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Comparative Evaluation Of Different Anatomical Sites In Buccal Shelf Region For Mini Screw Insertion In Skeletal Class II And Class III Patients-A CBCT Study

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Abstract:
Background*: To evaluate different anatomical sites in buccal shelf region at different levels (4mm, 6mm, 8mm, 10mm) from cemento-enamel junction for mini screw insertion in skeletal class II and class III patients using cone beam computed tomography (CBCT).*
Materials and Methods*: The sample consists of cone beam computed tomography images of 48 subjects (24 skeletal class II and 24 skeletal class III) were evaluated. Mandibular buccal shelf area was evaluated at the regions (i) mesial to lower first molar (ML6) (ii) between the mesiodistal roots of the first molar (iii) distal to lower first molar (DL6) (iv) mesial to lower second molar (ML7) (v) between mesiodistal roots of the second molar (vi) distal to lower second molar (DL7) and cortical bone thickness was determined at 4, 6, 8, 10 mm level from cemento-enamel junction*
Results*: Mandibular buccal shelf bone thickness increases from mesial surface of first molar to distal surface of second molar and from cemento-enamel junction to 8 mm level. Comparative evaluation between class II and class III shows significant differences ($p<0.05$) at the level of 8mm distal to second molar in the mandibular buccal shelf region.*
Conclusion: *Skeletal class III subjects have more cortical bone thickness than class II subjects at the level of 8mm distal to second molar in the buccal shelf region.*
Key Word*: Temporary anchorage devices, mandibular buccal shelf region, CBCT*

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I. Introduction

To facilitate tooth movement, temporary anchorage devices are commonly implanted in various locations in the maxilla and mandible, such as the inter-radicular space, infrazygomatic crest, paramedian palate, and retromolar area.[1] While inter-radicular miniscrews are the most frequently used, their insertion can be challenging in the posterior mandible. Recently, the mandibular buccal shelf (MBS) has gained popularity as an insertion site for orthodontic miniscrews due to its sufficient bone volume and good bone quality.[2] Distal en masse movement of the mandibular dentition has proven highly effective for patients with Class III malocclusions.

Buccal shelf region is bounded medially by the crest of residual ridge, laterally by the external oblique line, anteriorly by the buccal frenum and distally by the retromolar pad. It is covered by compact bone therefore it serves as a primary stress bearing area. Studies have shown that cortical bone thickness varies in individuals with different skeletal types—short, average, and long-faced—which suggests that bone thickness in the buccal shelf region may differ depending on a patient's skeletal structure.[3]

Hence, this study aimed at evaluation of cortical bone thickness at varying levels from cemento-enamel junction for mini screw insertion in skeletal class II and class III patients.

II. Material And Methods

The sample size for this retrospective study was calculated using data obtained from the previous study conducted by Liu et al[2]. A total sample size of 48 with 24 samples each in 2 groups were required with an alpha error of 0.05 at 95% confidence level and 90% power. All CBCTs (24 skeletal class II and 24 skeletal class III)

were collected from, Department of Orthodontics, P.S.M college of Dental Science, Kerala. The approval for the study was acquired from the institutional research ethical committee under reference no (No.511/Ethic/PSMCDR/2021).

Inclusion Criteria:

- Patients having skeletal class II and class III malocclusion.
- Patients of age between13 – 27 years of age.
- Patients with full permanent dentition and fully erupted mandibular second molars

Procedure methodology

For all scans, the minimum field of view used was 13 X 10, and scan time ranged from 5.2 seconds with original axial thickness of 0.30 mm. The CBCT images are stored in DICOM format. Skeletal malocclusion categories were determined from sagittal scan synthesized from the CBCT using the maximum intensity projection technique.

Skeletal malocclusion was categorized by Wits appraisal. To assess the safe regions of the miniscrews implanted in the mandibular buccal shelf for the distalization of mandibular dentition, four sites were measured in the buccal shelf on each side as follows: (i) mesial to lower first molar (ML6) (ii) between the mesiodistal roots of the first molar (iii) distal to lower first molar (DL6) (iv) mesial to lower second molar (ML7) (v) between mesiodistal roots of the second molar (vi) distal to lower second molar (DL7) (fig 1). The buccal bone thickness was determined by orienting the CBCT images in sagittal, axial and coronal plane.

Initially, cemento-enamel junction (CEJ) of each tooth is considered as the reference plane. Then sagittal and coronal images were adjusted. The buccal bone thickness was then measured at 4, 6, 8, 10 level from CEJ (fig 2 and 3).

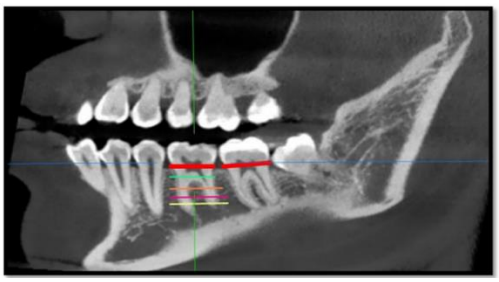

FIG 1- Sagittal slice with reference planes for buccal shelf region measurement (Red – cemento-enamel junction; Green – 4 mm; Orange – 6m; Rose – 8mm; Yellow -10mm)

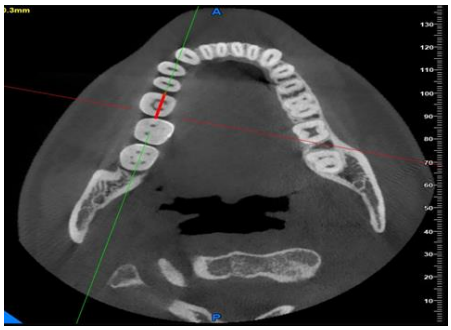

FIG 2 -Axial view showing reference plane in the first molar region

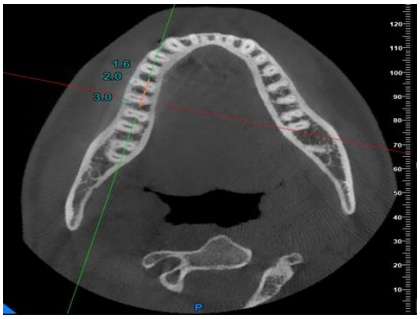

FIG 3- Measurement of cortical bone thickness at the level of 6mm

Statistical analysis

Data was analysed using IBM, SPSS (Statistical Package for Social Sciences, IBMCo., Armonk, NY, USA) version 26 statistical software. For comparison between the groups, one way analysis of variance (ANOVA) test was applied. Comparison of variables between Class II and Class III was done using Student's independent sample t test. Statistical significance was inferred at $p \leq 0.05$.

III. Result

Descriptive statistics for skeletal class II and skeletal class III subjects have been tabulated in table 1 and 2. The buccal cortical bone thickness in the buccal shelf region increases from the level of 4 mm to 10mm from mesial surface of first molar to distal surface of first molar of skeletal class II subject. Comparison of buccal shelf bone thickness at different levels between skeletal class II and skeletal class III have been tabulated in (table 3 – table 6). At 4 mm (table 3) and 6mm level (table 4) there is no statistically significant differences in the cortical bone thickness in the buccal shelf region in skeletal class II and class III in both right and left sides. The bone thickness shows statistically significant differences ($p<0.05$) only at the level of 8mm in skeletal class II and skeletal class III (table 5).

Table no 1 : Descriptive statistics of buccal shelf region for class II subjects'

Descriptives									
Sites for insertion of mini screw (Right)	Measurement points	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Mesial to first molar	4mm	24	1.34	.05	.01	1.32	1.36	1.30	1.40
	6mm	24	1.78	.05	.01	1.75	1.79	1.70	1.80
	8mm	24	1.89	.06	.01	1.77	1.82	1.70	1.90
	10mm	24	1.93	.07	.01	1.87	1.93	1.80	2.00
Between mesial and distal root of first molar	4mm	24	1.17	.05	.01	1.15	1.19	1.10	1.20
	6mm	24	1.29	.11	.02	1.25	1.34	1.20	1.50
	8mm	24	1.55	.13	.03	1.45	1.56	1.30	1.70
	10mm	24	2.08	.07	.02	1.99	2.06	1.80	2.10
Distal to first molar	4mm	24	1.56	.05	.01	1.51	1.55	1.50	1.60
	6mm	24	1.88	.08	.02	1.83	1.90	1.80	2.00
	8mm	24	2.06	.10	.02	2.00	2.08	1.90	2.20
	10mm	24	2.13	.09	.02	2.07	2.15	2.00	2.20
Mesial to second molar	4mm	24	1.87	.11	.02	1.82	1.91	1.70	2.10
	6mm	24	1.59	.07	.01	1.54	1.60	1.50	1.70
	8mm	24	2.33	.09	.02	2.19	2.26	2.10	2.40
	10mm	24	2.23	.08	.02	2.10	2.16	2.00	2.20
Between mesial and distal root of second molar	4mm	24	1.55	.10	.02	1.53	1.61	1.50	1.80
	6mm	24	2.15	.05	.01	2.02	2.07	2.00	2.10
	8mm	24	2.16	.08	.02	2.03	2.09	2.00	2.20
	10mm	24	2.10	.06	.01	2.09	2.14	2.00	2.20
Distal to second molar	4mm	24	1.70	.13	.03	1.64	1.75	1.60	2.00
	6mm	24	2.31	.05	.01	2.31	2.35	2.30	2.40
	8mm	24	2.82	.09	.02	2.29	2.37	2.20	2.50
	10mm	24	2.34	.03	.01	2.27	2.30	2.20	2.30

Table no 2 : Descriptive statistics of buccal shelf region for class III subjects'

Descriptives									
Sites for insertion of mini screw (Left)	Measurement points	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Mesial to first molar	4mm	24	1.46	.14	.03	1.40	1.52	1.30	1.70
	6mm	24	1.84	.05	.01	1.82	1.86	1.80	1.90
	8mm	24	2.01	.15	.03	1.85	1.98	1.70	2.20
	10mm	24	1.92	.07	.01	1.89	1.95	1.80	2.00
Between mesial and distal root of first molar	4mm	24	1.33	.16	.03	1.26	1.39	1.20	1.60
	6mm	24	1.31	.09	.02	1.28	1.35	1.20	1.40
	8mm	24	2.08	.18	.04	1.52	1.67	1.30	1.90
	10mm	24	2.07	.05	.01	2.05	2.09	2.00	2.10
Distal to first molar	4mm	24	1.68	.14	.03	1.62	1.74	1.52	2.00
	6mm	24	1.92	.08	.02	1.89	1.96	1.80	2.10
	8mm	24	2.59	.09	.02	2.02	2.10	1.90	2.20
	10mm	24	2.13	.07	.01	2.10	2.16	2.00	2.20
Mesial to second molar	4mm	24	1.88	.12	.02	1.83	1.93	1.80	2.10
	6mm	24	1.60	.05	.01	1.58	1.62	1.50	1.70
	8mm	24	2.82	.10	.02	2.25	2.33	2.10	2.40
	10mm	24	2.19	.11	.02	2.15	2.24	2.00	2.30
Between mesial and distal root of second molar	4mm	24	1.65	.16	.03	1.58	1.72	1.50	2.00
	6mm	24	2.13	.04	.01	2.11	2.14	2.10	2.20
	8mm	24	2.72	.09	.02	2.10	2.17	2.00	2.20
	10mm	24	2.13	.10	.02	2.09	2.18	1.90	2.20
Distal to second molar	4mm	24	1.75	.16	.03	1.69	1.82	1.60	2.10
	6mm	24	2.14	.16	.03	2.07	2.21	2.00	2.40
	8mm	24	3.09	.08	.02	2.30	2.37	2.20	2.40
	10mm	24	2.30	.09	.02	2.26	2.33	2.10	2.40

Table no 3 : Comparison of buccal shelf bone thickness between class II and class III at the level of 4mm

Sites of insertion of mini screw Comparison between Class 2 and Class 3	Independent Samples t-test for Equality of Means						
	t	df	Sig. (2-tailed) P value*	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper
Mesial to first molar	1.29	46	.20	.02	.01	-.01	.04
Between mesial and distal root of first molar	1.16	46	.25	.02	.01	-.01	.05
Distal to first molar	.32	46	.75	.00	.01	-.02	.03
Mesial to second molar	-.27	46	.79	-.01	.03	-.07	.05
Between mesial and distal root of second molar	.00	46	1.00	.00	.03	-.06	.06
Distal to second molar	.11	46	.91	.00	.04	-.07	.08

Table no 4 : Comparison of buccal shelf bone thickness between class II and class III at the level of 6mm

Sites of insertion of mini screw Comparison between Class 2 and Class 3	Independent Samples t-test for Equality of Means						
	t	df	Sig. (2-tailed) P value*	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper
Mesial to first molar	.23	46	.82	.00	.02	-.03	.04
Between mesial and distal root of first molar	.74	46	.47	.06	.08	-.11	.23
Distal to first molar	.51	46	.61	.02	.03	-.05	.08
Mesial to second molar	.56	46	.58	.04	.07	-.10	.17
Between mesial and distal root of second molar	-.51	46	.61	-.01	.02	-.04	.02
Distal to second molar	.09	46	.93	.00	.05	-.09	.10

Table no 5 : Comparison of buccal shelf bone thickness between class II and class III at the level of 8mm

Sites of insertion of mini screw Comparison between Class 2 and Class 3	Independent Samples t-test for Equality of Means						
	t	df	Sig. (2-tailed) P value*	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper
Mesial to first molar	.00	46	1.00	.00	.02	-.04	.04
Between mesial and distal root of first molar	.00	46	1.00	.00	.05	-.10	.10
Distal to first molar	.00	46	1.00	.00	.03	-.05	.05
Mesial to second molar	.00	46	1.00	.00	.03	-.06	.06
Between mesial and distal root of second molar	.00	46	1.00	.00	.03	-.05	.05
Distal to second molar	-2.22	46	.03	-.08	.04	-.15	-.01

Table no 6 : Comparison of buccal shelf bone thickness between class II and class III at the level of 10mm

Sites of insertion of mini screw Comparison between Class 2 and Class 3	Independent Samples t-test for Equality of Means						
	t	df	Sig. (2-tailed) P value*	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper
Mesial to first molar	-.46	46	.65	-.01	.02	-.04	.03
Between mesial and distal root of first molar	-.69	46	.49	-.01	.02	-.05	.02
Distal to first molar	.00	46	1.00	.00	.03	-.05	.05
Mesial to second molar	.19	46	.85	.00	.02	-.04	.05
Between mesial and distal root of second molar	.24	46	.81	.00	.02	-.03	.04
Distal to second molar	.00	46	1.00	.00	.01	-.02	.02

IV. Discussion

Distalizing the entire mandibular dentition has become a feasible approach for correcting a Class III anteroposterior relationship (such as a negative overjet or edge-to-edge occlusion) by utilizing miniscrews implanted in the mandibular buccal shelf (MBS).[1] The use of temporary anchorage devices has gained popularity in recent years due to their ability to provide absolute anchorage. This method allows for dentoalveolar compensation in patients with dental and skeletal discrepancies by camouflage, thereby reducing the need for surgical correction.[4] The success of this approach is closely tied to the anatomical structure of the mandibular buccal shelf. Choosing the correct implantation site in the MBS is also crucial. The selected site must offer sufficient stability for mandibular dentition distalization while avoiding interference with tooth movement. Mandibular buccal shelf region is the area between buccal frenum and anterior border of masseter muscle.[5] It extends medially from the crest of the ridge, laterally to the external oblique ridge and distally up to the retromolar pad. This region has thick submucosa overlying cortical plate. The buccal shelf region contains immense cortical bone, oriented perpendicular to vertical occlusal forces.

Cortical bone thickness varies tremendously throughout the maxilla and mandible. Bone density in general is higher in mandible than in the maxilla. Cortical bone thickness is on average 1.0- 1.5 mm in the anterior interradicular sites of the mandible, increases to 1.5-2.5 mm in the canine and premolar interradicular areas, and can reach thicknesses greater than 3.0 mm in the mandibular molar and retromolar region.[6] So, there comes the need for evaluating the bone quality three-dimensionally before miniscrew implantation.

In the present study the buccal cortical bone thickness in the mandibular buccal shelf region increases from mesial surface of mandibular first molar to distal surface of mandibular second molar and from CEJ to the level of 8mm, there is significant differences in all the site supporting the findings by Gandhi et al[7]. Hence, the safer site for miniscrew insertion in buccal shelf region is 5-6 mm below the CEJ.

The minimum bone thickness in the present study is seen at the region mesial to first molar at the level of 4mm. The regions distal to second molar shows increased bone thickness and hence considered the safest region for miniscrew insertion. However, there is decrease in bone thickness at the level of 10 mm in comparison to the level of 8mm. Areas of very thin bone will lead to stress in the bone and later lead to implant failure whereas very thick bone will have good initial stability.

In this study, there is no statistically significant differences in the buccal shelf cortical bone thickness in mandibular molar region of skeletal class II and class III patients except at 8mm level, which is corroborating with the findings by Nagham et al[8]. The study by Germec-Cakan et al.[9] also found no significant difference between buccal cortical thickness in subjects with different sagittal skeletal relation.

The present study analyzed only the osseous quantity of both the regions, soft tissue characteristics of these regions were not considered. As mentioned by Nucera et al[10] the mobility of the alveolar mucosa at the insertion site can affect the long-term stability of the miniscrew. The present study didn't consider other factors like age, sex, growth pattern of the subjects that could have some influence on the miniscrew implantation procedure. However, Miyawaki et al[11] found no correlation between mini-implant success rate and clinical parameters such as gender and implant location.

V. Conclusion

From this study it can be concluded that the area distal to second molar root of buccal shelf region have better cortical bone thickness at the level of 8mm from CEJ. Hence, the safer site of insertion of miniscrew. Skeletal class III subjects have more cortical bone thickness than class II subjects at the level of 8mm distal to second molar in the buccal shelf region.

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