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An In Vitro Investigation Of Palatal Locations For Mini Screw Insertion And The Impact Of Fundamental Stability On Bone

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Abstract

Introduction- The locations are commonly used in orthodontic applications for the placement of miniscrew because of their ease of access, the interradicular spaces are limited by the proximity of neighboring roots. **Methodology-** Cone-beam computed tomography (CBCT) scans of 30 consecutively healthy patients (12 men and 18 women) who went to the Department of Orthodontics and Dentofacial Orthopaedics made up the collection. Three grouping methods were applied for these patients: they were grouped by sex (12 males and 18 females), age (15 adolescents [14.4 ± 2.8 years of age] and 15 adults [25.6 ± 2.98 years of age]), and by sex and age (6 male adolescents, 9 female adolescents, 6 male adults, and 9 female adults). **Results-** Since no statistical differences were detected be- tween left and right sides for palatal thickness (hard tissue, soft tissue, and hardþsoft tissues) (*P* ¼ .296), the left and right side measurements were combined for statistical analyses. Two-way ANOVA with repeated measures revealed that the thickness of hard tissues was significantly influenced by different coronal planes (P1, P2, M1, and M2) (*P* , .001), different sites away from the midpalatal suture (0 to 10 mm) (*P* , .001), and by their interaction (*P* , .001). **Conclusion-** Clinicians are advised to map out the most appropriate and ideal locations for palatal mini-implants.

Keywords- CBCT, Miniscrew, Maxilla, Palate

Introduction

The locations are commonly used in orthodontic applications for the placement of miniscrew because of their ease of access, the interradicular spaces are limited by the proximity of neighboring roots presenting the following problems such as risk of damaging the roots or the periodontium, possibility of miniscrew-root contact resulting in early screw failure, risk of screw fracture during placement, due to the narrower miniscrew dimensions needed for interradicular positions and loss rate as high as 25%.[1]

These risk factors can be avoided by using "rootless areas" such as the hard palate, the maxillary tuberosity, or the portions of the zygomatic arches adjacent to the maxilla. The tuberosity cannot be regarded as entirely safe, since unerupted third molars or thick layers of gingiva may prevent successful insertion. Insertion into the inferior portion of the zygomatic arch carries the risk of perforating the maxillary sinus.[3] Therefore, the only safe alternatives to buccal miniscrew placement are in the palate.

The posterior palate has also been described as a suitable location for miniscrew applications such as skeletal support of posterior intrusion. Another alternative is the palatal alveolus between the maxillary first molar and second premolar, where the favorable position of the first molar's palatal root and the buccal angulation of the second premolar provide excellent access for direct insertion of a miniscrew. This location offers the largest interradicular space, a sufficiently wide cortical plate, and moderately thick attached gingiva.[3]

The options for orthodontic therapy have increased thanks to the introduction of orthodontic miniscrew implants as temporary anchoring devices (TADs).Miniscrews are temporarily utilised throughout treatment to create skeletal anchoring and then withdrawn with the aim of permitting challenging tooth movements and maybe avoiding orthognathic surgery.[2] They are largely held in place by mechanical interlocking in bone, and their surface is made to impede osseointegration for that reason.[4]

While many studies[5,6,7] have assessed the overall thickness of the palatal bone, very few have looked at the density of the palatal soft tissues or the effects of age and sex on the implantation of palatal mini-implants. With the goal to assist healthcare professionals in selecting the best locations for palatal mini-implants, the goals of the present research were to measure the thickness of palatal hard and soft tissues as well as to investigate the effects of age and sex on palatal thickness.

Methodology

The Ethical Committee of the Gurunanak Institute of Dental Sciences and Research gave its approval to this investigation. Cone-beam computed tomography (CBCT) scans of 30 consecutively healthy patients (12 men and 18 women) who went to the Department of Orthodontics and Dentofacial Orthopaedics made up the collection. Three grouping methods were applied for these patients: they were grouped by sex (12 males and 18 females), age (15 adolescents [14.4 ± 2.8 years of age] and 15 adults [25.6 ± 2.98 years of age]), and by sex and age (6 male adolescents, 9 female adolescents, 6 male adults, and 9 female adults). The exclusion criteria were (1) cleft palate or cleft lip; (2) impacted teeth in the palatal region; (3) obvious full or partial alveolar resorption; (4) pathological lesions in the jaw; (5) dental implants or dentures; and (6) previous palatal surgery. The results of CBCT were collected with a cone-beam-based three-dimensional volume scanner (MCT-1, J Morita Mfg Corp, Kyoto, Kyoto-fu, Japan). Slice thickness was adjusted to 0.5 mm, exposure period was 17.5 seconds, and the following settings were used: 85 kV (anterior posterior-latero lateral), 5.0 mA (anterior posterior), and 5.0 mA (latero lateral). The mesial-distal midpoints of the bilateral first premolars, second premolars, first molars, and second molars, correspondingly, were chosen as the four coronal planes. The planes were labelled P1, P2, M1, and M2 in that order (Figure 1a). The distance among the upper and lower margins of the palatal bone was used to determine the width of the palate hard tissue, while the distance between the lower edge of the palatal bone and the lower edge of the palatal soft tissue was used to assess the thicknesses of the palatal soft tissue. The distance between the upper edge of the palatal bone and the lower edge of the palatal soft tissue was used to describe the thickness of hard+soft tissue. The thickness of the hard and soft tissue was measured every 1 mm (0 mm, 1 mm, …, 10 mm) away from the midpalatal suture. The point at the midpalatal suture was defined as point 0, and the other points were defined as points 1 to 10. (Figure 1b).

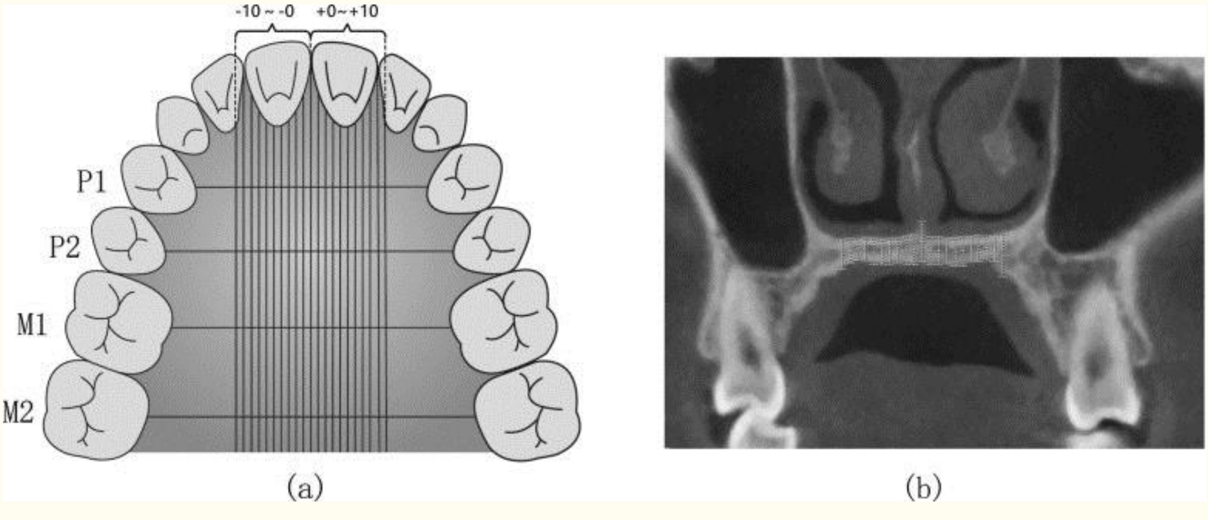


Figure 1.

Different measurement sites (−10 to ∼+10) at different planes (P1, P2, M1, and M2) in transverse and coronal views. a. Four coronal planes and measurement sites; b. An example of measurement sites at one coronal plane.

The same researcher replicated the measurements at random two weeks following the initial measurement. The reproducibility of the two measurements was examined using the intraclass coefficient (ICC) test (ICC = 0.863). For the final data, the average of the two separate measurements was used. The four planes (P1, P2, M1, and M2) at various distances (10 to +10 mm) from the midpalatal sutures were compared for palatal thickness (hard tissue, soft tissue, and hard+soft tissues) using a two-way analysis of variance (ANOVA). One-way ANOVA was applied to analyze the differences in palatal thickness of the same measuring point among different sex and age groups. Factorial design ANOVA was used to determine the interactions between age and sex. All data were analyzed using SPSS 25.0 and GraphPad 7.0, and a *P* value of less than .05 was considered statistically significant.

Results

Since no statistical differences were detected be- tween left and right sides for palatal thickness (hard tissue, soft tissue, and hardþsoft tissues) (*P* ¼ .296), the left and right side measurements were combined for statistical analyses. Two-way ANOVA with repeated measures revealed that the thickness of hard tissues was significantly influenced by different coronal planes (P1, P2, M1, and M2) (*P* , .001), different sites away from the midpalatal suture (0 to 10 mm) (*P* , .001), and by their interaction (*P* , .001). As displayed in Figure 2, for different sites away from the midpalatal suture, post hoc one-way ANOVA showed that, at the P1 plane, hard tissue thickness increased from point 0 to point 10 (*P* , .001), and soft tissue thickness decreased from point 0 to point 3 and then gradually increased from point 3 to point 10 (*P* ,.001). The trends in the changes of hard soft tissue thickness were similar to those of the hard tissue at theP1 plane. At the P2 plane, hard tissue thickness deceased from point 0 to point 7 and slightly increased thereafter, and soft tissue thickness gradually increased from point 0 to point 10. The trends in the changes of hard soft tissue thickness were consistent with those of hard tissue thickness at the P2 plane. The trends in the changes of palatal thickness (hard, soft, and hard soft) at the M1 and M2 planes were similar tothose at the P2 plane.

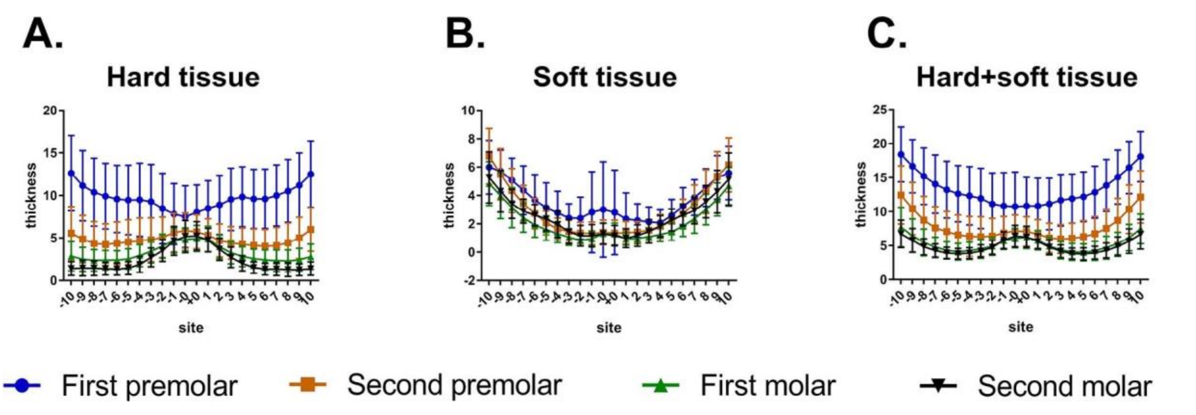


Figure 2. Comparison of palatal thickness of different sites and different planes. (A) Hard tissue. (B) Soft tissue. (C) Hard and soft tissue.

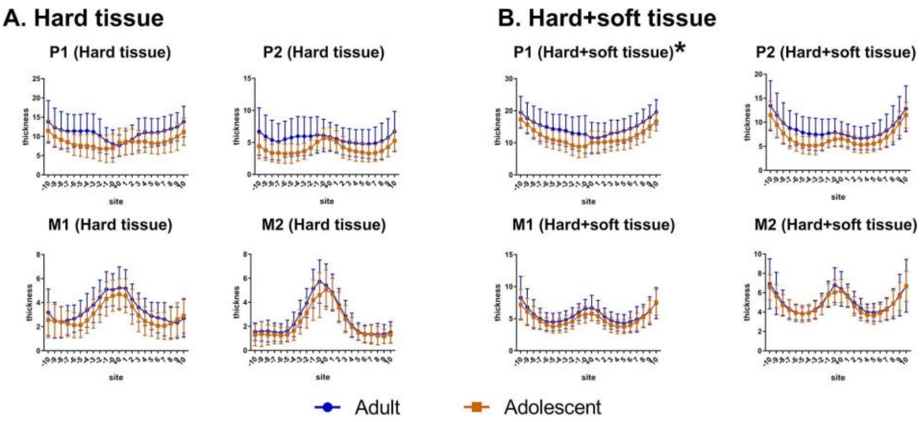


Figure 3. Comparison of the thickness at different planes in adults and adolescents. (A) Hard tissue. (B) Hard and soft tissue.

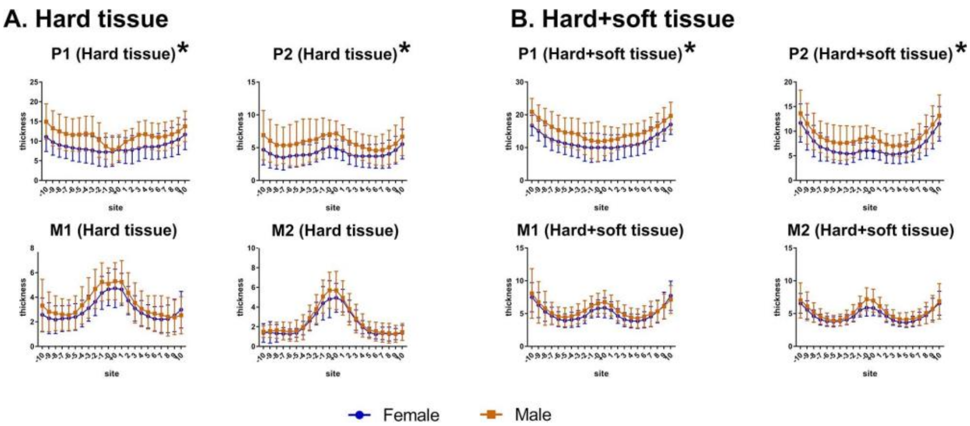
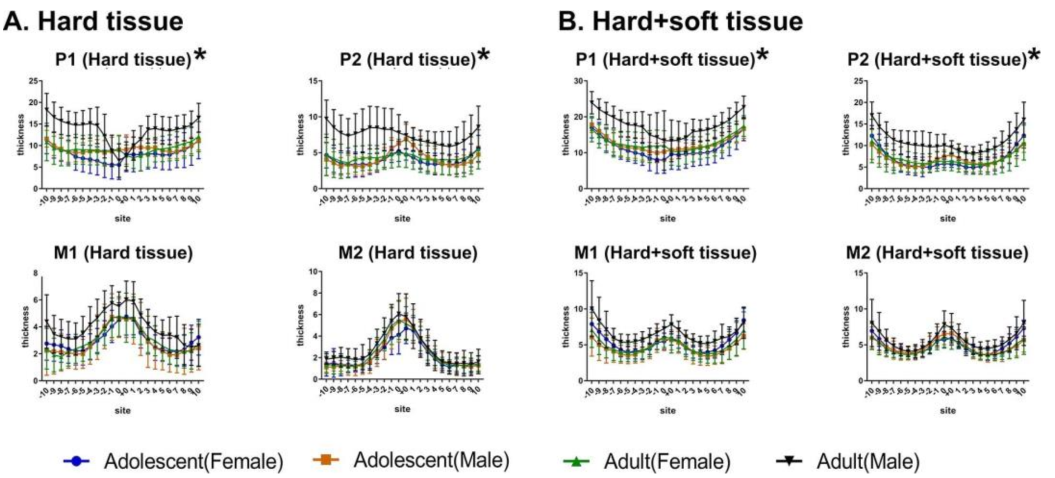


Figure 4. Comparison of the thickness at different planes at the same point in males and females. (A) Hard tissue. (B) Hardþsoft tissue.



Factorial ANOVA revealed that there were age and sex interaction impacts for the hard tissue at the P1 (P 14.007) and P2 (P 14.002) planes for the interactions between age and sex (Figure 5). For both hard and soft tissues, identical results were made (P1: P 14.002; P2: P 14.002). For soft tissues, no associations were discovered, albeit (P.05). In contrast to the other groupings that were comparable to one another (female adults, male adolescents, and female adolescents), male adults had the thickest hard tissue and hard soft tissue.

Figure 5. The interactions between sex and age on palatal tissue thickness. (A) Hard tissue. (B) Hard and soft tissue

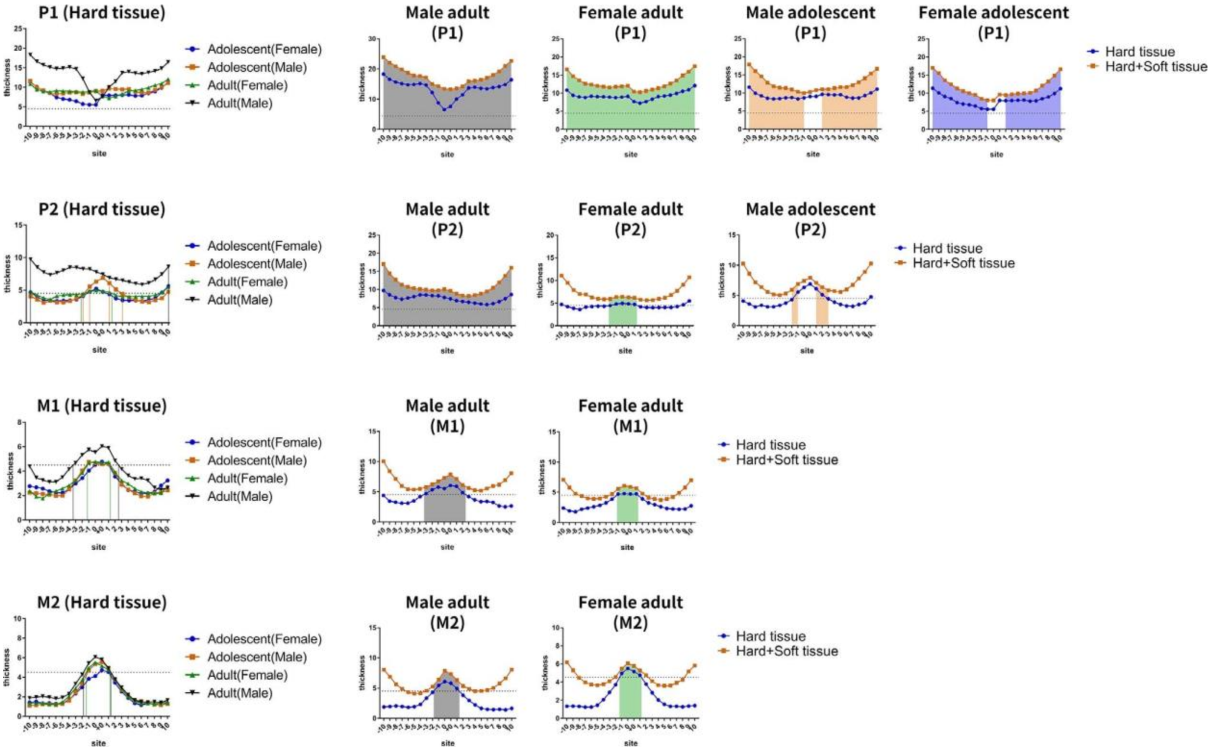


Figure 6. Thickness of hard tissue at different planes for different subgroups (male adults, female adults, male adolescents, and female adolescents). Horizontal dotted lines at the thickness of 4.5 mm are drawn in each diagram, and the resulting colored areas (thickness greater than 4.5 mm) were indicative of recommended palatal regions for mini-implants. Sites near midpalatal sutures of adolescents were avoided in consideration of anatomical factors.

Discussion

In order to find ideal locations for the placement of orthodontic palatal mini-implants, the thicknesses of hard tissue, soft tissue, and hard-soft tissue in the palatal region were measured in this study. The P1 plane's palatal tissues (hard, soft, and hard-soft) were the thickest of all the planes. Age and gender might affect palatal thickness. According to the findings, the P1 plane had the thickest hard tissue and hard-and-soft tissue thicknesses out of the four, followed by the P2, M1, and M2 planes. In accordance with the results of this investigation, Kang et al.[8] observed that the bone thickness reduced laterally and posteriorly. This alteration might be seen as the result of embryonic development. The main palate and the secondary palate are what make up the hard palate during development. The anterior and posterior palates are formed through their fusion during foetal development.9 Due to the quick development of the tongue, vertical thickening of the secondary palate is constrained, making the thickness of the posterior palate significantly thinner.

Similar findings were observed for the hard and soft tissue thickness in the coronal sections, where the thickness of the hard tissue at the P1 plane gradually increased from point 0 to point 10. The palatal thickness (hard and hardsoft tissues) decreased initially for the other planes (P2, M1, and M2) before marginally increasing. These results were in line with earlier research9 that showed lateral palate tissue thickening from the midline. Due to the nasal septum's presence and the bilateral palatal tissues' midpalatal fusion, the midpalatal tissues may be thicker. Mostly due to the presence of alveolar bone and teeth, the lateral sides of the hard palate were thicker. Thus, the areas between the midpalatal regions and the lateral sides were relatively thin, resulting in a V-pattern of the palatal thickness from median to lateral sites.

At the P1 and P2 planes, males' hard tissues and hard soft tissues were thicker than those of females. According to the present findings, several studies[8,10] found that males had considerably thicker palatal bones than females. According to Manni et al.[11], females had a considerably higher likelihood of failure for mini-implants than males, perhaps because to their lower bone density. Among adults and teenagers, there was no discernible difference in the thickness of the palate tissue. Gracco et al.[12] reported no variations in palatal bone thickness between adults and adolescents, which is consistent with these findings. However, Ryu et al[13] found that adolescent bone thickness was considerably lower than adult bone thickness. Different patient selection could be to blame for these erratic results. Although Ryu et al.[13] comprised adolescents with both early and late mixed dentition, patients in the teenage group in the present investigation and the one conducted by Gracco et al.[12] were all in the late stages of the mixed dentition. Mini-implants with insertion depths deeper than 4.5 mm in bone had good success rates, according to a recent study[14]. In order to show the ideal places for palatal mini-screws for the various combinations of sex and age, the preferred regions—hard tissue thickness larger than 4.5 mm—were mapped (Figures 6 through 7). These optimal zones—hard tissue thickness greater than mm and soft tissue thickness less than 2 mm.

Conclusion

In summary, palate thickness reduced in a V-pattern from anterior to posterior and from median to lateral. Age, sex, and their interactions all affected the thickness of the palatal bone. Clinicians are advised to map out the most appropriate and ideal locations for palatal mini-implants.

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