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RESEARCH ARTICLE

EVALUATION OF PALATAL BONE THICKNESS ON LATERAL CEPHALOGRAM AND ITS COMPARISON WITH CBCT SCANS

Manisha[1], Falguni Mehta[2], Renuka Patel[3], Harshik Parekh[4], Megha Goswami[5] and Ronitkumar Tiwari[6]
1. PG Student, Government Dental College and Hospital, Ahmedabad, Gujarat, India.
2. Head of Department and Professor, Government Dental College and Hospital, Ahmedabad, Gujarat, India.
3. Professor, Government Dental College and Hospital, Ahmedabad, Gujarat, India.
4. Assistant Professor, Government Dental College and Hospital, Ahmedabad, Gujarat, India.
5. Assistant Professor, Government Dental College and Hospital, Ahmedabad, Gujarat, India.
6. PG Student, Government Dental College and Hospital, Ahmedabad, Gujarat, India.

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Abstract

Aim: Aim of this study is to evaluate the palatal bone thickness on lateral cephalogram and its comparison with CBCT scans in different growth patterns and to find the gender differences if exists in palatal bone thickness at various measuring sites.
Materials and Method: In this study 90 subjects with age ranging from 16-25 years visiting the Department of Orthodontics were chosen. Subjects were categorized into average, horizontal and vertical growth pattern groups according to Jarabak's ratio. They were further divided into male and female group to determine gender dimorphism if any. Palatal bone height was measured antero-posteriorly at a distance of 3, 6, 9, 12, 15, 18, 21 and 24 mm posterior to incisive canal both on lateral cephalogram and CBCT.
Results: This study showed the palatal bone thicknessonlateral cephalograms is less when compared to CBCT at all the distances from incisive canal ($p<0.0001$). The horizontal growth pattern showed highest palatal bone thickness at all the intervals followed by average and vertical and a statistically significant difference was found between the three groups ($p<0.0001$). Independent t test reported higher amount of bone thickness in males as compared to females on both lateral cephalogram and CBCT ($p<0.05$).
Conclusion: Lateral Cephalogram showed less bone thickness when compared to CBCT. Horizontal growth pattern showed highest amount of bone thickness followed by average and vertical growth pattern.

Introduction:-

The hard palate is an important part of skull that separates the oral and nasal cavities[1]. Palatine bone has irregular morphology and structure[2]. It consist of thick and dense cortical bone. It's median and paramedian does not have major critical structures of nerves, blood vessels or roots which can hinder the placement of palatal implants[3]. Therefore, palate is one of the most chosen site in maxilla for anchorage control. Palatal implants are now very commonly used in orthodontics owing to its histo-morphology and simplicity in placement[4]. Thick dense cortical

Corresponding Author:- Manisha
Address:- Government Dental College and Hospital, Ahmedabad, Gujarat, India.

bone from hard palate provides support to palatal implants for sustaining orthodontic forces and keratinized gingiva which is less susceptible to inflammation, facilitates formation of compact connective tissue around its cervical part[5].

Proper length of palatal implants needs to be determined before its placement. This requires evaluation of palatal bone thickness (height) at various distances from incisive canal for the best choice of implants, its size[6].

Palatal height measurement needs to be determined radiologically. Lateral cephalograms being a common and gold standard radiological investigation in the field of orthodontics, can be used to measure palatal bone thickness[7]. However, the accurate measurement of bone height may be difficult because lateral cephalogram is a 2D view of 3D object and is prone to magnification and superimposition errors[8].

Cone-beam computed tomography (CBCT), provides three dimensional accurate and detailed picture of an object under view without any distortion. It has the advantage of dividing the palate into multiple slices and at various angles thus enabling a more thorough investigation[9]. However, this involves additional cost, increased radiation exposure, time and lack of availability due to the need of expertise associated with CBCT scan[9].

Therefore, this study is carried out to evaluate palatal bone thickness on lateral cephalogram at various distances from incisive canal and compare it to CBCT, check for gender dimorphism if any and also compare palatal bone height between different growth patterns.

Materials And Method:-

The present studywas carried out atthe Department of Orthodontics and Dentofacial Orthopedics,Government Dental College & Hospital, Ahmedabad. For this study 90 subjects with age ranging from 16-25 years visiting the Department of Orthodontics were chosen.

Inclusion criteria:

- Age group of the selected subjects in the range of 16-25 years.
- Presence of all the permanent teeth upto second molars.
- No history of previous orthodontic treatment.

Exclusion criteria:

- Individuals with craniofacial syndromes.
- Any history of dental trauma and facial trauma.
- Presence of odontogenic cysts and tumours.

Selection Criteria:

Standardized cephalometric radiographswere taken with “Vatech PHT 30 LFO” smart machine with85 kVp, 10.0 mA, scan time 12.9 sec, a film to focus distance of 150 cm and a film to medianplane distance of 15 cmin centric occlusion with lips relaxed and horizontally oriented Frankfort horizontal plane. Subjects were categorized into average, horizontal and vertical growth pattern groups according to Jarabak’s ratio.

$$\text{Jarabak's ratio} = \frac{posterior\ facial\ height}{anterior\ facial\ height} \times 100$$

They were further divided into male and female group to determine gender dimorphism if any.

Group		Jarabak’s Ratio	Total	Subgroups
A.	Average Growth Pattern	62-65%	30	A1= 15 males
				A2= 15 females
B.	HorizontalGrowth pattern	>65%	30	B1=15 males
				B2=15 females
C.	Vertical Growth Pattern	<62%	30	C1= 15 males
				C2= 15 females

"Ezdent-I ver.3.1.5.1 Console" was used to determine measurements at various distances from the incisive canal on lateral cephalograms. To identify and determine the position of incisive canal on lateral cephalogram "Delaire's analysis" was used. (Fig-1)
Following landmarks and reference lines were used in Delaire's analysis:
1) Point M- Junction of maxillofrontal, nasofrontal and maxillonasal suture.
2) Point CIp- Apex of posterior clinoid process.
3) Point FM- Frontomaxillary joint.
4) Line C3- A line joining the point FM and point C1p (apex of posterior clinoid process) extending posteriorly to the external surface of occipital bone.
5) Line CF1- A line perpendicular to C3 through FM.

The position of incisive canal is determined by the intersection of CF1 with the hard palate. A horizontal reference plane was determined from incisive foramen to posterior nasal spine (PNS). This is used as reference line for measurements at different intervals. Hard palate thickness was measured between the outer cortical layer of the caudal nasal floor and the outer cortical layer of the oral hard palate. All the measurements were done perpendicular to the reference line in antero-posterior direction at a distance of 3, 6,9,12,15,18,21 and 24 mm from the incisive canal on lateral cephalograms. (Fig-2)

Fig. 1:- Landmarks and reference lines in Delaire's analysis.

The CBCT scan was acquired with CS 9300 all in one imaging system.The CBCT images were acquired with the Carestream (CS 9300) Point- of-Care 3D CT (Carestream Health, Rochester, NY, USA) operated at 90 kvp, 5mA and 0.7 mm nominal focal spot size withexposure time of 18 sec, voxel size of $300 \times 300 \times 300$ µm. The subjects were oriented in natural head position with Frankfort horizontal plane parallel to the floor and the mid-sagittal plane perpendicular to the floor.A single 360º rotation,11.26 sec scan, comprising 306 basis projections were made of maxilla with a 17.0 cm (diameter) $\times$ 13.5 cm (height) field of view.On the axial view of CBCT, mid- sagittal plane was determined by a line joining the incisive foramen and posterior nasal spine (Fig: 3).


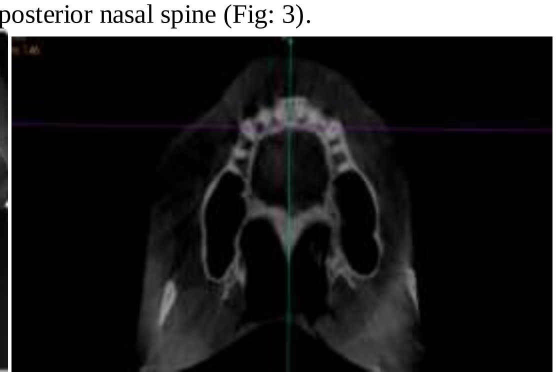

Fig. 2:- Measurements on Lateral Cephalogram.Fig. 3: Axial section of CBCT.

In sagittal view, reference line was projected through the distal margin of the incisive foramen and posterior nasal spine so that they both lie on the same horizontal plane. Palatal bone height was measured antero-posteriorly at a distance of 3, 6, 9, 12, 15, 18, 21 and 24 mm posterior to incisive canal. All the measurements were done perpendicular to the reference line between the outer cortical layer of the caudal nasal floor and the outer cortical layer of the oral hard palate (Fig: 4)

The measurements obtained were subjected to statistical analysis. Data was analyzed using the statistical package SPSS.0. Inferential statistics to find out the difference between and within the group done by Repeated measures of ANOVA. Independent 't' test was used for two groups comparison.

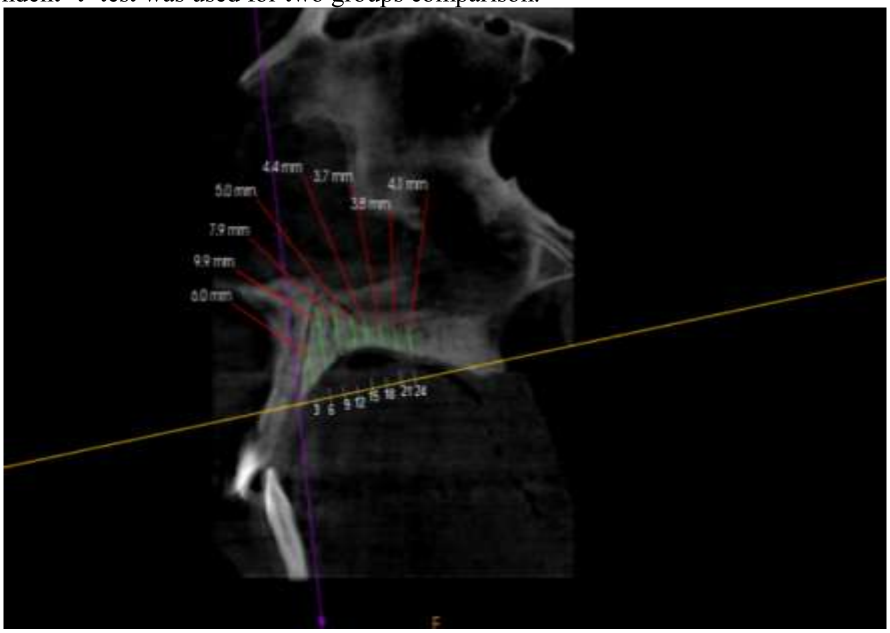

Fig. 4:- Sagittal section of CBCT.

Results:-

Table 1:- Mean palatal bone thickness on lateral cephalogram and CBCT at different levels from incisive canal.

OVERALL		
	LATERAL CEPH	CBCT
3 mm	**2.91±0.22**	**3.91±0.13**
6 mm	**4.83±0.24**	**6.15±0.36**
9 mm	**3.91±0.17**	**4.99±0.22**
12 mm	**2.45±0.03**	**3.72±0.10**
15 mm	**2.07±0.10**	**3.35±0.20**
18 mm	**1.85±0.06**	**3.19±0.30**
21 mm	**1.63±0.04**	**2.93±0.32**
24 mm	**1.48±0.06**	**2.68±0.31**

Table 2:- Comparing palatal bone thickness between lateral cephalogram and CBCT at different levels from incisive canal.

	OVERALL		
	LATERAL CEPH	CBCT	P VALUE
3 mm	**2.91±0.22**	**3.91±0.13**	**0.0001***
6 mm	**4.83±0.24**	**6.15±0.36**	

			0.0001*
9 mm	3.91±0.17	4.99±0.22	0.0001*
12 mm	2.45±0.03	3.72±0.10	0.0001*
15 mm	2.07±0.10	3.35±0.20	0.0001*
18 mm	1.85±0.06	3.19±0.30	0.0001*
21 mm	1.63±0.04	2.93±0.32	0.0001*

Table 3:- Mean palatal bone thickness on lateral cephalogram and CBCT in different growthpattern.

	LATERAL CEPH			CBCT		
	AVERAGE	HORIZONTAL	P VALUE	AVERAGE	HORIZONTAL	P VALUE
3 mm	2.7±0.5	3.23±0.13	0.0001*	3.73±0.42	4.05±0.11	0.0001*
6 mm	4.9±0.38	5.10±0.28	0.0001*	5.83±0.46	6.67±0.79	0.0001*
9 mm	4.1±0.22	4.97±0.45	0.0001*	4.9±0.19	5.29±0.11	0.0001*
12 mm	2.4±0.31	2.41±0.40	0.56	3.67±0.46	3.87±0.17	0.0001*
15 mm	2.1±0.18	2.93±0.23	0.0001*	3.24±0.28	3.64±0.01	0.0001*
18 mm	1.8±0.18	2.77±0.13	0.0001*	3.02±0.20	3.61±0.01	0.0001*
21 mm	1.62±0.05	2.57±0.08	0.0001*	2.73±0.16	3.39±0.09	0.0001*
24 mm	1.57±0.01	2.41±0.09	0.0001*	2.55±0.21	3.11±0.13	0.0001*

Table 4:- Comparison of palatal bone thickness between Average and Horizontal growth pattern.

	AVERAGE		HORIZONTAL		VERTICAL	
	LAT -CEPH	CBCT	LAT- CEPH	CBCT	LAT- CEPH	CBCT
3 mm	2.7±0.5	3.73±0.42	3.23±0.13	4.05±0.11	2.60±0.08	3.72±0.18
6 mm	4.9±0.38	5.83±0.46	5.10±0.28	6.67±0.79	4.2±0.02	5.66±0.20
9 mm	4.1±0.22	4.9±0.19	4.97±0.45	5.29±0.11	4.08±0.03	4.2±0.14
12 mm	2.4±0.31	3.67±0.46	2.41±0.40	3.87±0.17	2.30±0.13	3.63±0.01
15 mm	2.1±0.18	3.24±0.28	2.93±0.23	3.64±0.01	2.07±0.07	3.17±0.03
18 mm	1.8±0.18	3.02±0.20	2.77±0.13	3.61±0.01	1.78±0.01	2.98±0.09
21 mm	1.62±0.05	2.73±0.16	2.57±0.08	3.39±0.09	1.60±0.04	2.68±0.12
24 mm	1.57±0.01	2.55±0.21	2.41±0.09	3.11±0.13	1.54±0.01	2.48±0.13

Table 5:- Comparison of palatal bone thickness between Average and Vertical growth pattern.

	Lateral Ceph			CBCT		
	Average	Vertical	P value	Average	Vertical	P value

3 mm	**2.7±0.5**	**2.60±0.08**	**0.8**	**3.73±0.42**	**3.72±0.18**	**0.12**
6 mm	**4.9±0.38**	**4.2±0.02**	**0.06**	**5.83±0.46**	**5.66±0.20**	**0.06**
9 mm	**4.1±0.22**	**4.08±0.03**	**0.32**	**4.9±0.19**	**4.2±0.14**	**0.09**
12 mm	**2.4±0.31**	**2.30±0.13**	**0.06**	**3.67±0.46**	**3.63±0.01**	**0.32**
15 mm	**2.1±0.18**	**2.07±0.07**	**0.06**	**3.24±0.28**	**3.17±0.03**	**0.09**
18 mm	1.8**±0.18**	**1.78±0.01**	**0.12**	**3.02±0.20**	**2.98±0.09**	**0.2**
21 mm	1.62**±0.05**	**1.60±0.04**	**0.6**	**2.73±0.16**	**2.68±0.12**	**0.24**
24 mm	1.57**±0.01**	**1.54±0.01**	**0.6**	**2.55±0.21**	**2.48±0.13**	**0/08**

Table 6:- Comparison of palatal bone thickness between Vertical and Horizontal growth pattern.

	LATERAL CEPH			**CBCT**		
	VERTICAL	**HORIZONTAL**	**P VALUE**	**VERTICAL**	**HORIZONTAL**	**P VALUE**
3 mm	**2.60±0.08**	**3.23±0.13**	**0.0001***	**3.72±0.18**	**4.05±0.11**	**0.0001***
6 mm	**4.2±0.02**	**5.10±0.28**	**0.0001***	**5.66±0.20**	**6.67±0.79**	**0.0001***
9 mm	**4.08±0.03**	**4.97±0.45**	**0.0001***	**4.2±0.14**	**5.29±0.11**	**0.0001***
12 mm	**2.30±0.13**	**2.41±0.40**	**0.03***	**3.63±0.01**	**3.87±0.17**	**0.0001***
15 mm	**2.07±0.07**	**2.93±0.23**	**0.0001***	**3.17±0.03**	**3.64±0.01**	**0.0001***
18 mm	**1.78±0.01**	**2.77±0.13**	**0.0001***	**2.98±0.09**	**3.61±0.01**	**0.0001***
21 mm	**1.60±0.04**	**2.57±0.05**	**0.0001***	**2.68±0.12**	**3.39±0.09**	**0.0001***
24 mm	**1.54±0.01**	**2.41±0.01**	**0.0001***	**2.48±0.13**	**3.11±0.13**	**0.0001***

Table 7:- One Way ANOVA test to compare palatal bone thickness on lateral cephalogram in different growth pattern.

	AVERAGE	**HORIZONTAL**	**VERTICAL**	**P VALUE**
3 mm	**2.7±0.5**	**3.23±0.13**	**2.60±0.08**	**0.0001***
6 mm	**4.9±0.38**	**5.10±0.28**	**4.2±0.02**	**0.0001***
9 mm	**4.1±0.22**	**4.97±0.45**	**4.08±0.03**	**0.0001***
12 mm	**2.29±0.31**	**2.41±0.40**	**2.3±0.13**	**0.0001***
15 mm	**2.1±0.18**	**2.93±0.23**	**2.07±0.07**	**0.0001***
18 mm	1.8**±0.18**	**2.77±0.13**	**1.78±0.01**	**0.0001***
21 mm	1.62**±0.05**	**2.57±0.05**	**1.60±0.04**	**0.0001***
24 mm	1.57**±0.01**	**2.41±0.01**	**1.54±0.01**	**0.0001***

Table 8:- One Way ANOVA test to compare palatal bone thickness on CBCT in different growth pattern.

	AVERAGE	HORIZONTAL	VERTICAL	P VALUE
3 mm	3.73±0.42	4.05±0.11	3.72±0.18	0.0001*
6 mm	5.83±0.46	6.67±0.79	5.66±0.20	0.0001*
9 mm	4.9±0.19	5.29±0.11	4.2±0.14	0.0001*
12 mm	3.67±0.46	3.87±0.17	3.63±0.01	0.0001*
15 mm	3.24±0.28	3.64±0.01	3.17±0.03	0.0001*
18 mm	3.02±0.20	3.61±0.01	2.98±0.09	0.0001*
21 mm	2.73±0.16	3.39±0.09	2.68±0.12	0.0001*
24 mm	2.55±0.21	3.11±0.13	2.48±0.13	0.0001*

Table 9:- Overall comparison of palatal bone thickness at various intervals between maleandfemale group.

	LATERAL CEPH			CBCT		
	MALE	FEMALE	P VALUE	MALE	FEMALE	P VALUE
3 mm	3.15±0.19	2.68±0.36	0.0001*	4.15±0.01	3.67±0.26	0.0001*
6 mm	5.22±0.16	4.45±0.32	0.0001*	6.84±0.48	5.47±0.29	0.0001*
9 mm	4.32±0.08	3.51±0.29	0.0001*	5.21±0.12	4.77±0.32	0.0001*
12 mm	2.74±0.08	2.17±0.14	0.0001*	3.94±0.22	3.51±0.21	0.0001*
15 mm	2.23±0.06	2.1±0.16	0.01*	3.43±0.21	3.27±0.28	0.01*
18 mm	1.95±0.05	1.90±0.13	0.74	3.23±0.32	3.15±0.32	0.028*
21 mm	1.65±0.01	1.60±0.09	0.74	2.91±0.30	2.55±0.38	0.03*
24 mm	1.51±0.05	1.45±0.10	0.65	2.66±0.30	2.2±0.38	0.02*

Discussion:-

The palate being a high density bone structure with sufficient bone height is a good location for orthodontic screw placement.

The mid-sagittal area of the palate is a valuable insertion site for implants in order to provide a stable point for orthodontic correction in the maxilla[10]. The advantage of placing mini-screw in the palatal area is that there are no significant anatomical structures such as nerves, blood vessels or the roots, that interfere with the placement. Moreover, the palatal region is keratinized thereby causing less irritation to the tissue[36]. The median area of the palate contains high quality of cortical bone, which contributes to retention of the mini-implants[17]. Lack of adequate bone thickness at the mini-implant site can compromise the bone- implant surface area for stability and pose a risk of perforating into the incisive canal or nasal cavity. Assessment of the palatal thickness in case of skeletal anchorage using palatal mini-implants is the key to indicate or contraindicate the procedure[19].

During the process of growth and development, the palatal bone in normal situations undergoes a process of remodeling which can be affected by numerous genetic and environmental factors. The functional demand also have a significant effect on the growth and craniofacial development. Each of the facial pattern (average,horizontal and vertical) have different muscle load during function, due to skeletal compensation. Thus a correlation is assumed to exist between palatal bone height and different facial patterns[29].

The mean value of palatal thickness on CBCT is higher than that measured on lateral cephalogram at all the measuring sites.

The maximum mean palatal thickness is detected at 6 mm from incisive canal in both the lateral cephalogram and CBCT. These findings are in accordance with the study conducted by **Bernhart et al[12], A. Gahleitner et al[13]** who observed the maximum palatal thickness at 6 mm was 5.06 mm and 5.26±1.42 mm respectively. Thus the anterior region of the palate could be considered to be the most suitable site for implant insertion.

The minimum palatal thickness is observed at 24 mm in both the lateral cephalogram and CBCT. These findings are in accordance with the study conducted by **Abdul Baais Akhoon et al[22] and Gracco et al[4]** who observed minimum palatal thickness at 24 mm with a mean of 3.60±1.53 mm and 3.93±1.66 mm respectively.

The mean palatal thickness at 6 mm is greater than at 3 mm. This may be due to the fact that incisive canal extends in an oblique direction from the incisive foramen to the nasal cavity. The mean palatal thickness tends to decrease antero-posteriorly beyond 6 mm. These findings are in accordance with the study conducted by **Bernhart et al[12],Chhatwani et al[27], Manjula et al[17],Abdul Baais Akhoon et al[22] and Yadav et al[25]** who observed that palatal thickness decreased antero-posteriorly. This change is probably due to embryonic development. Moreover, the thickening of secondary palate is limited as a result of rapid development of the tongue, so the thickness of posterior palate is relatively thinner.

Palatal bone thickness shows increased values on CBCT as compared to lateral cephalogram. This is due to the fact that lateral cephalogram is a 2D presentation of 3D object. The difference between them is statistically highly significant (p=0.0001) for all the measuring sites.

These findings are in accordance with the study conducted by **Mohlhernrich et al[31]** (p=0.01)who observed the mean palatal bone height on CBCT to be significantly higher than the measurements on lateral cephalogram. **Wehrbein et al[11]** in his study observed the palatal thickness in the anterior and middle region to be higher than indicated on lateral cephalograms.

Total sample showed decrease in palatal bone thickness after 6 mm distance from incisive canal. Both on lateral cephalogram and CBCT, the subjects with horizontal growth pattern shows increased values at all the distances from incisive canal followed by average and vertical growth pattern.

This is in accordance with the study conducted by **Vidalon JA et al[29], Ning et al[28],Gabriella et al[19] and S Naghinejad Ahmadi et al[33]** who observed mean palatal thickness to be higher in group with horizontal group.

Statistically highly significant difference (p=0.0001) is observed between average and horizontal growth at all distances except at 12 mm where difference between them is statistically non significant (p=0.56). Similarly when palatal bone thickness between average and horizontal growth pattern subjects was measured on CBCT, showed highly statistically significant difference (p=0.0001) for all the distances measured from incisive canal.

This is in accordance with the study conducted by **Vidalon JA et al[29]** who observed mean palatal thickness to be greater in horizontal group and the difference between them is statistically significant (p<0.05). This is in contrast with the study conducted by **Ning et al[28]** who observed statistically non significant difference (p=0.257) at the level of premolar and molar region. Similar studies conducted by **Gabriella et al[19] and S Naghinejad Ahmadi et al[33]** also observed statistically non significant difference (p=0.738 and p=0.91 respectively). The discrepancy between the results might be due to factors such as difference in racial traits and difference in measurement sites.

On lateral cephalogram, when palatal bone thickness is measured between average and vertical growth pattern individuals shows statistically non significant difference (p=0.8, 0.06, 0.32, 0.06, 0.06, 0.12, 0.6 and 0.6 respectively) at all the distances.

Similarly palatal bone thickness measured on CBCT between average and vertical growth pattern subjects, shows statistically non significant difference at the level of 3 mm, 6 mm, 9 mm, 12 mm, 15 mm, 18 mm, 21 mm and 24 mm (p=0.12, 0.06, 0.09, 0.32, 0.09, 0.2, 0.24 and 0.08 respectively). This is in accordance with studies conducted by **Gabriella et al**[19] **and Ning et al**[28] who observed no statistically significant difference at 12 mm (corresponding to 1st premolar) between average and vertical growth pattern subjects (p=0.738 and p=0.25 respectively).

Statistically highly significant difference (p=0.0001) is observed between vertical and horizontal growth at all distances while at 12 mm the difference is statistically significant (p=0.03).

Similarly when palatal bone thickness between average and horizontal growth pattern subjects was measured on CBCT, showed highly statistically significant difference (p=0.0001) for all the distances measured from incisive canal.

These findings are in accordance with the study conducted by **Ning et al**[28] who observed the palatal thickness to be higher in horizontal groupand the difference between them is statistically significant (p=0.021). Similar study conducted by **Tiwari et al**[34]also observed a statistically significant difference between the two in the anterior region (p=0.03) and **Wang et al**[36]observed statistically significant difference in the posterior region (p<0.005). This is in contrast with the study conducted by **S. NaghiNejad et al**[33] **and Gabriella et al**[19] who observed statistically non significant difference between the two growth patterns (p=0.091 and p=0.738 respectively).

Since both lateral cephalogram and CBCT observed statistically significant difference between average and horizontal growth pattern and between vertical and horizontal growth pattern, One-Way ANOVA test was carried out to compare for differences if any.

Palatal thickness measured at 3 mm, 6 mm, 9 mm, 12 mm, 15 mm, 18 mm, 21 mm and 24 mm from incisive canal in average, horizontal and vertical growth pattern subjects showed statistically highly significant difference (p=0.0001) at all the levels on lateral cephalogram.

Similar results are observed for CBCT showing statistically highly significant difference between them (p=0.0001).

This is in accordance with the study conducted by **Ning et al**[28] **and Vidalon JA et al**[29] who observed a statistically significant difference (p<0.05) between the three groups with the mean palatal thickness to be highest in horizontal group. This is in contrast with the study conducted by **Gabriella et al**[19]who compared the palatal bone thickness at 1st premolar level and found statistically non significant difference between the three groups (p=0.738). Similarly a study conducted by **S. NaghiNejad Ahmadi et al**[33]also observed statistically non significant difference between the three groups (p=0.91). The contrasting results may be due to the difference in ethnic variation and different measuring sites.

On comparison between male and female group, it is observed that the mean palatal bone thickness is higher in males when compared to females at all the distances from incisive canal and the difference between them is statistically significant (p<0.05) except at 18 mm, 21 mm and 24 mm (p=0.74, 0.74 and 0.65 respectively).

Similar results are seen on CBCT, which also showed higher mean values for males at all the measuring sites and the difference between them is statistically significant (p<0.05). This may be attributed to more mass in males.

These findings are in accordance with the study carried out by **Chhatwani et al**[27]**, Ning et al**[28] **and Yadav et al**[25]who observed greater palatal thickness in males and the results were statistically significant (p=0.001, p=0.04 and p<0.001). Similarly, **Maike Holm et al**[21] in his study observed the mean palatal thickness to be significantly higher in males, having on an average 1.23 mm more thickness. Similar study conducted by **Zahraa M. Al- Fadily et al**[18]also obtained similar findings but the difference was statistically significant in the anterior region only(p= 0.002).

Contrarily,**Ryu et al**[16] **and Sumer et al20** observed statistically non significant difference between males and females (p=0.83 and p=0.270 respectively). Even **Gracco et al**[4] and **C.J Chang et al**[32] observed no statistically significant difference in both the sex groups. These contrasting results may be due to the ethnic variation.

Conclusion:-

The conclusions of this study are-

- Palatal bone thickness on lateral cephalograms is less when compared to CBCT at all the distances from incisive canal. Since, lateral cephalograms shows relatively less amount of bone thickness, it can be safely used while implant placement in the mid-palatal region.
- The maximum palatal bone thickness in all the subjects is found at a distance of 6 mm from incisive canal both in lateral cephalogram and CBCT. The palatal bone thickness tends to decrease antero-posteriorly after a distance of 6 mm in all the three facial patterns. Therefore, implants with proper length should be chosen if required to be placed posteriorly.
- Palatal bone thickness is found to be highest in horizontal growth pattern followed by average and vertical growth pattern at all the measuring sites. So, implant placement in vertical growth pattern should be done cautiously.
- Males showed higher mean palatal thickness than females at all the measuring sites, therefore shorter mini-screws may be required in females.

Variation in palatal bone thickness may be attributed to ethnicity, anatomic variation, sexual dimorphism along with different growth patterns. Larger sample size with different growth pattern for gender variation would be more conclusive.

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