CHAPTER 5

Discussion

Recently, the use of miniscrew implants to obtain absolute anchorage has become very popular in clinical orthodontic treatment.[1, 2] The buccal interradicular area is commonly selected for miniscrew implant placement.[6-9] Features, such as interradicular distance, buccolingual alveolar process width, and buccal cortical thickness, should be considered during placement of miniscrew implants because they relate to safety and stability of miniscrew implants.[3, 4, 6, 11, 12] Therefore, the purposes of the present study were 1) to evaluate the three dimensions of interradicular areas and the cortical bone thickness in Thai patients with either Class I or Class II skeletal pattern using Cone Beam Computed Tomography (CBCT) and 2) to compare the three dimensions of interradicular areas and the cortical bone thickness between Class I and Class II skeletal patterns.

5.1 Evaluation of three dimensions of interradicular areas and cortical bone thickness

According to the Table 5.1, these previous studies[3, 4, 7, 12, 16, 17, 28] have not taken the different dentoskeletal patterns into account for the assessment of the measurements, except for Chaimanee *et al*.[11] which assessed the interradicular space in different dento-skeletal patterns using periapical radiograph. The result of present study showed that the greatest mesiodistal distances (MD) in the maxilla were between the second premolar and the first molar in both Class I and Class II skeletal patterns. Similar result has been reported by Park and Cho[4], Fayed *et al.*,[6] Sawada *et al.*,[3] Chaimanee *et al.*,[11] Schnelle *et al.*,[28] and Hu *et al.*[17] However, they are different from the study of Poggio *et al.*[16] which reported that the greatest MD in the maxilla were between the first and second premolars on buccal side and between the second premolar and the first molar on palatal side. These differences are probably due to difference in the methods of measurement in those studies.

Table 5.1 Summary of articles identifying the greatest mesiodistal distance (MD) in the interradicular areas

Author	Method	Maxilla	Mandible
Poggio *et al.,*[16] 2006	CBCT	4-5 B, 5-6 P	4-5
Park and Cho,[4] 2009	CBCT	5-6	6-7
Fayed *et al.,*[6] 2010	CBCT	5-6 B, P	5-6 B, 4-5 L
Monnerat *et al.,*[12] 2009	CT	Not mentioned	6-7
Sawada *et al.,*[3] 2011	Micro-CT	5-6	Not mentioned
Chaimanee *et al.,*[11] 2011	Periapical radiograph	5-6 Cl I, Cl II	6 -7 Cl I, Cl II
Schnelle *et al*.,[28] 2004	Panoramic radiograph	5-6	5-6, 6-7
Hu *et al.,*[17] 2009	Cross sections of human jaws	5-6	6-7
Our study	CBCT	5-6 Cl I, Cl II	6-7 Cl I, 4-5 Cl II

4-5, between first and second premolars; 5-6, between second premolar and first molar; 6-7, between first and second molars; B, buccal side; P, palatal side; L, lingual side; Cl I, Class I skeletal pattern; Cl II, Class II skeletal pattern

In the mandible, the greatest MD were between the first and second molars in the patients with Class I skeletal pattern and between the first and second premolars in the patients with Class II skeletal pattern. According to the Table 5.1, these results support the study of Park and Cho[4], Monnerat *et al.*[12] and Hu *et al.*[17] for Class I group; Poggio *et al.*[16] for Class II skeletal pattern. However, they are different from the studies of Fayed *et al.*[6] which reported that the greatest MD from the buccal side were between the second premolar and the first molar and from the lingual side were between the first and second premolars, and Schnelle *et al*.[28] using panoramic radiograph, which reported that the greatest MD in the mandible were between the second premolar and the first molar and between the first and second molars, probably due to difference in the method of measurement in these studies. Moreover, Chaimanee *et al.*[11] reported that the greatest MD in the mandible were between the first and second molars in both Class I and Class II skeletal patterns.

Although the greatest MD in the patients with Class I and Class II skeletal patterns were different. No statistically significant difference in MD between the first and second premolars and between the first and second molars at 2, 4, and 10 mm-heights was observed.

In both maxilla and mandible, the MD tended to increase from the CEJ to the apex in both Class I and Class II skeletal patterns. These results were found to be in agreement with those obtained in the study of Park and Cho[4], Monnerat *et al.,*[12] Hu *et* *al.*,[17] Chaimanee *et al.*,[11] and Sawada *et al.*[3] However, this pattern was not found between the first and second molars in the maxilla of the patients with Class I skeletal pattern. Similar result has been reported by Fayed *et al.*[6]

The present study showed that the greatest buccolingual alveolar process width (BL) in the maxilla and mandible were between the first and second molars in both Class I and Class II skeletal patterns. This is consistent with those previous studies[3, 4, 6, 12, 16, 17] as showed in the Table 5.2.

Table 5.2 Summary of articles identifying the greatest buccolingual alveolar process width (BL) in the interradicular areas

Author	**Method**	**Maxilla**	**Mandible**
Poggio *et al.*,[16] 2006	CBCT	6-7	6-7
Park and Cho,[4] 2009	CBCT	6-7	6-7
Fayed *et al.*,[6] 2010	CBCT	6-7	6-7
Monnerat *et al.*,[12] 2009	CT	Not mentioned	6-7
Sawada *et al.*,[3] 2011	Micro-CT	6-7	Not mentioned
Hu *et al.*,[17] 2009	Cross sections of human	6-7	6-7
Our study	CBCT	6-7 Cl I, Cl II	6-7 Cl I, Cl II

4-5, between first and second premolars; 5-6, between second premolar and first molar; 6-7, between first and second molars; Cl I, Class I skeletal pattern; Cl II, Class II skeletal pattern

In the maxilla and mandible, the BL tended to increase from the CEJ to the apex in both Class I and Class II skeletal patterns. These results support the study of Hu *et al.*,[17] Monnerat *et al.*,[12] Fayed *et al.*,[6] and Sawada *et al.*[3] In addition, our study revealed that the BL in the maxilla and mandible tended to increase from the anterior to posterior regions in both Class I and Class II skeletal patterns. This is consistent with the study of Park and Cho,[4] Hu *et al.*,[17] Monnerat *et al.*,[12] Fayed *et al.*,[6] and Sawada *et al.*[3] The BL gradually increased from the anterior to the posterior regions in both maxilla and mandible. The increase in the buccolingual width can be anatomically explained by the greater buccolingual width of the roots of the teeth from the anterior to the posterior regions in both arches.[19]

The present study showed that the greatest buccal cortical bone thicknesses (BC) in the maxilla were between the first and second molars in the patients with Class I skeletal pattern and between the first and second premolars in the patients with Class II skeletal pattern. These results support the study of Baumgaertel and Hans,[7] Park and

Cho,[4] and Hu *et al*.[17] for Class I skeletal pattern; Fayed *et al*.[6] and Sawada *et al*.[3] for Class II skeletal pattern, as showed in the Table 5.3.

Table 5.3 Summary of articles identifying the greatest buccal cortical bone thickness (BC) in the interradicular areas

Author	**Method**	**Maxilla**	**Mandible**
Baumgaertel and Hans,[7] 2009	CBCT	6-7	6-7
Park and Cho,[4] 2009	CBCT	6-7	6-7
Fayed *et al.*,[6] 2010	CBCT	4-5	6-7
Monnerat *et al.*,[12] 2009	CT	Not mentioned	6-7
Sawada *et al.*,[3] 2011	Micro-CT	4-5	Not mentioned
Hu *et al.*,[17] 2009	Cross sections of human	6-7	6-7
Our study	CBCT	6-7 Cl I, 4-5 Cl II	6-7 Cl I, Cl II

4-5, between first and second premolars; 5-6, between second premolar and first molar; 6-7, between first and second molars; Cl I, Class I skeletal pattern; Cl II, Class II skeletal pattern

In the mandible, the greatest BC were between the first and second molars in both Class I and Class II skeletal patterns. Similar result has been reported by Baumgaertel and Hans,[7] Park and Cho,[4] Monnerat *et al*.,[12] Hu *et al*.,[17] and Fayed *et al*.[6]

Although the greatest BC in the patients with Class I and Class II skeletal patterns in the maxilla were different. No statistically significant difference in BC between the first and second premolars, between the second premolar and first molar, and between the first and second molars, at all heights of measurement, was observed.

In the maxilla, the BC gradually increased from the CEJ to the apex. This result is consistent with the study of Sawada *et al*.[3] However, our results are not consistent with those reported by Hu *et al*.[17] which reported that the buccal cortical bone thickness in maxilla did not change from the cervical line to the apex, the study of Baumgaertel and Hans[7] which reported that the buccal cortical bone thickness decreased at the 4-mm height, and then it increased again at the 6-mm height from the alveolar crest, and Fayed *et al*.[6] which reported that the buccal cortical bone thickness increased as the cuts moved apically from the CEJ to the 4-mm height, and then decreased again at the 6-mm height. Moreover, Baumgaertel and Hans[7] and Hu *et al*.[17] reported that buccal cortical bone thicknesses increased from the anterior to posterior regions, which were not consistent with our study, revealed that the buccal cortical bone thickness between the different interradicular areas were not different at the same vertical height.

In the mandible, the BC gradually increased from the CEJ to the apex and increased from the anterior to posterior regions. This result is consistent with the studies of Baumgaertel and Hans[7], Park and Cho[4], Monnerat *et al.,*[12] Hu *et al.,*[17] and Fayed *et al.*[6] Furthermore, this study also revealed that the buccal cortical bone thickness between the first and second molars was greatest. These results might be explained with the presence of the external oblique ridge in the mandible. This ridge extends obliquely upward direction across the buccal side of the mandible from the mental tubercle, lies below the mental foramen to the anterior border of the ramus. It is usually not prominent except in the molar area.[19]

5.2 Comparison between maxilla and mandible

In present study, the mesiodistal distances (MD) between the first and second premolars and between the first and second molars of the mandible were significantly larger than those of the maxilla. Similar results have been reported by with Park and Cho.[4] These results might be explained with the study of Chaimanee *et al.*[47] which revealed that the number of divergent tooth roots between the first and second premolars and between the first and second molars in mandible were greater than maxilla in both Class I and Class II skeletal patterns.

The buccolingual alveolar process widths (BL) between the first and second premolars, between the second premolar and the first molar, and between the first and second molars of the maxilla were greater than those of the mandible. This might be explained by differences in the root shape of the maxillary and mandibular posterior teeth. In the maxilla, the first premolars usually present with 2 roots while the first molars commonly have 3 roots. Additionally, these teeth often have root divergences in buccolingual dimension. On the other hand, the root form of mandibular posterior teeth has lesser buccolingual dimension when compared to those of the maxillary posterior teeth.[19]

The buccal cortical bone thicknesses (BC) at all interradicular areas and all heights of measurement of the mandible were greater than those of the maxilla. These results supported the studies of Baumgaertel and Hans[7], Park and Cho[4], Lim *et al*.,[48] and Hu *et al.*[17] This difference can be attributed to the transmission of masticatory forces to the basal bone through the teeth. The mandible was found to have greater BC than the maxilla, which could be explained by the difference in loads (compression, tension, and torsion) to which the maxilla and mandible are exposed. Functional loading dictates the osseous anatomy of opposing jaws. The mandible is subjected to substantial torsion and flexion caused by muscle pull and masticatory function. Thick and dense mandibular cortices are needed to resist the torsional and bending strain. The maxilla, however, is loaded predominately in compression. It has no major muscle attachments and transfers much of its load to the rest of the cranium. Because of the entirely different functional role, the maxilla is predominantly trabecular with thin cortices.[49]

5.3 Comparison between Class I and Class II skeletal patterns

In present study, there were significant differences between Class I and Class II skeletal patterns in the mesiodistal distance (MD) between the first and second premolars and between the first and second molars in the maxilla. In the maxilla, the MD of the patients with Class II skeletal pattern were greater than those of the patients with Class I skeletal pattern. In the mandible, our present study revealed that there was no significant difference between Class I and Class II skeletal patterns in the MD.

These results might be explained with the previous studies that evaluated the dentoalveolar compensatory changes in the axial inclination of the maxillary and mandibular teeth related to the variation in the anteroposterior jaw base relationships.[11, 32]

Chaimanee *et al*.[11] found that subjects with Class II skeletal patterns presented significantly greater interradicular distances and larger areas in the maxilla when compared with the subjects with skeletal Class III patterns. In contrast, in the mandible, the interradicular distances and areas in the subjects with skeletal Class III patterns were greater than those in the subjects with skeletal Class II patterns. A probable explanation for the results is the difference in dentoalveolar compensation observed between these groups. Subjects with skeletal Class II patterns presented with retrognathic mandibles and more upright maxillary incisors than did the subjects with skeletal Class III patterns; as a result, the subjects with skeletal Class II patterns presented with greater amounts of interradicular space in the maxillary arch. In contrast, subjects with skeletal Class III patterns presented with prognathic mandibles combined with excessively retroclined mandibular incisors; therefore, greater amounts of mandibular interradicular space were observed in these subjects than in the subjects with skeletal Class II patterns. Accordingly, it is possible to conclude that the availability of interradicular space was mainly influenced by the axial inclination of teeth due to dentoalveolar compensatory changes for variations in sagittal skeletal discrepancies. Greater dental inclination presented with less interradicular space, whereas more upright teeth presented with more interradicular space.

In addition, the axial inclination of teeth in Class I skeletal pattern presented with more mesially inclined of maxillary posterior teeth especially in the second molars, than did the subjects with skeletal Class II patterns.[47] Therefore, it was consistent with our results which revealed that the MD between the first and second premolars and between the first and second molars in the maxilla of the patients with Class I skeletal pattern presented with less MD than those of the patients with Class II skeletal pattern.

Kim *et al*.[32] investigated maxillary and mandibular sagittal growth differences and their effect on the changes in molar relationships from the early transitional dentition to the adult permanent dentition in three different groups. In group A, the mandible grew more than did the maxilla; in Group B, growth was about the same; and in group C, the maxilla grew more than did the mandible. They reported that the mesial shift of the maxillary molars was significantly different among the groups. In group C, where maxillary growth exceeded mandibular growth, the maxillary molar moved less mesially than did those in group A and group B. However, the amounts of mesial shift of the mandibular molars were not significantly different among the three groups. They also suggested that skeletal growth influences the physiologic mesial shift of all molar teeth, but that the maxillary first molars may be under greater influence than are the mandibular first molars.

These findings support with those of the present study, which found that the MD in the maxilla of the patients with Class II skeletal pattern were greater than those of the patients with Class I skeletal pattern. Moreover, they also support the present result which there was no significant difference in the MD in the mandible between the patients with Class I and Class II skeletal patterns.

The buccolingual alveolar process widths (BL) between the first and second premolars at 2 and 4-mm heights, and between the second premolar and the first molar at 2-mm height in the maxilla of the patients with Class I skeletal pattern were greater than those of the patients with Class II skeletal pattern. These results might be explained with the previous study regarding dentoalveolar compensatory mechanism.

Lux *et al*.[50] found that subjects with maxillary skeletal base widths were smallest in the Class II division 1 groups and largest in the Class I and good-occlusion groups. This study confirmed in Class II subjects a close association between anteroposterior malocclusion and the transverse dimensions both of the maxillary skeletal base and the maxillary dental arch. They mentioned that in a Class II relationship, the buccal overjet increases because of the posterior displacement of the mandible. Subsequently, a compensatory mechanism, i.e., a palatal movement of the maxillary posterior teeth, was assumed, which reduces buccal overjet, thus achieving a better buccolingual interdigitation. These findings support with those of the present study, which found that the BL between the first and second premolars and between the second premolar and the first molar at cervical regions in the maxilla of the patients with Class II skeletal pattern presented with less BL than those of the patients with Class I skeletal pattern.

The buccal cortical bone thicknesses (BC) between the first and second premolars and between the second premolar and the first molar, at 2-mm height, of the patients with Class I skeletal pattern were greater than those of the patients with Class II skeletal pattern. These results might be also explained with the study of Lux *et al*.[50] by dentoalveolar compensatory mechanism of Class II subjects which usually presented with large buccal overjet. The palatal movement of the maxillary posterior teeth to reduce buccal overjet, achieving a better buccolingual interdigitation, might reduce the cortical bone thickness in these areas.

5.4 Guideline for miniscrew implant placement in buccal interradicular areas

According to the results of present study, we has provided a guideline to assist the clinician for determination of sites for miniscrew implant placement at the buccal interradicular areas in Thai patients with either Class I or Class II skeletal pattern. The measurements of mesiodistal distance (MD), buccolingual alveolar process width (BL), and buccal cortical bone thickness (BC) as showed in Table 4.8, 4.9, and 4.10, suggested the guideline as the following criterions.

To prevent damage to the dental root, Poggio *et al.*[16] recommended a minimum clearance of 1.0 mm of alveolar bone around the miniscrew implant in order to provide periodontal health. Therefore, they recommended MD above 3.1 mm as safe for miniscrew implants with a maximum diameter of 1.2-1.3 mm. The miniscrew implant with a 1.5-mm diameter required at least 3.5 mm of space.

The BL can guide clinicians in choosing the appropriate miniscrew implant length and placement angulation.[12, 17] However, Poggio *et al.*[16] suggested that it should not be embedded miniscrew implant for more than 6.0 to 8.0 mm of BL because it might reach the narrowest interradicular space.

The BC is related to the stability of miniscrew implant. To achieve successful implantation, Motoyoshi *et al.*[27] suggested that the prepared site should be established in an area with a cortical bone thickness of more than 1.0 mm.

For vertical height, in maxillary molar region, the implantation of miniscrew implant more than 8.0 mm above the alveolar crest or 9.5 mm above the cementoenamel junction (CEJ) should be careful because of the presence of the maxillary sinus.[4, 16] The mental foramen is usually located between the apices of the mandibular premolars.[23] The caution is advised when placing miniscrew implant in this area, particularly starting at the height of 9.0 mm from the alveolar crest or 10.5 from CEJ. [4, 12] Therefore, it should be confirmed radiographically when we place the miniscrew implant in those areas.[17]

According to the measurements of MD in the Table 4.8, the site for placing 1.5-mm diameter of miniscrew implant was located between the second premolar and the first molar at 10-mm height for both Class I and Class II skeletal patterns in the maxilla. However, the clinician should be careful about maxillary sinus position. The site of between the second premolar and the first molar at 8-mm height, was suitable for 1.2-1.3-mm diameter of miniscrew implant for Class I skeletal pattern. In the mandible, the sites for placing 1.5-mm diameter of miniscrew implant were located between the first and second premolar at 6, 8, 10-mm heights, between the second premolar and the first molar at 10-mm height, and between the first and second molar at 8, 10-mm heights for both Class I and Class II skeletal patterns. However, the clinician should be careful about the mental foramen position between the first and second premolar. The sites of between the first and second premolars at 4-mm height, between the second premolar and the first molar at 8-mm height, and between the first and second molars at 6-mm height, were suitable for 1.2-1.3-mm diameter of miniscrew implant for both Class I and Class II skeletal patterns. In addition, all sites which met the criterion of MD, met the criterions of BL and BC, as showed in Table 4.9 and 4.10.

Miniscrew implants with larger diameters result in more increased implant-bone interface, resulting in improved primary stability.[2, 26, 44] Moreover, increased size of miniscrew implants prevents risks of miniscrew fracture during insertion or removal procedures.[44] Therefore 1.5-mm diameter of miniscrew implant is preferred to use in the buccal interradicular area if it has more availability of the interradicular space. However, if it has the limited interradicular space, the decreased diameter of 1.2-1.3 mm miniscrew implant facilitates insertion to sites with root proximity without the risk of root contact.[16]

Moreover, the attached gingiva, besides MD, BL, and BC, should be considered to minimize inflammation when placing a miniscrew implant. Therefore, the range of attached gingiva should be taken into consideration when placing miniscrew implant for orthodontic anchorage.[1, 48]

This present study used the 3-dimensional radiograph of CBCT. The advantages of CBCT are more accuracy and reliability when compare with the 2-dimensional conventional radiographs, such as the periapical radiograph and the lateral cephalogram. Since the 2-dimensional radiographic views impose further limitation, such as magnification, distortion, and superimposition of the structures.[14] Therefore, the measurements in buccolingual alveolar process width and cortical bone thickness were not possible. However, the effective dose detriment of CBCT is several to many times higher than 2-dimensional conventional radiographs, it is recommended in specific cases, in which 2-dimensional conventional radiographs cannot supply satisfactory diagnostic information, and its use has been substantiated to enhance diagnosis and treatment planning and in which its benefits exceed the risks from radiation dose.[14, 37, 40]

Limitations of this study were the small sample size and limited field of view (FOV) of the CBCT images. It might be preferable to increase sample size and use the CBCT that provide the FOV cover the whole skull, in order to the 3-dimensional cephalometric analysis can be included for a future study. Moreover, the attach gingiva should be also included in a future study for the better determination of choosing the sites for miniscrew implant placement.