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Locating possible micro-osteoperforation sites and alveolar bone thickness by CBCT among kurdish young adults with class I skeletal relationship

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ABSTRACT

Objectives. Micro-osteoperforation (MOP) was introduced as a minimum invasive surgical intervention employed to accelerate orthodontic tooth movement. This study aimed to determine proposed MOP sites with the available alveolar bone thickness (ABT) needed in the maxilla (Mx.) and the mandible (Mand.) at both genders using cone-beam computed tomography (CBCT).

Methods. Pre-operative CBCT images of 48 skeletal Class I relationship (18-30yrs old) patients (22 males, 26 females) were analyzed. NewTom's NNT software was used to measure ABT. Measurements were done in 13 bilateral Mx. and Mand. inter-radicular sites at 3 levels corresponding to the proposed MOP sites. Statistical Package for Social Sciences, version 21 was used. Descriptive statistic values and Independent samples t-test were used to test the gender and Mx.-Mand. ABT difference, P ≤0.05.

Results. There was a general tendency toward increasing ABT gradually from the inter-incisal region distally toward the molar and from near cement-enamel junction toward the apical region in Mx. arch in both genders. In Mand., the same trend was observed as in Mx., especially for the males. No statistically significant gender ABT difference found at both dental arches except those of females who had significantly higher Mx. ABT at specific locations. No statistically significant difference was found in the comparison between both dental arches at P ≤ 0.05 except for certain locations where the Mx. had significantly larger values than Mand.

Conclusions. The outcome of this study can facilitate the site selection for the orthodontic MOPs beside mini-screws. As a clinical consideration, the best and the safest sites of MOPs can be specified for clinicians.

Keywords: Cone-beam computed tomography, micro-osteoperforations, orthodontics, tooth movement

INTRODUCTION

The long duration of orthodontic treatment is one of the chief problems facing both the patient and the orthodontist [1], which can raise the severity and the risk of the originated adverse effects from orthodontic therapy [2]. Since the start of orthodontic treatment, many interventions have been made to curtail the total time of treatment, employing diverse appliances and approaches with variable success rates. The non-surgical approaches include electromagnetic fields [3], custom-made brackets and wires [4], self-ligating brackets [5], medications [6], low-level laser and photodynamic therapy [7], low-intensity high-rate vibrations [8] and cell mediators injection [9].

Some evidences; obtained by meta-analysis and randomized controlled trials; indicated that the sur-

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gical approaches may be more effective in terms of accelerating the rate of tooth movement [10]. Invasive surgical approaches, such as osteotomies [11], corticotomies [12] associated with or without a bone graft, and less invasive approaches as piezocisions [13], piezopuncture and micro-osteoperforation (MOP) [14] have been conducted for stimulating the bone natural mechanisms [15], increasing the inflammatory mediators; triggered by orthodontic forces [16]; that temporarily upgrade the bone metabolism and resorption and could possibly affect the tooth movement rate [17].

Among the recent modalities introduced to accelerate orthodontic tooth movement is MOP, in other words, bone puncturing using mini-screw or propel device to induce micro-trauma to the alveolar bone initiating a regional acceleratory phenomenon [18]. MOP; has been introduced to meet the growing need for accelerating orthodontic treatment, especially by adult patients; is an approach based on principles of sound bone biology. It is a minimally invasive, safe approach that can be employed in conjunction with any orthodontic appliances and can be performed by the orthodontist, not only to accelerate orthodontic tooth movement with no or less pain or discomfort [14,19,20], but in many other orthodontic situations, obviously for changing the tooth movement type or creating differential anchorage [21]. According to Aboalnaga et al. [22], Alqadasi et al. [23], Fattoria et al. [24] and Mittal et al. [25], MOPs were not able to accelerate the tooth movement rate; nevertheless, they seemed to assist root movement. Shahabee et al. [26] in their systematic review and meta-analysis evaluated the effects of MOP on the tooth movement rate emphasizing that MOP can be suggested after weighing the benefits and drawbacks of this approach.

The determination of alveolar bone thickness (ABT) is a critical step in predicting treatment outcomes related to MOP procedures. No previous study in the literature was found with the detailed ABT at different locations in the maxilla (Mx.) and mandible (Mand.) for both genders, specially concerning MOP sites. Thus, the objective of the current study was to determine Mx. and Mand. ABT; especially concerning the determination of proposed MOP sites using a high-resolution CBCT system in the young adult population; at 3, 5 and 7 mm level from cemento-enamel junction (CEJ) and to reveal the gender and Mx.-Mand. ABT differences. The tested hypothesis was that there were no gender or Mx.-Mand. differences in ABT.

MATERIALS AND METHODS

Study protocol and registration: The study protocol was registered and approved (at session No. UoM.Dent/H.68/22) by the Research Ethics Committee of the College of Dentistry/ University of Mosul/ Iraq and (at session No. 193/23; meeting No.48) by the Research Ethics Committee of the College of Dentistry/ University of Sulaimani /Iraq.

Study design and sample characteristics

This was a retrospective observational study and the sample represented CBCT images of orthodontic patients that were previously treated orthodontically. The selected CBCT images were chosen according to the next eligibility criteria:

Inclusion Criteria

Eastern Mediterranean young adult Kurdish (18-30 years old) patients having Class I skeletal relationship, with upper and/or lower dental arch length discrepancy of up to 6mm as detected previously from the preliminary orthodontic records (CBCT images and study casts) by the treating orthodontist. CBCT images were presented including the nasal bone to the chin area. All CBCT images had been gotten with maximum intercuspation.

Exclusion Criteria

Congenitally missing or extracted teeth except for third molars, incomplete erupted teeth or impacted teeth, supernumerary teeth, facial asymmetry, craniofacial deformity, horizontal or vertical alveolar bone loss due to periodontal disease seen in CBCT images, restorations involving CEJ and orthodontic treatment history.

After applying selection criteria on 89 CBCT images, 48 images (22 for males and 26 for females) with mean age of 29.25 and 26.5 years, respectively, were involved in this study. The following formula was used for sample size calculation: $n = 2\sigma^2/\Delta^2 (z\alpha + z\beta)^2$. The resulted number was adjusted, and the final sample size in each group = n + (n × 0.2). In this study, n is considered as the number of subjects, σ (standard deviation) = 1.22 mm (representing the standard deviation of Mx.ABT according to Andrewsa et al. [27], (Δ) precision = 0.2 unit, $z\alpha$= 1.96 for α= 0.05 and $z\beta$ =0.84 for 80% power. According to this, for each gender group, the calculated sample size was approximately 11 subjects. And for more accurate and precise results, larger than this number was used in each group.

The images were previously performed using Cone Beam Tomography NewTom machine (NewTom VGi scanner; QR s.r.l., Verona, Italy). NewTom CBCT machine was set at Full Scale Voltage (FSV) 90 KV, 50.25 mAs, with 0.15 mm nominal slice thickness, field of view (FOV) 8*5 HRes, and exposure time 9.0s.

Measurements

NewTom's NNT software was used to measure ABT. After the software was opened, CBCT image was downloaded. A multi-planer option was chosen from the toolbar, and four views coordinated with each other appeared on a screen including: axial, panoramic, sagittal and 3D rendering images (Figure 1-A). The axial and panoramic views were used to determine the inter-radicular site intended to be measured, and the sagittal view that was highly outlined with red color was used to measure ABT. For each CBCT image, bilateral measurements were done for ABT in 13 Mx. inter-radicular sites from the mesial site of the right (R) second molar to the distal site of the left (L) first molar and 13 bilateral Mand. sites from the mesial site of the L second molar to the distal site of the R first molar corresponding to the proposed MOP sites. For each site, ABT was measured perpendicularly from the buccal cortical plate to the lingual/palatal cortical plate at 3, 5 and 7 mm levels from CEJ parallel to it (Figure 1-B). All measurements were recorded in millimeters.

All the measurements were accomplished by one observer. Intra- and inter-class reliability correlations were calculated using 10 randomly selected CBCT images.

Statistical analyses

The measurements were analyzed using SPSS (Statistical Package for Social Sciences), version 21 (SPSS Inc., Chicago, IL) as follows: Data was firstly inspected for normal distribution using Shapiro-Wilk's normality test. The mean and standard deviation values were calculated. An independent samples t-test was used to test the gender and Mx.-Mand. differences in ABT. The level of significance was P≤ 0.05.

RESULTS

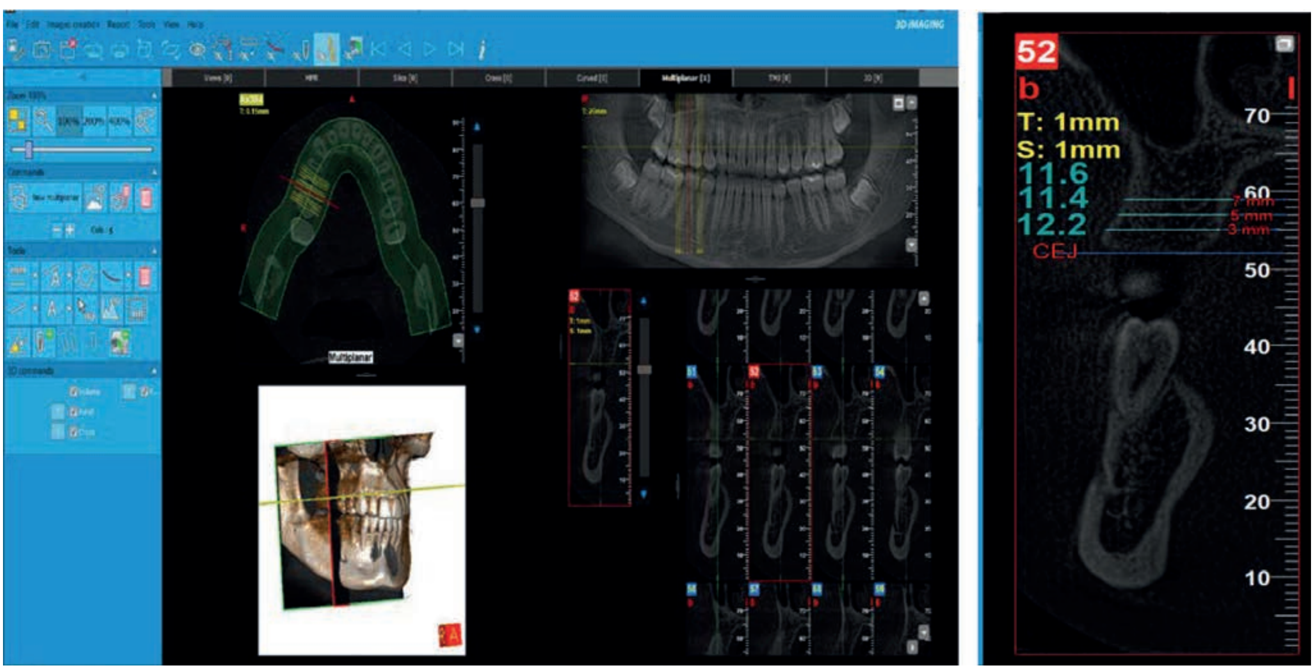
For all measured parameters, the inter- and intra-class reliability were (>0.8) representing good inter- and intra-observer reliability. Shapiro-Wilk's Test revealed a normal distribution of data at P ≤0.05. Thus parametric statistics were followed.

Descriptive statistics

Tables 1 and 2 revealed the descriptive statistics of Mx.-Mand. ABT at different levels from CEJ for the males and females. The least value was for males at Mand. anterior region Mesial to R1 at 3mm level (5.09 ± 0.87), while the highest value was for Males at Mx. posterior region distal to L6 at 7mm level (14.23 ± 1.57).

For males and females, the mean bilateral values of Mx. ABT at the anterior, the premolar and at the molar regions were observed at Figure 2. There is a tendency toward increasing in Mx. ABT gradually from inter-incisal distally toward molar and from near CEJ toward apical regions, in both genders,

The mean bilateral values of Mand. ABT of males and females at the anterior, the premolar and at the molar regions were noticed at Figure 3. Also, there is a tendency toward increasing Mand. ABT gradually from inter-incisal distally toward molar and from near CEJ toward apical regions, especially in the males.



A B

FIGURE 1. NewTom's NNT software for CBCT images. (A) showed four views include: Axial, Panoramic, Sagittal and 3D rendering images; (B) Bone thickness measured in sagittal view at 3,5 and 7 mm from cemento-enamel junction

TABLE 1. Descriptive statistics of maxillary alveolar bone thickness at different levels from cement-enamel junction for males and females with gender comparison

Site	Level (mm)	Males	Females	Sig.
		Mean (SD)	Mean (SD)	
Mesial to R7	3	12.63 (1.54)	13.99 (1.06)	S
	5	13.55 (0.92)	14.48 (0.95)	S
	7	13.87 (1.29)	14.70 (0.91)	NS
Mesial to R6	3	10.47 (1.27)	10.75 (1.06)	NS
	5	10.83 (1.15)	11.18 (0.70)	NS
	7	11.31 (1.29)	11.43 (0.86)	NS
Mesial to R5	3	8.75 (0.83)	8.93 (1.34)	NS
	5	9.21 (0.80)	9.59 (1.10)	NS
	7	9.18 (0.75)	9.90 (0.99)	NS
Mesial to R4	3	8.97 (1.37)	8.92 (1.26)	NS
	5	9.41 (1.23)	10.36 (1.18)	NS
	7	8.98 (1.51)	11.33 (2.05)	S
Mesial to R3	3	7.48 (1.11)	8.24 (1.40)	NS
	5	9.19 (1.94)	9.82 (2.24)	NS
	7	9.47 (2.40)	10.57 (2.61)	NS
Mesial to R2	3	8.90 (2.50)	8.76 (2.21)	NS
	5	9.82 (2.12)	10.61 (2.77)	NS
	7	10.12 (1.97)	11.16 (2.83)	NS
Mesial to R1	3	7.49 (1.68)	7.69 (1.03)	NS
	5	7.62 (2.34)	7.95 (1.09)	NS
	7	7.90 (2.68)	8.27 (1.40)	NS
Distal to L1	3	8.59 (1.93)	9.18 (1.97)	NS
	5	9.50 (1.82)	10.06 (2.28)	NS
	7	9.72 (1.99)	10.49 (1.77)	NS
Distal to L2	3	8.01 (2.25)	8.89 (1.87)	NS
	5	9.11 (2.08)	10.19 (2.07)	NS
	7	9.07 (2.32)	10.64 (2.61)	NS
Distal to L3	3	8.47 (1.06)	8.88 (1.20)	NS
	5	8.83 (0.91)	9.84 (1.19)	NS
	7	9.14 (1.57)	10.06 (1.73)	NS
Distal to L4	3	8.61 (1.14)	9.18 (0.98)	NS
	5	9.10 (1.39)	9.86 (1.11)	NS
	7	8.89 (1.56)	9.96 (1.18)	NS
Distal to L5	3	10.04 (0.48)	10.84 (0.71)	S
	5	10.77 (1.04)	11.17 (0.73)	NS
	7	10.79 (1.35)	10.98 (0.95)	NS
Distal to L6	3	13.32 (1.05)	13.70 (0.97	NS
	5	13.91 (1.28)	14.41 (1.09)	NS
	7	14.23 (1.57)	14.17 (1.19)	NS

R = Right, L = Left, Mx = Maxillary, Mand = Mandibular, ABT = Alveolar Bone Thickness, SD = Standarad Deviation, Males = 22, Females = 26, Sig. = significant at P ≤0.05, S = significant, NS = non ignificant

TABLE 2. Descriptive statistics of mandibular alveolar bone thickness at different levels from cement-enamel junction for males and females with gender comparison

Site	Level (mm)	Males	Females	Sig.
		Mean (SD)	Mean (SD)	
Mesial to R7	3	10.49 (1.00)	11.86 (2.51)	NS
	5	11.84 (1.14)	13.73 (2.08)	S
	7	12.69 (1.95)	14.46 (1.62)	S
Mesial to R 6	3	8.91 (1.23)	8.67 (1.19)	NS
	5	9.81 (1.05)	10.09 (1.31)	NS
	7	10.41 (0.92)	10.90 (1.44)	NS
Mesial to R5	3	8.00 (1.38)	7.27 (0.81)	NS
	5	9.05 (1.66)	8.21 (1.29)	NS
	7	9.40 (2.03)	8.93 (1.59)	NS
Mesial to R4	3	7.90 (1.36)	7.16 (1.05)	NS
	5	9.31 (1.81)	8.16 (1.18)	NS
	7	9.62 (2.26)	8.55 (1.46)	NS
Mesial to R3	3	7.35 (1.82)	6.62 (344)	NS
	5	8.32 (1.60)	7.35 (1.18)	NS
	7	8.07 (1.81)	7.42 (1.46)	NS
Mesial to R2	3	6.90 (2.88)	6.03 (0.68)	NS
	5	6.75 (1.74)	6.77 (1.13)	NS
	7	6.54 (1.97)	6.55 (1.44)	NS
Mesial to R1	3	5.09 (0.87)	5.46 (0.78)	NS
	5	5.89 (1.40)	5.73 (1.01)	NS
	7	6.24 (1.36)	6.35 (1.09)	NS
Distal to L1	3	10.38 (1.43)	11.40 (1.61)	NS
	5	11.25 (1.56)	13.22 (1.78)	NS
	7	12.03 (1.77)	12.13 (2.63)	NS
Distal to L2	3	8.48 (1.16)	9.00 (0.96)	NS
	5	8.91 (1.50)	9.82 (1.02)	NS
	7	9.26 (1.69)	10.63 (1.05)	NS
Distal to L3	3	7.56 (1.48)	7.46 (0.92)	NS
	5	8.60 (1.76)	8.22 (1.29)	NS
	7	9.02 (1.51)	8.90 (1.46)	NS
Distal to L4	3	8.49 (1.14)	7.31 (1.63)	NS
	5	9.27 (1.48)	8.43 (1.62)	NS
	7	9.24 (1.64)	8.74 (1.58)	NS
Distal to L5	3	6.92 (0.94)	6.84 (1.31)	NS
	5	7.93 (1.48)	7.59 (1.38)	NS
	7	7.52 (1.67)	7.56 (1.57)	S
Distal to L6	3	6.47 (0.90)	6.26 (0.79)	NS
	5	7.10 (0.65)	6.86 (0.67)	S
	7	6.93 (1.14)	6.87 (0.74)	NS

R = Right, L = Left, Mx = Maxillary, Mand = Mandibular, ABT = Alveolar Bone Thickness, D = Standarad Deviation, Males = 22, Females = 26, Sig. = significant at P ≤0.05, S = significant, NS = non ignificant

Gender comparison

Tables 1 and 2 displayed significant statistical difference in ABT, in comparison between both gender, in the following sites: Mx. Mesial to R7 at level of 3 and 5mm, Mx. Mesial to R4 at level 7mm, Mx. Distal to L5 at 3mm level, Mand. Mesial to R7 at level of 5 and 7mm and Mand. Distal to L5 at level 7mm in which the females have the largest value and Mand. Distal to L6 at a level of 5mm in which the males have the largest value. The rest sites were not statistically significant.

Maxillary-mandibular comparison

For males, Mx.-Mand. comparison of ABT (Table 3) showed that there was significant difference in the following sites in which Mx. was larger than

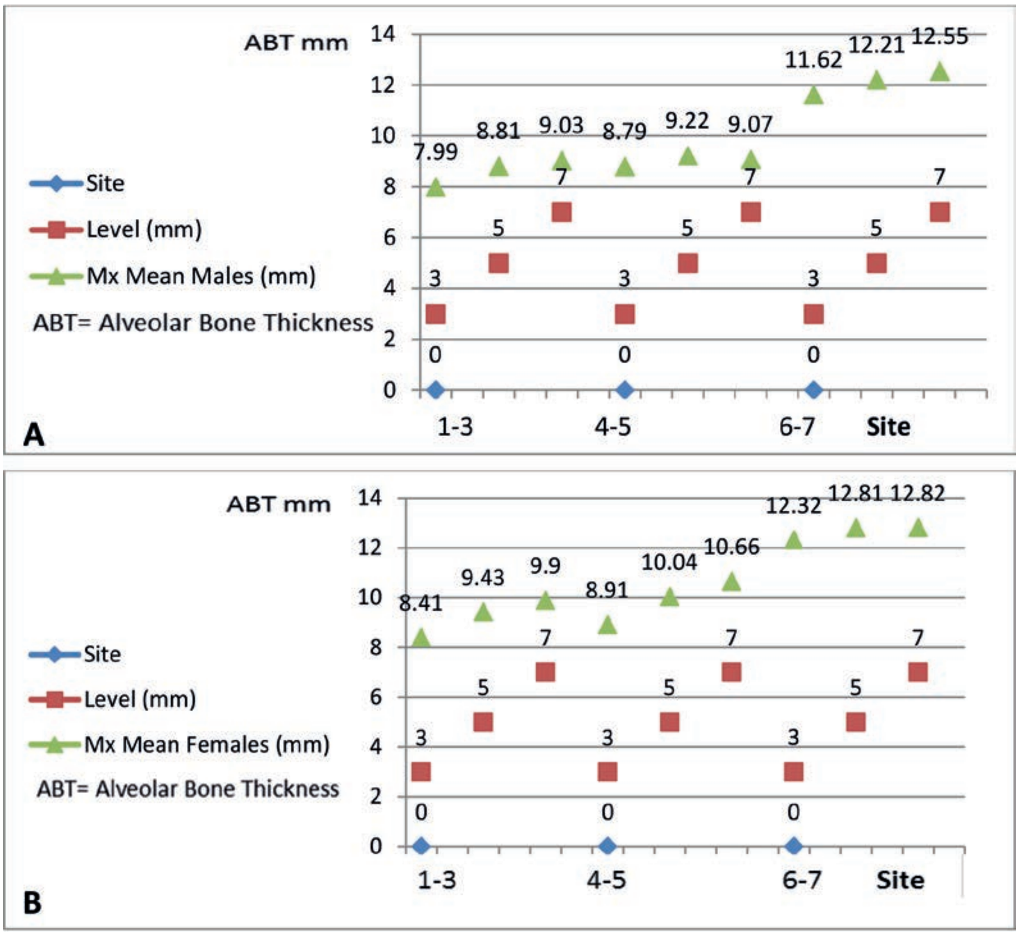


FIGURE 2. Bilateral maxillary mean alveolar bone thickness at different levels for males (A) and females (B)

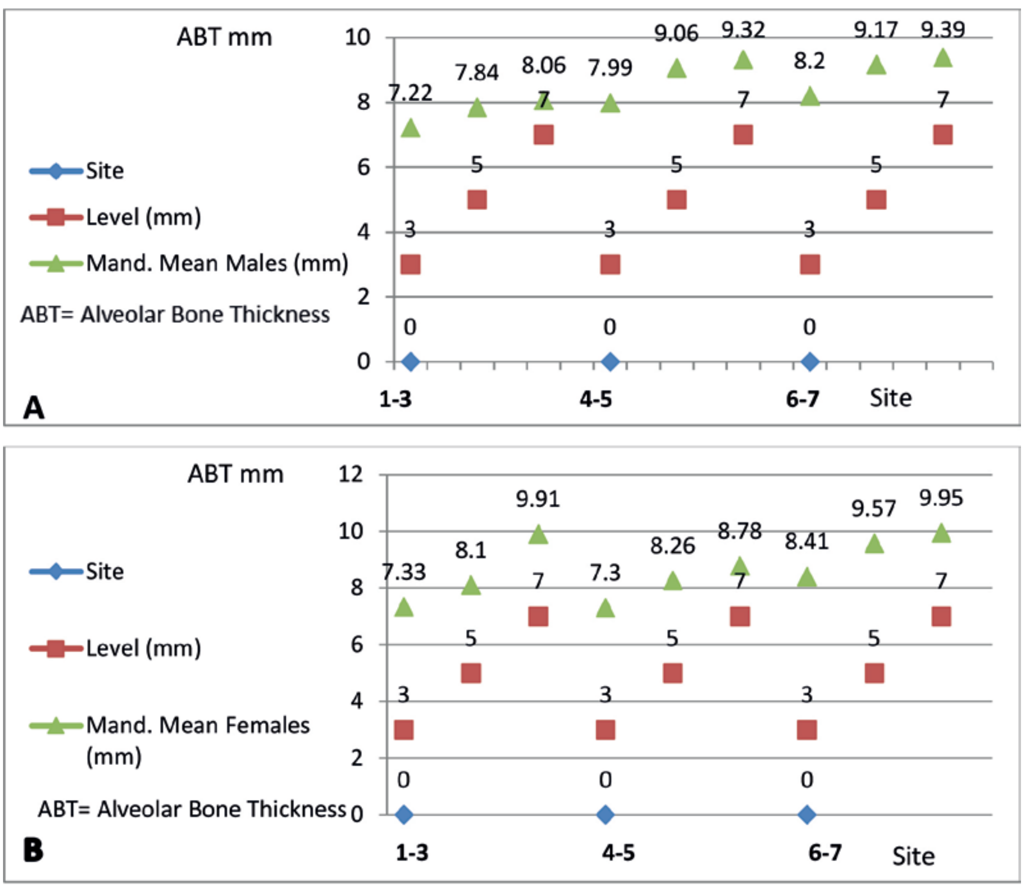


FIGURE 3. Bilateral mandibular mean alveolar bone thickness at different levels for males (A) and females (B)

TABLE 3. Maxillary-mandibular comparison of alveolar bone thickness at different levels from cement-enamel junction for males

Variable	Level (mm)	R			L		
		Mx. Mean (SD)	Mand. Mean (SD)	Sig.	Mx. Mean (SD)	Mand. Mean (SD)	Sig.
Mesial to 7	3	12.63 (1.54)	10.38 (1.43)	S	13.32 (1.05)	10.49 (1.00)	S
	5	13.55 (0.92)	11.25 (1.56)	S	13.91 (1.28)	11.84 (1.14)	S
	7	13.87 (1.29)	12.03 (1.77)	S	14.23 (1.57)	12.69 (1.95)	NS
Mesial to 6	3	10.47 (1.27)	8.48 (1.16)	S	10.04(0.48)	8.91(1.23)	S
	5	10.83 (1.15)	8.91 (1.50)	S	10.77 (1.04)	9.81 (1.05)	S
	7	11.31 (1.29)	9.26 (1.69)	S	10.79 (1.35)	10.41 (0.92)	NS
Mesial to 5	3	8.75 (0.83)	7.56 (1.48)	S	8.61 (1.14)	8.00 (1.38)	NS
	5	9.21 (0.80)	8.60 (1.76)	S	9.10 (1.39)	9.05 (1.66)	NS
	7	9.18 (0.75)	9.02 (1.51)	NS	8.89 (1.56)	9.40 (2.03)	NS
Mesial to 4	3	8.97 (1.37)	8.49 (1.14)	NS	8.47 (1.06)	7.90 (1.36)	NS
	5	9.41 (1.23)	9.27 (1.48)	NS	8.83(0.91)	9.31(1.81)	NS
	7	8.98 (1.51)	9.24 (1.64)	NS	9.14 (1.57)	9.62 (2.26)	NS
Mesial to 3	3	7.48 (1.11)	6.92 (0.94)	NS	8.01(2.25)	7.35 (1.82)	NS
	5	9.19 (1.94)	7.93 (1.48)	NS	9.11(2.08)	8.32 (1.60)	NS
	7	9.47 (2.40)	7.52 (1.67)	S	9.07 (2.32)	8.07 (1.81)	NS
Mesial to 2	3	8.90 (2.50)	6.47 (0.90)	S	8.59 (1.93)	6.90 (2.88)	NS
	5	9.82(2.12)	7.10(0.65)	S	9.50(1.82)	6.75(1.74)	S
	7	10.12(1.97)	6.93(1.14)	S	9.72(1.99)	6.54(1.97)	S
Mesial to 1	3	7.49(1.68)	5.09(0.87)	S	7.49(1.68)	5.09(0.87)	S
	5	7.62(2.34)	5.89(1.40)	S	7.62(2.34)	5.89(1.40)	S
	7	7.90(2.68)	6.24(1.36)	NS	7.90(2.68)	6.24(1.36)	NS

R = Right, L = Left, Mx = Maxillary, Mand = Mandibular, ABT = Alveolar Bone Thickness, SD = Standarad Deviation, Males = 22, Sig. = significant at P ≤ 0.05, S = significant, NS = non significant

TABLE 4. Maxillary-mandibular comparison of alveolar bone thickness at different levels from cement-enamel junction for females

Variable	Level (mm)	R			L		
		Mx. Mean (SD)	Mand. Mean (SD)	Sig.	Mx. Mean (SD)	Mand. Mean (SD)	Sig.
Mesial to 7	3	13.70 (0.97)	11.40 (1.61)	S	13.70 (0.97)	11.86 (2.51)	S
	5	14.41(1.09)	13.22 (1.78)	NS	14.41(1.09)	13.73 (2.08)	NS
	7	14.17 (1.19)	12.13 (2.63)	NS	14.17 (1.19)	14.46 (1.62)	NS
Mesial to 6	3	10.75 (1.06)	9.00 (0.96)	S	10.84 (0.71)	8.67 (1.19)	S
	5	11.18 (0.70)	9.82 (1.02)	S	11.17 (0.73)	10.09 (1.31)	S
	7	11.43 (0.86)	10.63 (1.05)	S	10.98 (0.95)	10.90 (1.44)	NS
Mesial to 5	3	8.89 (1.30)	7.46 (0.92)	S	9.18 (0.98)	7.27 (0.81)	S
	5	9.59 (1.10)	8.22 (1.29)	S	9.86 (1.11)	8.21 (1.29)	S
	7	9.90 (0.99)	8.90 (1.46)	NS	9.96 (1.18)	8.93 (1.59)	NS
Mesial to 4	3	8.92 (1.26)	7.31(1.63)	S	8.88 (1.20)	7.16 (1.05)	S
	5	10.36 (1.18)	8.43 (1.62)	S	9.84 (1.19)	8.16 (1.18)	S
	7	11.33 (2.05)	8.74 (1.58)	S	10.06 (1.73)	8.55 (1.46)	S
Mesial to 3	3	8.24 (1.40)	6.84 (1.31)	S	8.89 (1.87)	6.62 (1.16)	S
	5	9.82 (2.24)	7.59 (1.38)	S	10.19 (2.07)	7.35 (1.18)	S
	7	10.57 (2.61)	7.56 (1.57)	S	10.64 (2.61)	7.42 (1.46)	S
Mesial to 2	3	8.76 (2.21)	6.26 (0.79)	S	9.18 (1.97)	6.03 (0.68)	S
	5	10.61 (2.77)	6.86 (0.67)	S	10.06 (2.28)	6.77 (1.13)	S
	7	11.16 (2.83)	6.87 (0.74)	S	10.49 (1.77)	6.55 (1.44)	S
Mesial to 1	3	7.69 (1.03)	5.46 (0.78)	S	7.69 (1.03)	5.46 (0.78)	S
	5	7.95 (1.09)	5.73 (1.01)	S	7.95 (1.09)	5.73 (1.01)	S
	7	8.27 (1.40)	6.35 (1.09)	S	8.27 (1.40)	6.35 (1.09)	S

R = Right, L = Left, Mx = Maxillary, Mand = Mandibular, ABT = Alveolar Bone Thickness, SD = Standarad Deviation, Females = 26, Sig = significant at P ≤0.05, S = significant, NS = non significant

Mand.: R and L Mesial to 7 and Mesial to 6 at three levels (except L Mesial to 7 and 6 at 7mm level); R Mesial to 5 at 3 and 5 levels; R Mesial to 3 at 7mm level; R and L Mesial to 2 (except at 3mm level at L side) and R and L Mesial to 1 at 3 and 5 mm levels. The rest sites were not statistically significant.

For females, ABT Mx.- Mand. comparison [Table 4] displayed significant differences with the Mx. ABT was higher than Mand. except in the following sites in which there were no significant differences: R and L Mesial to 7 at 5 and 7 mm levels; L Mesial to 6 at 7mm level and R and L Mesial to 5 at 7 mm levels.

DISCUSSION

Advanced CBCT systems; in the current study was NewTom CBCT machine; with high spatial resolution, sub-millimeter voxel sizes, small FOV, and a smaller focal spot are considered highly accurate in regard to linear measurements as stated by Sönmez et al. [28].

Safe MOPs with no trauma to the neighboring anatomical structures such as the roots, nasal cavity, Mx. sinus, blood vessels or nerves are among the most important factors to be considered in the selection of MOP sites. Likewise, both the quality and quantity of the AB play a vital role in the success of MOP placement. Sangsuwon et al. [21] gave general guidelines to perform MOPs that can be performed in both the buccal and lingual cortical plates around the target tooth to encourage more bone remodeling with the buccal cortical plate is the most favorable site for placement of MOPs. Thus, in the current study different sites at different levels from both buccal and palatal/lingual sides were measured to construct more detailed guidelines for the orthodontist when performing MOPs at different Mx.-Mand. locations.

Three different levels from CEJ were selected to find the maximum ABT available to perform MOPs. According to Sangsuwon et al., perforation depth of MOPs can be increased to compensate for the smaller number of perforations when a higher number of MOPs is not feasible. The number and depth of MOPs affect the inflammatory response and thus turnover of the bone as proved by Fokas et al.[29]. In the current study, CEJ was used for this purpose due to its constant position, easy access, and visibility by the examiner. Other studies measuring ABT depended on different anatomical landmarks as reference points such as the alveolar crest [30] or CEJ [31-33] as they used their corresponding software to measure ABT at variables levels apical to the CEJ.

The recommended penetration depths of MOPs should be in the range of 3-7 mm into the bone as suggested by Sangsuwon et al. [21]. In the current study, the lowest mean ABT; for proposed MOPs; was at Mand. anterior teeth at a 3mm level from CEJ, which was greater than the range recommended by Sangsuwon et al. [21].

The trend for the increase in ABT, i.e., increasing from the anterior toward the molar region was the same as in Katranji et al.[34] cadaver study in edentulous and dentate regions of elderly in different regions correlating to molar, premolar, and anterior teeth, however, Katranji et al. [34] determined buccal and lingual cortical bone plates thickness separately instead of total ABT as in the present study. A possible explanation for this trend may be attributed to heritability estimates of ABT, especially around Mx. and Mand. incisors. According to Goshtasbi et al. [35], genetic factors played significant roles in determining ABT around these teeth which is moderate to high effect.

The tendency toward increasing Mx. and Mand. ABT gradually from inter-incisal distally toward molar and from near CEJ toward apical regions, came in agreement with the general findings of Golshah et al. [36], who found that optimal ABT varies depending on the sagittal skeletal pattern of Persian adults for miniscrew insertion and that the maximum ABT in the Mx. and the Mand. in class I patients were posteriorly at the site of first and second molar at 2, 4 and 6 mm levels and were higher in Mx. than Mand.

The general trend in the current study was increased ABT in Mx. than Mand., this came in contrast to Khumsarn et al. [31] findings as they found; among the measured variables; in their comparative study of Class I and Class III sagittal skeletal patterns of Thai patients, Mand. alveolar process was thicker and wider in Class I patients than Mx. process. Likewise, Coşkun and Kaya [33] results of ABT (the combined Buccal cortical bone, cancellous bone, and lingual cortical bone thicknesses) disagreed with current findings in that ABT in the Mand. was higher than in Mx. Likewise, there is disagreement with the findings of above mentioned Golshah et al. (2021) [36] study. Similarly, in Andrewsa et al. [27] study, ABT in untreated optimal occlusions was more in the Mand. than in Mx. Such differences in the outcomes may be attributed to different sample populations, different settings and resolution of the CBCT system, different voxel sizes used for the CBCT measurements, different software accuracy used, or using different anatomical landmarks as reference points for determination of ABT and suspected subjective variations in landmark identification and variable measurement.

From the above mentioned results, the tested hypothesis was rejected as there were gender and Mx.-Mand. differences in ABT except for specific locations.

CONCLUSIONS

The current study revealed detailed ABT at different levels and locations in Mx. and Mand. for both genders, especially concerning selecting clinically- suitable orthodontic MOPs sites. Non-significant gender differences were found for most measured ABT sites with a tendency toward increasing ABT in Mx. and Mand. gradually from the inter-incisal region distally toward the molar and from near CEJ toward apical regions, indicating that posterior regions are more suitable to perform deeper and/ or multiple MOPs while anterior regions could be selected to perform less depth MOPs at both Mx. and Mand. However, further studies are suggested to highlight the age-related bone density variations and their relation to ABT at different bimaxillary sites and consequently their reflection on the suitable MOPs site selection.

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