ISSN: 2581-5989
PubMed - National Library of Medicine - ID: 101738774

International Journal of Dental Science and Innovative Research (IJDSIR)
IJDSIR : Dental Publication Service
Available Online at: www.ijdsir.com
Volume – 2, Issue – 3, May - June- 2019, Page No. : 226 - 236

A Comparison of Palatal Bone and Palatal Cortical Plate Thicknesses for Micro-Implant Placement between Adolescents and Adults, In Both the Genders – A CBCT Study

[1]Dr. Kamini Singh, [2]Dr. Parag Gangurde,[3]Dr. Girish Karandikar, [4]Dr. Alok Shah, [5]Dr. Shashank Gaikwad, [6]Dr. Pallavi Shinde

[1]Dr. kamini singh, PG student, Bhararti Vidyapeeth Dental College and Hospital Deemed To Be University Navi Mumbai, Kharghar, India

[2]Dr. Parag Gangurde, Professor in the Department of Orthodontics and Dentofacial Orthopedics, Bhararti Vidyapeeth Dental College and Hospital Deemed To Be University Navi Mumbai, Kharghar, India

[3]Dr. Girish Karandikar, Head of the Department of Orthodontics and Dentofacial Orthopedics, Bhararti Vidyapeeth Dental College and Hospital Deemed To Be University Navi Mumbai, Kharghar, India

[4]Dr. Alok Shah, Assistant Professor in the Department of Orthodontics and Dentofacial Orthopedics, Bhararti Vidyapeeth Dental College and Hospital Deemed To Be University Navi Mumbai, Kharghar, India

[5]Dr. Shashank Gaikwad, Reader in the Department of Orthodontics and Dentofacial Orthopedics, Bhararti Vidyapeeth Dental College and Hospital Deemed To Be University Navi Mumbai, Kharghar, India

[6]Dr. Pallavi Shinde, Lecturer, Bhararti Vidyapeeth Dental College and Hospital Deemed To Be University Navi Mumbai, Kharghar, India

Corresponding Author: Dr. Kamini Singh, PG Student of department of Orthodontics and Dentofacial Orthopaedics, Bharti Vidhyapeeth Dental Deemed to be University ,Navi Mumbai, India.

Conflicts of Interest: Nil

Type of Publication: Original Research Paper

Conflicts of Interest: Nil

Abstract

Aim: To compare palatal bone thickness in various median and paramedian regions and palatal cortical plate thickness in inter-radicular spaces for suitable micro-implant placement between adolescents and adults, in both the genders using Cone Beam Computed Tomography (CBCT).

Materials and Methods: CBCT scans of 100 patients were selected and divided into 4 groups: Group 1A: 25 Adolescent male (11 to 17 years), Group 1B: 25 Adult female (11 to 17 years), Group 2A: 25 Adolescent male (21 to 30 years), Group 2B: 25 Adult female (21 to 30 years). Palatal bone thickness was measured at 28 sites and Palatal cortical plate thickness were measured at 12 sites by using InVivo Dental 5.0 software. The bony thickness was compared between the two groups (adults and adolescents) for differences using unpaired 't' – test. To evaluate the effect of gender on the bone thickness in adults and adolescents was analyzed using analysis of covariance (ANCOVA) with age group as a factor and gender as a covariate. Adjusted means for bone thickness was estimated for adults and adolescents. All testing was done using two-sided tests at alpha 0.05.

Results: Palatal bone thickness in the adults ($P<0.05$)

were significantly higher than those in the adolescents. Anterior palate had maximum thickness in all the groups. Gender comparison revealed that males had greater palatal; bone thickness than their male counterparts. No significant (P>0.05) difference was found for cortical plate thickness at inter-radicular sites between adults and adolescents. Palatal cortical plate thickness was maximum between fist molar and second molar.

Conclusion: Bone thickness of the palate differs greatly depending on the measurement sites.

Also individual variations were great. Palate constitutes a site of choice for insertion of micro-implant for anchorage reinforcement in orthodontic treatment.

Keywords: Micro-Implant, Cone-Beam Computed Tomography, Palatal Bone, Cortical Plate, Inter-Radicular, Median and Paramedian regions.

Introduction

Anchorage control plays a critical role in successful execution of orthodontic treatment because unwanted and unplanned tooth movement due to effect of counter movements of mechanics used results in undesirable consequences during orthodontic treatment. The forces used to retract anterior teeth will have an equal and opposite force on the posterior anchorage units. This tends to cause mesial movement of molars which is generally undesirable. In such situations, reinforcement of anchorage is necessary. Anchorage reinforcement methods include use of suitable intra-oral (teeth, bone and implants) and extra-oral (headgear and facemasks) adjunctive measures and/or appliances. Micro-implants in the recent years have been popularized as an alternative for stationary anchorage. It is a relatively new and developing clinical tool. The small size of micro-implants increases their clinical utility by allowing them to be placed in the bone between adjacent teeth. The anatomy of micro-implant placement site will influence the selection of the micro-implant in term of its dimensions, location and orientation. Factors contributing to placement of micro-implants are anatomic structures in the vicinity of the site of placement, bone quality, soft tissue thickness and patient comfort. Since the thickness of cortical bone differs in different parts of jaws in the same patient and cortical bone thickness plays an important role in achieving stability of the TADs, the purpose of this study was to compare the bone thickness of various palatal areas in the median and paramedian region and also palatal cortical plate thickness in inter-radicular regions among subjects between adolescents and adults in both the genders by using Cone Beam Computed Tomography (CBCT) for the most appropriate sites of micro-implant placement. The results of this study were expected to offer a valuable clinical guideline for adopting appropriate options and/or to confirm the basis of earlier studies on placing palatal micro-implants.

Materials and Methods

The study sample consisted of CBCT records of patients who visited Insight CBCT Centre, Vashi, Navi Mumbai. Permission was sought from the INsight CBCT centre for sharing of previous records. The sample consisted of 100 CBCT records. Records with healthy palate with good bone quality were considered. 1. Group 1A: 25 Adolescent Male patients (Age group: 11 to 17 years) 2. Group 1B: 25 Adolescent Female patients (Age group: 11 to 17 years) 3. Group 2A: 25 Adult Male patients (Age group: 21 to 30 years) 4. Group 2B: 25 Adult Female patients (Age group: 21 to 30 years). Patients with obvious pathologies in the palatal region on CBCT were excluded from the study. CBCT records were taken using i-CAT 17-19 CBCT scanner (Imaging Sciences International) with a spatial resolution of 10 line pairs per centimeter and an isotropic 0.4-mm voxel size. The settings were120 kVp; 47.74 mA; field of view, 17 x 23 cm; exposure time, 07 seconds. Invivodental5.0, a volumetric imaging software, was used to measure bone thickness. The palate was divided in paracoronal sections at 4, 8, 12, 16, 20 and 24mm from the incisive foramen. The palatal bone thickness was measured at 0, 2, 4 and 6 mm lateral to the mid palatal suture on either side.(Figure: 1 and 2) 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 mm2. The measurements were made at the intersection points of the reference. Palatal cortical bone thickness (in mms) was measured at interradicular locations on maxillary palatal area on either side at level of 4mm, 6mm and 8mm apical to the alveolar crest : 1. Between the canine and first premolar 2. Between first and second premolars 3. Between second premolar and first molar 4. Between first and second molars.(figure 3 and 4) Only one side of the palate was randomly measured because it was previously shown that there are no significant differences in cortical bone thickness between sides of jaw. Cortical bone measurement at 2, 4 and 6mm beyond alveolar crest. Total number of measurements that would be recorded: 28. In total measurements per patient: 73. Sample size was not based on any calculations, assumptions and statistical computations and it is planned to include a total of 100 CBCT records on the study. All data were entered into a Microsoft Office Excel (version 2013) in a spreadsheet which will be prepared and validated for the data form. Data will be entered and checked for errors and discrepancies. Data analysis will be done using windows based 'MedCalc Statistical Software' version 13.3.1 (MedCalc Software bvba, Ostend, Belgium; http://www.medcalc.org; 2014). The thickness of the bone (cortical and palatal bone) was expressed as means standard deviation (SD) and standard error of mean (SEM). 95% confidence intervals (CI) will be presented. The bony thickness was compared between the two groups (adults and adolescents) for differences using unpaired 't' – test. To evaluate the effect of gender on the bone thickness in adults and adolescents was analyzed using analysis of covariance (ANCOVA) with age group as a factor and gender as a covariate. Adjusted means for bone thickness was estimated for adults and adolescents. All testing was done using two-sided tests at alpha 0.05. Thus, the criteria for rejecting the null hypothesis was a 'p' value of <0.05.

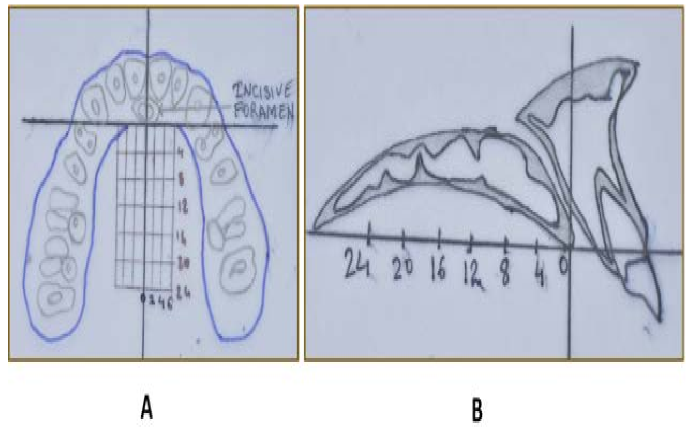


Figure 1: Schematic diagram of the measurements that were made at the intersection points of the reference lines: **(A)** in paracoronal sections at 0, 4, 8, 12, 16, 20 and 24mm from the incisive foramen and **(B)** at 0, 2, 4 and 6 mm lateral to the mid palatal suture on either side

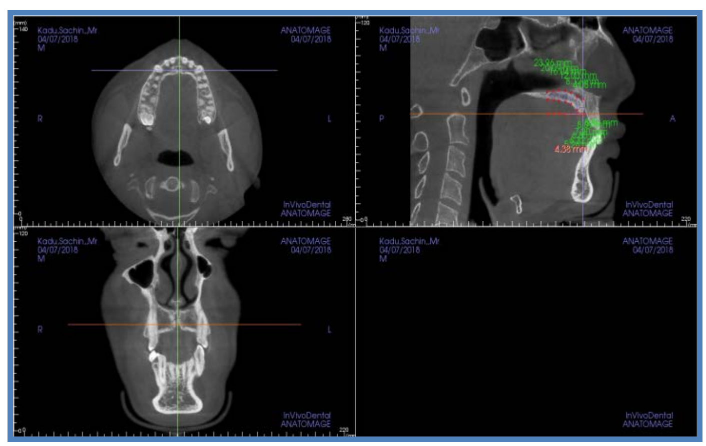


Figure 2: Bone thickness measurement at 2mm from midpalatal suture at various coronal sites.

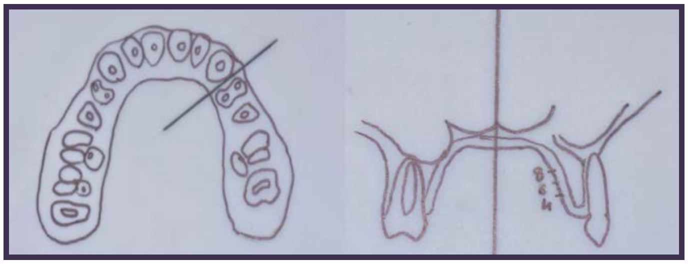


Figure 3: schematic representation of measurements done at interradicular locations in maxillary palatal side at level of 4mm, 6mm and 8mm apical to the alveolar crest

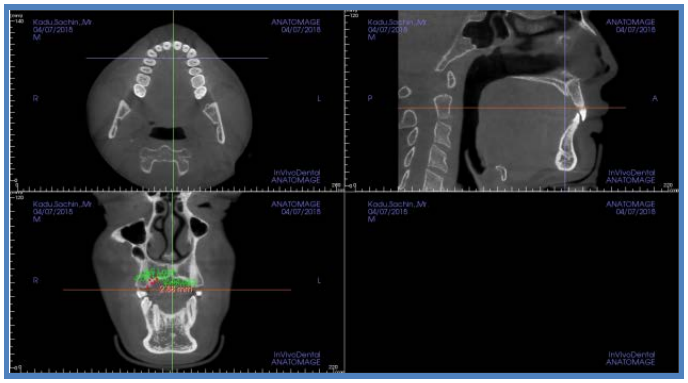


Figure 4: Palatal cortical plate thickness measurement at interradicular locations on maxillary palatal side at the level of 4mm, 6mm and 8mm apical to the alveolar crest between the canine and first premolar.

Results

Bone thickness at various coronal sites on mid–palatal suture: Mean calculated by descriptive statistics indicated that mean for bone thickness at mid-palatal was maximum with Group 2A with SD (2.58168) followed by Group 1B with SD (2.74336) followed by Group 2B with SD (2.85935) followed by Group 1A with SD (3.35185). Analysis of variance (ANOVA) statistics showed significant (P<0.05) variation in bone thickness at various coronal sites at mid-palatal suture between adolescents and adults. (Table 1, graph A) Whereas, the gender comparison showed no dimorphism (P=0.283). (Table 2)

Bone thickness at various coronal sites 2mm lateral to mid–palatal suture: Analysis of variance (ANOVA) statistics showed significant (P<0.05) variation in bone thickness at various coronal sites 2mm from mid-palatal suture between adolescents and adults and males and females (P=0.000, P=0.040). (Table 1 and 2)

Bone thickness at various coronal sites 4mm lateral to mid–palatal suture: Analysis of variance (ANOVA) statistics in table 2.1, 2.2, 3.3 showed significant (P<0.05) variation in bone thickness at various coronal sites 4mm from mid-palatal suture between adolescents and adults and males and females (P=0.000, P=0.008). (Table 1 and 2)

Bone thickness at various coronal sites 6mm lateral to mid–palatal suture: Analysis of variance (ANOVA) statistics in table 2.1, 2.2, 3.4 showed significant (P<0.05) variation in bone thickness at various coronal sites 6mm from mid-palatal suture between adolescents and adults and males and females (P=0.000, P=0.047). (Table 1 and 2) Palatal bone thickness in the Mid-palatal (median and paramedian) region decreased lateral to mid-palatal suture.

Palatal cortical plate thickness between canine and premolar: Analysis of variance (ANOVA) statistics showed no significant (P=0.419) variation in palatal cortical plate thickness at 4, 6 and 8 mm between adolescents and adults. Whereas, cortical plate thickness between canine and premolar as shown in table 2.4, 3.5 was significant(P=0.30) between males and females. (Table 3, 4 and Graph B)

Palatal cortical plate thickness between first premolar and second premolar: Analysis of variance (ANOVA) statistics showed no significant (P=0.224) variation in palatal cortical plate thickness at 4, 6 and 8 mm between adolescents and adults and between males and females(P=0.859). (Table 3, 4)

Palatal cortical plate thickness between second premolar and first molar: Analysis of variance (ANOVA) statistics showed no significant (P=0.453) variation in palatal cortical plate thickness at 4, 6 and 8 mm between adolescents and adults. Whereas, cortical plate thickness between second premolar and first molar was significant(p=0.012) between males and females. (Table 3, 4)

Palatal cortical plate thickness between first and second molar: Analysis of variance (ANOVA) statistics showed significant (P=0.047, P=0.000) variation in palatal cortical plate thickness at 4, 6 and 8 mm between adolescents and adults and between males and females. Palatal cortical plate thickness was maximum between 2nd premolar and first molar, followed by cortical plate thickness between 1st and 2nd molar. (Table 3, 4) Mean calculated by descriptive statistics indicated palatal cortical plate thickness was highest between 2nd premolar and 1st molar (SD= 0.54973, Mean=1.5738), followed by cortical plate thickness between 1st and 2nd molar (SD=0.53113, Mean=1.7319), followed by cortical plate thickness between 1st and 2nd premolar and between canine and 1st premolar (SD=0.60996,0.60045; Mean=1.9503, 1.0715).

Discussion

The use of micro-implants for anchorage reinforcement in orthodontic treatment has been examined both experimentally and clinically over the years.[3,4] There are two phases of implant stability: (i) initial and (ii) late. Good mechanical interlocking between the implant and the bone provides initial stability. Therefore, the key to overall success of micro-implant anchorage is obtaining initial stability[5,6]. Bone quantity is one factor that influences initial stability. Micro-implants are used for molar distalization to prevent undesirable reciprocal effect and to eliminate patient's co-operation. Lack of appropriate bone thickness at the micro-implant site can compromise the stability and pose a risk of perforating into the incisive canal or the nasal cavity . As adequate bone thickness is required for micro-implant placement, bone quantity of several placement sites in palate was evaluated in different age groups and in both the genders in this study. Hence, Knowledge of palatal bone thickness can prevent nasal perforation during placement.

Table 1: Comparison of palatal bone thickness in median and paramedian regions at various coronal sites between adolescents and adults.

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
Midpalatal suture * Coronal (Palatal)	Between Groups(Combined)	2526.159	6	421.026	81.291	.500
2 mm lateral to midpalatal suture * Coronal (Palatal)	Between Groups(Combined)	4092.362	6	682.060	134.935	.400
4 mm lateral to midpalatal suture * Coronal (Palatal)	Between Groups(Combined)	5903.475	6	983.913	223.423	.080
6 mm lateral to midpalatal suture * Coronal (Palatal)	Between Groups(Combined)	7464.491	6	1244.082	247.059	.060

Table 2: Comparison of palatal bone thickness in median and paramedian regions at various coronal sites between males and females.

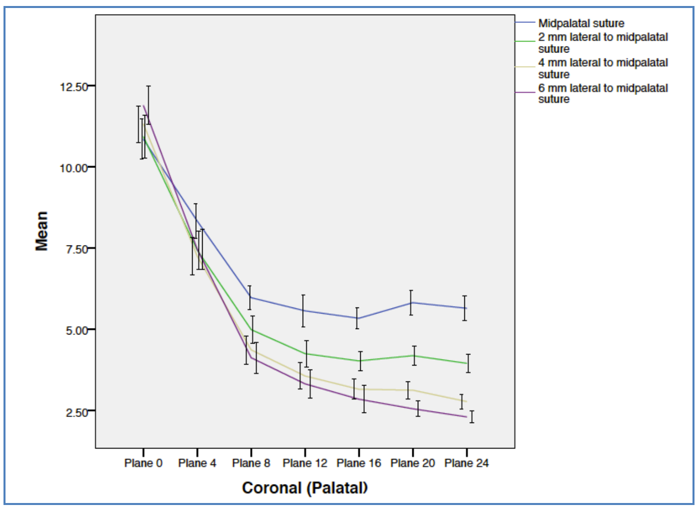
		Sum of Squares	df	Mean Square	F	Sig.
Midpalatal suture * Gender	Between Groups(Combined)	10.114	1	10.114	1.156	.283
2 mm lateral to midpalatal suture * Gender	Between Groups(Combined)	45.752	1	45.752	4.230	.060
4 mm lateral to midpalatal suture * Gender	Between Groups(Combined)	91.059	1	91.059	7.170	.080
6 mm lateral to midpalatal suture * Gender	Between Groups(Combined)	61.758	1	61.758	3.958	.077

Table 3: Comparison of palatal cortical plate thickness at various inter-radicular sites between adolescents and adults

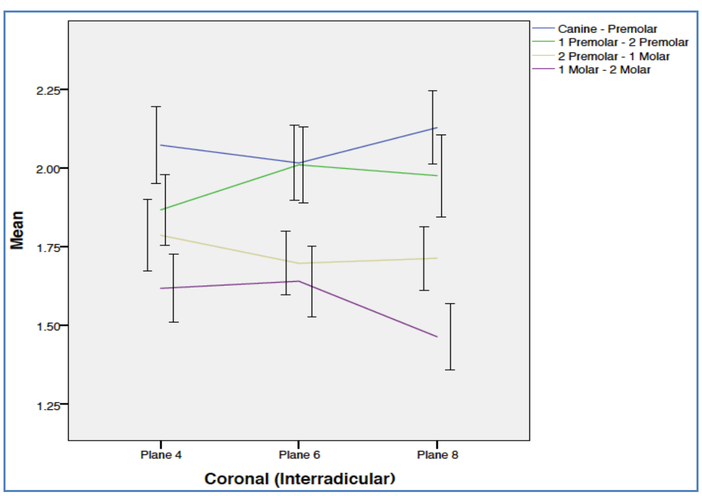
		Sum of Squares	df	Mean Square	F	Sig.
Canine - Premolar * Coronal (Interradicular)	Between Groups(Combined)	.629	2	.315	.872	.419
1 Premolar - 2 Premolar * Coronal (Interradicular)	Between Groups(Combined)	1.114	2	.557	1.502	.224
2 Premolar - 1 Molar * Coronal (Interradicular)	Between Groups(Combined)	.449	2	.225	.795	.453
1 Molar - 2 Molar * Coronal (Interradicular)	Between Groups(Combined)	1.840	2	.920	3.086	.047

Table 4: Comparison of palatal cortical plate thickness at various inter-radicular sites between males and females

		Sum of Squares	df	Mean Square	F	Sig.
Canine - Premolar * Gender	Between Groups (Combined)	1.688	1	1.688	4.739	.030
1 Premolar - 2 Premolar * Gender	Between Groups (Combined)	.012	1	.012	.032	.859
2 Premolar - 1 Molar * Gender	Between Groups (Combined)	1.791	1	1.791	6.465	.012
1 Molar - 2 Molar * Gender	Between Groups (Combined)	3.924	1	3.924	13.529	.000



Graph –A



Graph – B

Graph: (A) Estimated Marginal Means of palatal bone thickness at various coronal planes; (B) Estimated Marginal Means of palatal cortical plate thickness at various inter-radicular sites of micro-implant on palatal side and aid in selecting the proper micro- implant length.

Although inter-radicular sites in the buccal alveolar area is most commonly used for micro-implant placement, inter-radicular spaces are limited by the proximity of neighbouring roots. The risk-factors associated with placement of micro-implant in inter-radicular spaces can be avoided by using "rootless area" such as palate, maxillary tuberosity, or inferior portion of zygomatic arches adjacent to the maxilla. Tuberosity is not considered as entirely safe site for micro-implant placement, as un-erupted third molars or thick gingival tissue may prevent successful insertion of micro-implant. And insertion of micro-implant into the inferior portion of the zygomatic arch carries a high risk of perforating the maxillary sinus. Therefore, palate is an ideal insertion site in the maxilla.

In agreement with this present study, Kang et al[7] and Ryu[8] et all reported that palatal bone thickness was maximum in anterior palate and bone thickness decreased posteriorly in adults. For adolescents, results of this study showed that bone thickness is greatest in median and paramedian regions of anterior palate. This was consistent with the study of King et al,[9] 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. But bone thickness at mid-palatal suture was not measured in their study.

In 1996, Wehrbein et al[10] described a highly sophisticated implant system for the anterior palate three years later, this group reported a 100% success rate for en masse retraction of upper anterior teeth, a biomechanically demanding procedure. After the introduction of the orthosystem palatal implant by Wehrbein et al,[10] the anterior hard palate has become one of the ideal insertion sites for micro-implant placement in orthodontics. Park has documented a 100% success rate for miniscrews inserted in the anterior palate.[11] Wilmes and colleagues, using coupled miniscrews and a rigid miniplate in the anterior palate, demonstrated high stability and success rates. The anterior palate may also offer greater patient comfort and, thus, greater acceptance compared to other locations.[12] Both Crismani et al[13] and Cousley[14] have published guidelines for safe insertion in the anterior hard palate, describing limitations and risks. On the other hand, Kim et al recorded a success rate of 88.2% for miniscrews placed in the palatal suture.[15]

The present study showed significantly greater palatal bone thickness in anterior median and paramedian regions as compared to that of posterior palatal median and paramedian regions in all the groups. This could be due to difference in the amount of remodeling growth between anterior and posterior parts of the palate.[16]

The study conducted showed significant difference in palatal bone thickness between adults and adolescents. In contrast, Gracco et al.[17] found no significant difference in palatal thickness between adults and adolescents. Therefore, the clinician should not only consider site at which micro-implant is to be inserted but also age of the patient should be taken into account for successful application of the micro-plant in palate. Results of this study can provide a clinical guideline for proper placement in the palate to distalize molars in Class II adolescents.

When stability and injury to the anatomic structure is considered, the minimum thickness of bone required for placement is still controversial. Results of this study showed highest bone thickness at plane 0 and 4 from incisive foramen. Kuroda et[18] al concluded that the proximity of a temporary skeletal anchorage device to roots is a major risk factor for their failure. Also, Poggio et al[19] suggested that 1 mm of bone should be around temporary skeletal anchorage devices for safe placement. When taken this into consideration, results of the present study indicates the palatal bone thickness is sufficient for high safety and stability of micro-implant placement anteriorly and posteriorly in all groups.

The present study found significant gender differences only in the palatal cortical bone thickness. In accordance with Kang et al.[7], results of this study showed greater palatal bone thickness in males than in females. However, Chun and Lim[20] did not find any significant difference, suggesting that the presence of gender difference may be dependent on the specific sites being examined in the palate.

Bernhart et al.[21] reported that the most suitable area in adults for implant placement in the palate was located 6 to 9 mm posterior to the incisive foramen and 3 to 6 mm para-median to the suture. However, results of this study indicated that the palatal cortical bone thickness extended 16 mm posterior to the incisive foramen in the median and paramedian regions and 6 mm lateral to mid-palatal suture. In clinical practice, it may be helpful to recognize that this area closely approximated the second premolar region in most of the cases.

The palatal bone thickness of this study was consistent with the report by Wehrbein,[22] who concluded that the density of the median palate was high enough to support mini-implants. He also suggested that the reported 10% failure rate of micro-implants inserted in the palatal area may be attributed to factors other than bone density.

Since the number of micro-implants currently being used in adolescents is increasing, identification and selection of the greater palatal bone thickness in this younger age group should be worthwhile. The anterior palatal bone thickness in adolescents was comparably higher to those of the posterior area of the adults. Therefore, it could be recommended to focus placement of TADs in the anterior region if they are considered for adolescent patients. A case-report be Kook YA 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.[23] 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.[17,19,21,23-25]

There are two factors affecting the success of mini-implants are the thickness of the cortical bone and root proximity. Results of this study showed no significant difference in palatal cortical plate thickness at inter-radicular sites between adolescents and adults.

A cortical bone thickness of at least 1 mm is necessary to achieve mini-implant stability as studied by Poggio et al.[19] They conducted a study to measure cortical bone thickness and found out there was a tendency for the superior part of the alveolar process to be thicker than the inferior part. Therefore, placement of micro-implant in the portion above the alveolar process is preferred whenever possible. They concluded that it was important to identify sites with a thickness of 1 mm or more in the portion farther down of the alveolar process as well, to assure safe placement. Results of this study showed palatal cortical plate thickness between 3-4, 4-5, 5-6, 6-7 was 1 mm or greater at 4, 6 and 8mm from alveolar crest. The highest cortical plate thickness being between first and second molar.

Kurodo et al[18] in 2007 reported that contact between the micro-implant and a tooth root can lead to implant failure. Because of this, it is important to ascertain the root proximity. Park et al.[11] 2001; Bae et al.[26] 2002; Kyung et al.[27] 2003; Deguchi et al.[28] 2006; Kuroda et al.[18] 2007 used Micro-implants with a diameter of 1.3–1.5 mm. Taking the width of the periodontal membrane into consideration, they found out that it is necessary to assure root proximity of at least 2.5 mm. They concluded that root proximity increases in the direction of the root apex, so adequate root proximity can be assured at a site close to the root apex.[11,26-28] Therefore, ideal site of micro-implant placement in the interradicular area would be 8mm from alveolar crest.

A study done by Joorok park et al[2] and Sawada et al[29] reported that the buccal cortical bone was thinner than the palatal cortical bone. Therefore, placement of micro-implant in palatal aspect is an ideal site. However, when placement is necessary at a lower level, adequate root proximity can be assured in the lower portion at 4–5 and 5–6. Because there is less interdental space at 3–4 and 6–7, Particular caution is required concerning contact between the mini- implant and the tooth root when placing the mini-implant at these sites.[29]

Conclusion

1. Palate constitutes a site of choice for insertion of micro-implant for anchorage reinforcement in orthodontic treatment.
2. Palatal bone thickness was significantly higher in adults than in adolescents.
3. Anterior palate in adults and in adolescents, in males and in females has maximum bone thickness.
4. Posterior region of the palate also has appropriate thickness. Hence, posterior region of the palate is also a suitable site for micro-implant placement.
5. In all the groups bone thickness decreased laterally from midpalatal suture.
6. There was significant gender difference in palatal bone thickness. Males had greater palatal bone thickness than females, in both adults and adolescents.
7. Palatal inter-radicular cortical plate thickness increased from crest to base of alveolar process.
8. Palatal cortical plate thickness was significant between second premolar and first molar, and first and second molar. Hence, the palatal alveolus between the roots of the second premolar and first molar may be considered as an alternative miniscrew location, with some limitations.

References

1. Keim RG. The biomechanics of TADs. J Clin Orthod. 2008 May;42(5):261-2.
2. 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.e1–314.12
3. Bousquet, F., Bousquet, P., Mauran, G. & Parguel, P. (1996) Use of an impacted post for anchorage. Journal of Clinical Orthodontics 5: 261–265.
4. Higuchi, K.W. & Slack, J.M. (1991) The use of titanium fixtures for intraoral anchorage to faciliate orthodontic tooth move- ment. International Journal of Oral and Maxillofacial Im- plants Volume 6, Number 3: 338–344.
5. Dalstra M, Cattaneo PM, Melsen B. Load transfer of miniscrews for orthodontic anchorage. J Orthod 2004;1:53-62.
6. Roberts WE, Helm F, Marshall K, Gongloff R. Rigid endosseous implants for orthodontic and orthopedic anchorage. Angle Orthod 1989;59:247-56.
7. Kang S, Lee SJ, Ahn SJ, Heo MS, Kim TW. Bone thickness of the palate for orthodontic mini-implant anchorage in adults. Am J Orthod Dentofacial Orthop 2007;131(Suppl):S74-81.
8. Ryu JH, Park JH, Vu Thi Thu T, Bayome M, Kim Y, Kook YA. Palatal bone thickness compared with cone-beam computed tomography in adolescents and adults for mini-implant placement. Am J Orthod Dentofacial Orthop. 2012Aug;142(2):207-12.
9. King KS, Lam EW, Faulkner MG, Heo G, Major PW. Vertical bone volume in the paramedian palate of adolescents: a computed tomography study. Am J Orthod Dentofacial Orthop 2007;132: 783-8.
10. Wehrbein, H.; Glatzmaier, J.; Mundwiller, U.; and Diedrich, P.: The Orthosystem—a new implant system for orthodontic anchorage in the palate, J. Orofac. Orthop. 57:142-153, 1996.
11. Park, H.S.: Clinical study on success rate of microscrew implants for orthodontic anchorage, Kor. J. Orthod. 33:151- 156, 2003.
12. Wilmes, B.; Drescher, D.; and Nienkemper, M.: A miniplate system for improved stability of skeletal anchorage, J. Clin. Orthod. 43:494-501, 2009.
13. Crismani, A.G.; Bernhart, T.; Tangl, S.; Bantleon, H.P.; and Watzek, G.: Nasal cavity perforation by

palatal implants: False-positive records on the lateral cephalogram, Int. J. Oral Maxillofac. Impl. 20:267-273, 2005.

14. Cousley, R.: Critical aspects in the use of orthodontic palatal implants, Am. J. Orthod. 127:723-729, 2005.
15. Kim, Y.H.; Yang, S.M.; Kim, S.; Lee, J.Y.; Kim, K.E.; Gianelly, A.A.; and Kyung S.H.: Midpalatal miniscrews for orthodontic anchorage: Factors affecting clinical success, Am. J. Orthod. 137:66-72, 2010.
16. Enlow DH, Hans MG. Essentials of facial growth. Philadelphia: Saunders; 1996. p. 79-98.
17. Gracco A, Lombardo L, Cozzani M, Siciliani G. Quantitative evalu- ation with CBCT of palatal bone thickness in growing patients. Prog Orthod 2006;7:164-74.
18. Kuroda S, Yamada K, Deguchi T, Hashimoto T, Kyung HM, Takano-Yamamoto T. Root proximity is a major factor for screw failure in orthodontic anchorage. Am J Orthod Dentofacial Orthop 2007;131(Suppl):S68-73.
19. Poggio PM, Incorvati C, Velo S, Carano A. “Safe zones”: a guide for miniscrew positioning in the maxillary and mandibular arch. Angle Orthod 2006;76:191-7.
20. Chun YS, Lim WH. Bone density at interradicular sites: implications for orthodontic mini-implant placement. Orthod Craniofac Res. 2009;12:25–32.
21. Bernhart T, Freudenthaler J, Dortbudak O, Bantleon HP, Watzek G. Short epithetic implants for orthodontic anchorage in the paramedian region of the palate: a clinical study. Clin Oral Implants Res. 2001;12:624–631.
22. Wehrbein H, Merz BR, Diedrich P. Palatal bone support for orthodontic implant anchorage--a clinical and radiological study. Eur J Orthod. 1999 Feb;21(1):65-70.
23. Kook YA, Kim SH, Chung KR. A modified palatal anchorage plate for simple and efficient distalization. J Clin Orthod 2010;44: 719-30.
24. Tosun T, Keles A, Erverdi N. Method for the placement of palatal implants. Int J Oral Maxillofac Implants. 2002;17: 95–100.
25. Schlegel KA, Kinner F, Schlegel KD. The anatomic basis for palatal implants in orthodontics. Int J Adult Orthodon Orthognath Surg. 2002;17:133–139.
26. Bae, S.M., Park, H.S., Kyung, H.M., Kwon, O.W. & Sung, J.H. (2002) Clinical application of micro-implant anchorage. Journal of Clinical Orthodon- tics 36: 298–302.
27. Kyung, H.M., Park, H.S., Bae, S.M., Sung, J.H. & Kim, I.B. (2003) Development of orthodontic micro-implants for intraoral anchorage. Journal of Clinical Orthodontics 37: 321–328.
28. Deguchi T, Nasu M, Murakami K, Yabuuchi T, Kamioka H, Takano-Yamamoto T. Quantitative evaluation of cortical bone thickness with computed tomographic scanning for orthodontic implants. Am J Orthod Dentofacial Orthop 2006;129:721.e7-12.
29. Sawada K, Nakahara K, Matsunaga S, Abe S, Ide Y. Evaluation of cortical bone thickness and root proximity at maxillary interradicular sites for mini-implant placement. Clin Oral Implants Res. 2013 Aug;24 Suppl A100:1-7.