

## BEHAVIOR OF IMPLANT STABILITY DURING IMPLANT TREATMENT: IN VIVO STUDY

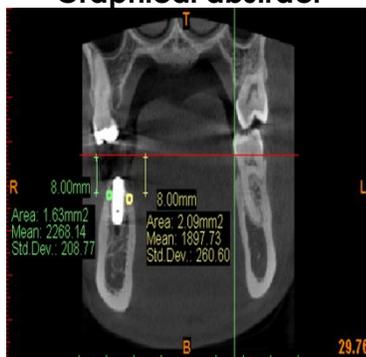
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### Graphical abstract



### Abstract

Implant stability is essential parameters that indicate the success of the implant treatment. However, the relation between implant stability, osseointegration and also remodeling process during that period is still unclear. This study was to evaluate the behavior of implant stability during implant treatment period. To investigate the behavior of the implant stability and its relation with quality and quantity of the bone during implant treatment, eight dental implant patients have been involved. Series of monitoring stages were conducted. The implant stability for each stage were measured using Resonance Frequency Analysis (RFA) device and the behavior of quality and quantity of the bone during treatment have been monitored by using CBCT data. The phases of monitoring are divided into 3 phases; phase 1 is immediately after implant insertion, phase 2 is immediately after crown installation (4 month after implant insertion), and phase 3 is 1 month after crown installation (5 month after implant insertion). The results were tabulated and analyzed using statistical software namely SPSS 20.5 to examine the correlation between basic measurement of bone quality and quantity and ISQ. The results show that during 4 month after implant insertion period, the density of bone around the implant are decrease, this period was predicted as remodeling process. After 5 month since implant insertion, the density start to increase. This phase possibly indicated the starting phase of osseointegration process. In addition, the ISQ for each patient was increased significantly. The primary implant stability was correlated with the space availability and bone quantity and quality, the result shows that the implant stability is proportional with the height of the mandibular and cortical thickness and inversely with width of mandibular. The highest correlation with the primary implant stability is the product of cortical thickness with the height of mandibular. There is a significant correlation between implant stability (ISQ) with dimension of site implant and density of bone.

**Keywords:** Implant stability, bone quality and quantity, implant insertion

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## 1.0 INTRODUCTION

The success of implant treatment correlates with the achievement of high implant stability in long life of implant. Not only primary implant stability, the secondary implant stability also supports the success rate of the implant treatment. However, the report on the characteristic or behavior of the implant stability during implant treatment is still rare. This paper discussed the behavior of implant stability during

implant treatment on delayed immediate (two phases) implant, in vivo study.

To achieve the success of implant dentistry, there are many factors that should be considered such as: bone quality and volume, peri-implant clinical parameters, implant stability, factor related to the surgical technique and the selection of the implants itself [1]. Monitoring on behavior of those factors can give same descriptions about the progress of remodeling and osseointegration of the bone. This information can provide the early diagnostic for the

status of the implant and can be considered in the next clinical treatment and diagnostic.

## 2.0 MATERIAL AND METHODS

### 2.1 Study Sample

The ethical approval for this study was obtained from the Human Research and Ethics Committee of University Sains Malaysia (USM) [No.254.4 (1.3)].

The studies involved eight dental implant patients that consist of 3 males and 5 female with range of age from 25 to 55 years old. All the patient are in sufficient level of oral hygiene, there is no infection was reported during period of treatment and each patient was treated with the MEGA GEN implant for replacing one of the edentulous of molar tooth on mandible. The dental implant treatments were performed by specialist in USM hospital.

In general, the monitoring stages are grouped into three stages; stage 1 is conducted in the same day

with the implant placement, stage 2 is conducted about 3 months after implant placement which represent the pre loading condition, and stage 3 is conducted 4 month after implant placement or 1 month after crown installation, this condition represents the post loading condition. For every stages, the RFA and bone quality are measured.

### 2.2 RFA Measurement

Implant stability was evaluated using Ostelltm mentor device (Integration Diagnostic AB, Goteborg, Sweden) with the smart peg abutment from same manufacturer. This measurement is based on the resonance frequency analysis (RFA) with the result is provided in the Implant Stability Quotient (ISQ) with the scale ranges from 0 to 100 [2].

The RFA measurement is performed by mounted the smart peg into implant and tightened it. The transducer with L-shaped was directly connected perpendicular to the implant as recommended by the manufacturer (Figure 2). The measurements followed the Barewal (3) and Bischof (6) protocol.



(a)



(b)

**Figure 1** a) Implant insertion surgery b) Implant stability measurement using RFA Ostell mentor device

### 2.3 Bone Quality and Quantity Measurement

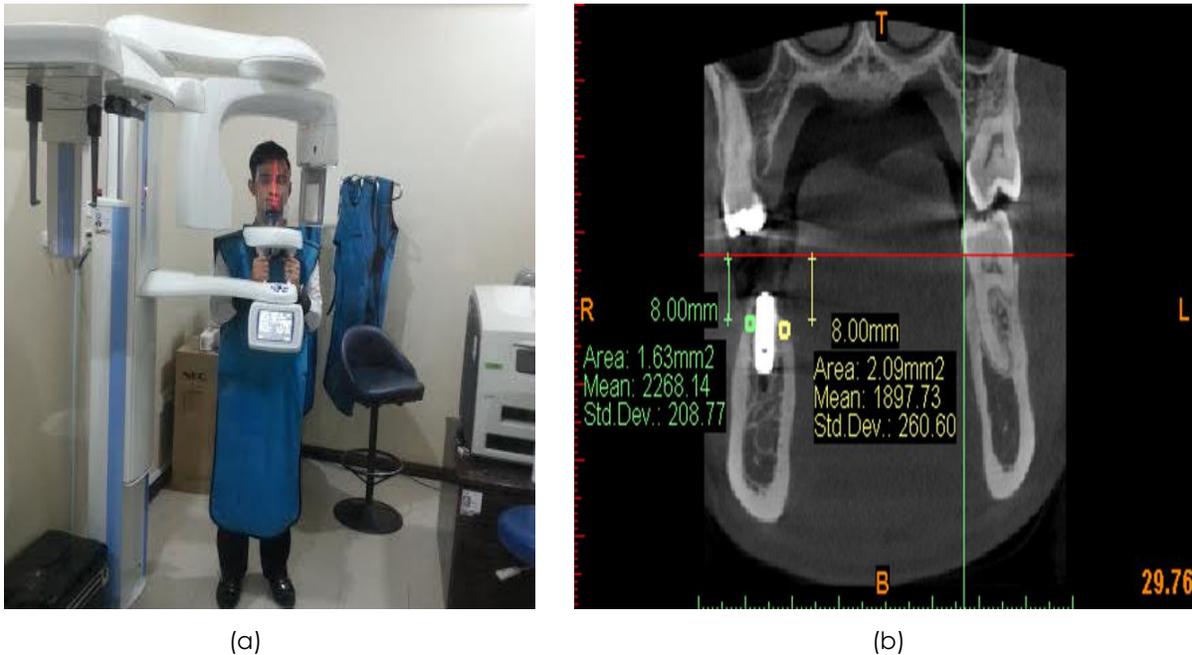
Bone quality and quantity were evaluated through CBCT scanning. The CBCT scanning were taken using CBCT machine (Promax 3-D, Planmeca, Finland) with the voltage, current, resolution, and field of view (FOV) are same in every stage measurement. The CBCT parameters are: 84 kVp, 8 mA, 320- $\mu$ m voxel resolution, and FOV of 16 cm. The effects of different angle are minimized by maintained the same position for every scanning. The standing position with the head upright positioned so that the intersection lines were straight horizontally and vertically through the center of the region of interest is used as reference position (see

figure 2). The CBCT data was interpreted using MIMICS software and evaluations on densities of bones were conducted in the location near to implant at level 8 mm from Cemento Enamel Junction (CEJ) level. The cortical thickness of bone also measured at this level. While the height and widths of mandibular were measured in the location close to the implant.

### 2.4 Data Analysis

The statistical analysis including correlation and comparisons were performed based on paired T-test using SPSS 20 software package. The statistical

significant has determined by set the confidence levels of  $P < 0.05$ .



**Figure 2**(a) Patient position for CBCT measurement (b) CBCT data processing in meimics

### 3.0 RESULTS

#### 3.1 Cortical Thickness And Space Availability

The cortical thickness, width and height of mandibular were measured to investigate whether these parameters related to the primary implant stability. The plot between these parameters with primary implant stabilities are shown in Figure. 3.

#### 3.2 Bone Density Behavior

Bone density around the implant has been monitored during implant treatment by using CBCT scanning for every stage. The density of bone was estimated using MIMICS software with the density tools facility. The measurement was conducted on both buccal and lingual side and the average value of it was used to represent the density of this area. The result of eight

patients for each stage measurement is shown in Figure 4.

The densities in two patients were decreasing monotonly from stage 1 to stage 3, decrease from stage 1 to stage 2 and increase again from stage 2 to stage 3 in the four patients, and the densities was increase from stage 1 to stage 3 in the two patients. In general, the mean of density was decrease from stage 1 to stage 2 (significant  $P=0.17$ ) and increase again from stage 2 to stage 3 (significant  $P=0.122$ ) as shown in Figure 3 (red-bold line). Statistically, the bone density decreasing significantly from stage 1 to stage 2 and increase not significantly from stage 2 to stage 3.

#### 3.3 Bone Density – Implant Stability Relation

The relation between bone densities that are estimated based on HU of CBCT with Implant stabilities that are measured in ISQ for each stage of all patients are shown in Figure. 5.

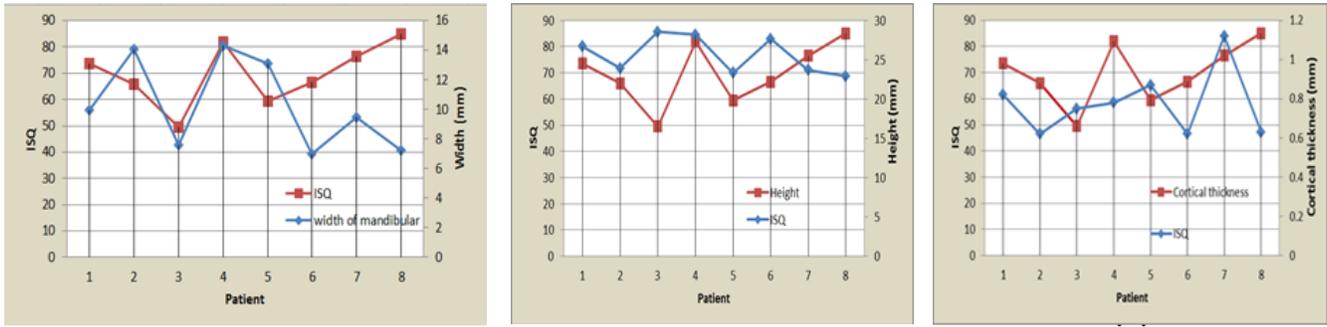


Figure 3 Primary implant stability relation with a) Width of mandibular b) Heigh of mandibular and c) Cortical thickness of mandibular bone

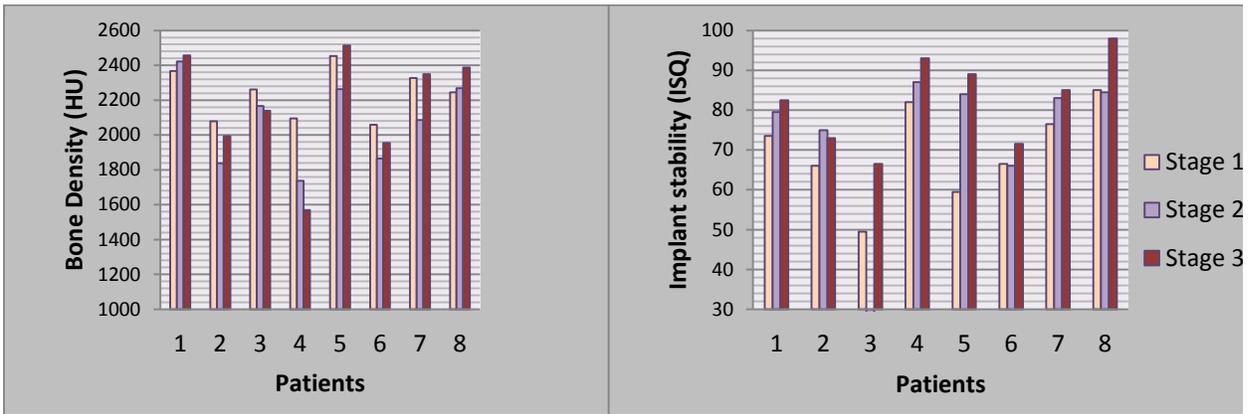


Figure 4 (a)Plot of bone density and (b) Implant stability, for every patient in every stage

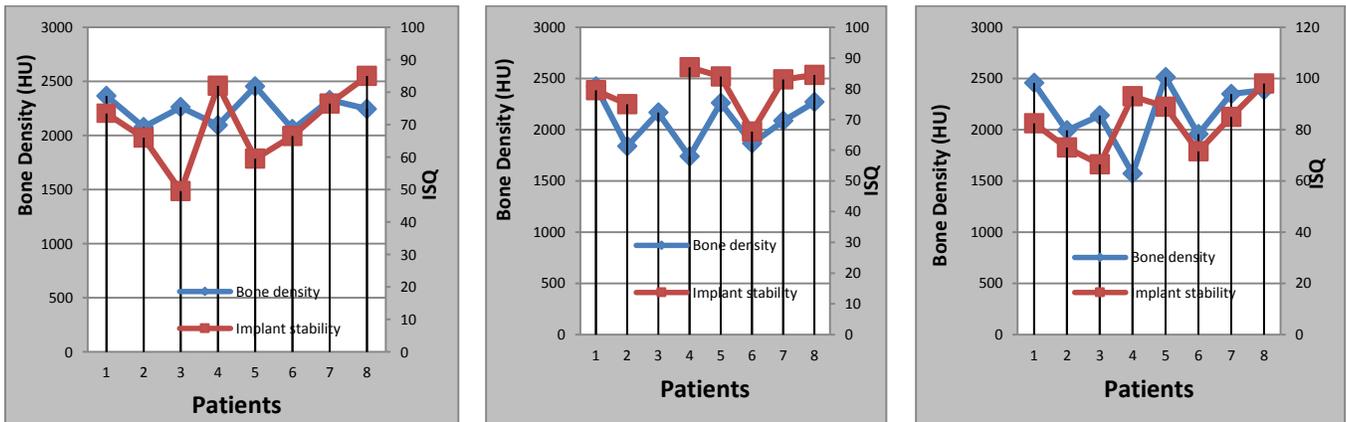


Figure 5 Bone density and implant stability plot a) Stage 1 b) Stage 2 and c) Stage 3

### 4.0 DISCUSSIONS

Implant insertion into dental system can be regarded as biomechanical system that integrated the effect of biological processes of dental system and mechanical properties of the environment surrounding the implant. Not only the size of the

implant that contributes to implant stability [3] which the certain shape of implant is recommended for certain condition but also the bone quality and quantity for the implant such as cortical thickness and density of bone has been reported have strong correlation with implant stability [4][5][6]. Plotting between size of space availability for the implant shows that the trend of variation on width of

mandibular associated with the change of implant primary implant stability as shown in the Figure. 3.a-b. The patient with wider or higher dimension of his/her bone and the cortical thickness has high primary implant stability.

Figure 4 shows the plot of density and implant stability which is measured for each stage of monitoring. The results shows that the most patient underwent the decreasing on bone density from stage 1 to stage 2 which is the gap time is about 4 month and some patient underwent the increasing in bone density after stage 2. It is possible to correlate the decreasing in bone density with the healing process or remodeling process of the bone post-surgery which is happen until 4-6 month [7] or 3-4 month for lower jaw [8]. Fortunately, mostly the implant stability was increase since stage 1 to stage 3, even the increasing in implant stability is not too significant from stage 1 to stage 2 compared with from stage 1 to stage 3. The implant stability increases significantly after stage 3. This increasing on implant stability possibly indicates that the osseointegration have been started.

The correlation between bone density and implant stability qualitatively is shown in the Figure 5. In each stage the variation in bone density of the patients were followed by implant stability changes. The increasing in density is proportional with increasing in implant stability. It is possible that osseointegration that caused the bone density increase has been achieved. If so, it will give us the expectation that monitoring of density using radiology technique such as CBCT can be used as an alternative method for monitor of implant stability.

## 5.0 CONCLUSION

There is a correlation between dimension of implant site that are width and height of mandibular and also cortical thickness and density of bone. However, the significant correlation still needs to be investigated further by involving more patients.

The density around the implant decreased during 4 month after implant insertion which is predicted as remodeling process as showed in the monitoring result

from stage 1 to stage 2. After stage 3, the implant stability increase significantly compared with stage 1, it is possible that the osseointegration occurred after 5 month since implant is inserted.

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