ISSN Print: 2394-7489
ISSN Online: 2394-7497
IJADS 2017; 3(4): 472-477

www.oraljournal.com
Received: 20-08-2017
Accepted: 27-09-2017

Dr. Abdul Baais Akhoon
Post graduate Scholar of Orthodontics and Dentofacial Orthopaedics, Orthopaedics, Govt. Dental College and Hospital, Shereen Bagh, Srinagar, Jammu and Kashmir, India

Dr. Mohammad Mushtaq
Professor and Head of the Department, Department of Orthodontics and Dentofacial, Orthopaedics, Govt. Dental College and Hospital, Shereen Bagh, Srinagar, Jammu and Kashmir, India

Correspondence
Dr. Abdul Baais Akhoon
Post graduate Scholar of Orthodontics and Dentofacial Orthopaedics, Orthopaedics, Govt. Dental College and Hospital, Shereen Bagh, Srinagar, Jammu and Kashmir, India

Quantitative evaluation of palatal bone thickness for safe mini-implant placement using CBCT

Dr. Abdul Baais Akhoon and Dr. Mohammad Mushtaq

Abstract
The purpose of this study was to evaluate the most suitable region of the palate for the insertion of miniscrews. We analysed 4 different paracoronal sections of Digital Volumetric Tomographies of 23 patients with ages ranging between 14 and 42 years and measured the thickness of the palatine bone in 20 different sites. For each section we measured the height of the palatal bone at 0, 3 and 6 mm increments laterally from the midline. The results indicate that the thickest part of the palate is found 6 mm to the left and right of the suture in the anterior part of the palate, 4 mm from the incisal foramen. In the other paracoronal sections, the thicknesses tend to decrease progressively, but the highest values are always found corresponding to suture. Therefore, we can conclude that the thickest part of the palate is the anterior region. Although the bone is thinner in the posterior region of the palate, it is also suitable for the insertion of miniscrew.

Keywords: Quantitative evaluation, palatal bone thickness, mini-implant placement using CBCT

Introduction
In recent years, the use of miniscrews has become widespread and commonplace in orthodontic practice. The application of miniscrews has enabled the use of skeletal anchorage for various conditions because miniscrews can be positioned in many areas of the alveolar bone and can be loaded immedialtely. Numerous studies have been carried out to identify and evaluate the ideal site for insertion of the miniscrews [1-3] and most of these have indicated the palate. The palatal bone appears to be the most suitable site for miniscrew insertion due to its histomorphology and the ease of application of the miniscrews in this area [4-8].
With the exception of the incisal canal region, the median and paramedian areas of the palate consist of cortical bone that is thick and dense enough to support one or more miniscrews which can sustain orthopaedic loads. This area retains the obvious advantage of not having anatomical structures, such as nerves, blood vessels or dental roots, which can impede the insertion of miniscrews [9, 10]. Furthermore, the soft tissue of the median palate is, on average 3.06 +/-0.45 mm thick between the first and second premolars. This thickness, associated with the intrinsic characteristics of the palatine mucosa, guarantees biomechanical stability upon insertion of the screws [9, 10]. In the past, this site was used for insertion of implants to support orthodontic devices [11-15], although the methods of insertion and removal were very intrusive and painful for the patient, not to mention costly, as they required the intervention of a surgeon. In these cases, the only suitable insertion site was limited to the anterior region of the maxilla. Additionally, it was necessary to wait for osteointegration of the implant before applying a load [5, 16, 17]. Recently, however, palatine skeletal anchorage has been achieved using miniscrews. In particular, Kyung, in 2003, successfully used a miniscrew inserted into the median zone of the palate for distalisation of the upper molars [10]. Lee, in 2004, utilised miniscrews in the palate for intrusion [18] and Melsen, in 2005 [19], indicated the palate as a possible site of insertion of the miniscrews, even though Carano, in 2005 [20], asserted that the insertion of miniscrews with a diameter of less than 2 mm into the palate does not guarantee total stability. Park, in 2006 [21], employed a palatine miniscrew to move the incisor segment posteriorly in lingual treatment. Kircelli, in 2006 [22], modified a pendulum appliance for molar distalization with a miniscrew inserted palatally in the anterior part of the palate, obtaining rapid distalization without loss of anchorage. Byloff, in 2005 [23], described the Graz Implant-Supported Pendulum applance, in which skeletal anchorage is provided by two components:

an internal component consisting of a titanium miniplate featuring two solder-fitted pins fixed to the bone with four screws and an external component; a modified Pendulum Appliance. Yildizhan [24], in a study of 22 specimens of the human hard palate to compare the vertical height in the sagittal and transverse dimensions, found that the highest point is 8.08 mm in the anterior median region and there is a reduction of 3.34 mm in the paramedian region, 3 mm to the left and right of the median line. The average height of the palate decreases from the front to the back and from the median to the paramedian region, thereby indicating the anterior median region of the palate as the ideal site for insertion. This study also highlights how insertion of the miniscrew in the median region is preferable in adult patients, citing calcified median sutures, and in the paramedian region in growing patients [11]. In the present study, we analysed the Digital Volumetric Tomographies of 23 patients with ages ranging between 14 and 42 years and measured the thickness of the palatine bone in 20 different sites in an attempt to identify the region of the palate most suitable for the insertion of miniscrews.

Material and Methods

We randomly selected the Digital Volumetric Tomographies of 23 healthy subjects with ages ranging between 14 and 42 years (11 males and 12 females). The Data for the study were obtained from CBCT scans taken as part of Orthodontic diagnosis and treatment planning protocol in the department of Orthodontics & Dentofacial Orthopaedics, Government Dental College and Hospital, Shereen Bagh, Srinagar. The scans were selected according to the following inclusion and exclusion criteria:

Inclusion Criteria

1. Complete eruption of permanent dentition (except for third molars).
2. No missing teeth (exclude third molars).
3. No severe craniofacial disorders.
4. No severe periodontitis or periapical lesion.
5. No severe crowding and spacing in the teeth.

Exclusion Criteria

1. Periapical or peri-radicular pathologies or radioluciences of either periodontal or endodontic origin.
2. A significant medical or dental history (e.g., use of bisphosphonates or bone altering medications or diseases).
3. Severe facial or dental asymmetries.

Methodology

Sample Size and power

A sample size was calculated using G*Power software (Ver. 3.0.10). For a power of 80%, α=0.05 Type I, and β=0.20 Type II error rates, a sample size of at least 20 patients was determined.

The data were obtained using the New Tom 3G Volume Scanner QRsr 1 Verona, Italy. The New Tom 3G Volume Scanner is based on a cone-beam technique that uses x-ray emissions efficiently, thus reducing the dose absorbed by the patient. The following settings were used:

X ray source: HF, Constant potential (DC), 90 kV; 2 mA (pulsed)
Imaging mode: CBCT
Focal spot: 0.5 mm
Dose: 80-100 µSv
Scan: 11 cm × 8 cm and 8 cm × 8 cm
Scan time: 18 seconds
Slice thickness: 1 mm.

Using the NNT Newtom®3G software for each patient, we initially identified the buccal incisal foramen from the axial section of the upper jaw. 90° paracoronal views of the palate region were reconstructed at 4, 8, 16 and 24 mm posterior from the incisal foramen, and measurements of the bone height were made in each reconstruction at 0, 3, and 6 mm increments laterally from the midline to describe the thickness of palate (Figs.1, 2 and 3). 20 measurements were recorded in each of the 23 patients for a total of 460 measurements. Each measurement was taken on the computer display monitor with the Newtom®3G measure software.

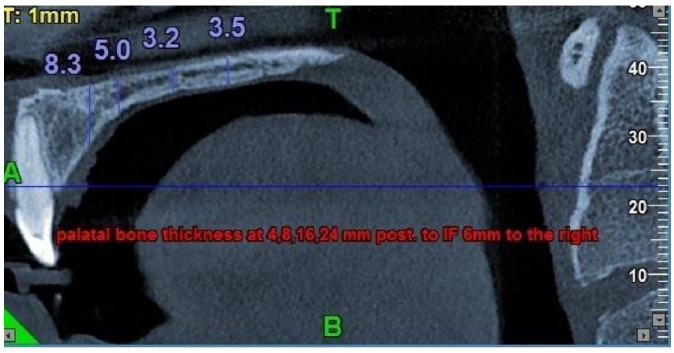

Fig 1: Palatal bone thickness at 4,8,16 and 24 mm posterior to incisal foramen, 6 mm to the right of mid-palatal suture

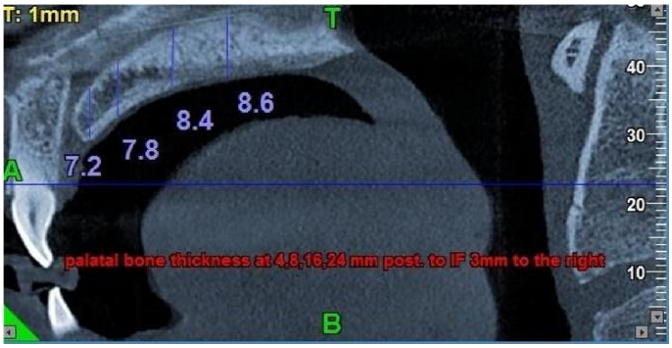

Fig 2: Palatal bone thickness at 4,8,16 and 24 mm posterior to incisal foramen, 3 mm to the right of mid-palatal suture

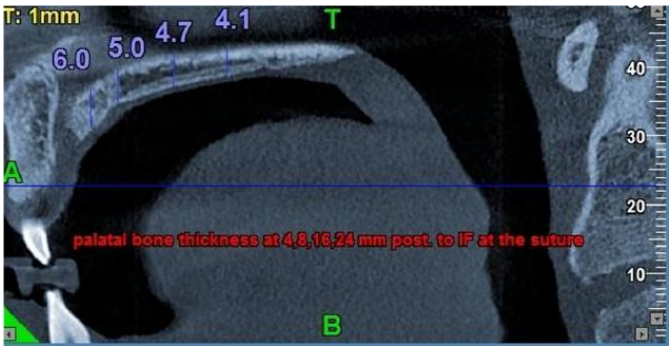

Fig 3: Palatal bone thickness at 4,8,16 and 24 mm posterior to incisal foramen at the midpalatal suture. Statistical analysis

The statistical analysis of data was carried with the help of means, ranges and standard deviations.

Student's t-test was used to test the difference between means of various variables. A P-value of less than 0.05 was considered statistically significant. Statistical package SPSS (Version, 20.0) was used to carry out the statistical analysis of data.

Based on the normalcy of the distribution of the data, results

obtained were statistically analyzed and compared using SPSS software**.** The statistical analysis included:

- **Descriptive statistics:** *Including;* mean, minimum, maximum, and standard deviation ▪ *Independent-samples t-test:* For the comparison of various variables.

Informed consent regarding the benefits and protocol of study was obtained from all patients.

Reliability of the Measurements

The measurements of palatine height in the 23 patients were carried out by two different operators. The results were compared using analysis of variance and did not show statistically significant differences.

Results

The means and standard deviations of the palatal bone thickness of the maxilla is shown in Table 1.

Table 1: Descriptive statistics of palatal bone thickness in maxilla

Distance from incisal foramen		6mm to the left of suture	3mm to the left of suture	At the Suture	3mm to right the of suture	6mm to right the of suture
4 mm	Mean	8.88	7.70	7.99	7.30	8.00
	SD	3.17	2.42	3.73	2.48	2.48
	Min	4.4	5.1	2.3	1.5	2.4
	Max	17.8	16.6	16.8	14.4	12.6
8 mm	Mean	3.92	4.11	6.01	4.00	3.27
	SD	2.01	1.77	2.24	1.77	1.57
	Min	1.4	1.4	3.9	1.5	0.8
	Max	8.1	8.4	11.4	7.8	6.8
16 mm	Mean	2.00	2.37	4.13	2.46	1.54
	SD	1.61	1.28	1.35	1.95	0.97
	Min	0.3	0.4	1.8	0.2	0.3
	Max	6.8	5.4	7.5	8.4	3.2
24 mm	Mean	1.37	2.03	3.60	2.76	1.51
	SD	1.17	1.39	1.53	2.09	0.88
	Min	0.2	0.5	0.8	0.5	0.3
	Max	6.0	5.3	6.6	8.6	3.5

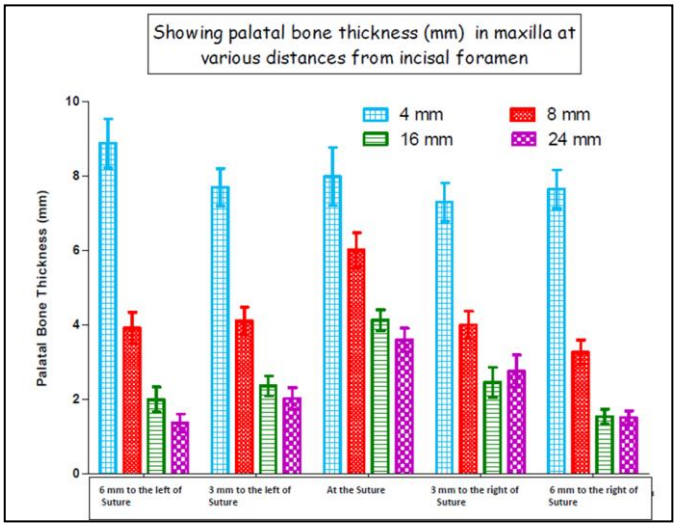

Fig 4: Palatal bone thickness at 4, 8, 16 and 24 mm from the incisal foramen

The palatal bone was thickest at 4-mm from the incisal foramen and 6-mm to the left (8.88 ± 3.17 mm) and right (8. 00 ± 2.48 mm) of the mid-palatine suture. Thickness at the suture was 7.99 ± 3.73 mm, and at 3-mm to the left was 7.70 ± 2.42 mm and 7.30 ± 2.48 mm to the right.

At 8-mm from the incisal foramen thickness at the suture was 6.01 ± 2.24 mm, at 3-mm to the left was 4.11 ± 1.77 mm and 4.00 ± 1.77 mm to the right, and at 6-mm to the left was 3.92 ± 2.01 mm and 3.27 ± 1.57 mm to the right.

At 16-mm from the incisal foramen thickness at the suture was 4.13 ± 1.35 mm, at 3-mm to the right was 2.46 ± 1.95 mm and 2.37 ± 1.28 mm to the left, and at 6-mm to the left was 2.00 ± 1.61 mm and 1.54 ± 0.97 mm to the right.

At 24-mm from the incisal foramen thickness at the suture was 3.60 ± 1.53 mm, at 3-mm to the right was 2.76 ± 2.09 mm and 2.03 ± 1.39 mm to the left, and at 6-mm to the right was 1.51 ± 0.88 mm and 1.37 ± 1.17 mm to the left (least thickness).

Discussion

Skeletal anchorage in the anterior palate is optimal for supporting various treatment mechanics, including distalization, protraction of buccal teeth, rapid maxillary expansion, space closure, and intrusion mechanics. Biomechanics can be designed in nearly any direction and can usually be changed in the mid-treatment using the same anchorage set-up.

Although these locations are commonly used in orthodontic applications because of their ease of access, the inter-radicular spaces are limited by the proximity of neighboring roots, presenting the following problems:

- 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 inter-radicular positions.
- A loss rate as high as 25% [25].

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 [1]. Insertion into the inferior portion of the zygomatic arch carries the risk of perforating the maxillary sinus. Therefore, the only safe alternatives to buccal miniscrew placement are in the palate. In the mandible, where lingual screw insertion is associated with higher loss rates [26], the mentalis region is better suited for miniscrews and miniplates [27]. In the maxilla, the hard palate appears to be an ideal insertion site. While the anterior palate definitely offers sufficient bone, consensus has yet to be reached regarding the

minimal amount of bone required to avoid penetration into neighboring anatomical structures. Liou [28] and colleagues suggested 2 mm, Poggio [1] and colleagues recommended 1 mm, and Maino [29] and colleagues considered 0.5 mm to be sufficient. Miniscrew dimensions must be selected according to the desired insertion site, considering that smaller screw diameters present a higher risk of fracture during placement. Although insertion into attached gingiva is preferable, the thickness of the tissue must not be excessive; at least half the screw length should be embedded in cortical bone, with the head of the screw still accessible. The shaft of the screw must not impede root movement, and the location should allow biomechanical alterations to be made in the treatment plan if necessary.

The anterior palate satisfies all these requirements. In 1996, Wehrbein and colleagues described a highly sophisticated implant system for the anterior palate [4]; three years later, this group reported a 100% success rate for en masse retraction of upper anterior teeth, a biomechanically demanding procedure [6]. Park has documented a 100% success rate for miniscrews inserted in the anterior palate [30]. Wilmes and colleagues, using coupled miniscrews and a rigid miniplate in the anterior palate, demonstrated high stability and success rates [31]. The anterior palate may also offer greater patient comfort and, thus, greater acceptance compared to other locations [32].

Palatal Hard Tissue

The main factor determining the success of miniscrew placement, whether in the buccal alveolus or the palate, is the quantity of surrounding bone. Since the introduction of the Orthosystem* palatal implant by Wehrbein and colleagues [4], the anterior hard palate has become the most thoroughly investigated region for skeletal anchorage in orthodontics, including three dimensional computed-tomography (CT) studies.

Two substantially different investigation protocols have been used to determine landmarks and coordinates in this region. In radiographic observation, measurements are made from the distal aspect of the incisive foramen [27, 32, 33, 34]. In the clinical anatomic method, the contact points between the canine, premolars, and molars are used as references, with lateral measurements made from the midpalatal suture [41].

Radiographic Landmarks

The reviewed radiographic landmark studies clearly demonstrate that the thickest vertical bone repositories are located 3-4 mm distal to the incisive foramen and 3 mm paramedian to the palatal suture [27, 32, 33, 34]. Both Crismani and colleagues [35] and Cousley[16] have published guidelines for safe insertion in the anterior hard palate, describing limitations and risks. The screw should be inserted perpendicular to the palatal surface and angled toward the incisor roots to ensure optimal retention and effectiveness. Although an occlusal view suggests the possibility of root contact, 3D CT scans prove that such concerns are unfounded. While the midpalatal suture might appear to be the best insertion site, considering its high bone quantity and quality, this conclusion is not borne out by the literature. The median suture (coordinate 1/1, 3-4 mm posterior to the incisive foramen) does have a thick vertical layer of bone, but there is a substantial standard deviation in this thickness. Bernhart and colleagues found a mean bone thickness of only 2.94 mm at the suture and, therefore, recommended an insertion site 3-6 mm paramedian to the suture and 6-9 mm distal to the incisive foramen [11], emphasizing the interindividual variability of the 22 patients (age 13-48 years) in their study. In comparison, Gracco and colleagues reported 9.04 mm ± 2.44 mm of bone at coordinate 1/1 in a group of 52 patients (age 10-15 years) [36]. Kang and colleagues found smaller mean values of 5.6 mm ± 1.6 mm in a group of 18 patients (age 18-35 years); they also showed a bone thickness of 9.2 mm ± 2.5 mm just 3 mm lateral to the suture [37]. Based on the high standard deviations, these authors recommended a more individualized diagnostic regimen, with more anterior screw placement closer to the suture. King and colleagues evaluated 138 patients (age 10-19 years), but did not measure bone thickness at the midpalatal suture [33]. They advised placing screws 4 mm distal to the incisive foramen and 3 mm lateral to the suture.

Wehrbein reported considerable success with implants in the anterior palate, both medial and paramedian to the suture [38]. On the other hand, Kim and colleagues recorded a success rate of 88.2% for miniscrews placed in the palatal suture [39]. This difference could be attributable to the narrower diameter of the miniscrews, but some CT scans have also shown reduced bone height and/or minimal levels in interdigitation of the suture—factors that could significantly influence the results from a small sample such as that in the Kim study. Wilmes and Drescher have developed a system that combines the ease of use of miniscrews with the stability of palatal implants, reporting higher success rates for both medial and paramedian locations [40].

Clinical Anatomic Landmarks

Although the radiographic method is more reliable than clinical observation because it is unaffected by tooth movement, the disadvantage of radiographic measurement is the difficulty of interpreting and applying the results in clinical practice. Baumgaertel proposed easily identifiable clinical landmarks on dental crowns in his CT study, with lateral measurements following the suture at distances of 2 mm, 4 mm, 6 mm, 8 mm, and 10 mm [41]. The areas 2 mm paramedian to the suture and between the canine and first-premolar contact points (8.7 mm ± 2.3 mm of bone) and first- and second-premolar contact points (8.68 mm ± 3.68 mm) were described as ideal insertion locations. While Baumgaertel's results concur with those of the radiographic landmark studies, this clinical method should be applied only to dental arches with minimal tooth movement.

Palatal Soft Tissue, Blood Vessels, and Nerves

The quality of the palatal gingiva, much like the quality and quantity of bone, is an important factor in determining the success of miniscrew anchorage. The thinner attached gingiva is most desirable for screw placement [42]. While the mucosa is rather thick around the lateral aspects of the palatal arch, it forms a constant layer of only 1-4 mm at the midpalatal suture distal to the incisive foramen [43]. Because blood-vessel density is low in the anterior palate, the risk of iatrogenic injury from miniscrew insertion is minimal. The major palatine foramen with its dense vascular bundle can be problematic, however, if miniscrews are inserted in that area.

Considering all the aforementioned parameters, the suitability of various miniscrew insertion locations in the hard palate can be evaluated and charted. This information should enhance the clinician's ability to select appropriate locations for miniscrew placement.

In the present study, we analysed the Digital Volumetric Tomographies of 23 patients with ages ranging between 14 and 42 years and measured the thickness of the palatine bone

in 20 different sites in an attempt to identify the region of the palate most suitable for the insertion of miniscrews. This study analysed the bone thickness at 4 different paracoronal sections in patients with ages ranging between 14 and 42 years. For each section the height of the palatal bone at 0, 3 and 6 mm increments laterally from the midline was measured. The results highlight that the major thicknesses of the palate are found at 6 mm to the left and right of the suture in the anterior part of the palate, 4 mm from the incisal foramen.

Nevertheless, it is interesting to observe, using the different sections, how the morphology of the palate varies. In the anterior part of the palate, the thickest bone is found laterally at 6 mm from the midline while the thinnest bone is at 3 mm.

In the 8 mm section, the variations are smaller but the morphology changes noticeably as the thickest bone was at the suture and thinner bone continued to be found bilaterally at 3 mm. In the 16 mm section, the situation changes further. The thickest bone is again noted at the suture. However, the bone thicknesses at 3 and 6 mm, which are almost similar, are much lower with respect to the suture.

Finally, in the 24 mm section, the palatine morphology changes further as the thicknesses tend to progressively decrease from the suture to the sides.

Also these data show that, even if the morphology of the palate varies, all the bone height mean values (suture, 3, 6 mm laterally) measured in 4 mm paracoronal view are higher than those recordered in the 8 mm paracoronal view (Tab.1). The mean values decrease further in the 16 and in the 24 mm paracoronal sections (Tab.1), but the reduction is not as large as in the anterior part of the palate. Therefore, we can conclude that the thickness of the palatine bone progressively decreases posterior to the incisal foramen even if in a different way in the four paracoronal views.

These data also confirm those already reported in the literature[12] that the palate is a site of choice for insertion of miniscrews. In particular, the largest bone thicknesses are found in the anterior region of the palate, 4-8 mm from the foramen both at the suture and at the paramedian areas. The more posterior regions of the palate are also suitable for housing the miniscrews despite the fact that the bone is thinner because the quality of the bone (double cortical) and the thickness of the adhering mucosa which covers it provide stability for the minicrews.

It is necessary to point out there is concensus agreement that the suture, despite being among the thickest sites in the different palatal sections, is not the site of choice for the insertion of miniscrews due to its incomplete calcification that can also be seen in adult subjects. Consequently, the paramedian region is the most suitable area for the positioning of miniscrews and the best areas are those at 6 mm in the 4 and 8 mm paracoronal view and those at 3 mm in the 16 and 24 mm paracoronal view because the bone is thickest in these sites.

The miniscrews inserted in the palate provide skeletal anchorage suitable for orthodontic purposes. Thanks to these results on bone thickness and previous data on distalising appliances and anchorage loss, a new distalising orthodontic device known as the “Distal Screw”, has been constructed and tested which represents the evolution of the Distal Jet and which takes advantage of the skeletal anchorage supplied by the palatal insertion miniscrews in order to eliminate anchorage loss.

Conclusions

The palate constitutes a site of choice for the insertion of miniscrews for orthodontic purposes. The thickest part of the palate is the anterior part of the palate. The bone thickness in the posterior region of the palate is also suitable for the insertion of screws of appropriate thickness.

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; 11:10-15.
3. 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.
4. Wehrbein H, Glatzmaier J, Mundwiller U and Diedrich P. The Orthosystem—a new implant system for orthodontic anchorage in the palate. J Orofac Orthop. 1996; 57:142-153.
5. Wehrbein H, Merz BR, Hämmerle CHF. 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 and Diedrich P. Palatal implant anchorage reinforcement of posterior teeth: A prospective study. Am J Orthod. 1999; 116:678-686.
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(4):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(1):65-70.
9. Misch CE. Contemporary Implant Dentistry, 2nd ed., Mosby, St. Louis. 1999, 113.
10. Kyung SH, Hong SG, Park YC. Distalization of Maxillary Molars with a Midpalatal Miniscrew. J Clin Orthod. 2003; 37(1):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(6):595-601.
12. Schlegel KA, Kinner F, Schlegel KD. The anatomic basis for palatal implants in orthodontics. Int J Adult Orthodon Orthognath Surg. 2002; 17(2):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(5):720-2.
14. Tosun T, Keles A, Erverdi N. Method for the placement of palatal implants. Int J Oral Maxillofac Implants. 2002; 17(1):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. 2005; 127:723-729.
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(2):109-15.
18. Lee JS, Kim DH, Park YC, Kyung SH, Kim TK. The Efficient Use of Midpalatal Miniscrew Implants. Angle

Orthod. 2004; 74(5):711-4.
19. Melsen B. Mini-Implants: WhereAre We? J Clin Orthod. 2005; 39(9):539-47; quiz 531-2.
20. Carano A, Velo S, Leone P, Siciliani G. Clinical implication of the miniscrew anchorage system. J Clin Orthod. 2005; 39(1):9-24; quiz 29-30.
21. Park HS. A Miniscrew-Assisted Transpalatal Arch for Use in Lingual Orthodontics. J Clin Orthod. 2006; 40(1):12-6.
22. Kircelli BH, Pektas Z, Kircelli C. Maxillary Molar Distalization with a bone-anchored pendulum appliance. Angle Orthod. 2006; 76(4):650-9.
23. Kinzinger G, Wehrbein H, Byloff F K, Yildizhan F, Diedrich P. Innovative Anchorage Alternatives for Molar Distalization– an Overview. J Orofac Orthop. 2005; 66(5):397-413.
24. Yildizhan F. Strukturparameter des medianen Gaumens und orthodontische Verankerungsimplantate. Eine radiologische, histologische und histomorphometrische Studie. Med. Diss. Aachen, 2004.
25. Chen YJ, Chang HH, Lin HY, Lai EH, Hung HC, Yao CC. Stability of miniplates and miniscrews used for orthodontic anchorage: experience with 492 temporary anchorage devices. Clin oral implants Res. 2008; 19:1188-96.
26. Wiechmann D, Meyer U, Bu¨ chter A. Success rate of mini and micro-implants used for orthodontic anchorage: a prospective clinical study. Clin Oral Implants Res. 2007; 18:263-267.
27. Heymann GC, Cevidanes L, Cornelis M, De Clerck HJ, Tulloch JF. Three- dimensional analysis of maxillary protraction with intermaxillary elastics to miniplates. Am J Orthod. 2010; 137:274-284.
28. Liou EJ, Pai BC, Lin JC. Do miniscrews remain stationary under orthodontic forces? Am J Orthod Dentofacial Orthop. 2004; 126:42-7.
29. Maino BG, Mura P, Bednar J. Miniscrew implants: The Spider Screw anchorage system. Semin Orthod. 2005; 11:40-46.
30. Park HS. Clinical study on success rate of microscrew implants for orthodontic Anchorage. Kor J Orthod. 2003; 33:151-156.
31. Wilmes B, Drescher D, Nienkemper M. A miniplate system for improved stability of skeletal anchorage. J Clin Orthod. 2009; 43:494-501.
32. Gündüz E, Schneider-Del Savio TT, Kucher G, Schneider B, Bantleon HP. Acceptance rate of palatal implants: A questionnaire study. Am J Orthod. 2004; 126:623-626.
33. 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. 2007; 132:783788.
34. Gracco A, Lombardo L, Cozzani M, Siciliani G. Quantitative evaluation with CBCT of palatal bone thickness in growing patients. Prog Orthod. 2006; 7:164-74.
35. Crismani AG, Bernhart T, Tangl S, Bantleon HP, Watzek G. Nasal cavity perforation by palatal implants: False-positive records on the lateral cephalogram. Int J Oral Maxillofac Impl. 2005; 20:267-273.
36. Gracco A, Lombardo L, Cozzani M, Siciliani G. Quantitative evaluation of palatal bone thickness with cone beam computed tomography. European Orthodontic Society Congress, Berlin, Germany, 2007.
37. 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(4):S74-81.
38. Wehrbein H. Bone quality in the midpalate for temporary anchorage devices. Clin Oral Impl Res. 2009; 20:45-49.
39. Kim YH, Yang SM, Kim S, Lee JY, Kim KE, Gianelly AA, *et al*. Midpalatal miniscrews for orthodontic anchorage: Factors affecting clinical success. Am J Orthod. 2010; 137:66-72.
40. Wilmes B, Drescher D. A miniscrew system with interchangeable abutments. J Clin Orthod. 2008; 42:574-580.
41. Sebastian Baumgaertel. Quantitative investigation of palatal bone depth and cortical bone thickness for mini-implant placement in adults. Am J Orthod Dentofacial Orthop. 2009; 136:104-8.
42. Costa A. Intraoral hard and soft tissue dimensions for temporary anchorage device placement, in Ortho TADs: The Clinical Guide and Atlas, 1st ed., ed. J.B. Cope, Under Dog Media LP, Dallas. 2007, 109-117.
43. Kim HJ, 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.