

Quantitative cone-beam computed tomography evaluation of palatal bone thickness for orthodontic miniscrew placement

Antonio Gracco,^a Luca Lombardo,^b Mauro Cozzani,^c and Giuseppe Siciliani^d

Ferrara, Italy

Introduction: The purpose of this study was to evaluate the 3-dimensional thickness of the palate to determine the best location to place miniscrews. **Methods:** We selected digital volumetric tomographs from 162 healthy subjects, aged 10 to 44 years (80 male, 82 female). The sample was divided into 3 groups. Group A included 52 subjects (ages, 10-15 years; 28 boys, 24 girls); group B included 38 subjects (ages, 15-20 years; 18 males, 20 females), and group C had 72 subjects (age, 20-44 years; 34 men, 38 women). Ninety-degree paracoronal views of the palatal region at 4, 8, 16, and 24 mm posterior to the incisive foramen were reconstructed, and bone height was measured laterally from the midline in each reconstruction at 0-, 3-, and 6-mm increments to describe the topography of the palate. Measurements of palatal height in 27 of the 162 patients were made by 2 different investigators. Method error was calculated according to the Dahlberg formula ($S^2 = \Sigma d^2/2n$), and systematic error was evaluated with the dependent Student *t* test, with $P < 0.05$ considered significant. **Results:** The thickest bone (4-8 mm) was found in the anterior part of the palate, at the suture and in the paramedian areas, but the posterior region, despite its reduced thickness, is also suitable for miniscrews. The Kruskal-Wallis test showed no significant differences between the groups in the various palatal sections (median suture, 3 and 6 mm to the right and left of the suture) except between groups A and C in the 16-mm paracoronal section at 6 mm to the right and left of the suture. There were no statistically significant differences due to sex or between the right and left sides of the palate. **Conclusions:** The anterior region is the thickest part of the palate, but the bone thickness in the posterior region is also suitable for screws of appropriate diameter and length. (Am J Orthod Dentofacial Orthop 2008;134:361-9)

Recently, the use of miniscrews has become widespread and common in orthodontic practice. Their application has increased the viability of skeletal anchorage, thanks to their suitability for positioning in many areas of the alveolar bone, and because they lend themselves to immediate use, without osteointegration. The introduction of immediately loadable miniscrews has further expanded their therapeutic potential.

Several studies have been carried out to discover and evaluate ideal sites for the placement of miniscrews; most of these have indicated the suitability of the palate.¹⁻³ In all probability, the palatal bone is the most suitable site for

miniscrew placement because of its histomorphology and the ease of placing miniscrews in this area.⁴⁻⁸

With the exception of the incisive canal region, the median and paramedian areas of the palate consist of cortical bone, which is thick and dense enough to support at least 1 miniscrew and can sustain orthopedic loads. This area has the obvious advantage of no anatomical structures, such as nerves, blood vessels, or roots that can impede the placement of miniscrews.^{9,10}

Furthermore, the thickness of the soft tissue of the median palate between the first and second premolars is, on average, 3.06 ± 0.45 mm.² This thickness, with the intrinsic characteristics of the palatal mucosa, guarantees biomechanical stability for placement of miniscrews.^{9,10}

In the past, this site was used for implants for orthodontic anchorage, although the methods of placement and removal were rather complicated and time consuming, as well as costly for the patient because they required surgical intervention.¹¹⁻¹⁵ In these cases, the only suitable placement site was the anterior region of the maxilla, and it was also necessary to wait for osteointegration of the implant before applying a load.^{5,16,17}

From the University of Ferrara, Ferrara, Italy.

^aVisiting professor, Department of Orthodontics.

^bResearch assistant, Department of Orthodontics.

^cAdjunct professor, Department of Orthodontics.

^dChairman, Department of Orthodontics.

Reprint requests to: Antonio Gracco, Department of Orthodontics, University of Ferrara, Via Montebello 31, 44100 Ferrara, Italy; e-mail, antoniogracco@gmail.com.

Submitted, October 2006; revised and accepted, January 2007.

0889-5406/\$34.00

Copyright © 2008 by the American Association of Orthodontists.

doi:10.1016/j.ajodo.2007.01.027

Recently, however, palatal skeletal anchorage has been achieved with miniscrews. In 2003, Kyung et al¹⁰ successfully used a miniscrew in the median zone of the palate for distalization of the maxillary molars. Lee et al,¹⁸ in 2004, used miniscrews in the palate for intrusion, and Melsen¹⁹ indicated the palate as a possible site for miniscrew placement in 2005, although Carano et al²⁰ asserted that miniscrews with a diameter of less than 2 mm in the palate do not guarantee total stability.

In 2006, Park²¹ used a palatal miniscrew to move the whole frontal group back in an orthodontic lingual treatment, and Kircelli et al²² modified a pendulum for molar distalization with a miniscrew placed palatally in the premaxillary region, obtaining rapid distalization without loss of anchorage.

In 2005, Kinzinger et al²³ described the Graz implant-supported pendulum, in which skeletal anchorage is guaranteed by 2 components: an internal component consisting of a titanium miniplate with 2 solder-fitted pins fixed to the bone with 4 screws, and an external component of a modified pendulum appliance.

Yildizhan²⁴ studied 22 specimens of the human hard palate to compare vertical height in the sagittal and transverse dimensions, and found the highest point of 8.08 mm in the anterior median region. This author also documented a reduction of 3.34 mm in the paramedian region, 3 mm to the left and right of the median line. The mean height of the palate decreases from the front to the back, and from the median to the paramedian regions, thereby indicating the anterior median region as the ideal site for placement. This study also highlighted that miniscrew placement in the median region is preferable in adults, citing calcified median sutures in the paramedian region in growing patients.¹¹

In this study, we attempted to discover the most suitable region of the palate for miniscrew placement. We analyzed the digital volumetric tomographs of 162 patients aged from 10 to 44 years and measured the thickness of the palatal bone at 20 sites.

MATERIAL AND METHODS

We selected digital volumetric tomographs from 162 healthy subjects (80 male, 82 female). We excluded those with craniofacial malformations or syndromes, and those who had suffered trauma or undergone surgery to the stomatognathic apparatus. The sample was divided into 3 groups by age. Group A (ages, 10-15 years) included 52 subjects (28 boys, 24 girls), group B (ages, 15-20 years) consisted of 38 subjects (18 males, 20 females), and group C (ages, 20-44 years) comprised 72 subjects (34 men, 38 women).

Our data were obtained by using a 3D volume scanner (QR Verona, Newtom 3G, Verona, Italy) based on a cone-beam technique that uses x-ray emissions efficiently, thus reducing the dose absorbed by the patient.¹ The following settings were used: field of view, 12 in; 110 kV (anterio posterior-latero lateral), 2.00 mA (anterio posterior), and 1.00 mA (latero lateral); exposure time, 5.4 seconds; and slice thickness, 0.50 mm.

Using Newtom 3G software, we initially identified the buccal incisive foramen of each patient from an axial section of the maxilla.

Ninety-degree paracoronal views of the palatal region were reconstructed at 4, 8, 16, and 24 mm posterior to the incisive foramen, and measurements of bone height were made in each reconstruction at 0-, 3-, and 6-mm increments laterally from the median suture to describe palatal morphology (Figs 1 and 2).

A total of 3240 measurements, 20 for each of the 162 patients, were recorded, and each measurement was displayed on a computer monitor with the Newtom software. The means and standard deviations of the measurements were then calculated.

The measurements of palatal height in 27 patients were made by 2 different investigators. The method error (ME) was evaluated according to Dahlberg's formula ($S^2 = \Sigma d^2/2n$),²⁵ and the systematic error was calculated with the dependent Student *t* test, with $P < 0.05$ considered significant.

On average, the ME of the measurements at the suture was 0.54 ($P = 0.062$), whereas the ME of the measurements at 3 mm to the right of the suture was 0.55 ($P = 0.478$), and, at 6 mm to the right, the ME was 0.57 ($P = 0.116$).

For the measurements at 3 mm to the left of the suture, the ME was 0.43 ($P = 0.654$), and, for those at 6 mm to the left, the ME was 0.54 ($P = 0.152$).

No statistically significant difference was found in any of these cases.

Statistical analysis

The mean and standard deviation of every measurement were calculated for each paracoronal view.

Because the distribution of the sample was not normal or symmetrical, the Kruskal-Wallis test was used not only to highlight any differences in each age group (10-15, 15-20, and 20-44 years) in relation to sex (male or female), side (right or left), distance from the midline, or linked to the various sections (4, 8, 16, and 24 mm from the incisive foramen), but also to show any age-related differences between the groups.

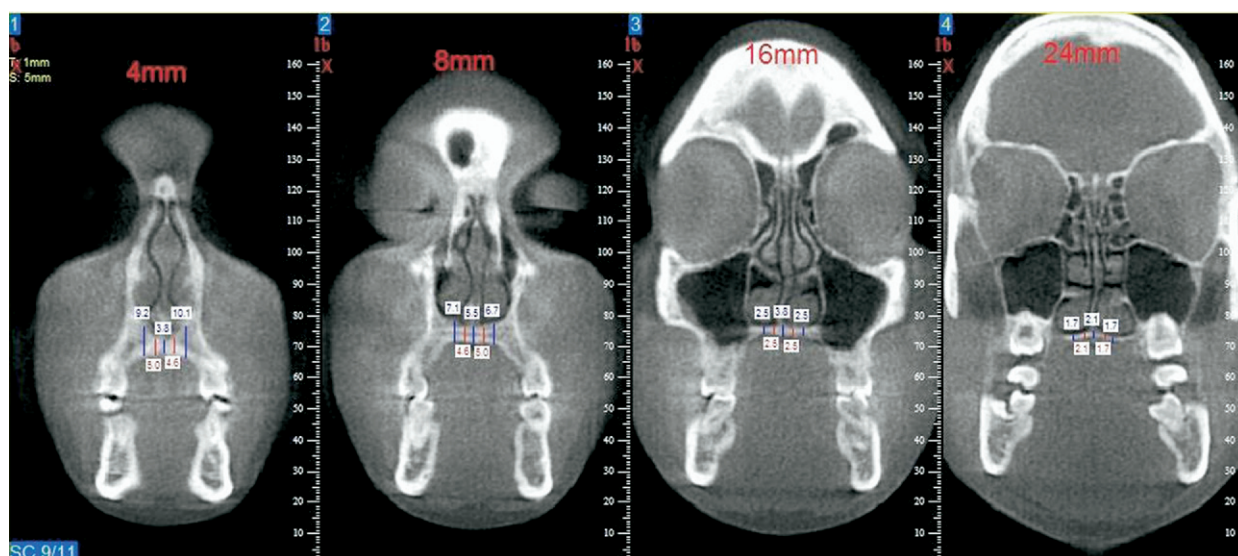


Fig 1. Paracoronal views at 4, 8, 16, and 24 mm posterior from the incisal foramen, and bone height measurements at 0-, 3-, and 6-mm increments laterally from the midline.

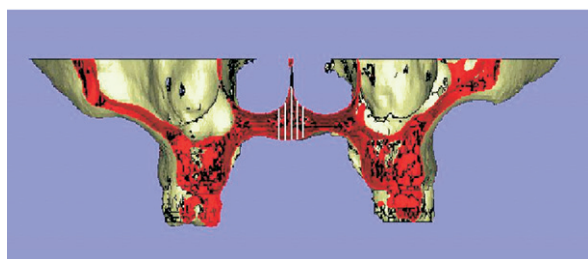


Fig 2. Rendering of 16-mm paracoronal view.

RESULTS

The mean values and the standard deviations of the measurements of palatal bone thickness in the 3 groups are given in [Tables I, II, and III](#).

The data were then used to compare the 3 groups and to evaluate the differences between the measurements in the paracoronal sections of each group.

Comparison of all the mean measurements (6 mm to the right, 3 mm to the right, suture, 3 mm to the left, and 6 mm to the left of the suture) in group A with those for group B failed to indicate any differences between the paracoronal sections considered, and the mean values for group A differed significantly from those of group C only at 6 mm from the left and right of the suture for the measurements in the paracoronal section at 16 mm ([Table IV](#)).

We then compared the mean bone thicknesses at the various paracoronal sections in the 3 groups of our sample.

In group A, the means of the palatal bone thickness ([Fig 3](#) and [Table I](#)) and the *P* values associated with the nonparametric Kruskal-Wallis test led us to conclude that, at 3 and 6 mm to the left and right of the suture, the mean bone thicknesses registered in the 4-mm paracoronal section were significantly greater than those in the 8-mm section. The mean bone thicknesses in the 16- and 24-mm sections were significantly less than those measured at 4 and 8 mm from the incisive foramen, but no significant differences were found in the mean thicknesses at the suture between the 4- and 8-mm paracoronal sections (9.03 vs 6.51 mm), or between the 16- and 24-mm (4.91 vs 4.62 mm) sections.

At the suture, the measurements in the 4- and 8-mm paracoronal sections were significantly greater with respect to the 16- and 24-mm sections ($P = 0.0000$).

In group B, at 6 mm to the left and right of the median suture ([Fig 4](#) and [Table II](#)), the mean thicknesses in the 4-mm paracoronal section were significantly greater than those in the 8-mm paracoronal section, although no significant differences were found between the 16- and 24-mm sections.

The mean thicknesses at 16 and 24 mm were, however, significantly less than those measured at 4 and 8 mm from the incisive foramen.

At 3 mm to the left and right of the suture, the mean thicknesses at 4 mm were not significantly different from those at 8 mm from the incisive foramen; no significant differences were found between the mean palatal bone thicknesses at 16 and 24 mm from the foramen, but these

Table I. Statistical analysis of palatal bone thicknesses at 4, 8, 16, and 24 mm from the median suture in the 52 patients of group A (the distance from the suture and the paracoronal section at which the values were taken are given in the first 2 columns, respectively)

Side and distance from median suture	Distance from incisive foramen (mm)	Mean	SD	Minimum	Maximum	Median
6 mm right	4	10.27692	3.002784	5.100000	16.10000	10.55000
	8	6.12308	2.475022	2.500000	12.80000	5.70000
	16	3.61538	1.540993	1.000000	8.00000	3.65000
	24	2.92308	1.040666	1.300000	5.90000	2.50000
3 mm right	4	8.61154	2.769417	4.000000	14.80000	8.40000
	8	5.83846	2.059045	2.500000	11.30000	5.50000
	16	3.84615	1.216143	2.000000	7.60000	3.80000
	24	3.35000	0.851872	1.700000	5.00000	3.40000
Suture	4	9.03846	2.435775	5.500000	14.80000	8.75000
	8	6.51346	1.718073	3.800000	10.10000	6.30000
	16	4.90769	1.288386	2.500000	7.70000	4.65000
	24	4.62692	1.464095	2.500000	10.10000	4.60000
3 mm left	4	8.77250	2.637749	4.500000	15.50000	8.35000
	8	5.54231	2.264850	2.400000	10.70000	5.00000
	16	3.46154	1.150133	1.300000	6.70000	3.40000
	24	3.18077	0.897499	1.400000	4.90000	3.10000
6 mm left	4	10.36923	3.085738	5.000000	18.50000	9.75000
	8	6.28269	2.115371	2.500000	11.80000	5.95000
	16	3.56154	1.370008	1.700000	8.40000	3.50000
	24	2.88846	0.919218	1.100000	4.60000	2.90000

Table II. Statistical analysis of the palatal bone thickness at 4, 8, 16, and 24 mm from the median suture in the 38 patients in group B (the distance from the suture and the paracoronal section at which the values were taken are given in the first 2 columns, respectively)

Side and distance from median suture	Distance from incisive foramen (mm)	Mean	SD	Minimum	Maximum	Median
6 mm right	4	9.92368	2.908369	5.000000	18.90000	9.70000
	8	5.24474	2.333273	1.300000	12.80000	4.95000
	16	2.81053	1.115442	1.300000	6.40000	2.50000
	24	2.26316	0.957593	1.300000	5.90000	2.05000
3 mm right	4	8.40000	3.008816	3.800000	17.90000	7.75000
	8	5.24211	2.366390	2.100000	13.00000	4.75000
	16	2.96053	1.103199	1.500000	6.30000	2.70000
	24	2.99211	1.272024	1.500000	7.10000	2.50000
Suture	4	8.76842	3.086860	3.800000	17.60000	8.05000
	8	6.66316	1.962819	3.800000	13.00000	6.30000
	16	4.08158	1.063359	2.100000	6.30000	3.80000
	24	4.06579	1.667540	1.200000	8.40000	3.95000
3 mm left	4	8.60000	2.976484	4.600000	17.20000	7.90000
	8	5.52632	2.471971	1.700000	14.30000	5.00000
	16	3.08421	1.188350	1.300000	5.90000	2.95000
	24	2.73947	0.883953	1.300000	4.60000	2.70000
6 mm left	4	10.34474	2.905698	5.900000	19.20000	9.80000
	8	5.92632	2.737989	2.100000	15.10000	5.50000
	16	2.89737	0.904788	1.300000	5.00000	2.70000
	24	2.41316	0.852713	1.500000	4.60000	2.10000

means were significantly lower than those measured in the 4- and 8-mm paracoronal sections.

In group B, no significant differences were observed in the mean thickness registered at the suture

between the 4- and 8-mm paracoronal sections or between the 16- and 24-mm sections, but the measurements at 4 and 8 mm from the incisive foramen were greater than those at 16 and 24 mm.

Table III. Statistical analysis of the palatal bone thickness at 4, 8, 16, and 24 mm from the median suture in the 72 patients in group C (the distance from the suture and the paracoronal section at which the values were taken are given in the first 2 columns, respectively)

Side and distance from median suture	Distance from incisive foramen (mm)	Mean	SD	Minimum	Maximum	Median
6 mm right	4	10.35556	3.245404	3.800000	18.90000	10.45000
	8	5.60417	2.379101	1.700000	11.30000	5.55000
	16	2.81528	1.009764	1.300000	5.90000	2.50000
	24	2.39167	0.865578	0.800000	5.00000	2.15000
3 mm right	4	8.25972	3.037821	2.900000	16.40000	7.60000
	8	5.07639	1.887952	1.700000	10.20000	4.80000
	16	2.93333	0.853493	1.700000	6.70000	2.90000
	24	2.92083	1.271457	1.300000	6.90000	2.50000
Suture	4	8.66389	3.155737	2.900000	17.20000	8.00000
	8	6.55694	2.028725	2.500000	10.90000	6.00000
	16	4.02361	1.364489	1.700000	8.00000	3.75000
	24	3.93472	1.664980	1.300000	8.50000	3.80000
3 mm left	4	8.35000	2.880581	2.800000	16.40000	8.45000
	8	5.22917	2.049077	1.700000	10.40000	4.60000
	16	2.90972	1.262811	0.800000	6.70000	2.50000
	24	2.79306	1.187295	1.300000	5.90000	2.50000
6 mm left	4	9.95556	3.157370	3.400000	19.30000	10.10000
	8	5.82639	2.128412	1.700000	11.00000	5.80000
	16	2.72222	1.231193	1.200000	7.60000	2.50000
	24	2.28889	0.913522	1.000000	6.30000	2.00000

Table IV. Comparison of the differences between the mean palatal bone thicknesses of each group (group A, 10-15 years; group B, 15-20 years; group C, 20-44 years) at each paracoronal section (4, 8, 16, and 24 mm)

Section	Differences in mean palatal bone thicknesses between groups A and B	Differences in mean palatal bone thicknesses between groups A and C	Differences in mean palatal bone thicknesses between groups B and C
4 mm	NS	NS	NS
8 mm	NS	NS	NS
16 mm	NS	Statistically significant differences at 6 mm to the right and left of the suture	NS
24 mm	NS	NS	NS

NS, Not significant.

In group C (Fig 5 and Table III), the mean bone thicknesses at 6 and 3 mm to the left and right of the suture were significantly greater in the 4-mm paracoronal section than in the other sections. The mean bone thicknesses in the paracoronal section at 8 mm from the incisive foramen were not different from those in the 16-mm paracoronal section but were greater than those at 24 mm. The mean bone thicknesses in the 24-mm section were less than those in the other sections.

At the suture, no significant differences in mean bone thickness were found between the 4- and 8-mm paracoronal sections or the 16- and 24-mm paracoronal sections, but the former 2 sections were thicker than the latter 2, although only the mean thicknesses measured 8 mm from the incisive foramen were significantly greater than those in the 24-mm section.

In each patient group, 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 by using the Kruskal-Wallis test; no significant differences were found between the left and right sides of the palate.

Comparison of the mean palatal bone thicknesses by sex in each group yielded no statistically significant difference.

We compared the thickness at the suture and at 3 and 6 mm to the right and left of the suture in each group and in each paracoronal section of the palate using the Kruskal-Wallis test. In the 24 mm section, we found that the thicknesses at the suture in groups A and C were significantly greater than at 6 mm from the

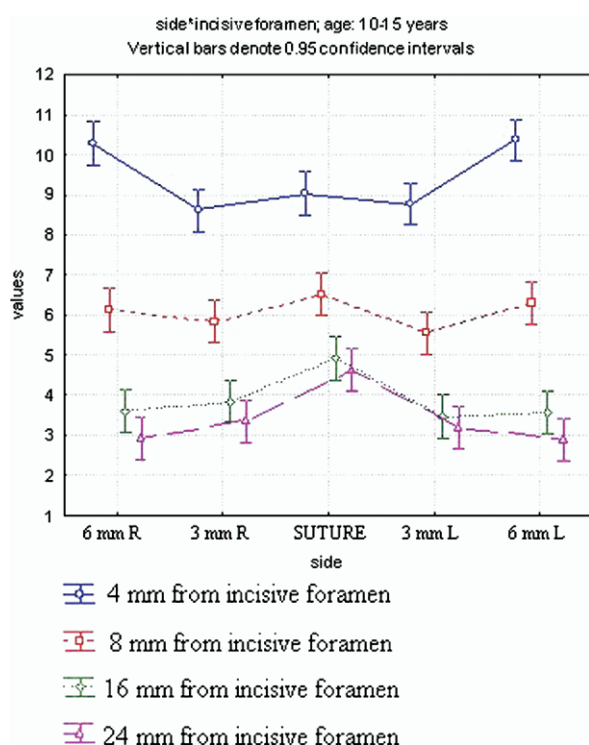


Fig 3. Mean palatal bone thicknesses left and right of the suture compared at 4, 8, 16, and 24 mm from the incisive foramen in group A. Vertical bars denote 0.95 CI.

suture on either side. In all other cases, the thickness at the suture was not significantly different from the measurements at 3 and 6 mm to the left and right of the suture.

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

DISCUSSION

The palate is a high-density bone structure with sufficient bone height (from the midpalatal suture to the cresta nasalis); it is a good location for orthodontic screw placement.²⁶ As for the type of screws to be used in this area, Block and Hoffman²⁷ suggested a subperiosteal disc of 10 mm in diameter, whereas Wehrbein et al,⁶⁻⁸ who studied maximum bone height at the midpalatal suture area for placing orthodontic screws without perforating the nasal cavity, recommended small diameter (3.3 mm), short to medium length (4-6 mm) screws. These studies showed that the midpalatal suture can be reliably used to place orthodontic screws

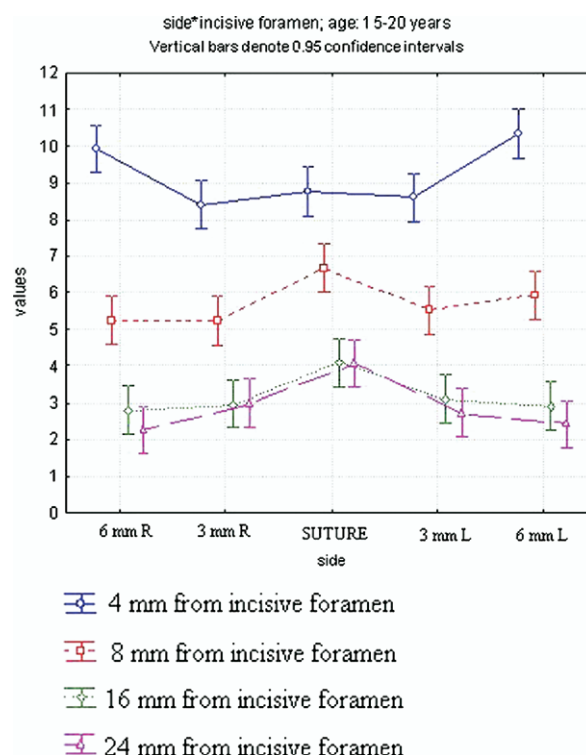


Fig 4. Mean palatal bone thicknesses left and right of the suture compared at 4, 8, 16, and 24 mm from the incisive foramen in group B. Vertical bars denote 0.95 CI.

with at least 2 mm of additional bone height (estimated from lateral cephalograms).

In a previous study, we analyzed palatal bone thickness at 4 paracoronal sections in young patients aged 10 to 15 years and concluded that the thickest part of the palate is the anterior, but bone thickness in the posterior region of the palate is also suitable for screws of appropriate thickness.²⁸

Because digital volumetric tomography is the best tool for studying palatal bone thickness and for understanding which parts are suitable for miniscrew insertion, we analyzed digital volumetric tomography images from patients in various age groups.

We found no significant differences between the different age groups in the various palatal sections (4, 8, 16, and 24 mm from the incisive foramen) at the suture, or at 3 and 6 mm to the right and left of the median suture, except between groups A and C in the 16-mm paracoronal section at 6 mm to the right and left of the suture. This indicates that there were no great differences between the 3 groups, even with their different ages.

This finding agrees with the literature, in which

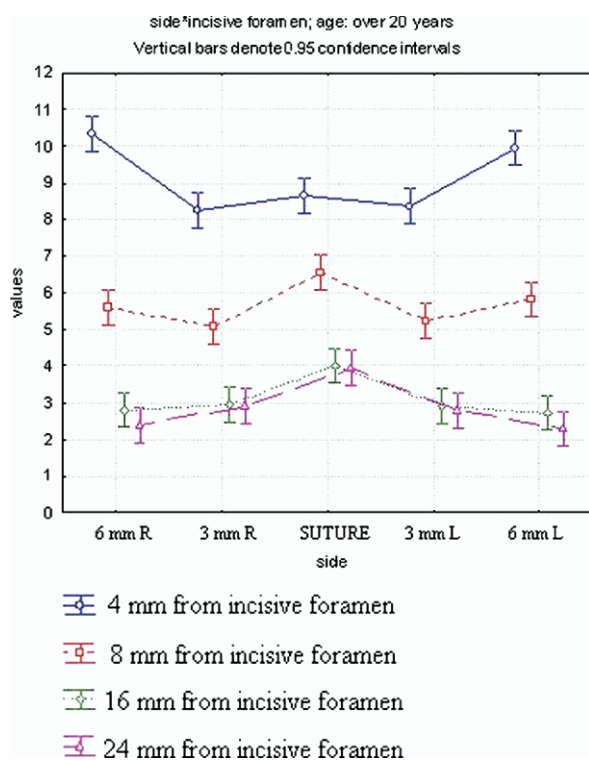


Fig 5. Mean palatal bone thicknesses left and right of the suture compared at 4, 8, 16, and 24 mm from the incisive foramen in group C. Vertical bars denote 0.95 CI.

only 3 studies used digital volumetric tomography to analyze palatal bone thickness in depth, although none of those studies can be considered conclusive.^{2,28,29} King,²⁹ in spite of a large sample (183 patients), only considered patients in a limited age range (ages, 10-19), as did Gracco et al,²⁸ who studied only patients 10 to 15 years of age. The findings of Costa et al,² on the other hand, were derived from the study of only a few patients. Our research, therefore, was proposed to complete the picture for palatal bone thickness over various age ranges (10-44 years). In contrast to the previous studies, this approach permitted us to determine whether the morphology of the palate changes with age, since orthodontics is not used exclusively in growing patients but also in adults in whom miniscrew treatment is particularly indicated.

To understand how the morphology of the palate changes at increasing distances from the incisive foramen, we compared measurements taken in 4 paracoronal sections (4, 8, 16, and 24 mm from the incisive foramen) and found that the measurements at 3 and 6 mm to the left and right of the suture in groups A and B were similar; the thicknesses in the paracoronal

sections at 16 and 24 mm in each group did not differ significantly. The palatal bone in the 4-mm section was always thicker than in the 8-mm section, except in group B, with similar bone thickness at 3 mm to the left and right in the 4- and 8-mm sections. Thus, to the left and the right sides of the suture, the thickest part is almost always in the 4-mm section, and palatal thickness tends to progressively decrease from the foramen toward the 16- and 24-mm sections, where bone thickness remains constant. Group C differed from the other groups at 3 and 6 mm to the left and right of the suture; bone thicknesses at 4 mm were greater than all the others, but the bone thickness at 24 mm was less than the others. The thicknesses in the 8- and 16-mm sections were, however, similar. This indicates that the thickest part of the palate in group C was always at 4 mm from the incisive foramen, and that bone thickness tends to progressively decrease, despite, in this case, remaining constant between 16 and 24 mm from the incisive foramen and decreasing again at 24 mm.

At the suture, no difference in bone thickness was found between the 3 groups. The mean thicknesses in the 4 and 8 mm paracoronal sections were not significantly different, and neither were those in the 16- and 24-mm sections. Overall, the mean thicknesses measured at 4 and 8 mm from the incisive foramen were always higher than those in the 16- and 24-mm sections in groups A and B, whereas the thicknesses at 8 and 16 mm in group C were similar, unlike in the other 2 groups.

In the transverse direction, no significant difference was noted in bone thickness at the suture or at 3 and 6 mm from the suture, except for the 24-mm section for groups A and C. These conclusions agree with those already reported in the literature that the palate is the site of choice for miniscrew placement.¹⁰ In particular, the greatest bone thicknesses were found in the anterior part of the palate (4-8 mm), both at the suture and at the paramedian areas.

In the posterior region, despite the reduction in thickness, the bone is also suitable for miniscrews, guaranteeing their stability because of the quality of the (double cortical) bone and the reduced thickness of the mucosa that covers it.

There is, however, a general consensus that the suture, despite being one of thickest sites in the various sections of the palate, is not suitable for miniscrews because of incomplete calcification, even in adults and the possibility of interposition of connective tissue between the screws and the bone, which would reduce primary stability.⁴⁻⁸

Therefore, because the reduced bone thickness is compensated for by its greater density and resistance, the paramedian region could be the site of choice for

miniscrew placement, and the optimal areas are those at 6 mm from the median suture and 4 and 8 mm from the incisive foramen, and at 3 mm from the suture and 16 and 24 mm from the foramen.

In making an informed choice as to which miniscrews to use in terms of length and diameter, we believe that the palate is an ideal site to guarantee skeletal anchorage in orthodontic practice. We agree with Carano et al,²⁰ who stated that, to achieve sufficient stability in the palate, the thickness of the miniscrews must be no less than 2 mm. The use of miniscrews with smaller diameters (1.2-1.3 mm) is justified at the level of the interraderic alveolar bone, where there is a risk of damage to the roots of the dental elements, but, in the palate, the absence of blood vessels, nerves, and other structures allows thicker and more resistant miniscrews without the danger of causing lesions. According to this study, more careful attention must be paid, instead, to the length of the miniscrews to ensure that both the bone cortices of the palatal processes are used, and that penetration of the nasal cavity is avoided. To take advantage of the most anterior region of the palate (4 mm from the incisive foramen), it is necessary to use miniscrews with a functional (threaded) part of at least 10 mm. At 8 mm from the incisive foramen, the functional part must be at least 8 mm in length, whereas, in the posterior part of the palate (16-24 mm from the incisive foramen), miniscrews with functional parts of 4 to 5 mm in length are sufficient. The definitive length of the miniscrews should also take into account the thickness of the mucosa, because soft-tissue measurements at the midpalatal suture area show that the thickest portion is 4 mm posterior to the incisive papilla, and that the thickness remained consistent at 1 mm posterior to this point. This area, with its consistent soft-tissue thickness, might be the most appropriate location to place an orthodontic implant.²⁶

No significant differences were found between the mean palatal bone thickness to the left and the right of the suture in each group, and, in contrast to that reported by King,²⁹ no sex-related differences were noted.

CONCLUSIONS

The palate is the site of choice for the placement of miniscrews for orthodontic purposes. The thickest part of the palate is the anterior region, but bone thickness in the posterior region is also suitable for screws of appropriate diameter and length.

We thank Dr. C. Perissinotto for help with this work.

REFERENCES

1. 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.
2. Costa A, Pasta G, Bergamaschi G. Intraoral hard and soft tissue depths for temporary anchorage devices. *Semin Orthod* 2005;11:10-5.
3. Deguchi T, Nasu M. Quantitative evaluation of cortical bone thickness with computed tomographic scanning for orthodontic implants. *Am J Orthod Dentofacial Orthop* 2006;129:721.e7-12.
4. Wehrbein H, Glatzmaier J, Mundwiler U, Diedrich P. The Orthosystem—a new implant system for orthodontic anchorage in the palate. *J Orofac Orthop* 1996;57:142-53.
5. Wehrbein H, Merz BR, Hämmerle CH, Lang NP. Bone-to-implant contact of orthodontic implants in humans subjected to horizontal loading. *Clin Oral Implants Res* 1998;9:348-53.
6. Wehrbein H, Feifel H, Diedrich P. Palatal implant anchorage reinforcement of posterior teeth: a prospective study. *Am J Orthod Dentofacial Orthop* 1999;116:678-86.
7. Wehrbein H, Merz BR, Diedrich P, Glatzmaier J. The use of palatal implants for orthodontic anchorage. Design and clinical application of the Orthosystem. *Clin Oral Implants Res* 1996;7:410-6.
8. Wehrbein H, Merz BR, Diedrich P. Palatal bone support for orthodontic implant anchorage—a clinical and radiological study. *Eur J Orthod* 1999;21:65-70.
9. Misch CE. Contemporary implant dentistry. 2nd ed. St Louis: Mosby; 1999. p. 113.
10. Kyung SH, Hong SG, Park YC. Distalization of maxillary molars with a midpalatal miniscrew. *J Clin Orthod* 2003;37:22-6.
11. Bernhart T, Vollgruber A, Gahleiter A, Dortbudak O, Haas R. Alternative to the median region of the palate for placement of an orthodontic implant. *Clin Oral Implants Res* 2000;11:595-601.
12. Schlegel KA, Kinner F, Schlegel KD. The anatomic basis for palatal implants in orthodontics. *Int J Adult Orthod Orthognath Surg* 2002;17:133-9.
13. Martin W, Heffernan M, Ruskin J. Template fabrication for a midpalatal orthodontic implant: technical note. *Int J Oral Maxillofac Implants* 2002;17:720-2.
14. Tosun T, Keles A, Erverdi N. Method for the placement of palatal implants. *Int J Oral Maxillofac Implants* 2002;17:95-100.
15. Bantleon H, Bernhart T, Crismani AG, Zachrisson BU. Stable orthodontic anchorage with palatal osseointegrated implants. *World J Orthod* 2002;3:109-16.
16. Cousley R. Critical aspects in the use of orthodontic palatal implants. *Am J Orthod Dentofacial Orthop* 2005;127:723-9.
17. Gedrange T, Bourauel C, Kobel C, Harzer W. Three-dimensional analysis of endosseous palatal implants and bones after vertical, horizontal, and diagonal force application. *Eur J Orthod* 2003;25:109-15.
18. Lee JS, Kim DH, Park YC, Kyung SH, Kim TK. The efficient use of midpalatal miniscrew implants. *Angle Orthod* 2004;74:711-4.
19. Melsen B. Mini-implants: where are we? *J Clin Orthod* 2005;39:539-47.
20. Carano A, Velo S, Leone P, Siciliani G. Clinical implication of the miniscrew anchorage system. *J Clin Orthod* 2005;39:9-24.
21. Park HS. A miniscrew-assisted transpalatal arch for use in lingual orthodontics. *J Clin Orthod* 2006;40:12-6.

22. Kircelli BH, Pektas Z, Kircelli C. Maxillary molar distalization with a bone-anchored pendulum appliance. *Angle Orthod* 2006;76:650-9.
23. Kinzinger G, Wehrbein H, Byloff FK, Yildizhan F, Diedrich P. Innovative anchorage alternatives for molar distalization—an overview. *J Orofac Orthop* 2005;66:397-413.
24. Yildizhan F. Strukturparameter des medianen gaumens und orthodontische verankerungsimplantate. Eine radiologische, histologische und histomorphometrische studie [dissertation]. Aachen, Germany: University of Aachen; 2004.
25. Dahlberg G. Statistical methods for medical and biological students. New York: Interscience Publications; 1940.
26. Kim K, Yun HS, Park HD, Kim DH, Park YC. Soft-tissue and cortical-bone thickness at orthodontic implant sites. *Am J Orthod Dentofacial Orthop* 2006;130:177-82.
27. Block MS, Hoffman DR. A new device for absolute anchorage for orthodontics. *Am J Orthod Dentofacial Orthop* 1995;107:251-8.
28. Gracco A, Lombardo L, Cozzani M, Siciliani G. Quantitative evaluation with CBCT of palatal bone thickness in growing patients. *Prog Orthod* 2006;2:164-74.
29. King K. Paramedian palate morphology in the adolescent: a cone beam computed tomography study [abstract]. *Am J Orthod Dentofacial Orthop* 2005;128:262.