Computed tomography bone density in Hounsfield units at dental implant receiving sites in different regions of the jaw bone

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ABSTRACT

Background: Determination of local bone mineral density (BMD) with cortical thickness and bone height may offer a comprehensive description of the bone the surgeon will encounter when he or she actually sets the implant. Quantitative computed tomography (CT) (i.e., quantitative interpretation of values derived from Hounsfield units with a suitable calibration procedure) is the modality of choice to determine BMD. The aim of the present clinical study is to determine the local bone density in dental implant recipient sites using computerized tomography.

Material and method: The sample consisted of (72) Iraqi patients whom referred to Al-Kharkh General hospital, Spiral CT scan Department for bone quality and quantity assessment after one week of dental implants insertion, the average of bone density was measured for 120 areas indifferent sectors of maxilla and mandible in Hounsfield unite.

Results: As a mean, males show higher bone density than females, decreased with increased age significantly, mandible show significantly higher bone density than maxilla. Maxilla revealed no significant difference between the three sectors, while in the mandible there was significant difference between posterior sector (613.1HU)and both anterior (821.3 HU) and premolar sectors (779.6 HU) with no significant difference between anterior and premolar sectors.

Conclusion: CT-Scan may provide a valuable aid to predict bone quality at potential implant sites and could be used to assess the change of bone density around dental implants.

Key words: Computed tomography, dental implants, Hounsfield unit. **(J Bagh Coll Dentistry 2014; 26(1):92-97).**

الخلاصة

معلومات أساسية : تحديد كثافة العظام (BMD) مع سماكة القشرة العظمية و ارتفاع العظم قد تقدم وصفا شاملا للعظم للجراح ليحدد امكانية زراعة الأسنان بالاعتماد على قياس الكثافة العظمية بوحدة هاونسفيلد بواسطة التصوير المقطعي (CT). إن الهدف من هذه الدراسة السريرية الحالية هو تحديد كثافة العظام المحلية في بعد غرز الزرعات السنية بأسبوعبوحدةهاونسفيلد باستخدام التصوير المقطعي.

طرق البحث: تم قياس متوسط كثافة العظام ل 72 مريض بوحدة الهاونسفيلد باستخدام الأشعة المقطعية في مستشفى الكرخ العام ، قسم الاشعة المقطعية ل 120 لمنطقة ما حول الزرعهفي مختلف مناطق الفكين العلوي والسفلي .

النتائج:كثافة العظم تكون اكبر عند الرجال والأصغر سنا وفي الفك السفلي اكثر من لعلوي. ولا توجد فروقات محسوسة بين مناطق الفك العلوي, لكن في الفك السفلي هناك فرق بين المقطع الخلفي عن المقطعين الأمامي والضواحك.

الخلاصة: الأشعة المقطعية قد توفرمساعدة قيمة للتنبؤ بجودة العظام في مواقع زرع المحتملة ويمكن أن تستخدم لتقييم التغيرفي كثافةالعظم حول الزرعات السنية.

INTRODUCTION

Computed Tomography is the best method for the morphological, quantitative and qualitative assessment of the available bone on potential recipient site for implant placement [(1,2)].

The most popular current method of bone quality assessment is that developed by Lekholm and Zarb, who introduced a scale of 1–4, based on both the radiographic assessment, and the sensation of resistance experienced by the surgeon when preparing the implant site [(3)].

The grading refers to individual experience, and furthermore, it provides only a rough mean value of the entire jaw. Therefore, their classification has recently been questioned due to poor objectivity and reproducibility [(4,5)].

De Oliveira et al [(6)] concluded that different qualities of bone can be found in any of the anatomical regions studied (anterior and posterior sites of maxilla and mandible), which confirms the importance of a site-specific bone tissue evaluation prior to implant installation.

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The bone densities assessed by HU fell into the range of optimal bone densities associated with acquired primary implant stability proposed in the literature [(7).]

The bone densities assessed by HU fell into the range of optimal bone densities associated with acquired primary implant stability proposed in the literature [(7)]. The mean bone density in the maxilla was significantly lower than that in the mandible ($P< 0.05$); the mean bone densities in the 4 jaw regions decreased in the following order: anterior mandible > anterior maxilla > posterior mandible > posterior maxilla [(8)].

Previous studies that focus on the beneficial of measuring the bone density in HU showed its importance and accuracy. The trabecular structure, by means of density distribution, around the implant showed similarities to the CT images at many regions [(9)].

CT-Scan could be use to assess the cange of bone density around dental implants. Bone density around dental implant was increased after placement. The increased rate of bone density could be determined by the quality of jaw bone before implant placement [(10)].

Valiyaparambil et al [11] research showed that there was a strong correlation between CBCT gray values and HU. CBCT gray values increased linearly with increasing calcium hydroxyapatite or bone equivalent density material.

Although the bone densities varied markedly among individuals [12], more detailed assessments of bone density may be useful to enhance initial stability of implants in the posterior maxilla because the outcomes of Ozan et al. study [13], indicate that bone drilling is not an effective technique for improving implant stability when lower bone density values have resulted in the greater angular deviations in the group was noticed, in whom the implants were placed after the surgical guides were removed. This deviation might have been derived from the freehand placement of the implants and the poor quality of the bone. So bone quality must be assessed well to indicate the solutions before surgical dental implant insertion like pure-phase multiporous beta-TCP that may enhance the bone density when inserted into the bone gaps around immediate dental implants [14].

MATERIAL AND METHODS

The sample consisted of (72) Iraqi patients indicated for dental implant (males and female), age range between (20-70) years old. They were examined during a time period started from December 2012 to April 2013. .

The total sample was attended to different center of implantology in Baghdad subjected to clinical examination, pre-surgical panoramic radiographical evaluation.

All the patients indicated for implant treatment were referred to Al-Kharkh General hospital, Spiral CT scan Department for bone quality and quantity assessment to receive dental implants by using Multi-Detector Computed Tomography after one week from dental implant insertion after checking for primary stability. Average of bone density was measured in Hounsfield unite around 120 fixture's receiving areas.

The sites included were divided to the following sectors (10 males and 10 females for each sector):

1. Upper anterior area (canine to canine area).
2. Upper premolar area.
3. Upper posterior area
4. Lower anterior area (canine to canine area).
5. Lower premolar area.
6. Lower posterior area

RESULTS

Distribution of the sample (60 male and 60 females) according to age and gender was illustrated in table (1). Regarding age, the sample were divided to three groups : <35, 35-49, and 50+.

The bone density measured in Hounsfield unites by the aid of CT scan according to gender and age, as a mean, males show higher bone density than females (680.2 for males and 581.5 for females). Bone density decreased with increased age significantly, with mean of 716.1, 623.9, 514.7 for <35, 35-49, and 50+ respectively and mandible show significantly higher bone density than maxilla (738.0 and 523.6 respectively) as shown in table (2)

When bone density classified according to jaw sectors , measurements related to maxilla revealed no significant difference between the three sectors , while in the mandible there was significant difference between posterior sector (613.1HU)and both anterior (821.3 HU)and premolar sectors (779.6 HU) with no significant difference between anterior and premolar sectors as shown by table (3).

According to jaw sector in relation to gender as shown in table 4, the accepted range of normal value (5^{th}-95^{th} percentile) was for females, as a total it was (268-947) HU for the mandible, the highest bone density for premolar sector (659-987) HU then (376-892) HU for molar and (238-873) HU for anterior sector. While for the maxilla it was (345-658) HU, (382-687) HU, (246-658) HU for anterior sector, premolar sector, and molar sector respectively with total (345-658) HU.

For males, in the mandible the bone density was (876-1135) HU for anterior sector, premolar sector (646-876) HU, and molar sector (340-1082) HU with total (407-1135) HU. While in the maxilla (408-743) HU for the anterior sector, (436-784) HU for premolar sector, (398-657) HU for molar sector, and for total bone density was (408-779) HU. (Table 4)

As shown in table 5, the net and independent effect of gender, jaw type , jaw sector , and age on bone density was evaluated by a multiple linear regression model was statistically significant and able to explain 52% of observed variation in the dependent variable (bone density).

Being a male is expected to significantly increase in bone density by a mean of 101.6 HU compared to females (Table 5), after adjusting for the remaining explanatory factors included in the model (jaw type, jaw sector, and age).

Upper jaw is associated with a statistically significant decrease in bone density by a mean of 208.6 HU compared to lower jaw (Table 5), after

adjusting for the remaining explanatory factors included in the model (gender, jaw sector, and age).

There was no important or statistically significant difference in mean of bone density between premolar and anterior sector (Table 5), while molar sector showed a statistically significant decrease in bone density by a mean of – 93.5 HU compared with anterior sector after adjusting for the remaining explanatory factors included in the model (gender, jaw type, and age).

Age had a statistically significant negative impact on bone density. Being an older age group (35-49) is expected to decrease bone density by a mean of 85.8 HU compared to very young adults (<35 years of age). Being older age (50+ years) is expected to decrease bone density by 171.6 HU compared to youngest age (<35 years of age) after adjusting for the remaining explanatory factors included in the model (gender, jaw type, and jaw sector) (Table 5).

DISCUSSION

This study was done for its importance in implantology because significant correlations found between bone quality and implant stability parameters indicate that clinicians may predict primary stability before implant insertion, and they may modify their treatment plans (i.e., implant locations, longer healing periods) before implant surgery, where the bone quality is poor [(15)], although HU values alone could be a misleading diagnostic tool for the determination of bone density [(16)].

Most of previous studies suggested that bone density is more in males than females [(17)], young than old age people [(18)] and in mandible than maxilla [(19)] and this was proved in this study.

In the present study, the anterior mandible sector presents higher bone density than the premolar and molar sectors in the mandible, followed by bone densities in the sectors of maxilla and this data is in agreement with Farré-CvijetićAvdagić et al [(17)].

This data is in agreement also with Norton and Gamble [(18)]. However, in their study, they identified a higher mean bone density in the anterior region of the maxilla than in the posterior region of the mandible, 696Hu and 669Hu respectively. Whereas, we observed higher density values in the posterior of the mandible than in the anterior of the maxilla, 613.1 Hu and 541.7 Hu respectively.

Moreover, in this study, it was detected a mean density value of 821.3 Hu in the anterior mandibular region, lower than that described by Norton and Gamble [(21)] (970Hu), and even lower than that described by Turkyilmaz et al. [(22)], who described a bone density value in said region of 994.9Hu. Values are also lower than those described by these authors in the posterior maxilla. This may be due to the patient age of the sample, and with percentage of patients older than the sample average. Given that the older the patient, the greater the decrease of bone density.

Different qualities of bone can be found in any of the anatomical regions studied (anterior and posterior sites of maxilla and mandible), which confirms the importance of a site-specific bone tissue evaluation prior to implant installation [(6)].

In the present study, both jaws were divided in three sectors anterior, premolar, and molar sectors and from the measurements done it is important to have such divisions specially for the mandible because there was significant difference between posterior sector (613.1HU) and both anterior (821.3 HU) and premolar sectors (779.6 HU) with no significant difference between anterior and premolar sectors but unfortunately no previous could be found using same measurements. This may lead to variations in the results with other studies when compared.

As a conclusion; CT-Scan may provide a valuable aid to predict bone quality at potential implant sites and could be used to assess the change of bone density around dental implants. Jaw type (Maxilla vs. Mandible) and age were the strongest predictors of bone density followed by gender and lastly the jaw sector.

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Table 1: Distribution of the study sample

Age group (years)	N	%
<35	41	34.2
35-49	52	43.3
50+	27	22.5
Total	120	100.0
Gender		
Female	60	50.0
Male	60	50.0
Total	120	100.0

Table 2: Bone density assessed by CT in Hounsfield unite

	Range	Mean	SD	SE	N	P
Gender						0.006
Female	238-987	581.5	186.3	24.06	60	
Male	340-1135	680.2	202.8	26.18	60	
Age group(years)						0.001
<35	238-1135	716.1	201.5	31.47	41	
35-49	268-1135	623.9	186.2	25.81	52	
50+	246-998	514.7	514.7	31.82	27	
Upper jaw Vs. lower jaw						0.001
Mandible	238-1135	738.0	738.0	27.25	60	
Maxilla	246-784	523.6	523.6	14.65	60	
Gender						0.006
Female	238-987	581.5	186.3	24.06	60	
Male	340-1135	680.2	202.8	26.18	60	
Age group(years)						0.001
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50+	246-998	514.7	514.7	31.82	27	
Upper jaw Vs. lower jaw						0.001
Mandible	238-1135	738.0	738.0	27.25	60	
Maxilla	246-784	523.6	523.6	14.65	60	

Table 3: Bone density assessed by CT in Hounsfield unit according to jaw type

	Range	Mean	SD	SE	N	P
Gender						0.006
Female	238-987	581.5	186.3	24.06	60	
Male	340-1135	680.2	202.8	26.18	60	
Age group(years)						0.001
<35	238-1135	716.1	201.5	31.47	41	
35-49	268-1135	623.9	186.2	25.81	52	
50+	246-998	514.7	514.7	31.82	27	
Upper jaw Vs. lower jaw						0.001
Mandible	238-1135	738.0	738.0	27.25	60	
Maxilla	246-784	523.6	523.6	14.65	60	

Table 4: Bone density assessed by CT in Hounsfield unit according to jaw sectorin each gender using 5th-95th percentile

	Range	Mean	SD	SE	N	5th-95th percentile
Female						
Mandible						
Anterior sector	238-873	629.9	233.6	73.87	10	238-873
Premolar sector	659-987	808.8	118.2	37.37	10	659-987
Molar sector	376-892	586.4	185.8	58.75	10	376-892
Total	238-987	675.0	203.9	37.22	30	268-947
Maxilla						
Anterior sector	345-658	502.4	101.4	32.07	10	345-658
Premolar sector	382-687	510.0	100.7	31.85	10	382-687
Molar sector	246-658	451.2	112.3	35.52	10	246-658
Total	246-687	487.9	104.7	19.11	30	345-658
Male						
Mandible						
Anterior sector	876-1135	1012.7	78.7	24.89	10	876-1135
Premolar sector	646-876	750.4	68.5	21.65	10	646-876
Molar sector	340-1082	639.7	198.4	62.75	10	340-1082
Total	340-1135	800.9	202.3	36.93	30	407-1135
Maxilla						
Anterior sector	408-743	581.0	117.0	37.01	10	408-743
Premolar sector	436-784	559.9	136.0	43.02	10	436-784
Molar sector	398-657	537.3	85.4	27.00	10	398-657
Total	398-784	559.4	112.2	20.48	30	408-779

Table 5: Multiple regressions with bone density as the dependent (outcome)

	Partial regression coefficient	P	Standardized coefficient
(Constant)	876.7	<0.001	
Male gender to females	101.6	<0.001	0.255
Upper jaw to lower jaw	-208.6	<0.001	-0.523
Premolar to anterior sector	1.5	0.96 [NS]	0.004
Molar to anterior sector	-93.5	0.005	-0.221
Age group(years)			-0.320
35-49 to < 35	-85.8	<0.001	
50+	-171.6	<0.001	