Research Article

The reliability of insertion torque as an indicator for primary stability in immediate dental implant: A prospective clinical study

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Abstract: Background: The primary stability of the dental implant is a crucial factor determining the ability to initiate temporary implant-supported prosthesis and for subsequent successful osseointegration, especially in the maxillary non-molar sites. This study assessed the reliability of the insertion torque of dental implants by relating it to the implant stability quotient values measured by the Osstell device. Material and methods: This study included healthy, non-smoker patients with no history of diabetes or other metabolic, or debilitating diseases that may affect bone healing, having non-restorable fractured teeth and retained roots in the maxillary non-molar sites. Primary dental implant stability was evaluated using a torque ratchet from the dental implant kit and ISQ values generated from the Osstell device. Results: Twenty patients (13 female and 7 male) with an age range of 25-65 years received twenty immediate dental implants. The insertion torque value ranged from 15 to 50 N/cm with a mean of 28 N/cm. At the same time, the ISQ values ranged between 50 and 80 ISQ values, with a mean of 63 ISQ values. The results showed a statistically significant positive correlation between the insertion torque of the dental implant measured by torque rachet and ISQ values checked with Osstell. Conclusion: The insertion torque can be used as a reliable method to estimate the primary stability of the immediately inserted dental implants in the maxillary non-molar sites comparable to the Osstell device ISQ values. In addition, torque ratchet is readily available in the dental implant kit at no additional cost, making it a valuable choice over the Osstell device.

Keywords: primary stability; implant stability; ISQ; RFA; insertion torque; implant.

Introduction

Primary stability of dental implant can be defined as the resistance encountered during implant insertion into the bone bed. It depends significantly on the mechanical engagement of the dental implant threads into the alveolar bone [1,2].

It is worth mentioning that multiple factors could affect the dental implant's primary stability, like the dental implant design, implant site drilling protocol used, and alveolar bone density [3-5].

Correct estimation of the primary stability of the dental implant is considered the critical factor for the subsequent bone healing, successful osseointegration, and esthetic outcome, especially in the case of immediate insertion of the dental implant in the extraction socket [6-8].

A number of factors are responsible for the difficulty of immediate implant placement in the anterior regions. These include the limited availability of bone in the maxillary anterior region, as well as the fact that more than 80% of the upper anterior teeth have a thin buccal bone plate that is prone to resorbing rapidly after extraction of the teeth. In addition to challenging drilling techniques, the presence of a gap between the implant and host bone may require bone augmentation, which may compromise the primary implant's stability and temporization [9,10].

The surgical technique can be modified to maximize the insertion torque value in the anterior maxillary region. However, there is no agreed minimum value for the primary implant stability with which osseointegration can be granted [11].

It is important to note that the optimal insertion torque may vary depending on the implant system, implant diameter, and bone quality. Therefore, clinicians should follow the manufacturer's guidelines for each implant system and consider the individual characteristics of every patient in order to determine the appropriate insertion torque [12-14].

A recent systematic review found that an insertion torque of 35 N/cm or greater was essential for achieving adequate primary stability for immediate dental implants inserted in the upper anterior region [15].

Another accurate and reliable noninvasive technique in measuring dental implant primary stability is the Resonance Frequency Analysis (RFA), where a transducer (multi peg) is screwed into the dental implant and excited by a range of sound frequencies, and the measurement of the dental implant stability expressed as ISQ value appeared on the digital screen of the device [16].

Precisely estimating the primary stability of the immediately inserted dental implant in the anterior maxillary non-molar sites is essential for predicting the prognosis and planning for temporization in this highly esthetic critical area. The limited availability of the Osstell devices, primarily used for research purposes, raises the need for a trusted, readily available tool to estimate an implant's primary stability.

This study assessed the reliability of the insertion torque of dental implant (IT) by relating it to the implant stability quotient (ISQ) values measured by the Osstell device for immediately inserted dental implants in the maxillary non-molar sites. Moreover, correlating subapical bone density measured in standardized CBCT with the serum vitamin D level, insertion torque, and ISQ values from the Osstell device.

Materials and Methods

A prospective observational clinical study was conducted at the Department of Oral and Maxillofacial Surgery, Dental Teaching Hospital of the College of Dentistry/ University of Baghdad, in accordance with the ethical principles and in compliance with the Declaration of Helsinki and its later amendments. This study had been ethically approved by the institutional Research Ethics Committee (protocol number 388121). Moreover, the study was registered at the Thai clinical trial registry with a registration number (TCTR 20220908001).

The study's sample size was calculated using GPower 3.1 software. The calculation data were obtained from a study by Bavetta et al. [11] as the power set at 0.90 and an alpha error of 0.05 within an effect size of 0.8; the estimated sample size was 18 implants, with an extra two implants added to account any potential bias. Any patient with non-restorable fractured teeth or retained roots in the maxillary non-molar sites surrounded by natural sound teeth and with at least 3mm of sound bone over the root apex with a ridge width of 6.5mm or more were included in the study. All these patients were healthy non-smokers with no history of diabetes or other metabolic, debilitating diseases that may affect bone healing. Patients with signs of acute infection and purulent exudates at the site of implant placement, as revealed by clinical or radiographic examination, were excluded from the study.

Radiological examination with Cone Beam Computed Tomography (CBCT) scans (cone beam 3D system Kavo OP 3D PRO, Germany), set at 90 KV, 9.2 mA, and 8.1s with (13 ᵕ Ø15) c FOV and 0.5 mm slice in thickness, were performed for preoperative assessment of the planned implant site. The assessment was performed using OnDemand3D™ software (Cybermed Inc.©, Seoul, Korea); it included the bone height and width of the alveolar ridge at the proposed implant site with an estimation of the subapical bone

density by the creation of a virtual box (3mm height, 5 mm width) apical to the tooth to be extracted and replaced by the immediate dental implant, as shown in Figure 1.

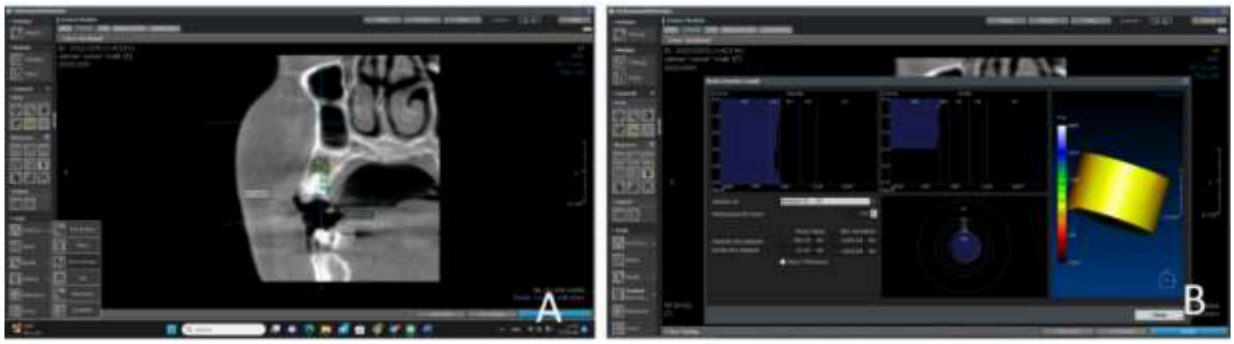

Figure 1: The preoperative assessment and measuring of the bone density at the apical region of the accused tooth by CBCT. (A) A coronal view assessed the upper right second premolar retained root bone width and height with the placement of a virtual box (3mm height, 5 mm width) apical to the root apex. (B) the estimated bone density inside that virtual box.

Furthermore, a laboratory investigation was performed to evaluate the serum level of vitamin D3 Before initiation of the surgical intervention.

After infiltration of a local anesthetic agent of lidocaine hydrochloride 2% and epinephrine (1:80,000). Atraumatic tooth extraction was accomplished using periotome and waldent tooth extraction forceps for the upper roots, followed by copious irrigation of normal saline and curettage of the extraction socket.

The pilot drill was used to mark a point at the mid-height of the extraction socket's palatal wall; then, the subsequent implant drills were used to adjust the angulation and increase the size of the preparation site, with an implant micromotor engine rotating at a speed of 800 rpm and torque of 35 N/cm with copious saline irrigation into a diameter 0.7mm narrower than the implant diameter. Implants (from Binnovation®, Brazil) were inserted into the osteotomy site 1-1.5 mm below the crestal bone level with the torque ratchet. Then, the primary stability of dental implants was assessed using the Osstell® device and smart pegs.

The data was analyzed using Statistical Package for Social Sciences (SPSS) software, version 25. The data were presented as mean (± standard deviation, SD), and ranges, while frequencies and percentages present the categorical data. The Shapiro-Wilk test was used to assess the normality of the data distribution. In the statistical analyses. Pearson correlation coefficient test was used to assess the correlations between the implant insertion torque recorded by the ratchet and the mean ISQ values at different directions obtained from Osstell device.

Results

Twenty eligible patients (13 females and 7 males) were enrolled in this study with an age range of 25-65 years and mean age of 39.24± 10.42. All patients had single non-restorable retained roots in the maxillary non-molar sites, bounded by natural sound teeth. Immediate dental implants measuring 3.5 and 4.0 mm in diameter with 11 or 13 mm length were used. The insertion torque value ranged from 15 to 50 N/cm with a mean of (28 ± 11.74) N/cm. At the same time, the ISQ values ranged between 50 and 80, with a mean of (63±18.66). There was no statistically significant difference between males and females regarding all study variables except for the preoperative serum vitamin D3 level (Table 1).

Table 1: The differences in the main characteristics between males and females

Variables	Patient's sex		p. value
	Male	Female	
No. of the implants	7	13	
Age (Mean ± SD) years	37.29 ± 10.47	34.31 ± 10.17	0.32
Insertion torque (Mean ± SD) N/cm	33.57 ± 9.45	25.38 ± 12.33	0.15
ISQ value (Mean ± SD)	64.63 ± 3.78	63.42 ± 5.79	0.50
Apical bone density (Mean ± SD) Hounsfield units	341.09 ± 69.64	413.38 ± 159.85	0.34
Ridge width (Mean ± SD) mm	7.74 ± 1.83	7.67 ±1.34	0. .58
Serum Vitamin D3 (Mean ± SD) ng/ml	22.66 ± 5.03	17.92 ± 7.88	0.02*

*Independent T test.

On the other hand, Statistical analysis showed a weak positive correlation between Vitamine D3 level and dental implant primary stability (measured by insertion torque ratchet or ISQ values from the Osstell device), with the subapical bone density measured by standardized CBCT, as detailed in table 2.

Table 2: Correlations of the insertion torque, ISQ values and level of the serum vitamin D3 with the subapical bone density

Variables	Correlation with the subapical bone density	
	Person correlation r	P Value
insertion torque N/cm	0.07	0.765
ISQ values from Osstell device	0.37	0.104
Serum vitamin D3 level ng/ml	0.13	0.575

Pearson's correlation coefficient test.

Furthermore, this study showed a statistically significant positive correlation between the insertion torque of the dental implant measured by torque rachet and ISQ values checked with Osstell, as showed Table 3 and represented in Figure 2.

Table 3: Correlation of insertion torque value and the mean primary stability ISQ values

Mean Primary stability with Osstell ISQ	Mean Insertion torque with torque ratchet N/cm	Person correlation r	P Value
64.05 ± (4.88)	28.25 ± (11.84)	0.5	0.027

Pearson's correlation coefficient test.

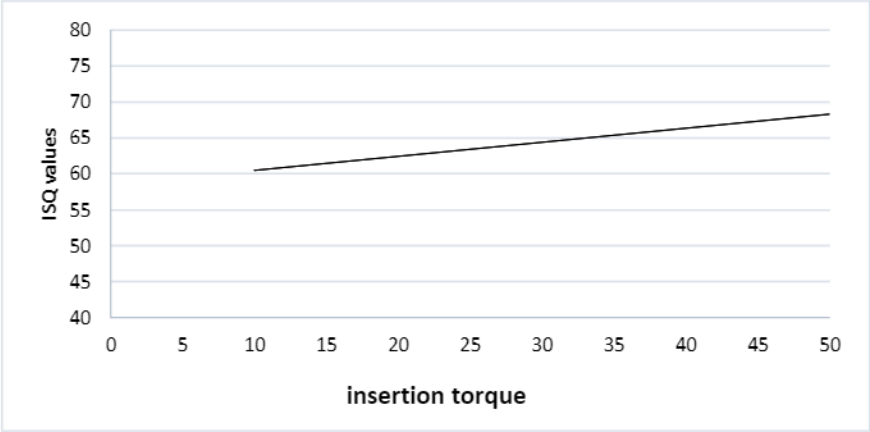

Figure 2: Correlation between the insertion torque and ISQ values of immediate dental implants in maxillary non-molar sites.

Discussion

Different methods have been used to estimate bone density; the Hounsfield Unit (HU) generated from a computerized tomography (CT) scan is considered the most routinely used method to assess bone density (17,18). On the other hand, the CBCT has been widely employed for oral and maxillofacial imaging, with lower radiation dose, less expensive, and comparable dimensional accuracy compared to CT scans. Nevertheless, unlike CT, the grayscale density values of the CBCT images are not absolute (19). In a recent study (20), the possibility of correlating the gray density values recorded by CT and CBCT was demonstrated; in fact, a correlation between the Voxel value of CBCT and Hounsfield Unit (HU) values of multislice CT was observed. According to these facts, CBCT was used in this study to evaluate the apical bone density and correlate it with study variables.

It had been reported that female peak bone density might be reached at 35 years old, then slowly decrease until 50, followed by a rapid reduction after 50. While male bone densities only had linear decreases at the same age range [21]. In this study, the mean patient's age and the limited subapical area where bone density was estimated may influence these results, where non-significant differences regarding the apical bone density lead to insignificant differences in the dental implant primary stability, whether measured by Osstell or torque ratchet. Furthermore, these results suggest that the sex-based discrepancy in alveolar bone density and dental implant insertion torque is age-related.

However, serum vitamin D3 levels showed statistically significant differences between males and females; these decreased levels of the serum vitamin D3 in females may be attributed to hormonal differences, besides the cultural and religious factors in the middle east, where females had to cover most of their skin that affects the vitamin D synthesis in the skin [22]. Interestingly, a recent clinical study by Odhaib et al. concluded that females who wear traditional clothing, such as burqas, have significantly lower vitamin D levels than those who do not [21]. Furthermore, females may have a lower intake of vitamin D-rich diets, rendering them more susceptible to vitamin D deficiency [23].

Since vitamin D3 level did not affect the average volumetric bone growth in Sprague-Dawley rats, who were subjected to the vitamin D3 deficient protocol, as demonstrated by Mengatto et al. in 2011 [22]. That may explain the weak positive correlation in this study between the serum level of vitamin D3, the apical bone density, and, subsequently, primary implant stability, whether measured by the torque ratchet or osstell device.

A recent systematic review assessing the relationship between the dental implant insertion torque and resonance frequency analysis with the Osstell device concluded that there was no correlation between these measurements at the time of dental implant placement [23]. The authors stated that 11 out of 12 studies included in this review had a severe risk of bias. The evidence level of these studies needed to be higher, which makes it more difficult to generalize the findings of this study. Furthermore, only one retrospective study was included in this review investigating the correlation between these two measurement methods in the immediately inserted dental implants in non-molar sites of both jaws with the same conclusion [24]. The retrospective nature of this study, performed with additional surgeries (bone condensation, sinus lifting) in maxillary and mandibular non-molar sites (with different bone densities), may influence their results and conclusion.

While this study showed a statistically significant positive correlation between the insertion torque values measured by torque rachet and Resonance frequency analysis (ISQ values) checked with Osstell. These results can be explained by the strict inclusion criteria of patients (single immediate dental implant in maxillary non-molar sites for middle age patients of both sexes with no statistically significant differences in the apical bone density among all sites using standardized CBCT measurements, no need for additional surgeries like sinus lifting, and all of the sites had a bone gap of 2mm.

The ISQ value may be affected by the bone rebounding phenomena and visco-elastic behavior after dental implant placement in different ranges, which may lead to a discrepancy between torque rachet and osstell readings [24]. In contrast to this study, the limited bone volume engaged by the dental implant in the immediate cases compared to the delayed implant may reduce this discrepancy.

This study is limited by its observational design. Also, the torque rachet did not provide an exact measurement of the insertion torque, and the amount of the subapical bone engagement by the dental implant was not standardized.

Conclusion

Despite the limitations of this study, it can be concluded that the insertion torque can be used as a reliable method to estimate the primary stability of the immediately inserted dental implants in the maxillary non-molar sites comparable to the Osstel device ISQ values. In addition, torque ratchet is readily available in the dental implant kit at no additional cost, making it a valuable choice over the Osstell device.

Conflict of interest

All authors declare no conflicts of interest/competing interests in this study.

Availability of data and material:

(The XLE. Sheets) of data used to support the findings of this study are available from the corresponding author upon request.

Author contributions

Sample collection, data Curation, and formal analysis were made by "IAD." Supervision, conceptualization, methodology, surgical operations, and writing the original draft were made by "AFA." Reviewing editing of the manuscript was made by "NA."

Authorship confirmation

We confirm that the manuscript " The reliability of insertion torque as an indicator for primary stability in immediate dental implant: prospective clinical trial" has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but need to be listed. We further confirm that all have approved the order of authors listed in the manuscript of us.

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All authors declare that no funds were received in this study.

Informed consent

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

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موثوقية عزم الدوران كمؤشر للاستقرار الأولي في زراعة الأسنان الفورية: تجربة سريرية مستقبلية

اخلاص عبد دخيل ، أحمد فاضل ، نورا العتيبي

المستخلص:

الخلفية: يعد الثبات الاولي لزرعة الأسنان عاملاً حاسماً في تحديد القدرة على وضع التركيب الصناعي المسنود بالزرعة بالاضافة الى اهميته في تحقيق الاندماج العظمي الناجح بين الزرعة وعظم الفك، خاصة في المنطقة الأمامية للفك العلوي (المنطقة الجمالية). قامت هذه الدراسة بتقييم موثوقية عزم دوران زراعة الأسنان من خلال ربطه بقيم حاصل ثبات الزرعة المقاسة بجهاز Osstell. المواد والطرق: شملت هذه الدراسة المرضى الذين يعانون من أسنان مكسورة غير قابلة للترميم في المنطقة الجمالية (من الضاحك العلوي الأيمن إلى الضاحك الثاني العلوي الأيسر)، من غير المدخنين، والمرضى الأصحاء الذين ليس لديهم تاريخ لمرض السكري أو أي اضطرابات استقلابية أخرى و الأمراض الاخرى التي قد تؤثر على شفاء العظام. بعد عملية قلع الجذور، تم تقييم ثبات زراعة الأسنان الأولية باستخدام عتلة عزم الدوران ومقارنتها مع قيم ISQ المتولدة .ن جهاز Osstell. النتائج: عشرون مريضا (13 انثى و 78 ذكور) تتراوح أعمارهم بين (25-65) سنة حصلوا على عشرين زراعة أسنان فورية. تراوحت قيمة عزم الإدخال من 15-50 نيوتن/سم بمتوسط 28 نيوتن/سم. وفي الوقت نفسه، تتراوح قيم ISQ بين 50 و80 قيمة ISQ، بمتوسط 63 ISQ. أظهرت النتائج وجود علاقة إيجابية قوية بين عزم الإدخال لزراعة الأسنان المقاسة بعتلة عزم الدوران وقيم ISQ التي تم فحصها باستخدام Osstell. الخلاصة: يمكن استخدام عتلة عزم الدوران كطريقة موثوقة لتقدير الاستقرار الأولي لزرعات الأسنان الفورية في المنطقة الامامية للفك الاعلى وبقيم مماثلة لقيم ISQ لجهاز osstell؛ ومع ذلك، فإن سهولة توفر عتلة عزم الدوران .ون أي تكلفة إضافية تجعلها خيارًا جذابًا لهذه الحالات.