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Cone beam computed tomography imaging guides for ortodontic miniscrew placement

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Abstract

The aim of this retrospective study is to present a guide for the clinicians by detecting the best mini screw placement areas with the measurement of cortical bone thickness in the patients who have cone beam computed tomography (CBCT) images. Additionally to be protected from root damage and a potential damage to environmental anatomic tissues, related measurements will also be held in the determined areas.This study has been evaluated by using the images of 52 patients taken by cone beam computed tomography for diagnosis and cure.In the mandibular measurements which were done by using CBCT, the buccal cortical bone thickness has been found out to increase while going towards the posterior region and going down to the apical region at the same area. In addition, it was observed mostly between second premolar and first molar teeth at the farthest area from the top of the crest, along the mandibular canal. The distance between base of the nose and maxillar sinus floor to the hill of the crest has also been observed that decreased towards the posterior region.Although it can vary according to the person, in mini screw applications, mandibular cortical bone structure and the interradicular range is more suitable than the upper jaw. To be protected from the potential complications and for a better stability, radiologic analysis is recommended to the patient before the mini screw placement.

Keywords: Propofol, ketamine, cerebral oximeter, elderly patients

Introduction

After the use of dental implants in dentistry for prosthetic purposes, the idea that this application can be used for orthodontic anchorage was proposed [1]. Miniscrews developed for this purpose started to be used dentistry after the 1970s [2]. Miniscrews have increased their popularity and have found widespread use in recent years due to the fact that they can be applied effortlessly in a short period of time and used in various areas within the mouth, suggesting high patient comfort and cheapness [3].

The success of miniscrews is measured by their stability. The stability obtained immediately after the screw is placed is the primary stability. The stability, which is formed after the screw is placed and osseointegration is achieved, is the secondary stability. The primary stability in screw success is of great importance [4]. After the screw is applied, a mechanical locking occurs between the screw surface and bone, so that no mobility is expected in the screw [5]. There is no doubt that cortical bone thickness (CBT) is one of the important factors in ensuring screw stability [6].

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The imaging systems used in the examination of the head and neck area are among the most important diagnostic and treatment planning tools in this area. Traditional imaging methods that are widely used today are two-dimensional systems, and their ability to analyze is limited because they compress the three-dimensional anatomy of the area into a two-dimensional image. Three-dimensional imaging systems have been developed to eliminate these limitations and to carry out further investigation. Cone Beam Computed Tomography (CBCT) systems are the most common three-dimensional imaging system used in dentistry today.

As all necessary radiographic images such as cephalometric, panoramic, occlusal and TME graphs can be obtained with CBCT systems in a very short time, and these systems have a wide range of use in the field of orthodontics [7]. In particular, the evaluation of alveolar bone, position of impacted teeth, respiratory analysis, soft tissue relations and three-dimensional analysis of the head and neck region are the most needed orthodontic usage areas.

The aim of this retrospective study was to analyze the most appropriate screw placement sites to guide clinicians through measuring cortical bone thickness in patients with cone beam computed tomography images. It guides clinicians in a radiological way for protection against potential root damage and environmental anatomical damages.

Materials and Method

The present study was performed on CBCT images of the patients with various complaints, which were taken using flat-panel CBCT device (Newtom 5G, Verona, Italy) in Department of Oral and Maxillofacial Radiology.

The images were taken while the patients were lying on their back, while their head was positioned in the supine position, and while the hard palate was parallel to the gantry and positioned vertically to the ground. The device works with Cone Beam technique at 1-20 mA and 110 kVp as standard.

Our study was performed with retrospective examination of CBCT images of 104 half-jaws belonging to 52 patients with a total age range of 17-43, including 26 female and 26 male.

The evaluation was carried out with the NNT software on the sections with a voxel value of 0.2 mm, and with a thickness of 0.2 mm. The areas that the miniscrews were applied most frequently were determined as measuring area. These were interdental area between premolar 1 and 2, premolar 2 and molar 1, and molar 1 and 2 both in maxilla and mandible. Previous studies reported that the left and right sides of same jaw were not different in terms of cortical bone thickness, therefore, only one side of each jaw was measured by randomly selecting [8,9].

Firstly crest apex were marked on axial sections (Figure 1). After the Crest apex were marked on axial sections, bone thickness measurements were performed from the cross sections and from the 3, 6, and 9 mm apical apex of the Crest apex (Figure 2).

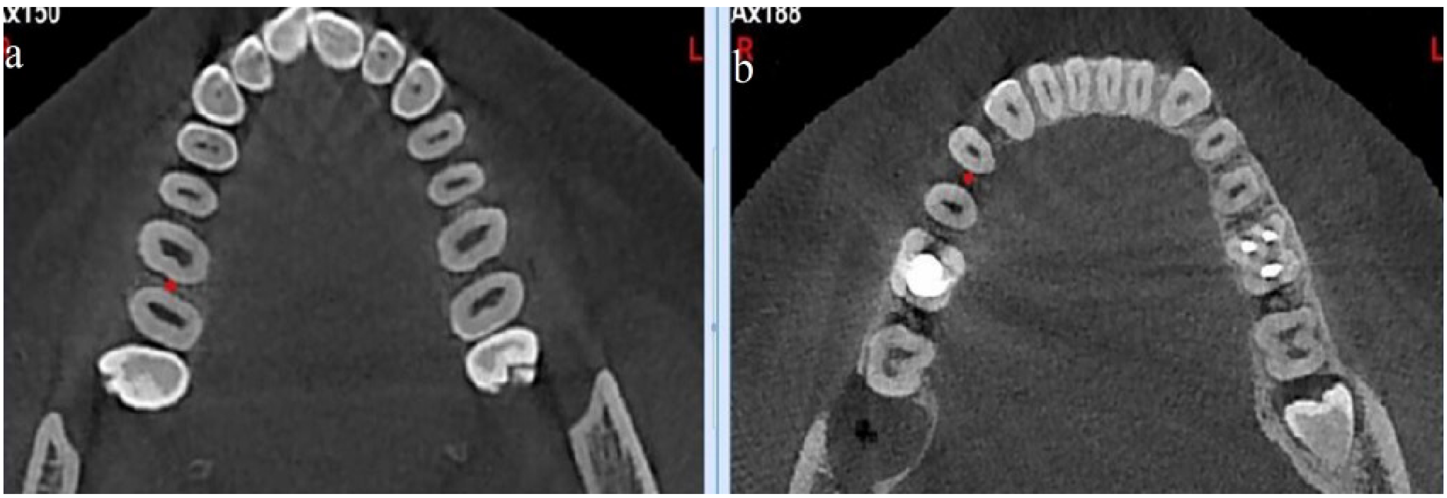

Figure 1. (a) Crest apex marking in axial sections of maxilla. (b) Crest apex marking in axial sections of mandible

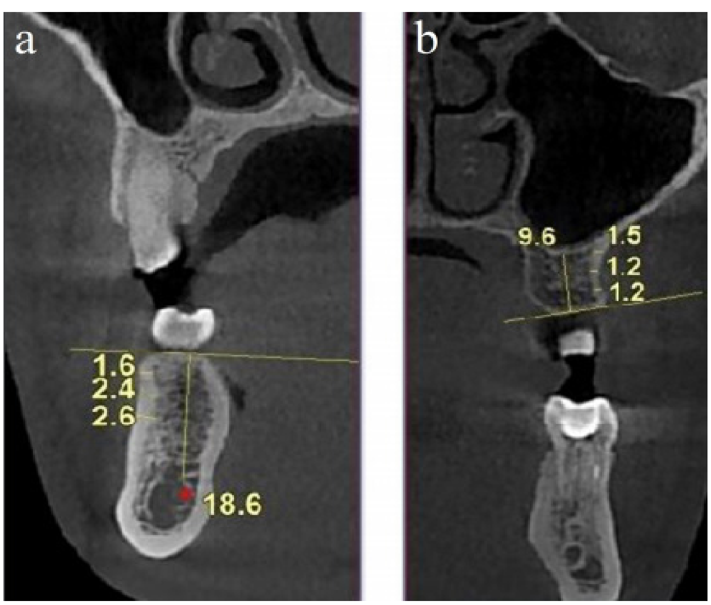

Figure 2. (a) Buccal cortical bone thickness measurements in cross-sections of the mandible (b) Buccal cortical bone thickness measurements in cross-sections of the maxilla.

Progressing along 3, 6, and 9 mm apical directions from Crest apex marked on axial sections, the interdental distance was measured from the narrowest region (Figure 3).

Thanks to the 1 mm panoramic images taken over the CBCT records, the mandibular canal course was found and marked. In this way, the distance to the crest apex of the mandibular canal was measured in cross sections (Figure 4).

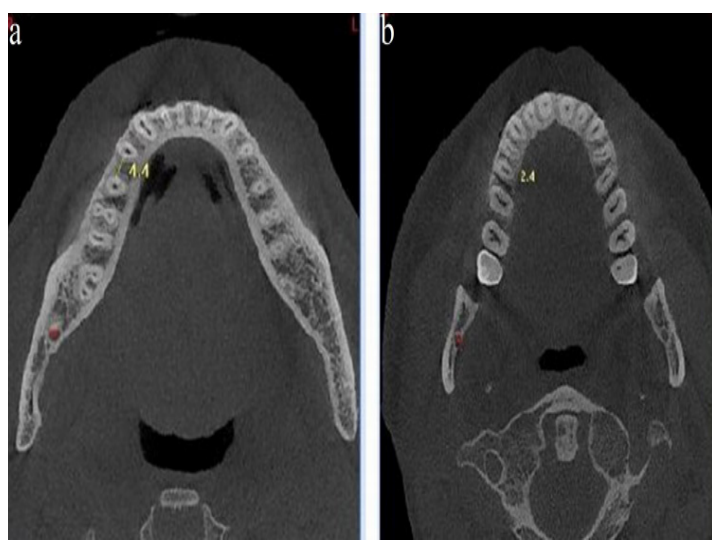

Figure 3. (a) Interdental area measurements in axial sections of the mandible. (b) Interdental area measurements in axial sections of the maxilla.

Statistical Analysis

Analysis of data was evaluated in SPSS 18.0 statistical package software (Statistical Package for Social Science, Chicago, Illinois, USA).

Kolmogorov Smirnov test was applied to determine the normal distribution of continuous variables. Analysis of the data was evaluated using ANOVA, Tukey and Kruskal Wallis test. Significance level was accepted as $p<0.05$

Results

The height of the mandibular canal was measured by cross-sections. The maximum distance on average was found between the second premolar and first molar (Table 1).

The distance from the cross sections of the sinus or nasal floor to the crest apex was measured. As progressing towards the posterior, it can be clearly seen that the sinus base is approaching crest apex (Table 2).

Figure 4. Marking the mandibular canal course from multiple panoramic images on the mandible

Interradicular measurements were taken by progressing from the crest apex towards apical on the axial sections. According to the average values of the measurements on the maxilla, the interdental region between molar 1 and 2 is seen to be significantly lower (Table 3).

The mandibular measurements of the interradicular area between molar 1 and 2 are seen to be higher (Table 4).

Table 1. Distance of the mandibular canal to the crest apex

	Between first-second premolar	Between second premolar-first molar	Between first-second molar	p
Canal Height	15.3327	**17.8288***	16.3346	0.013
Std. Deviation	3.24531	2.15264	2.48477	
***p<0.05**				

Table 2. Distance of sinus/nasal base to the crest apex

	Between first-second premolar	Between second premolar - first molar	Between first-second molar	p
Sinus/Nasal Floor.	**17.3***	11.7346	9.2731	0.006
Std. Deviation	4.04935	4.27257	3.10301	
***p<0.01**				

Table 3. Interradicular distance in maxilla

	Between first-second premolar	Between second premolar-first molar	Between first-second molar	p
İnterrad. Dis.	3.1173	3.4237	**2.3731***	0.02
Std. Deviation	0.95718	0.81959	1.03768	
***p<0.01**				

Table 4. Interradicular distance in the mandible

	Between first-second premolar	Between second premolar- first molar	Between first-second molar	p
Interrad. Dis.	4.0141	3.8224	**4.4833***	0.009
Std. Deviation	0.98351	0.73457	1.19625	
***p<0.05**				

Cortical bone thicknesses were measured from the crest apex towards apical on cross-sections. According to the measurement results, the thickness of the buccal cortical bone (BCB) increases significantly as progressing towards posterior of the mandible (Table 5). The mean thickness of BCB in the maxilla differed significantly in interdental area between the first and second molar teeth, and there was no statistically significant difference in the other regions (Table 6).

Table 5. Measurements of BCB thickness in the mandible

Mandible	Between first-second premolar	Between second premolar-first molar	Between first-second molar	p
Mean	1.4205 (±0.34535)	1.7763 (±0.48849)	**2.2558*** (±0.54839)	**0.002**
***p<0.05**				

According to the depth differences in the BCB thickness, it is observed that the BCB thickness of the mandible in each region increases as progressing towards the apical (Table 7). In the maxilla, there was significant difference in interdental area between the first and second molar teeth and no difference in the other regions (Table 8).

Table 6. Measurements of BCB thickness in the maxilla

Maxilla	Between first-second premolar	Between second premolar-first molar	Between first-second molar	p
Mean	1.0071 (±0.21271)	1.0365 (±0.27275)	**1.1744*** (±0.29444)	**0.03**
***p<0.05**				

Table 7. Measurements of BCB thickness in the mandible at different depths

Mandible	3 mm	6 mm	9 mm	
Between first-second premolar	1.1404 (±0.34825)	1.4115 (±0.42916)	**1.7096*** (±0.50769)	**0.007**
Between second premolar-first molar	1.5173 (±0.45189)	1.8538 (±0.46462)	**2.0902*** (±0.54157)	**0.02**
Between first-second molar	1.8731 (±0.58481)	2.2096 (±0.68492)	**2.6846*** (±0.60598)	**0.01**
***p<0.05**				

Table 8. Measurements of BCB thickness in the maxilla at different depths

Maksilla	3 mm	6 mm	9 mm	
Between first-second premolar	0.9692 (±0.26534)	0.9423 (±0.25387)	1.1096 (±0.37847)	
Between second premolar-first molar	0.9365 (±0.23011)	0.9827 (±0.30275)	1.1904 (±0.49715)	
Between first-second molar	1.0250 (±0.32532)	1.1212 (±0.39325)	**1.3769*** (±0.48974)	**0.001**
***p<0.05**				

Discussion

In miniscrew applications, the most important factor that requires the clinician to be careful is the environmental anatomical structures. Especially mandibular canal, maxillary sinus, adjacent roots, nasal cavity, and neurovascular tissues should be protected from potential damage in miniscrew applications [10,11].

In a study evaluating the risks and complications of the miniscrews, Kravitz et al. noted that miniscrews in the retromolar region should be placed carefully to avoid possible damage to the buccal and lingual nerves. Also, they suggested that the length of the miniscrews should not be longer than 8 mm and the application area should be near the buccal region at the anterior ramus to avoid nerve damage [12].

In the research on mandible of 15 human cadavers, Monnerat C. et al. [13] found the distance of the mental foramen to Crest apex at an average of 12.4 ± 3.25 mm. The researchers warned that this distance may vary by person, so the safety range should begin at the 9 mm apical of crest apex to avoid any complications [13]. In the present study, although the course of the mandibular canal may vary, it was found to be minimum 9.2±3.2 mm in accordance with the literature.

Maxillary sinus and nasal floor perforations can be observed for the miniscrew applications in the incisive teeth and posterior and zygomatic arc regions of maxilla. In particular, in the applications on maxillary posterior atrophic crests, the maxillary sinus perforations may pose major risk [14]. In this study, the distances between Crest apex and maxilla posterior region, as well as, nasal floor and maxillary sinus lower wall were measured. The minimum distance was observed between the Crest apex of molar 1 and 2 and sinus base, but it increased as progressing to the anterior.

For miniscrews to be applied in interdental areas, the safe range may vary in different parts of the jaws. Poggio et al. [15] also found the biggest mesiodistal distance on the palatinal side between first molar teeth and second premolar teeth in the maxilla. The narrowest distance was found in tuber region. It is stated that the most common area in the mesiodistal direction in mandible is between the first and second premolar teeth. In this direction, the minimum distance was found between the first premolar and canine teeth [15]. In another study on the mandibular cadavers, the interradicular distance was found to increase from cervical to apical in each region. The widest distance was found between the molar 1 and 2 [13]. Park et al. [16] found the minimum distance between the first and second molar teeth in the maxilla and found the maximum between the second premolar and first molar teeth, also, the maximum distance in the maxilla was between the first and second molar teeth, and the minimum distance in the maxilla was between the canine and first premolar teeth [16]. In the present study, we found the maximum distance between the second premolar and first molar teeth in the maxilla and the minimum distance between the first and second molar teeth. In the mandible; the biggest interradicular distance was between the first and second molar teeth, while the narrowest distance was between the second premolar and the first molar teeth.

There are many studies on CBC measurement in the literature, but in Turkey, very little research were conducted in this subject. According to a study conducted in 2011, the distance was observed to increase as progressing towards the posterior of buccal region of the mandible, both in adults and young adults. In the buccal region of maxilla of adults, the thickest area of BCB was found to be between the second premolar and the first molar, while the thinnest area was between the lateral incisor teeth [17]. In a study conducted by Baumgaertel and Hans, the mandibular BCB was found more than the maxilla in each region. The thickest BCB was found 6 mm depth on the maxilla, while the thinnest was 4 mm depth. In the mandible, the BCB was observed to increase as progressing from the crest apex to the apical. Moreover, the BCB increases as progressing to the posterior side of the mandible, while the maxilla has no significant difference in this respect [18]. Suer et al. [19)] conducted one of the rare studies of our country on this issue in 2015. According to the results of the study; For both the mandible and the maxilla of people with a short face profile, the thickness of the BCB is more than people with a long facial profile having the Class 2 orthodontic problem. Based on the results of the mandible compared to the maxilla, the BCB thickness of the mandible was found to be more than the maxilla in people with both a short face and a long face profile.

Based on a research that investigates the relationship of dento-skeletal differences with the CBC, Miyawaki et al. [3] concluded that a significant relationship between the high mandibular plane angle and the BCB thickness exist. Similarly, Masumoto et al. [20], and Tsunori et al. [21] found that BCB thickness increased in parallel with the decrease of gonial angle and mandibular plane angle. Varrela et al. [22] stated that there was a significant correlation between the gonial angle and muscle activity. In other words, people with high mandibular angles were determined to have a weaker chewing function characteristic. The increase in the BCB may be associated with increased chewing function [22].

In this study, buccal cortical bone thickness was measured from the 3, 6 and 9 mm apical of crest apex. According to the measurement results of the thickness of the mandibular CBC, the thickest area is the first and second molar interdental region, followed by the second premolar – first molar, and the first premolar – second premolar teeth region, and in accordance with the literature, the thickness of the BCB increases as progressing toward the posterior of the mandible. Also, the thickness of BCB increases as progressing towards the apical of each region in the mandible. According to the BCB thickness of maxilla, the thickest region is between first and second molar teeth, while there is no statistically significant difference between the other regions.

Conclusions

As a result, before the miniscrew applications, the area to be applied should be examined in a radiologically detailed manner for anatomical differences. For this purpose, CBCT is recommended as the first choice due to its detailed analysis capability.

Competing interests
The authors declare that they have no competing interests.

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Ethical approval
This research was approved by Inönü University Scientific Research and publication ethics committee dated 01.03.2016 and numbered 2016/4-6.

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