Bone Density Level Difference between Maxillary and Mandibular 2nd Premolar and 1st Molar in Iraqi Adults with Class I Occlusion

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ABSTRACT

Background: Development of techniques that could adequately provide anchorage in moving individual tooth or groups of teeth in desired direction is one of the major concerns of orthodontic. Mini-implants provide reliable stable anchorage. The aim of this study was to compare of the bone density between two points within alveolar bone to decide which one was more reliable for insertion of mini-implant.

Materials and method: Computed tomographic images were obtained for 70 patients (24 males and 46 females) with an age range 18-30 years. Bone density of buccal cortical and cancellous bones was measured between 2nd premolar and 1st molar at two preselected level (points 3 and 6 mm) from the alveolar crest in both maxilla and mandible.

Results: According to independent t-test, the bone density at point 6 mm was higher than that at point 3 mm with a statistically significant difference between them in both maxilla and mandible except in maxillary cancellous bone which shows a non-significant difference.

Conclusions: It was concluded that the alveolar bone density increased from the alveolar bone crest toward the basal bone. Point 6 mm is more recommended in the upper jaw, while in the lower jaw, point 3 mm is more recommended.

KEYWORDS

Bone density, orthodontic mini-implant, computerized tomography.

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الإختلاف في مستوى كثافة العظم بين الضاحك الثاني والطاحن الأول في الفك العلوي والسفلي لدى البالغين العراقيين ذوي الإطباق من الفئة الأولى

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المستخلص

الخلفية: واحدة من الأهتمامات الرئيسية لتقويم الأسنان هو تطوير التقنيات التي يمكن أن توفر مرسى على نحو كاف في تحريك سن واحد أو مجموعة من الأسنان في الإتجاه المناسب. الزرعات التقويمية توفر مرسى موثوق وثابت. الهدف من هذه الدراسة هو لمُقارنة كثافة العظام بين نقطتين ضمن العظم السنخي لتحديد أيهما أكثر موثوقية لإدراج الزرعات المصغرة.

المواد والطرق: تم الحصول على الصور التوموغرفية ل٧٠ مريض (٢٤ ذكور و ٤٦ إناث) الذين تتراوح أعمارهم بين ١٨-٣٠ سنة. وقد تم قياس كثافة العظام القشرية والاسفنجية بين الضاحك الثاني والطاحن الاول على مستويين مختاريين هما (٣ و ٦ ملم) من القمة السنخية في كلا الفكين العلوي والسفلي.

النتائج : أظهرت النتائج التي تم الحصول عليها بالأعتماد على اختبارات المستقلة، أن كثافة العظم عند نقطة ٦ ملم كانت أعلى منها في النقطة ٣ ملم مع وجود فرق ذي دلالة إحصائية بينهما في كل من الفك العلوي والفك السفلي بإستثناء العظم الأسفنجي للفك العلوي الذي لم يظهر أي فرق ذو أهمية.

الاستنتاجات : خلص إلى أن كثافة العظم السنخي تزداد من قمة العظم السنخية نحو العظم القاعدي. وأن النقطة ٦ ملم يوصي بها أكثر في الفك العلوي، في حين أن النقطة ٣ ملم يوصي بها أكثر في الفك السفلي.

الكلمات المفتاحية

كثافة العظم، الزرعات التقويمية، الأشعة المقطعية.

INTRODUCTION

Mini-implants provide reliable three-dimensional anchorage, leading to predictable treatment outcomes and less reliance on patient cooperation[1], also mini-implants are less invasive, less expensive, and simpler, ensuring their widespread use in orthodontics [2].

The primary implant stability of orthodontic mini-implants is affected by the bone quantity (ratio of compact to trabecular bone) and bone quality (mineral density) [3]. Bone mineral density has been used to establish a treatment plan to ensure the stability of implants in dentistry. During early stages, bone density appears to be the key determinant for stationary anchorage of mini-implants in the sites with inadequate cortical bone thickness because primary retention of mini-implants is achieved by mechanical means rather than through osseointegration [4].

Bone density is the amount of bone tissue in a certain volume of bone [5,6]. It is the mass of extracellular organic bone matrix whether it is mineralized or not and the volume of bone matrix exclusive of the marrow spaces, osteonal canals, lacunae and canaliculi [7].

Misch [8] classified bone density into five

categories as evaluated on CT scan by correlation to a range of Hounsfield units as follows:

- **(D1)** was defined as densities greater than **1250 HU.**
- **(D2)** was defined as densities value between **850-1250 HU.**
- **(D3)** was defined as densities value between **350-850 HU.**
- **(D4)** was defined as densities value between **150-350 HU.**
- **(D5)** was defined as densities less than **150 HU.**

The goal of this study was to help the clinician to plan proper site for implant placement in the area of the alveolar bone between 2nd premolars and 1st molars in both jaws in order to increase the success rate of the treatment.

MATERIALS AND METHODS

Sample

The sample of the present study was selected from the patients who were attending the Computed Tomography Department in Al Karkh General Hospital in Baghdad. Only 70 patients (24 males and 46 females with an age range from 18 to 30 years) who met the following criteria:

1. No history of systemic disease and no previous chronic use of medications that affect bone density.
2. No history of previous orthodontic treatment and/or orthognathic surgery.
3. No regular smoking and/or alcohol consumption.
4. No clear facial asymmetry and TMJ problem by clinical examination.
5. Skeletal and dental Class I.

The following criteria were considered in selected side:

a. No missing teeth excluding 3rd molar.
b. Well aligned teeth with no cross bite, rotation, spacing or crowding more than 2 mm [9].
c. No massive carious lesions and/or filling restorations and no teeth wearing.
d. No pathological lesion in the examined area which was determined by clinical and radiographic examination (CT).
e. No pathological periodontal problem according to the gingival index and no alveolar bone loss from CT.

Method

Patients were informed about the aims and objectives of the study. For each patient, the agreement to participate in this study was taken during his/her CT scan appointment.

Computerize Tomography (CT) Scan Measurements were taken as following:

- Measurement of ANB Angle**:** For further assurance that the selected subject was skeletal Class I, ANB angle was measured according to Steiner [10] by using the option of two dimensions x-ray (cephalometric) in CT scan (Figure 1).

Figure 1: Measurement of ANB angle from CT.

- Measurement of Bone Loss**:** Alveolar bone crest level was measured in 3 dimensions facial bone (skull) from CT scan (Figure 2). The alveolar crest should be slightly apical to the cementoenamel junction (CEJ) by approximately 1.5 to 2 mm.[11]

Figure 2: Measurement of alveolar bone loss.

- Measurement of Bone Density: Bone density was measured in the mid-way between 2nd premolar and 1st molar in the left or right side (the side fulfill the inclusion criteria) in both maxillary and mandibular arch. Bone density of the alveolar bone was measured at two levels from the alveolar crest (3 and 6 mm) for the buccal cortical and cancellous bones in both jaws. Eight points were measured for each patient; 4 points in maxilla and 4 points in mandible (2 points in buccal cortical and 2 points in

cancellous bone of each jaw).

To measure the bone density of alveolar bone, the axial view was selected, and then selects the bone window to clarify the bone details from soft tissue. The measurement of buccal cortical bone density was made in the center point of its thickness. The measurement of cancellous bone density was made at the trabeculae, located halfway buccolingually between the buccal and palatal/lingual cortical plates. [12] Densities of the bone were measured in Hounsfield units (HU). These measurements were illustrated in figures (3-6).

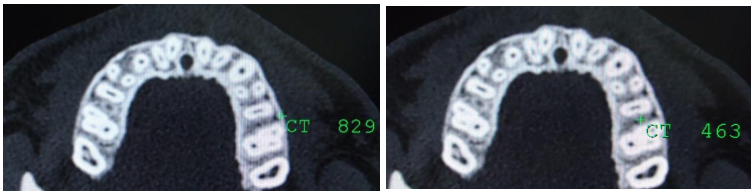

Figure 3: Bone density measurement in maxilla; 3 mm from alveolar crest: (a) cortical bone; (b) cancellous bone.

Figure 4: Bone density measurement in maxilla; 6 mm from alveolar crest: (a) cortical bone; (b) cancellous bone.

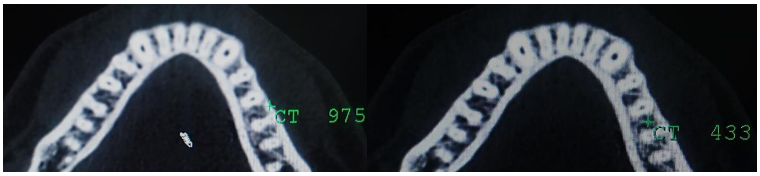

Figure 5: Bone density measurement in mandible; 3 mm from alveolar crest: (a) cortical bone; (b) cancellous bone.

Figure 6: Bone density measurement in mandible; 6 mm from alveolar crest: (a) cortical bone; (b) cancellous bone.

RESULTS

It is clear from table (1) that bone density at point 6 mm was higher than that at point 3 mm with a statistically significant difference between them in both maxilla and mandible except in maxillary cancellous bone which shows a non-significant difference according to independent t-test. The bone density was symbolized according to Misch's [8] classification for clarifying.

DISCUSSION

The sample of this study was selected to have skeletal Class I with normal occlusion to exclude any effect of malocclusion that may affect bone density.

The area of the alveolar bone between 2nd premolar and 1st molar in maxilla was preselected to measure the bone density because of the good quality of bone density and the largest inter-dental width in this area[13] which allow a safe space for mini-implants without damaging the dental roots [14-16]. The same area was preselected in the mandible for standardization.

Attention was paid to measure the bone density in the alveolar bone, since the measurements of the alveolar bone in the maxilla and the mandible 3 to 7 mm above the alveolar crest along the height of the attached gingiva was more favorable for mini-implant success than free mucosa which is known to cause irritation, inflammation, and more frequent mini-implant failure[13,17], while attention was not paid to the side and gender because previous studies demonstrated no significant differences regarding bone density [12,18,19].

The present study showed that the bone density (cortical and cancellous) at point (6 mm) in maxilla and mandible was higher than that at point (3 mm). This can be explained as point 6 mm become nearer to the basal bone and since bone densities in both maxilla and mandible significantly increased from the

alveolar crest toward basal bone in posterior areas,[4,20] this increasing can be attributed to the transmission of masticatory forces to the basal bone through the teeth [21].

On the other hand, the difference in the bone density between point (6 mm) and point (3 mm) appeared statistically significant in mandibular cancellous bone, while non-significant in maxillary cancellous bone.

This could be explained by association with the different biomechanical functions. The mandible and maxilla exposed to different loads (compression, tension, and torsion) [22]. Functional loading dictates the osseous anatomy of opposing jaws. The mandible is subjected to substantial torsion and flexion caused by muscle pull and masticatory function. The maxilla, however, is loaded predominately in compression and experience higher strain during function. The maxilla has no major muscle attachments and transfers much of its load to the rest of the cranium. Because of the entirely different functional role, the maxilla is predominantly trabecular with thin cortices [21].

From a clinical point of view and according to Mish's[8] classification, this study found that the mean maxillary cortical, cancellous, and mandibular cancellous bone densities were D2, D4, and D4 respectively in both points 3 and 6 mm and as the bone density at point 6 mm was higher than that at point 3 mm, so it is more preferable to place mini-implant at point 6 mm.

Although higher bone density seems to be important for successful placement of mini-implants, this cannot be applied to the mandibular cortical bone since the mean bone density at point 6 mm was D1 and despite it is higher than that at point 3 mm which was D2 but it is not recommended for placement of mini-implant because it has been reported that placing implants in D1 bone results in increased failure compared with placement in D2 and D3 bones[23]. This may be explained in part by the observation that heat generated during implant placement increases in dense bone, resulting in implant failure due to bone necrosis [24].Otherwise, water irrigation may be needed to reduce heat generation when one is implanting into dense bone with sufficient volume [12].

Table 1: Cortical and cancellous bone density (HU) level difference (at points 3 and 6 mm) in maxilla and mandible.

Variables		*Points Level*	Total Samples (*N*=70)				
			Range	*Mean*	*SD*	*SE*	*P-value*
Maxilla	Cortical BMD	3mm	517-1310 D_3 - D_1	980.2 D_2	168.6	20.2	0.003 [HS]
		6mm	623-1448 D_3 - D_1	1021.8 D_2	166.9	19.9	
	Cancellous BMD	3mm	102-483 D_5 - D_3	**254.8 D_4**	86.9	10.4	0.07 [NS]
		6mm	124-502 D_5 - D_3	269.2 D_4	92.4	11	
Mandible	Cortical BMD	3mm	747-1735 D_3 - D_1	**1185.7 D_2**	197.3	23.6	<0.001 [HS]
		6mm	770-1644 D_3 - D_1	1283.5 D_1	183.7	22	
	Cancellous BMD	3mm	106-455 D_5 - D_3	262.9 D_4	87.6	10.5	0.015 [S]
		6mm	101-491 D_5 - D_3	284.5 D_4	101.7	12.2	

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