

Research Article

The relationship of implant stability quotient and insertion torque in dental implant stability

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Abstract: Background: The insertion torque (IT) values and implant stability quotient (ISQ) values are the measurements most used to assess primary implant stability. This study aimed to assess the relationship between ISQ values and IT. Materials and methods: This study included 24 patients with a mean (SD) age of 47.9 (13.64) years (range 25-75 years). The patients received 42 dental implants (DI), 33 in the mandible and 9 in the maxilla. The DI were installed using the motorized method with 35 Ncm torque, When DI could not be inserted to the requisite depth by the motorized method, a hand ratchet was used and the IT was recorded as > 35 Ncm. Implant stability was measured utilizing Osstell® ISQ. The secondary stability was measured after 16 weeks postoperatively. Results: The DI installed in mandible demonstrated significantly higher primary stability ISQ values than those installed in maxilla (P=0.0101). There was no such significant correlation linked between the secondary stability and the recipient jaw (P=0.2026). A non-significant correlation was found between the primary and secondary implant stability ISQ values and IT (P=0.2785 and 0.4194, respectively). No significant difference was reported regarding the IT relative to the recipient jaw of DI (P=0.1349). Conclusion: This study demonstrated that there was no relationship between the ISQ values and the IT, and that they should be used independently. DI installed in mandible demonstrated significantly higher primary stability ISQ values than those installed in maxilla. Also, there was a non-significant correlation of the secondary stability and IT with the recipient jaw.

Keywords: Dental implants, insertion torque, implant stability.

5 Introduction

The successful outcome of dental implants (DI) depends on a sequence of patient-related and procedure dependent elements, including general health conditions, biocompatibility of the implant material, the implant surface features, the surgical procedure, and the local bone quality and quantity (1).

Implant stability may be defined as "the capacity of implant to withstand loading in axial, lateral and rotational direction", (2) it is split into two parts: primary and secondary. Primary stability refers to "the mechanical bracing of the implant in bone and absence of any micro-movement", While secondary stability is referred to "successful osseointegration of the implant with the surrounding" (3).

At the time of implant insertion, primary stability is crucial. The most important factor for successful osseointegration is a solid anchoring of the implant within the host bone, free of micro-motions. Micro-motions may develop if an implant is not sufficiently stable at the time of implant

placement, disrupting the normal healing process and forming a fibrous tissue capsule, resulting in clinical mobility and eventual implant failure⁽⁴⁾.

There are numerous techniques to assess implant stability. These can be divided into two categories: the invasive and noninvasive methods⁽³⁾. The insertion torque (IT) (during surgery, for primary stability), and resonance frequency analysis (RFA) (during and after surgery to measure primary and secondary stability) are the two most common noninvasive approaches for determining implant stability nowadays. RFA device measurements (Implant stability quotient, ISQ) have been shown to give crucial information to the surgeon on the present status of the bone implant interface which, together with clinical/radiographic findings, can aid decision-making during implant placement and follow-up in terms of healing durations, loading technique, and the identification of implants at risk of failure⁽⁵⁾.

It is critical to determine whether or not the IT and ISQ values are equivalent. Both approaches can be employed in clinics, particularly because the ISQ has been widely used owing to its applicability in a variety of settings, including implant placement, healing, and with the prosthesis in place⁽⁶⁾. The aim of this study was to assess the relationship between the ISQ values and IT as a measurement of implant stability.

Materials and methods

This clinical prospective observational study was conducted at the Department of Oral and Maxillofacial surgery, College of Dentistry, University of Baghdad from September 2019 to June 2021. It included patients who presented with missing teeth that were restored with implant supported fixed prostheses.

The institutional Research Ethics Committee approved the protocol of this study (protocol number 036118), and patients were informed about the nature of the study and they signed an informed consent to participate in this study.

The inclusion criteria were; adult patients ≥ 18 years old of both genders with good general health presenting with partially edentulous maxilla or mandible with a minimum of 6 months after teeth extraction. The patients should have sufficient alveolar bone ridge dimensions with a minimum 6 mm width and 10 mm height.

The exclusion criteria were; any uncontrolled systemic disease that could interfere with normal healing, current pregnancy, history of irradiation of the head and neck region or chemotherapy over the past 5 years, patients treated with bisphosphonate drugs which affect bone metabolism, any local condition such as the presence of infection or local pathological conditions in the proposed implant zone, active periodontitis and patients with clinical evidence of para-functional habits.

A CBCT (cone beam 3D system Kavo OP 3D PRO, Germany), set at 90 KV, 9.2 mA and 8.1s with (13 × Ø15) c FOV and 0.5 mm slice in thickness, was taken 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 alveolar ridge at the proposed implant site and also to determine the dimensions of the implant to be installed so that the implant apex is to be at least 2 mm above mandibular canal and 2 mm away from mental foramen, 1 mm below nasal cavity and 1 mm below the floor and the anterior wall of maxillary sinus as shown in (Fig. 1).



Figure 1: The CBCT cross section view with bone dimensions measurement.

All the procedures were performed under local anesthesia lidocaine hydrochloride 2% with epinephrine (1:80,000). A mucoperiosteal flap was reflected and the implant site preparation proceeded using osteotomy drills of increasing diameter corresponding to the implant dimensions with an implant micromotor (Dental surgery micromotor iCT, Dentium, Korea) rotating at a speed of 800 rpm with copious saline irrigation. The implants (Superline, Dentium, Seoul, Korea) were installed into the osteotomy site using the motorized method with the engine set at 50 rpm and 35 Ncm torque, so that the implant platform is 0.5-1 mm below the bone level. When the implant could not be inserted to the requisite depth by the motorized method, a hand ratchet was used and the IT was recorded as > 35 Ncm. Accordingly, in this study, implants were categorized into two groups regarding the IT; one group with 35 Ncm insertion torque and the other > 35 Ncm. Immediately after insertion of DI, the primary stability was measured using Osstell®ISQ (Osstell®, Gothenburg, Sweden). Two repeated measurements were obtained for each implant along the buccolingual and mesiodistal axis and the mean of these two readings was taken (Fig. 2).

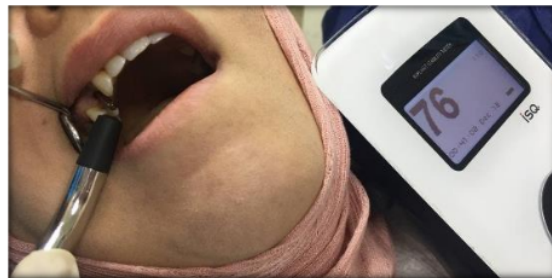


Figure 2: Implant stability measurement using Osstell® ISQ.

Patients were instructed for follow up visit at 16 weeks postoperatively. The implants were uncovered and the secondary stability was measured in the same manner described in primary stability measurement.

The outcome variables were the primary and secondary stability measured as implant stability quotient (ISQ) and the IT and their correlations with the recipient jaw. GraphPad Prism version 6 for Windows was used to carry out the statistical analysis (GraphPad Software, La Jolla, CA, USA). Percentages, mean, standard deviation (SD) were all computed as part of descriptive statistical

analysis. The inferential analysis included using Shapiro-Wilk normality test, unpaired t-test, and Chi-square test. The probability value <0.05 was considered statistically significant.

Results

This study included 24 patients, 14 females (58.3%) and 10 males (41.7%). The mean (SD) age of patients was 47.9 (13.64) years (range 25-75). The patients received 42 DI, of which 33 (78.6%) were installed in the mandible and the remaining 9 (21.4%) in the maxilla.

The mean (SD) of the primary stability was 79.58 (5.27) ISQ, while that of the secondary stability was 74.3 (6.34) ISQ. In 22 DI (52.4%), the IT was 35 Ncm, while in the remaining 20 DI (47.6%), an IT of > 35 Ncm was needed for the final seating of the DI. At the end of this study all the implants were clinically stable achieving an early survival rate 100%.

The effect of the recipient jaw on the primary stability ISQ values

The DI installed in the mandible demonstrated significantly higher primary stability ISQ values than those installed in the maxilla, Table (1).

Table (1): The differences of the primary stability ISQ value in relation to the recipient jaw.

recipient jaw	Number of values	Primary stability/ ISQ		P value
		Mean	SD	
mandible	33	80.65	5.23	0.0101 [S]*
maxilla	9	75.67	3.33	

Abbreviations: ISQ, Implant stability quotient; SD, Standard deviation; S, Significant; *, Unpaired t-test.

The effect of the recipient jaw on the secondary stability ISQ values

There was a non-significant difference in the secondary stability ISQ values relative to the recipient jaw, Table (2).

Table (2): The differences of the secondary stability ISQ value in relation to the recipient jaw.

recipient jaw	Number of values	secondary stability/ ISQ		P value
		Mean	SD	
mandible	33	75.09	6.44	0.2026 [NS]*
maxilla	9	72.00	5.87	

Abbreviations: ISQ, Implant stability quotient; SD, Standard deviation; NS, Non-Significant; *, Unpaired t-test.

Correlation of IT and the primary stability ISQ values

There was a non-significant difference in the primary stability ISQ values between the DI that were installed with an IT of 35 Ncm and those installed with an IT > 35 Ncm, Table (3).

Table (3): The differences of the primary stability ISQ value between the DI that were installed with an IT of 35 and > 35 Ncm.

Insertion torque/ Ncm	Number of values	Primary stability/ ISQ		P value
		Mean	SD	
>35	22	78.93	5.32	0.2785
35	20	80.30	5.26	[NS]*

Abbreviations: IT, Insertion torque; ISQ, Implant stability quotient; SD, Standard deviation; NS, Non-Significant; *, Unpaired t-test.

Correlation of IT and the secondary stability ISQ values

There was a non-significant difference regarding the secondary stability ISQ values between DI that were installed with an IT of 35 Ncm and those installed with an IT > 35 Ncm, Table (4).

Table (4): The differences of the secondary stability ISQ value between the DI that were installed with an IT of 35 and > 35 Ncm.

Insertion torque/ Ncm	Number of values	Secondary stability/ ISQ		P value
		Mean	SD	
>35	22	73.55	6.40	0.4194 [NS]*
35	20	75.15	6.32	

Abbreviations: IT, Insertion torque; ISQ, Implant stability quotient; SD, Standard deviation; NS, Non-Significant; *, Unpaired t-test.

The effect of the recipient jaw on the IT

There was a non-significant difference regarding the IT relative to the recipient jaw, Table (5).

Table (5): The differences of the IT in relation to the recipient jaw.

Recipient jaw	IT < 35 Ncm/ number of implants	IT > 35 Ncm/ number of implants	P value
Mandible	15	18	0.1349 [NS]*
Maxilla	7	2	

Abbreviations: IT, Insertion torque; NS, Non-Significant; *, Fisher's exact test.

Discussion

The most commonly used methods for assessing primary implant stability are IT and RFA (7). The link between these methods is poorly understood in the literature. The downside of IT is that it can only be measured once, at the moment of implant placement, whereas RFA may be utilized during the whole implant treatment phases (8).

Meredith et al. (9) stated that RFA is a method that may be used as a research tool and is beneficial in evaluating the behavior of implants in surrounding tissue. Also, Jaramillo et al. (10) reported that RFA technologies in Osstell® Mentor and Osstell® ISQ provide nearly perfect reproducibility, repeatability, and precision. However, Degidi et al. (11) demonstrated that in clinical practice, the IT is still a simple and accurate metric for assessing the primary stability of DI.

The findings of this study revealed that DI installed in the mandible demonstrated significantly higher primary stability ISQ values than those installed in the maxilla. This finding is in line with

other studies, ^(12,13) and it may be explained by the fact that the mandible is characterized by denser bone than the maxilla ⁽¹⁴⁾.

Primary stability arises from the compression of bone and it is linked to the ¹⁰ mechanical engagement of implant with the surrounding bone and it depends on the quantity and quality of local bone in addition to other factors ⁽¹⁵⁾. Moreover, many studies indicated a ¹⁶ positive correlation of primary implant stability and bone density ⁽¹⁶⁻¹⁸⁾. Conversely, Other studies ⁽¹⁹⁾ reported that there was no significant relationship between the implant stability and bone density.

Secondary stability, on the other hand, demonstrated a non-significant association relative to the recipient jaw, which concurs with Gómez-Polo et al. ⁽²⁰⁾ who stated that regardless of bone type, the progressive development of bone surrounding the implant associated with secondary stability compensates for any differences in mechanical anchoring primary stability.

In this study, there was a non-significant difference in primary stability ISQ values between the DI that were installed with an IT 35 Ncm and those installed with IT > 35 Ncm. Other authors ^(6, 21) also reported that IT and RFA appeared as two independent features of primary stability. A recent systematic review ⁽⁶⁾ concluded that ³ irrespective of the implant dimensions and protocol used in the previous studies, there was no relationship between the two ² methods of assessing primary stability, it proposed that the two values should be assessed separately, because a high torque does not always imply a high ISQ and vice versa. A plausible explanation could be related to the relaxation that would take place immediately after implant insertion, this can have an effect on both ISQ and bone implant contact measurements. Furthermore, it is well understood that both ISQ and bone contact measurements may be influenced by the viscoelastic nature of the bone and possibly simultaneous relaxation that occurs directly after implant placement ⁽²²⁾. However, other studies ^(12, 20) reported a significant relationship between IT and primary stability ISQ values, indicating that a higher IT predicts greater primary ISQ values.

In this study, there was no relationship between secondary stability and IT of DI. This finding is in a line with Gómez-Polo (20), and can be attributed to the fact that bone remodeling and bone apposition on DI surface (osseointegration) that occurs during the healing period may reduce the effect of implant IT.

A non-significant difference regarding IT was observed relative to the recipient jaw of DI. This coincides with Farré-pagès et al. ⁽¹²⁾ who found no statistically significant differences according to different jaws locations. They observed only a slight trend of IT increase in the mandible than in the maxilla (42.34 and 40.22 Ncm, respectively). On the other hand, Salimov et al. ⁽¹³⁾ indicated higher IT values for DI placed in the mandible when compared to the maxilla.

Conclusions

The small sample size may limit the generalization obtained in this study; nevertheless it demonstrated that there was no relationship between the ISQ values and the IT, and that they should be used independently for estimating the bone implant interface condition ¹. The findings of this study also showed that DI installed in mandible demonstrated significantly higher primary stability ISQ values than those installed in maxilla. Whereas, there was no such significant correlation of the secondary stability and IT with the recipient jaw.

Conflict of interest: None declared

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العنوان: العلاقة بين حاصل ثبات الغرسة وعزم الإدخال في ثباتية غرسة السن
 الباحثون: علي طريف نعمان I, سلوان يوسف حنا
 المستخلص:

الخلفية: قيم عزم الإدخال (IT) وقيم حاصل استقرار الغرسة (ISQ) هي القياسات الأكثر استخداماً لتقييم استقرار الغرسة الأولية. هدفت هذه الدراسة إلى تقييم العلاقة بين قيم حاصل استقرار الغرسة ISQ وقيم عزم الإدخال (IT).
 المواد وطرق العمل: شملت هذه الدراسة 24 مريضاً. كان متوسط عمر المرضى 47.9 (13.64) سنة (المدى 25-75 سنة). تلقى المرضى 42 زرعاً أسنان (33 زرعاً أسنان في الفك السفلي و 9 في الفك العلوي). تم أخذ التصوير المقطعي المحوسب بحزمة مخروطية قبل الجراحة (CBCT) ، تم إجراء عملية تحضير موقع الزرع بطريقة متسلسلة ، وتم تثبيت زرع أسنان (دنتيوم ، كوريا) باستخدام الطريقة الآلية بعزم دوران 35 نيوتن سم ، عندما تعذر إدخال زرع أسنان إلى العمق المطلوب ، تم استخدام المساطة اليدوية وتسجيل قيم عزم الإدخال على أنها أكثر من 35 نيوتن سم. تم قياس ثبات الغرسة باستخدام جهاز Osstell® ISQ. تم توجيه المرضى لزيارة المتابعة بعد 16 أسبوعاً من الجراحة ، وتم قياس الاستقرار الثانوي. النتائج: أظهرت زرع الأسنان المثبتة في الفك السفلي قيم ISQ للثبات الأولي أعلى بكثير من تلك المثبتة في الفك العلوي. لم يكن هناك ارتباط معنوي بين الثبات الثانوي والفك المستلم. تم العثور على علاقة غير ذات دلالة إحصائية بين قيم ISQ استقرار الزرع وقيم عزم الإدخال. لم يتم الإبلاغ عن اختلاف كبير فيما يتعلق بقيم عزم الإدخال بالنسبة إلى الفك المستلم لزرعات الأسنان.
 الاستنتاج: خلصت هذه الدراسة إلى أن قيم ISQ وقيم عزم الإدخال غير مرتبطة ، ويجب استخدامها بشكل مستقل لتقدير حالة زرع الأسنان مع واجهة العظم.

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