ARAŞTIRMA/ORIGINAL ARTICLE

Gülhane Tıp Derg 2015;57: 221 - 228

doi: 10.5455/gulhane.183915

Evaluation of safe zones for miniscrew placement in Class II patients with different vertical skeletal patterns

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SUMMARY

The aim of this study was to compare interradicular space, buccolingual alveolar distance, and cortical bone thickness in skeletal Class II patients with long face and short face. The gender differences were also evaluated. 30 CBCT images obtained from patients with skeletal Class II malocclusion were divided into two groups according to patients' facial type. 15 patients (9 girls, 6 boys) with short face comprised SF group and 15 patients (6 girls, 9 boys) with long face comprised LF group. Interradicular space, buccolingual bone distance and cortical bone thickness between first and second molars, second premolar and first molar, first and second premolars were examined at four different depths from the alveolar crest. LF and SF groups and gender differences were compared with Mann-Whitney U test. Interradicular space between mandibular molars and mandibular premolars were smaller in LF group and cortical bone was thicker at some sites in SF group. Girls' buccolingual bone distance was lower than boys' in both maxilla and mandible. Mandibular interradicular space is shorter and cortical bone is thinner in long-faced skeletal Class II patients. Sex only affects the buccolingual bone distance and it is shorter in girls.

Key Words: *Angle Class II; Cone-Beam CT; miniscrew; orthodontic anchorage*

ÖZET

Farklı vertikal iskeletsel paterne sahip Sınıf II maloklüzyonlu hastalarda mini vida yerleşimi açısından güvenli bölgelerin incelenmesi

Bu çalışmanın amacı, uzun yüz ve kısa yüzlü iskeletsel Sınıf II maloklüzyonlu hastalarda, kökler arası mesafe, bukko-lingual alveoler mesafe ve kortikal kemik kalınlıklarının karşılaştırılmasıdır. Aynı zamanda cinsiyet farklılıkları da incelenmiştir. 30 iskeletsel Sınıf II maloklüzyonlu hastadan elde edilen Konik ışın demetli Bilgisayarlı Tomografi (KIBT) görüntüleri hastaların yüz tipine göre iki gruba ayrılmıştır. Kısa yüz grubu 9 kız 6 erkekten oluşurken, uzun yüz grubu ise 6 kız 9 erkekten oluşmaktadır. Ölçümler alt ve üst çene molar ve premolar dişler arasında ve alveol kret tepesinden itibaren 4 farklı derinlikte gerçekleştirilmiştir. Gruplar arası ölçüm farklılıkları Mann-Whitney U testi ile incelenmiştir. Alt çene molar ve premolar dişlerde kökler arası mesafe uzun yüz grubunda daha az iken, kortikal kemik kısa yüz grubunda daha incedir. Cinsiyet sadece bukko-lingual kemik kalınlığını etkilemektedir ve kızlarda her iki çenede de erkeklerden daha incedir.

Anahtar Kelimeler: *Angle Sınıf II; Konik ışın demetli BT; minivida; ortodontik ankraj*

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Makalenin Geliş Tarihi: 03.04.2015 • **Kabul Tarihi:** 26.05.2015 • **Çevrim İçi Basım Tarihi:** 25.10.2015

Introduction

Miniscrews have been frequently used in achieving maximum anchorage without the need of patient compliance. Safety and stability are the major factors that should be taken into consideration during miniscrew placement. Adequate interradicular space is required for safety while sufficient bone thickness and bone mineral density are needed for stability of the miniscrew (1, 2).

Anatomy and interproximity of the roots should be examined carefully before the placement of the miniscrew. Root proximity is important not only for root damage risk but also for the stability of the miniscrew. Kuroda et al. (3) showed that the proximity of a miniscrew to the root is the major risk factor for the failure of the screw, especially in the mandible. Poggio et al. (4) assumed that the minimum amount of bone between miniscrew and root of neighbor tooth must be at least 1 mm to prevent the root injury and to preserve the periodontal health. Schnelle et al. (5) reported the requirement of interradicular space larger than 3 mm for safe placement of miniscrew.

In several studies, safe zones in the interradicular spaces for miniscrew placement was assessed by using periapical radiographs (6), panoramic radiograph (5), computerized tomography (3, 7-9), and cone beam computerized tomography (4, 10-12). In most of these studies, the subjects had minor or no malocclusion and patients with skeletal discrepancies were not included in the assessment of availability of interradicular spaces. Only Chaimanee, et al. (6) evaluated the influence of different dentoskeletal patterns on availability of interradicular spaces by using periapical radiographs. The findings of this study revealed that in patients with skeletal Class II pattern maxillary interradicular spaces were greater than those in patients with skeletal Class III pattern. On the other hand, in patients with skeletal Class III pattern mandibular interradicular spaces were greater than those in patients with skeletal Class II. The results of this study emphasized that dentoskeletal pattern influences the root proximity. Neither of the studies considered the facial type while evaluating the interradicular spaces but it is a known fact that facial type affects the morphological features (13). In some previous studies, a relationship among facial type and cortical bone thickness of the mandibular body was evaluated and thicker buccal cortical bone was reported to be associated with smaller gonial angle and mandibular plane angle (14, 15).

In this study, it was intended to compare the interradicular spaces, buccolingual bone distance, and cortical bone thickness in long-faced and short-faced skeletal Class II patients by using cone beam computerized tomography (CBCT). The purpose of this study was to evaluate whether facial type and/or gender have to be taken into consideration while inserting a miniscrews to a patient with skeletal Class II malocclusions.

Material and methods

Data acquisition

This study was initiated after obtaining institutional approval from the Ethic Committee of our Academy. 30 patients (15 girls and 15 boys) participated in this study, and all signed informed consent forms. The participants were selected from among the patients referred to our hospital for orthodontic treatment.

During selection, patients' cephalometric analyses were evaluated to determine the sagittal and vertical position of the jaws. 30 patients (15 short-faced and 15 long-faced) with skeletal Class II malocclusion due to mandibular retrognathia (ANB>4°, SNB<78°) were included to the study. Short-faced patients' facial index (posterior facial height/anterior facial height ratio; SGo/NMe) was higher than 65%, mandibular plane angle was lower than 32°, and gonial angle was lower than 130°. Long-faced patients' facial height index was lower than 62%, mandibular plane angle was higher than 32°, and gonial angle was higher than 130°. All of the patients were in permanent dentition. Missing teeth, interdental caries lesion, and signs of periodontal disease were the exclusion criteria. The selected patients composed 2 groups according to their facial type; short-face group (SF) and long-face group (LF). There were 9 girls and 6 boys with a mean age of 15.2±3.77 years in SF group. LF group comprised 6 girls and 9 boys with a mean age of 15.4±3.36 years. To compare the gender differences, the patients were also grouped as boys (BG) (15 boys; mean age of 15±3.46 years) and girls (GG) (15 girls; mean age of 15.6±3.65 years).

CBCT images were acquired by using ILUMA (IMTEC, 3M Company, Ardmore, Oklahoma, USA) with a reconstructed slice thickness of 0.29 mm and a 728x728 matrix. The device had been operated at 120 kV and 0.15 mAs. A single 40-s high-resolution scan had been made with a pixel size set at 0.290 mm, and a 21.8x21.8 cm field of view. The raw images were exported into DICOM multifiles by using the ILUMA native software. The DICOM images were loaded into SimPlant Master Crystal v13 (Materialise Dental, Leuven, Belgium) for measurement. To establish uniform segmentation, automatic bone thresholding values in the SimPlant software (min.:500, max.:3071 HU) was used.

Measurements

Before measurements, axial images were set parallel to occlusal plane. Alveolar crests between maxillary second and first molar (U76), maxillary first molar and second premolar (U65), maxillary second and first premolars (U54), mandibular second and first molars (L76), mandibular first molar and second premolar (L65), and mandibular second and first premolars (L54) were determined by using coronal, axial, sagittal slices and 3D images. The vertical levels of measurements were established by using axial slice thickness. Since the axial slice thickness of the images was 0.29 mm, 10 axial slices apically apart from the alveolar crest was 2.9 mm (ex. 0.29mm x10=2.9mm). 5.8, 8.7, and 11.6 mm were determined by the same method and the measurements were performed on these axial slices (Figure 1). Mesiodistal interradicular space between the roots, buccolingual alveolar distance, and buccal and palatal cortical bone thickness were measured at four different depths from the alveolar crest; 2.9, 5.8, 8.7, and 11.6 mm. Measurements were made only for right side of each image.

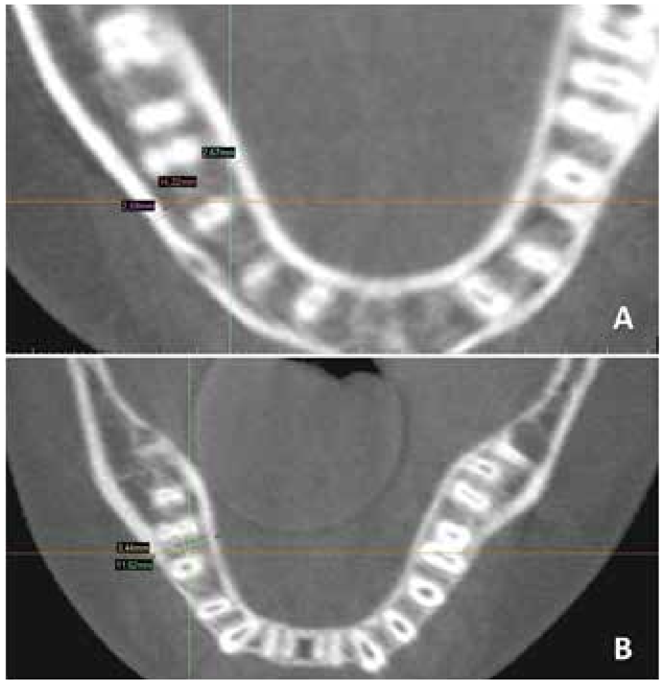

Figure 1: Measurements on the axial CT images of buccolingual distance, cortical bone thickness (A) and, interradicular space (B).

Statistics

The statistical analysis was performed by using SPSS (SPSS Inc, Chicago, Ill) statistical program. All descriptive statistics were given as mean and standard deviation. Mann Whitney U non-parametric test was used to evaluate the differences between LF group and SF group. Gender differences were also detected by the same test. The points and measurements of 15 patients were remeasured 1 month later, and reliability of the measurements was evaluated with combination of the intraclass correlation coefficient (ICC). The ICC for all of the measurements was >0.86.

Results

The interradicular space larger than 3mm is required to insert a miniscrew of 1.2mm in diameter. Safe zones in SF and LF groups are illustrated in Figures 2 and 3, respectively.

Differences of maxillary interradicular space between SF and LF were not statistically significant (p>0.05). Evaluation of the mandibular interradicular spaces revealed that all of the L76 measurements were higher in SF group (p<0.05). Similarly, measurements of 2.9mm and 5.8mm in L54 interradicular spaces were higher in SF group (p<0.05). However, L65 measurements were statistically insignificant (p>0.05) (Table I). Comparison of buccolingual bone distance between SF and

LF groups was insignificant for both maxillary and mandibular measurements (p>0.05) (Table II).

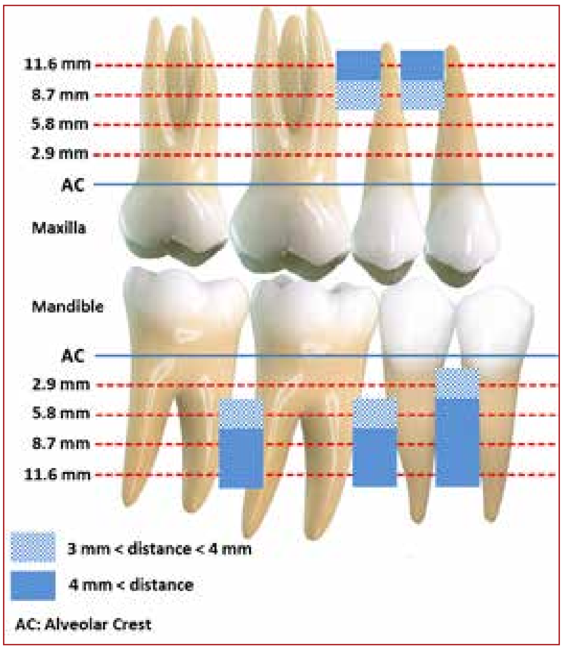

Figure 2. Illustration shows safe zones in SF group.

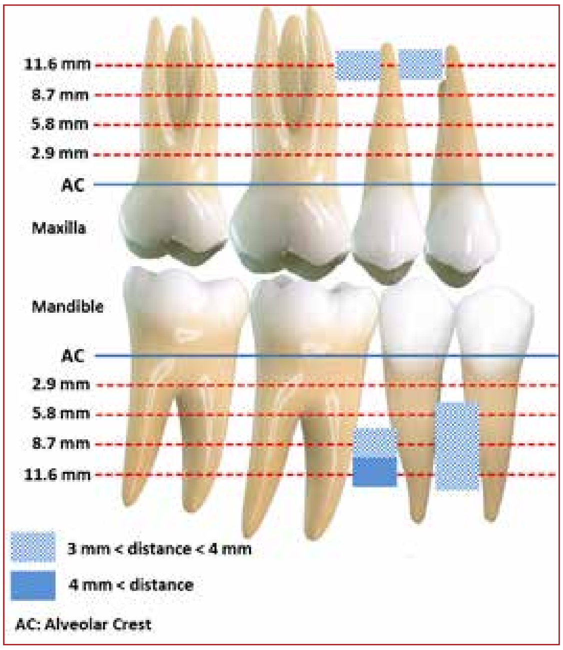

Figure 3. Illustration shows safe zones in LF group.

Table I. Comparison of interradicular space measurements between SF-LF and GG-BG groups.

		SF	LF		GG	BG	
		Mean ± SD	**Mean** ± SD	**P**	**Mean** ± SD	**Mean** ± SD	**P**
U76	**2.9 mm**	1.58 ± 0.79	1.76 ± 0.81		2.18 ± 0.77	1.16 ± 0.23	
	5.8 mm	1.27 ± 0.35	1.53 ± 0.62		1.57 ± 0.35	1.22 ± 0.59	
	8.7 mm	1.85 ± 0.38	1.85 ± 0.41		2.26 ± 1.13	1.44 ± 0.65	
	11.6 mm	2.16 ± 0.61	2.59 ± 1.67		2.98 ± 1.37	1.77 ± 0.71	
U65	**2.9 mm**	2.39 ± 0.86	2.23 ± 0.57		2.25 ± 0.91	2.37 ± 0.49	
	5.8 mm	2.86 ± 1.20	2.12 ± 0.66		2.27 ± 1.31	2.71 ± 0.62	
	8.7 mm	3.35 ± 1.32	2.39 ± 1.13		2.55 ± 1.59	3.20 ± 0.88	
	11.6 mm	4.25 ± 1.36	3.58 ± 0.85		3.66 ± 1.33	4.17 ± 0.85	
U54	**2.9 mm**	2.38 ± 0.62	2.21 ± 0.48		2.41 ± 0.59	2.18 ± 0.51	
	5.8 mm	2.73 ± 0.70	2.30 ± 0.53		2.65 ± 0.75	2.38 ± 0.53	
	8.7 mm	3.25 ± 1.30	2.45 ± 1.09		2.82 ± 1.66	2.88 ± 0.71	
	11.6 mm	4.36 ± 1.38	3.09 ± 0.91		3.50 ± 1.80	3.95 ± 0.61	
L76	**2.9 mm**	2.54 ± 0.96	1.84 ± 0.60		2.67 ± 0.96	1.72 ± 0.32	
	5.8 mm	3.23 ± 0.69	1.94 ± 0.43	*	3.03 ± 0.80	2.15 ± 0.76	
	8.7 mm	4.27 ± 1.41	2.00 ± 0.67	*	3.96 ± 1.71	2.31 ± 1.02	
	11.6 mm	4.42 ± 0.86	2.88 ± 0.99	*	4.15 ± 0.86	3.15 ± 1.36	
L65	**2.9 mm**	2.42 ± 0.67	1.97 ± 0.87		2.17 ± 0.82	2.22 ± 0.81	
	5.8 mm	3.50 ± 0.26	2.78 ± 1.27		2.62 ± 1.13	3.66 ± 0.24	*
	8.7 mm	4.27 ± 0.73	3.36 ± 1.86		3.27 ± 1.73	4.36 ± 0.89	
	11.6 mm	5.27 ± 1.15	4.40 ± 1.72		4.53 ± 1.92	5.14 ± 0.90	
L54	**2.9 mm**	3.18 ± 0.18	2.33 ± 0.57	*	2.70 ± 0.70	2.81 ± 0.56	
	5.8 mm	4.40 ± 0.24	3.06 ± 1.21	*	3.68 ± 1.44	3.78 ± 0.75	
	8.7 mm	5.41 ± 0.73	3.35 ± 1.67		4.23 ± 2.01	4.54 ± 1.37	
	11.6 mm	5.71 ± 0.95	3.96 ± 1.93		4.93 ± 1.97	4.74 ± 1.62	

SD; standard deviation, SF; Short Face, LF; Long Face, GG; Girls Group, BG; Boys Group. * P<0.05; ** P<0.01; *** P<0.001

Table II. Comparison of buccolingual bone distance measurements between SF-LF and GG-BG groups.

		SF	LF		GG	BG	
		Mean ± SD	Mean ± SD	P	Mean ± SD	Mean ± SD	P
U76	2.9 mm	14.34 ± 2.24	14.80 ± 1.17		13.46 ± 0.97	15.67 ± 1.59	*
	5.8 mm	15.04 ± 2.38	15.91 ± 0.60		14.50 ± 1.75	16.45 ± 1.02	
	8.7 mm	16.15 ± 2.62	16.39 ± 0.67		15.07 ± 1.57	17.47 ± 1.12	*
	11.6 mm	17.86 ± 2.91	18.69 ± 2.15		16.67 ± 1.54	19.88 ± 2.16	*
U65	2.9 mm	12.93 ± 1.29	13.72 ± 1.27		12.42 ± 1.04	14.23 ± 0.74	**
	5.8 mm	13.64 ± 1.50	14.70 ± 0.61		13.46 ± 1.25	14.88 ± 0.72	
	8.7 mm	15.05 ± 1.84	14.53 ± 1.60		13.72 ± 1.76	15.86 ± 0.39	*
	11.6 mm	14.59 ± 2.35	15.83 ± 2.42		13.94 ± 1.34	16.48 ± 2.54	
U54	2.9 mm	10.93 ± 1.51	11.85 ± 1.45		10.51 ± 1.08	12.27 ± 1.34	
	5.8 mm	11.78 ± 1.38	12.61 ± 1.23		11.26 ± 1.10	13.13 ± 0.67	*
	8.7 mm	11.83 ± 1.28	12.40 ± 1.63		10.98 ± 0.88	13.26 ± 0.68	**
	11.6 mm	12.80 ± 1.18	12.11 ± 1.21		12.05 ± 1.92	11.86 ± 0.97	
L76	2.9 mm	12.46 ± 1.84	13.63 ± 2.69		11.44 ± 0.90	14.65 ± 2.05	*
	5.8 mm	14.47 ± 2.89	14.95 ± 2.56		13.56 ± 2.05	15.85 ± 2.21	
	8.7 mm	14.58 ± 2.19	15.50 ± 1.20		14.20 ± 1.45	15.89 ± 1.69	
	11.6 mm	13.39 ± 2.34	14.36 ± 1.87		13.19 ± 2.05	14.56 ± 1.45	
L65	2.9 mm	10.46 ± 1.15	11.67 ± 1.38		10.17 ± 0.83	11.95 ± 1.21	*
	5.8 mm	10.79 ± 1.26	11.92 ± 1.85		10.36 ± 0.82	12.35 ± 1.63	
	8.7 mm	11.80 ± 1.69	12.31 ± 2.23		10.98 ± 1.37	13.13 ± 1.80	
	11.6 mm	12.34 ± 1.50	12.39 ± 2.53		11.60 ± 1.38	13.14 ± 2.29	
L54	2.9 mm	8.27 ± 0.51	9.47 ± 1.04		8.22 ± 0.50	9.51 ± 0.98	*
	5.8 mm	8.73 ± 0.92	9.74 ± 1.82		8.21 ± 0.56	10.26 ± 1.35	*
	8.7 mm	9.77 ± 1.12	9.85 ± 2.20		8.69 ± 1.02	10.94 ± 1.37	*
	11.6 mm	10.24 ± 1.19	9.98 ± 2.48		9.03 ± 1.58	11.19 ± 1.50	

SD; standard deviation, SF; Short Face, LF; Long Face, GG; Girls Group, BG; Boys Group. * P<0.05; ** P<0.01; *** P<0.001

When the maxillary cortical bone thickness was compared, it was found that buccal and palatal cortical bone in U76 measurements at 2.9mm (p<0.05 and p<0.01, respectively) and palatal cortical bone at 5.8mm was thicker (p<0.05) in SF group. In U65, thicker palatal cortical bone at 5.8mm (p<0.05) was also determined in SF group. Evaluation of cortical bone in U54 revealed that at 2.9mm buccal and palatal sides (p<0.05) and at 5.8mm buccal side (p<0.01) were thicker in SF group. When the mandibular cortical bone thickness was compared, statistically significant differences were found only in L65. At 2.9mm buccal and lingual sides (p<0.05 and p<0.01, respectively) and at 5.8mm and 8.7mm lingual sides (p<0.05) were thicker in SF group (Tables III and IV).

When the measurements were compared according to the gender, it was determined that the interradicular space of L65 was higher in BG at 5.8 mm (p<0.05) (Table I). Evaluation of the maxillary buccolingual distance revealed that measurements of U76 at 2.9mm, 8.7mm, and 11.6mm were higher in BG. Similar findings were also found in U65 at 2.9mm and 8.7mm (p<0.01 and p<0.05, respectively), and in U54 at 5.8mm and 8.7mm (p<0.05 and p<0.01, respectively). In the mandible, buccolingual distance in L76, L65, and L54 at 2.9mm were higher BG (p<0.05). Similar finding was also determined in L54 at 5.8mm and 8.7mm (p<0.05) (Table II).

Comparison of cortical bone thickness between the genders revealed statistically insignificant differences (p>0.05) (Tables III and IV). Figures 4 and 5 demonstrate the mean values of interproximal root distance, buccolingual bone distance, and cortical bone thickness in maxilla and mandible according to facial type and gender.

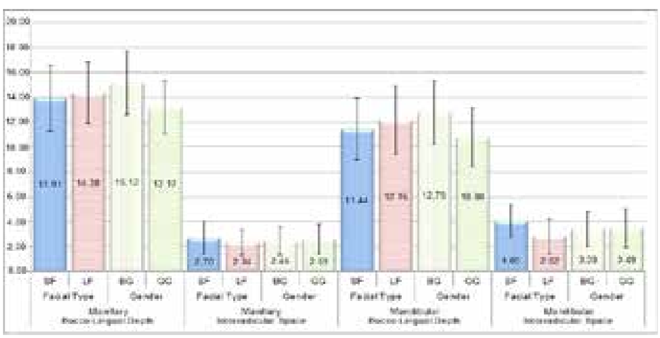

Figure 4. The mean values of buccolingual distance, interradicular space in maxilla and mandible according to facial type and gender. SF: Short Face, LF: Long Face, BG: Boys Group, GG: Girls Group.

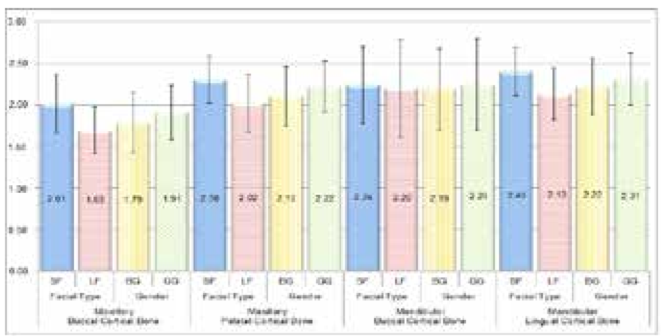

Figure 5. The mean values of cortical bone thickness in maxilla, mandible according to facial type and gender. SF: Short Face, LF: Long Face, BG: Boys Group, GG: Girls Group.

Discussion

This study was carried out with the CBCT images of orthodontic patients with Class II malocclusion. Only the right sides of the images were evaluated since Monnerat et al. (9) found no significant differences between right and left sides of mandible in term of CT measurement means. It was also previously shown that there were no differences in cortical thickness between the sides of the jaws (16-18). In some previous studies, periapical radiographs (6) and panoramic radiographs (5) were used to determine the safe zones to place miniscrews. However, these techniques have some disadvantages like magnification and distortion. CT images have also been used despite high radiation dose (7-9). In our study, CBCT images were used since two-dimensional representations of three-dimensional anatomic structures could not provide accurate and reliable results (19). Kuroda et al. (3), Park and Cho (2), Poggio et al. (4), Kim et al. (10) also used CBCT in their studies. In our study, not only the effects of sagittal and vertical discrepancies but also effects of sex on interradicular space, buccolingual bone distance, and cortical bone thickness were evaluated. In other words, the subjects with Class II malocclusion were evaluated from two aspects; according to facial type and gender.

Table III. Comparison of buccal cortical bone thickness measurements between SF-LF and GG-BG groups.

		SF	LF		GG	BG	
		Mean ± SD	**Mean** ± SD	**P**	**Mean** ± SD	**Mean** ± SD	**P**
U76	**2.9 mm**	2.23 ± 0.60	1.40 ± 0.30	*	1.72 ± 0.68	1.91 ± 0.63	
	5.8 mm	1.93 ± 0.38	1.67 ± 0.33		1.88 ± 0.36	1.72 ± 0.39	
	8.7 mm	2.08 ± 0.26	1.81 ± 0.51		1.85 ± 0.21	2.05 ± 0.55	
	11.6 mm	2.16 ± 0.14	1.97 ± 0.43		1.99 ± 0.18	2.13 ± 0.43	
U65	**2.9 mm**	1.99 ± 0.37	1.70 ± 0.10		1.87 ± 0.28	1.81 ± 0.35	
	5.8 mm	2.13 ± 0.38	1.68 ± 0.08		1.84 ± 0.16	1.98 ± 0.49	
	8.7 mm	2.00 ± 0.48	1.64 ± 0.13		1.73 ± 0.14	1.91 ± 0.54	
	11.6 mm	2.04 ± 0.46	1.69 ± 0.18		1.80 ± 0.34	1.93 ± 0.44	
U54	**2.9 mm**	1.93 ± 0.19	1.55 ± 0.23	*	1.69 ± 0.39	1.80 ± 0.14	
	5.8 mm	2.04 ± 0.23	1.58 ± 0.12	*	1.80 ± 0.40	1.82 ± 0.21	
	8.7 mm	1.74 ± 0.17	1.72 ± 0.22		1.71 ± 0.08	1.76 ± 0.27	
	11.6 mm	1.82 ± 0.28	1.84 ± 0.25		1.79 ± 0.14	1.87 ± 0.34	
L76	**2.9 mm**	2.49 ± 0.43	2.38 ± 0.62		2.24 ± 0.36	2.63 ± 0.60	
	5.8 mm	2.66 ± 0.41	3.00 ± 0.70		2.98 ± 0.65	2.68 ± 0.50	
	8.7 mm	3.00 ± 0.30	2.93 ± 0.41		3.13 ± 0.33	2.81 ± 0.29	
	11.6 mm	2.71 ± 0.41	2.60 ± 0.45		2.86 ± 0.32	2.44 ± 0.40	
L65	**2.9 mm**	2.00 ± 0.28	1.71 ± 0.04	*	1.91 ± 0.34	1.80 ± 0.10	
	5.8 mm	2.04 ± 0.13	2.03 ± 0.24		2.07 ± 0.18	2.00 ± 0.19	
	8.7 mm	2.10 ± 0.16	2.30 ± 0.46		2.25 ± 0.41	2.16 ± 0.30	
	11.6 mm	2.42 ± 0.17	2.29 ± 0.39		2.42 ± 0.26	2.29 ± 0.33	
L54	**2.9 mm**	1.77 ± 0.24	1.53 ± 0.17		1.66 ± 0.15	1.64 ± 0.31	
	5.8 mm	1.83 ± 0.12	1.70 ± 0.17		1.71 ± 0.18	1.83 ± 0.10	
	8.7 mm	1.84 ± 0.09	1.84 ± 0.13		1.85 ± 0.09	1.83 ± 0.13	
	11.6 mm	1.97 ± 0.21	2.03 ± 0.27		2.03 ± 0.21	1.97 ± 0.27	

SD; standard deviation, SF; Short Face, LF; Long Face, GG; Girls Group, BG; Boys Group. * $P<0.05$; ** $P<0.01$; *** $P<0.001$

Table IV. Comparison of palatal/lingual cortical bone thickness measurements between SF-LF and GG-BG groups.

		SF	LF		GG	BG	
		Mean ± SD	Mean ± SD	P	Mean ± SD	Mean ± SD	P
U76	2.9 mm	2.24 ± 0.26	1.78 ± 0.21	**	1.93 ± 0.40	2.08 ± 0.27	
	5.8 mm	2.33 ± 0.23	1.80 ± 0.34	*	2.12 ± 0.36	2.01 ± 0.46	
	8.7 mm	2.28 ± 0.25	1.91 ± 0.47		2.08 ± 0.25	2.11 ± 0.56	
	11.6 mm	2.32 ± 0.26	1.95 ± 0.36		2.22 ± 0.35	2.05 ± 0.37	
U65	2.9 mm	2.22 ± 0.32	1.96 ± 0.29		2.14 ± 0.28	2.04 ± 0.37	
	5.8 mm	2.63 ± 0.25	2.11 ± 0.18	*	2.27 ± 0.29	2.48 ± 0.39	
	8.7 mm	2.50 ± 0.33	2.19 ± 0.29		2.31 ± 0.21	2.38 ± 0.45	
	11.6 mm	2.50 ± 0.28	2.23 ± 0.56		2.35 ± 0.43	2.38 ± 0.50	
U54	2.9 mm	2.17 ± 0.10	1.84 ± 0.26	*	2.04 ± 0.28	1.97 ± 0.25	
	5.8 mm	2.20 ± 0.12	2.11 ± 0.20		2.09 ± 0.15	2.22 ± 0.16	
	8.7 mm	2.07 ± 0.30	2.18 ± 0.27		2.23 ± 0.34	2.02 ± 0.16	
	11.6 mm	2.16 ± 0.20	2.20 ± 0.27		2.16 ± 0.28	2.20 ± 0.19	
L76	2.9 mm	2.39 ± 0.25	2.09 ± 0.25		2.27 ± 0.35	2.21 ± 0.23	
	5.8 mm	2.53 ± 0.37	2.45 ± 0.17		2.44 ± 0.17	2.54 ± 0.36	
	8.7 mm	2.47 ± 0.19	2.55 ± 0.16		2.60 ± 0.14	2.42 ± 0.15	
	11.6 mm	2.54 ± 0.48	2.28 ± 0.16		2.57 ± 0.38	2.25 ± 0.31	
L65	2.9 mm	2.32 ± 0.17	1.73 ± 0.13	**	2.01 ± 0.32	2.04 ± 0.40	
	5.8 mm	2.35 ± 0.25	1.89 ± 0.22	*	2.13 ± 0.18	2.11 ± 0.46	
	8.7 mm	2.50 ± 0.19	2.07 ± 0.31	*	2.24 ± 0.23	2.34 ± 0.44	
	11.6 mm	2.57 ± 0.24	2.40 ± 0.20		2.44 ± 0.27	2.53 ± 0.20	
L54	2.9 mm	2.07 ± 0.12	1.81 ± 0.29		1.97 ± 0.24	1.91 ± 0.27	
	5.8 mm	2.24 ± 0.16	2.01 ± 0.26		2.20 ± 0.18	2.05 ± 0.28	
	8.7 mm	2.38 ± 0.39	2.16 ± 0.10		2.24 ± 0.32	2.30 ± 0.30	
	11.6 mm	2.46 ± 0.27	2.13 ± 0.16		2.26 ± 0.35	2.33 ± 0.22	

SD; standard deviation, SF; Short Face, LF; Long Face, GG; Girls Group, BG; Boys Group. * $P<0.05$; ** $P<0.01$; *** $P<0.001$

Assessment of interradicular space is important because root proximity is a critical factor for the safety of the teeth and stability of the miniscrew. Kuroda et al. (3) reported a correlation between the success rate and the proximity of the miniscrew to the roots because of the occlusal forces transmitted to the screws through the root of the tooth in proximity. Additionally, the authors reported that contact of the miniscrew with the adjacent tooth inhibited remodeling around the miniscrew and promoted failure. A minimum distance of 1 mm is required around the miniscrew in the alveolar bone. Monnerat et al. (9) suggested that any area above 3.5 mm could be considered perfectly safe; between 3 and 3.5 mm the risk was average; and below 3 mm, the risk was high for the placement of mini-implants up to 1.5 mm in diameter. In our study, the subjects with skeletal Class II malocclusion were grouped according to their facial type and it was found that safe interradicular spaces (3 mm and above) were more in SF group (Fig. 4,5). Comparison of SF and LF groups revealed that facial type affected the root proximity especially in the mandible. In SF group the interradicular spaces between mandibular first and second molars at 5.8, 8.7 and 11.6 mm; and between mandibular first and second premolars at 2.9 and 5.8 mm were more than it was in LF group. Subjects with long face have hyperdivergent growth pattern and subjects with short face have hypodivergent growth pattern so facial characteristics are different from each other. Microgenia, narrow and long symphysis, narrow and high palate, short ramus, over erupted incisors despite an open-bite tendency, tooth-size/jaw-size discrepancy caused by large teeth, and weak temporal muscles are some of the characteristics features of long face syndrome (20). On the other hand, macrogenia, flat palatal vault with a wide dental arch and small teeth, crowded mandibular incisors as a result of deep-bite or spaced dentition, long ramus, heavy masseter muscles with vertical pull and strong temporal muscles are some of the commonly observed characteristics in patients with short face. In our study, the roots of first and second molars, and the roots of first and second premolars were closer to each other in long-faced subjects probably due to the small mandible size. Nevertheless, gender had very little effect on the interradicular distance and in boys it was higher than girls only between mandibular first molar and second premolar at 5.8 mm. Lim et al. (8), Kim et al. (10), and Fayed et al. (11) found no statistically significant difference between sexes in the interradicular measurements.

Buccolingual distance of alveolar bone is important to determine the appropriate length of the miniscrew and placement angulation. The results of this study showed that facial type did not have any effect on the buccolingual distance. However, evaluation of the differences between sexes revealed that girls' buccolingual distance was lower than boys. It may be appropriate to use shorter implants in girls or to place the miniscrew with a higher angulation. Similar to our results, Fayed et al. (11) reported that males had higher buccolingual distance at posterior sides of both maxilla and mandible.

Cortical bone thickness is a critical factor for the stability of the miniscrew. Thicker cortical bone provides more successful anchoring for the miniscrew. Dalstra et al. (21) reported that thickness of cortical bone affected the stability of the screw since the major part of the load transfer occurs in the cortical shell. Miyawaki et al. (22) who evaluated the factors affecting the stability of titanium screws concluded that high mandibular plane angle and thin cortical bone were associated with the mobility of the screw placed in the posterior region for orthodontic anchorage. Similarly, Masumoto et al. (15) and Tsunori et al. (14) also reported that thicker cortical bone was associated with smaller gonial angle and mandibular plane angle. The results of our study also supported the previous findings and showed that cortical bone thickness was related with facial type. Patients with short face had thicker cortical bone in the comparison with long-faced patients. In other words, failure risk of miniscrew may be more in patients with long face because of thinner cortical bone. The cortical bone thickness of posterior region was reported to be influenced by masticatory function (15). Varrela (23) showed a correlation between muscle activity during maximal clenching and small gonial angle. Craniofacial morphology of the patients with weak masticatory function is characterized by a large angle between the mandibular and palatal planes. Bite force is related with facial type and it is stronger in short faced patients (24-26). In our study, thicker cortical bone observed in SF group depended on the stronger masticatory function. The results of our study showed that gender did not affect the cortical bone thickness. Similar to our findings Lim et al. (8) reported that cortical bone thickness did not depend on sex. However, the result of Fayed et al. (11) who found higher cortical bone thickness in males especially in the maxilla was conflicting with our finding.

Conclusion

The findings of this study revealed that:

- Facial type affects the mandibular interradicular space and cortical bone thickness while gender affects the buccolingual distance of the alveolar bone in subjects with skeletal Class II malocclusion.
- In long-faced skeletal Class II subjects, interradicular space between mandibular first and second molars and between mandibular first and second premolars is shorter than short-faced patients.
- In long-faced skeletal Class II subjects' mandibular and maxillary cortical bone is thinner than short-faced patients.
- Safety and stability of miniscrew may be critical in long-faced skeletal Class II subjects because of the thinner cortical bone and shorter interradicular space.
- Buccolingual distance of the alveolar bone is shorter in females.

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