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Palatal bone thickness compared with cone-beam computed tomography in adolescents and adults for mini-implant placement

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Introduction: The purpose of this study was to compare the bone thickness of the palatal areas in early and late mixed and early permanent dentitions according to dental age. **Methods:** Cone-beam computed tomography scans of 118 subjects were selected and divided into 38 early mixed (8.03 ± 0.93 years), 40 late mixed (11.51 ± 0.92 years), and 40 permanent (20.92 ± 1.17 years) dentition subjects. The measurements of palatal bone thickness were made at 49 sites by using InVivoDental5.0 software (Anatomage, San Jose, Calif). Repeated measures analysis of variance was used to analyze intragroup and intergroup differences as well as sex dimorphism. **Results:** There was significantly lower bone thickness in the early mixed dentition group than in the 2 other groups ($P < 0.001$). Bone thickness was higher in the anterior region than in the middle and posterior regions ($P < 0.001$). Also, significant differences were found among the midline, medial, and lateral areas of the palate. **Conclusions:** Palatal bone thicknesses were significantly lower in the early mixed dentition group than in both the late mixed and permanent dentition groups. These findings might be helpful for clinicians to enhance the successful use of temporary anchorage devices in the palate. (Am J Orthod Dentofacial Orthop 2012;142:207-12)

New treatment paradigms have reduced the importance of patient compliance as a significant factor in the treatment of adolescents.[1] Temporary skeletal anchorage devices are frequently placed buccally and palatally to achieve several types of tooth movements. However, buccal placement of temporary skeletal anchorage devices in the mixed dentition is difficult because of narrow interradicular spaces and erupting permanent teeth.[2]

Several authors have placed temporary skeletal anchorage devices in the palate to produce various desired movements. The nontooth-bearing area of the palate is often selected for placement of temporary skeletal anchorage devices because of sufficient bone quality and less possibility of root damage to the adjacent teeth. In addition, this anchorage is highly successful without hindering tooth movement during treatment.[3,4]

Nevertheless, in adolescents, the incomplete obliteration of the midpalatal suture might increase placement risks.[4-9] Recently, Kook et al[10] reported the placement of a palatal plate for molar distalization in patients with late mixed and permanent dentitions. This plate was designed to be placed in the paramedian palatal area to prevent interference with the growth of the midpalatal suture.

The palate was reported to be a reliable and stable placement site for temporary skeletal anchorage devices because it offers both sufficient quality and quantity of bone.[11-18] In particular, palatal bone thickness was considered to be a key factor for the success of temporary skeletal anchorage devices.[11,13,14,17] King et al[14] evaluated the palatal bone volume for placement

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Table. Comparison with repeated measures analysis of variance of palatal bone thickness among subjects with early and late mixed and permanent dentitions (in millimeters)

	Early mixed dentition (EMD) (n = 38)							*Late mixed dentition (LMD) (n = 40)*						
	Midline		*Medial*		*Lateral*			*Midline*		*Medial*		*Lateral*		
	Mean	*SE*	*Mean*	*SE*	*Mean*	*SE*	P *value**	*Mean*	*SE*	*Mean*	*SE*	*Mean*	*SE*	P *value**
Anterior	4.44	0.15	7.02	0.41	7.42	0.35	<0.001	4.87	0.14	8.87	0.37	9.52	0.32	<0.001
Middle	5.40	0.25	4.08	0.23	3.21	0.24		5.93	0.22	4.48	0.21	3.44	0.22	
Posterior	5.62	0.28	3.76	0.24	2.27	0.19		6.50	0.26	4.47	0.22	2.65	0.17	
P value*			<0.001							<0.001				

Midline, The area at the midpalatal suture; *medial*, the area from lines 2 and 4 mm laterally to the midpalatal suture; *lateral*, at line 6 mm lateral to the midpalatal suture; *anterior*, the areas from lines 0, 4, and 8 mm posterior to the incisive foramen; *middle*, the areas from 12 and 16 mm posterior to the incisive foramen; *posterior*, the areas from 20 and 24 mm posterior to the incisive foramen.
*Significance of the effect of the anteroposterior position in the early and late mixed and permanent dentition groups; †significance of the effect of the mediolateral position in the early and late mixed and permanent dentition groups; ‡significance of the comparison of the 3 groups.

of implants in adolescents using computed tomography. However, their sample's mean age was 14 years. Gracco et al[19] also compared bone thickness in adults to that of adolescents using cone-beam computed tomography and reported insignificant differences. Nevertheless, previous studies did not include subjects in the early mixed dentition.

Therefore, the purpose of this study was to compare the bone thickness of various palatal areas among subjects with early and late mixed dentition and permanent dentition by using cone-beam computed tomography to guide clinicians in selecting the most appropriate sites for temporary skeletal anchorage devices in the palate, especially in adolescents.

MATERIAL AND METHODS

The sample consisted of cone-beam computed tomography scans of 118 randomly selected patients who had visited the dental department of Seoul St. Mary's Hospital, The Catholic University of Korea. The settings were 120 kVp; 47.74 mA; field of view, 17 × 23 cm; exposure time, 40 seconds; we used an i-CAT scanner (Imaging Sciences International, Hatfield, Pa) with a spatial resolution of 10 line pairs per centimeter and an isotropic 0.4-mm voxel size. Group 1 included 38 subjects with early mixed dentition (13 girls, 25 boys; mean age, 8.03 ± 0.93 years), group 2 contained 40 subjects with late mixed dentition (21 girls, 19 boys; mean age,11.51 ± 0.92 years), and group 3 included 40 subjects with permanent dentition (20 women, 20 men; mean age, 20.92 ± 1.17 years). The grouping of the early and late mixed dentitions was based on the stage of dental development as reported by Björk et al.[20] The exclusion criteria included patients with general diseases that might affect bone quality and quantity, pathologic lesions, or craniofacial deformities in the maxillary and palatal areas. The institutional review board of The Catholic University of Korea reviewed and approved the study. Informed consents were obtained from all patients or their parents or guardians.

InVivoDental5.0 (Anatomage, San Jose, Calif), a volumetric imaging software, was used to measure bone thickness (window width, 5000 HU; window level, 1500 HU). The palatal bone thickness was measured at 0, 2, 4, and 6 mm lateral to the midpalatal suture on the coronal plane and from 0 to 24 mm at 4-mm intervals posterior to the level of the posterior margin of the incisive foramen on the sagittal plane. The measurements were made at the intersection points of the reference lines over a set of equally sized grids formed by 49 sites covering 288 mm^2.

In the sagittal view of InVivoDental5.0, the slice thickness was set to 0.5 mm, and then the image was rotated so that the posterior rim of the incisive foramen and the posterior nasal spine were on the same horizontal plane. Then, the thickness of the palatal bone was measured perpendicular to the horizontal plane at each designated point (Figs 1 and 2).

To test intraexaminer reliability, 5 randomly selected scans from each group were measured 2 weeks later by the same person (T.V.).

Statistical analysis

The data were analyzed by using SPSS (version 16.0.2.1; SPSS, Chicago, Ill). An intraclass correlation coefficient test was performed to assess intraexaminer reliability. Because there were no significant statistical differences between the left and right side measurements, only data from the right side were used for further analysis.

Table. Continued

Permanent dentition (PD) (n = 40)								
Midline		Medial		Lateral				
Mean	SE	Mean	SE	Mean	SE	P value†	P value‡	Pairwise comparison
4.66	0.14	8.83	0.37	9.24	0.32	<0.001	0.007	EMD vs LMD: 0.006
5.50	0.22	4.36	0.21	3.76	0.22			EMD vs PD: 0.06
5.91	0.25	4.00	0.21	2.45	0.17			LMD vs PD: 1
		<0.001						

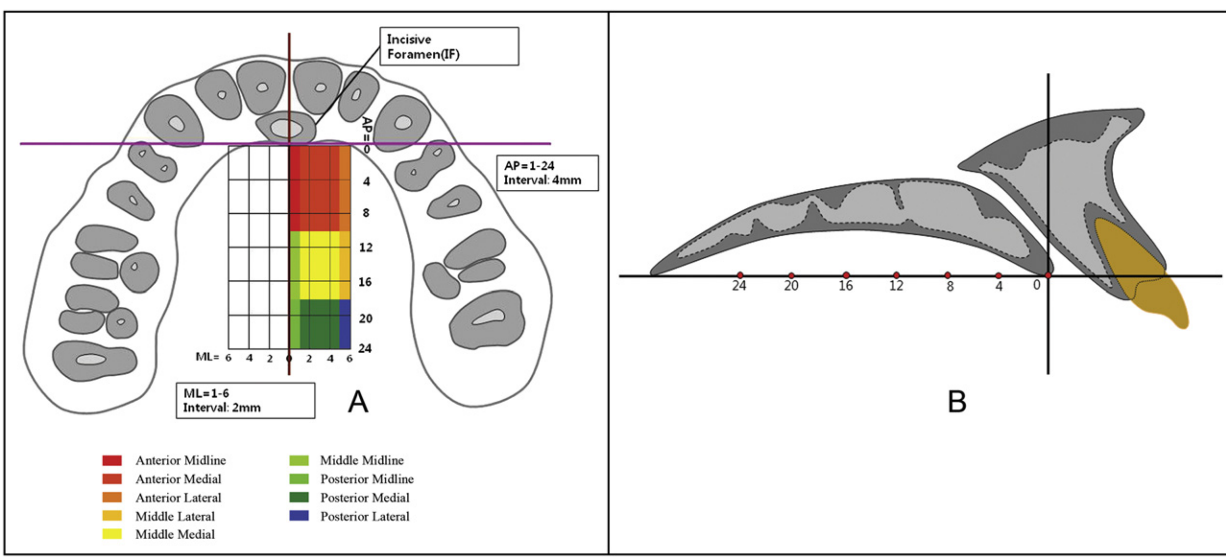

Fig 1. Reference lines for measuring palatal bone thickness: **A,** occlusal view; **B,** sagittal view.

The measured bone thickness values were averaged for the subjects, maintaining their groupings with these 3 designated mediolateral areas: the midline area at the midpalatal suture, the medial area at the reference lines 2 and 4 mm lateral to the midpalatal suture, and the lateral area at the line 6 mm lateral to the midpalatal suture.

Likewise, there were 3 anteroposterior areas: the anterior area at lines 0, 4, and 8 mm; the middle area at lines 12 and 16 mm; and the posterior area at 20 and 24 mm posterior to the incisive foramen. Repeated measures analysis of variance was used to test for differences in bone thickness. Between-subjects factors were sex and the 3 groups. Within-subjects variables were the 3 mediolateral areas and the 3 anteroposterior areas. Statistical significance was determined at $P < 0.05$.

RESULTS

The results of the intraclass correlation coefficient test showed high reliability between the 2 assessments (>0.8).

The Table shows bone thicknesses at the various palatal areas in the 3 groups. There was significantly lower bone thickness in the early mixed dentition group than in the 2 other groups ($P < 0.001$). However, no significant differences were found between the late mixed and permanent dentition groups. The sex comparison showed no sexual dimorphism ($P = 0.83$).

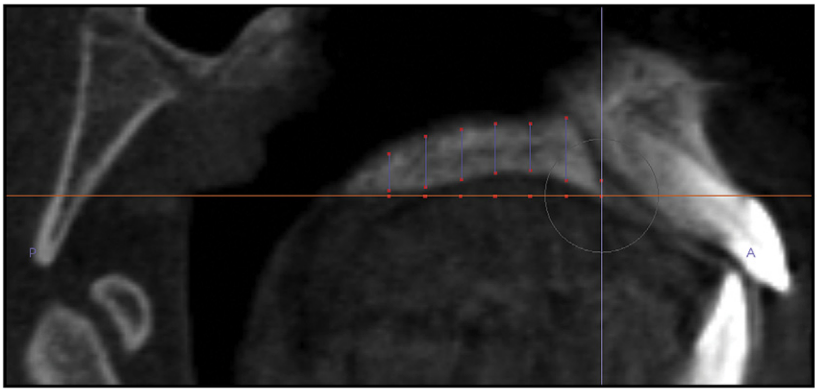

Fig 2. Sagittal section through the palate, with bone thickness measurements every 4 mm.

Bone thickness was significantly different among the 3 anteroposterior areas of the palate, with higher values in the anterior region and lower values in the posterior region (P <0.001), except for the midline area. Also, significant differences were found among the midline, medial, and lateral areas of the palate (P <0.001). The total lateral area demonstrated significantly less bone thickness than did the medial and midline areas (P <0.001), which showed no significant difference (P = 0.85).

However, there was a significant interaction between the anteroposterior and mediolateral areas (P <0.001), and among the anteroposterior and mediolateral areas and the 3 groups (P = 0.001) (Fig 3, Table).

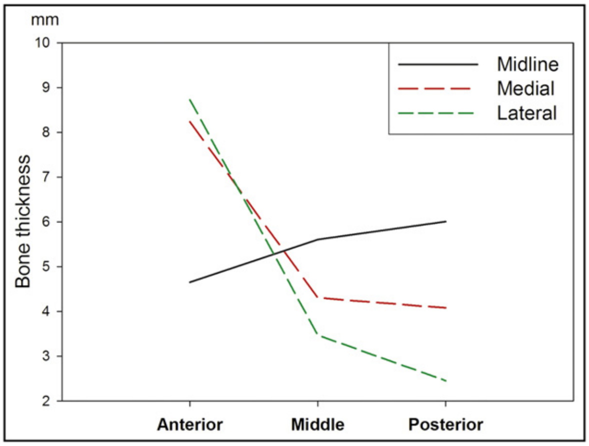

Fig 3. Palatal bone thickness in the total sample showing interaction between the mediolateral and anteroposterior positions.

DISCUSSION

In adolescent patients with Class II malocclusion, the use of temporary skeletal anchorage devices for molar distalization prevents undesirable reciprocal effects and eliminates the dependence on the patient's cooperation. Because adequate bone thickness must be available to allow for temporary skeletal anchorage device placement, the bone quantity of several placement sites was evaluated in the different age groups in our study.

Kokich[21] reported the successful use of dental implants for anchorage before placing an abutment in partially edentulous patients, and Wehrbein et al[22,23] described a palatal implant system with a 100% success rate for en-masse retraction of maxillary anterior teeth. Also, several authors have demonstrated high stability and high success rates for temporary skeletal anchorage devices placed in the anterior palate.[24,25] Additionally, a questionnaire showed that patients tended to prefer the palate to other insertion sites.[26]

Recently, a case report showed the application of a palatal plate to efficiently distalize the maxillary molars without invasive procedures in patients with late mixed and early permanent dentitions.[10] The palatal bone might be significantly thin in the midsagittal area because of incomplete ossification of the midpalatal suture. Therefore, placement of temporary skeletal anchorage devices in the paramedian palatal area has been recommended because of its thin keratinized soft tissue and sufficient cortical bone.[4,6-9,13,19,27,28]

In agreement with our study, Kang et al[13] reported that bone thickness decreased laterally and posteriorly in the paramedian area in adults. They reported greater bone thickness in men than in women. However, the sex comparison showed no sexual dimorphism (P = 0.83) in our study. This might be because their sample size was too small to evaluate sex differences.

For adolescents, our results showed that the anterior medial and lateral areas had the thickest palatal bones

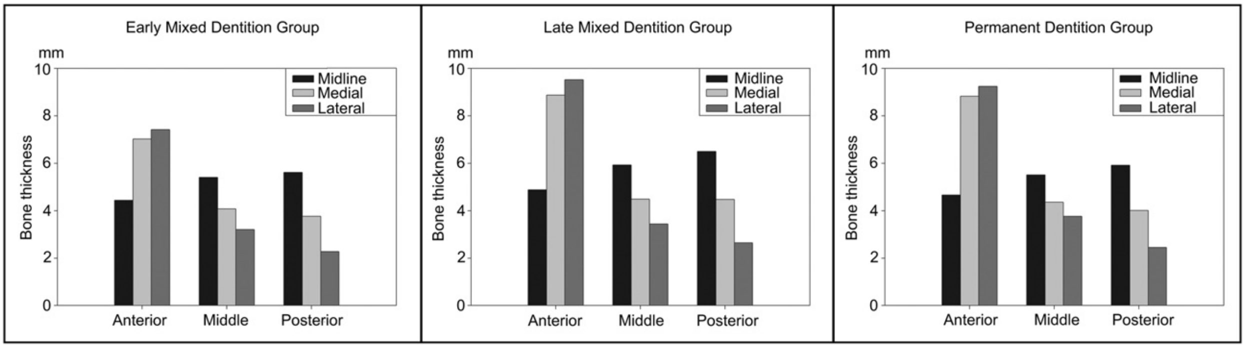

Fig 4. Comparison of palatal bone thickness according to the mediolateral and anteroposterior areas in the early and late mixed and permanent dentition groups.

(Fig 4). This was consistent with the study of King et al,[14] who demonstrated sufficient vertical bone depth at 4 mm distal and 3 mm lateral to the incisive foramen to install a 3-mm-long implant in adolescents. Unfortunately, a group of younger adolescents was not included, nor was bone thickness measured at the midpalatal suture in their study.

In contrast, Gracco et al[19] found no significant differences in palatal bone thickness between adults and adolescents. However, their youngest group was over 10 years old, whereas our study focused on adolescents and subdivided them into early mixed dentition (mean age, 8.0 years) and late mixed dentition (mean age, 11.5 years) groups. The early mixed dentition group had significantly less bone thickness than did the 2 other groups, mainly in the anterior area. This inconsistency might have been caused by differences in methodology.

To successfully apply temporary skeletal anchorage devices to the palate, the clinician should consider not only the mediolateral and anteroposterior positions, but also the patient's age, because there was a significant interaction among the mediolateral and anteroposterior positions and the age groups. Our results can provide a clinical guideline for proper placement in the palate to distalize molars in Class II adolescents. Nonetheless, it might be necessary to conduct a clinical study to further assess the correlation between failure rates and bone thickness.

The minimum thickness of bone necessary for placement is still controversial, especially considering stability and avoiding injury to other anatomic structures. Our results indicated that the area of highest bone thickness in the paramedian area extended 8 mm posteriorly to the incisive foramen. Nevertheless, Kuroda et al[29] concluded that the proximity of a temporary skeletal anchorage device to roots is a major risk factor for their failure. Also, Poggio et al[30] suggested that 1 mm of bone should be around temporary skeletal anchorage devices for safe placement. As our study indicates, the palate provides sufficient bone thickness for high safety and stability of temporary skeletal anchorage devices in all groups.

The significant interaction between the mediolateral and anteroposterior positions in our results indicated that the anterior region was thicker than the middle and posterior ones in the paramedian area, but vice versa in the midline area. Also, the thickness in the anterior area was greater laterally but decreased to less than that in the medial and midline areas in the middle and posterior areas (Figs 3 and 4).

The anterior paramedian area showed significantly greater bone thickness than did the posterior area in all 3 groups of our study. This might be due to the difference in the amounts of remodeling growth between the posterior and anterior parts.[31]

In our results, the early mixed dentition group had significantly thinner bone compared with the other 2 groups (P <0.001), which had no significant difference between them. This might be attributed to skeletal age, because the ages of the early and late mixed dentition groups were approximately similar to the consecutive stages of cervical vertebral maturation in the study of Gu and McNamara.[32]

Further research regarding the combination of bone quality and quantity factors as a key element in the success rate of temporary skeletal anchorage devices is warranted. Moreover, 3-dimensional evaluations of palatal bone thickness related to palatal shape, arch form type, and classification of malocclusion might provide important information for clinicians.

CONCLUSIONS

Our findings regarding palatal bone thickness of adolescents and adults can be summarized as follows:

1. The early mixed dentition group showed significantly thinner bone compared with the late mixed and permanent dentition groups, which were not significantly different.
2. Bone thickness decreased laterally except in the anterior area and posteriorly except in the midpalatal suture area in all 3 groups.

These findings can be useful for clinicians to help enhance the successful use of temporary skeletal anchorage devices in the palate, especially in adolescent patients.

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