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Original Article

Cone-Beam Computed Tomographic Assessment of Bone Thickness in the Mandibular Anterior Region for Application of Orthodontic Mini-Screws

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Main Points

- The best choice for the placement of mini-screws in the anterior region of the mandible is the interdental area of the lateral incisor and canine teeth.
- At the level of 8 mm from the CEJ, mini-screws could be applied more successfully due to proper mesiodistal and labiolingual bone dimensions.
- Mini-screws of 1.3-1.7 mm diameter and 5-7 mm length provides the best fit in the mandibular anterior region for orthodontic anchorage procedures.

ABSTRACT

Objective: To determine the proper zones for placement of orthodontic mini-screws, based on cone-beam computed tomography (CBCT) measurements in the anterior mandibular region.

Methods: The current cross-sectional study was performed on CBCT images of 77 individuals in the age range of 18-60 years. Axial slices at the levels of 2, 5, and 8 mm from the cementoenamel junction (CEJ) of the mandibular anterior teeth were selected. Interdental distances were measured in the mesiodistal direction, parallel to the midline of the mandibular arch. Areas with more suitable width were investigated for measuring the minimum interdental space. On the reconstructed cross-sectional images, labiolingual thickness of the bone was measured at the levels of 2, 5, 8, and 11 mm from the CEJ. The Kruskal–Wallis test, Mann–Whitney test with Bonferroni correction, Welch test, and Tukey's multiple analogy test were used to analyze the data.

Results: Mesiodistal and labiolingual distances between the roots in every measured region had the highest values at the levels of 8 and 11 mm from the CEJ. The highest measured values were related to the interdental region between the lateral incisor and canine teeth on both sides of the arch. There were no statistically significant differences between these values ($P < .001$).

Conclusion: The lateral incisor–canine areas at the level of 8 mm from the CEJ are introduced as the optimal sites for placement of orthodontic mini-screws. In addition, the results recommend the application of mini-screws with 1.3-1.7 mm diameter and 5-7 mm length.

INTRODUCTION

One of the most challenging issues in orthodontics is obtaining sufficient anchorage to make intended tooth movements.[1] Introduction of mini-screws that help to obtain anchorage redefined the concept of infinite anchorage. Mini-screws are easily placed and removed without the need for muco-periosteal flaps, and can be easily exposed to external forces after placement.[2]

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Achieving primary stability is the key to successful mini-screw anchorage. To achieve stability, the mechanical interlocking between the mini-screw and the bone should be administered carefully; 3 factors are more important in that regard: (a) bone quality (host factor); (b) mini-screw design (i.e., material factor); and (c) placement technique (i.e., operator factor). For bone quality, the cortical bone thickness is the most important determinant of primary stability.[3] Many parameters should be considered before placing an orthodontic mini-screw, such as biomechanics employed (i.e., direct or indirect anchorage) and the placement site anatomy. The placement site anatomy depends on the individual characteristics, which means it differs from person to person. However, some outcomes are relatively predictable.[4-6]

When planning for the design and placement of orthodontic mini-screws, the cortical bone thickness and bone width are 2 important micro-and macro-anatomical factors that should be considered.[7] Evaluation of distances at the mid-root level is also important in the treatment planning since it affects both the safety and stability of mini-screws.

Root proximity is of crucial importance in the final outcome of the mini-screws. According to the literature, there is a significant correlation between stability and safety margins around mini-screws. This not only confirms the usefulness of using relatively smaller diameter screws but also shows that adequate distance from the roots is a vital factor in ensuring the stability of mini-screws.[8,9] To achieve adequate anchorage and to prevent damage to the roots or adjacent teeth, and it is necessary to measure the buccolingual and mesiodistal inter-radicular dimensions of the recipient bone.[10]

The application of cone-beam computed tomography (CBCT) is now a popular method for measuring bone thickness.[11] The main feature of CBCT is that it uses multiple planar projections acquired by a single rotational scan to construct a volumetric dataset. It results in adequate tissue contrast and minimized image distortion and adjacent tooth overlapping. Moreover, it provides diverse views from the anatomical structures. Thus, CBCT overcomes many limitations of conventional radiographic techniques. Another advantage is the significant dose reduction compared to conventional CT.[12]

The current study aimed to evaluate the labiolingual bone thickness and mesiodistal root distances of the anterior mandibular teeth at different levels using CBCT images. The main purpose was to determine which areas have sufficient and appropriate thickness and could be considered safe for placement of mini-screws to achieve maximum anchorage during orthodontic treatments.

METHODS

The current cross-sectional study was performed on CBCT images of 77 patients who were referred to the Faculty of Dentistry, Guilan University of Medical Sciences. The scans had been prescribed for various purposes, including implant surgery, evaluation of impacted posterior teeth, supernumerary teeth, and endodontic management of the posterior teeth during orthodontic treatments from 2016 to 2019. Sample size was calculated based on a pilot study on 30 subjects by assuming α = 0.05, 95% CI, standard deviation = 1.19, and study power = 80%.

CBCT images were acquired by a VATECH Pax-i3D device (Gyeonggi-do, Korea), and measurements were performed using Ez3D-i software Version 4.1 (Gyeonggi-do, Korea). The study was approved by the Research Ethics Committee of Guilan University of Medical Sciences (Approval ID: IR.GUMS.REC.96.268.). Informed consent was taken from the patients with regard to the use of their CBCT data. The patients were assured that their personal information would not be published in the research.

Inclusion criteria were the age range of 18-60 years, presence of mandibular anterior teeth, absence of horizontal and vertical bone loss around the anterior teeth, and absence of retained primary teeth in the mandibular anterior region. Cases with crowding or spacing more than 3 mm, craniofacial syndromes and deformities, pathologies of the maxillofacial region, old or new fracture in the anterior mandible, and significant distance (>1 mm) between the CEJs of adjacent teeth were excluded from the study.

Axial mandibular sections at the levels of 2, 5, and 8 mm from the CEJs of the mandibular anterior teeth were used to measure the mesiodistal distances of the teeth roots. These measurements were made in the midline of the arch and parallel to a curved line connecting the midpoints of proximal portions of the adjacent roots (Figure 1). Subsequently, cross-sectional slices perpendicular to this curved line were reconstructed with 2 mm thickness and 1 mm distance. Maximum Sharpness was applied to the images to determine the distal border of the available bone. The CEJ was identified as a reference line in the acquired sections. Consequently, parallel lines were drawn and measured at the levels of 2, 5, 8, and 11 mm from the CEJ (Figure 2).

The results of the first part of the research were analyzed by the Kruskal–Wallis test. In the second step, after obtaining the results

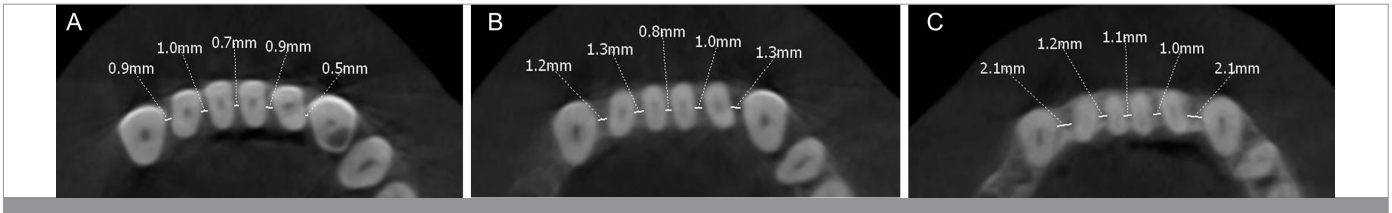

Figure 1. Mesiodistal distances between roots of the anterior mandibular teeth on axial views at the levels of 2 (A), 5 (B) and 8 mm (C) from the CEJ.

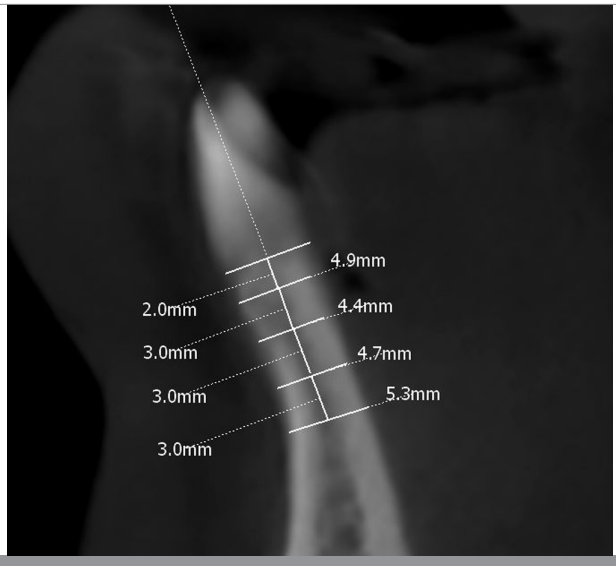

Figure 2. Cross-sectional view from the alveolar bone between the right mandibular canine and lateral incisor teeth showing the labiolingual bone thickness at the level of 2, 5, 8 and 11 mm from the CEJ.

and statistical analysis, the areas between the mandibular lateral incisors and the canines on both sides were identified as areas with proper mesiodistal width for the placement of mini-screws. The roots of these teeth on both sides were measured at the levels of 2, 5, and 8 mm from the CEJ to determine the proper diameter for the mini-screws (Figure 3).

Statistical Analysis

To check the normality of quantitative variables (i.e., mesiodistal and labiolingual measurements of the available bones between roots of the anterior teeth), kurtosis and skewness values, histograms, Q–Q plots, and Shapiro–Wilk tests were used. As the data were normally distributed and variances were homogeneous, non-parametric Kruskal–Wallis test (for asymmetrically distributed data), Mann–Whitney test with Bonferroni correction, Welch test (for normally distributed data with non-homogenous variances), and Tukey's multiple comparison test (to examine if the differences between mean values are significant in 2 or more groups) were used for further analysis. Statistical significance was set at a .05 probability level. All analyses were conducted using SPSS software Version 18 (Chicago, IL, USA).

RESULTS

Median and interquartile ranges of the mesiodistal distances between roots of the anterior teeth at the levels of 2, 5, and 8 mm from the CEJ are provided in Table 1. The highest median amount was at the level of 8 mm from CEJ, and the findings showed a statistically significant difference between the levels.

Median and interquartile ranges of the mesiodistal distances between roots of the anterior teeth at the levels of 2, 5, and 8 mm from the CEJ are provided in Table 1. The highest median amount was at the level of 8 mm from CEJ, and the findings showed a statistically significant difference between the levels.

Median and interquartile ranges of the mesiodistal distances between roots of the anterior mandibular teeth, regardless of the distance from CEJ, are shown in Table 2. The highest median amount was related to the right, followed by the left lateral incisor–canine regions. There was a statistically significant difference between the regions ($P < .001$).

Median and interquartile ranges of the minimum mesiodistal distances between roots of the lateral incisor and canine teeth at the levels of 2, 5, and 8 mm from the CEJ on both sides are presented in Table 3. On both sides, the highest median amount was obtained at the level of 8 mm. Statistically significant differences were found between the different levels in the canine–lateral incisor region ($P < .001$).

Using the Mann–Whitney test, a pairwise comparison of the least mesiodistal distances among the different levels from the CEJ (2, 5, and 8 mm) indicated statistically significant differences between each of the 2 groups ($P < .001$).

Mean labiolingual bone thickness values at the levels of 2, 5, 8, and 11 mm from the CEJ are given in Table 4. The highest mean value was at the level of 11 mm from the CEJ. Overall, there were statistically significant differences between the mean labiolingual values at the different levels in each region.

Median and interquartile ranges of the labiolingual distances between roots of the anterior mandibular teeth, regardless of the distance from CEJ are shown in Table 5. The highest median value was related to the right, followed by the left lateral incisor–canine regions. There was a statistically significant difference between the median labiolingual distances between the roots in the different regions ($P < .001$).

According to the findings, mesiodistal width of the available bone between the anterior mandibular teeth at the level of 8 mm from the CEJ was the greatest. The highest mesiodistal distance was observed between the lateral incisor and canine teeth on both sides.

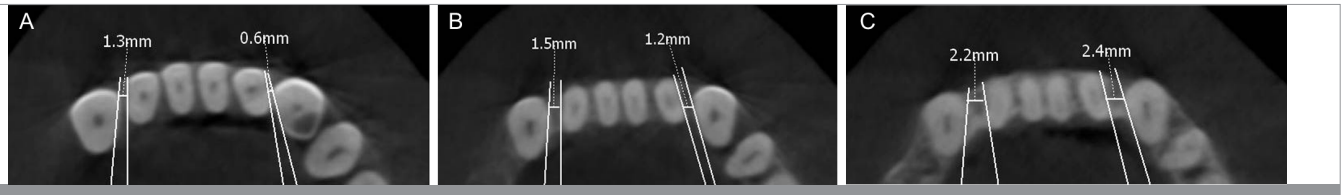

Figure 3. Axial views of the mandible at the levels of 2 (A), 5 (B) and 8 (C) mm from the CEJ of the anterior teeth showing the minimum mesiodistal distance between the roots of canine and lateral incisor teeth.

Table 1. Comparison of the mesiodistal distances between roots of the anterior mandibular teeth at different levels of 2, 5, and 8 mm from the CEJ

Region	Level from the CEJ	Number	Median (Interquartile range)	Minimum	Maximum	*P**
Right lateral and canine	2 mm	77	2.60[a] (2.15-3.00)	1.10	4.00	<.001
	5 mm	77	2.80[b] (2.50-3.30)	1.50	4.60	
	8 mm	77	3.40[c] (2.90-3.80)	1.50	6.20	
Right central and lateral	2 mm	77	2.50[a] (1.80-2.75)	1.10	4.90	.003
	5 mm	77	2.30[b] (1.90-2.80)	1.10	4.50	
	8 mm	77	2.60[c] (2.25-3.20)	1.00	5.30	
Left and right centrals	2 mm	77	2.50[a] (1.85-3.00)	1.10	4.50	.002
	5 mm	77	2.40[b] (2.20-3.00)	1.20	4.60	
	8 mm	77	2.80[c] (2.30-3.50)	1.00	5.50	
Left central and lateral	2 mm	77	1.20[a] (1.80-2.70)	1.00	4.60	.007
	5 mm	77	2.30[b] (1.90-2.75)	1.20	4.80	
	8 mm	77	2.60[c] (2.20-3.20)	1.30	5.20	
Left lateral and canine	2 mm	77	2.4 0[a] (2.10-2.90)	1.20	4.30	<.001
	5 mm	77	2.70[b] (2.40-3.30)	1.70	4.50	
	8 mm	77	3.10[c] (2.70-3.80)	1.60	6.00	
All mandibular anterior teeth	2 mm	385	2.40[a] (1.90-2.90)	1.00	4.90	<.001
	5 mm	385	2.60[b] (2.10-3.10)	1.10	4.80	
	8 mm	385	2.90[c] (2.40-3.50)	1.00	6.20	

*Kruskal Wallis test ($P < .05$); Identical uppercase letters indicate no statistically significant difference in Mann-Whitney comparative test with Bonferroni correction ($P < .017$).

After identifying the regions with greater mesiodistal widths in the anterior portion of the mandible, the minimum mesiodistal distances between the roots in these regions were measured at 2, 5, and 8 mm from the CEJ. Based on the measurements, in the regions between the left lateral incisor and canine teeth at the level of 2 mm from the CEJ, only 19.5% of the subjects indicated a minimum mesiodistal width of about 2.3 mm for insertion of the thinnest mini-screws. At levels of 5 and 8 mm from the CEJ, this frequency was 37.7 and 76.6%, respectively.

In the right lateral incisor–canine region, 6.28, 48.1, and 81.8% of the subjects had available bone with a mesiodistal width of 2.3 mm or more, at the levels of 2, 5, and 8 mm from the CEJ, respectively. Considering the minimum standard of 60% as the least mesiodistal bone width to indicate a suitable location for mini-screw insertion, the width is not appropriate at distances of 2 and 5 mm from the CEJ, while at a distance of 8 mm from the CEJ, there is sufficient width on both sides to secure mini-screw placement.

The greatest labiolingual thickness of the bone among the mandibular anterior teeth was at the level of 11 mm from the CEJ. Also, the highest labiolingual bone thickness was observed in the lateral incisor–canine regions. There was no significant difference between the right and left sides. Considering both mesiodistal and labiolingual thicknesses, at the level of 8 mm from the CEJ, the lateral incisor–canine region is an optimal area for insertion of mini-screws. Furthermore, if adequate attached gingiva exists, the level of 11 mm from the CEJ is also suitable for the insertion of mini-screws. Additionally, this level (11 mm) has the highest available labiolingual alveolar

Table 2. Comparison of mesiodistal distances between the roots in different regions

Region	Number	Median (Interquartile range)	Minimum	Maximum	*P**
Right lateral and canine	231	2.90[a] (2.50-3.50)	1.10	6.20	<.001*
Right lateral and central	231	2.40[b] (1.90-2.90)	1.00	5.30	
Right central and Left central	231	2.60[b] (2.10-3.20)	1.00	5.50	
Left central and lateral	231	2.40[b] (1.90-2.80)	1.00	5.20	
Left lateral and canine	231	2.80[a] (2.40-3.30)	1.20	6.00	

*Kruskal Wallis test ($P < .05$); Identical uppercase letters indicate no statistically significant difference in Mann-Whitney comparative test with Bonferroni correction ($P < .05$).

Table 3. Comparison of the minimum mesiodistal distances between the roots of the canine and lateral incisor teeth at the levels of 2, 5, and 8 mm from the CEJ on both sides

Region	Level from the CEJ	Number	Median (Interquartile range)	Minimum	Maximum	*P**
Right lateral and canine	2 mm	77	2.00[a] (1.65-2.60)	1.00	3.80	<.001
	5 mm	77	2.30[b] (2.10-2.90)	1.30	4.50	
	8 mm	77	2.90[c] (2.50-3.45)	1.60	6.20	
Left lateral and canine	2 mm	77	2.00[a] (1.60-2.20)	0.40	3.70	<.001
	5 mm	77	2.30[b] (2.00-2.70)	0.90	4.00	
	8 mm	77	2.70[c] (2.40-3.10)	1.50	5.40	

*Kruskal Wallis test ($P < .05$); Identical uppercase letters indicate no statistically significant difference in Mann-Whitney comparative test with Bonferroni correction ($P < .017$).

bone thickness. The mesiodistal distances between the mandibular anterior teeth at the level of 11 mm were not measured since roots of the anterior teeth, except for the canines, do not extend to this level. Therefore, there is less concern about root damage at the level of 11 mm from the CEJ. However, individual alveolar bone and soft tissue examinations are essential prior to treatment planning.

Another important point is the diameter and length of the mini-screws that can be inserted in the anterior mandibular region. Mini-screws generally have a diameter ranging from 1.3-2 mm and a length of 5-12 mm (more commonly 6-8 mm).[13] The minimum suggested distance between a mini-screw and the adjacent tooth root is 0.5 mm.[14] The recommended length for the mini-screws inserted at the level of 8 mm from the CEJ in the

Table 4. Comparison of the mean labiolingual bone thickness between the anterior mandibular teeth at the levels of 2, 5, 8 and 11 mm from the CEJ

Region	Level from the CEJ	Number	Mean ± Standard deviation	Confidence interval 95%	Minimum	Maximum	*P**
Right lateral and canine	2 mm	77	6.98[a] ± 1.06	(6.74,7.22)	4.10	9.00	.002
	5 mm	77	7.07[a] ± 1.06	(6.83,7.32)	4.40	9.70	
	8 mm	77	7.14[a] ± 1.26	(6.86,7.43)	3.50	9.70	
	11 mm	77	7.78[b] ± 1.51	(7.44,8.12)	4.20	11.10	
Right central and lateral	2 mm	77	6.13[a] ± 0.81	(5.95,6.32)	4.30	8.00	<.001
	5 mm	77	6.27[a] ± 0.90	(6.07,6.48)	3.90	8.80	
	8 mm	77	6.49[a] ± 1.15	(6.23,6.75)	3.50	9.00	
	11 mm	77	7.32[b] ± 1.55	(6.96,7.67)	3.20	11.40	
Left and right central	2 mm	77	5.35[a] ± 0.79	(5.18,5.54)	4.00	7.30	<.001
	5 mm	77	5.77[a] ± 0.96	(5.55,5.98)	3.60	8.70	
	8 mm	77	6.51[b] ± 1.31	(6.21,6.80)	3.60	8.90	
	11 mm	77	7.69[c] ± 1.75	(7.29,8.09)	4.10	11.40	
Left central and lateral	2 mm	77	6.26[a] ± 0.78	(6.08,6.43)	5.00	8.80	<.001
	5 mm	77	6.26[a] ± 0.95	(6.05,6.48)	4.50	9.10	
	8 mm	77	6.57[a] ± 1.20	(6.30,6.85)	3.70	9.50	
	11 mm	77	7.45[b] ± 1.60	(7.09,7.82)	3.90	11.00	
Left lateral and canine	2 mm	77	7.04[a] ± 0.83	(6.86,7.23)	5.00	8.80	.001
	5 mm	77	7.01[a] ± 0.89	(6.81,7.22)	4.50	9.10	
	8 mm	77	7.13[a] ± 1.22	(6.58,7.41)	3.70	9.50	
	11 mm	77	7.83[b] ± 1.53	(7.48,8.17)	3.90	11.00	
Total	2 mm	385	6.35[a] ± 1.06	(6.25,6.46)	4.00	9.00	<.001
	5 mm	385	6.48[a] ± 1.07	(6.37,6.59)	3.60	9.70	
	8 mm	385	6.77[b] ± 1.26	(6.64,6.90)	3.30	9.90	
	11 mm	385	7.78[c] ± 1.51	(7.45,7.77)	3.20	12.80	

* Welch test ($P < .05$); Identical uppercase letters indicate no statistically significant difference in Tukey's multiple comparison test.

Table 5. Comparison of the labiolingual distances between the roots in different regions

Region	Number	Median (Interquartile range)	Minimum	Maximum	*P**
Right lateral and canine	308	7.30 [a] (6.40-8.00)	3.50	11.10	<.001
Right central and lateral	308	6.40 [b] (5.70-7.30)	3.20	11.40	
Left and right centrals	308	6.10 [c] (5.30-7.30)	3.60	11.40	
Left central and lateral	308	6.60 [b] (5.80-7.40)	3.30	12.80	
Left lateral and canine	308	7.20 [a] (6.50-8.00)	3.70	11.00	

*Kruskal Wallis test ($P < .05$); Identical uppercase letters indicate no statistically significant difference in Mann-Whitney comparative test with Bonferroni correction ($P < .05$).

lateral incisor–canine regions is 5-7 mm. Long mini-screws, which pass through the medullary bone and reach the cortical layer on the opposite side, can provide more stability; however, they are rarely applied.[15]

To the best of our knowledge, this is the first study to focus on the mandibular anterior region for the application of orthodontic mini-screws using CBCT images. In situations where proper anchorage could not be achieved solely from the posterior regions due to factors such as lack of sufficient bone or the need for applying arbitrary forces to a tooth or a group of teeth, the need for anterior anchorage is more highlighted.

Previous studies which have examined both the anterior and posterior regions of the mandible to determine the appropriate location for insertion of mini-screws have confirmed the superiority of posterior areas owing to the greater bone volume.

Lee et al.[16] evaluated the tooth-bearing alveolar bone for orthodontic mini-screw placement by using CBCT images. They examined the tooth-bearing alveolar bone of the maxilla and the mandible in 30 patients with an average age of 27.8 years, with normal occlusion, and without a history of orthodontic treatments. Linear measurements at the levels of 2, 4, 6, and 8 mm from the CEJ were performed in the mesiodistal and buccolingual dimensions. Accordingly, the maximum mesiodistal and buccolingual bone thickness were 2.02 $\pm$ 0.66 mm and 3.06 $\pm$ 0.87 mm, respectively, which were recorded in the lateral incisor–canine region at the level of 8 mm from the CEJ.

Fayed et al.[17] investigated appropriate locations for mini-screw placement using CBCT images. A total of 100 patients were included and divided into 2 age groups (13-18 and 19-27 years). Buccolingual bone thickness, mesiodistal space on the buccal and lingual/palatal sides, and cortical bone thickness were measured in different areas of the jaws at the levels of 2, 3, and 5 mm from the CEJ. The maximum mesiodistal spaces on the buccal and lingual sides of the mandible on the right side were 3.28 $\pm$ 0.88 and 2.78 $\pm$ 1.13 mm, respectively. On the left side, these values were 3.89 $\pm$ 1.33 and 3.12 $\pm$ 1.51 mm, respectively. They also reported that the maximum buccolingual thickness was 7.83 $\pm$ 1.36 mm on the right side and 7.75 $\pm$ 1.43 mm on the left side, being related to the lateral incisor–canine region at the level of 6 mm from the CEJ.

Purmal et al.[18] conducted a study to determine the safe zones in the maxilla and mandible for placement of inter-maxillary fixation screws. They evaluated 98 maxillary and 95 mandibular CBCT images. Linear measurements were performed at distances of 2, 5, 8, and 11 mm from the alveolar crest. The mesiodistal distances were measured parallel to the midline of the arch and the buccolingual/palatal distances were measured on reconstructed sagittal cross-sectional images. According to the results, the maximum mesiodistal distance and buccolingual bone thickness on the right side of the mandible were 3.99 $\pm$ 0.32 and 8.25 $\pm$ 1.41 mm, respectively. On the left side, these values were 3.91 $\pm$ 0.31 mm and 10.1 $\pm$ 1.56 mm, respectively. Statistical analysis of the results indicated significant differences between the right and left sides ($P < .05$). As a result, the mesiodistal dimension in the interdental area between the lateral incisor and canine teeth at the level of 11 mm from the CEJ on the right side was proved to be the most appropriate. The same region on the left side was shown to be the most proper location with regard to the buccolingual dimension. The authors also reported that the interdental area of the lateral incisor–canine teeth, at the level of 11 mm from the CEJ, is more suitable for placement of mini-screws for inter-maxillary fixation.

Sadeghian et al.[19] conducted an anthropometric analysis of the buccal and lingual bone thickness of the anterior mandibular teeth by CBCT. They examined the buccal and lingual bone thickness of the mandibular anterior teeth of 20 patients aged 18-40 years by considering 4 reference lines. The alveolar bone thickness of the canine teeth on both lingual and buccal sides was greater than the rest of the anterior teeth. In all of the anterior teeth, the thickness of the lingual plate was larger than that of the buccal plate. The distance between the root apex of the canine tooth to the deepest buccal curvature was also higher than the same distance for the other teeth. No statistically significant differences were observed between males and females.

By comparing the above-mentioned studies[6,17,18,19] with the present study, there is an agreement with regard to the appropriateness of the lateral incisor–canine region for insertion of orthodontic mini-screws. Results of the current study are consistent with the previous findings[6,17,18,19] and can be justified in 2 ways: First, the presence of a nearly uniform conical root in the mandibular anterior teeth may contribute to the increased amount of available bone from the CEJ toward the apex, both in the mesiodistal and the labiolingual dimensions. Nevertheless, there may be exceptions due to various skeletal malocclusions,

root morphology, and tooth alignment in the mandibular arch. Second, the distinct position of the canine tooth at the curvature of the mandibular arch, in addition to its position in relation to the lateral incisor root, results in a sufficient amount of bone in the mesiodistal and labiolingual dimensions at this location.

One of the limitations of our study was that the facial height and malocclusion type were not considered; however, it should be noted that Gracco et al.[20] assessed morphology of the mandibular symphysis in various facial heights (short, long, and normal heights) and found that despite the greater total thickness of the symphysis in the short-face group, no statistically significant difference exists in the total and cancellous areas of the symphysis among the 3 facial types.

CONCLUSION

The interdental area of the lateral incisor–canine teeth at the level of 8 mm from the CEJ is suitable for the application of orthodontic mini-screws in the mandible owing to sufficient mesiodistal and labiolingual dimensions. Mini-screws with a diameter range of 1.3-1.7 mm and length of 5-7 mm is recommended for anterior anchorage in orthodontic treatments.

Ethics committee approval: This study was approved by Ethics committee of Guilan University, (Approval No: IR. GUMS .REC.96.268).

Informed consent: Written informed consent was obtained from the patients who agreed to take part in the study.

Peer review: Externally peer-reviewed.

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