secondary).

Introduction

The primary stability of dental implants is defined as the lack of clinical movement at the moment of implant insertion, and achieving high primary stability allows for unhindered healing and osseointegration since there is less implant micromotion [1]. In contrast, secondary stability is provided by biological stability via bone remodeling and regeneration [2].

Implant stability can be assessed using various methods, but their dependability was questioned in several studies. The most commonly employed digital techniques are resonance frequency analysis (RFA) and damping capacity assessment (DCA) [3]. The RFA-based device (Osstell®, Goteborg, Sweden) operates predominantly by producing an electric or magnetic impulse that excites a transducer connected to the implant; the resultant oscillation causes a minor implant displacement laterally, with the conversion of the resonance frequency value to implant stability quotient (ISQ), with a greater ISQ score indicating a more stable implant [4].

Periotest® (Medizintechnik Gulden, Germany) is a DCA instrument initially developed to measure tooth movement quantitatively [5]; it is made up of a small computer linked to a handpiece with a tapping rod [6]. Using an accelerometer, the Periotest® calculates the time the tapping head takes to make contact with a tooth or implant. The findings are reported in the form of Periotest values (PTVs), which can range between −8 and +50. Lower numbers indicate higher stability [7].

In recent times, Neobiotech Co., Ltd., Korea developed a modified DCA device (AnyCheck®); like ISQ, the modified DCA device uses an implant stability test (IST) that ranges between 1 and 99, with greater values suggesting a more stable implant [8]. The device impacts the healing abutment six times in three seconds with force smaller than Periotest® and includes an automatic stop feature to preserve the implant when the stability is poor [9]. In clinical terms, an IST of 1–59 suggests poor stability, 60–64 denotes intermediate stability, and >65 represents good stability [10].

Only a few published clinical studies have evaluated the stability of dental implants using the three aforementioned devices, therefore, this study aimed to measure primary and secondary implant stability using 3 devices that are based on RFA (Osstell®) and DCA (Periotest® and AnyCheck®) and to assess the correlations of the measurements obtained by these devices.

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Materials and methods

Study design

This prospective observational clinical study was conducted from December 2021 to December 2022. It included patients with single or multiple missing teeth who received dental implants using a delayed implantation protocol.

This study was performed according to the principles of the Declaration of Helsinki (2013) [11], approved by the Research Ethics Committee of the College of Dentistry-University of Baghdad (Protocol number: 412121), and guided by the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines [12]. After being informed of the nature of the study, the treatment, and the potential complications that may arise, each patient signed an informed consent form.

To ensure meaningful and reliable results the sample size was estimated using G Power 3.1.9.7 for Windows software (Heinrich-Heine University, Dusseldorf, Germany) based on the results of a previous study [1] that investigated the correlation of implant stability values assessed by Periotest and Osstell Mentor devices. The following parameters were used: Tail (s) = Two, Correlation ρ H1 = 0.7 [1], significant level α err prob = 0.05, Power (1-β err prob) = 0.95, Correlation ρ H0 = 0.

Eligibility criteria

The inclusion criteria were normal healthy adult patients with American Society of Anesthesiologists physical status classification category one (ASA I) presenting with healed edentulous areas of adequate bone height and width based on a preoperative CBCT.

The patients were excluded from the study if they demonstrated signs of active infection at the site of the proposed implant, had any uncontrolled systemic disease, or had a history of radiotherapy. Patients who required complicated surgical procedures such as bone augmentation were also excluded from the study.

Radiographic assessment

A preoperative CBCT (Kavo OP 3D PRO, Germany) was performed with the following parameters: 90 Kv, 9.2 mA, 8.1 seconds, (13 × 15) cm field of view, and 0.5 mm slice thickness. The CBCT was used to measure the bone dimensions (height and width) of the proposed implant site and the average bone density using virtual implant properties in the OnDemand3D program (Cybermed Inc., Seoul, Korea). Using the "Implant pick & place tool", the virtual implant was placed in the proposed implant site (Fig. 1).

Surgical procedure

The dental implants used in this study were T6 standard bone-level implants (NucleOSS™, Izmir, Turkey) with double, reverse buttress, and self-cutting threads, internal connection, and sandblasted and acid-etched (SLA) surface treatment.

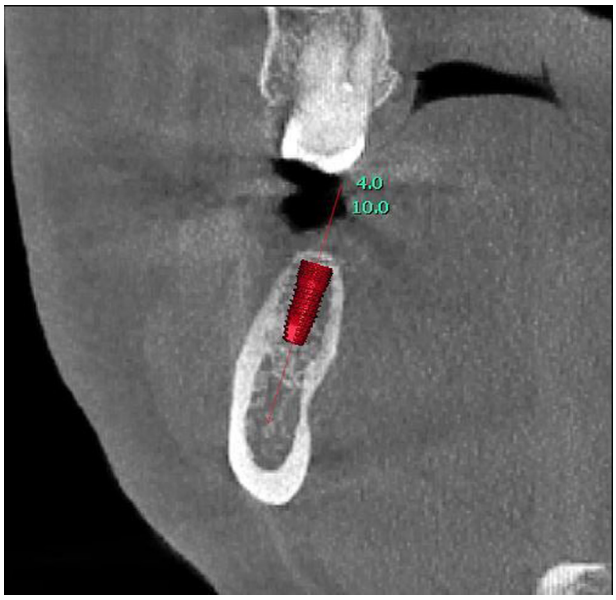

Fig. 1. Virtual implant placed in the planned position using OnDemand 3D software.

All the surgical procedures were carried out under local anesthesia; after reflection of a full-thickness mucoperiosteal flap, the implant site was prepared through sequential drilling (clockwise drilling with a drilling speed of 800 rpm and copious irrigation with normal saline).

The implants were inserted using a motorized technique with a rotational speed of 50 rpm and 50 N/cm torque. A hand ratchet was used to place the dental implant to the desired depth when the insertion torque exceeded 50 N/cm.

After placement of implants, the primary implant stability was measured by the three devices: The first measurement was performed using the RFA Osstell® device and a single-use Smartpeg™ type 21 transducer from Osstell® (Goteborg, Sweden) that is connected to the implant. The measurement was taken from two directions (buccolingual and mesiodistal), the mean of these values represented the primary stability and was recorded as ISQ.

The second measurement was taken by the DCA device Periotest® after connecting a 4 mm height healing abutment to the implant with a standardized torque of 20 N/cm. Three repeated stability measurements were obtained for each implant and the mean stability value was recorded in PTV.

The third measurement was made using the DCA device AnyCheck® and the same healing abutment, two readings were taken for each implant and the mean stability value was recorded as IST.

After measuring the primary stability by the three devices, the healing abutment was removed, the cover screw was applied, and the flap was sutured. Twelve weeks after implant placement, the secondary implant stability was measured similarly using the 3 devices.

Study variables and statistical analysis

The predictor variables were the primary and secondary implant stability measurements using the three devices recorded as ISQ, PTV, and IST, in addition to the insertion torque, which was recorded as ≤50 or >50 N/cm. The primary outcome variable was the correlations of implant stability measurements among the three devices. The secondary outcome variable was the relationship between implant stability and insertion torque.

GraphPad Prism version 6 for Windows (GraphPad Software, La Jolla, CA, USA) was used for the statistical analysis. The descriptive statistics comprised the numbers and the percentages of the categorical variables and the mean, standard deviation (SD), and median of the numerical variables; the distribution of the numerical variables was assessed using the Shapiro-Wilk normality test. The inferential statistics comprised the Mann-Whitney U test, the Unpaired t-test, the Spearman correlation, and the Pearson correlation. Statistical significance was attributed to probability values of ≤0.05.

Results

The study included 16 patients with an age range of 21–60 years and a mean (SD) and median of 46.4 (10.8) and 47.5 years, respectively. They consisted of 11 females (68.8%) and 5 males (31.2%). The patients received 35 implants; the basic clinical characteristics of the dental implants are illustrated in Table I.

For the primary stability, there was a strong positive correlation between Osstell® and AnyCheck® and moderate negative correlations between Periotest® and both Osstell® and AnyCheck®. While for the secondary stability, strong correlations with similar patterns were observed among the 3 devices (Tab. II).

The dental implant inserted with an insertion torque of >50 N/cm demonstrated higher primary and secondary stability measured by the three devices compared to dental implant inserted with ≤50 N/cm insertion torque, as shown in Table III.

Discussion

Implant stability must be maintained for satisfactory clinical results in dental implants [1]. Evaluating implant stability aids in making appropriate judgments about loading status, allows for good protocol selection on a patient-by-patient basis, identifies conditions when it is preferable not to load, increases patient trust, encourages good communication, and enhances documentation of the case [13]. There are many methods to evaluate implant stability, among which are the RFA and DCA, which are considered non-invasive quantitative objective methods [14].

Table I. The basic clinical characteristics of the dental implants ($n = 35$).

Clinical characteristic	
Bone density of implant site/ mean (SD), median HU	251.4 (168.7), 220.9
Recipient jaw/ number (%)	
Maxilla	12 (34.3)
Mandible	23 (65.7)
Implant dimensions/ number (%)	
Width	
3.5 mm	10 (28.6)
4.1 mm	25 (71.4)
Length	
8 mm	7 (20)
10 mm	28 (80)
Primary stability	
Osstell/mean (SD), median ISQ	75.09 (4.17), 74
Periotest/mean (SD), median PTV	−4.21 (1.91), −4.53
AnyCheck/mean (SD), median IST	75.03 (4.68), 76
Secondary stability	
Osstell/mean (SD), median ISQ	73.49 (6.98), 75.50
Periotest/mean (SD), median PTV	−3.01 (2.44), −3.65
AnyCheck/mean (SD), median IST	74.33 (4.04), 75.00
Insertion torque/ number (%)	
>50	19 (54.3)
≤50	16 (45.7)

Abbreviations: HU, Hounsfield Units, ISQ, Implant Stability Quotient, PTV, Periotest Value, IST, Implant stability test.

Table II. The correlations between the three devices in primary and secondary dental implant stability measurements.

Device	*r*	*P*-value
Primary stability measurements		
Osstell/ISQ *vs.* Periotest/PTV	−0.6	0.0002* [S]
Osstell/ISQ *vs.* AnyCheck/IST	0.7	<0.0001* [S]
Periotest/PTV *vs.* AnyCheck/IST	−0.6	<0.0001* [S]
Secondary stability measurements		
Osstell/ISQ *vs.* Periotest/PTV	−0.9	< 0.0001‡ [S]
Osstell/ISQ *vs.* AnyCheck/IST	0.9	< 0.0001* [S]
Periotest/PTV *vs.* AnyCheck/IST	−0.8	< 0.0001* [S]

ISQ, Implant stability quotient; PTV, Periotest value; IST, Implant stability test.
‡ Spearman correlation.
* Pearson correlation; S, Significant.

In the current study, the mean values of the secondary stability measured by the 3 devices were slightly lower than the mean values of the primary stability; this finding is in line with

Table III. The relationship between the primary and secondary dental implant stability and insertion torque.

Insertion torque N/cm	Osstell/ISQ			Periotest/PTV			AnyCheck/IST		
	Mean	SD	Median	Mean	SD	Median	Mean	SD	Median
Primary stability measurements									
≤50	72.9	3.6	72.0	−3.2	1.9	−2.6	73.3	4.9	74.0
>50	76.9	3.8	77.0	−5.1	1.5	−4.8	76.5	4.1	77.0
P-value	0.002‡ [S]			0.002* [S]			0.035‡ [S]		
Secondary stability measurements									
≤50	70.1	7.8	74.2	−1.4	3.5	−2.5	72.1	4.1	72.5
>50	76.2	4.7	76.5	−4.3	1.4	−4.3	76.1	3.0	76.0
P-value	0.022‡ [S]			0.003* [S]			0.002* [S]		

ISQ, Implant stability quotient; PTV, Periotest value; IST, Implant stability test; SD, Standard deviation; S, significant.
‡ Mann Whitney *U* test.
* Unpaired *t*-test.

Gomez-polo *et al.*, who suggested that high primary implant stability tends to decrease with time; in contrast, low primary implant stability tends to increase over time [15]. In addition, Andersson *et al.* maintained that the decrease in primary implant stability over time could be due to mechanical relaxation and/or remodeling of the bone in response to high stresses encountered during dental implant insertion [16]. Nevertheless, both primary and secondary stability values recorded in this study are considered to be high according to the standards of the used devices that consider ISQ values >70 using Osstell®, PTV of −8 to 0 using Periotest®, [14] and IST values >65 using AnyCheck® to indicate high stability [8].

The primary and secondary stability measurements showed moderate to strong correlations among the three devices, which concurs with Pyo *et al.*, who demonstrated that high IST values were associated with high ISQ values and low PTV values [17]. Also, Oh *et al.* showed that an increase in ISQ value is accompanied by a decrease in PTV value at different points of time after installation of the dental implant and vice versa and concluded that the findings obtained from Periotest and Osstell Mentor were correlated [7].

The PTV is inversely related to implant stability, with low values indicating good stability and high values indicating poor stability. PTVs between −8 and 0 indicate efficient osseointegration and "good stability," while values between 1 and 9 indicate "moderate stability", and values between 10 and 50 indicate "poor stability" [14]. The 3 devices detected the high primary and secondary stabilities recorded in this study with moderate to strong correlations, suggesting that they were reliable in measuring implant stability.

A recent study by Shim *et al.* (2023), on the other hand, demonstrated a general pattern of weak to moderate correlations in stability measurements among the three devices at different time points, the authors reported a strong negative correlation between PTV and IST values only in one follow up visit at 2 months after surgery [18].

The present study showed that increasing insertion torque leads to high primary and secondary implant stability, which is in keeping with Joshi *et al.*, who maintained that the primary and secondary implant stabilities are predominantly influenced by insertion torque [19]. On the other hand, Cassetta *et al.* demonstrated that implants installed with an insertion torque >50 N/cm do not necessarily lead to higher secondary stability. As a result, increasing insertion torque during implant installation may result in enhanced primary implant stability without enhancing secondary implant stability [20]. This may be due to the fact that high insertion torque may lead to high compression forces that may cause local microcirculation disturbance, necrosis of the osteocyte, and bone resorption [21]. Also, Lages *et al.* reported in a systematic review that included 12 studies that the operators should define just one method for the assessment of dental implant stability because RFA and insertion torque are independent and non-comparable techniques for the evaluation of primary implant stability [22]. Noaman *et al.*, however, showed a non-significant correlation between insertion torque and implant stability [23]. Moreover, Degidi *et al.*, in their study that included a sample of 4135 dental implants, concluded that insertion torque and ISQ value appear to be independent features of primary implant stability, and only insertion torque is affected by bone density [24].

It is noteworthy to mention that implant stability measurement with DCA devices is associated with some technical limitations. Obtaining valid readings requires that the patient be seated in an upright position and the device be held in a horizontal posture with an acceptable upward or downward angulation of about 25 degrees, which may result in slight difficulty in measuring stability in posterior implants, also a certain distance should be maintained between the tip of the probe and the implant during measurement. Lee *et al.* (2023) in an in vitro study demonstrated that the reliability of

Periotest and Anycheck (DCA devices) was significantly affected by the position of the bone model and implant location and that Osstell showed consistently reliable results [25].

The results of this study need to be interpreted after considering its main limitation related to the observational design.

Within the limitations of this study, it can be concluded that RFA (Osstell®) and DCA (Periotest® and AnyCheck®) are reliable in measuring implant stability and that high insertion torque can improve primary and secondary implant stability.

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Conflicts of interest

The authors declare that they have no conflict of interest.

Data availability statement

The data will be provided upon request.

Ethics approval

This study was conducted in accordance with the Declaration of Helsinki guidelines and was approved by the institutional Research Ethics Committee (protocol # 412121).

Informed consent

Each patient signed informed consent to participate in this study.

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