Three-dimensional assessment of the ideal insertion angle and position of temporary anchorage devices in the anterior palate: (in a sample of erbil city)

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Background and Objectives: Mini-screws may be used in a variety of alveolar bone sites and can withstand loading, allowing for better orthodontic anchoring. The position and placement of mini-screws are determined by the quality and quantity of bone. This study aims to anatomically assess the anterior palate as the insertion site for the orthodontic bone screw.

Method: A retrospective study was done by collecting three-dimensional data of the anterior palate for 40 patients with an age range of (20-30 years). The setting of the study was a private Maxillofacial Radiology Center in Erbil City. Measurements at 32 reference points and angulations were done with the help of a Radiologist to determine the ideal insertion point and angulation for TADs in the anterior palate.

Results: The thickness of the anterior palate was found to differ significantly (p=0.00) among the 32 points studied, including 20 points at a zero angle to a vector perpendicular to the curve of the palate and three additional angles at 10, 20, and 30 degrees to a vector perpendicular to the curve of the palate. The thickest point in the anterior palate was 6mm away from the midline at the contact point between canine and first premolar on both the left and right sides. The reference point with the least thickness was determined to be 3mm to 6mm distant from the midline at the intersection with the center of the second premolar on the right and left.

Conclusion: In conclusion, the thickness of the palatal hard tissue decreased from the anterior to the posterior.

Keywords: Anterior palate, CBCT, TADs, Mini-screw

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Introduction

The importance of anchorage during orthodontic treatment with fixed appliances, particularly in extraction cases, cannot be overstated [(1)]. Anchoring may be difficult owing to a lack of teeth or periodontal disease, necessitating the use of additional extra- or intraoral anchorage. [1, 2]

Because of the decreased treatment duration, low patient compliance, small surgical procedure, and high patient acceptability, the use of mini-screws as temporary anchoring devices has been popular in orthodontic practice during the last two decades.[2, 3] These mini-screws may be placed in a variety of alveolar bone locations and can tolerate rapid loading, resulting in increased orthodontic anchoring.[4] The quality and amount of bone determine the location and placement of mini-screws.[5] The buccal aspect, palate, and infrazygomatic crest are all common TADs insertion sites in the maxilla. [1, 6, 7]

Because of its amount and quality of bone, the palate has become a preferred location for temporary anchoring devices (TADs). The temporary anchoring device (TAD) is a commonly used orthodontic device that has greatly increased the scope of orthodontic therapy. [8, 9] Wehrbein et al. have been reporting TAD implantation in the front palate since 1996.[10] Due to its sufficient bone amount and keratinized gingiva, this has been indicated in the literature as a good location for the insertion of orthodontic miniscrews.[8, 11, 12] Several orthodontic appliances, such as Maxillary Skeletal Expansion and Beneslider® for molar distalization, have been developed to work with palatal TAD for various objectives.[8, 13] TAD insertion in the middle or posterior palate cannot be ruled out to provide the necessary biomechanics for orthodontic tooth movement.[14,15] Because mechanical retention, rather than osteointegration, is the primary determinant of TAD stability,[14, 15] it is critical to learn about the total and cortical bone thicknesses of the whole palate. [8]

Except for the incisive canal area, the median and paramedian areas of the palate are formed of cortical bone that is robust and thick enough to support one or more miniscrews that can sustain orthopaedic pressures. [16, 17] This area appears to have the benefit of being free of anatomical components like nerves, blood arteries, and dental roots that might hinder the insertion of mini -screws.[16,17] Between the first and second premolars, the soft tissue of the median palate is 3.06 +/-0.45 mm thick on average.[16,18] This thickness, along with the palatine mucosa's inherent features, ensures biomechanical stability during screw insertion.[16,18] This location was previously utilized for implant insertion to support orthodontic devices however the procedures of insertion and removal were highly invasive and unpleasant for the patient, not to mention expensive, because they needed the involvement of a surgeon.[16] The only acceptable insertion location in these situations was the anterior area of the maxilla.[16] Winsauer et al. did a review to look at the vertical palate's bone height,[19] they discovered that the imaging technology and coordinating mechanism were not uniform, six of the sixteen investigations used histology techniques or cephalograms to determine the cadaver's vertical bone height. CT scans were used for measurements in six of the remaining 10 reports, the measurement of vertical bone thickness on lateral cephalometric films, on the other hand, was incorrect.[19,20] The resolution of pictures when assessing bone thickness might be affected by the slice thickness of medical CT.[8] Meanwhile, when utilized in normal clinical practice, the radiation dosage of medical CT has been a major source of concern [(21)]. Although the radiation dosage of cone-bean computed tomography (CBCT) is significantly lower than that of medical CT, the harmful effects of radiation remain a concern in developing patients.[8]

Justification: It is critical to determine total and cortical bone thicknesses of the palate before TADs installation in patients to minimize recurrent exposure to radiation and the risk of placement failure. Only a few studies have looked at palatal breadth, cortical bone thickness, and total bone thickness in specific regions of the palate in adults and developing adolescents. As a result, we need to use a conventional grid system and CBCT scans to measure the total and cortical bone thicknesses of the whole palate, as well as the palatal breadth.

Aim: The study aimed to anatomically assess the anterior palate as the insertion site for the orthodontic TADs.

Methods

Sample

The maxillary Cone-Beam Computed Tomographic (CBCT) scans of 40 patients (20 men and 20 women) were collected retrospectively and examined with the help of a radiologist. All the cbct images were taken previously in the radiology center selected for different diagnosis and treatment purposes. For standardization, a private Radiology Center in Erbil, Iraq's Kurdistan Region, was chosen.

Inclusion Criteria: Orthodontically untreated patients between the age of 20-30 years were included in the study.

Exclusion criteria: Patients with palatally displaced teeth, craniofacial malformations, pathologic processes in the maxilla, and syndromic missing teeth in the maxilla were excluded.

CBCT Examinations

The selected Radiology center used a NEWTOM GIANO three-dimensional CBCT scanner (Verona, Italy) with 90KV, 10 mA, emission time (3.6 s /9.0 s), and scan time (3.6 s /9.0 s) (14 s). The CBCT pictures taken had a field of view of 11*5. To analyze all of the images, Newtom (NNT) software, version 10.0 (Verona, Italy), was employed. The study proposal was reviewed by the ethical committee of Dentistry College/

HMU, no consent form or ethical agreements were needed since all the patients were referred by other dentists to the radiology center retrospectively for taking CBCT for treatment purposes and none of the patients were exposed to CBCT for the purpose of this study.

Measurements of Palates

All the CBCT images were imported to the Newtom Software. A new multiplanar was made for each patient. In the axial setup 0.15 mm thickness was chosen. In the Panorex setup, the maximum (51) panorex were created, with 1mm thickness and distance to draw the 3mm and 6mm sagittal planes accurately. Cross set up was enabled with a width of 60 mm to have a wide view during working. The thickness of the front palate as an inserting site for Temporary Anchorage Devices was measured. Five sagittal slices were retrieved, one along the median plane and bilaterally at 3 mm and 6 mm spacing measured from the midline, respectively. The median plane was drawn at the contact point between the two incisors and along through the incisive papilla to the posterior palate.

At the contact point between the canine and first premolar, the middle point of the first premolar, the contact point between the first and second premolar, and the middle point of the second premolar, four dental reference points were projected to the curve of the palate parallelly within each of the five sagittal slices and made a 20-points intersection grid. Measurements were taken at each of the 20 intersection points at a zero angle to a vector perpendicular to the curve of the palate, as well as three additional angles at 10, 20, and 30 degrees to a vector perpendicular to the local palatal curvature for the four dental references positioned on the Median Plane. As a result, 20 points with zero angle and 12 posteriorly positive angles were constructed (32 measurements). The distance between the upper and lower borders of palatal bone was used to determine the thickness of palatal hard tissue at the insertion points within the different angulations.

Statistical Analyses

Statistical Package for the Social Sciences (SPSS) was used with the help and consultation of a statistician. One way Analysis of Variances (ANOVA) was used to compare all the 32 points located at the 5 sagittal slices (Midline, Right 3mm away from the midline, Right 6mm away from the midline, Left 3mm away from the midline and Left 6mm away from the midline), to compare the differences in the palatal hard tissue thickness in the different points and angles. One-way Analysis of Variances (ANOVA) was also used to compare the points and the angles located on the midline to show the differences between the thickness of the hard anterior palate when measured at different angles. Descriptive Statistics were used to find out the thickest point at the anterior palatal region regarding the hard tissue.

Results

One way Analysis of Variances (ANOVA) showed a very highly significant difference

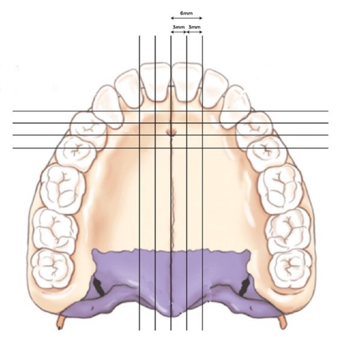

Figure 1: A Diagram visualizing the 20-point intersection grid.

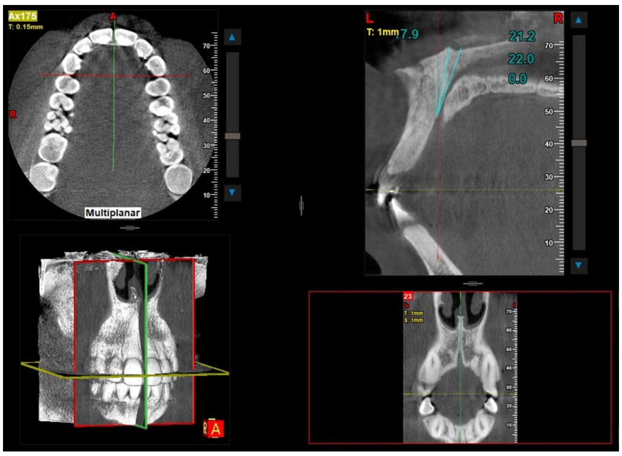

Figure 2: Palatal Thickness Measuring Using CBCT

(p= 0.00) in the thickness of the anterior palate among the 32 points including the 20 points at a zero angle to a vector perpendicular to the curve of the palate and the three additional angles at 10, 20, and 30 degrees to a vector perpendicular to the local palatal curvature as shown in (Table 1). This showed that positioning TADs in different points at the anterior palate can significantly change the outcome and success of the treatment as it is directly proportional to the bone thickness of the area. Another ANOVA test was done to test the differences in bone thickness when changing the angulation of insertion of TADs, the result of this test was very highly significant as well (p= 0.00) as shown in (Table 2). Descriptive statistics showed that the thickest point in the anterior palate was 6mm away from the midline at the contact point between canine and first premolar on both left and right sides with means of 15.2 mm and 14.9 mm respectively, followed by 3mm away from the midline at the contact point between canine and first premolar on both left and right sides with means of 14.4 mm and 14.9 mm respectively. The reference point with the least thickness was found to be 3mm to 6mm away from the midline at the intersection with the middle of the second premolar on right and left with means ranging from 4.7mm to 5.3 mm. Regarding the effect of angulation changing on the midline points, the best angle was 10 on the midline between the first and the second premolar as shown in (Table 3).

Table 1: One Way ANOVA Test for Differences between all the reference points.

	Sum of Squares	df	Mean Square	F	Sig.
Between Points	**12758.451**	**31**	**411.563**	**22.959**	**.000**
Within Points	**22371.293**	**1248**	**17.926**		
Total	**35129.744**	**1279**			

* p < 0.05

Table 2: One Way ANOVA Test for Differences between the reference points on the midline.

	Sum of Squares	df	Mean Square	F	Sig.
Between Angles	**3406.969**	**15**	**227.131**	**13.466**	**0.000**
Within Angles	**10524.929**	**624**	**16.867**		
Total	**13931.898**	**639**			

* p < 0.05

Table 3: Means of the reference points from highest to lowest.

Reference Points	Minimum	Maximum	Mean
Left/ 6mm with contact of canine & first premolar	7.4	23.6	15.180
Right/ 6mm with contact of canine & first premolar	9.0	21.2	14.910
Right/ 3mm with contact of canine & first premolar	7.2	23.6	14.620
Left/ 3mm with contact of canine & first premolar	8.7	20.4	14.410
Midline/ Between canine & first premolar angle 10	1.1	21.2	13.208
Midline/ Between canine & first premolar angle 0	5.9	20.1	12.888
Midline/ Middle of first premolar angle 30	6.0	19.0	12.105
Left/ 6mm middle of first premolar	6.2	18.9	11.645
Right/ 6mm with middle of first premolar	4.7	18.3	11.575
Midline/ Between canine & first premolar angle 20	0.5	22.1	11.435
Midline/ Middle of first premolar angle 20	6.5	30.1	11.383
Left/ 3mm middle of first premolar	5.7	17.4	10.310
Midline/ between first & second premolar angle 30	4.9	16.7	10.263
Right/ 3mm middle of first premolar	1.8	23.1	10.145
Midline/ Between first & second premolar angle-20	5.2	13.5	9.203
Midline/ Middle of first premolar angle 10	0.5	20.2	9.118
Midline/ Between first & second premolar angle 10	4.5	13.0	8.505
Left/ 6mm between first & second premolar	2.2	16.5	8.055
Midline/ Middle of second premolar angle 30	1.7	12.9	8.013
Midline/ Between first & second premolar angle-0	3.8	14.9	7.928
Right/ 6mm between first & second premolar	2.0	15.0	7.870
Midline/ Middle of second premolar angle 20	2.6	11.9	7.418
Right/ 3mm between first & second premolar	2.6	16.4	7.290
Left/ 3mm between first & second premolar	2.4	14.3	7.130
Midline/ Middle of second premolar angle 10	2.7	10.9	7.030
Midline/ Middle of second premolar angle 0	2.7	12.8	6.868
Midline/ Middle of first premolar 0	0.5	15.5	5.898
Midline/ Between canine & first premolar angle 30	0.0	18.0	5.628
Right/ 3mm middle of second premolar	1.1	15.5	5.343
Right/ 6mm middle of second premolar	1.1	9.6	4.785
Left/ 6mm middle of second premolar	1.2	11.3	4.768
Left/ 3mm Middle of second premolar	1.1	8.6	4.748

Discussion:

This study was done to measure the thickness of the hard tissue in the anterior palate in a sample of Erbil city to determine the ideal insertion position and angulation for inserting Temporary Anchorage Devices. The results of the study showed a very highly significant difference among the measurements at different points as well as showing the very highly significant role of changing the angulation of insertion. According to the results the thickness of the hard tissue in the anterior palate decreased as in all of the 5 sagittal planes as measurements were compared from the anterior palate to the posterior palatal area and this result agreed with a study done by Lyu et al.[22]

The thickest area in the palatal hard tissue was found in the area located 3mm and 6mm bilateral to the midline in the contact point of the canine and first premolar along with the middle of the first premolar in agreement with studies done previously.[23,24] In the midline the best point for insertion of TADs according to the data was at the area between canine and first premolar as well with an angulation of 10 degree posteriorly. The worst point and angulation in the midline was at the contact point of canine and first premolar with 30 degrees posteriorly due to the proximity to the Nasopalatine Nerve in agreement to another study.[25] In the areas of the middle of the first premolar, between the first and the second premolar, and the middle of the second premolar, the hard tissue measurement of the palate was found to be higher in the midline compared to the points located on the 4 paramedian sagittal plane. Due to the union of bilateral palatal tissues at midpalatal locations and the existence of the nasal septum, the midpalatal tissues may be thicker.[26] In line with prior investigations, there was a lot of variation in effective bone height among the sample. Given the wide range of bone density in the studied areas, the question of whether the findings are accurate enough to warrant broad recommendations for palatal implant insertion locations and angles emerges. This viewpoint is shared by certain authors.[22,23]

Conclusion:

In conclusion, the thickness of the palatal hard tissue decreased from the anterior to the posterior. Palatal thickness was higher in points located at the paramedian sagittal planes anterior to the first premolar while paramedian sagittal planes points showed higher thickness compared to the median plane points at the area between the middle of the first premolar and the middle of the second premolar.

Conflict of interest

The author reported no conflict of interests.

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