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ASSESSMENT OF MANDIBULAR ALVEOLAR BONE PARAMETERS IN IRAQI ADULTS USING CONE BEAM COMPUTED TOMOGRAPHY

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ABSTRACT

Background and objectives: The increased popularity of using temporary anchorage devices like miniscrews in orthodontic treatment makes it necessary to have a comprehensive knowledge of the morphology of mandibular alveolar processes to help clinicians in selecting optimal sites for miniscrew installation. This study aimed to measure the alveolar cortical bone thickness and interradicular spaces in four sites of each side of mandible, among different sites and levels from cementoenamel junction. Materials and Methods: This study was conducted using cone beam computed tomographic records of 40 subjects (18 male, 22 female) with age range of 20-35 years. The radiographic images for both right and left sides of mandible were used to measure; cortical bone thickness both buccally and lingually, width of alveolar process and interradicular distances at buccal, middle and lingual aspects. The interradicular sites studied were: between canine and first premolar, first and second premolars, second premolar and first molar, and first and second molars. All these sites were examined at three different levels (4, 6 and 8mm) from cemento-enamel junction. The NNT software was used to process the radiographic images and to perform the measurements. Results: all alveolar bone parameters showed an increased value on moving in apical direction. Lingual cortical bone was thicker than buccal cortical bone with significant difference noticed in most sites and levels. All variables in mandible showed the highest dimensions between first and second molars. Regarding levels of measurement the highest dimensions were recorded at 8 mm level for all parameters. Conclusion: The cortical bone for all levels of measurement showed adequate thickness. Adequate alveolar process width was available for insertion of 6 mm screw in all sites and levels. Adequate interradicular distance was found distal to first premolar at the 3 levels with increased distance on moving apically and posteriorly.

INTRODUCTION

One of the important factors in orthodontic force system is the anchorage. Skeletal anchorage using orthodontic miniscrews have greatly enhanced orthodontic treatment by facilitating different tooth movements without the need for supporting teeth [1,2]. Because of the increased application of miniscrews orthodontist are becoming more worried about the factors affecting its success rate. Several studies have investigated the various factors affecting stability and success of miniscrews including design of the screw, bone density and thickness, insertion site, root proximity, and orthodontic force applied [3-7]. Stability of miniscrew is derived mainly from mechanical retention in bone [8]. Several researchers have investigated the influence of alveolar cortical bone thickness on primary stability of miniscrews and reported that inserting miniscrews in areas of thicker cortical bone

will increase primary stability and produce a better resistance to pull out forces [9,6,4].

On the other hand root proximity is considered to be correlated with the success rate of miniscrews in orthodontic treatment [10]. Significantly improved success rate was found with Increasing the distance between root surface and miniscrew [11,4]. Preoperative assessment of interradicular sites is also important to ensure safe installation of miniscrew without damaging periodontal ligament or dental root [1]. Several researchers have attempted to provide anatomical map of maxillary and mandibular alveolar processes to quid clinicians in selecting optimal sites for miniscrew insertion using different radiographic imaging modalities [12-14,23,24].

Recently, 3-dimensional imaging using cone beam computed tomography (CBCT) became widely used for imaging of oral and maxillofacial structures [15,16]. CBCT can provide thinner cross-sections compared to spiral CT (SCT) offering a combination of high diagnostic value with a relatively low radiation dose [17]. In addition it permits measurements to be performed in planes of space not available or accurately displayed in traditional 2-D radiography [18].

There is an increased trend towards using CBCT technology in assessing small maxillofacial structures [19] like bone thickness and interradicular spaces for preoperative assessment of implant site [20-22].

In order to provide the clinicians with a detailed assessment regarding the availability of alveolar bone for miniscrew insertion in different interdental sites the present study was conducted using CBCT radiographic records of mandible in a sample of Iraqi adults.

MATERIALS AND METHODS

The patients were recruited from the specialized dental polyclinic in Howler city /Iraq. The patients who were referred for CBCT for evaluation of orthodontic patient prior to the treatment were selected for the study. The selected patients were further evaluated by CBCT to get more accurate details about cortical bone thickness.

The scans were selected according to the following inclusion criteria included, patient Age between 20-35ys of either sex. No missing or impacted teeth (excluding third molars) [23] Absence of periodontal bone loss evaluated on radiograph [23] and finally, absence of rotated, malformed and heavily restored teeth [24]. NNT software was used and The CBCT scans will use through (version 6.2, Verona, Italy).

Image acquisition:

The patients were positioned in upright direction (Wheel chair accessible),the x-ray tube and CBCT sensor was rotated 360 degree around patient head, scanning the targeted volume by cone shape x-ray beam,360 images were reconstructed by NNT(6.2) software to get multi planner reformatted images of 8 x11 cm volume. The CBCT images were evaluated on New Tom Gianosoftware program, axial images were performed with a thickness of 1mm and an interval of 1mm and the required time for the reconstruction of volumetric image was 4 minutes.

Detection and measurements:

To evaluate the thickness of cortical bone, the images were all aligned and adjusted in axial view using a standard method for accurate measurements of bone thickness (According to the device instructions). In axial images, a zero line adjusted to midway between buccal and lingual cortex to get true coronal and sagittal images. Multiple sagittal and coronal images are obtained with 0.15mm images thickness and 0.15mm steps between each 2 images (market lines as shown in [Fig.1.]) through using special tool in the NNT viewer software of the CBCT machine and on multi-planar. The reconstructed images were evaluated for difference in thickness from lingual and buccal at 3 levels (4, 6, 8 mm respectively) as shown in [Fig.1.]. Measurement of alveolar bone variables in The CBCT images were analyzed to identify the following described Alveolar bone measurements in the posterior region of mandibular alveolar process at 4 interradicular sites; between canine and first premolar, first and second premolars, second premolar and first molar, and finally between first and second molars as follows:

1. **Cortical bone thickness:** The thickness of cortical plate was measured at the middle of each interradicular site on buccal and lingual aspects of mandibular alveolar process, as shown in [Fig.2.].
2. **Middle interradicular distance:** Measurement of the shortest distance between the roots of two adjacent teeth in the mid-area of interradicular space [24]. [Fig.3.]
3. **Thickness of alveolar process:** This was measured from the external aspect of the cortical bone on the buccal side to the external aspect of cortical bone on lingual sides. [25] .As shown in [Fig.4.]
4. **Buccal interradicular distance:** This was measured as the widest distance between the roots of two adjacent teeth on the buccal aspect.The measurement was done parallel to the line tangent to buccal root surfaces of adjacent teeth. As shown in [Fig.5.].
5. **Lingual interradicular distance:** It represented the widest distance between roots on the lingual aspect which measured parallel to the tangent to palatal root surfaces of adjacent teeth, as shown in [Fig.5.].

Reliability of measurement:

There was no significant difference between the repeated measurements of the five patients ($P \leq 0.05$).

Statistical Analysis:

The collected data were analyzed by using SPSS software (Statistical Package for Social Sciences,version 21.

RESULTS

The descriptive statistics of alveolar bone measurements for mandibular right and left sides are demonstrated in Tables (1) and (2). All alveolar bone dimensions showed an increased value on moving from 4 mm level to 8 mm level, in right and left sides of mandible. In both sides of mandible the width of alveolar process showed a consistent pattern of increased value on moving from canine-first premolar interradicular site to first molar-second molar interradicular site. Buccal and middle interradicular distances also showed a similar pattern except for interradicular distances between first and second molars at 4 mm and 6 mm levels on right side of mandible. The highest buccal cortical thickness was found at 8-mm level between first and second molars in both right (2.56±0.61) and left (2.31±0.82) sides. Lingual cortical thickness showed the largest value at 8 mm level between first and second premolars on right side (2.14+0.6) and between canine and first premolar (2.23±0.66) on left side. For alveolar process width the largest dimension was at 8-mm level between first and second molars on right (13.25±0.98) and left (13.11±0.97) sides.

Considering interradicular bone distances at buccal, middle and lingual aspects, the largest interradicular space was recorded at 8 mm level between first and second molars on buccal aspect for right side (4.33±1.26) and on the lingual aspect for left side (4.15 ±1.85). The largest middle interradicular distance was also recorded at 8 mm level between first and second molars on both right (3.89±1.20) and left (3.78±1.98) sides of mandible. The lowest IRD was in the middle aspect between canine and first premolar at 4 mm levels on right (1.73±0.46) and left (1.75±0.47) sides.

Table 1. Descriptive statistics of alveolar bone measurements in 4 interradicular sites at 3 levels from CE junction for right mandible

Level	Variables	Right Side							
		3-4		4-5		5-6		6-7	
		Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD
4mm	BC Thickness	1.23	0.40	1.40	0.43	1.22	0.28	1.81	0.50
	LC Thickness	1.74	0.46	1.55	0.59	1.58	0.34	1.90	0.64
	Alveolar Process Width	6.90	1.40	7.40	0.84	9.26	0.92	11.39	1.72
	Buccal IRD	2.32	0.90	2.38	0.93	3.54	1.14	2.94	0.79
	Middle IRD	1.73	0.67	1.99	0.82	2.68	0.98	2.55	0.76
	Lingual IRD	2.19	0.84	3.45	1.08	3.10	0.84	2.95	0.78
6mm	BC Thickness	1.28	0.43	1.69	0.55	1.51	.030	2.14	0.48
	LC Thickness	1.86	0.43	1.90	0.47	1.91	0.42	1.84	0.47
	Alveolar Process Width	7.98	1.44	7.95	0.91	9.67	0.94	12.47	1.63
	Buccal IRD	2.43	0.96	2.95	1.07	3.61	1.15	3.38	1.07
	Middle IRD	1.83	0.77	2.25	0.82	2.98	1.30	2.90	0.79
	Lingual IRD	2.25	1.02	3.52	1.26	3.01	1.14	3.33	0.87
8mm	BC Thickness	1.46	0.45	1.95	0.46	1.64	0.33	2.56	0.61
	LC Thickness	1.96	0.44	2.14	0.60	1.98	0.50	1.96	0.48
	Alveolar Process Width	8.38	1.09	8.55	0.98	9.98	1.03	13.25	0.98
	Buccal IRD	2.58	0.86	3.27	1.02	3.63	1.45	4.33	1.26
	Middle IRD	2.12	0.92	2.70	0.99	3.31	1.26	3.89	1.20
	Lingual IRD	2.50	1.05	3.72	1.05	3.39	1.44	4.24	1.19

Number of sample=40; SD=standard deviation; BC= buccal cortical; LC=lingual cortical; IRD= interradicular distance.

Table 2. Descriptive statistics of alveolar bone measurements in 4 interradicular sites, at 3 levels from CE junction for left mandible

Level	Variables	left Side							
		3-4		4-5		5-6		6-7	
		Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD
4mm	BC Thickness	0.80	0.22	1.25	0.39	1.37	0.56	1.60	0.62
	LC Thickness	1.66	0.59	1.63	0.46	1.68	0.61	1.87	0.63
	Alveolar Process Width	6.92	1.22	7.38	0.81	9.06	0.80	11.51	0.89
	Buccal IRD	2.35	0.70	3.01	1.39	3.12	0.86	3.10	1.28
	Middle IRD	1.75	0.47	2.32	0.70	2.73	0.73	2.89	1.20
	Lingual IRD	2.32	0.74	3.17	0.94	3.12	0.62	3.27	0.95
6mm	BC Thickness	0.95	0.37	1.40	0.43	1.54	0.42	1.96	0.72

	LC Thickness	1.99	0.51	2.17	0.63	1.90	0.66	2.07	0.50
	Alveolar Process Width	7.79	1.12	7.75	0.80	9.51	1.22	12.62	1.03
	Buccal IRD	2.25	0.56	3.30	0.79	3.38	1.04	3.47	1.49
	Middle IRD	1.94	0.53	2.82	0.70	2.99	0.86	3.34	1.39
	Lingual IRD	2.56	0.90	3.72	0.74	2.95	0.82	3.57	1.26
8mm	**BC Thickness**	1.13	0.37	1.70	0.49	1.73	0.48	2.31	0.82
	LC Thickness	2.23	0.66	2.04	0.70	2.07	0.55	2.10	0.67
	Alveolar Process Width	7.97	1.08	8.29	1.16	9.83	1.18	13.11	0.97
	Buccal IRD	2.50	0.77	3.63	0.92	3.81	1.36	3.95	2.12
	Middle IRD	2.30	0.84	3.33	0.73	3.46	1.03	3.78	1.98
	Lingual IRD	2.80	1.16	4.00	1.08	3.32	1.35	4.15	1.85

Number of sample=40; SD=standard deviation; BC= buccal cortical; LC=lingual cortical; IRD= interradicular distance.

Figure 1. The lines used for evaluation cortical bone thickness using NNT software

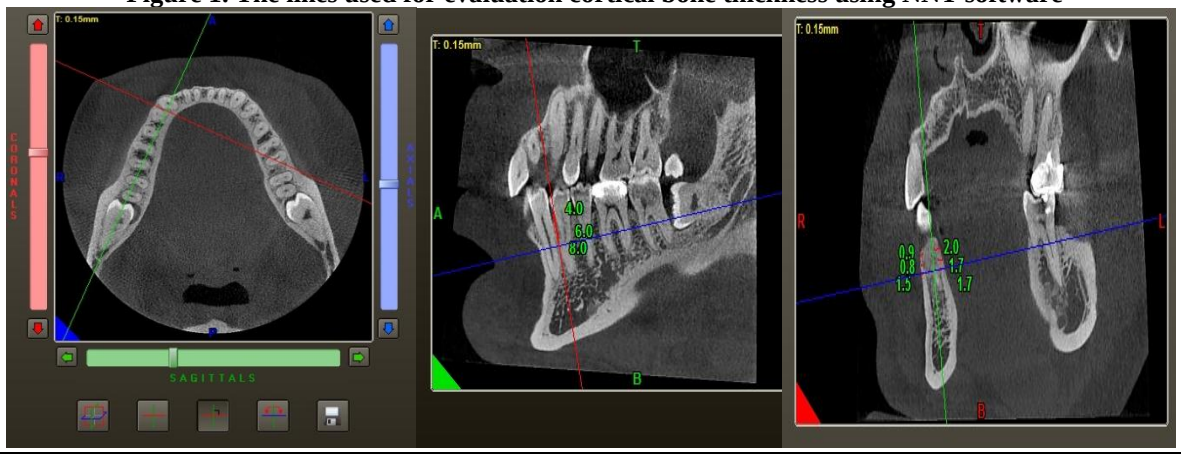


Figure 2. buccal and lingual cortical bone thickness

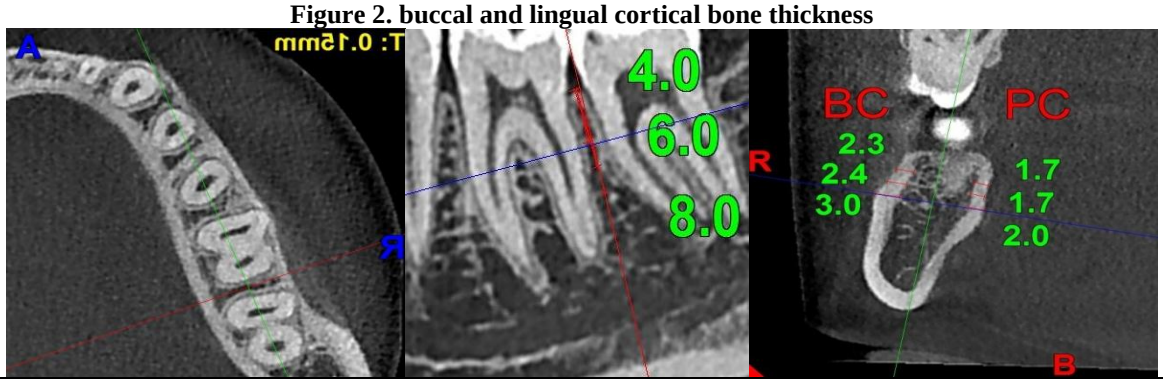


Figure 3. middle inter radicular distance

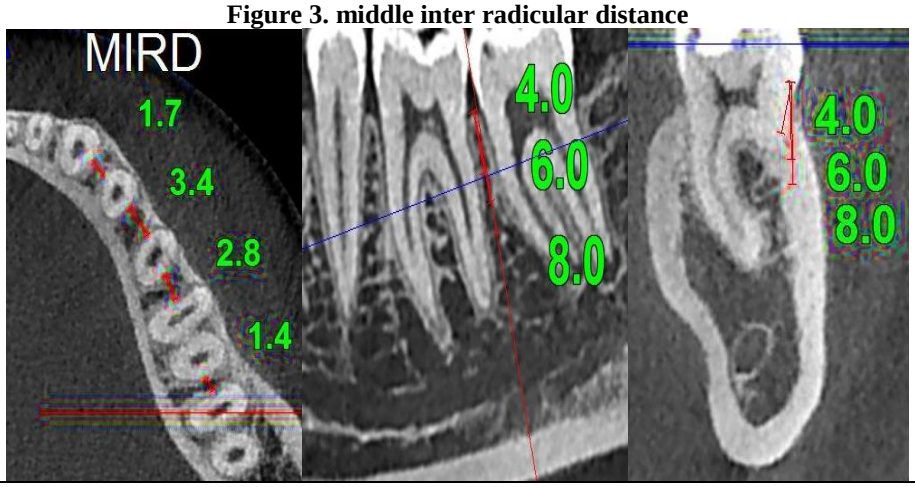


Figure 4. Thickness of alveolar process

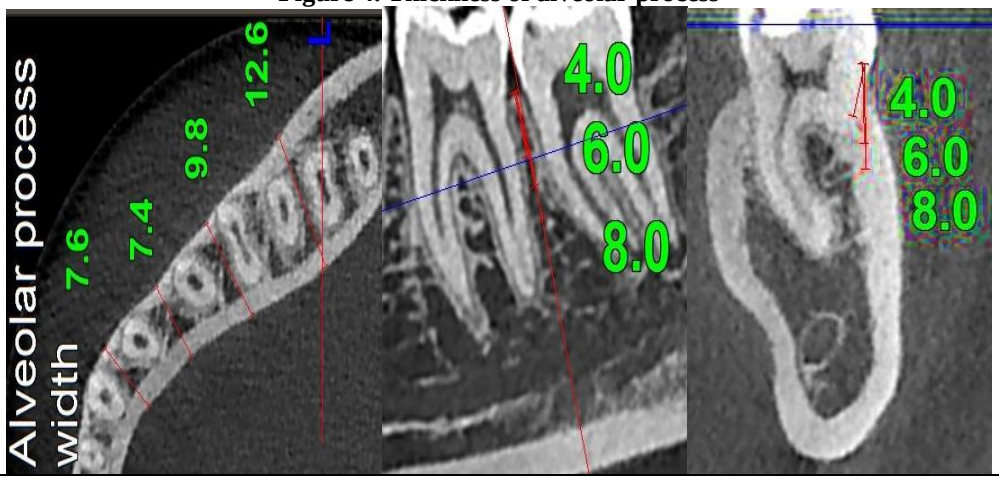
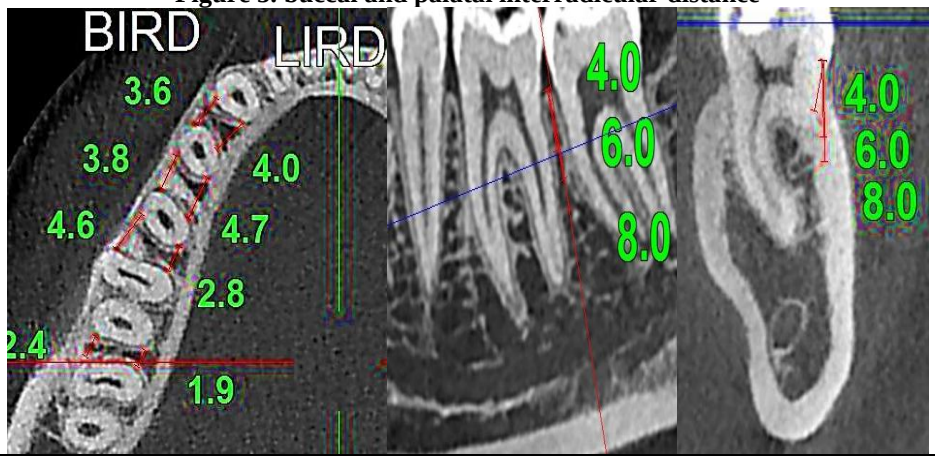


Figure 5. buccal and palatal interradicular distance



DISCUSSION

Until now, the research was focused on the rate of the success of mini screws in alveolar process comparing with dental implants and mini-plates. Unfortunately, they find the rate of success of mini screws is lower than dental implants in addition to mini plates [10]. Mini screws are widely used now in orthodontic treatments. Many factors may exert influence on the durability of these mini screws which has direct effect on the treatment plan of the patient.

These factors includes, type, diameter, length of the implant, patient related (sex, age, physical posture), surgical related (orientation of mini-screw placement and torque placement), orthodontic related (magnitude and timing of force), position related (cortical bone thickness, peri-implant bone quantity, keratinized versus oral mucosa) and miniscrew-maintenance related [26], many of these factors are not fully clear [26].

The present study examined the skeletal data gathered from 40 patients with CBCT images to determine the optimal sites for mini-implant placement by measuring thickness of cortical plate in the buccal and lingual aspects from canine to second molar teeth in addition to the interradicular bone dimensions at three different vertical levels (4 mm, 6 mm, and 8 mm) measured from the CEJ. The measurement technique to this study was established by Intraobserver reliability system [27-29].

The CEJ was selected as the starting point for the measurements, contrasting in other studies by Poggio PM et al. [28] and Monnerat C et al. [30] that used the alveolar crest and many periodontal ligament problems could be affected. It is advisable to place the mini-implants in areas of attached gingival, the maximum level of measurement in this study was selected to be 8 mm from CEJ. Lim WH et al. [31] excluded levels higher than 8 mm in their study on interradicular soft tissue for the same reason.

The buccal cortical bone thickness in the mandible showed increased significantly from 4 to 8 mm for all teeth that measured, and it's consistent with Baumgaertel and Hans [32]. Monnert et al. [30] delineated lingual cortical bone thicknesses had a gradual increase as the cuts moved apically and these finding is similar to our result.

As per our study, in the mandible, the highest BC thickness and alveolar process width between first and second molar first and second molar and this is as evidenced by fayed et al. [25] who stated that the largest buccolingual and buccal cortical thicknesses were between

the first and second molars. However, the highest buccal and lingual IRD and PC thickness between first and second molar first and second molar and result unable to correspond with fayed et al. [25], concluded that the greatest mesiodistal buccal measurement was between the 2nd bicuspid and the 1st molar, the greatest mesiodistal lingual measurements was between the 1st and 2nd bicuspid, the greatest lingual cortical thickness was between the canine and the 1st bicuspid.

We observed very high SD values and range values for the interradicular spaces; this discovered a great inter-individual difference. In the past study suggested by Deguchi et al [29], that mini implant with angulation between 15–30" could allow the clinician to use a longer mini screws in cases with a mesially curved first molar mesio-buccal root. This approach would increase the miniscrew⁄bone contact area. It was declared by Deguchi et al. [29], that by varying the miniscrews inclination, the bone⁄miniscrew interface may be improved by up to 50%. From the clinical view, the two purposes to clarify the previous studies, the first one the precaution before insertion should be taken to avoid root damage and secondly, the long miniscerws should be used to increase the stability and to decrease the failure rate coming from contact surface between the root and miniscerws [33] From the histological view, A past study (Kadioglu O et al [34] suggested that, when miniscrews insertion damaged the dental roots, a healing procedure was started by cementum cells. For more details, a research done by chen YH et al [35] with mongrel dogs reported that miniscrews failed will be happened when they tough the adjacent roots, may be related to high percentage of inflammation, and this inflammation lead to root resorption which caused more rate of failure.

We observed gradual increase in the alveolar cortical bone thickness at different areas from the alveolar crest was found. These results is consistent with the findings by Deguchi et al [29] and Ono et al [36] who reported that the cortical bone thickness face to be more thicker at greater heights level and thinner at low levels.

Also Sawada et al [12] concluded a percentage for the high level of the alveolar process to be thicker than the low level. Our results concluded that cortical bone thickness was differ with the measurement distance from the alveolar crest in the interradicular area. Chun and Lim [37] suggested that more success rate of mini-screws insertion at 6mm apically to alveolar bone crest.

One of the important sign of root proximity during insertion of mini scerws is increase resistance or torque. Kuroda et al [10] reported that root proximity is a major factor for miniscerws failure. Increased root contact or periodontal tissue damage may lead to increase chance of failure rate. [38-40,10]

Many researches mentioned that the maximum distance between the implant and the root should be between 0.5 mm to 0.6 mm to provide adequate space to prevent early failure [40,41]. For this reason, the accidental damaging of the periodontal tissue should be differentiated when mini implant are inserted close to the interradicular area. From the theoretical view, the primary resistance for insertion may be due to more thick cortical bone near by the root should not increase in a smooth insertion, sometime the pain coming with insertion if the root contact toughed with miniscrews or increase of the torque insertion [42].

CONCLUSION

1- The buccal and lingual cortical bone thickness increased significantly from 4 to 8 mm for all teeth that measured.

2- The cortical bone thickness in lingual greater than in buccal site.

3- The highest buccal cortical thickness and alveolar process width between first and second molar, the highest buccal, middle and lingual IRD and lingual cortical thickness between first and second molar.

4- All area and sites that we measured at three levels considered safety places for mini screws insertion but the rate of success increase with increase the cortical bone thickness.

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CONFLICT OF INTEREST:

The authors declare that they have no conflict of interest.

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