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Evaluation Of Bone Thickness At Different Anatomical Sites In Infrazygomatic Crest For Miniscrew Insertion In Skeletal Class II Patients – A CBCT Study

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Abstract:
AIM*: To assess infrazygomatic crest bone thickness at different anatomical sites at a distance of 5mm, 7mm, 9mm and 11mm apical to cementoenamel junction, 70 degree to occlusal plane in skeletal class II patients using cone beam computed tomography (CBCT).*
Materials and Methods*: The sample consists of cone beam computed tomography images of 23 class II subjects were evaluated. Infrazygomatic crest bone thickness was evaluated at the six horizontal regions (i) interdental area between maxillary second premolar (PM2) and first molar(M1) (ii) Mesiobuccal root of maxillary first molar (MB root of M1) (iii) Distobuccal root of maxillary first molar(DB root of M1) (iv) interdental area between maxillary first molar(M1) and second molar(M2) (v) Mesiobuccal root of maxillary second molar(MB root of M2) (vi) Distobuccal root of maxillary second molar (DB root of M2) at a vertical distance of 5mm,7mm,9mm and 11mm apical to cementoenamel junction, 70 degree to occlusal plane.*
Results*: The buccal bone thickness increase from mesial surface of maxillary first molar to mesial surface of maxillary second molar from cement enamel junction at the level of 11mm, 70 degree to the occlusal plane. The bone thickness decreases at the second molar level.*
Conclusion: *The safe site for insertion of miniscrews in the infrazygomatic crest were the interdental region between the maxillary first and second molars at the heights of 11 mm from cementoenamel junction and 70 degree to the occlusal plane.*

Key Word: *infrazygomatic crest, Cone beam computed tomography, miniscrew, class II*

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I. Introduction

Temporary Skeletal Anchorage Devices (TSADs) are extensively used in orthodontics to provide reliable anchorage, making tooth movement more predictable and efficient. They enhance orthodontic mechanics and require minimal patient cooperation. Orthodontic miniscrews, are favoured for their ease of insertion and removal, as well as their availability in various diameters and lengths. These miniscrews can be placed in multiple locations within the mouth, offering great flexibility in treatment planning[1]

Orthodontic miniscrews were initially used in the interradicular regions, when placed in the inter-radicular area pose a risk of injuring the roots and can also impede tooth movement. Therefore the best way to prevent root injury is to place TADs in the extra alveolar site such as infrazygomatic crest (IZC)[2]

The infrazygomatic crest (IZC) is an extra alveolar site in the maxilla for placement of orthodontic miniscrews or miniplates. Their insertion in the infrazygomatic crest allows efficient orthodontic mechanics. Infrazygomatic crest miniscrews provides enmass anterior retraction, canine retraction, intrusion of the posterior teeth and total arch distalization[3]

The individual structures of bones vary significantly based on the patient's skeletal pattern. Cortical bone thickness and mineralization characteristics differ across various facial types. Specifically, the thickness of

the available bone in the infrazygomatic crest can vary greatly among patients, which can affect the insertion and stability of Temporary Skeletal Anchorage Devices (TSADs)[4]

This study was performed using CBCT to analyse the bone thickness in the region of the IZC in the skeletal class II for TSAD insertion, which would render this procedure safer, easier, predictable, and most likely to succeed.

II. Material And Methods

This retrospective study was performed by evaluating 23 CBCT scans of adult patients of both sexes, aged above19 years were randomly selected.

Inclusion criteria:

1. Skeletal class II malocclusion
2. Patients above 19 years of age
3. No history of previous orthognathic or orthodontic treatment
4. Patients with all erupted permanent maxillary teeth (except for the third molars)
5. Good dental and periodontal health,
6. No clinical signs and symptoms of temporomandibular joint dysfunction

Exclusion criteria:

1. Patients with developmental disorders of bone,
2. Patients with craniofacial anomalies and osseous related diseases,
3. Patients with systemic and periodontal diseases
4. History of facial trauma.

Before the study was initiated, it was approved by the institutional research ethics committee (No. 512/Ethics/PSMCDSR/2021 at 19/5/2022).The cone beam computed tomography (Newtom, 13 .1, India) images of 23 subjects were analysed. Subjects were scanned standing with the head oriented in the natural head position. For all scans, the minimum field of view used was 13×10, and scan time range from 5.2 seconds with original axial thickness of 0.3mm. The CBCT images were stored in DICOM format and were analysed using MicroDicom software. Skeletal malocclusion categories were determined from sagittal view of CBCT using WITS appraisal.

To assess safe regions for miniscrew implantation in the infrazygomatic crest, six horizontal sites were measured on right and left sides as follows: (i) interdental area between maxillary second premolar (PM2) and first molar(M1) (ii) Mesiobuccal root of maxillary first molar (MB root of M1) (iii) Distobuccal root of maxillary first molar(DB root of M1) (iv) interdental area between maxillary first molar(M1) and second molar(M2) (v) Mesiobuccal root of maxillary second molar(MB root of M2) (vi) Distobuccal root of maxillary second molar (DB root of M2) at a vertical distance of 5mm,7mm,9mm and 11mm apical to cement enamel junction, 70 degree to occlusal plane. The infrazygomatic bone thickness was determined by obtaining the CBCT images in sagittal, axial and coronal plane.

Initially from axial view of CBCT, areas of measurements were selected (figure 1). Reference plane along CEJ at the areas of measurements in sagittal slice of CBCT were marked (figure 2). From CEJ reference line, vertical measurements of 5mm, 7mm, 9mm and 11mm in the sagittal view were marked (figure 3). In the coronal view, measurements taken from sagittal view were marked and the 70 degree angle to the occlusal plane were measured (figure 4). Bone thickness at IZC were measured from markings obtained from coronal view to the floor of the sinus and 70 degree to the occlusal plane (figure 5).

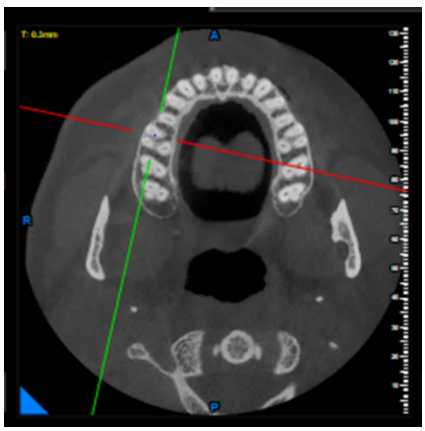

Figure. 1. Axial view for selecting areas of measurements

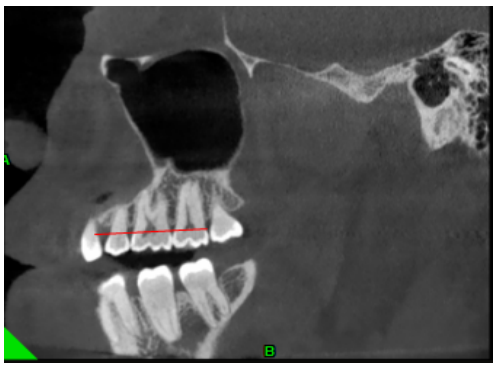

Figure 2. Sagittal slice with reference plane along CEJ

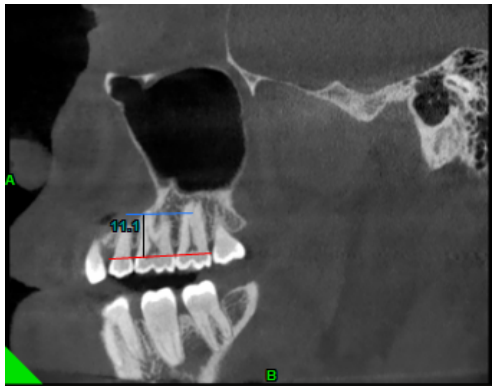

Figure 3. Sagittal slice with 11 mm marking from reference plane along mesiobuccal root of upper first molar

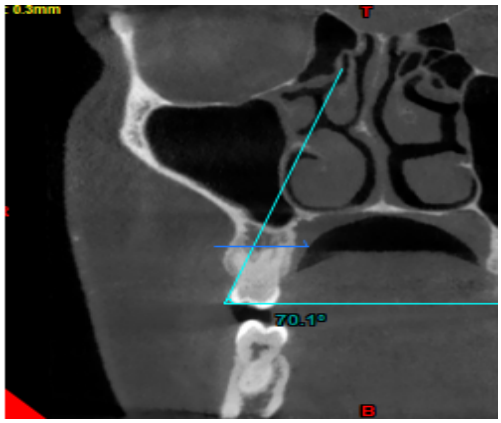

Figure 4. Coronal slice with 11mm marking and measurements of angle to the occlusal plane.

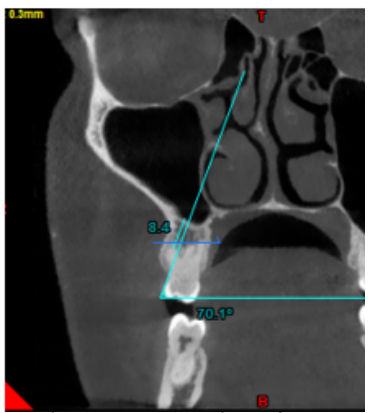

Figure 5. measurements of IZC bone thickness to the sinus floor at the level of 11mm along MB root of first molar region 70 degree to the occlusal plane

Statistical analysis

The study was conducted to measure the bone thickness in the infrazygomatic crest (IZC) in skeletal class II at different anatomical sites. The total sample size consisted of CBCT of 23 patients. Data were analysed using IBM, SPSS (Statistical Package for Social Sciences, IBM Co. Armonk, NY, USA) version 26 statistical software. Descriptive statistics were used to summarize the data. Normality of data was checked using Shapiro wilk test. For comparison between the groups, One way Analysis of variance (ANOVA) test was applied with Tukey's post hoc tests for multiple comparison. Statistical significance was inferred at $p \leq 0.05$.

III. Result

The descriptive statistics for skeletal class II IZC region for right and left sides have been tabulated (table 1 and 2). Analysis of variance (ANOVA) shows there is significant difference ($p<.05$) in the bone thickness between groups on right and left side. In skeletal class II, among six horizontal slices of each vertical height, maximum bone thickness shows at interdental area between maxillary first molar and second molar and minimum cortical bone thickness shows at mesiobuccal root of maxillary first molar on both right and left side at 5, 7 and 9mm vertical level, bone thickness measured in interdental areas to the sinus floor increases from interdental area between second premolar and first molar and interdental areas between first molar and second molar. Similarly buccal cortical bone thickness increases from mesiobuccal root of first molar to distobuccal root of second molar (due to root interference, only buccal cortical bone thickness was measured along the roots at 5, 7 and 9 mm level). At 11 mm vertical level bone thickness measured up to sinus floor increases from interdental areas between second premolar and first molar to interdental area between first molar and second molar and then decreases at second molar root apex (at 11mm level there is no root interference, so bone thickness measured to the sinus floor at all six horizontal slices)

Table no 1: Comparison of mean values of IZC bone thickness at right side

Variables(right side)	5mm	7mm	9mm	11mm
Interdental area between PM2 and M1 (mean ±SD)	10.25±0.14	8.26 ±0.12	7.27±0.13	6.26±.13
MB root of M1 (mean ± SD)	0.64 ±0.03	1.56 ±0.37	1.63±0.22	6.27±0.14
DB root of M1 (mean ± SD)	1.52±0.29	1.57±0.29	1.64±0.29	6.33±0.16
Interdental area b/w M1 and M2 (mean ± SD)	11.28±0.16	10.34±0.13	8.20±0.15	7.27±0.13
MB root of M2 (mean ± SD)	2.53±0.26	2.44± 0.18	2.42±0.17	6.37±0.13
DB root of M2 (mean ± SD)	2.54±0.31	2.45± 0.14	2.43±0.13	6.35±0.14
P value(ANOVA)	0.000	0.000	0.000	0.000

Table 2: Comparison of mean values of IZC bone thickness at left side

Variables(left side)	5mm	7mm	9mm	11mm
Interdental area between PM2 and M1 (mean ±SD)	10.28±0 .13	8.30±.13	7.27±0.14	6.27±0.12
MB root of M1 (mean ± SD)	0.65± 0.04	1.57±0.25	1.57±0.25	6.28±0.17
DB root of M1 (mean ± SD)	1.51±0.27	1.58±0.28	1.58±0.27	6.31±0.13
Interdental area b/w M1 and M2 (mean ± SD)	11.23±0.13	10.33±0.11	8.23±0.14	7.27±0.14
MB root of M2 (mean ± SD)	2.53±0.25	2.37±0.13	2.39±0.16	6.36±.13
DB root of M2 (mean ± SD)	2.67±0.29	2.38±0.17	2.4±0.13	6.37±.11
P value(ANOVA)	0.000	0.000	0.000	0.000

IV. Discussion

The use of miniscrews as auxiliary anchorage in orthodontics has been increasingly incorporated into routine clinical practice, and research pertaining to these devices has been increasing. The insertion site may vary according to the orthodontic mechanics planned and the anatomy of the chosen area, which can individually vary according to the patient's facial type[5]

Numerous anatomical sites for placement of miniscrews have been discussed by Park[6], where he inserted micro-implants into the alveolar bone between the roots of the posterior teeth to change the direction of the applied force towards increasing the horizontal component of the force. He observed that the inter-radicular

space between the second premolar and first molar root in the upper arch and inter-radicular space between the first molar and the second molar root in the lower arch were suitable sites.

Wherein studies by Kuroda[7] stated that placing TADs interradicularly increases the risk of root approximation, which can impede tooth movement. This issue does not occur with extra-alveolar placement, making it preferable to position mini-implants above the alveolar process.

The extra-alveolar sites available for placement of TADs include incisive fossa, premaxillary region, midpalatal region, and symphysis, canine fossa, infrazygomatic (IZ) crest, anterior external oblique ridge, retromolar area, and sublingual fossa.

Anatomically, the IZC is a thick pillar of cortical bone along the zygomatic process of the maxilla. Clinically, it is a palpable bony ridge running along the curvature between the alveolar and zygomatic processes of the maxilla[8]. IZC is a bony depression in the zygomatic process of maxilla just below the zygomatic arch and above the roots of first and second maxillary molar. Studies of Kanomi[9] concluded that it is between the maxillary second premolar and first molar, in younger subjects and is above the maxillary first molar in adults. Eric Liou[10] stated that the IZC has two cortical plates, the buccal cortical plate and the sinus floor. This is anatomically advantageous as it allows for bicortical fixation and also offers a better primary stability of the miniscrew.

Deguchi[11] said that a thicker cortical bone allows a greater miniscrew biting depth, more osseous contact, and better primary stability of the miniscrew. Failure of implants stability was directly associated with the thinner cortical bone in the posterior regions, when used as orthodontic anchorage, this was proved by Miyawaki[12]

The current study was to measure and compare the alveolar bone thickness in the infrazygomatic crest (IZC) along the maxillary premolar and molar regions at four different heights from the cement enamel junction (vertically) and along six different slices taken from interdental area between maxillary second premolar and maxillary first molar to distobuccal root of maxillary second molar (horizontally) in skeletal class II to determine safe zones for ideal placement of temporary anchorage devices (TADs).

So, there comes the need for evaluating the bone quantity and quality three dimensionally before miniscrew implantation. Cone beam computed tomography is an appropriate tool for measuring bone quality in all the three planes that conventional radiograph is unable to reproduce.

Ribeiro[13] in his study concluded that CBCT is a ground-breaking diagnostic method in dentistry as it provides high dimensional accuracy of the facial structures and a reliable method for quantifying the behavior of the maxillary halves, dental tipping, bone formation at the suture in all the three planes of space, as well as alveolar bone resorption and other consequences of palatal expansion.

With regard to the precise placement location of IZC mini-screw implant, Eric J.W. Liou et al[14], measured the thickness of the IZC above the maxillary first molar at different angles to the maxillary occlusal plane as guidance for inserting mini screw implants in the IZC without injuring the mesiobuccal root of the maxillary first molar. As a result they recommended the IZC at 14 to 16 mm above the maxillary first molar, and at an angle of 55° to 70° to the maxillary occlusal plane.

According to Srishti et al[15] studies, as the insertion angle increases, the thickness of the bone at the infrazygomatic crest also increases. So the optimal angle for mini screw insertion in the infrazygomatic crest were reported to be 70 degree. Similarly present study also used 70 degree angulation.

Liu conducted a study[16] to analyse buccal alveolar bone in 3 regions of 60 patients between the maxillary second premolar and first molar, between the mesiodistal roots of the first molar, and between the maxillary first and second molars. Alveolar bone thickness at the buccal side of the roots and the inter-radicular space at the buccal side of the roots were measured at the heights of 5, 7, 9, and 11 mm apically from the alveolar crest to the maxillary sinus floor. The results of this study suggest that the interdental area between upper first and second molar at 11mm height were the most ideal safe zone for placing miniscrews in the infrazygomatic crest region.

Similarly in present study, CBCT data of 23 patients were selected and the cortical bone thickness was measured along six regions from mesial surface of maxillary first molar to distal surface of maxillary second molars at heights of 5mm, 7mm, 9mm and 11mm apically from the cementoenamel junction 70 degree to the occlusal plane. Regarding safe zones for mini-implant placement in the infrazygomatic crest region in the present study, the interdental area between first and second molar, 11mm from cement enamel junction, 70 degree to the occlusal plane were considered with mean alveolar bone thickness of 7.27mm in skeletal class II patients.

Regarding the infrazygomatic crest region in the present study, the buccal bone thickness increase from mesial surface of maxillary first molar to mesial surface of maxillary second molar from cementoenamel junction at the level of 11mm, 70 degree to the occlusal plane.

This correlates with the previous study by Ono et al[17], where he evaluated buccal cortical bone thickness between the first premolar and first molar at vertical heights ranging from 1 to 15 mm below the

alveolar crest in the maxilla and mandible in 43 adult patients using computed tomography. They found that, in maxilla, the cortical bone thickness distal to the maxillary first molar at heights of 6-15 mm was thicker than mesial to first molar.

Also current study results showed decreased bone thickness at the level of maxillary second molar. This is consistent with a study by Deguchi[11], when he quantitatively evaluated the cortical bone thickness in various locations in the maxilla and the mandible. He found that there was significantly less buccal bone present at the maxillary second molar region compared with the mesial and distal areas of the first molars.

Alveolar bone thickness varies with skeletal pattern. Vertical skeletal pattern is an important variable influencing cortical bone and mini screw implant stability. But study by Matias[18] have revealed that there is no significant difference in the availability of ideal bone thickness for the insertion of extra-alveolar miniscrews in the infrazygomatic crest region at any insertion height in different facial skeletal pattern i.e.,brachyfacial, mesofacial and dolichofacial.

Studies shows influence of sagittal skeletal morphology on implant stability in relation to cortical bone thickness. But according to Nagham Al-Jaf et al[19], for Class II, and class III, the sites with highest cortical mean values were located more anteriorly and no significant difference between buccal cortical thicknesses at posterior region.

For miniscrew placement, the vertical level 5mm, 7mm , 9mm from CEJ were not considered since it interfere with tooth roots. The reason was IZC bone screw are steel devices with 2 mm diameters and are wider than the diameters of the conventional ones. During the selection of a site for the insertion of an orthodontic miniscrew, a safe distance of at least 0.5 mm from the tooth roots is recommended. Hence, to insert a screw of 2 mm diameter in the IZC area, at least a bone thickness of 3 mm should be available for safe and effective insertion, 0.5 mm distance from the root, 2 mm of the screw, and 0.5 mm distance from the most vestibular point of the adjacent alveolar cortical bone which guarantees a minimum safe distance from the root of the adjacent tooth and also the bone-implant contact ratio to the screw.

The limitations of present study was it didn't consider other factors like age, sex, growth pattern of the subjects that could have some influence on the mini screw implantation procedure.

However, Miyawaki et al[12] found no correlation between mini-implant success rate and clinical parameters such as gender and implant location. Study by Margherita Rosi et al[20] also found no significant correlation in the cortical bone thickness values between the three skeletal patterns, and according to sex and age.

The present study analyzed only the osseous quantity, soft tissue characteristics of these regions were not considered. As mentioned by Nucera et al[21], the mobility of the alveolar mucosa at the insertion site can affect the long-term stability of the miniscrew.

The other limitation was that, it did not correlate the bone thickness with various angulations in which the mini-screws are placed. It is an important parameter in the success of mini-implant as it can engage more cortical bone when angulated, this in turn accentuates the primary stability of the implant.

V. Conclusion

Based on the outcome of this study, it is reasonable to conclude that the infrazygomatic crest region is an optimal extra-alveolar site for placement of Temporary Anchorage Devices (TADs) .The safe site for insertion of TADs in the infrazygomatic crest were the interdental area between maxillary first and second molars at the heights of 11 mm from cementoenamel junction and 70 degree to the occlusal plane. It is better to avoid placing TADs distal to maxillary second molar region as the bone in that region is thinner comparatively

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