



A CORRELATION BETWEEN IMPLANT STABILITY AND BONE HEIGHT MEASUREMENTS AFTER A ONE YEAR FOLLOW UP

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ABSTRACT

Background: Implant stability and bone height measurements have been identified as an important criteria for maintaining and achieving successful Osseo integration. Resonance frequency analysis (RFA) under the brand name of Osstell has been used to monitor implant stability during the various follow ups of clinical research owing to its high reproducibility. Cone beam CT (CBCT), recently has proved to be a valuable tool to detect bone height measurements in 3dimensions.

Materials and Methods: Three implants were installed in the mandibular inter-formainal region of ten completely edentulous patients. After three month from implant installation patients were divided randomly into two groups; ball attachment and locator attachment. Implant stability was recorded for all patients initially during implant installation and at the day of delivery of the attachment, then after 12 month follow up. CBCT was made for all patients at the day of loading and then after 12 month follow up period. A correlation between the ISQ values of all implants in both groups of patients and bone height measurements was made after a 12 month follow up.

Results: After a one year follow up, there was a significant poor positive correlation $r = 0.114$, p (2-tailed) ≤ 0.001 , between implant stability recorded using the Osstell (RFA), and bone height measurements recorded from CBCT.

Discussion: Osstell has proven to be used as a reliable tool for measuring the stiffness of bone –implant contact. An increase in the Osstell readings (ISQ values), would indicate an increase in implant stability during the different follow up intervals. Additionally, an increase in bone height measurements from CBCT, will indicate an increase in the amount of bone to implant contact. When correlating the implant stability values and the bone height measurements, a poor positive correlation was detected, indicating that over a one year follow up, an increase in implant stability (ISQ value) will be accompanied by an increase of bone to implant contact.

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INTRODUCTION

Implant stability and bone height measurements have been identified by ^{1,2}, as an important criteria to evaluate a successful osseointegration.

Assessment of implant stability will depend mainly on implant and bone related factors. Implant related factors will be concerned with the implant geometry, including thread shape and design, tapered or cylindrical implant, and the surface treatment of the implant. While bone related factors will consider the bone quantity and quality, with major concern to bone density ³.

A variety of methods and devices has been used to record and monitor implant stability such as; histologic analysis at the bone –implant interface, insertion torque, reverse torque, and percussion tests. All of these methods have many limitations lacking the required reproducibility and accuracy for monitoring stability.

The Resonance frequency analysis (RFA) was found with the commercial name of Osstell (Integration diagnostics AB)⁴. This method makes use of a wireless method that will deliver a sine wave signal to an aluminum smart peg that will be screwed to the implant. Numeric values ranging from 1 to 100 (ISQ units) that would correspond to the resonance frequency that is derived from the smart peg.

Resonance frequency analysis has been recently used as a validated tool for determining the implant initial primary stability and the prognostic outcome of implant installation⁵. It has been affected by many factors as bone quality and quantity, implant length and diameter and surface characteristics. Low or decreasing ISQ values will be indicative of an instable implant while on the other hand a high or increasing ISQ during follow ups will reveal implants that would maintain good stability. There is actually no prognostic value to indicate implant instability when considering RFA.

Recently Cone Beam Computerized Tomography (CBCT) has been used to analyze the different bone structures ⁶. In addition to that, the three dimensional (3D) image based planning software would enable the measurements of bone height and width in several dimensions and cross sections, overcoming all the limitation of the 2 dimensional peri-apical radiographs ⁷.

Several studies have reported the accuracy and reliability of the 3D image based planning software ⁸⁻¹². A study *have* compared the absolute errors between the CBCT and direct measurements of buccal bone height and buccal bone thickness and concluded that the errors were small with no significant differences or bias for under-estimation or over-estimation¹³.

Assessment of bone height measurements could be carried out either through a 2dimensional standardized peri-apical x rays, which would provide only mesial and distal bone height changes, on the other hand the use of the 3D CBCT will provide ; mesial, distal, buccal and lingual bone height measurements.

The aim of this clinical trial is to detect if there is any correlation between implant stability measured using the Osstell and the bone height changes recorded from the CBCT after a one year follow up.

MATERIALS AND METHODS

Ten completely edentulous patients were selected from the out- patient clinic of the Prosthodontics Department, Cairo University. The patients were selected to meet certain criteria. Patients' age ranged from 50 to 75 years old. They were also required to perform a glycosylated hemoglobin test (HbA1C); those with up to 8 HbA1C were included in the study. Inclusion criteria also entailed patients complaining that their lower dentures were not retentive, and those who have received complete dentures and were willing to install three implants in the lower

jaw. Exclusion criteria included patients above 75 years of age, patients with systemic conditions that would contraindicate implant placement, and TMD patients. Patients who refused to sign the informed consent or comply with the follow up instructions were also excluded from the study.

All patients included in the study received upper and lower complete dentures, following all of the conventional steps of fabrication. For those patients who already had their own dentures; retention, stability and occlusion of the both maxillary and mandibular dentures were checked.

After 6 weeks of adaptation with their complete dentures. The lower denture was then duplicated into a clear acrylic resin radiographic stent, CBCT were done for all patients to be used for pre-operative implant planning. The radiographic stent was then modified to be used as a surgical stent during implant installation. Implant installation Patients were instructed to have a dose of 2gm of amoxicillin 2 hours before the surgery. Drilling was commenced using the Implant Direct surgical kit. The implants** inserted were 3.7mm in diameter, and 10mm in length. Initial implant stability was recorded for all implants installed by screwing of the smart peg to each implant, and using the osstell to

record all of the four surfaces; mesial, distal, buccal, and lingual were recorded (**Fig1, Fig 2**)

A CBCT was made at the day of implant installation to be a base line value for recording bone height measurements. All Patients were instructed to be on painkillers for 48 hours after surgery. After 24 hours, the fitting surface of the dentures was relined using a soft liner. After 3 month from implant placement a secondary stage surgery was carried out for all Patients. A small crestal incision was made at the site of implant installation, and then a healing abutment was screwed to each implant to allow complete healing.

The ten completely edentulous patients were randomly divided into two groups: Ball attachment*** group and Locator**** attachment group. Randomization was carried out in sealed envelopes. Each patient was allowed to pick an envelope after the healing abutment was installed. Pick up of the attachment in each group of patients were then carried out. Ostell readings were recorded for all patients in both groups, and a CBCT was carried out at the day of loading of the implants.

Patients were recalled 12 month from the initial loading of implants, where implant stability and a CBCT was carried out.



Fig. (1) Osstell recording

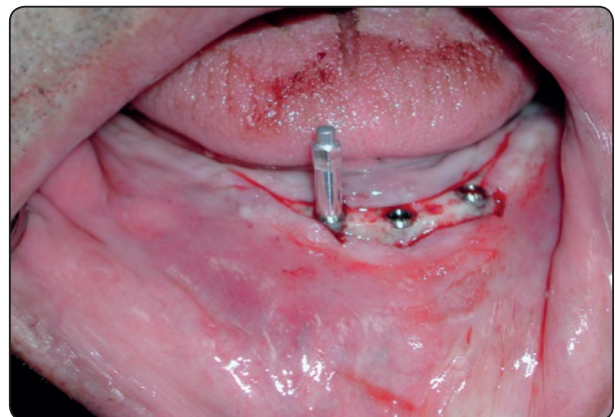


Fig. (2) Smart peg screwed to the implants

Bone height Measurements from the CBCT

A CBCT was made at the day of implant installation, then at the day of loading, then after 12 month. The Blue sky Bio soft ware was used for recording all of the measurements. All measurements were carried out from the first coronal point of bone to implant contact to the full length of the implant, in all the buccal, lingual, mesial and distal surfaces. (Fig 3,4,5)

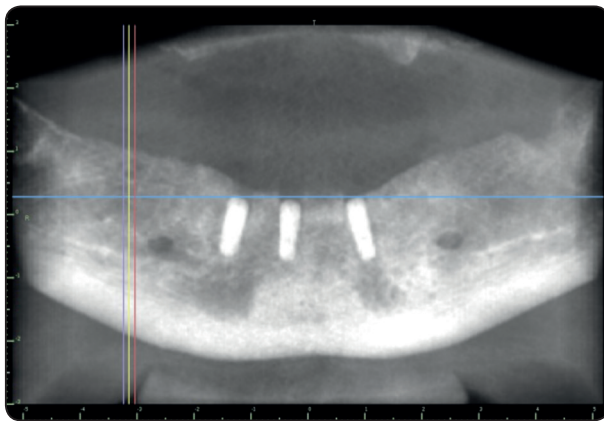


Fig. (3) CBCT showing 3 implants installed in the mandible

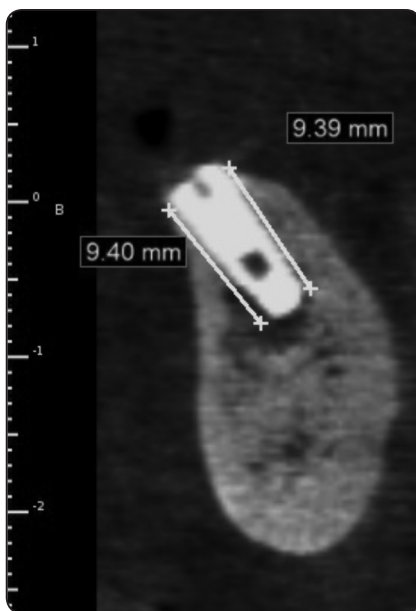


Fig 4: Cross section showing the buccal and lingual measurements (mm)

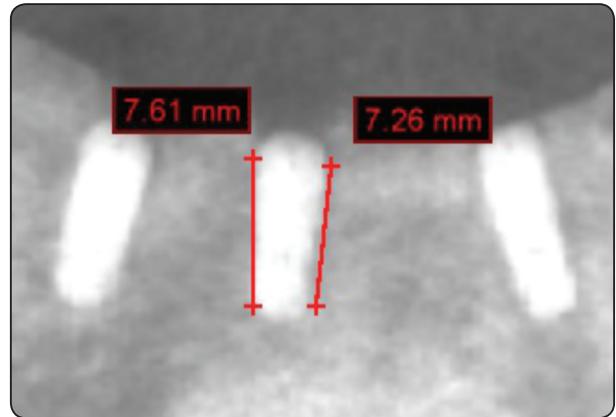


Fig. (5) Mesial and distal measurements

RESULTS

The mean and standard deviation values of each group were calculated. Data were explored for normality using Kolmogorov-Smirnov and Shapiro-Wilk tests and showed normal (Parametric) distribution. One way ANOVA was used to compare between different surfaces (B, P, M and D) in different groups. Independent sample t-test was used to compare implant stability and bone height measurements between two non-related samples for the two groups of patients; patients with a ball attachment and those with a locator attachment.

Pearson correlation was used to find the correlation between Stability and Bone height in each of Ball attachment and locator attachment groups.

The significance level was set at $p \leq 0.05$. The significance level was set at $P \leq 0.05$. Statistical analysis was performed with IBM® SPSS® Statistics Version 20 for Windows.

When comparing the mean ISQ values of implant stability of the four surfaces of each implant within each group of patients; receiving a ball attachment, and those receiving a locator attachment, there was no statistically significant difference between the mean values of the four surfaces; Buccal, Palatal, Mesial and Distal. Patients with a Ball attachment

where $p=0.642$ and patients with a locator attachment where $p=0.241$ after a 12 month follow up. As a result of the statistically insignificant values of four surfaces of each implant, the ISQ value of the four surfaces of each implant were added to obtain a mean that represent the ISQ value of each implant with in each group.

When comparing the four mean surfaces of bone height measurements of each implant it was found that there was no statistically significant difference between the Buccal, Palatal, Mesial and Distal with in each group of patients; the group receiving a Ball attachment where $P=0.300$ and the group receiving a locator attachment $P=0.141$ after a one year follow up. Accordingly, all of the mean bone height measurements of the four surfaces were added to obtain one mean value of bone height measurement for each implant.

When comparing the mean values of the ISQ of each implant and the mean value of bone height measurement between the two groups; the ball attachment and the locator attachment. There was no statistically significant difference between the mean values of the ISQ and the mean bone height measurement between the two groups after a 12 month follow up (*Table 1*).

TABLE (1): Mean values and standard deviations of mean scores of ISQ and bone height measurements in mm after 12 month follow up.

Variables	Stability		Bone height measurement	
	Mean	SD	Mean	SD
Ball attachment	72.51 ^a	5.08	10.73 ^a	1.51
Locator attachment	70.27 ^a	5.36	10.32 ^a	1.46
<i>p-value</i>	0.165ns		0.132ns	

A General correlation was made between the mean ISQ value of each implant and the mean value of bone height measurements in both groups. A

significant poor positive relationship between the mean ISQ value of implant stability and the mean value of bone height Measurement was found, $r = 0.114$, p (2-tailed) ≤ 0.001 .

TABLE (2): correlation between mean value ISQ and mean bone height changes after a 12 month follow up.

Variables	General Correlation	
Stability and Bone height measurement	Correlation coefficient	+0.114
	Sig. (2-tailed)	$\leq 0.001^*$

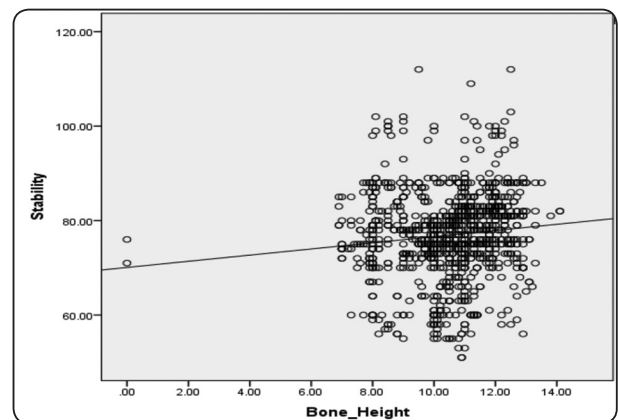


Diagram showing a poor positive correlation between stability and bone height changes after a 12 month follow up.

DISCUSSION

Initial and secondary implant stability, together with bone height measurements are two very important determinants for successful Osseo integration. Osstell device has been one of the most recently reproducible and accurate device to record implant stability throughout the different follow up intervals. Maintaining an ISQ value of greater than 60 is interpreted as a “stable implant”, while ISQ values below 50 would indicate very cautious measures has to be followed when directing loads to this implant and would make the prognosis of this implant very unpredictable.

CBCT allowed measuring and detecting any bone height changes that are in direct contact with the four surfaces of the implant; facial, mesial, distal and lingual. All efforts are being directed to minimize crestal bone level changes following implant installation and to preserve the facial bone¹⁴, by avoiding; peri-implantitis¹⁵, improper three-dimensional implant positioning¹⁶, poor implant design and horizontal loads directed towards the implants¹⁷.

An important goal of successful osseointegration, is maintaining an implant stability ISQ value of 60, with minimum bone height changes of less than 0.2mm per year. The osstell device have very successfully monitored the implant stability ISQ values, and the implant to bone contact, and can predict bone loss or bone pattern changes¹⁸. A decrease in marginal bone height of greater than 2mm, will probably result in a decrease in the ISQ value. In the present study, a poor positive correlation has been identified when correlating the ISQ values and bone height changes; which indicates that an increase in osstell values will be accompanied by an increase in bone height changes or bone height changes that would be less than 2mm. This will come in accordance with a study¹⁹ that identified that both the periostest and osstell can detect marginal bone loss of greater than 2mm, this would agree with all of the clinical findings which have studied stability and marginal bone height changes^{3,20}. It was concluded that both the osstell and periostest device were unable to identify periapical bone loss, only when a large volume of bone has been removed¹⁹.

The small sample size, and the short follow up period could be some of the limitations of this study, accordingly recommendation of a larger sample size with longer follow up period would probably result in more conclusive results.

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