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ORIGINAL PAPER

Anatomical Variations of the Mandibular Symphysis in a Normal Occlusion Population Using Cone-Beam Computed Tomography

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ABSTRACT

This study aimed to assess the anatomical variations of the mandibular symphysis in a normal occlusion population using cone-beam computed tomography (CBCT).

This retrospective cross-sectional study evaluated 200 CBCT scans of patients aged ≥17 with class I occlusion, 1-3 mm overbite and overjet, and <3 mm crowding. The CBCT scans were obtained with NewTom 3G scanner with the exposure settings of 110 kVp, 1.2 mA, 5.4 s time, and six-inch field of view and saved in NNT Viewer. The anterior loop length, labial bone thickness, mandibular bone height at the symphysis, and cortical bone thickness at the right and left canine teeth and central and lateral incisors were measured and compared between males and females and different age groups using one-way ANOVA.

The intra- and inter-observer agreements for all landmarks were ICC >0.9 (excellent). The mean length of the anterior loop in females was significantly greater than that in males (P=0.02). Different age groups had significant differences in cortical bone width at the site of the left canine (P=0.03) and vertical bone height at the site of the right central incisor (P=0.05).

The majority of parameters related to the mandibular symphysis were greater in normal occlusion males than females. Preoperative CBCT assessment of the mandibular symphysis can greatly help in diagnosis and treatment planning as well as bone harvesting from this area.

Keywords: mandibular symphysis, cone-beam computed tomography, class I occlusion.

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INTRODUCTION

Bone grafting is commonly performed for ridge augmentation especially before dental implant placement. Autogenous bone is the gold-standard for bone grafting, and is often preferred for bone blocks since it has lower rate of graft rejection (1, 2). Autogenous bone grafts are often harvested from the iliac crest, mandibular symphysis, anterior ramus or the coronoid process (1). Rib bone was used for many years as the donor site of choice for reconstruction of cleft palate. However, the mandibular symphysis was later preferred for this purpose due to its developmental origin. It has been demonstrated that bones with ectomesenchymal origin such as the mandible and other intraoral donor sites are superior to bones with mesenchymal origin such as the iliac crest for reconstruction of alveolar clefts (3-5). The intraoral donor sites for bone grafts include the maxillary tuberosity, zygoma, palate, coronoid process and mandibular symphysis. Fewer complications have been reported for bone harvesting from the mandibular symphysis compared with other areas such as the iliac crest and ribs for alveolar ridge reconstruction (6). Also, grafts harvested from bones with intramembranous ossification such as the mandibular symphysis undergo less resorption than bone grafts harvested from bones within tracartilaginousossification, which can be attributed to the high rate of revascularization of intramembranous bones (7, 8). Other advantages of bone grafts harvested from the mandibular symphysis include fewer postoperative complications compared to intraoral sites and subsequently shorter hospitalization, lower cost and postoperative discomfort, and not leaving scars (6). Verdugo *et al*. (9) harvested 2.3 mL of bone graft from the mandibular symphysis.

However, bone grafts harvested from the mandibular symphysis also have shortcomings such as the risk of intra-operative bleeding, wound dehiscence, mental nerve damage, pulpal obliteration of the teeth in the area or loss of pulp vitality (10). Thus, determination of the width, length and depth of the mandibular symphysis is imperative prior to bone graft harvesting from this area to prevent traumatization of vital structures in this region.

Cone-beam computed tomography (CBCT) provides maxillofacial images in axial, sagittal, coronal and even oblique views. It is often preferred to computed tomography for dental purposes due to lower radiation dose, shorter scanning time, and allowing greater image reconstructions (11). Also, CBCT enables measurement of the anterior loop length and mandibular symphysis dimensions such as bone height and width, and assessment of the mental foramen position. Moreover, it has a higher accuracy than the conventional radiographic modalities for this purpose (12-14). In order to harvest a bone block from the mandibular symphysis, preoperative assessment of the anatomical variations of this region is imperative to ensure safe bone harvesting and minimize the rate of postoperative complications.

Studies on the amount of available bone for harvesting from the mandibular symphysis are limited. Moreover, the relationship between the morphological characteristics of the symphyseal area and occlusion has not been well elucidated. Thus, this study aimed to assess the anatomical variations of the mandibular symphysis in a normal occlusion population using CBCT to find a safe zone for bone harvesting. ❑

MATERIALS AND METHODS

This retrospective cross-sectional study evaluated 200 CBCT scans of patients presenting to the Oral and Maxillofacial Radiology Department of School of Dentistry, Hamadan University of Medical Sciences, Iran. The CBCT scans

FIGURE 1. Measurement of the anterior loop

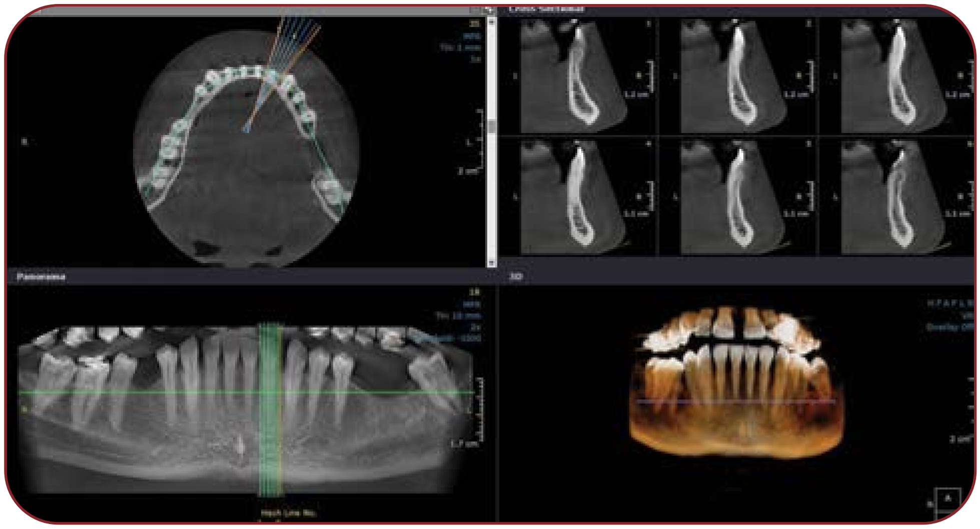

FIGURE 2. Measurement of the labial bone thickness on cross-sectional images passing through the center of each of the six anterior teeth

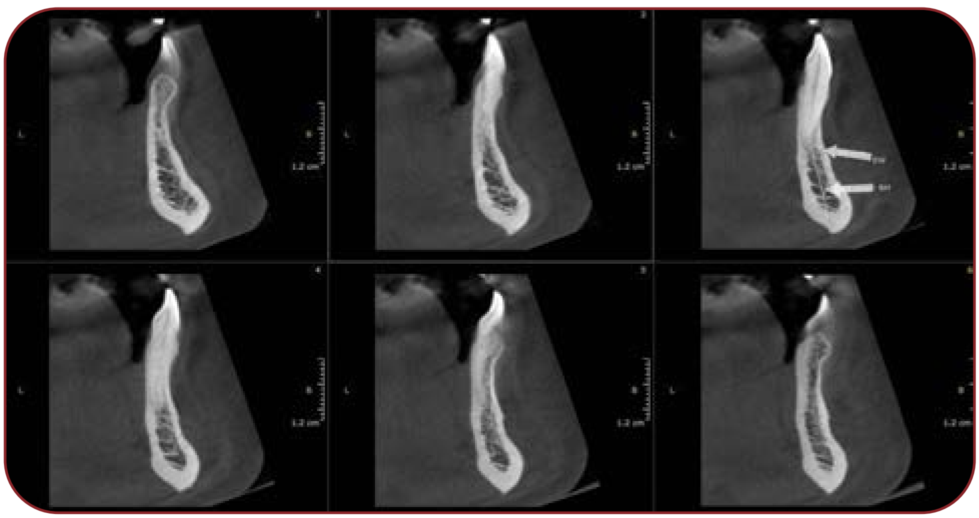

FIGURE 3. Measurement of the bone height (BH) and bone width (BW) from the apex tip

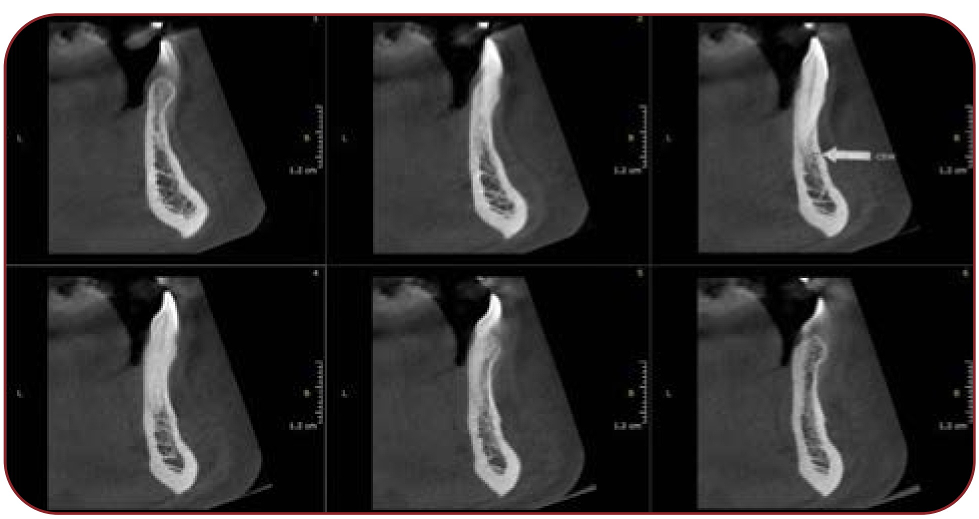

FIGURE 4. Measuring the cortical bone width (CBW) from the apex tip

taken from 2018 to 2020 for different purposes not related to this study were retrieved from the archives and evaluated.

The sample size was calculated to be 200 assuming a standard deviation of 3.6, and accuracy of 0.5 unit with 95% confidence interval according to a study by Lee *et al* (15). This study was approved by the ethics committee of Hamadan University of Medical Sciences (Iran.UMSHA.REC.1398.451).

The inclusion criteria were as follows: age over 17 years, class I occlusion, presence of six anterior teeth, and complete visualization of the mandibular symphysis on CBCT scans. The exclusion criteria included noticeable crowding of the anterior teeth, periodontal disease, history of pathological lesions in the area, history of mandibular trauma, and poor quality of CBCT images such that the mental foramen or the apex of the anterior teeth were not clearly visible. Class I normal occlusion was defined as overjet and overbite by 1-3 mm, complete eruption of permanent teeth, absence of an edentulous area, carious teeth, and teeth with prosthetic crowns, less than 3 mm of crowding, less than 1 mm of interdental space, and absence of asymmetry and crossbite (16).

Cone-beam computed tomography images were obtained with NewTom 3G (NewTomcompany, Verona, Italy) CBCT scanner with the exposure settings of 110 kVp, 1.2 mA, 5.4 s time and six-inch field of view. The images were saved in NNT Viewer software, converted to DICOM format, and transferred to OnDemand software (Cybermed Inc., Seoul, Korea). All measurements were made by the software ruler and targeted several parameters, as described below.

Anterior loop – The thinnest part of the inferior mandibular canal was considered as the anterior border of the anterior loop, and the distance between the anterior border of the loop and foramen was measured and recorded. For this purpose, the location of the mental foramen and anterior border of the anterior loop were marked on the axial section and the distance between the two was measured (Figure 1).

Next, the following measurements were made on reconstructed cross-sectional images with 1 mm slice thickness passing right from the center of each of the six anterior teeth (right and left central and lateral incisors and canine teeth) (Figure 2).

Labial bone thickness – the horizontal distance between the labial cortex and apex of the anterior teeth (Figure 3).

Mandibular bone height at the symphysis: The vertical distance between the inferior border of the mandible and the apex of the anterior teeth (Figure 3).

Cortical bone thickness – thickness of the labial cortex (Figure 4).

Two observers made the measurements twice with a two-week interval to assess the intra- and inter-observer agreements. The results were statistically analyzed using SPSS version 25. The mean, standard deviation, minimum, and maximum values were calculated and reported for all variables, and separately based on gender and age group. Males and females were compared using Student t-test while the age groups were compared by one-way ANOVA. The correlation of variables with age was calculated by the Pearson's correlation coefficient. The intra- and inter-examiner agreements were assessed by calculating the intra- and inter-class correlation coefficients (ICC). The level of statistical significance was set at 0.05. ❑

RESULTS

The CBCT scans of 200 patients with a mean age of 26.2±5.3 years (range 18-42 years) were evaluated. Of all, 94 (47%) were between 18-25 years old, 64 (32%) between 25-30 years old, 29 (14%) between 30-35 years old, and 13 (6%) ≥35 years old. Also, of all patients, 136 (68%) were females and 64 (32%) males. The results showed intra- and inter-rater agreements over ICC >0.9 (excellent) for all the measured parameters.

Table 1 presents the mean values for the measured parameters. As shown, of all measured values, bone width at the site of left canine and left central and lateral incisors and right central incisor, cortical bone width at the site of left canine, left central incisor, right lateral incisor and right canine, and vertical bone height at the site of right central incisor were significantly greater in males than females (P <0.05).

The mean length of the left anterior loop was significantly greater in females compared to males (P=0.02). No significant difference was noted between males and females in other parameters (Table 2).

Table 3 compares the vertical bone height, bone width and cortical bone width in different age groups. According to one-way ANOVA, the cortical bone width at the site of left canine (P=0.03) and vertical bone height at the site of right central incisor (P=0.05) were significantly different in different age groups. No other significant differences were noted.

Table 4 shows the correlation of the measured parameters on CBCT scans with age according to the Pearson's correlation coefficient.

Variable	Mean	Standard deviation	Minimum	Maximum
Vertical bone height at the left canine	19.32	3.51	12.55	28.67
Bone width at the left canine	3.91	0.96	1.73	6.9
Cortical bone width at the left canine	2.19	0.43	1.06	3.46
Vertical bone height at the left lateral incisor	19.93	3.83	11.1	28.6
Bone width at the left lateral incisor	3.86	1.27	1.52	7.79
Cortical bone width at the left lateral incisor	1.99	0.44	1.02	3.21
Vertical bone height at the left central incisor	21.39	3.74	10.4	32.67
Bone width at the left central incisor	3.92	1.23	1.25	7.6
Cortical bone width at the left central incisor	1.87	0.45	1.03	3.6
Vertical bone height at the right central incisor	20.96	3.89	11.5	32.65
Bone width at the right central incisor	3.91	1.2	1.3	7.3
Cortical bone width at the right central incisor	1.85	0.45	1.02	3.6
Vertical bone height at the right lateral incisor	19.49	3.84	10.07	30.47
Bone width at the right lateral incisor	4.09	1.32	1.12	9.35
Cortical bone width at the right lateral incisor	1.98	0.42	1.04	3.28
Vertical bone height at the right canine	19.41	3.81	10.56	32.22
Bone width at the right canine	4.02	1.14	2.09	7.87
Cortical bone width at the right canine	2.25	0.47	1.0	5.03
Right anterior loop	1.79	0.89	0.11	4.5
Left anterior loop	2.06	0.66	0.23	4.56

TABLE 1. Measures of central dispersion for the vertical bone height, bone width, and cortical bone width of the right and left canine and central and lateral incisors on CBCT scans

Variable	Females (136) Mean±SD	Males (64) Mean±SD	P value
Vertical bone height at the left canine	19.29±3.68	19.36±3.17	0.9
Bone width at the left canine	3.78±0.92	4.18±1.01	0.007
Cortical bone width at the left canine	2.14±0.45	2.32±0.36	0.005
Vertical bone height at the left lateral incisor	19.86±3.79	20.09±3.94	0.68
Bone width at the left lateral incisor	3.83±1.23	3.92±1.35	0.68
Cortical bone width at the left lateral incisor	1.88±0.37	2.25±0.45	0.001
Vertical bone height at the left central incisor	21.36±3.71	21.45±3.83	0.87
Bone width at the left central incisor	3.6±1.14	4.58±1.14	0.001
Cortical bone width at the left central incisor	1.79±0.41	2.03±0.49	0.001
Vertical bone height at the right central incisor	20.59±3.77	21.77±4.77	0.05
Bone width at the right central incisor	3.57±1.08	4.63±1.14	0.001
Cortical bone width at the right central incisor	1.76±0.41	2.03±0.48	0.001
Vertical bone height at the right lateral incisor	19.4±3.84	19.7±3.88	0.61
Bone width at the right lateral incisor	4.06±1.31	4.14±1.35	0.71
Cortical bone width at the right lateral incisor	1.88±0.36	2.19±0.46	0.001
Vertical bone height at the right canine	19.39±3.86	19.46±3.72	0.89
Bone width at the right canine	3.93±1.1	4.23±1.19	0.08
Cortical bone width at the right canine	2.21±0.44	2.34±0.52	0.05
Right anterior loop	1.81±0.84	1.77±0.99	0.77
Left anterior loop	2.13±0.65	1.89±0.67	0.02

SD: standard deviation

TABLE 2. Mean vertical bone height, bone width, and cortical bone width at the right and left canine and central and lateral incisors on CBCT scans of male and female patients

TABLE 3. Mean vertical bone height, bone width, and cortical bone width at the right and left canine and central and lateral incisors on CBCT scans of different age groups

Variable	18-25 years (n=94) Mean±SD	25-30 years (n=64) Mean±SD	30-35 years (n=29) Mean±SD	>35 years (n=13) Mean±SD	P value
Vertical bone height at the left canine	3.36±19.71	3.63±18.84	3.94±19.58	2.89±18.29	0.31
Bone width at the left canine	1.01±3.95	0.97±3.83	0.82±4.02	0.9±3.76	0.74
Cortical bone width at the left canine	0.42±2.22	0.44±2.21	0.35±1.99	0.53±2.39	0.03
Vertical bone height at the left lateral incisor	3.73±19.63	3.88±20.23	4.04±20.73	3.74±18.9	0.37
Bone width at the left lateral incisor	1.3±3.88	1.33±3.93	1.15±3.64	1.05±3.97	0.78
Cortical bone width at the left lateral incisor	0.45±1.97	0.43±2.02	0.38±1.96	0.49±2.09	0.74
Vertical bone height at the left central incisor	3.94±21.64	3.53±21.55	3.86±20.86	2.88±19.97	0.39
Bone width at the left central incisor	1.27 ± 3.9	1.2 ± 4.01	1.15 ± 3.84	1.35±3.73	0.86
Cortical bone width at the left central incisor	0.48 ± 1.91	0.44 ± 1.79	0.36 ± 1.87	0.44±1.88	0.49
Vertical bone height at the right central incisor	3.66 ± 20.29	4.33 ± 21.46	4.09 ± 22.36	2.19±20.29	0.05
Bone width at the right central incisor	1.24 ± 3.88	1.14 ± 3.95	1.22 ± 3.96	1.34 ± 3.74	0.93
Cortical bone width at the right central incisor	0.49 ± 1.89	0.43 ± 1.82	0.36 ± 1.78	0.49 ± 1.84	0.68
Vertical bone height at the right lateral incisor	3.95 ± 19.66	3.81 ± 19.32	4.17 ± 19.01	2.32 ± 20.29	0.72
Bone width at the right lateral incisor	1.36 ± 4.22	1.06 ± 4.11	1.35±3.77	1.96 ± 3.96	0.28
Cortical bone width at the right lateral incisor	0.42 ± 1.95	0.43 ± 2.03	0.41±1.98	0.44 ±1.99	0.71
Vertical bone height at the right canine	3.64 ± 19.11	3.97 ± 19.83	4.09±19.37	3.76±19.69	0.69
Bone width at the right canine	1.14 ± 3.97	1.24 ± 4.12	0.97±4.09	0.98±3.78	0.58
Cortical bone width at the right canine	0.44 ± 2.22	0.56 ± 2.28	0.34±2.22	0.49 ±2.39	
Right anterior loop	0.88 ± 1.82	0.89 ± 1.72	0.92±1.83	0.97±1.98	0.77
Left anterior loop	0.64 ± 2.06	0.71 ± 2.1	0.64 ± 1.91	0.68 ± 2.09	0.63

SD: standard deviation

TABLE 4. Correlation of vertical bone height, bone width and cortical bone width at the sites of right and left canine teeth and central and lateral incisors using the Pearson's correlation coefficient

Variable	Vertical bone height/left canine	Bone width/left canine	Cortical bone width/left canine	Vertical bone height/left lateral	Bone width/left lateral	Cortical bone width/left lateral
Ager*	-0.092	-0.022	-0.057	0.018	-0.006	0.02
P value**	0.19	0.76	0.42	0.8	0.94	0.78
Variable	Vertical bone height/left central	Bone width/left central	Cortical bone width/left central	Vertical bone height/right central	Bone width/right central	Cortical bone width/right central
Ager*	-0.074	-0.019	-0.068	0.137	-0.002	-0.093
P value**	0.29	0.79	0.34	0.05	0.98	0.19
Variable	Vertical bone height/right central	Bone width/right central	Cortical bone width/right central	Vertical bone height/right canine	Bone width/right canine	Cortical bone width/right canine
Ager*	-0.041	-0.143	0.038	0.055	-0.04	0.048
P value**	0.57	0.06	0.59	0.44	0.58	0.5
Variable	Right anterior loop	Left anterior loop				
Ager*	-0.033	-0.169				
P value**	0.64	0.02				

As shown, vertical bone height had a greater correlation with age than bone width. ❑

DISCUSSION

This study assessed the anatomical variations of the mandibular symphysis in a normal occlusion population, using CBCT to find a safe zone for bone harvesting. To find the most suitable height of bone block in bone graft harvesting from this region, the bone height was measured from the apex of the canine, and central and lateral incisors in the present study. To prevent traumatization of the teeth and the mandible, surgeon should be well aware of a safe area in the donor site. A previous study considered a

10-mm safe zone from the tooth apex (16). In the present study, the available bone height for harvesting at the sites of canine and central and lateral incisor teeth was found to be 9.32, 9.93, and 11.39 mm on the left side and 10.96, 9.49 and 9.41 mm on the right side. The amount of available bone in a study by Lee *et al*. (15) was found to be 10.3 mm, which was close to the values in the present study.

The mean bone width at the site of left canine and central and lateral incisors was 3.91, 3.86 and 3.92 mm, respectively. These values were 3.91, 4.09 and 4.02 mm in the right side, respectively. Also, the mean cortical width at the sites of canine, and lateral and central incisors was 2.19, 1.99, and 1.87 mm in the left and 1.85, 1.98 and 2.25 mm in the right side, respectively. In a study by Lee *et al*. (17) the mean bone width and cortical bone thickness at the mandibular symphysis were 4.5 and 2.3 mm, respectively. Considering the relatively greater cortical bone thickness and bone width at the distal area, more autogenous bone may be harvested from the more distal areas.

In the present study, the majority of the measured parameters were significantly greater in males than females. Nonetheless, different age groups only had significant differences in cortical bone width at the site of left canine, and vertical bone height at the site of right central incisor. Similarly, Lee *et al*. (15) found significant differences in some parameters between males and females such that the mean interforaminal distance, anterior loop length, bone width, cortical bone thickness, and vertical bone height were significantly greater in males. Thus, further attention should be paid to the depth of harvesting bone blocks from the mandibular symphysis in females.

Several factors affect the cortical bone size, tooth position, and ridge width (18). The cortical bone structure depends on physiological conditions, age and level of testosterone hormone (19, 20). However, further studies are warranted on this topic. Lee *et al*. (17) showed that the cortical bone size at the mandibular symphysis was correlated with gender but not with age. On the other hand, Velásquez *et al*. (21) reported that age or gender had no significant effect on this parameter. Some others (22) reported that parameters related to the thickness of the mandible and maxilla were greater in males.

The anterior loop refers to the extension of the inferior alveolar nerve beyond the mental foramen (23), which is detectable in most patients. This loop includes a neurovascular bundle. Thus, its traumatization can cause sensory disturbances (12). In a previous study, the anterior loop had a maximal length of 4.6 mm (12). It has been discussed that surgeons should keep a minimum of 2 mm distance from the anterior part of the mental foramen in surgical procedures such as osteotomy (14, 24, 25). In the present study, the mean length of the anterior loop was 1.79 mm on the right side and 2.06 mm on the left side (range 0.1 to 11 mm). Race plays an important role in length of the anterior loop (26). In a study by Vujanovic-Eskenazi *et al*. (27), the mean length of the anterior loop was 1.59 mm. Studies using CBCT reported a mean value ranging from 0.89 mm (28) to 3.54 mm (29). The longest loop was 4.56 mm on the left side and 4.50 mm on the right side in the present study, compared to 4 mm in the study conducted by Vujanovic-Eskenazi *et al*. (27). The mean length of the anterior loop was 1.9 mm on CBCT scans in a study performed by Lee *et al*. (15), but it was found to be 4.13 mm in a study by Neiva *et al*. (13). In the present study, the mean length of the anterior loop was greater in females than males and this difference was significant on the left side. However, the mean length of the anterior loop had no correlation with age, which was in agreement with the result of a previous study (26). Also, the presence and length of the anterior loop had no correlation with side of the jaw in our study, which was in line with the findings of a previous study (29) and in contrast to some others (29, 30-34). Some researchers (14, 24, 25) have recommended to keep a 1-6 mm safe zone in front of the mental foramen as a reference guide in dental implant treatment. However, not determining the length of the anterior loop in such cases may result in farther placement of dental implant at the mesial side of the mental foramen or damaging the mental nerve. For instance, Uchida *et al*. (32) reported that the mean length of the anterior loop ranged from 0 to 9 mm; thus, selecting a 1 mm safe zone would result in damaging the mental nerve given that the length of the anterior loop exceeds 1 mm (35). On the other hand, a 6 mm safe zone recommended by Solar *et al*. (25) would result in more mesial placement of dental implants relative to the mental foramen (especially in absence of the anterior loop). According to the present results, recommending a particular safe zone relative to the mental foramen does not seem logical. However, most distal implants should have at least 2 mm distance from the anterior part of the loop to prevent its traumatization during surgery. In such cases, the anterior loop can serve as a landmark (36). In cases where there is a larger incisive canal, some certain surgical precautions should be taken (37). Considering the optimal efficacy of CBCT in estimation of the dimensions of the mandibular symphysis and detection of the anterior loop and measuring its length, its use is recommended in procedures such as dental implant treatment and harvesting bone grafts from the mandibular symphysis to prevent traumatization of the mental nerve or the neurovascular bundle. However, a risk of patient radiation should also be taken into account (38).

This study had some limitations such as patients' limited age range, with the majority of candidates for bone grafting being over the age of 30 years, and the fact that patients with facial deformities or malocclusions were not included (21). Thus, our results could only be generalized to normal occlusion patients. Moreover, strict eligibility criteria limited our sample size.

It should be noted that some patients may have concerns regarding chin deformity or depression after graft harvesting from the mandibular symphysis. These concerns can be eliminated by placement of bone substitutes, not completely degloving the mandible, and suturing the tissues behind their initial position. Others may have concerns regarding paresthesia of the chin or the mandibular anterior teeth after graft harvesting from the mandibular symphysis. Appropriate surgical technique, correct patient selection, and precise preoperative assessment can minimize such risks. Patients with either mandibular anterior teeth with long roots or inadequate mandibular height or width or lesions decreasing the vertical height of the bone as well as those requiring reconstructive surgery in an area larger than the width of four anterior teeth are not suitable candidates for graft harvesting from the mandibular symphysis.

In total, bone width (distance between the two mental foramina and their anterior loop), bone height (distance between the tooth apex and inferior border of the mandible) and bone depth (thickness of the symphyseal cortical bone), as well as safe margins (to minimize traumatization of vital anatomical structures such as the anterior loop, tooth apex, and inferior border of the mandible) should be evaluated prior to graft harvesting from this area. Preoperative CBCT assessment can greatly help in diagnosis and treatment planning of patients, also minimizing the risks and complications of graft harvesting from the mandibular symphysis.

Further studies are required to assess the anatomical variations of the mandibular symphysis in patients with different malocclusions and compare them with normal occlusion individuals. Also, symphyseal dimensions measured on CBCT scans should be compared to measurements made on panoramic radiographs. ❑

CONCLUSION

The majority of parameters related to the mandibular symphysis were greater in normal occlusion males than females. However, no significant difference was noted in this respect between different age groups. Preoperative CBCT assessment of the mandibular symphysis can be of great help in diagnosis and treatment planning as well as bone harvesting from this area. ❑

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