Determination of Implant Primary Stability: A Comparison of the Surgeon's Tactile Sense and Objective Measurements

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ABSTRACT

Background: Evaluation and measurement of primary stability could be achieved by several methods, including the resonance frequency analysis (RFA) and implant insertion torque (IT) values. The need for a sufficient primary stability, guaranteed by an adequate insertion torque and implant stability quotient values, increased its importance mainly in one stage implants or in immediate loading protocols. The aims of this study was to find if there is a correlation between the peak insertion torque (PIT) and ISQ values of implants inserted in the jaws of different bone quality which regarded as two important clinical determinant factors for prediction of implant primary stability, and to evaluate and compare whether an experienced clinician could precisely predict the primary stability of an implant on insertion with different surgical procedures using his own tactile perception.

Materials and methods: A total of (60) Iraqi adult patients, (28) males and (32) females, age ranged (22-66) years old were enrolled in this clinical prospective study. The maximum torque value recorded on implant insertion using calibrated manual torque ratchet adopting three categories: low (10 to 30 N/cm), medium (30 to 50 N/cm), and high insertion torque (50 to 70 N/cm). The oral surgeon was asked to indicate the perceived ISQs values according to his perception then Implant stability quotient were measured by Osstell ™. Bone density (type) was determined according to subjective bone resistance encountered while drilling as proposed by Lekohlm and Zarb.

Results: A total of 160 implants were inserted. The mean peak IT value was 49 ± 2.61N/cm. The mean ISQ value was 71.7 ± 8.86. Statistical analysis show a significant correlation between ISQ values and PIT values ($P<0.001$) , between IT values and bone types and between perceived primary stability and actual primary stability ($P<0.001$) .

Conclusions: The corresponding significant correlations between insertion torque, and ISQ values may help clinicians to predict primary stability on implant insertion, that may be associated with implant survival and success rates. A moderate reliability (correlation) between perceived ISQ values and those measured using RF analyzer(Ossttel device).

Key words:peak insertion torque, RFA, perceived primary stability. **(J Bagh Coll Dentistry 2017; 29(4): 65-71)**

INTRODUCTION

Primary implant stability is crucial for the long-term success of dental implants. It is of paramount importance to achieve osseointegration . Thus, the main goal for the oral implantologist, after dental implant surgical procedures, is represented by reaching a sufficient primary stability that ensures high success rates.[(2,3)]

Several methods for primary stability evaluation have been used, including resonance frequency analysis (RFA) and implant insertion torque (IT) values. Before these techniques were available, the surgeon was requested to evaluate the primary stability by percussion testing or by subjective perception during implant insertion unfortunately, these are still the most widely used methods in daily practice. [(4)]

Atsumi et al[(5)],reviewed various methods for dental implant stability assessment at time of placement and during healing period. It was established that resonance frequency analysis (RFA) is the most objective rather than other techniques of assessing implant stability during the different stages of implant treatment. The values recorded by RFA were noted as implant stability quotient ISQ.[(5,6)]

Insertion torque is an important factor for the implant primary stability at time of surgery and in deciding the loading protocol, which in turn is essential for implant survival. High IT values might lead to higher primary stability.[(7)]

Sennerby and Meredith[(8)], suggested that RFA and IT represent two different features of implant primary stability, with the first demonstrating the resistance to bending load and the later signifying the resistance to shear forces.

An important correlation can be established between bone density and insertion torque, both of which contribute to implant stability.[(6,8)]

Many studies positively correlate the ISQ and PIT values and other quantitative factors affecting implant stability.[(9,10)] On the other hand several studies [(11,12)]failed to find the level of correlation between the ISQ and PIT values. It is because of this discrepancy and inconclusive results in these previous studies that this study was conducted hypothesizing the presence of positive correlation between ISQ and PIT values.

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MATERIALS AND METHODS

This prospective study was conducted at the dental implant unit of the Department of Oral and Maxillofacial Surgery, College of Dentistry, University of Baghdad, during the period extending from November 2015 to August 2016. The study sample included patients who were seeking dental implant supported prosthodontic rehabilitation of single or multiple missing maxillary or mandibular teeth. Informed written consent to use their data for research purposes, approved by the scientific committee of the department of oral and maxillofacial surgery, was obtained from the patients.

Inclusion Criteria Included:

1. Absence of local or systemic conditions that would contraindicate dental implant surgery.
2. Patient aged over 18 years of either gender.
3. Partially or completely edentulous patients.
4. Sufficient bone volumes (height, length and width), with or without localized bone augmentation and narrow alveolar ridges .
5. Patients who are well motivated for implant therapy and maintaining good oral hygiene.

Exclusion Criteria

1. Patients who had general contraindications for oral surgery.
2. Evidence of residual infection at implant sites.
3. Presence of local pathological lesions in the area of implantation, as revealed by the clinical and/or radiographic examination.
4. Sites showing severe alveolar bone destruction and inability to achieve reasonable primary implant stability.

Clinical and Radiographical assessment

Thorough general extraoral and intraoral examination was conducted . All information were recorded in a special case sheet prepared for this study. A pre-operative panoramic radiograph (OPG) was obtained for all the patients.

Patients were instructed to rinse their mouths with chlorhexidine 0.12 % mouth-wash for 30 seconds before surgery, then the skin around the mouth was disinfected with a sterile gauze swapped by povidone-iodine solution . Surgery was performed by one experienced surgeon in all cases under local anesthesia with (lidocaine 2%, adrenalin 1:100000, 2.2 ml cartridge, Septodent, France), by block and/or infiltration technique on both the buccal and palatal/lingual sides.

A full-thickness mucoperiosteal flap was reflected and dental implant osteotomy site was prepared according to the manufacturers' instructions. The tactile perception of bone drilling was assessed during the penetration of the first bur while creating the initial drill hole. At this time the surgeon made an assessment of the bone density as type I, II, III, IV according to the scoring system devised by Lekholm and Zarb. [1] This assessment was based on the cutting resistance felt by the operator during preparing the implant site. After pilot drilling, the parallel pins were inserted inside the prepared holes to optimize the correct position and alignment of planned dental implants.

Sequential stepped drilling until reaching the suitable final drill size. Self-threaded titanium implant was inserted and tightened until a sufficient primary stability was achieved. The implant was inserted by using a manual non-calibrated implant ratchet supplied with the basic implant surgical kit or by the motorized way at speed of 20-40 rpm with a torque ranged between 35-45 N/cm .

Once the implant was nearly placed, a manual calibrated torque gauge ratchet(fig.1) was used to place the implant in its final position and the peak insertion torque(PIT) applied was noted on the torque gauge scale and recorded (fig.2).

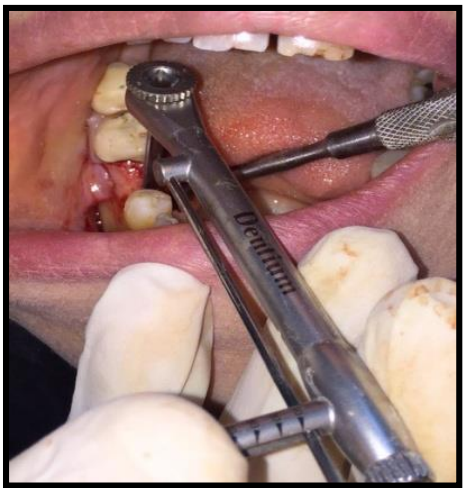

Figure 1: Implant insertion using manual calibrated torque ratchet

Figure 2: Manual calibrated torque ratchet with torque scale(10-70N/cm) (Dentium Co., Korea).

After implant insertion the surgeon was asked to indicate the probable RFA values (ISQs) according to his perception. After that, the actual ISQs were measured using the Osstell™ ISQ (Goteborg, Sweden, 4th generation) (fig.3) with

magnetic RFA measurements. The measurements were taken twice in the bucco-lingual and mesio-distal directions, the mean of the two readings represented the ISQ value for each implant at base line record.
The cover screw was coated with fucidin ointment 2% as a lubricant and tightened into the fixture. Finally, the flap was sutured back in place utilizing interruptive suturing technique with a 3/0 black silk suture.

Figure 3: Osstell TM ISQ (Goteborg, Sweden, 4th generation).

Study variables:-

Bone Type Assessment

For each implant site the surgeon made bone density assessment according to the scoring system classified by Lekholm and Zarb.[1] This assessment depend up on the resistance felt during cutting as preparing the implant site and placing the implant.

Evaluation of Peak Insertion Torque

Peak insertion torque was taken as the maximum torque value recorded during implant insertion using calibrated manual torque ratchet. The peak insertion torque records were grouped as follows: low insertion torque (10 to 30 N/cm), medium insertion torque (30 to 50 N/cm), and high insertion torque (50 to 70 N/cm).

Resonance Frequency Analysis

The RFA records were grouped as follows: low ISQ values (1 to 59), medium ISQ values (60 to 69), and high ISQ values (70 to 100).All values were recorded as the mean of two measurements taken along the buccolingual and mesiodistal axis which represent the dental implant primary stability.

Data collection and Statistical analysis

All data follow normal distribution tested using Anderson darling test, Chi square test was used to analyze the difference in distribution of discrete variables. Cohen's kappa analysis of agreement was used to assess the possible agreement (or disagreement) and it's magnitude for similarity between 2 discrete variables, results presented as kappa (k) which value range from -1 to +1, and can be interpreted as a rule of thumb values of Kappa from 0.40 to 0.59 are considered moderate, 0.60 to 0.79 substantial, and 0.80 outstanding. [13] Intraclass correlation used to analyze the reliability between two continuous variables (between perceived and actual stability), Bland Altman plot used which is a graphical method to compare two measurements techniques. All data were analyzed using SPSS 20 program and Microsoft Office Excel 2007. p values were considered to be significant if <0.05 (level of significance).

RESULTS

Sixty Patients (28males and 32 females), aged between (22-66 years old), who received (160) implants were included in the data record. The implants distributed according to arches as follow: (76.25%) of implants were placed in the maxillary arch and (23.75%) in the mandibular arch. The posterior sites received the highest numbers: (115) implants while (45) introduced in the anterior regions (table 1) .

Implant diameter (4.3 mm) was used in (34.4%) of cases, (3.8 mm) was used in (33.1%) of cases, (3.4 mm) was used in (29.4%) of cases and (4.8 mm) was used in (3.1%) of cases. The most prevalent length used was (12mm), followed by(10mm) , (14mm) and (8mm).

The mean PIT was 49 ± 2.61.The mean RFA was 71.7±8.86 ISQ. Ordinal regression analysis shows the presence of statistically significant ($p<0.001$) positive correlation between PIT and RFA,

The mean actual ISQ is 71.7±8.86, the mean perceived ISQ is 69.71±8.86, the percentage of dental implants perceived with low ISQ value is (3.12%) while with low actual ISQ value (10.62%), the percentage of dental implants perceived with medium ISQ value is (32.5%) while with medium actual ISQ value (18.75%), finally the percentage of dental implants perceived with high ISQ value is (64.37%) while with high actual ISQ value (70.62%).

Intraclass correlation analysis demonstrated that there is a moderate reliability (correlation), and since intraclass correlation coefficient **(**= 0.745), this indicate that there is a moderate agreement between perceived and actual primary stability (ISQ), but when using Bland – Altman method showed that there is fixed bias (2.3%) and since the confidence interval did not include (0%) this mean that there is a significant difference.(fig.4) .

The distribution of the implants inserted in healed sites by bone type is as follows: 3 in DI bone (1.87%), 54 in DII bone (33.75%), 101 in DIII bone (63.12%), and 2 in DIV bone (1.25%).
Statistical analysis of the present study revealed a significant correlation between PIT values and bone types (p=0.001), between ISQ values and implant diameters, ISQ values and gender, PIT and gender and between bone types and age. The non-significant correlations reported between ISQ values and bone types, ISQ values and implant lengths, PIT and implant dimensions, ISQ values and age, PIT and age and between bone types and gender.

Table 1: Distribution and mean PIT and ISQ of the implants by surgical area

	Maxilla	Mandible	Total
Anterior sites	43	2	45
Posterior sites	79	36	115
Total	122	38	160
%	76.25%	23.75%	100%
Mean IT value	48 ± 2.66	50 ±2.57	49 ± 2.61
Mean ISQ value	72.59 ± 9.53	71.16 ± 8.40	71.7 ± 8.86

Table2: Correlation between mean ISQ and insertion torque values

Primary stability	Insertion torque N/cm			OR	95%CI
	≤30	>30	>50		
Mean ISQ value	59± 19	69 ± 9	74 ± 8	0.92	0.89 – 0.96
P value<0.001					
Ordinal logistic regression analysis					

Table 3:Distribution and mean PIT and ISQ of the implants by bone type

Bone type	Implants number	Mean PIT value	Mean ISQ value
DI	3	36 ± 4.52	40.3 ± 19.1
DII	54	54 ± 3.02	73.1 ± 7.0
DIII	101	51 ± 1.52	71.8 ± 8.5
DIV	2	40 ± 2.91	64.5 ± 12

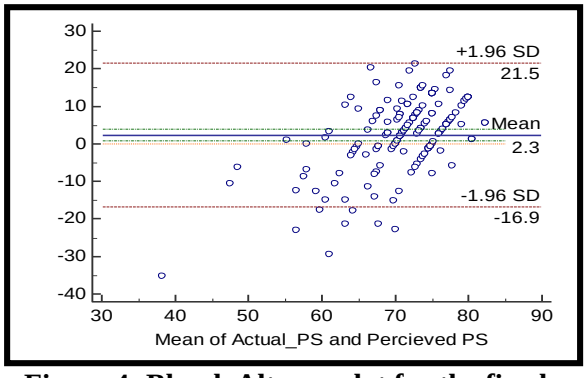

Figure 4: Bland–Altman plot for the fixed biased for the two measurements of primary stability (actual and perceived).

DISCUSSION

Primary stability has important influence on the successful outcome of implant treatment. Thus, the correlations among the techniques giving predictable information about implant stability (subjective bone classification during drilling procedure, insertion torque during implant placement, and RF analysis immediately after implant placement) may help the clinicians to determine proper treatment planning, implant design, surgical procedures and the proper time for early and-or immediate loading of dental implant, also this study aimed to find a correlation between these variables.
The results of this study reveal a significant correlation between total mean ISQ value 71.7±8.86 and total mean IT value 49± 2.61N/cm, the mean ISQ value for each IT category was respectively (low mean ISQ value 59±19 with IT ≤ 30 N/cm), (medium mean ISQ value 69±9 with IT >30 N/cm) and (high mean ISQ value 74±8 with IT >50N/cm). Since the odd ratio is less than (1.0) and the P value is less than (0.05) this indicate that when there is an increase in the IT value there will be an increase in the mean (ISQ) value , but there is a weak direct relationship between these two values in this study .
This result coincides with several recent studies that showed a significant positive correlation between IT value and ISQ value in which high measures of IT often associated with high implant primary stability ISQ readings.[9,10,14,16]
The clinical importance of such positive correlation between ISQ values and PIT values could be summarized in that it will provide the clinicians to use this convenient method (Insertion torque) for clinical determination of primary stability during dental implant placement as a supplemental and/or alternative method to RFA.
Many clinical, experimental, histological and radiological studies affirmed that there is no statistical correlation between ISQ values (primary stability) and placement torque (PIT) . [11,15,17]
The percentage of dental implants which have been seated with IT values >30N/cm and recorded ISQ values >65 was (81.25%), in other words 130 from 160 total number of dental implants that were included in this study, subsequently this high degree of primary implant stability is considered a key prerequisite for immediate or early immediate loading.
Although this study demonstrated no statistical significant correlation between bone type and ISQ values, there was a significant difference between bone type group (II and III) in relation to both type I and type IV regarding ISQ values, but this result cannot be adopted clinically because of the small sample size included in this study regarding bone type I and IV.

This result is in accordance with several studies using Lekholm and Zarb classification of bone quality in which no correlation between implant primary satability and bone quality had been reported.[19] Also many recent clinical studies using CBCT, CT scan for the recording bone density, maintain that there is no correlation between bone density and implants stability.[20,21]

The present study results show a significant association between peak insertion torque values and various bone types (P = 0.001) as illustrated in table (2).

The results of this study coincide with many different studies [14,22] which report a statistically significant correlation between the density values(bone types) and torque values in accordance with the Lekholm and Zarb index. Also several recent studies using micro CT and CBCT for bone mineral density measurements revealed a statistically significant correlation between bone density and insertion torque values table (3).[20,23,24]

In contrast, data from a clinical study[25] showed that there was no correlation between total mean placement torque and bone type as assessed by using the Lekholm and Zarb index (1985). This may be attributed to the subjective nature of the latter method which is purely based on the surgeon's perception of bone density during the implant site drilling.

Regarding the determination of perceived primary stability by surgeon tactile sense, there is a moderate correlation between perceived and actual primary stability (ISQ).

When the actual mean RFA values were divided into three different groups, it became clear that ISQ values were generally high or medium, while low ISQ values were quite rare. [8,26,27]

These data seem to confirm that RFA represent primary stability indicating the resistance to bending load and this could be explained due to the variations in surgical procedures that have been used in this research.

The results of this study revealed a non-significant correlation between the dental implants (fixtures) lengths and the mean ISQ values which is in line with other studies confirming that the use of long implant is not always essential for obtaining higher implant stability.[16,19, 28]

In contrast to this study, ,many clinical and experimental studies found that the implant length has no significant outcome on ISQ value when high level of bone stiffness is present; they also report that implant length could affect the ISQ values at seating of the implants [29,30]; but in an experimental study, Barikani et al concluded that implant length was a determinant factor to achieve more primary stability in low bone quality.[31]

The results of this study revealed a significant correlation (P=0.015) between the dental implants (fixtures) diameters used and the mean ISQ values, this study was in accordance with several studies, and this could be attributable to increase in the bone implant contact (BIC) surface area. [32,33]

In contrast to this study, some authors found that there was no significant correlation between implant diameter and ISQ values and they concluded that ISQ values are not dependent on diameter of implant. [34,35]

Many studies explained that the positive relation between implant stability (ISQ values) and implant length and diameter, related to the bone types (cortical and trabecular) and their locations in the jaws but not for length and diameter of the inserted fixture only.[28,36]

Diameter and length of the implants do not seem to influence the PIT values. This result is in keeping with many previous clinical and biomechanical reports.[16,37,38]

Many other clinical, in vitro and biomechanical studies demonstrated a statistically significant correlation between insertion torque values and dental implant fixtures diameters, maintain that insertion torque increases with the increase of BIC and the amount of cortical bone engagement on using a wider implant [16,37,39]

This study is limited in many aspects; first, the subjective assessment of bone quality and ISQ values was performed by a single operator without calibration. Second, there is no standardization in the surgical procedures of dental implants which may be considered as a confounder that can affect the ISQ and PIT reading. Third, the calibrated manual torque ratchet has limited accuracy due to the possibility of fatigue after prolonged use. The significant correlation between peak insertion torque and ISQ values may help clinicians to predict primary stability on implant insertion, that may be associated with implant survival and success rates. A moderate reliability (correlation) between perceived ISQ values and those measured using RF analyzer (Ossttel device).

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تعيين الثباتية الاولية لزرعات الاسنان: مقارنة بين الحاسة اللمسية للجراح و القياسات الموضوعية

الخلفية: تقييم وقياس الثباتية الأولية لزرعة الاسنان يمكن تحقيقه من خلال عدد من الطرق، بما في ذلك تحليل الترددات الرنينية لغرض قياس الثباتية للزرعات و لقياس الاندماج العظمي وقياس عزم الدوران المطلوب لتثبيت الزرعة. الحاجة إلى ثباتية اولية كافية للغرسة مقرونا بعزم دوران ووحدات ثباتية للزرعة عالية نسبيا ، زادت أهميتها بشكل رئيسي في البروتوكول التقليدي او البروتوكول الفوري لزراعة الاسنان. وكانت أهداف هذه الدراسة لمعرفة لايجاد ما إذا كان هناك علاقة بين عزم الدوران النهائي اللازم لتثبيت الزرعة بصورة نهائية ووحدات قياس ثباتية الزرعات باستخدام جهاز **Ostell ™ ISQ** في وقت الجراحة واعتبارهما كاثنين من العوامل المحددة لاستنتاج الثباتية الابتدائية للزرعة في وقت الجراحة. أيضا لتقييم ومقارنة ما إذا كان الطبيب ذوي الخبرة العالية في زراعة الاسنان يمكن أن يتنبأ بقيم ثباتية الزرعة اثناء اجراء عملية الزراعة عن طريق قابليته الحسية الخاصة.

المواد وطرق العمل: ما مجموعه (60) مريضا عراقيا بالغا ، (28) من الذكور و (32)من الإناث، تراوحت أعمارهم ما بين (22-66) سنة في هذه الدراسة السريرية. تلقوا ما مجموعه (160) زرعة سنية وضعت في كل من الفكين، (45) منهم في المنطقة الأمامية و (115) في المنطقة الخلفية للفكين. القيم القصوى المسجلة لعزم دوران الزرعات باستخدام آلة خاصة مدرجة لقياس قوة العزم النهائية سجلت ثلاث فئات: منخفضة (10-30 نيوتن / سم) والمتوسطة (30 إلى 50 نيوتن / سم)، وعزم دوران العالي (50-70 نيوتن / سم). تم قياس التغيرات الحاصلة في ثباتية الزرعات باستخدام جهاز **Ostell ™ ISQ** (غوتنبرغ، السويد، الجيل الرابع) خلال عملية الزراعة وبعد ادخال الزرعات بشكل تام داخل العظم ، طلب من جراح الفم للإشارة لقيم ثباتية الزرعات وفقا لتصوره. وتم تحديد كثافة العظام (النوع) وفقا لمقاومة العظام للحفر اثناء وقت الجراحة وفقا للتصنيف العالمي الذي استخدمه العالمان ليكهولم و زارب.

النتائج: ما مجموعه (160) زرعة سنية تم استخدامها. وبلغت متوسط القيمة النهائية لقوة عزم الدوران اللازمة لتثبيت الزرعات مع الانحراف المعياري (49 ± 2.61نيوتن / سم). كان متوسط ثباتية الزرعات مع الانحراف المعياري (71.7 ± 8.86) وحدة ثباتية زرعة. التحليل الإحصائي اثبت وجود علاقة ذات دلالة إحصائية بين قيم الثباتية وقيم قوة العزم ، وبين قيم العزم ونوع العظم وبين قيم الثباتية المتنبئة وقيم الثباتية المقاسة بالجهاز.

الاستنتاجات: إن العلاقة الايجابية بين قيم قوة عزم تثبيت الزرعة، وبين قيم ثباتية الزرعات المقاسة قد تساعد الأطباء على التنبؤ بالثباتية الابتدائية لزرعة الاسنان خلال عملية الجراحة، التي قد تترافق مع معدلات بقاء ونجاح الزرعات. هناك علاقة ارتباط معتدلة نوعا ما بين دقة الجراح الحسية في تقرير الثبات الأساسي للزرعة وقيم الثباتية المقاسة بجهاز **Ostell ™** .