

Assessment of palatal bone thickness in adults with cone beam computerised tomography

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Aims: To determine the most suitable region of the palate for the insertion of miniscrews.

Methods: The subjects were 72 adult patients between 20 and 44 years of age. The thickness of the bony palate was determined with digital volumetric tomography. Bone thickness was measured 4, 8, 16 and 24 mm posterior to the incisive foramen and 0, 3, and 6 mm lateral to the midline of the palate.

Results: The thickest bone was found 4 mm behind and 6 mm lateral to the incisive foramen. The bone thinned progressively from anterior to posterior and from medial to lateral. A median ridge of bone was present in the 8, 16 and 24 mm sections. In these sections the thickest bone was close to the suture.

Conclusion: The hard palate offers several suitable sites for the insertion of miniscrews for orthodontic purposes. The areas behind the incisive foramen and to one side of the median palatal suture have adequate bone for miniscrews.

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Introduction

Miniscrews can be placed in many different intra-oral bony sites. Once placed they can be used immediately, without having to wait for osseointegration. Several studies have been carried out to determine the ideal sites for insertion of the miniscrews.^{1–3}

In the maxilla the palate is considered a suitable site for miniscrews because of its structure and ease of access.^{4–7} With the exception of the incisive canal region, the median and paramedian areas of the palate consist of thick, dense bone capable of supporting one or more miniscrews and orthopaedic loads.⁸ In these areas there are no anatomical structures, such as nerves, blood vessels or dental roots, which may impede the insertion of miniscrews or lead to complications.^{9,10}

The soft tissue in the midline of the palate between the first and second premolars is, on average 3.06 +/- 0.45 mm thick.² The thickness and intrinsic characteristics of the palatal mucosa may enhance the stability of a miniscrew inserted in this area.^{9,10} Early implants for stable anchorage required a flap operation for insertion and removal, could only be placed in the anterior region of the palate and could not be

loaded until osteointegration had occurred.^{5,11–17} Miniscrews have successfully overcome these disadvantages. For example, Kyung et al.¹⁰ successfully used a miniscrew inserted into the median zone of the palate to distalise upper molars, and Lee et al.¹⁸ used palatal miniscrews to intrude teeth. However, miniscrews less than 2 mm in diameter may not be stable in this site.^{19,20}

Miniscrews have a place in facilitating other forms of orthodontic treatment. For example, palatal miniscrews have been used to facilitate distal movement of the anterior teeth in lingual treatment, and have been used with a modified pendulum appliance to distalise the upper teeth.^{21,22} The Graz implant-supported pendulum appliance uses miniscrews and a titanium miniplate to distalise the upper molars.²³

The bone in the anterior region of the midline of the palate is considered an ideal site for insertion of a miniscrew, but there is a lack of detail about the thickness of palatal cortical bone antero-posteriorly and medio-laterally, particularly in adults.^{11,24} In the present study we aim to use cone beam technology to determine the thickness of the palatal bone at four levels posterior to the incisive foramen. At each level

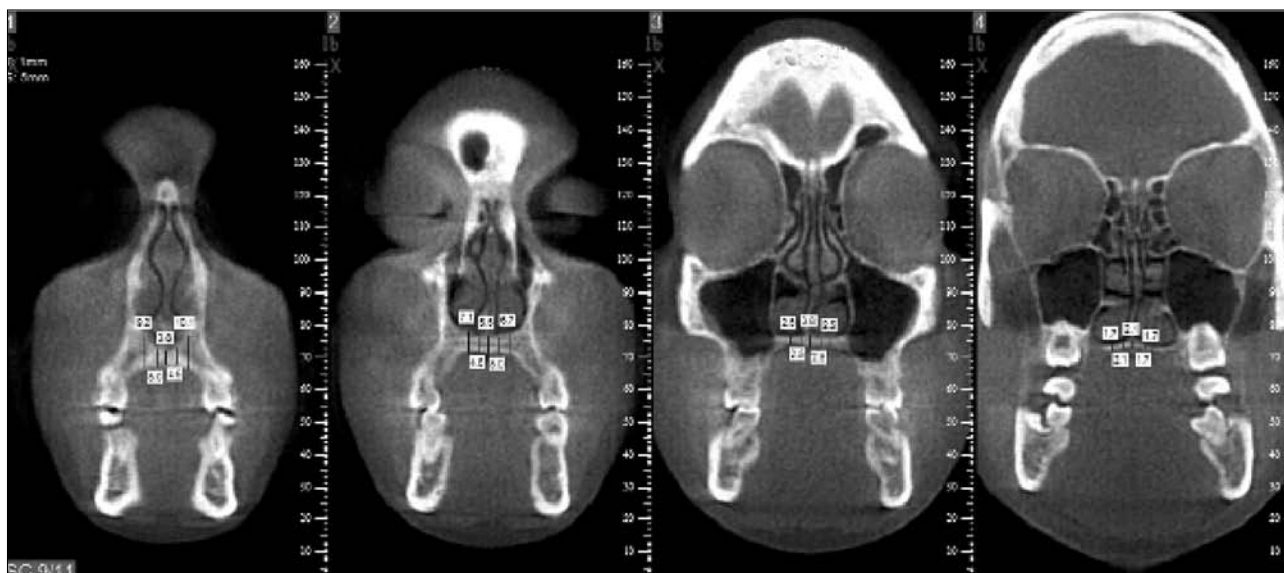


Figure 1. Paracoronal sections 4, 8, 16 and 24 mm posterior to the incisive foramen.



Figure 2. Rendering of a 16 mm paracoronal view.

bone thickness will be measured at the suture 3 and 6 mm on both sides of and at right angles to the median palatal suture.

Material and methods

The digital volumetric tomograms of 72 healthy adults (34 males, 38 females), between 20 and 44 years of age, were randomly selected from the files held in the Postgraduate School of Orthodontics of the University of Ferrara. We excluded subjects with craniofacial malformations and/or syndromes, individuals with a history of facial trauma and those who had undergone surgery to the facial structures.

Data were obtained using the Newtom 3G Volume Scanner QRsr1 Verona, a cone beam X-ray machine. Images obtained from this scanner have the advantages of sufficient detail and a lesser radiation dosage

when compared with a conventional CT.^{25–26} The settings used were: 12 inch field of view, 110 kVp (AP-LL), 2.00 mA (AP) e 1.00 mA(LL), exposure time 5.4 s, slice thickness 0.50 mm.

Using the NNT Newtom 3G software, we identified the incisive foramen on the axial section of the upper jaw for each subject. Paracoronal views of the palatal region were reconstructed at 4, 8, 16 and 24 mm posterior to the incisive foramen. Measurements of the bone height were then made at the median palatal suture, and 3 mm and 6 mm on both sides of and at right angles to the suture (Figures 1 and 2). Twenty measurements for each patient were made on the computer display monitor with the Newtom 3G measurement software. The measurements of palatal height in 27 patients were carried out by two different investigators.

The method error was determined with Dahlberg's formula and the systematic error with the Student's *t*-test, where $p < 0.05$ was considered significant. On average, the method errors of the measurements at the suture were 0.54 ($p = 0.062$), 3 mm on right and left sides of the suture it was 0.55 mm ($p = 0.478$) and 0.43 mm ($p = 0.654$) respectively, and 6 mm on the right and left sides of the suture it was 0.57 mm ($p = 0.116$) and 0.54 mm ($p = 0.152$) respectively. No statistically significant difference was found in any of these cases.

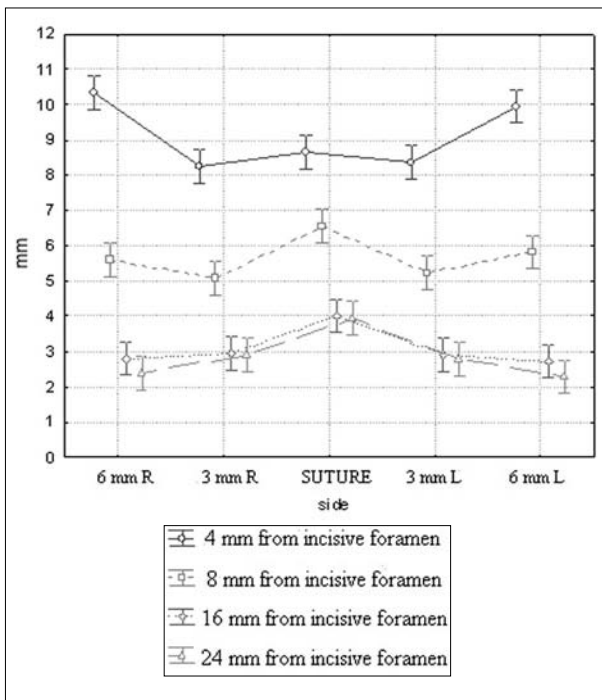


Figure 3. The mean palatal bone thicknesses at different distances from the incisive foramen (4, 8, 16 and 24 mm) and 0, 3 and 6 mm on both sides of the suture. The vertical bars denote 0.95 confidence intervals.

Taking into account that the distribution of the sample was not normal or symmetrical, the Kruskal-Wallis test was used to highlight any differences within the sample in relation to side (right/left), distance from the midline (3 mm/6 mm), or linked to the different sections/levels (4, 8, 16 and 24 mm from the incisive foramen).

Results

The means and the standard deviations of palatal bone thickness in the sample are reported in Table I and Figure 3. Considerable variation in bone thickness was found at all sites. There were no statistically significant differences in the thickness of palatal bone in the male and female patients.

Bone thickness – antero-posteriorly

The bone in the midline of the palate was, on average, 8 mm thick 4 mm behind the incisive foramen. The midline bone thickness fell, on average, to 6–7 mm 8 mm behind the foramen and to 5–6 mm 16 and 24 mm behind the foramen. The thickness of the bone 6 mm and 3 mm on the left and

right sides of the suture also thinned as the sections moved from anterior to posterior. Considerable variation in bone thickness was found in all sections. For example, in one subject there was 6 mm of bone (6 mm to the left) in the 24 mm section and at the same site in another subject the bone was only 1 mm thick.

At the suture, no significant differences in mean bone thickness were found between the 4 mm and the 8 mm paracoronal sections or between the 16 and 24 mm paracoronal sections. Bone in the former two sections was, on average, thicker than the bone in the latter two sections.

Bone thickness – medio-laterally

The mean palatal bone thicknesses calculated for each section (4, 8, 16 and 24 mm from the incisive foramen) at 3 and 6 mm to the right and left of the suture were compared using the Kruskal-Wallis test. No significant differences were found between the left and the right sides of the palate.

We compared bone thickness at the suture and 3 mm and 6 mm to the right and left of the suture in each patient and in each paracoronal section of the palate using the Kruskal-Wallis test. In the sample we found that the bone at the suture in the 24 mm section was significantly thicker than that found at 6 mm on the right and left sides of the suture. In all other cases the bone at the suture was not significantly thicker than the bone 3 mm and 6 mm on the right and left sides of the suture.

We also compared the thickness bone 3 mm to the left of the suture with that found at 6 mm to the left of the suture in each section (4, 8, 16 and 24 mm) in each patient, and then repeated the comparisons for the right side of the palate. No statistically significant differences were found.

Discussion

To understand how the morphology of the palate changes antero-posteriorly and medio-laterally we measured the thickness of the cortical bone in four paracoronal sections (4, 8, 16, and 24 mm from the incisive foramen) taken with a cone beam X-ray machine. The thickest bone (approximately 1 cm) was found in the most anterior and lateral sites, that is 4 mm behind the incisive foramen and 6 mm lateral to median palatal suture. Although the bone thinned

Table 1. Palatal bone thickness.

Distance from median suture	Distance from incisive foramen (mm)	Mean	SD	Min	Max
6 mm R	4	10.4	3.24	3.8	18.9
	8	5.6	2.38	1.7	11.3
	16	2.8	1.01	1.3	5.9
	24	2.4	0.87	0.8	5.0
3 mm R	4	8.3	3.04	2.9	16.4
	8	5.1	1.89	1.7	10.2
	16	2.9	0.85	1.7	6.7
	24	2.9	1.27	1.3	6.9
Suture	4	8.7	3.16	2.9	17.2
	8	6.6	2.03	2.5	10.9
	16	4.0	1.36	1.7	8.0
	24	3.9	1.66	1.3	8.5
3 mm L	4	8.3	2.88	2.8	16.4
	8	5.2	2.05	1.7	10.4
	16	2.9	1.26	0.8	6.7
	24	2.8	1.19	1.3	5.9
6 mm L	4	10.0	3.16	3.4	19.3
	8	5.8	2.13	1.7	11.0
	16	2.7	1.23	1.2	7.6
	24	2.3	0.91	1.0	6.3

progressively from anterior to posterior and from medial to lateral, a marked ridge of bone was left in the vicinity of the suture. This median ridge of bone was 6–7 mm thick 8 mm behind the foramen, but only 4 mm thick in the 16 and 24 mm sections. The bone in the most lateral sites (i.e. 6 mm lateral to the median palatal suture) also thinned progressively from anterior to posterior and from medial to lateral. Bone thickness fell from approximately 1 cm in the 4 mm paracoronal section, to 5–6 mm in the 8 mm section, to 2–3 mm in the 16 and 24 mm sections.

Our findings agree with and extend the work reported by previous studies of palatal bone thickness in children and adolescents.^{2,27–29} In our previous study, we measured the thickness of the palatal bone in paracoronal sections in patients between 10

and 15 years of age.²⁸ In agreement with our present findings we found that the thickest bone in children and adolescents was in the most anterior part of the palate 6 mm to the right and left of the median palatal suture. While the bone in the posterior region of the palate was markedly thinner it is in the form of two plates of bone. The overlying mucosa in this area is also thinner. Because of these factors this area can support an appropriately sized miniscrew.

The length of a miniscrew is thought to be an important factor in screw stability. In the anterior region of the palate, miniscrews with a functional (threaded) part of approximately 10 mm can be used, although we found in some individuals the bone in this area was very thin. Eight millimetres behind the incisive foramen, the functional part can, on average, be at least 8 mm in length, while in the posterior part of the palate (16–24 mm from the incisive foramen) 4–5 mm miniscrews can be used in some individuals. The length of a miniscrew should also take into account the thickness of the palatal mucosa, which is thickest in the mid-palatal suture area 4 mm behind the incisive papilla. Moving posterior from the papilla the mucosa is consistently 1 mm thick, which is a favourable thickness for a miniscrew.²⁷

This study highlights the importance of selecting the correct length of miniscrew so that both cortical plates are engaged by the screw and the nasal cavity is not penetrated. To ensure that screws do not loosen it has been suggested that the diameter of a palatal screw should be no less than 2 mm.²⁰ Miniscrews with smaller diameters (1.2–1.3 mm) may be justified if they are to be placed in inter-radicular alveolar bone where there is a risk of damage to the roots of the teeth. However, in the midpalate there are no blood vessels, nerves and other structures likely to interfere with insertion or cause complications when large diameter miniscrews are used.

There is a general consensus that the suture, despite being one of thickest sites in the palate, is not suitable for insertion of miniscrews due to incomplete calcification. Even in adult subjects the possibility exists that connective tissue in the suture might become interposed between a screw and the surrounding bone and cause the screw to loosen.^{4–8} The sites adjacent to the suture offer better sites for placement of miniscrews. The greater density and resistance of the bone adjacent to the suture compensates for the thinner bone found posteriorly and laterally.

Conclusions

Although the bone forming the palate thins progressively from anterior to posterior and from medial to lateral, the bone in the posterior part of the palate is suitable for the insertion of screws of appropriate diameter and length. The bone in the latter site is laid down in the form of two plates.

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