Hard palate bone density and thickness determination using CT scan and their relationships with body compositions measured by bioelectrical impedance analysis for Iraqi adult sample

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ABSTRACT

Background: This study was conducted to evaluate the hard palate bone density and thickness during 3rd and 4th decades and their relationships with body mass index (BMI) and compositions, to allow more accurate mini-implant placement.

Materials and method: Computed tomographic (CT) images were obtained for 60 patients (30 males and 30 females) with age range 20-39 years. The hard palate bone density and thickness were measured at 20 sites at the intersection of five anterioposterior and four mediolateral reference lines with 6 and 3 mm intervals from incisive foramen and mid-palatal suture respectively. Diagnostic scale operates according to the bioelectric impedance analysis principle was used to measure body weight; percentages of body fat, water, and muscle; bone mass; and basal and active metabolic rates.

Results: No significant difference in overall bone density and thickness of hard palate during 3rd and 4th decades. The gender should be considered in regard to bone thickness. Cortical bone density and thickness showed a tendency to decrease posteriorly, while the cancellous bone density showed a tendency to increase posteriorly. In the mediolateral areas, no specific patterns were observed. With increasing BMI, the cortical bone density was increased. The relationships of bone density and thickness with most scale measurements were not significant.

Conclusion: Mini-implants for orthodontic anchorage can be effectively placed in most areas of hard palate regarding the bone density. While regarding bone thickness, care should be taken during the planning of their placement in hard palate. A new classification for bone thickness of hard palate has been developed.

Keywords: Bone density, bone thickness, computerized tomography, hard palate, orthodontic mini implant. (J Bagh Coll Dentistry 2015; 27(2):163-172).

INTRODUCTION

Anchorage is of fundamental importance in orthodontic treatment [(1)]. Orthodontic mini-implants have expanded the scope of traditional orthodontic treatment because they provide an excellent alternative to traditional compliance-dependent, tooth-borne anchorage methods [(2)].

The non-tooth bearing area of the hard palate has been used as a host site for orthodontic implant anchorage because of sufficient bone quality and less possibility of root damage or interference with tooth movement during treatment in addition to the easy access of placing mini-screws in this area [(3)]. Furthermore, thick and keratinized palatal mucosa is related to less inflammation [(4)] and guarantees biomechanical stability for placement of miniscrews [(5)].

Bioelectrical Impedance analysis (BIA) is used to estimate body composition using the difference of conductivity based on the biological characteristic of tissue. Conductivity is proportional to water and electrolyte and it is decreased when cell shape is closer to a round form.

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Adipose tissue is composed of round shape cell and contains relatively less water than other tissues like muscle, so conductivity is decreased according to the increase of body fat [(6)].

As the bone density and thickness are two critical factors for success of mini-implant, this study aimed to obtain data that will serve as a guiding map to select the most suitable sites for placement of mini-implants in the hard palate regarding bone density (cortical and cancellous) and thickness during 3rd and 4th decades, and to assess if there is any relationships with BMI and different body compositions.

MATERIALS AND METHODS

Sixty Iraqi patients were selected from the patients attending MRI and CT department of AL-Sader Medical City in AL-Najaf and divided equally into: group I (20-29 years); and group II (30-39 years). Inclusion criteria included:

1. Skeletal Class I with normal occlusion.
2. Full set of dentition in the upper and lower left and/or right side (excluding third molar).
3. No erupted supernumerary and/or any impacted teeth within the area of measurement.

4. No history of a systemic disease and no previous chronic use of any medication that could affect bone health.
5. No syndromes of cleft palate, and no pathological lesion in the palate.
6. No history of orthodontic treatment and/or orthognathic surgery.
7. No regular tobacco smoking and/or alcohol consumption.

This study was approved by the Scientific Committee of College of Dentistry University of Baghdad. For each patient, informed consent was obtained before the start of examination.

Body Weight and diagnostic scale measurements (Body Fat, Water, Muscle Percentages; Bone Mass; and Basal (BMR) and Active (AMR) Metabolic Rates were recorded while the subject wearing light clothes (during summer season), bare feet and was in a stable standing on a diagnostic scale (Beurer, Germany) which operates according to BIA principle. Then BMI was calculated.

CT images were obtained by 64-slice multi-detector CT scanner (Philips, Holland, Brilliancetm CT, V 4.0) and used to measure hard palate bone density in Hounsfield unit (HU) and thickness in millimeter (mm). The reference lines were determined to be from 0 to 24 mm at 6 mm intervals posterior to the level of the posterior margin of the incisive foramen and from 0 to 9 mm at 3 mm intervals lateral to the mid-palatal suture with the aid of equally sized grid of 3 mm intervals (Figure 1). The measurements were made at the intersection points of the reference lines over 20 sites covering 216 mm^2 in the left or right side depending on the previous studies [4,7-9], that refer there were no statistical significant differences between the left and right side measurements.

At each determined point (sagittal view); the midpoint of the cortical bone thickness was selected to represent the cortical bone density, the density of the cancellous bone was measured at the trabeculae, located halfway incisoapically between the two cortical plates, and the hard palate bone thickness (sum of cortical bone facing the oral cavity, cancellous bone and cortical bone facing the nasal cavity) was measured perpendicular to the horizontal plane. Some of these measurements were illustrated in Figure (2).

The measured values were averaged for each sample, keeping specific to the designated area. According to the reference lines, there were 3 designated anteroposterior areas: anterior (0,6 mm); middle (12 mm); and the posterior (18,24 mm). Likewise, 4 designated mediolateral areas: mid-palatal area (0 mm); medial (3 mm); middle (6 mm); lateral (9 mm) (Figure 1).

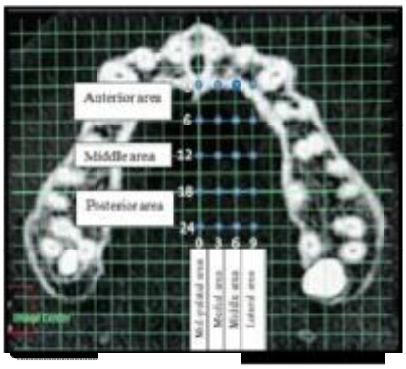

Figure 1: Grid, reference lines, points of measurements in CT (axial view).

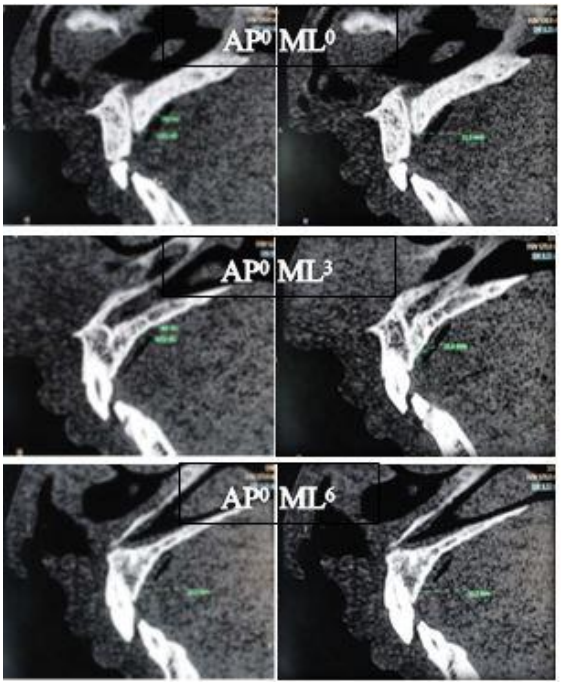

Figure 2: Measurement of bone density and thickness at different points (sagittal view).

In order to make the evaluation more clinical, the most common tooth or the area between two teeth that appeared in each reference line was recorded. It was observed:

Anteroposteriorly (AP);

Line 0 - distal third of the canine.
Line 6 - distal margin of the first premolar.
Line 12 - distal margin of the second premolars.
Line 18 - distal third of the first molar.
Line 24 - mesial third of the second molars.

Mediolateraly (ML);

Line 0 - the area between two central incisors.
Line 3 - distal third of the central incisor.
Line 6 - mesial margin of the lateral incisor.
Line 9 - distal margin of the lateral incisor.

RESULTS

There were no statistically significant differences in the overall bone density and bone thickness between group I and II (Table 1). According to this result, the matching measurements from both groups were combined.

There was no statistically significant difference between the males and females in the bone density measurements; while a statistically significant difference between them in the bone thickness measurements (Table 2). Based on this result, the bone density measurements of males and females were combined.

The males tended to show greater mean value than females with a statistically significant difference between them in the anterior area and in all mediolateral areas (Table 3). Comparisons of bone density and bone thickness for male and female among the three anteroposterior areas and the four mediolateral areas were performed by repeated measure analysis. There were a highly statistically significant difference ($p<0.001$) in bone density among these areas. Consequently, Cohen's d and Bonferonni adjusted paired tests were done for each paired comparisons of these areas as illustrated in tables 4 and 5.

According to ANOVA trend, the relationship of BMI with cortical bone density was statistically significant, as with increasing the BMI, the cortical bone density increased, while with cancellous bone density and bone thickness for males and females was not (Table 6).

The relationship of the cortical bone density with diagnostic scale measurements was not statistically significant. The results of the cancellous bone density were similar to those of the cortical bone density except with body water percentage which was statistically significant. While the relationship of the bone thickness with bone mass and with BMR and AMR was statistically significant (Table 7).

In the present study, the bone density of the designated areas of the hard palate was distributed according to Misch's[10] classification; while the bone thickness, according to the new classification that has been developed by this study (Table 8 and 9) which includes:

* T_1 thick bone - bone thickness **greater than 13 mm**.
* T_2 proper bone - bone thickness value **greater than7 to13 mm**.
* T_3 risky bone was - bone thickness value between **4-7 mm**.
* T_4 improper bone - bone thickness **less than 4 mm**.

DISCUSSION

The age range of the sample was selected to be (20-39 years) because before this age, the peak bone mass still not achieved [11], and after this age subsequent age-related bone loss appears [12].This may explain the no age difference.

This study found no significant gender differences in the bone density. Since males and females eat essentially the same types of food, the strains produced during mastication might be expected to be similar, as would bone density. Other studies showed that females had greater palatal cortical bone density than males did [7,13]. On the other hand, the present study found significant gender differences of bone thickness in the anterior area and in all mediolateral areas. This can be explained as males acquire more bone mass than females (a bigger-not a denser-skeleton) [14], and may be attributed to the fact that the females have a reduced tongue strength compared to males [15]. According to Wolff's law that states "bone structure is altered depending on the loads that are placed on it" [16], and as the tongue plays an important role in speech, mastication and swallowing by its contact with the hard palate [17]. Furthermore, the magnitude and duration of the tongue pressure were found to be significantly larger in the anteriomedian and smaller in the posteriomedian parts of hard palate compared to the other parts [18]. Ryu et al. [9] and Gracco et al. [19] found no statistically significant differences due to gender in bone thickness of the hard palate. These differences with others may be explained by factors of race, hormones, and life style and also may belong to the difference in the measuring sites and/or the difference in the CT scanning machine setting.

The result of present study showed that the cortical bone density and bone thickness had a tendency to decrease significantly anteroposteriorly, while the cancellous bone density had a tendency to increase. The mean of cancellous bone density in the posterior area was higher than that in the middle area but statistically not significant.Menegaz et al.[20]foundthe data that support a role of mechanical loading in the determination of palatal morphology and that elevated masticatory loading developed hard palate with significantly greater bone area, and thicker anterior palates. Role, magnitude and duration of tongue pressure were significant in the anteromedian part of hard palate [17,18]. Furthermore and just as could be expected from the triangular sagittal cross section of the palate, the result of present study regarding cortical bone density and thickness can be explained as the anterior area is nearest to masticatory function of

the teeth and tongue pressure than middle and posterior areas. About the cancellous bone density, the anterior area had higher bone thickness than the middle and posterior areas, so the decrease in the thickness of bone is associated with more concentrated trabeculae. The result of present study is in agreement with Han et al. [7] and Moon et al. [13] regarding the cortical bone density, and in disagreement with Han et al. [7] regarding the cancellous bone density who found it decreasing posteriorly. Regarding the bone thickness, the result is in agreement with others [8,9,19,21-23].

The bone density and thickness didn't take organized pattern mediolaterly, as mid-palatal area showed lowest cortical bone density and highest cancellous bone density and bone thickness. Medial area showed highest cortical bone density and lowest cancellous bone density, while middle area showed lowest bone thickness. Direct comparison with other studies is difficult since there was no previous study investigating the area of mid-palatal suture and there is difference in the way of designing mediolateral areas.

Concerning mid-palatal suture, in the immediate postnatal period, the fine cancellous bone of the palate was replaced by bone having a cortex and medullary spaces, and the medial ends of the palatal processes gradually thickened. During the first 2 years, the inferior cortical layer remained cancellous in nature due to the rapid deposition of bone on its oral surface; the intermaxillary suture increased markedly in height and became narrower [24]. This fact can explain that the bone in the mid-palatal suture has specific characteristics differ from that in the others mediolateral areas.

Explanation of other results related to mediolateral areas may be attributed to the facts mentioned previously about the shape of hard palate bone in coronal section, effect of tongue pressure on the cortical bone density and bone thickness, and as cancellous bone in the lateral area lies adjacent to the roots of the maxillary teeth and is subjected to the stress of masticatory forces.

The sample of present study included normal, overweight and obese categories of the international classification of BMI [25]. It was found that obesity leads to upper airway narrowing due to enlargement of soft palate, lateral pharyngeal walls, para-pharyngeal fat pads, and tongue [26,27]. Furthermore, the weight of a muscle reflects the forces that it exerts on bones to which it is attached and that muscle weight is an important determinant of bone mass [28]. Accordingly, the result of this study may be explained as that increase in BMI is associated with an enlargement of tongue which implied more pressure on the cortical bone. There is no previous study examining this relationship.

In this study, the hard palate bone density was not related to the body composition, except the cancellous bone density in relation to the body water percentage which may be belong to the fact that the water ratio is higher in trabecular than in cortical bones [29]. The relationships of bone thickness with bone mass, BMR and AMR were statistically significant. There is no previous study examining these relationships. This result may be explained as if all individuals had the same size of hard palate whatever their skeleton size, some would have hard palate that was inadequate for the task and others would be at a disadvantage through having hard palate that was significantly heavier than it needed to be. Additionally, the BMR and AMR are influenced by weight and height [30]. So it is expected that the heavier individuals (including their hard palate) will have fastest BMR and AMR.

The bone density measurements of the present study were distributed according to Misch's [10] classification who classified the bones into 5 categories according to density. Consequently, the mean of cortical bone density in the anteroposterior and mediolateral areas was D2 (850-1250HU), while the mean of cancellous bone density in the anteroposterior and mediolateral areas was D3 (350-850HU). There is no previous classification of bone thickness. In the palate, the big challenge is the length of mini-screws.[23] So the present study classified the bone thickness into four categories depending on mini-screw length as there must be sufficient bone thickness to receive the functional part of the mini-screw, without perforating the nasal cavity plus a safety zone of 1 mm. T_1 and T_2 categoriesare classified as there will be sufficient bone thickness to receive the functional part of the mini-screw, ranging from 6 to 12 mm in length, without perforating the nasal cavity [4,8,19] and a safety margin of 1 mm is recommended [31]. T_3 category is classified asthe limited availability of palatal bone height which was the reason for the development of special short palatal implants for orthodontic anchorage (3 to 6 mm long) [32]. T_4 category is classified as the shortest endosseous part of short palatal implant is 3 mm long [31]. Also it has been reported that a risky region for palatal implant placement is one with a height of less than 4 mm [4,33]. So T_4 is considered as improper bone for placement of mini-screw. The present study found that anteroposteriorly, the

mean of bone thickness for males and females in the anterior area was T_2, in the middle area was T_3, while in the posterior area was T_3 for males and was T_4 for females. Mediolaterally, the mean of bone thickness in the mid-palatal area was T_2 for males and was T_3 for females. In other mediolateral areas, the mean of bone thickness for both males and females was T_3.

It was concluded that bone thickness is more important than the bone density to be considered when planning to place mini-implant for orthodontic anchorage in the hard palate. A new classification for bone thickness of the hard palate has been developed and a preliminary guiding map to select the most suitable sites for placement of mini-implants in the hard palate was established.

REFERENCES

1. Wu TY, Kuang SH, Wu CH. Factors associated with the stability of mini-implants for orthodontic anchorage: a study of 414 samples in Taiwan. J Oral Maxillofac Surg 2009; 67(8): 1595-9.
2. Favero L, Brollo P, Bressan E. Orthodontic Anchrage with Specific fixtures: Related Study Analysis. Am J Orthod Dentofacial Orthop 2002; 122: 84-94.
3. Jung BA, Kunkel M, Gollner P, Liechti T, Wehrbein H. Success rate of second-generation palatal implants. Angle Orthod 2009; 79: 85-90.
4. Kang S, Lee S, Ahn S, Heo M, Kim T. Bone Thickness of the Palate for Orthodontic Mini-implant Anchorage in Adults. Am J Orthod Dentofacial Orthop 2007; 131: S74-80.
5. Kyung SH, Hong SG, Park YC. Distalization of maxillary molars with a midpalatal miniscrew. J Clin Orthod 2003; 37: 22-6.
6. Gang J. Suitable Method to Body Fat Assessment and Follow-up Examination. The 10th Workshop of KOSSO in 2005; 261-9.
7. Han S, Bayome M, Lee J, Lee YJ, Song HH, Kook YA. Evaluation of palatal bone density in adults and adolescents for application of skeletal anchorage devices. Angle Orthod 2012; 82: 625-31.
8. Baumgaertel S. Quantitative investigation of palatal bone depth and cortical bone thickness for mini-implant placement in adults. Am J Orthod Dentofacial Orthop 2009; 136: 104-108.
9. RyuJH, Park JH, Thu TVT, Bayome M, Kim YJ, Ah Kook Y. Palatal bone thickness compared with cone-beam computed tomography in adolescents and adults for mini-implant placement. Am J Orthod Dentofacial Orthop 2012; 142: 207-12.
10. Misch CE. Density of bone: effect on treatment plans, surgical approach, healing, and progressive bone loading. Int J Oral Implantol 1990; 6(2): 23-31.
11. Gardner DG, Shoback D. Greensspan's basic and clinical endocrinology. 9th ed. McGraw-Hill, 2011.
12. Riggs BL, Melton ILJ, Robb RA, Camp JJ, Atkinson EJ, Peterson JM, Rouleau PA, McCollough CH, Bouxsein ML, Khosla S. A population-based study of age and sex differences in bone volumetric density, size, geometry and structure at different skeletal sites. J of Bone Mineral Research 2004; 19(12): 1945-54.
13. Moon CH, Park HK, Nam JS, Im JS, Baek SH. Relationship between vertical skeletal pattern and success rate of orthodontic mini-implants. Am J Orthod Dentofacial Orthop 2010; 138(1): 51-7.
14. Callewaert F, Venken K, Kopchick JJ, Torcasio A, Lenthe GHV, Boonen S, Vanderschueren D. Sexual Dimorphism in Cortical Bone Size and Strength But Not Density Is Determined by Independent and Time-Specific Actions of Sex Steroids and IGF-1: Evidence from Pubertal Mouse Models. American Society for Bone and Mineral Research 2010; 25(3): 617-26.
15. Youmans SR, Youmans GL, Stierwalt JAG. Differences in Tongue Strength Across Age and Gender: Is There a Diminished Strength Reserve? Dysphagia 2009; 24 (1): 57-65.
16. Wolff J. Das Gestetz der Transformation der Knocken .Hirshewold, Berlin 1892.
17. Hori K, Ono T, Nokubi T. Coordination of tongue pressure and jaw movement in mastication. J Dent Res 2006; 85(2): 187-91.
18. Ono T, Hori K, Nokubi T. Pattern of tongue pressure on hard palate during swallowing. Dysphagia 2004; 19(4): 259-264.
19. Gracco A, Lombardo L, Cozzani M, Siciliani G. Quantitative cone-beam computed tomography evaluation of palatal bone thickness for orthodontic miniscrew placement. Am J Orthod Dentofacial Orthop 2008; 134: 361-9.
20. Menegaz RA, Sublett SV, Figueroa SD, Hoffman TJ, Ravosa MJ. Phenotypic Plasticity and Function of the Hard Palate in Growing Rabbits. The Anatomical Record 2009; 292: 277-84.
21. Jayakumar G, Rajkumar, Biju T, George MA, Krishnaswamy NR. Quantitative assessment of palatal bone thickness in an ethnic Indian population: A computed tomography study. Indian J Dent Res 2012; 23(1): 49-52.
22. Farnsworth D, Rossouw PE, Ceen RF, Buschang PH. Cortical bone thickness at common miniscrew implant placement sites. Am J Orthod Dentofacial Orthop 2011; 139(4): 495-503.
23. Marquezan M, Nojima LI, Freitas AOA, Baratieri C, Júnior MA, Nojima MCG, Araújo MTS. Tomographic mapping of the hard palate and overlying mucosa. Brazilian Oral Research 2012; 26(1): 36-42.
24. Latham RA. The development, structure and growth pattern of the human mid-palatal suture. J Anat 1971; 108(1): 31-41.
25. **WHO.** Obesity: preventing and managing the global epidemic. Report of a WHO Consultation. WHO Technical Report Series 894. Geneva: World Health Organization, **2000.**
26. Horner RL, Mohiaddin RH, Lowell DG, Lowell DG, Shea S, Burman ED. Sites and sizes of fat deposits around the pharynx in obese patients with obstructive sleep apnoea and weight matched controls. European Respiratory J 1989; 2(7): 613-22.
27. Chi L, Comyn FL, Mitra N, Reilly MP, Wan F, Maislin G, Chmiewski L, Thorne-FitzGerald MD, Victor UN, Pack AI, Schwab J. Identification of craniofacial risk factors for obstructive sleep apnoea using three-dimensional MRI. European Respiratory Journal 2011; 38(2): 348-58.
28. Doyle F, Brown J, Lachance C. Relation between bone mass and muscle weight. The lancet 1970; 295(7643): 391-3.

29. Gong JK, Arnold JS, Cohn SH. Composition of trabecular and cortical bone. The Anatomical Record 1964; 149(3): 325-331.
30. Guyton AC, Hall JE. Text book of medical physiology. 12th ed. Elsevier 2010.
31. King KS, Lam EW, Faulkner MG, Heo G, Major PW. Vertical bone volume in the paramedian palate of adolescents: a computed tomography study. Am J Orthod Dentofacial Orthop 2007; 132: 783-8.
32. Wehrbein H, Feifel H, Diedrich P. Palatal implant anchorage reinforcement of posterior teeth: a prospective study. Am J Orthod Dentofacial Orthop 1999; 116: 678-86.
33. Bernhart T, Vollgruber A, Gahleitner A, Dortbudak O, Haas R. Alternative to the median region of the palate for placement of an orthodontic implant. Clin Oral Implants Res 2000; 11: 595-601.

Table 1: Comparison between the two groups in bone density (HU) (cortical and cancellous) . and bone thickness (mm) measurements.

			Male (n=30)		Age group difference	Female (n=30)		Age group difference
	Descriptive statistics		Group I (n=15)	Group II (n=15)	P-value	Group I (n=15)	Group II (n=15)	P-value
Bone Density	Cortical	Range	821.00	860.20	0.72 (NS)	936.10	953.00	0.6 (NS)
			1287.4	1290.7		1299.5	1131.5	
		Mean	1121.5	1103.7		1153.1	1131.5	
		SD	140.65	128.11		113.63	106.72	
	Cancellous	Range	546.30	463.30	0.29 (NS)	615.40	539.30	0.12 (NS)
			994.40	913.10		1048.3	971.10	
		Mean	751.70	700.10		782.20	711.20	
		SD	131.31	128.02		126.48	114.23	
Bone thickness		Range	3.9000	5.0000	0.21 (NS)	4.0000	4.2000	0.73 (NS)
			9.5000	9.6000		7.5000	7.3000	
		Mean	6.400	7.1000		5.7000	5.8000	
		SD	1.4700	1.3700		1.1900	0.9900	

Table 2: Gender difference in the bone density (HU) (cortical and cancellous) and bone thickness (mm) measurements of the hard palate.

	Descriptive statistics		Male (n=30)	Female (n=30)	Gender difference (P-value)
Bone Density	Cortical	Range	821.00	936.10	0.35 (NS)
			1290.7	1313.5	
		Mean	1112.6	1142.3	
		SD	132.50	108.86	
	Cancellous	Range	463.30	539.30	0.53 (NS)
			994.40	1048.3	
		Mean	725.90	746.70	
		SD	130.09	123.79	
Bone Thickness		Range	3.9000	4.0000	0.005 (S)
			9.6000	7.5000	
		Mean	6.7000	5.8000	
		SD	1.4400	1.0800	

Table 3: Gender difference in the bone thickness (mm) of different areas of the hard palate.

		Areas	Descriptive Statistics	Male (n=30)	Female (n=30)	Gender difference (P-value)
Bone Thickness	Anteroposterior Areas	Anterior Area	Range	5.10	6.40	0.002 (HS)
				15.2	12.3	
			Mean	10.3	8.70	
			SD	2.15	1.65	
		Middle Area	Range	2.50	2.20	0.06 (NS)
				8.10	7.00	
			Mean	5.00	4.30	
			SD	1.49	1.20	
		Posterior Area	Range	2.30	2.10	0.11 (NS)
				6.0	6.30	
			Mean	4.00	3.50	
			SD	1.22	0.94	
	Mediolateral Areas	Mid-Palatal Area	Range	6.10	5.10	0.013 (HS)
				12.00	10.3	
			Mean	8.60	7.70	
			SD	1.55	1.30	
		Medial Area	Range	3.60	3.10	0.028 (HS)
				9.80	7.80	
			Mean	6.30	5.40	
			SD	1.66	1.30	
		Middle Area	Range	2.80	2.70	0.003 (HS)
				8.30	6.70	
			Mean	5.70	4.60	
			SD	1.43	1.09	
		Lateral Area	Range	3.30	3.00	0.012 (HS)
				9.10	8.80	
			Mean	6.30	5.30	
			SD	1.63	1.38	

الخلاصة

الخلفية:لتقييم كثافة وسمك عظم الحنك الصلب خلال العقدالثالث والرابع من العمروعلاقتهما مع دليل كتلةالجسم ومكوناته للسماح بوضع الزرعات التقويمية بشكل أكثر دقة.

المواد والأدوات: جمعت صور المفراس الحلزوني ل٦٠ شخص (٣٠منالذكورو٣٠من الأناث) تتراوحأعمارهمبين٢٠-٢٩سنة. كثافة عظم الحنك الصلب وسمكه قيست ل٢٠ موقع عند تقاطع خمس خطوط إشارة أمامية خلفيةمع أربع خطوط إشارة قريبة جانبية بمسافة ٦ و ٣ (مليمتر)من الثقب الحاد والدرز الحنكي الوسطي على التوالي.الميزان التشخيصيالذي يعمل بمبدء تحليل الممانعة الكهربائية استخدم لقياس وزن الجسم؛ النسبة المئوية لدهون الجسم، الماء والعضلات؛ كتلة العظم والنسبةالأيضية الأساسية والنسبةالأيضية النشيطة.

النتائج:لاتوجدفروق ذات دلالة إحصائية في كثافةعظم الحنك الصلب وسمكه الكلية خلال العقد الثالث والرابع من العمر. ينبغيالنظرفيالجنسينفيمايتعلقبسماكةعظم الحنك الصلب. بينت كثافة العظم القشري وسمك العظم ميول للتناقص خلفياً، بينما كثافة العظم الإسفنجي بينت ميول للتزايد خلفياً. بالنسبة للمناطق القريبة الجانبية، لم يلاحظ نموذج مخصص. لقدلوحظأن هنالك تزايد في كثافة العظم القشري تحدث مع الزيادة في دليل كتلة الجسم.لقد تبين أن العلاقة بين كثافة العظموسمك العظم مع قياسات الميزان التشخيصي معظمها ليست ذات دلالة إحصائية.

الاستنتاج: الزرعات التقويمية من الممكن وضعها في معظم مناطق عظم الحنك الصلب وفقاً لكثافة العظم، بينما وفقاً لسمك العظم يجب توخي الحذر عند التخطيط لوضع الزرعات التقويمية في عظم الحنك الصلب. تصنيف جديد لسمك عظم الحنك الصلب تم وضعه

Table 4: Comparisons between the areas of the hard palate in bone density (HU).

			Descriptive statistics	Areas		Mean difference	Cohen s d	P-value
				Anterior	*Middle*			
Anteroposterior area	Bone Density	Cortical	Mean	1246.4	1104.8	141.6	1.06 (LE)	0.001 (HS)
			SD	113.55	150.40			
		Cancellous	Mean	633.20	775.30	-142.1	-0.83 (LE)	0.001 (HS)
			SD	124.50	207.44			
				Anterior	*Posterior*			
	Bone Density	Cortical	Mean	1246.4	1019.8	226.6	1.63 (LE)	0.001 (HS)
			SD	113.55	160.78			
		Cancellous	Mean	633.20	819.80	-186.6	-1.25 (LE)	0.001 (HS)
			SD	124.50	169.70			
				Middle	*Posterior*			
	Bone Density	Cortical	Mean	1104.8	1019.8	85.00	0.55 (ME)	0.001 (HS)
			SD	150.40	160.78			
		Cancellous	Mean	775.30	819.80	-44.50	-0.23 (SE)	0.2 (NS)
			SD	207.44	169.70			
Mediolateral areas				*Mid-Palatal*	*Medial*			
	Bone Density	Cortical	Mean	1099.6	1183.3	-83.7	-0.6 (ME)	0.001 (HS)
			SD	116.70	160.78			
		Cancellous	Mean	832.90	637.90	195	1.22 (LE)	0.001 (HS)
			SD	112.38	195.51			
				Mid-Palatal	*Middle*			
	Bone Density	Cortical	Mean	1099.6	1113.2	-13.6	-0.09 (SE)	1 (NS)
			SD	116.70	165.76			
		Cancellous	Mean	832.90	757.30	75.6	0.47 (ME)	0.028 (HS)
			SD	112.38	199.30			
				Mid-Palatal	*Lateral*			
	Bone Density	Cortical	Mean	1099.6	1113.6	-14.00	-0.11 (Small effect)	1 (NS)
			SD	116.70	144.99			
		Cancellous	Mean	832.90	717.00	115.9	0.79 (ME)	0.001 (HS)
			SD	112.38	174.40			
				Medial	*Middle*			
	Bone Density	Cortical	Mean	1183.3	1113.2	70.10	0.43 (ME)	0.002 (HS)
			SD	160.78	165.76			
		Cancellous	Mean	637.90	757.30	-119.4	-0.6 (ME)	0.001 (HS)
			SD	195.51	199.30			
				Medial	*Lateral*			
	Bone Density	Cortical	Mean	1183.3	1113.6	69.7	0.46 (ME)	0.006 (HS)
			SD	160.78	144.99			
		Cancellous	Mean	637.90	717.00	-79.1	-0.43 (ME)	0.041 (HS)
			SD	195.51	174.40			
				Middle	*Lateral*			
	Bone Density	Cortical	Mean	1113.2	1113.6	-0.40	0 (NE)	1 (NS)
			SD	165.76	144.99			
		Cancellous	Mean	757.30	717.00	40.3	0.22 (SE)	0.41 (NS)
			SD	199.30	174.40			

Table 5: Comparisons between the areas of the hard palate in bone thickness (mm) for male and female.

	Descriptive Statistics	Areas for male		Mean difference	Cohen s d	P-value	Areas for female		Mean difference	Cohen s d	P-value
		Anterior	*Middle*				*Anterior*	*Middle*			
Anteroposterior Areas	**Mean**	10.3	5.00	5.3	2.86 (LE)	0.001 (HS)	8.70	4.30	4.4	3.o6 (LE)	0.001 (HS)
	SD	2.15	1.49				1.65	1.20			
		Anterior	*Posterior*				*Anterior*	*Posterior*			
	Mean	10.3	4.00	6.3	3.60 (LE)	0.001 (HS)	8.70	3.50	5.2	3.88 (LE)	0.001 (HS)
	SD	2.15	1.22				1.65	0.94			
		Middle	*Posterior*				*Middle*	*Posterior*			
	Mean	5.00	4.00	1.0	0.74 (ME)	0.001 (HS)	4.30	3.50	0.8	0.74 (ME)	0.001 (HS)
	SD	1.49	1.22				1.20	0.94			
Mediolateral Areas		*Mid-Palatal*	*Medial*				*Mid-Palatal*	*Medial*			
	Mean	8.60	6.30	2.3	1.43 (LE)	0.001 (HS)	7.70	5.40	2.3	1.77 (LE)	0.001 (HS)
	SD	1.55	1.66				1.30	1.30			
		Mid-Palatal	*Middle*				*Mid-Palatal*	*Middle*			
	Mean	8.60	5.70	2.9	1.95 (LE)	0.001 (HS)	7.70	4.60	3.1	2.58 (LE)	0.001 (HS)
	SD	1.55	1.43				1.30	1.09			
		Mid-Palatal	*Lateral*				*Mid-Palatal*	*Lateral*			
	Mean	8.60	6.30	2.3	1.45 (LE)	0.001 (HS)	7.70	5.30	2.4	1.79 (LE)	0.001 (HS)
	SD	1.55	1.63				1.30	1.38			
		Medial	*Middle*				*Medial*	*Middle*			
	Mean	6.30	5.70	0.6	0.39 (ME)	0.001 (HS)	5.40	4.60	0.8	0.67 (ME)	0.001 (HS)
	SD	1.66	1.43				1.30	1.09			
		Medial	*Lateral*				*Medial*	*Lateral*			
	Mean	6.30	6.30	0.0	0.0 (NE)	1 (NS)	5.40	5.30	0.1	0.07 (SE)	1 (NS)
	SD	1.66	1.63				1.30	1.38			
		Middle	*Lateral*				*Middle*	*Lateral*			
	Mean	5.70	6.30	-0.6	-0.39 (ME)	0.001 (HS)	4.60	5.30	-0.7	0.56 (ME)	0.001 (HS)
	SD	1.43	1.63				1.09	1.38			

Table 6: The relationship of the bone density (cortical and cancellous) and bone thickness (for male and female) with BMI.

		Descriptive statistics	BMI (Kg/m2)-categories			ANOVA trendP-value
			Normal (18.5-24.9)	Overweight (25-29.9)	Obese (≥30)	
Bone Density	Cortical	**n=60**	**n=24**	**n=23**	**n=13**	**0.016 (S)**
		Range	821.00	860.20	1026.3	
			1313.5	1299.5	1290.7	
		Mean	**1091.1**	**1129.5**	**1190.8**	
		SD	137.00	111.30	80.600	
	Cancellous	**n=60**	**n=24**	**n=23**	**n=13**	**0.22 (NS)**
		Range	463.30	586.40	605.00	
			994.40	1048.3	913.10	
		Mean	**708.50**	**750.20**	**763.00**	
		SD	146.80	113.60	104.20	
Bone Thickness	Male	**n=30**	**n=16**	**n=7**	**n=7**	**0.76 (NS)**
		Range	3.9	5.8	5.2	
			9.5	9.6	8.2	
		Mean	**6.5**	**7.1**	**6.7**	
		SD	1.6	1.4	1.3	
	Female	**n=30**	**n=8**	**n=16**	**n=6**	**0.78 (NS)**
		Range	4.9	4.0	4.1	
			7.5	7.5	7.3	
		Mean	**6.0**	**5.6**	**5.9**	
		SD	1.0	1.1	1.1	

Table 7: The Relationship of the bone density (cortical and cancellous) and bone thickness with diagnostic scale measurements.

		Descriptive statistics	Variables					
			Fat%	Water%	Muscle%	Bone Mass	BMR	AMR
Cortical Bone Density	Lowest quartile (≤1042.5) n=15	Mean	**27.5**	**52.9**	**39.3**	**10.0**	**1709.3**	**2380.4**
		SD	5.70	4.16	4.54	2.46	243.79	379.23
	Interquartile range (1042.6 – 1209.7)n=30	Mean	**29.3**	**51.6**	**37.7**	**9.10**	**1649.9**	**2260.4**
		SD	8.11	5.92	6.09	2.30	253.14	376.68
	Highest quartile (1209.8) n=15	Mean	**29.3**	**52.2**	**37.7**	**9.20**	**1644.3**	**2276.8**
		SD	7.15	6.19	5.51	2.26	229.98	381.53
	P-Value (ANOVA Trend)		**0.5 (NS)**	**0.73 (NS)**	**0.46 (NS)**	**0.37 (NS)**	**0.47 (NS)**	**0.46 (NS)**
Cancellous Bone Density	Lowest quartile (≤638.1) n=15	Mean	**30.1**	**51.0**	**37.7**	**9.80**	**1699.7**	**2344.2**
		SD	7.08	5.17	5.65	2.95	334.08	487.39
	Interquartile range (638.2 – 833.4) n=30	Mean	**30.0**	**51.0**	**37.1**	**9.30**	**1654.6**	**2285.0**
		SD	6.58	5.17	5.04	2.17	214.86	333.72
	Highest quartile (833.5) n=15	Mean	**25.4**	**55.1**	**40.5**	**9.10**	**1644.5**	**2263.7**
		SD	8.10	6.51	6.07	1.98	197.23	349.18
	P-Value (ANOVA Trend)		**0.07 (NS)**	**0.043 (S)**	**0.16 (NS)**	**0.39 (NS)**	**0.54 (NS)**	**0.56 (NS)**
Bone Thickness	Lowest quartile (≤5.1)n=15	Mean	**29.0**	**52.4**	**37.0**	**8.30**	**1548.1**	**2104**
		SD	8.23	6.85	6.13	1.67	154.33	271.67
	Interquartile range (5.2 – 7.2) n=30	Mean	**28.8**	**52.0**	**38.2**	**9.40**	**1667.8**	**2309.4**
		SD	7.01	5.11	5.47	2.22	236.86	368.72
	Highest quartile (7.3) n=15	Mean	**28.8**	**52.0**	**39.1**	**10.5**	**1769.7**	**2455.1**
		SD	7.29	5.32	5.27	2.68	285.79	414.22
	P-Value (ANOVA Trend)		**0.93 (NS)**	**0.84 (NS)**	**0.32 (NS)**	**0.009 (HS)**	**0.012 (S)**	**0.01 (S)**

Table 8: Classification of bone density and thickness of hard palate for the anteroposterior areas.

Anterioposterior Areas	Descriptive Statistics	Bone Density		Bone Thickness	
		Cortical	Cancellous	Male	Female
Anterior Area	Range	D_2-D_1	D_3-D_2	T_3-T_1	T_3-T_2
	Mean	**D_2**	**D_3**	**T_2**	**T_2**
Middle Area	Range	D_3-D_1	D_3-D_2	T_4-T_2	T_4-T_2
	Mean	**D_2**	**D_3**	**T_3**	**T_3**
Posterior Area	Range	D_3-D_2	D_3-D_2	T_4-T_3	T_4-T_3
	Mean	**D_2**	**D_3**	**T_3**	**T_4**

Table 9: Classification of bone density and thickness of hard palate for the mediolateral areas.

Mediolateral Areas		Descriptive Statistics	Mid-Palatal Area	Medial Area	Middle Area	Lateral area
Bone Density	Cortical	Range	D_3-D_1	D_3-D_1	D_3-D_1	D_3-D_1
		Mean	**D_2**	**D_2**	**D_2**	**D_2**
	Cancellous	Range	D_3-D_2	D_4-D_2	D_3-D_2	D_4-D_2
		Mean	**D_3**	**D_3**	**D_3**	**D_3**
Bone Thickness	Male	Range	T_3-T_2	T_4-T_2	T_4-T_2	T_4-T_2
		Mean	**T_2**	**T_3**	**T_3**	**T_3**
	Female	Range	T_3-T_2	T4-T2	T_4-T_3	T_4-T_2
		Mean	**T_3**	**T_3**	**T_3**	**T_3**