Thickness of Buccal Bone at Various Sites of the Mandible and Its Clinical Significance in Monocortical Screws Placement Using Multi-Slice Computed Tomography

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ABSTRACT

Background:Open reduction and internal fixation (ORIF) of using miniplates and screws is the treatment of choice of mandibular fractures. It is important to know both: the region where the bone provides a firm anchorage, and the topography of the dental apices and inferior alveolar nerve to avoided imaging them when inserting the screw. The aim of this study is to determine the thickness of buccal cortical plate and that of buccal bone at the parasymphysis and mandibular body, thereby determining the area that provide a firm anchorage and the maximum length of mono-cortical screws that can be safely placed in these regions without injuring the tooth roots or mandibular nerve.
Materials and Methods: The sample of the present study was 110 Iraqi subjects (77 males & 33 females) aged (18-35) years old who admitted to Computed Tomography scan unit in AL-Sadr Teaching Hospital in Al-Najaf city to get Computed Tomographic examination of facial bones. The conventional sections of CT (axial, coronal) used to do the measurements and dental planning analysis also used. The thickness of buccal cortical plate and the thickness of buccal bone were measured at the level of root apex of (canine, first premolar, second premolar) and at the level ofroot apex and inferior alveolar canal in mesial and distal root of first and second molar.
Results: There was no statistical significant difference in buccal cortical plate and buccal bone thickness between age and gender at most measured sites. Using of 4mm screw is safe in distal root region of 2nd molar at the level of apex and that of inferior alveolar canal for both males and females. Moving slightly forward in position to the mesial root of 2nd molar 1mm will be lost from safety margin, while making only the 3mm screw is safe. For the remaining anterior positions only the minimum screw length of 2 mm is safe.
Conclusions: Thickness of buccal cortical plate and buccal bone in various sites could be measured precisely using Multislice Computed tomography which can guide surgeons in selecting the proper screw length without causing injury to tooth apex or inferior alveolar nerve.
Keywords: Mandibular fracture, buccal bone, mini-plate, Computed tomography. (J Bagh Coll Dentistry 2015; 27(4):78-84).

INTRODUCTION

Computed Tomography (CT) scanning is the best option to the present date for the diagnosis, surgical planning, and treatment of bone lesions, owing to its specific properties[1].Multi-detector (Multislice) computed tomography (MDCT) is considered one of the most valuable imaging modalities for preoperative procedures, because it allows the acquisition of fast, reliable and reproducible images [2]. The mandible is the largest, strongest and lowest bone in the face. It has a horizontally curved body that is convex forwards, and two broad rami that ascend posteriorly [3].

The mandibular canal is a canal within the mandible that contains the inferior alveolar nerve, and inferior alveolar vein. It runs obliquely downward and forward in the ramus, and then horizontally forward in the body, where it is placed under the alveoli and communicates with them by small openings[4].Mandibular fracture is one of the most common facial skeletal injuries[5].Its main causes are road crashes and violence, and the relation between these causes varies from one country to another.

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The prevalence of mandibular fractures was higher in male subjects in all age groups [6].Open reduction and internal fixation (ORIF) using miniplates and screws are the treatment of choice for mandibular fracture. ORIF of fractures involving the mandibular body and parasymphysis requires the placement of screws along the ideal line of osteosynthesis; this carries a risk of injury to the roots of the teeth and to the branches of mandibular nerve. Miniplate fixation has been shown to bear masticatory forces reliably. Screws are used to anchor miniplates to bone; therefore, it is important to know the distance from the outer cortex to the tooth apices and to the inferior alveolar canal to avoid injuring these structures. Although the screw should be long enough to provide stability, it should be short enough to avoid damage to any vital structure [7].

MATERIALS AND METHODS

The sample composed of 110 Iraqi subjects with age range (18-35) years old. The sample selected from the subjects attendedCT unit in Al-Sadr medical city in Najaf for facial bone examination from November 2013 till May 2014.

The subjects divided into two groups: 1- group composed of 58 subjects (40 males, 18 females). 2- Group composed of 52 subjects (37 male, 15 female). These groups according to the sections of computed tomography used to do the measurements. The CT machine used was 64-slice multi-detector CT scanner, Philips, Holland, Brilliance CT, V4.0.

The images were generated at 120kv and 250 mAs, the slice thickness of the image was 0.9 mm. The study measures the thickness of buccal cortical plate and buccal bone (cortical and cancellous) in the mandible at the level of root apex of canine, 1st premolar, 2nd premolar, 1st molar and 2nd molar.

The measurement in molar area also done at the level of inferior alveolar canal. In the first group of subjects, the measurements done for the canine, 1st premolar, 2nd premolar only using the ordinary axial section as shown in figure 1(a,b).The exact tooth and position of the apex can be known by checking the axial section with coronal and sagittal section. In the second group of subjects the measurements done for the canine, 1st premolar, 2nd premolar, 1st molar (apex, IAC), 2nd molar (apex, IAC) using dental planning analysis protocol as shown in figure 2(a,b) and figure 3(a,b).

Statistical Analysis:

Statistical analyses were done using SPSS version 21 computer software (Statistical Package for Social Sciences). Frequency distribution for selected variables was done first. The outcome quantitative variable (bone thickness measurements at selected areas) was shown to be normally distributed. Such quantitative variables are best described by mean, SD, SE. The independent samples t-test was used to assess the statistical significance of difference in mean between 2 groups.

The statistical significance, strength and direction of linear correlation between 2 quantitative normally distributed variables was assessed by Pearson's linear correlation coefficient. Cohen's d is a standardized measure of effect size for difference between 2 means, which can be compared across different variables and studies, since it has no unit of measurement. Cohen's d = (mean1-mean2) / Pooled SD of the 2 groups. Cohen's d<0.3 small effect, 0.3-0.7 (medium effect), while 0.8 and higher is a large effect.

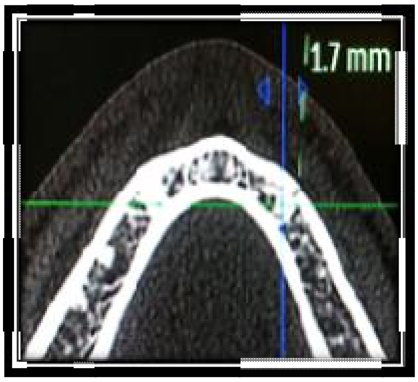

Figure (1a): Axial Section of CT Showing Thickness of the Buccal Cortical Plate atCanine Apex.

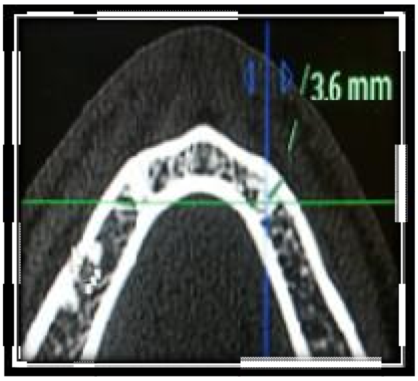

Figure (1b): Axial Section of CT Showing Thickness of the Buccal Bone atCanine Apex.

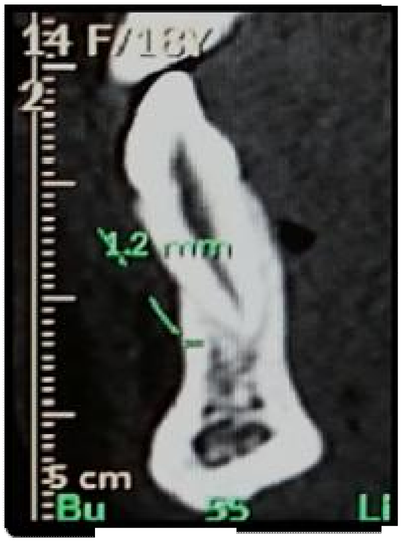

Figure (2a): DentalAnalysis of CT Image Showing Thickness of the Buccal Cortical Plate atCanine Apex.

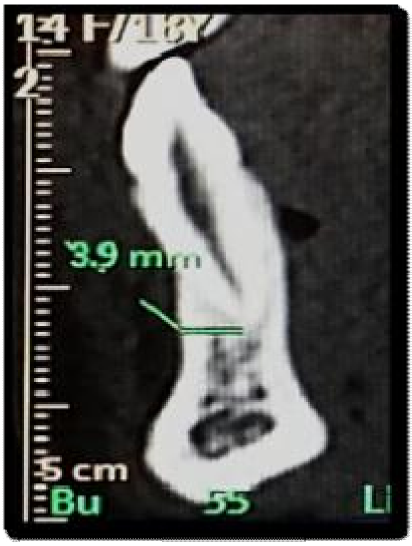

Figure (2b):Dental Analysis of CT Image Showing Thickness of the Buccal Bone atCanine Apex.

Figure (3b):Dental Analysis of CT Image Showing Thickness of the Buccal Bone in Molar Area.

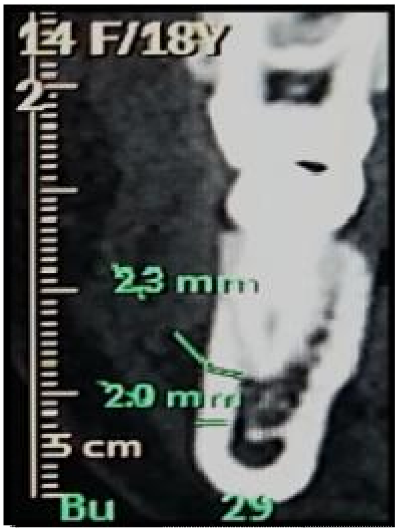

Figure (3a):Dental Analysis of CT Image Showing Thickness of the Buccal Cortical Plate in Molar Area.

RESULTS

At most measured sites, the mean of the buccal cortical plate and buccal bone thickness was larger in males than females; however, the difference was too small to reach the level of statistical significance. The mean buccal cortical plate thickness was significantly higher in male compared to female at the level of root apex for canine, 1st premolar and mesial root of 1st molar. The effect of gender on buccal cortical plate thickness was strongest at the level of mesial root apex of 1st molar (Cohen's d 0.7) followed by the level of canine and 1st premolar (Cohen's d 0.54).The mean buccal bone thickness was significantly higher in male compared to female at the level of root apex for canine and 2nd premolar(tables1,2,3,4).

There was no obvious or consistent difference in the buccal cortical plate and buccal bone thickness between the very young age group (18-24 years) and the older one (25-35 year).Using of 4mm screw was safe in distal root region of 2nd molar at the level of apex and that of inferior alveolar canal for both males and females. Moving slightly forward in position to the mesial root of 2nd molar we will lose 1mm of safety margin, making only the 3mm screw safe. For the remaining anterior positions only the minimum screw length of 2mm was safe(tables 5, 6).

Table (1): Gender Difference in the Buccal Cortical Plate Thickness at the Level of RootsApices

		Descriptive statistics	Female	Male	P-value	Cohen's d
Buccal cortical plate thickness at the level of	canine apex	Range	0.9-2.2	0.9-2.4	0.002	0.54
		Mean	1.4	1.6		
		N	33	77		
	1st premolar Apex	Range	0.9-2.1	0.8-2.4	0.002	0.54
		Mean	1.5	1.7		
		N	33	77		
	2nd premolar Apex	Range	1-3	1-3.5	0.05 (NS)	0.4
		Mean	1.6	1.8		
		N	33	77		
	mesial root apex of 1st molar	Range	1-3.2	1.5-3.9	0.039	0.7
		Mean	2	2.4		
		N	15	37		
	distal root apex of 1st molar	Range	1-3.4	1.5-3.7	0.75 (NS)	0.17
		Mean	2.4	2.5		
		N	15	37		
	mesial root apex of 2nd molar	Range	1.7-3.4	1.5-4.2	0.15 (NS)	0.35
		Mean	2.5	2.7		
		N	15	37		
	distal root apex of 2nd molar	Range	1.7-4.4	1.2-3.7	0.99 (NS)	0
		Mean	2.7	2.7		
		N	15	37		

Table (2):Gender Difference in the Buccal Cortical Plate Thickness at the Level ofIAC.

		Descriptive statistics	Female	Male	P-value	Cohen's d
Buccal cortical plate thickness at the level of	IAC at mesial root region of 1st molar	Range	1.5-3.2	1.5-3.2	1 (NS)	0
		Mean	2.2	2.2		
		N	15	37		
	IAC at distal root region of 1st molar	Range	1.6-4.9	1.2-3.4	0.16 (NS)	-0.56
		Mean	2.5	2.2		
		N	15	37		
	IAC at mesial root region of 2nd molar	Range	1.8-3.2	1.2-4.2	0.67 (NS)	-0.18
		Mean	2.5	2.4		
		N	15	37		
	IAC at distal root region of 2nd molar	Range	1.7-3.4	1.2-3.4	0.61 (NS)	-0.2
		Mean	2.5	2.4		
		N	15	37		

Table (3): Gender Difference in the Buccal BoneThickness at the Level of Roots Apices

		Descriptive statistics	Female	Male	P-value	Cohen's d
Buccal bone thickness at the level of	canine apex	Range	1.2-6.9	1.6-7.8	0.005	0.53
		Mean	3.7	4.3		
		N	33	77		
	1st premolar Apex	Range	1.2-6	1.2-7.1	0.2 (NS)	0.26
		Mean	3.6	3.9		
		N	33	77		
	2nd premolar Apex	Range	1.2-8.7	1-7.1	0.02	0.49
		Mean	3.5	4.1		
		N	33	77		
	mesial root apex of 1st molar	Range	1-5.9	1.5-6.6	0.09 (NS)	0.49
		Mean	3	3.6		
		N	15	37		
	distal root apex of 1st molar	Range	1-8.1	3.2-7.6	0.53 (NS)	0.22
		Mean	4.8	5.1		
		N	15	37		
	mesial root apex of 2nd molar	Range	3.9-11.3	2.7-10.5	0.45 (NS)	0.24
		Mean	6.9	7.3		
		N	15	37		

	distal root apex of 2nd molar	Range	5.6-10.8	5.6-12	0.4 (NS)	0.21
		Mean	7.6	7.9		
		N	15	37		

Table (4):Gender Difference in the Buccal Bone Thickness at the Level ofIAC.

Buccal bone thickness at the level of		Descriptive statistics	Female	Male	P-value	Cohen's d
	IAC at mesial root region of 1st molar	Range	2-6.6	2.2-6.6	0.74 (NS)	0.1
		Mean	4.7	4.8		
		N	15	37		
	IAC at distal root region of 1st molar	Range	2.9-7.1	2.7-9	0.53 (NS)	0.23
		Mean	5.3	5.6		
		N	15	37		
	IAC at mesial root region of 2nd molar	Range	3.2-7.4	3.7-9.7	0.27 (NS)	0.31
		Mean	5.6	6		
		N	15	37		
	IAC at distal root region of 2nd molar	Range	4.2-6.6	3.7-9.1	0.12 (NS)	0.5
		Mean	5.4	6		
		N	15	37		

Table (5):Predicted Injury to Tooth Apex and Inferior Alveolar Nerve Using Different Screw Lengths with a Standard Plate Thickness of 1mm (Female)

Injury rate percentage	Screw length					
		2	3	4	5	6	7
	Canine apex	0	6.1	24.2	60.6	93.9	97
	1st premolar apex	0	6.1	21.2	72.7	90.9	100
	2nd premolar apex	0	15.2	33.3	72.7	90.9	97
	Mesial root apex of 1st molar	6.7	26.7	60	80	93.3	100
	IAC at mesial root region of 1st molar	0	6.7	6.7	26.7	53.3	93.3
	Distal root apex of 1st molar	6.7	6.7	6.7	33.3	53.3	80
	IAC at distal root region of 1st molar	0	0	6.7	20	40	60
	Mesial root apex of 2nd molar	0	0	0	6.7	13.3	40
	IAC at mesial root region of 2ndmolar	0	0	0	6.7	26.7	53.3
	Distal root apex of 2nd molar	0	0	0	0	0	20
	IAC at distal root region of 2nd molar	0	0	0	0	40	73.3

Table (6):Predicted Injury to Tooth Apex and Inferior Alveolar Nerve Using Different Screw Lengths with a Standard Plate Thickness of 1mm (Male)

Injury rate percentage	Screw length						
		2	3	4	5	6	7
	Canine apex	0	1.3	13	41.6	74	92.2
	1st premolar apex	0	6.5	23.4	49.4	85.7	96.1
	2nd premolar apex	1.3	2.6	14.3	53.2	80.5	96.1
	Mesial root apex of 1st molar	0	13.5	29.7	70.3	86.5	94.6
	IAC at mesial root region of 1st molar	0	0	5.4	27	51.4	89.2
	Distal root apex of 1st molar	0	0	0	18.9	45.9	70.3
	IAC at distal root region of 1st molar	0	0	5.4	10.8	29.7	51.4
	Mesial root apex of 2nd molar	0	0	2.7	2.7	10.8	16.2
	IAC at mesial root region of 2nd molar	0	0	0	2.7	24.3	54.1
	Distal root apex of 2nd molar	0	0	0	0	0	5.4
	IAC at distal root region of 2nd molar	0	0	0	5.4	29.7	51.4

DISCUSSION

In general, male gender was associated with a higher bone thickness compared to females. This difference was however too small to reach the level of statistical significance given the constraints of the sample size for the current study. In some of the examined points the bone thickness was significantly higher in males. In these points the gender effect was evaluated as a moderately strong effect. At most measured sites the mean buccal cortical plate and buccal bone thickness was larger in males than females. There should be a clear distinction between the findings of a bigger vs. denser-skeleton in males compared to females. A longitudinal study on mice provided strong evidence that skeletal gender dimorphism is determined by independent and time specific effects of sex steroid. Although males have a larger bone compared to females the bone density is not affected. In addition the gender differences are likely to be highlighted at certain age intervals[8].

Hu et,al.,[9] in their study on a sample of 20 dry mandibles showed no statistically significant difference in cortical plate thickness and total bone thickness between males and females. The sample size used in Hu study was too small to allow for a valid and meaningful comparison between the two genders.

Al-Jandan*et,al.,*[7] in their study on a sample of 50 mandibles with an age range comparable to our study reach to a similar conclusion in respect to absence of a noticeable gender difference in buccal cortical or total bone thickness at the tooth apex or IAC. The same study also reported some exceptions in the general conclusion. For example a higher buccal bone thickness in males compared to females in the 2nd molar region. One of the plausible explanations of the absence of consistent differences in gender is the wide range of individual variations in facial type and teeth inclinations especially in the buccolingual direction which greatly affects the bone thickness.

Masumoto et,al.,[10] stated that facial types are associated with the cortical bone thickness of the mandibular body and with the buccolingual inclination of 1st and 2nd molar. The sampling units in the current study were selected in a restricted age interval. All the study subjects of the present study were young adults with an age ranging between 18-35 years. Therefore the study failed in detecting any obvious or consistent difference in the buccal cortical plate and buccal bone thickness between the very young age group (18-24 years) and the older one (25-35 year).

Riggs et,al.,[11] in their population-based study about age and sex differences in bone volumetric density and size at different skeletal sites concluded that age related bone loss begins after the age interval used in the current study.

Wowern and Stoltze[12] argued that the mean cortical width (MCW) and absolute bone mass are greater in males than in females and show a parallel age related decrease after the age of 50. Furthermore, the age related increase in cortical thinning and porosity is dependent on the individual as well as on age. Marked individual variation may limit the use of these parameters to group analysis.

Hu et,al.,[9] failed to detect any association between the age and buccal cortical plate thickness or total bone thickness in a sample of 20 mandibles. Many studies recommended the use of screws 5-7mm long to ensure good fixation in combination with standard miniplates of 1mm thickness[13,14]. The current study employed the worst estimate scenario in predicting injury to tooth apex or nerve. It was found that the use of 4mm screw was safe in distal root region of 2nd molar at the level of apex and that of inferior alveolar canal for both males and females.

Moving slightly forward in position to the mesial root of 2nd molar we will lose 1mm of safety margin, making only the 3mm screw safe. For the remaining anterior positions only the minimum screw length of 2mm is safe. The minimum screw length of 5mm recommended by previous studies may result in a very low injury rate ranging between 2.7 and 5.4 in both genders at the molar region. One may consider such a risk as a very low one and may be willing to tolerate at the expense of good stability. The maximum recommended screw length of 7mm on the other hand is too risky since the injury rate may be up to 73.3% in the molar region.

Needless to say that the injury rate will increase steeply to reach up to 100% with 7 mm screw length. Al-Jandanet,al.,[7] reported similar measurements for buccal cortical plate and buccal bone thickness at the level of teeth apices from canine to 2nd molar. No stratified analysis by gender was done and the exact tooth root for molars was not specified. Direct comparison with findings from other studies will not be possible in all measured sites.

Leonget,al.,[13] studied 26 dentate jaws cadavers. The average buccal cortical plate thickness in dentate mandibles was 2.76mm. This figure is comparable to the maximum estimate in our study for cortical plate (2.7mm for 2nd molar root apex) and is expected to be higher than the overall average.

Katranjiet,al.,[14] in their study to determine the average thickness of buccal and lingual plates, 28 cadaver heads (68% male and 32% female) with an average age of 73.1 years were measured at various locations correlating to molar (M), premolar (PM), and anterior (A) regions and found that the buccal cortical bone thickness in the area of premolars 1.2mm, which is lower than the current study result (1.5-1.7 mm) for females and males respectively. In molar area they found that the buccal cortical bone thickness was 1.98 mm which is also lower than the current study result (2.4-2.6mm) for females and males respectively. This difference may be due to the average age of the cadavers in their study being 73.1 years.

Hu et,al.,[9]reported the mean buccal cortical plate thickness as 1.5mm in the canine region, 2.2mm in the premolar region and 3.8mm in the molar region. The previously mentioned measurements were done using dried mandibles and a strict cross sectional plane. It is therefore expected that these measurements are over estimates for the measurements done in our study in which the distance was measured perpendicular to bone surface.

Jin et,al.,[15] had their study on a sample of 66 individuals examined by CT scan to measure buccal bone thickness at the level of 1st and 2nd molar root apex without referring to gender. They reported a mean of 8.5 mm at the distal root of 2nd molar which is slightly higher than the current study estimate (7.6-7.9 mm for females and males respectively). The mean buccal bone thickness at the mesial root of 2nd molar was comparable (7.3mm) to our estimate (6.9-7.3mm for females and males respectively).

The same study of Jin et,al.,[15] reported a mean of 5.2mm at the distal root of 1st molar which is comparable to the current study estimate (4.8-5.1mm for females and males respectively). The mean buccal bone thickness at the mesial root of 1st molar was slightly higher (4.1mm) than our estimate (3-3.6mm for females and males respectively). Levineet,al.,[16] reported that the inferior alveolar canal was of 4.9 mm from the buccal cortex at the 1st molar region. These estimates are close to the present study results, the mean buccal bone thickness at mesial root region in male 4.8 mm and in female 4.7 mm.

Nagadiaet,al.,[17]reviewed CT scans of mandible for a sample of Chinese adults, emphasizing the anatomical position of the mandibular canal in relation to cortical bone and molar teeth The mandibular canal was farthest from the buccal cortex at the second molar region (mean buccal bone thickness of 6.79 mm and a minimum of 4.80 mm). These estimates were higher than the current study measurements (mean buccal bone thickness of 5.6 to 6mm and a minimum of 3.2 to 3.7 for females and males respectively).

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