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A MEASUREMENT OF PALATAL BONE THICKNESS IN VARIOUS ARCH FORM FOR PALATAL MINI IMPLANT INSERTION SITE DETERMINATION- A CBCT STUDY

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ABSTRACT

Thirty Pretreatment CBCT images of orthodontic patients, age 13-30 years were selected. The samples were divided based on Square, Ovoid & Tapered arch form using Palatal bone thickness was measured on both the right and left sides. The thicknesses of palatal hard tissue were measured at the various coronal planes. Data were analyzed by One way ANOVA. The level of significance was established at $P<0.05$. Bone thickness is highest anteriorly at mid palatal suture. This is consistent for all the three arch forms, & it is statistically significant. Bone thickness reduces posteriorly. When compared within three arch forms, bone thickness is found to be highest in tapered arch form.Square arch form is having bone thickness higher than Ovoid arch form. Bone thickness measurements on Right & left are significantly similar.Anterior mid palatal region is suitable site for palatal mini-implant placement. Higher bone thickness in Tapered arch form allows more sites for mini-implant placement. Bone thickness was higher in Square arch form compared to Ovoid arch form

Keyword: Arch form, CBCT, Palatal Bone thickness, Mini implant.

INTRODUCTION

Orthodontic treatment aims for correction of various malocclusions through use of various fixed mechano therapy. Orthodontic mini-implants have been widely used in practice for a variety of tooth movements. Although mini-implants can be inserted either buccally or palatally to achieve diverse tooth movements, palatal mini implants are usually preferred based on their superior

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stability[1-3]. The hard palate has significant mechanical and anatomic advantages over the other insertion sites. It is surgically accessible, offers excellent peri implant conditions due to the attached mucosa, provides reduced hindering of tooth movement during treatment, and allows versatility in appliance design[4]. The associated disadvantages are the possible lack of vertical bone thickness and its anatomic variability among patients. Three basic qualitative arch forms have been repeatedly described in the literature, namely, tapered, oval, and square. Many geometric forms and mathematical functions have been proposed as quantitative models of the human dental arch, such as parabolic equation. Several factors influence arch form such as malocclusion, Bolton'sratio, shape of a face, tooth size, habits, and muscularand patient's profile. Growth and development of hard palate takes place in anterior – posterior and vertical dimensions. That makes tapered arch to have more constricted palate and palatal depth is increased compared with other two types of arch forms. With the help of CBCT imaging technique three-dimensional accurate positioning of mini-implant into desired location can be achieved.

AIM:

Measure palatal bone thickness for mini-implant placement & find a correlation between arch form and change in palatal bone thickness.

METHODS

This study analyzes the pretreatment CBCT of 30 patients, age 13- 30 yrs taken for orthodontic treatment & was divided into 3 groups based on different arch forms, following inclusion & exclusion criteria:

INCLUSION criteria are

- Full eruption of permanent dentition (except for 3rd molar) &
- Individual with full set of permanent teeth with normal development of jaw & musculature.

EXCLUSION criteria were,

- Missing or Extracted teeth in upper jaw,
- Impacted tooth in upper arch,
- Cleft Lip Cleft Palate or any other craniofacial disorders, Pathological lesion in the jaw, or any previous palatal surgical interventions.

CBCT Examinations:

CBCT data were obtained using a three-dimensional volume scanner (Genoray Papaya 3D+, South Korea).The following settings were used: 60kV, 5.0 mA, exposure time 9-17seconds Field of view 40 x 45 mm, voxel size 75 µm and slice thickness 0.3 mm. Acquired images were stored in Digital Imaging and Communication in Medicine (DICOM) 3D format. TRIANA Genoray image analyzing software was used for image reconstruction and analysis. Measurements of palatal thickness were made on coronal sections at various levels.

Arch Form:

To divide samples into three arch forms, Intercanine Width, Canine Depth, Intermolar Width, and Molar Depth were measured for all samples on CBCT transverse section at the occlusal plane level. Based on these observations, the arch form ratio was calculated as (Fig I)

Arch Form Index Formula =CD x MW / CW x MD[5]

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(1) If the ratio is less than 45.30%: Square arch form; (2) If the ratio is between 45.30% - 53.37%:
Oval arch form; (3) If the ratio more than 53.37%: Tapered arch form is expected
Each sample was then divided into three categories: Square, Ovoid, and Tapered, arch form.

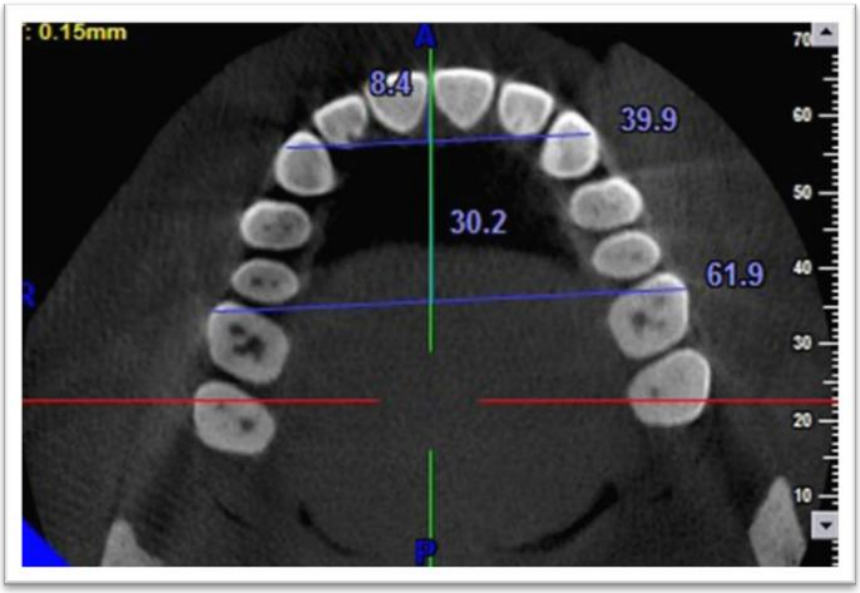

Figure. I: Arch Form

Grid:
A grid is formed on transverse section of palate, with X, Y coordinates, originating from distal surface of incisive foramen. Coronal planes are selected distal to incisive foramen at an interval of 5 mm till distal surface of maxillary permanent 1st molar, ending before the fovea palatine that marks the end of anatomic hard palate. Over a Transverse section, passing at the level of Anterior nasal spine, Midsagital reference line is projected on the mid palatal suture. A horizontal line is drawn passing through the distal margin of Incisive foramen. A grid was formed, at 3, 6, 9 mm interval from vertical reference line & at 0, 5, 10, 15, 20, 25, 30 mm from Horizontal reference line (Fig II).

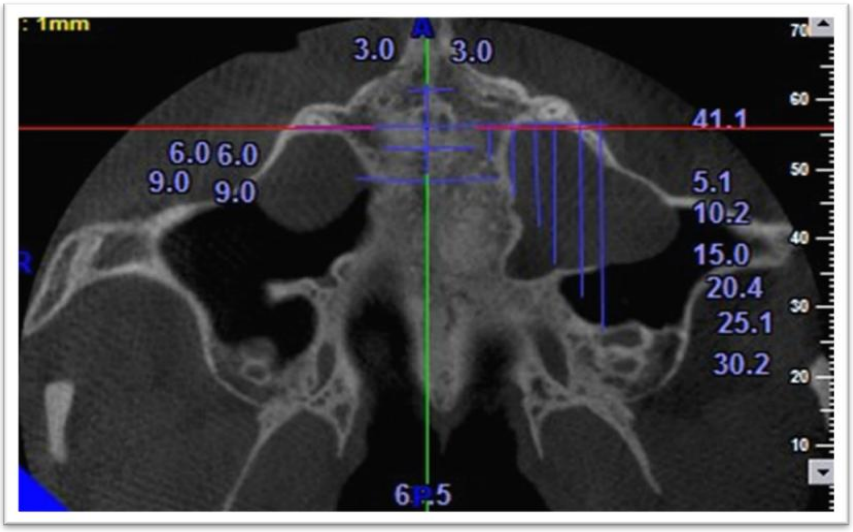

Figure II: Grid for Measurement

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All subsequent measurements were made through the grid junction points on midline and Right & left side. The thickness of hard palate is measured on each coronal plane at and from mid palatal suture, at 3mm interval laterally (Fig III).

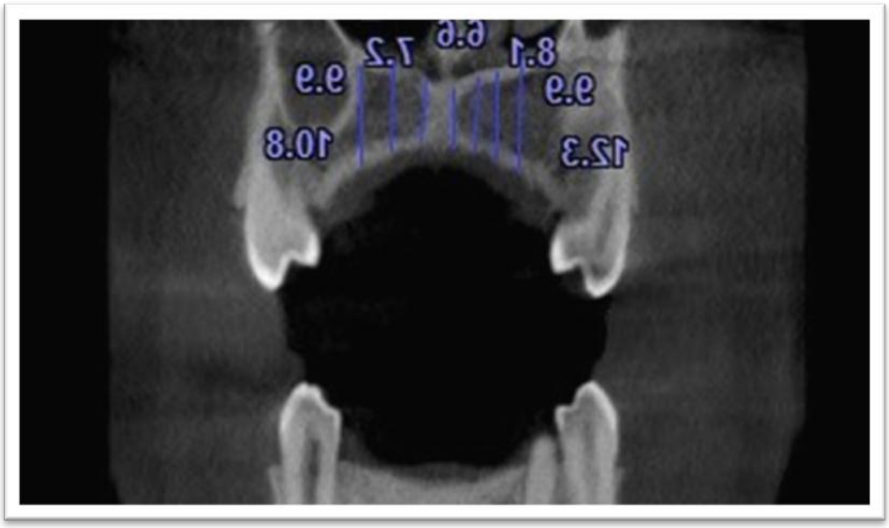

Figure: III Bone Thickness Measurement

The thickness of the hard tissue was measured every 3 mm (0 mm, 3 mm, 6mm, and 9mm) away from the midpalatal suture. A gathered data is noted and analyzed. Total of 70 measurements were taken at different locations as designated for each sample[6].

RESULT:

A Two way ANOVA test was performed to measure mean bone thickness at Anterior- Posterior dimension along the various coronal sectional planes in different arch forms (Table I). The mean bone thickness, at 0mm was found highest. Mean bone thickness decreases progressively from Anterior to posterior. Mean bone thickness at 10 & 15 mm are least among the all samples. Statistically, significant difference was present at anterior- posterior dimensions.

On lateral measurements, Mean Bone thickness were highest at Midline and least at 6 mm laterally in study subjects. Statistically, significant difference was present in Bone thickness at various lateral points in study samples as shown in Table II.

Pearson correlation was measured to check correlation between measurements taken on Right & Left side as shown in Table IV.

Repeated measure ANOVA test was performed to check mean bone thickness among various Anterior – Posterior and Lateral distribution in all arches. Mean Bone thickness was highest at 0 mm in study subjects with tapered arch and least at 30 mm in study subjects with square arches. Statistically, significant difference was present in Bone thickness with different arches as shown in Table III.

Table I Antero-posterior distribution

Groups		Number	Mean	SD	P Value
Square	**0**	70	7.71	1.68	≤ 0.05*
	5	70	4.21	1.30	
	10	70	2.77	1.04	

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	15	70	2.11	1.27	
	20	70	2.02	1.28	
	25	70	1.60	1.30	
	30	70	1.40	1.14	
Ovoid	**0**	70	6.01	2.04	
	5	70	3.31	1.60	
	10	70	2.23	1.27	
	15	70	2.11	1.16	
	20	70	1.88	1.05	
	25	70	1.72	0.87	
	30	70	1.55	0.92	
Tapered	**0**	70	10.35	3.38	
	5	70	6.62	1.92	
	10	70	3.79	1.83	
	15	70	3.71	1.51	
	20	70	2.90	1.15	
	25	70	2.44	1.33	
	30	70	1.86	1.31	

Level of Significance P ≤ 0.05, * Significant, ** Non-Significant

Table II Lateral distribution

Groups		Number	Mean	SD	P Value
Square	**R9**	70	3.16	2.96	< 0.05*
	R6	70	2.72	2.53	
	R3	70	2.99	2.07	
	Midline	70	4.35	1.74	
	L3	70	2.95	1.92	
	L6	70	2.57	2.37	
	L9	70	3.07	2.87	
Ovoid	**R9**	70	3.14	2.73	
	R6	70	2.15	1.96	
	R3	70	2.39	1.48	
	Midline	70	3.84	1.34	
	L3	70	2.43	1.25	
	L6	70	1.90	1.49	
	L9	70	2.96	2.36	
Tapered	**R9**	70	5.14	4.32	
	R6	70	4.02	3.58	
	R3	70	4.00	3.00	
	Midline	70	5.47	2.04	
	L3	70	4.52	2.55	
	L6	70	3.99	3.26	
	L9	70	4.52	4.00	

Level of Significance P ≤ 0.05, * Significant, ** Non-Significant

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Table III Mean Bone Thickness

Groups	AP	Lateral						
		R9	R6	R3	MID	L3	L6	L9
Square	0	9.4	8.1	6.9	6.7	6.7	7.3	8.7
	5	4.2	3.5	3.9	5	3.7	3.9	4.8
	10	2.8	2.4	2.8	3.9	2.1	2.1	2.9
	15	1.7	1.8	2.1	3.5	2	1.6	1.8
	20	1.8	1.6	2.3	3.5	2	1.3	1.4
	25	0.9	0.9	1.4	4.1	2	0.8	0.8
	30	0.9	0.5	1.2	3.4	2	0.6	0.9
Ovoid	0	8.2	6.1	5.2	5.3	4.6	4.9	7.5
	5	4.2	2.7	2.7	3.9	2.9	2.3	4.2
	10	2.8	1.8	1.7	3.9	2	1.2	1.9
	15	2.1	1.1	1.8	3.5	2.1	1.4	2.4
	20	1.8	1.1	1.8	3.7	1.9	1.1	1.6
	25	1.4	1	1.9	3	1.9	1	1.5
	30	1.1	0.9	1.3	3.4	1.4	1	1.5
Tapered	0	12.1	10.7	10	9.1	9.4	9.7	11.2
	5	8.7	6.1	5	6.4	5.5	6.4	8
	10	4.3	3.2	2.8	4.7	4.1	3.3	3.7
	15	4.3	3	3.1	5	3.8	3	3.5
	20	3.2	2.5	2.5	4	3	2.5	2.3
	25	1.7	1.5	2.6	4.6	3.1	1.7	1.5
	30	1.3	0.8	1.7	4.3	2.5	1	1.2
P Value < 0.05*								

Level of Significance P ≤ 0.05, * Significant, ** Non-Significant

Table IV Right and Left side Correlation

Arch Form	Side		Correlation Value	P Value
Square	R9	**L9**	0.933	≤ 0.05*
	R6	**L6**	0.967	≤ 0.05*
	R3	**L3**	0.883	≤ 0.05*
Ovoid	R9	**L9**	0.914	≤ 0.05*
	R6	**L6**	0.922	≤ 0.05*
	R3	**L3**	0.857	≤ 0.05*
Tapered	R9	**L9**	0.975	≤ 0.05*
	R6	**L6**	0.971	≤ 0.05*
	R3	**L3**	0.921	≤ 0.05*

Level of Significance P ≤ 0.05, * Significant, ** Non-Significant

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DISCUSSION:

Orthodontic treatment is aimed at correction of dental & skeletal discrepancies alongwith improvement of soft tissue morphology. Graber[1] suggested Envelop of discrepancies, based on that malocclusion can be treated with Orthodontics alone or with Orthopedics or surgical approach. Skeletal anchorage was made popular and versatile to be used widely in orthodontics for multiple corrections, allowing treating cases without surgical approach. Hence, the application of mini implant in the field of orthodontics was introduced by Nienkemper et al[7] for absolute anchorage purpose. The TADs being considered an absolute source of skeletal anchorage for orthodontics, stability of the TAD plays a key role in the success of this entire treatment. Osseointegration of the TAD or mini-implant was consider to provide the desired anchorage to move teeth. **Heinrich Wehrbein in 1999**[8] reported, insertion and retrieval procedure were quick and simple. Anchor loss of the implant supported anchorage teeth was small ~1 mm, compared with the amount of canine and incisor retraction. Implant used as anchorage eliminated compliance dependent intraoral and extraoral anchorage aids, relatively predictable outcome, & favorable aesthetic. Clinically Maxillary anterior palatal bone with denser mucosal covering provides ideal site for stable anchorage. One of the most commonly used locations is the interradicular area between two teeth and Palatal Site. Melo[9] suggested Age, Sex habit and Growth pattern related factors does not affect implant failure rate. Karlien Asscherickx[10] reported in his study, the success rate of the palatal implants was that determines the palatal site is suitable to stable skeletal anchorage. So in this study we selected suitable sites for palatal mini implants. Palatal anchorage site being more closure to Center of Resistance of tooth, desired tooth movement is achieved more favorably.

Palatal bone thickness was found to be highest in anterior palatal region. Tapered arch form is having good bone height in Anterior and posterior region & at mid palatal and para median region. This finding can be utilized in clinical application while planning for MARPE or Bone anchored palatal appliances with Anterior and Posterior mini-implant insertion.

Pretreatment CBCT scans of patient were used for this study. CBCT technology has enabled the acquisition of valuable data in a single scan. Same radiographic data can be acquired from a single captured CBCT scan. New imaging techniques in dentistry and field of orthodontics are futuristic and now a reality as the paradigm in orthodontics shifts from landmarks, lines and distances and angles to surfaces areas and volumes. CBCT scan were taken for measurement of palatal bone thickness at various coronal planes as they are most accurate and reliable. Kumar et al[11] compared the CBCT synthesized lateral cephalograms with conventional lateral cephalograms to identify differences in cephalometric measurements between these imaging modalities. This study result shows the precision and accuracy of a CBCT synthesized lateral cephalograms. So CBCT are most reliable to determine the placement site, for palatal mini implant. In order to determine the optimal depth of insertion in the anterior palate, bone availability in the anterior palatal rugae are considered stable landmark Björn Ludwig[12]. The most amount of bone was found in the vertical dimension.

Aim of this study is to determine suitable position for implant placement. Stable landmark was selected for insertion site determination. Area distal to 3rd rugae, 6-9 mm from incisive foramen was considered suitable for implant placement[6]. Average bone thickness found in the present study in the said region is 3.79 mm to 2. 77 mm. The values at the 2nd rugae were 6.5and 7.4 mm. This means that even if a 6 mm of implants were selected, there would be clearance between the implant and the root surface. Clinically Implant size of 8 to 10 mm in length would be suitable for achieving bicortical engagement for maximum skeletal support.

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Our findings reveal that the insertion of implant at the level of the first and second rugae can be challenging and cannot guarantee safe placement. The findings of our investigation suggest that the distal to third palatal rugae should be used as a landmark for placement of palatal mini implant. The position of this landmark remains stable and is not influenced by tooth movements. This finding is in agreement with a previous study by Christou and Kiliaridis who used the same methodology and also revealed that the third palatal rugae remain anatomically stable over time[13]. The most distal third palatal ruga is a stable and easily identifiable anatomical landmark for the insertion of palatal mini implant in the anterior palate. Median and Paramedian region for palatal implant insertion are most suitable sites by all orthodontics because of easy access, thick keratinized palatal mucosal covering. This region is surgically very well accessible and offers excellent peri-implant conditions due to the attached mucosa. Sufficient bone thickness and less risk to injuring surrounding vital structures. Growth of midpalatal suture in adolescence and growing patient is a critical factor while planning palatal mini implant. The degree of obliteration of the median palatal suture in young patients has to be considered as a critical factor. Therefore, the range of indications of orthodontic implants should be limited to fully grown juveniles and adult patients. Paramedian site selection is important.thus it was included in this study to find alternate paramedian sites for palatal mini implant insertion. We find the similar results in a study done by Bernhart T[14],in his study examined for a alternative suitable site for palatal implant placement insertion. He concluded that area was located 3 to 9 mm paramedian, was suitable for implant placement under avoidance of the mid-palatal suture. Vertical bone height was found to be significant for primary implant stability. Growth & development of palate will decide the arch form of a patient. Arch forms have been broadly classified into Square, Ovoid, Tapered based on their Intercanine width, intermolar width & canine distance, molar distance ratio. Variation in soft tissue thickness, anatomic landmarks, age gender were noted. Moreover, we were unable to differentiate the palatal thickness in different arch form. The thickness of palatal soft tissue should also be taken into consideration for implant size and length selection. Secondary development of palate in embryonic stage is restricted with development of tongue. Xinwei Lyu[15] in his study for measurement of palatal soft tissue thickness reveals Results showed that the thicknesses of hard tissue and hard soft tissue at the premolar region were thickest, followed by those at the 2nd premolar and molar region planes. Kang et al reported that the bone thickness decreased laterally and posteriorly. Similar results were found in this study. A point was observed that Tapered arch form is having more palatal bone thickness in Para median region compared to Ovoid and Square arch forms. It could be considered that this change was attributed to embryonic development. Development of the hard palate consists of the primary palate and the secondary palate. They fuse in the fetal development process and form the anterior and posterior palate. Vertical thickening of the secondary palate is limited as a result of rapid development of the tongue, so the thickness of the posterior palate is relatively thinner[16]. So as transverse development is restricted, bone thickness in Tapered arch form was found to be highest in this study results. Square arch form was having more vertical bone thickness compared to ovoid arch form. And thickness was higher in mid sagittal region with progesssive reduction in paramedian region. Palatal thickness increased in most lateral distances.

CONCLUSION:

This study finds the following observations:

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Based on mathematical formula, using intercanine width, intermolar width, canine distance& molar distance ratio samples were successfully divided into three arch forms. Square, Ovoid, and Tapered.

- Bone thickness measured at various points suggests maximum bone thickness available is in anterior mid palatal region which reduces as we go posteriorly.
- Palatal bone thickness is highest in midpalatal region & it reduces on paramedian region around 3 & 6 mm laterally from midpalatal suture & found to be increased 9 mm away from midpalatal region.
- Overall palatal bone thickness was found to be highest in Tapered arch form followed by Square & Ovoid arch form.
- Based on following observations, anterior palate at and mid palatal region can be used successfully for palatal mini implant insertion site.

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