

Pre-implant computed tomography and insertion torque measurement in qualitative determination of trabecular bone density

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ABSTRACT

Background: Bone density is a very important factor in the successful plan of implant treatment. The aim of the study is to evaluate the trabecular bone density of potential dental implant sites in different region of the jawbone by using Computerized Tomography (CT) , and the relationship between bone density and insertion torque.

Materials and method: In this clinical study 64 patients were treated with 120 Xive FRIADENT DENTPLY system implants. The implant recipient sites were divided in two groups according to gender; 60 in males and 60 in females and each group was divided into subgroups according jaw (maxilla and mandible) and region (anterior and posterior). The bone density of each implant recipient site was recorded in Hounsfield units (HU) using CT. The maximum insertion torque (Ncm) values were recorded with torque controlling motor.

Results: There was a significant correlation between bone density and insertion torque in males ($r=0.983$, $p < 0.001$) and females ($r=0.955$, $p < 0.001$). The trabecular bone density values were (682 ± 98 HU, 481 ± 104 HU, 413 ± 92 HU, and 263 ± 67 HU) values in the anterior mandible, posterior mandible, anterior maxilla, and posterior maxilla, respectively. Trabecular bone density was higher in males in comparison to females and the bone quality was higher for the mandible than for the maxilla, and higher for the anterior region than for the posterior region of these bones. In females there is no significant difference in bone density ($p < 0.05$) between the posterior mandible and anterior maxilla and between males and females at posterior maxilla ($p < 0.001$).

Conclusion: Trabecular bone density is a key determinant for clinical success; CT is a useful tool for assessing the bone density

Key words: dental implants, computerized tomography, insertion torque, bone density. (J Bagh Coll Dentistry 2012;24(2):56-61).

INTRODUCTION

Dental implants have become a popular alternative in oral rehabilitation in the past two decades; even though the clinical outcome of an implant is influenced by many factors, including the implant body, skill of the surgeon, and the oral environment. The key factor for success is the primary stability at implant placement. The quality of the alveolar bone is the most important factor for achieving good primary stability ^(1, 2). There are many different definitions of bone quality, but it is generally presented as the sum of all of the characteristics of bone that influence its resistance to fracture ⁽³⁾. The term 'bone quality' was introduced to refer to the different bone density types. In the field of dentistry, Lekholm and Zarb classified jawbone density into four types based on the amounts of cortical bone versus trabecular bone evident on pantograph film ^(4, 5). Computed tomography (CT) is one of the most useful medical imaging techniques for assessing not only the structure of the body tissue, but also its density. Theoretically, the bone density, which is measured in Hounsfield units (HU), is directly related to the tissue attenuation coefficient ⁽⁶⁻⁸⁾.

Some researchers have reported that CT is a good tool for evaluating the bone density at potential dental implant sites ^(2, 4, 7, 9-17). The quality of bone in the jaw has been studied previously ^(4, 9, 11) but not in the Asian population. The aim of this study was therefore to evaluate the trabecular bone density of potential dental implant sites in different regions of the Iraq jawbone using CT images.

MATERIALS AND METHODS

A total of 73 Iraqi patients aged 23-45 years old, males and females, attend our private clinic in Holy Karbala' City. The study extended from November 2010 to July 2011. Out of these 73 patients full or partial edentulous, 64 subjects (31 males & 33 females) were included in this study. The implant recipient sites (120) were divided in two groups according to gender; 60 implant recipient sites in males and 60 implant recipient sites in females and each group was divided into subgroups according to the jaws (maxilla and mandible) and regions (anterior and posterior). 15 in anterior maxilla, 15 in posterior maxilla, 15 in anterior mandible and 15 in posterior mandible.

Selective criteria of study sample:

The patients were selected according to medical and potential implant site evaluation as follows:

(1) Master Student, College of Dentistry, University of Baghdad.

(2) Assistant Professor, Department Oral Radiology, College of Dentistry, University of Baghdad.

a- Medical evaluation:

Sample individual should have no history of any systemic disease that might affect bone metabolism like

- 1- Diabetes Mellitus.
- 2- Tuberculosis.
- 3- Cushing's syndrome.
- 4- Hyperparathyroidism.
- 5- Generalized osteoporosis.
- 6- Heavy smokers.
- 7- In patients with a long period of time having steroid therapy.
- 8- Radiotherapy (60GY) in patients with head and neck cancers⁽¹⁸⁻²⁰⁾.

b- Potential implant site:

- 1-The Region of interest is larger than 9.6mm².
- 2- Diameter greater than 3.5mm.
- 3- longer than 6 mm in the alveolar trabecular bone.

MaterialX-ray machine

A spiral Computed Tomography (CT) machine (GE LighSpeed VCT, 64 slice, USA) (in IRAQI MEDICAL CENTER- Holy KERBALA City) which will be calibrated daily according to the manufacturer's instruction.

A range of 5 cm will be covered in 9.9 seconds, Kv 140, mA 334, rot 0.50 second, slice width 1.25 mm and pixel size 512x512.

Dental implant:

The dental implants used in this study are XiVE Dentsply Friadent system. XiVE implants are available in diameter D 3.0- D 5.5 mm and in lengths of 8-18 mm.

Torque controlling motor:

High torque micro motor (FRios unit Si DENTSPLY FRIADENT), (W&H; Austeria) and contra-angle speed reduction (20:1) hand piece (W&H; Austria).

Statistical data analysis:

The data were processed and analyzed using SPSS (Statistical Package for Social Sciences) version 19 computer software.

- A. Use t-test to compare the mean of two groups (males and females).
- B. Pearson correlation to test the linear relationship between each two variables (average bone density and insertion torque).
- C. ANOVA test to test for differences in means of more than two groups. When the result proves significant this would be followed by LSD test.
- D. LSD (Least significant difference test) to check which two groups are different

(anterior mandible, posterior mandible, anterior maxilla and posterior maxilla.

- E. P value of less than the 0.05 level (P<0.05) of significance was considered statistically significant.

RESULTS**1-Relation between the average bone density (BD) and the maximum insertion torque (torque) in males and females**

The BD and torque in males (541±229 HU, 33±8 N cm) were higher than females (378±123 HU, 27 ±4 Ncm) and highly significant difference between males and females as shown in table (1).

There is significant correlation between average bone density and maximum insertion torque in males and females table (2).

2- Relation between the maxilla and mandible in average bone density (BD) and the maximum insertion torque.

BD and the torque were significantly higher in the mandibles (581±202 HU, 35±4 N cm) in comparison to the maxillae (338±80 HU, 26±3 N cm) and highly significant difference between mandibles and maxillae. There is significant correlation between average bone density and the maximum insertion torque in maxillae and mandibles table (3).

There is significant correlation between BD and the torque in maxillae and mandibles table (4).

3- Relation between the maxilla and mandible in average bone density and the maximum insertion torque at each region in males and femalesIn males

Higher BD and the torque had been found in the anterior mandible followed by the posterior mandible, then anterior maxilla and the last posterior maxilla. For the differences among the four regions in males figures (1) & (2); ANOVA test show a high significant difference in the BD and the torque in regions (p< 0.01). The LSD test also shows a high significant difference in the BD and the torque in each region in relation to others.

In females

Higher BD and the torque had been found in anterior mandible followed by the posterior mandible, then anterior maxilla, and the last posterior maxilla. For the differences among the four regions in females' figures (1) & (2). ANOVA test shows a highly significant difference in the BD and the torque in regions. The LSD test also shows a no significant difference in the BD and the torque between the posterior mandible and the anterior maxilla (p<0.05).

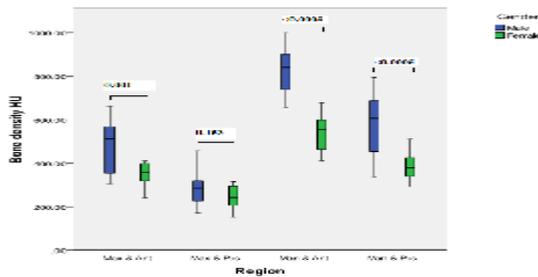


Figure 1: Box chart average of bone density in different regions in males and females

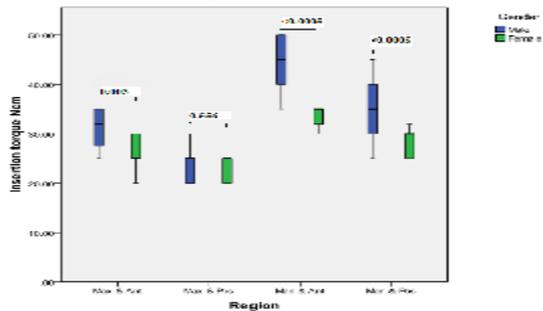


Figure 2: Box chart maximum insertion torques in different regions in males and females.

DISCUSSION

Bone density

Many studies have demonstrated that the survival rate of an implant is significantly affected by the host bone quality (21-25), and hence a preoperative evaluation of the bone condition is essential for assisting the dentist when planning implant therapy.

The use of CT, which is more objective and reliable for the assessment of the bone density of the patients requiring implant therapy, was introduced (26).

In this study, alveolar trabecular bone density was evaluated in different regions of the jawbone from spiral CT images.

It is not passable to make a direct comparison between the present study and previous studies because many previous studies on the bone density from CT included cadaver specimens (29-32).

In the present study, the male patients had a higher average bone density value at the implant sites than that in female patients (the mean of average bone density of all implant recipient sites was 541±229 HU in males; while in females 378±123 HU), there was a statistically higher significant difference in the average bone density of implant sites between males and females.

This finding may be explained with the hormonal peculiarities in females and generally higher bone mass in males. Previous studies

including the measurement of the bone mineral contents in the jaws and forearms have already indicated that, when compared to the males, lower bone mineral densities in females have been found throughout adult life (33). However, this finding is in agreement with (28,34).

In the present study, the difference in the average bone density of the implant recipient sites between the mandibles (581±202 HU) and the maxillae (338±80 HU) was statistically of high significance for all patients, this finding is in agreement with (35), who reported that the difference in the average bone density of the implant sites between the mandibles (828 ± 245 HU) and the maxillae (582 ±192 HU) was statistically significant for all patients.

The mean bone densities recorded in this study are lower than those reported by (35, 36) table (1), which might be due to the previous measurements including the trabecular bone and the outer cortical shell. The density of cortical bone is significantly higher than that of trabecular bone. However, we observed higher mean bone densities than did (37), which might be due to the use of different types of software. In the two studies de-Oliveira et al indicated that this could yield different bone density values from the same CT images.

In addition, the ranges of the mean bone density in the present study are broadly consistent with those of (38, 39) table (5). The differences between the present study and the previous studies come from the distribution of implant recipient sites. Because the effect of number of implant sites in region was neglected in previous studies.

As the bone is reduced in volume to C shape minus height (C-h), especially in the anterior mandible. The C-h mandible often exhibits an increase in torsion or flexure in the anterior segment between the mental foramens during function. This increased strain causes the bone to increase in density (40). In this study and all previous studies was found that most density was in the anterior mandible (35-39).

The bone density recorded in the present study were (682±98 HU, 481±104 HU, 413±92 HU, and 263±67 HU) values in the anterior mandible, followed by the posterior mandible, anterior maxilla, and posterior maxilla, respectively.

Shapurian et al. (38) found that the mean bone density was lower in the posterior mandible than in the posterior maxilla (in contrast to the results of the present study). These discrepancies might have resulted from the distribution of implant recipient sites, because a relatively high number

of their implant recipient sites were in the posterior mandible which has the lowest bone density values.

In this study, it has been observed that the average bone density value of the implant sites in the anterior regions of jaws was higher than that in the posterior regions (anterior mandible–posterior mandible; anterior maxilla–posterior maxilla).

This finding is in conformity with those reported by ⁽³⁵⁻³⁹⁾.

In the present study there is no significant difference in the mean bone density between the anterior maxilla and the posterior mandible in females, while in males there was a statistically significant between the posterior mandible and the anterior maxilla. This finding is partially in agreement with ⁽³⁵⁾; stated that there are differences in the average bone density of the implant sites that was not statistically significant between the posterior mandible and the anterior maxilla.

Insertion torque

The insertion torque is the latest value seen on the screen was recorded. Starting from 20Ncm, the insertion torque was increased in steps of 5Ncm, when the rotation stopped due to friction before the implant was fully inserted. Only a limited amount of torque could be applied in order to avoid mechanical overload of the equipment on bone tissue.

Statistically significant strong correlations between bone density and insertion torque were found at implant placement. This fact concurs with the previous studies ^(36, 39, 41, 42).

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Table 1: Comparison of BD and torque in males and females at level (p <0.01).

Males and females	t	Sig.
BD	4.840	0.0005
Torque	4.364	0.0005

Table 2: Correlation between average bone density and maximum insertion torque in males and females at the (p<0.01) level.

		Gender	
		Males	Females
BD	Pearson correlation	0.983	0.955
	Sig.	0.0005	0.0005

Table 3: Comparison of BD and torque in mandibles and maxillae at level (p <0.01).

Maxilla & Mandible	t-test for Equality of Means	
	t	Sig.
BD	8.62	0.0005
torque	8.01	0.0005

Table 4: Correlation between BD and torque in Maxilla & Mandible at the (p<0.01) level.

Maxilla & Mandible		torque
BD	Pearson correlation	0.938
	Sig.	0.0005
	N.	120

Table 5: Reference that shows bone densities in different regions of the jawbone [expressed in Hounsfield units (HU); numbers within parentheses are sample sizes]

	Region			
	Anterior mandible	Posterior mandible	Anterior maxilla	Posterior maxilla
Shapurian et al. (2006)	559±208(42)	321±1132(78)	517±177(45)	333±119(54)
Turkyilmaz et al. (2007a)	945±207(58)	674±227(28)	716±190(28)	455±122(21)
Turkyilmaz & Mcglumphy (2008)	846±234(100)	526±107(60)	591±176(70)	403±95(70)
de-Oliveira et al. (2008)	383±243(6)	306±187(28)	370±176(6)	255±184(29)
Fus et al. (2010)	530±161(15)	359±150(55)	516±132(47)	332±136(37)
This study	682±98(30)	481±104(30)	413±92(30)	263±67(30)