Bone Characteristics of the Maxillary Regions Commonly Used for Miniscrew Implant Placement: The Comparison between Different Vertical Skeletal Patterns

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Abstract

The purposes of this study were to evaluate the bone characteristics; the alveolar process width (APW), cortical bone thickness (CBT), cortical bone density (CoBD), and cancellous bone density (CaBD) of the maxillary regions commonly used for miniscrew implant placement and to compare the bone characteristics between patients with different vertical skeletal patterns. Using Cone-beam computed tomography (CBCT) images obtained from 39 patients, age 20-30 years, the APW, CBT and bone density were measured with Dolphin Imaging software. On buccal side, the APW, CBT, CoBD, and CaBD values ranged from 7.95±1.40 to 12.25±3.95 mm, 1.14±0.27 to 1.35±0.33 mm, 1,025.7±157.09 to 1,167.5±181.50 Hounsfield units (HU), and 398.54±45.47 to 408.71±44.48 HU, respectively. On palatal side, the APW, CBT, CoBD, and CaBD values ranged from 9.08±4.39 to 10.79±5.10 mm, 1.28±0.28 to 1.37±0.29 mm, 1,001.5±148.02 to 1,048.2±128.14 HU, and 416.29±41.76 to 421.73±53.74 HU, respectively. Comparing of bone characteristics between vertical skeletal patterns there were no statistically significant difference in this study parameter, except palatal CBT and buccal CaBD in hyperdivergent group were less than other groups. In conclusion, the bone characteristics of the maxillary interradicular spaces from premolar to molar regions were appropriate for miniscrew implant placement and the results indicated that it should be cautiously taken into account when placing miniscrew implants in the patients with hyperdivergent skeletal pattern.

Keywords: *Cone-beam computed tomography/ Bone characteristics/ Vertical skeletal pattern/ Miniscrew implant*

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Introduction

Nowadays, the miniscrew implant is considered as a standard technique in orthodontic treatment. Generally the dentist takes a radiograph at the placement site to find the optimal position and assesses the vital structures, especially in the miniscrew implant placement between the roots known as interradicular technique. The miniscrew implant which contacts the root surface during insertion can cause the complications, such as root resorption[1] and increased failure rate.[2-5] However, there are many factors which may affect the success of miniscrew implant and cannot be measured with 2-dimensional (2D) conventional radiograph, such as alveolar process width (APW), cortical bone thickness (CBT), and bone density.[2, 6, 7]

Although the miniscrew implant is currently used widely, the failure rate of the miniscrew implant is still relatively high. Herman et al[8] reported the failure rate up to 40.8 percent which was not satisfied. Sometimes miniscrew implant as anchorage may not be able to sustain for a desired time. One reason is that stability of miniscrew implant is primary stability (or mechanical stability), not secondary stability (direct structural and functional connection between lining bone and implant surface found in osseointegrated dental implant).[9] For a good mechanical stability, the bone quality for miniscrew implant placement is a critical factor.[10] Both the cortical bone thickness and bone density have to be considered for the bone quality assessment, this information is obtained from

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cone-beam computed tomography (CBCT) image. According to Misch's classification, the bone quality was classified into 5 types based on the computed tomography (CT) bone density. D1 defines bone density greater than 1,250 Hounsfield units (HU), D2 is between 850-1,250 HU, D3 is between 350-850 HU, D4 is between 150-350 HU, and D5 is less than 150 HU. Researchers found that the patients with type 1 to 3 bone quality had favorable success rate, whereas 55 per cent of all failure cases occurred in Type 4 patients with high risk of extreme bone resorption.[11, 12] In addition, the CBCT image is also useful for evaluating buccolingual thickness, including neighboring vital structures, such as the maxillary sinus or the mandibular canal in the case of miniscrew implant placement in the posterior maxilla or mandibular buccal shelf (MBS), respectively. The data from CBCT images can be used to select the optimal length of the miniscrew implant and reduce the chance of perforation of those vital structures.[13]

From review of literatures, the failure rate of miniscrew implant placement in each patient group may be different. The patients with hyperdivergent skeletal pattern had higher failure rate than those of hypodivergent and normodivergent groups.[14,15] The reason is still unclear. Possible explanation is that the patients with different vertical skeletal pattern have different bite forces[16,17] which may result in different bone density. Moreover, the vertical skeletal pattern may affect bone morphology as well as bone quality. Escobar-Correa et al[18] studied the MBS characteristics in the patients with different vertical skeletal patterns, and found that the hypodivergent patients tended to have the most favorable osseous characteristics with widest bone surface angulation, highest bone depth and CBT, but the differences were not statically significant.

From the aforementioned reasons, this study has 2 objectives including

1) To evaluate the characteristics of the maxillary interradicular bone for miniscrew implant placement in terms of the APW, CBT, CoBD, and CaBD in order to consider the suitability of the bone for miniscrew implant placement.

2) To compare these bone characteristics between the patients with hypodivergent, norm divergent and hyperdivergent skeletal patterns which will be the basis for describing the different success rates in all 3 groups of patients.

Materials and methods

Thirty-nine subjects (age 20-30 years) receiving treatment at Postgraduate Orthodontic Clinic, Faculty of Dentistry, Bangkokthonburi University were recruited in this study. The subjects were divided into 3 groups based on different vertical skeletal patterns, including 10 hypodivergent, 15 normodivergent and 14 hyperdivergent skeletal patterns. Classification criteria were 2 from 3 measurements including 1) the Frankfort-mandibular plane angle (FMA) 2) mandibular plane angle formed by lines sella turcica (S)-nasion (N) and gonion (Go)-gnathion (Gn) (SN-GoGn) and 3) the ratio of the posterior facial height (S-Go) to anterior facial height (N-menton (Me)). The exclusion criteria were as follows: 1) systemic diseases that affected bone characteristics such as thalassemia, G6PD, osteoporosis, rheumatoid arthritis, 2) current medications that affected bone metabolism such as nonsteroidal anti-inflammatory drugs (NSAIDs), bisphosphonates, and steroid, 3) radiographic bone loss visible on CBCT or panoramic radiographs, 4) presence of abnormalities that interfered radiographic interpretation, such as crown restoration, dental implant, large restoration, embedded tooth, incomplete eruption of crown and root canal treatment near the interesting area, 5) craniofacial abnormalities or any pathology in maxilla, such as cleft palate, tumour or cyst, 6) missing tooth or history of fracture in the interesting area, and 7) severe facial asymmetry.

To reduce error of the data interpretation, the standard posture of CBCT was oriented from 3 reference planes. First, from the sagittal view, the

palatal plane (ANS-PNS) was tilted until it was parallel to the horizontal plane. Second, in the axial view after jaw tilt setting, the landmarks were presented. The reference plane was finely adjusted by averaging the landmarks including posterior nasal spine (PNS), midpalatal suture (MPS), nasopalatine canal (NPC), and anterior nasal spine (ANS). The final step seen in coronal view, the line between mesiolingual cusps of left and right upper first molars were adjusted to parallel to the horizontal plane. After the antero-posterior (A-P), midline setting and transverse tilt setting, the image was in the standard posture (Figure 1).

On the buccal side, the interradicular spaces between the first and second premolars (4/5), second premolar and first molar (5/6), and first and second molars (6/7) were assessed whereas the interradicular spaces between second premolar and first molar (5/6), and first and second molars (6/7) were assessed on the palatal side. The APW, CBT, CoBD, and CaBD were vertically measured at 5, 7, and 9 mm from alveolar crest. From the axial view, the reference line (green line) had to be in the middle between two adjacent root surfaces. From the coronal view, the measurement line (yellow line) was perpendicular to the line of adjacent bone surface (Figure 2).

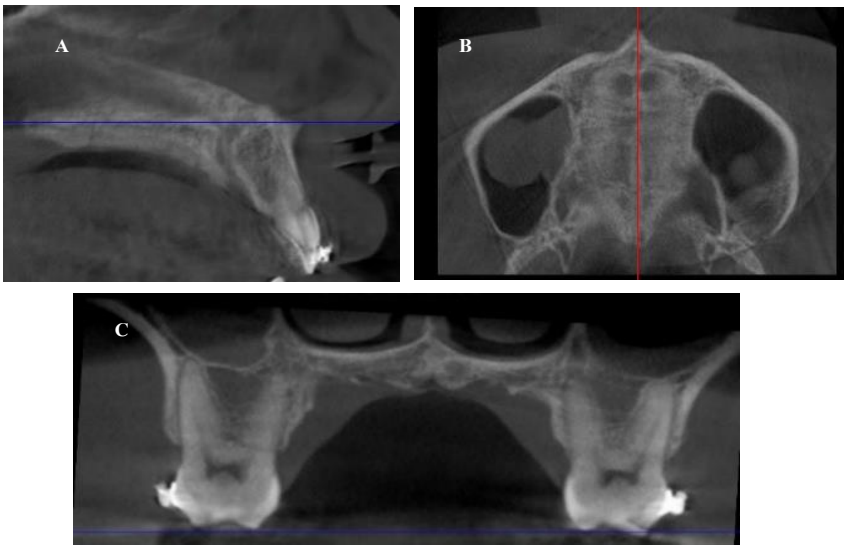


Figure 1 The standard posture of CBCT image. A) the palatal plane was parallel to the horizontal plane, B) the middle of palate, C) the line between mesiolingual cusps of left and right upper first molars parallel to the horizontal plane

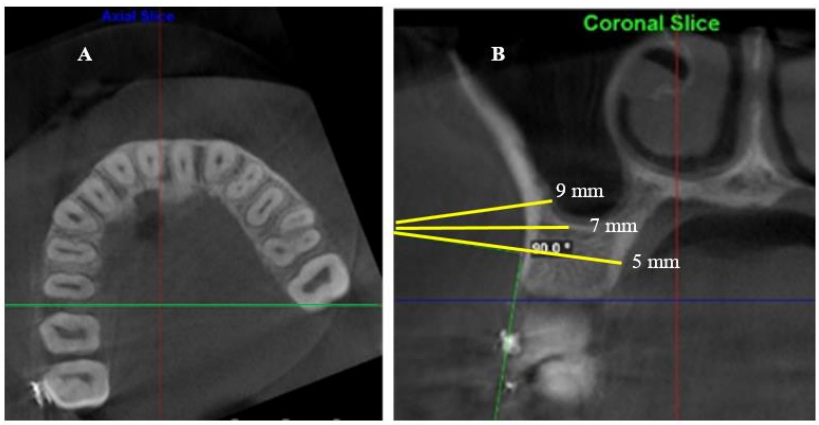


Figure 2 The reference and measurement lines. A) the reference line had to be in the middle between two adjacent root surfaces (axial view), B) the measurement line was perpendicular to the line of adjacent bone surface (coronal view). This figure showed the measurement lines at 5, 7, and 9 mm.

The measurements of bone density and quantity were performed as follows, APW was the distance between outer surface of cortical bone to the inner surface of cortical bone of the opposite side (Figure 3), CBT was the distance between external and internal surface of the cortex, CoBD was measured in the middle site of cortical bone thickness and CaBD was measured on 3 points of APW line, divided equally into 4 parts, then averaged to one value. One-way ANOVA test and Tukey's test were used for comparing the means of buccal side between each A-P position, the means of both buccal and palatal sides between each vertical position, and the means of both buccal and palatal sides between each vertical skeletal pattern. Paired t-test was used for comparing the means of palatal side between each A-P position. The pilot study was performed in the real setting in 15 random cases (5 selected CBCT images from each group). The parameters were measured twice for the accuracy and the intraclass correlation coefficients were above 0.894.

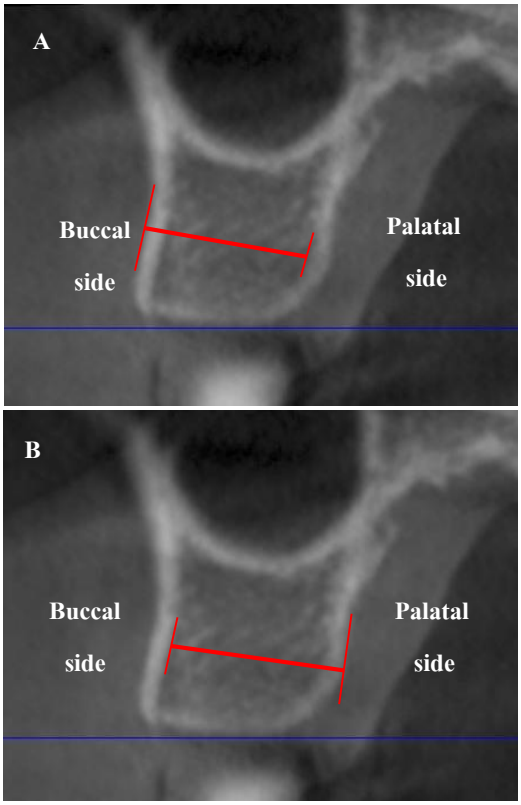


Figure 3 In the coronal view, APW was the distance between outer surface of cortical bone to the inner surface of cortical bone of the opposite side. A) the APW measurement on the buccal side, B) the APW measurement on the palatal side

Results

All data from the left and right sides were compared by paired t-test (Table 1) and no statistically significant difference was found, then all parameters on left and right sides were combined together. For overall analysis, the mean APW and CBT of different A-P and vertical positions on both buccal and palatal sides were shown in Table 2. Comparing between each A-P position, the APWs between 6/7 on buccal and palatal sides were 12.25±3.95 mm and 10.79±5.10 mm respectively, higher than those of other positions ($p<0.001$). Comparing between each vertical position, the highest APWs on buccal and palatal sides were found in the 5 mm depth positions (10.51±2.74 mm and 11.46±3.07 mm respectively), then the widths tended to decrease from cervical to apical regions ($p<0.001$). For the CBT analysis in each A-P position, the CBT between 6/7 on buccal side was 1.35±0.33 mm, higher than other positions ($p<0.001$), but the CBT between 6/7 (1.28±0.28 mm) on palatal side was lesser than those between 5/6 (1.37±0.29 mm) ($p<0.001$). The mean CBT in each vertical position on buccal and palatal sides ranged from 1.20 to 1.24 mm and 1.29 to 1.36 mm respectively with no statistical difference between each vertical position ($p>0.05$) (Table 2).

Table 1 Mean (and standard deviation) of APW, CBT, and bone densities, comparing between left and right sides

Parameters	Left side values	Right side values	p-value*
APW mm)	9.99±2.73	9.77±3.01	p>0.05
CBT (mm)	1.25± 0.42	1.24± 0.30	p>0.05
CoBD (HU)	1,068.0±167.5	1,066.0±157.7	p>0.05
CaBD (HU)	413.87±50.09	410.93±46.80	p>0.05

*Paired t-test for comparing the means of left and right sides of each parameter. All data, both buccal and palatal sides, in different A-P and vertical positions showed no statistically significant difference (p>0.05)

A-P position = antero-posterior position, APW = alveolar process width, CaBD = cancellous bone density, CoBD = cortical bone density, CBT = cortical bone thickness, and HU = Hounsfield unit

Table 2 Mean (and standard deviation) of the alveolar process width and the cortical bone thickness

Types	Regions	Mean ± Standard Deviation (mm) (A-P position)				Mean ± Standard Deviation (mm) (vertical position)			
		4/5	5/6	6/7	p-value	5	7	9	p-value
APW	Buccal	7.95±1.40	9.41±2.58	12.25±3.95	p<0.001*	10.51±2.74	10.43±3.15	8.68±3.77	p<0.001**
	Palatal	-	9.08±4.39	10.79±5.10	p<0.001	11.46±3.07	10.52±3.97	7.82±6.16	p<0.001**
CBT	Buccal	1.14±0.27	1.17±0.29	1.35±0.33	p<0.001***	1.20±0.31	1.22±0.32	1.24±0.31	p>0.05
	Palatal	-	1.37±0.29	1.28±0.28	p<0.001	1.32±0.25	1.36±0.29	1.29±0.31	p>0.05

One-way ANOVA test for comparing the means of buccal side between each A-P position, and the means of both buccal and palatal sides between each vertical position. Paired t-test for comparing the means of palatal side between each A-P position.

A-P position = antero-posterior position, APW = alveolar process width, and CBT = cortical bone thickness

4/5 = between first and second premolars, 5/6 = between second premolar and first molar, and 6/7 = between first and second molars

5 = 5 mm from alveolar crest, 7 = 7 mm from alveolar crest, 9 = 9 mm from alveolar crest

* From multiple comparison test, 4/5 was significantly different from 5/6 and 6/7, 5/6 was significantly different from 6/7

** From multiple comparison test, 9 mm was significantly different from 5 and 7 mm, and 5 mm was not significantly different from 7 mm

*** From multiple comparison test, 6/7 was significantly different from 4/5 and 5/6, and 4/5 was not significantly different from 5/6 mm

Mean of bone density in each A-P and vertical position was also compared (Table 3). On buccal side, the mean of CoBD at 5/6 area was 1,155.2±194.63 HU, close to those of 6/7 area (1,167.5±181.50 HU), and statistically different from those of 4/5 area (1,025.7±157.09 HU) (p<0.05). However, the mean of CoBD on palatal side of 6/7 area (1,001.5±148.0 HU) was lesser than those of 5/6 area (1,048.2±128.14 HU) (p<0.001). The means of CoBD in each vertical position on both buccal and palatal sides were not different (the ranges were 1,103.4 to 1,122.7 HU for buccal side, and 1,002.7 to 1,037.9 HU for palatal side) (Table 3).

The means of CaBD in each A-P position on both buccal and palatal sides were not different (the range were 398.54 to 408.71 HU for buccal side, and 416.29 to 421.73 HU for palatal side), whereas the means of CaBD in each vertical position were different (p<0.01). The highest CaBDs on buccal and palatal sides were found in 5 mm depth positions (418.06±47.30 mm and 429.3±45.6 mm respectively), then the cancellous densities tended to decrease from cervical to apical regions (Table 3).

Table 3 Mean (and standard deviation) of the cortical and cancellous bone densities

Types	Regions	Mean ± Standard Deviation (HU) (A-P position)				Mean ± Standard Deviation (HU) (vertical position)			
		4/5	5/6	6/7	p-value	5	7	9	p-value
CoBD	Buccal	1,025.7± 157.09	1,155.2± 194.63	1,167.5± 181.50	p<0.001*	1,103.4± 172.48	1,122.7± 203.23	1,122.3± 191.34	p>0.05
	Palatal	-	1,048.2± 128.14	1,001.5± 148.02	p<0.001	1,034.0± 128.20	1,037.9± 159.27	1,002.7± 129.28	p=0.05
CaBD	Buccal	408.30± 60.74	408.71± 44.48	398.54± 45.47	p=0.05	418.06± 47.31	407.15± 50.03	390.32± 51.66	p<0.001**
	Palatal	-	421.73± 53.74	416.29± 41.76	p>0.05	429.31± 45.63	417.72± 47.76	410.01± 49.30	p=0.001**

One-way ANOVA test for comparing the means of buccal side between each A-P position, and the means of both buccal and palatal sides between each vertical position. Paired t-test for comparing the means of palatal side between each A-P position.

A-P position = antero-posterior position, CaBD = cancellous bone density

CoBD = cortical bone density, and HU = Hounsfield unit

4/5 = between first and second premolars, 5/6 = between second premolar and first molar, and 6/7 = between first and second molars

5 = 5 mm from alveolar crest, 7 = 7 mm from alveolar crest, 9 = 9 mm from alveolar crest

* From multiple comparison test, 4/5 was significantly different from 5/6 and 6/7

** From multiple comparison test, 9 mm was significantly different from 5 and 7 mm

Comparing the bone characteristics (APW, CBT, CoBD, CaBD) between the patients with hypodivergent, normodivergent and hyperdivergent vertical skeletal patterns, there was no statistical difference between each vertical skeletal pattern except the palatal CBT (p<0.01) and buccal CaBD (p<0.001) (Table 4). Mean of palatal CBT in hyperdivergent group was 1.27±0.29 mm, different from those of hypodivergent and normodivergent groups (1.36±0.24 mm and 1.35±0.31 mm respectively, p<0.05). The means of buccal CaBD tended to decrease in hyperdivergent group and the significant difference was found between hypo- and hyperdivergent group (p<0.05), whereas the means of palatal CaBD tended to decrease from hypo- to normo- and hyperdivergent groups but there was no significantly different (p>0.05) (Table 4).

Table 4 Mean (and standard deviation) of bone characteristics in the patients with different vertical skeletal patterns

Types	Sides	Hypodivergent	Normodivergent	Hyperdivergent	Hypo-Normo	Hypo-Hyper	Normo-Hyper	p-value
APW (mm)	Buccal	9.93±3.35	9.79±3.30	9.92±3.42	0.14	0.01	-0.13	p>0.05
	Palatal	10.24±4.29	9.26±4.45	10.44±5.49	0.98	-0.21	-1.19	p=0.05
CBT (mm)	Buccal	1.22±0.29	1.24±0.31	1.21±0.33	-0.02	0.01	0.03	p>0.05
	Palatal	1.36±0.24	1.35±0.31	1.27±0.29	0.01	0.09*	0.08**	p<0.01
CoBD (HU)	Buccal	1,136.3±185.48	1,102.0±153.15	1,116.9±223.59	34.24	19.35	-14.89	p>0.05
	Palatal	1,046.4±146.63	1,012.4±126.08	1,022.9±148.80	33.99	23.50	-10.49	p>0.05
CaBD (HU)	Buccal	417.72±47.17	407.74±50.09	393.48±52.05	9.99	24.24*	14.26	p<0.001
	Palatal	425.59±33.69	419.64±47.97	413.64±56.09	5.95	11.94	5.99	p>0.05

One-way ANOVA test for comparing the means of both buccal and palatal sides between each vertical skeletal pattern.

APW = alveolar process width, CaBD = cancellous bone density, CBT = cortical bone thickness, and CoBD = cortical bone density,

HU = Hounsfield unit

* From multiple comparison test, hypodivergent group was significantly different from hyperdivergent group

** From multiple comparison test, normodivergent group was significantly different from hyperdivergent group

Discussions

This study showed the data about the bone thickness and density that are key factors to achieve primary stability and success of miniscrew implants in orthodontics. The APW tended to increase from anterior to posterior positions on both buccal and palatal sides significantly due to the anatomy of alveolar bone which the posterior part (molar region) was wider than anterior part (premolar region). When the width of the alveolar process was measured horizontally, the width in the crestal region should be less than those of the apical region. However, in our methodologies, the measurement line was perpendicular to the line of adjacent bone surface (Figure 2), so the measurement lines in the apical regions (7 and 9 mm) pointed to the floor of maxillary sinus which limited the length of miniscrew implant. That was an explanation why the APW in our study tended to decrease from cervical to apical regions. This measurement protocol was similar to the protocols of Park and Cho[19] and Poggio et al.[20], and our results were similar to their studies. This is clinically significant when the miniscrew implant is placed in the high position of posterior maxilla. Manufactures usually produce variety of screw length ranging from 5 to 15 mm,[21] so the clinician can use the APW in each position to select the proper miniscrew implant length.

From our results, the CBT tended to increase from anterior to posterior positions on buccal side only. On palatal side, CBT between 6/7 was less than those between 5/6 significantly. In vertical position, there were no significant difference between each region on both buccal and palatal sides. According to Park and Cho,[19] CBT was relatively similar in each A-P position and tended to increase from alveolar crest to the apex.

In the posterior maxillary region, especially the second molar area, there is the zygomatic buttress, the thick bone ridge which is subjected to the high compressive stress and strain,[22] so the highest CBT was found at the buccal side between 6/7 area. Opposing to the findings on palatal side, the 6/7 region is closed to the groove of greater palatine canal, so the palatal CBT between 6/7 was lesser than those of 5/6.

Although there was statistical difference of the CBT, the means were in range of 1.14-1.35 mm on buccal side and 1.28-1.37 mm on palatal side which might have no clinical difference. Fernandes et al[10] measured the primary stability of miniscrew implants in bovine femur, rabbit tibia and synthetic bone. They found that the primary stability was achieved in the bone with at least 2 mm CBT or 1 mm CBT with good quality cancellous bone. From our results, most of CBTs were in the range of 1-1.5 mm, so the study of CaBD was so important to determine the good mechanical implant stability and improve the success rate of miniscrew implant.

Compared to previous studies of Park and Cho[19] and Poggio et al[20], both researcher groups focused on bone dimensions, including APW and CBT. Most of our results conformed to their reports, but we further invstigated about the bone densities because the densities affect the miniscrew implant's primary stability [10] and success rate. For the CoBD analysis, the mean CoBDs were 1,001.5±148.02 HU to 1,167.5±181.50 HU, classified as D2 following Misch's Classification. The CoBD values of our study were comparable to the study of Park et al[23] which studied the bone density of alveolar and basal bones. They found that the CoBDs of alveolar bone were between 810-940 HU, whereas the basal bone densities were between 835-1,113 HU. The CoBDs of buccal side tended to increase from anterior to posterior positions ($p<0.001$), whereas the CoBD between 6/7 was lesser than those between 5/6. There was no

statistical difference between each vertical position ($p>0.05$). Interestingly, pattern of CoBD distribution was similar to CBT distribution.

Mean CaBDs were 398.54±45.47 to 421.73± 53.74 HU which were classified as D3. The CaBDs in each A-P position were relatively not different from each other but tended to decrease from the alveolar crest to apex significantly. Choi et al[24] studied the bone density including cortical and cancellous bone for areas of miniscrew implant placement. They reported that the bone densities were between 467 and 1,103 HU and tended to decrease with increasing in vertical position and A-P position which is similar to our results that the CaBD in each vertical position tended to decrease from the alveolar crest to apex significantly. Wolff's law states that the bone density changes depend on the functional forces on the bone. From Wolff's law, the apical region of alveolar process has less masticatory force than the alveolar crest region, so the CaBD at apical region is less than those of alveolar crest region.

Comparing the bone characteristics (APW, CBT, CoBD and CaBD) between the patients with hypodivergent, normodivergent and hyperdivergent skeletal patterns, there no statistical difference between each vertical skeletal pattern except the palatal CBT ($p<0.01$) and buccal CaBD ($p<0.001$). Escobar-Correa et al[18] studied the MBS characteristics in the patients with different vertical skeletal patterns, and found that the hypodivergent patients tended to have the most favorable osseous characteristics with widest bone surface, highest bone depth and CBT, but the differences were not statically significant. Horner et al[25] evaluated the APW and CBT of maxilla and mandible in the patients with different vertical skeletal patterns using cone-beam CT images, and found that the mean APW in hypodivergent group was greater than those of hyperdivergent group and the mean of CBT on both buccal and palatal sides in hypodivergent group was greater than those of hyperdivergent group, whereas our results revealed that there was no statistical difference between the APW mean of each vertical skeletal pattern group and there was only the difference between the CBT mean of hyperdivergent group and those of other groups ($p<0.05$).

Ozdemir et al[26] also used CBCT to study density of alveolar cortical bone. They found that the buccal CoBD in hypodivergent group was significantly greater than hyperdivergent group, whereas in our study, there was no difference of CoBD on both buccal and palatal sides. CaBD on the buccal side of hypodivergent group was greater than those of normodivergent and hyperdivergent groups. Li et al[27] also used CBCT to evaluate CaBD, their results were similar to the results of our study. They reported that in the posterior teeth, CaBD of hypodivergent group was significantly greater than those of normodivergent and hyperdivergent groups. Although most of the bone characteristics comparing between different vertical skeletal pattern revealed no statistical difference and each value was acceptable for miniscrew implant placement; mean APW was higher than 9.26 mm, mean CBT was higher than 1.22 mm, CoBD was D2 and CaBD was D3, some parameters in hyperdivergent group, such as palatal CBT and buccal CaBD, were lower than those of other groups. These might be the cause of higher miniscrew failure rate in this patient group.[14,15] We suggest further study which focuses on the hyperdivergent patients and their bite forces. For clinical application, in the patients with severe hyperdivergent pattern receiving miniscrew implant placement, the CBCT may be useful to evaluate the critical parameter affecting the outcome of miniscrew implant, such as CBT and bone density.

Conclusions

1. The APW on both the buccal and palatal sides tended to increase from the premolar to the molar regions. (7.95±1.40 to 12.25±3.95 mm), and

tended to decrease from the alveolar crest to the apex. The highest APWs were at the area between 6/7 (12.25±3.95 mm) on the buccal side, and at 5 mm from the alveolar crest on the palatal side (11.46±3.07 mm). In this study, the means of APW from premolar to molar regions demonstrated that these positions are suitable for placement of miniscrew implant due to the appropriate APW. However, it should be avoided to place the miniscrew implant at higher vertical position to prevent the maxillary sinus penetration.

2. The CBT on the buccal side tended to increase from the premolar to the molar regions (1.14±0.27 to 1.35±0.33 mm), but on the palatal side, CBT between 5/6 (1.37±0.29 mm) was greater than 6/7 (1.28±0.28 mm). On the buccal side, the CoBD tended to increase from the premolar to the molar regions (1,025.7±157.09 to 1,167.5±181.50 HU), but on the palatal side, CoBD between 5/6 (1,048.2±128.14 HU) was greater than 6/7 (1,001.5±148.02 HU). On both the buccal and palatal sides, the CaBD tended to decrease from the alveolar crest (429.31±45.63 HU) to the apex (390.32±51.66 HU), Therefore CBT, CoBD, and CaBD were suitable for primary stability of miniscrew implant.

3. Comparing between each vertical skeletal pattern, the palatal CBT of hyperdivergent group (1.27±0.29 mm) was less than those of hypodivergent group (1.36±0.24 mm), and the CBT of hyperdivergent group (1.27±0.29 mm) was less than those of normodivergent group (1.35±0.31 mm). The buccal CaBD of hyperdivergent (393.48±52.05 HU) was significantly less than those of hypodivergent group (417.72±47.17 HU) ($p<0.001$). There was no statistical significant difference in the other parameters. It should be cautiously taken into account when placing miniscrew implants in the hyperdivergent skeletal pattern, due to the least CBT and CaBD of this group, to ensure the stability and prevent miniscrew implant failure, especially in the patients with severe hyperdivergent pattern, the CBCT may be useful to evaluate these critical parameters.

References

1. Alves Jr M, Baratieri C, Mattos CT, Araújo MTdS, Maia LC. Root repair after contact with mini-implants: systematic review of the literature. Eur J Orthod 2013;35(4):491-9.
2. Papageorgiou SN, Zogakis IP, Papadopoulos MA. Failure rates and associated risk factors of orthodontic miniscrew implants: a meta-analysis. Am J Orthod Dentofacial Orthop 2012;142(5):577-95. e7.
3. Watanabe H, Deguchi T, Hasegawa M, Ito M, Kim S, Takano-Yamamoto T. Orthodontic miniscrew failure rate and root proximity, insertion angle, bone contact length, and bone density. Orthod Craniofac Res 2013;16(1):44-55.
4. Kuroda S, Yamada K, Deguchi T, Hashimoto T, Kyung H-M, Yamamoto TT. Root proximity is a major factor for screw failure in orthodontic anchorage. Am J Orthod Dentofacial Orthop 2007; 131(4):S68-73.
5. Chen YH, Chang HH, Chen YJ, Lee D, Chiang HH, Jane Yao CC. Root contact during insertion of miniscrews for orthodontic anchorage increases the failure rate: an animal study. Clin Oral Implants Res 2008;19(1):99-106.
6. Motoyoshi M, Yoshida T, Ono A, Shimizu N. Effect of cortical bone thickness and implant placement torque on stability of orthodontic mini-implants. Int J Oral Maxillofac Surg 2007;22(5):779-84.
7. Marquezan M, Lima I, Lopes RT, Sant'Anna EF, de Souza MMG. Is trabecular bone related to primary stability of miniscrews? Angle Orthod 2013;84(3): 500-7.
8. Herman RJ, Currier GF, Miyake A. Mini-implant anchorage for maxillary canine retraction: a pilot study. Am J Orthod Dentofacial Orthop 2006; 130(2):228-35.
9. Bollero P, Di Fazio V, Pavoni C, Cordaro M, Cozza P, Lione R. Titanium alloy vs. stainless steel miniscrews: an *in vivo* split-mouth study. Eur Rev Med Pharmacol Sci 2018;22:2191-8.

10. Fernandes D, Elias C, Ruellas A. Influence of screw length and bone thickness on the stability of temporary implants. Mater 2015;8(9):6558-69.
11. Misch CE. Dental Implant Prosthetics. 2nd ed. Missouri: Mosby; 2005. 237-50.
12. Jaffin RA, Berman CL. The excessive loss of Branemark fixtures in type IV bone: a 5-year analysis. J Periodontol 1991;62(1):2-4.
13. Kravitz ND, Kusnoto B. Risks and complications of orthodontic miniscrews. Am J Orthod Dentofacial Orthop 2007;131(4):S43-51.
14. Miyawaki S, Koyama I, Inoue M, Mishima K, Sugahara T, Takano-Yamamoto T. Factors associated with the stability of titanium screws placed in the posterior region for orthodontic anchorage. Am J Orthod Dentofacial Orthop 2003;124(4):373-8.
15. Yi Lin S, Mimi Y, Ming Tak C, Kelvin Weng Chiong F, Hung Chew W. A study of success rate of miniscrew implants as temporary anchorage devices in singapore. Int J Dent 2015;2015:294670.
16. Proffit W, Fields HW, Nixon W. Occlusal forces in normal-and long-face adults. J Dent Res 1983; 62(5): 566-70.
17. Abu Alhaija ES, Al Zo'ubi IA, Al Rousan ME, Hammad MM. Maximum occlusal bite forces in Jordanian individuals with different dentofacial vertical skeletal patterns. Eur J Orthod 2009; 32(1):71-7.
18. Escobar-Correa N, Ramírez-Bustamante MA, Sánchez-Uribe LA, Upegui-Zea JC, Vergara-Villarreal P, Ramírez-Ossa DM. Evaluation of mandibular buccal shelf characteristics in the Colombian population: A cone-beam computed tomography study. Korean J Orthod 2020;51(1):23-31.
19. Park J, Cho HJ. Three-dimensional evaluation of interradicular spaces and cortical bone thickness for the placement and initial stability of microimplants in adults. Am J Orthod Dentofacial Orthop 2009;136(3):314-5.
20. Poggio PM, Incorvati C, Velo S, Carano A. “Safe zones”: a guide for miniscrew positioning in the maxillary and mandibular arch. Angle Orthod 2006;76(2):191-7.
21. Alkadhimi A, Al-Awadhi EA. Miniscrews for orthodontic anchorage: a review of available systems. J Orthod 2018;45(2):102-14.
22. Prado FB, Freire AR, Cláudia Rossi A, Ledogar JA, Smith AL, Dechow PC, et al. Review of *in vivo* bone strain studies and finite element models of the zygomatic complex in humans and nonhuman primates: implications for clinical research and practice. Anat Rec 2016; 299(12):1753-78.
23. Park HS, Lee YJ, Jeong SH, Kwon TG. Density of the alveolar and basal bones of the maxilla and the mandible. Am J Orthod Dentofacial Orthop 2008; 133(1):30-7.
24. Choi JH, Park CH, Yi SW, Lim HJ, Hwang HS. Bone density measurement in interdental areas with simulated placement of orthodontic miniscrew implants. Am J Orthod Dentofacial Orthop 2009;136(6):766-7.
25. Horner KA, Behrents RG, Kim KB, Buschang PH. Cortical bone and ridge thickness of hyperdivergent and hypodivergent adults. Am J Orthod Dentofacial Orthop 2012;142(2):170-8.
26. Ozdemir F, Tozlu M, Germec-Cakan D. Cortical bone thickness of the alveolar process measured with cone-beam computed tomography in patients with different facial types. Am J Orthod Dentofacial Orthop 2013;143(2):190-6.
27. Li H, Zhang H, Smales RJ, Zhang Y, Ni Y, Ma J, et al. Effect of 3 vertical facial patterns on alveolar bone quality at selected miniscrew implant sites. Implant dent 2014;23(1):92-7.

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ลักษณะกระดูกในขากรรไกรบนในบริเวณที่ใช้ปักหมุดเกลียวขนาดเล็ก: การเปรียบเทียบระหว่างผู้ป่วยที่มีโครงขากรรไกรแนวดิ่งแตกต่างกัน

นิชนันท์ โพธิรัตน บุญศิวา ซูซูกิ** เอดวาร์โด ยูโก ซูซูกิ** ยสนันท์ จันทรเวคิน***

บทคัดย่อ

การศึกษานี้มีวัตถุประสงค์ดังนี้ เพื่อประเมินลักษณะของกระดูกเบ้าฟัน ได้แก่ ความกว้างของกระดูกเบ้าฟัน ความหนาของกระดูกทึบ ความหนาแน่นของกระดูกทึบและกระดูกโปร่งในขากรรไกรบนในบริเวณที่มักใช้ในการปักหมุดเกลียวขนาดเล็ก และ เพื่อเปรียบเทียบลักษณะของกระดูกระหว่างผู้ป่วยที่มีโครงขากรรไกรแนวดิ่งที่แตกต่างกัน จากภาพรังสีโคนบีมคอมพิวเต็ดโทโมกราฟฟี ในผู้ป่วยจำนวน 39 ภาพ อายุระหว่าง 20 ถึง 30 ปี ได้ทำการวัดความกว้างของกระดูกเบ้าฟัน ความหนาของกระดูกทึบ ความหนาแน่นของกระดูกทึบและกระดูกโปร่งโดยใช้ดอลฟินอิมเมจจิงซอฟต์แวร์ ผลการศึกษาพบว่า ค่าเฉลี่ยความกว้างของกระดูกเบ้าฟัน ความหนาของกระดูกทึบ ความหนาแน่นของกระดูกทึบและกระดูกโปร่งด้านแก้ม มีค่าอยู่ระหว่าง 7.95±1.40 ถึง 12.25±3.95 มิลลิเมตร 1.14±0.27 ถึง 1.35±0.33 มิลลิเมตร 1,025.7±157.09 ถึง 1,167.5±181.50 เฮาน์สฟิลด์ยูนิต และ 398.54±45.47 ถึง 408.71±44.48 เฮาน์สฟิลด์ยูนิต ตามลำดับ ส่วนด้านเพดาน ความกว้างของกระดูกเบ้าฟัน ความหนาของกระดูกทึบ ความหนาแน่นของกระดูกทึบและกระดูกโปร่ง มีค่าอยู่ระหว่าง 9.08±4.39 ถึง 10.79±5.10 มิลลิเมตร 1.28±0.28 ถึง 1.37±0.29 มิลลิเมตร 1,001.5±148.02 ถึง 1,048.2±128.14 เฮาน์สฟิลด์ยูนิต และ 416.29±41.76 ถึง 421.73±53.74 เฮาน์สฟิลด์ยูนิต ตามลำดับ เปรียบเทียบลักษณะของกระดูกระหว่างโครงขากรรไกรแนวดิ่งแต่ละกลุ่มพบว่าไม่มีความแตกต่างกันอย่างมีนัยสำคัญทางสถิติของตัวแปรในการศึกษานี้ ยกเว้นความหนาของกระดูกทึบด้านเพดานและความหนาแน่นของกระดูกโปร่งด้านแก้มในกลุ่มโครงขากรรไกรแนวดิ่งแบบสบเปิด ซึ่งมีค่าน้อยกว่ากลุ่มอื่น จึงสรุปได้ว่าลักษณะของกระดูกเบ้าฟันระหว่างรากฟันในขากรรไกรบนจากฟันกรามน้อยถึงฟันกรามมีความเหมาะสมต่อการปักหมุดเกลียวขนาดเล็ก และตัวแปรในการศึกษานี้แสดงให้เห็นว่าอาจต้องเพิ่มความระมัดระวังในการปักหมุดเกลียวขนาดเล็กในผู้ป่วยที่มีโครงขากรรไกรแนวดิ่งแบบสบเปิดเมื่อเปรียบเทียบกับกลุ่มอื่น

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