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The Relationship Between Primary (Mechanical) and Secondary (Biological) Implant Stability: A New Measurement Technique

Mustafa Faisal J Al-Jamal*, Hassanien A Al-Jumaily

Department of Oral and Maxillofacial Surgery, Dental Teaching Hospital, College of Dentistry, University of Baghdad, Iraq

ABSTRACT

Backgrounds: Dental implants are regarded as treatment for patients who are completely or partially edentulous, thus, a significant requirement for osteointegration is implant stability.
Objectives: The aim of this study was to compare primary and secondary stability measured by Implant Stability Test (IST®) between different bone types and to compare implant stability at different time points during 3 months of follow-up.
Material and Methods: A total of 40 implants were placed in 16 patients (9 males and 7 females with a range of 22-61 years (mean age 40.44 ± 12.3 years). Bone quality was evaluated according to Lekholm and Zarb index during drilling procedure. After inserting the implant, stability was measured by implant stability test IST immediately, and after 3 months.
Results: A statistically significant correlations were found between primary and secondary stability using implant stability test IST® among different bone types.
Conclusions: The primary stability lead to more efficient secondary stability achievement with different bone quality, and the CBCT technique is an efficient method for bone quality types assessment, and significantly correlated with implant stability parameters and Lekholm and Zarb index.

Key words: Dental Implants, CBCT, Primary Stability, Implant Stability Meter, Secondary Stability, Surgical Perception

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Corresponding author: Mustafa Faisal J Al-Jamal
e-mail ✉ : ali.mario28@yahoo.com
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INTRODUCTION

Implant stability is one of the most important factors in successful implant treatment, and it tends to be essential for osteointegration, especially for immediate loading. Primary stability is a mechanical phenomenon, while secondary stability is the result of a biological event (osteointegration) [1].

Bone quality and quantity as well as implant design and operating technique affect implant stability [2].

Multiple classifications for bone density have been suggested [3] and the most common one is a Lekholm–Zarb classification 4-type scale proposed. This collection is based on radiographic assessments and bone resistance assessed by the surgeon during drilling [4]. Variety of devices and techniques are developed to assess implant stability, including insertion torque test, cutting torque resistance analysis, reverse torque test, mobility measurement test, and resonance frequency analysis. Although, percussion and radiographic evaluation are commonly used, their results are not always reliable even in fibrous encapsulation cases [5].

Recently new device known as Any check device® or IST (Implant Stability Test), this is an implant stability meter that measure the stiffness of the alveolar bone implant interface through a tapping-motion. It reduces the risk of implant failure by indicating the most suitable time for prosthetics attachments. Implant stability can be evaluated objectively, noninvasively, and easily by this device.

MATERIALS AND METHODS

Patients and implants

Sixteen healthy patients (nine males and seven females with mean age group 40.44 ± 12.312 years, range: 22-61 years), this study was conducted at College of dentistry/ Baghdad University/Department of Oral and Maxillofacial Surgery from November 2019 to June 2020. The study was approved by the scientific committee of the department. Each patient signed an informed consent letter

The patients were either fully or partially edentulous. The patients who had any systemic disease were excluded, The patients who had tooth extraction in the implant recipient

site less than 6 months ago were not included in the study to provide the standardization of bone maturation, The patients who had bone augmentation procedures before or during implant surgery were also excluded from the study.

A total of 40 implants (3.4, 3.8, 4.2 and 4.8 mm in diameter and 8.5 ,10, 11.5 and 13 mm in length), (Evoss, implant, Turkey) were placed in sufficient and mature bone without any fenestration and dehiscence.

Radiographical evaluation

CBCT imaging was performed for all subjects with (KAVO, Germany); using specially modified software Figure 1.They were categorized into 4 types based on the Lekholm – Zarb classification: type I, compact homogeneous bone; type II, thick layer of cortical bone surrounds the core of trabecular bone; type III, thin layer of cortical bone surrounds the core of trabecular bone; and type IV, very thin layer of cortical bone surrounds the core of trabecula bone with low density.

Figure 1: Cross-sectional cone beam computed tomography image of pre-implant area showing type III bone density.

Surgical procedure

All surgical procedures were performed under local Anesthesia using Lidocaine hydrochloride 2% with adrenaline1:80000. Then a full mucoperiosteal flap is raised, the preparation of implant osteotomy sites was carried out with standard drills of sequential diameters according to the manufacturer's instructions, until reaching the desired implant size. After preparation, the implant fixture was inserted until the implant is fully seated Figure 2 A and 2B). The implant system recommendation using dental implant engine (Dentium, Korea) set at 600-1000 rpm and torque equal 35 N/cm. wound closure is accomplished utilizing interrupted 3/0 Nylon sutures.

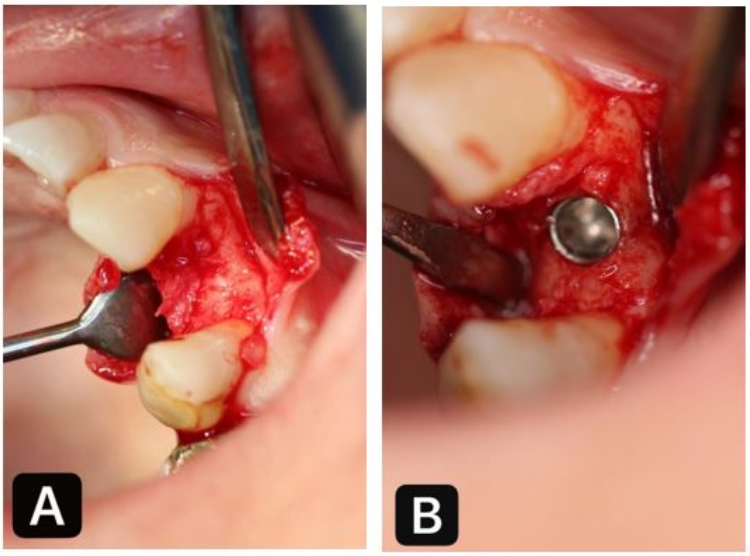

Figure 2: (A) Full mucoperiosteal flap reflection. (B) Fixure placement.

Evaluation of bone quality by surgical perception according to resistance to drilling

All implants were placed using a two-stage surgical procedure according to the manufacturer's instructions by the same surgeon. During drilling procedure, the surgeon scored the bone quality by tactile sensation according to resistance to drilling depending on the stiffness of the jawbone.

Implant stability test (IST®) measurement

Immediately after the implant placemen and three months after surgery, the healing abutment was attached, the implants stability was measure using (implant stability meter device IST®, Neobiotech Co, Seoul, Korea) Figure 3. Implant stability can be measured in less than 3 seconds, the light tapping of this device allows for safe measurement of implant stability. In low implant stability, the tapping-motion automatically stops after tapping twice while in the implants with high stability, the device taps up to 6 times.

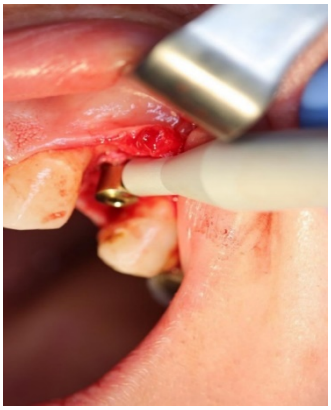

Figure 3: Implant stability meter (Any check device®) measure the implant stability immediately after installation.

Statistical analysis

The statistical analyses were performed using one-way analysis of variance ANOVA for descriptive and statistical test of implant stability meter IST (Immediately after insertion) and after 3 months among bone types. Pearson correlation coefficient (r) was used to assess the correlation. Between primary and secondary stability, and bone types. A value of P<0.05 was statistically significant.

RESULTS

According to the subjective bone quality types classification, 6 implants in type 2 bone, 15 implants were placed in type 3 bone, and 19 implants in type 4 bone. This study did not score type 1 for any implant site, with bone quality distribution 15 %, 37.50 %, 47.50%, type 2, type 3, type 4, respectively.

The mean implant stability meter IST immediately after insertion (primary stability), and after 3 months (secondary stability), (64.050 ± 8.814), (76.650 ± 4.447) respectively.

Descriptive and statistical test of implant stability meter IST (primary stability) and (secondary stability) among bone types, a statistically significant correlation observed with P<0.05 (Table 1 and Table 2)

A statistically highly significant correlations were found between primary stability IST® and secondary stability IST®, primary stability IST ® and bone type, secondary stability and bone type with (r=0.931, P=0.000), (r=0.742 , P=0.000), (r=0.742, P=0.000), respectively (Table 3).

Table 1. Descriptive and statistical test of implant stability meter IST (primary stability) among bone types using one-way analysis of variance (ANOVA).

Implant stability meter IST immediately after insertion (primary stability)							F	P value
Bone type	N	Mean	± SD	± SE	Minimum	Maximum		
Type 2	6	50.83	3.764	1.537	45	55		
Type 3	15	69.87	6.058	1.564	60	80	19.606	0.000 HS
Type 4	19	63.63	7.018	1.61	50	70		
p<0.01 HS (highly significant)								

Table 2: Descriptive and statistical test of implant stability meter IST (secondary stability) among bone types using one-way analysis of variance (ANOVA).

Implant stability meter IST after 3 months (secondary stability)							**F**	**P value**
Bone type	N	Mean	±SD	±SE	Minimum	Maximum		
Type 2	6	69.167	2.041	0.833	65	70		
Type 3	15	79.4	2.53	0.653	75	84	25.946	0.000 HS
Type 4	19	76.842	3.42	0.785	70	80		

p<0.01 HS (highly significant)

Table 3: Correlation between primary stability, secondary stability, bone type in the total implants. (Pearson correlation coefficient (r) was used to assess the correlation).

		2nd stability	Bone type
1st stability	R	0.931	0.746
	p value	0.000**	0.000**
2nd stability	R		0.742
	p value		0.000**
**=Highly significant at p<0.01, r>0.5 strong			

DISCUSSION

Stability of implants is one of the main considerations for effective implant therapy, primary stability is mechanical concept, number of factors may influence on it including, bone density, implant size, surgical operation [6]. On the other hand, secondary stability Is the outcome of a biological event, depends on, ossification around the implants [7]. According to our results, for all bone types, stability values increased in the following three months, these changes were a statistically significant.

Over time, many authors described changes in the stability of the implants [8]. founds the implants with low primary stability showed increase of implant stability quotient ISQ during the healing period, while implants with high primary stability showed reduction of stability values. Martinez et al. showed that primary stability was different among various bone densities, but secondary stability was similar [9].

Farré-Pagés et al. which found a statistically significant correlations between the bone density according to Lekholm – Zarb classification and ISQ value [10]. Furthermore Turkyilmaz et al. [11] Ikumi et al. [12], and Friberg et al. [13] showed a significant relationship between bone density and primary and secondary stability. Monje et al. suggested the primary stability leads to more efficient achievement of secondary stability, generally there is a liner correlation between primary and secondary stability [14].

These studies come with agreement with present study Were observed a statistically significant correlations between primary stability, bone density and secondary stability with p<0.01. On the other hand, several studies have demonstrated no correlations among bone density and primary and secondary stability. Beer et al. [2], there was no statistically significant relationship between bone density and primary stability. Furthermore Simunek et al. could not show a significant relationship between bone type and primary stability or primary and secondary stability [8].

In present study the primary and secondary stability Showed the correlation not significant with p>0.05, among the implant width and length. Han J et al. did not find a relationship of implant surface modification and diameter with ISQ value [15]. While Martinez H et al. found the implants with greater diameter have higher primary stability due to additional bone-to-implant contact (BIC) [9].

All implants within the time frame of this study were successfully Osseo integrated producing a success rate of 100%. No complication was observed in this study. This due to the CBCT examination before implant surgery that was helpful for evaluating bone type quality /density and predicting the stability of the implant, and implant stability test (IST®) that used in this study reduced the risk of implant failure by indicating the most appropriate time for prosthetic rehabilitation, degree of osseointegration was indicated, in addition the implant stability may be safely measured any time after the implant placement. The Measured value of implant stability test IST is like implant stability quotient ISQ scale, in case of weak stability, tapping motion automatically stops after tapping twice. Otherwise, taps up to six times.

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