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Original Article

Dentistry Section

Mandibular Buccal Shelf Characteristics of South Indian Population with Different Skeletal Patterns- A Retrospective Cone Beam Computed Tomographic Study

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ABSTRACT

Introduction: The morphology of the Mandibular Buccal Shelf area (MBS) which is one of the ideal extra-alveolar locations for Mini-Implants (MI) may vary depending on the population and growth patterns. The success or failure of MIs placed in MBS could be affected by these morphological variations.

Aim: The present study aimed to evaluate the angulation, bone width, and bone depth of the MBS area in South Indian population and the effect of age, gender, and skeletal patterns (both sagittal and vertical) on MBS dimensions using Cone Beam Computed Tomography (CBCT).

Materials and Methods: This retrospective study was conducted at Saveetha Dental college, Chennai, India, from January 2022 to June 2022. Forty-five CBCTs of participants with various sagittal skeletal patterns were equally divided into three groups- Group A: Class-I malocclusion; Group B: Class-II malocclusion; and Group C: Class-III malocclusion. Using the OSIRIX Lite software (version 12.0.3), the angulation, buccal bone width {4 and 6 mm from the Cementoenamel Junction (CEJ)} and buccal bone depth (6 and 11 mm from the CEJ) of the MBS were determined on CBCTs. The statistical analysis was performed by utilising Statistical Package for the Social Science (SPSS) software (version 23.0). Descriptive statistics were performed for all the parameters, Mann-Whitney U test was performed to compare the measurements in gender and each side of the arches, and the Kruskal-Wallis one-way analysis was performed to compare the measurements at different locations and different skeletal patterns. A p-value of <0.05 was considered statistically significant.

Results: No significant difference was found between genders for the angulation, bone width and bone depth of the MBS (p-value >0.05). A significant difference in the angulation and width at 11 mm from the CEJ was noted between the age groups (p-value=0.01). The MBS posterior region had higher values for all parameters. Significant difference was noted for the different sagittal and vertical growth patterns (p-value <0.01) except bone width in vertical skeletal pattern.

Conclusion: South Indian adults exhibited higher bone width in the MBS area. Sagittal skeletal Class-III subjects exhibited larger bone dimensions and hypodivergent patients reported greater apico-coronal bone depth than other growth patterns. The placement of MI in the MBS region must be done with caution considering the variations in different skeletal patterns.

Keywords: Bone angulation, Bone depth, Bone width, Mandible, Skeletal growth patterns

INTRODUCTION

Skeletal anchorage in orthodontic practice allows clinicians to perform difficult clinical procedures like correction of canted occlusal planes [1,2], intrusion of mandibular and maxillary molars etc., [3,4]. Interradicular MI are the most commonly used mode of skeletal anchorage, but they have been reported with higher failure rates, especially in the posterior region of the mandible [5-7]. Few studies have reported that they are more stable in the maxilla [5,6]. Primary stability is the most important aspect of clinical success for MI's as they are not osseointegrated [8] and its stability depends on the mechanical retention between MI surface and bone surrounding to it [9]. There are many factors that affects the stability like the site of placement, bone quality, insertion technique and time of load application [10]. The site of placement is one of the prime factors that needs to be considered for MI stability [11]. Many researchers have investigated various sites for MI insertion including the palatal bone [12,13], palatal side of the maxillary alveolar process [14], mandibular retromolar area [15], infra-zygomatic crest [16], maxillary and mandibular bucco-alveolar cortical plate [17] and the posterior palatal alveolar process [12].

The MBS area is located in the posterior part of body of the mandible bilaterally in front of the oblique line of the ramus and between the roots of the first and second mandibular molars buccally [18]. Few studies conducted on width and height of MBS region for the insertion of MI, have suggested MBS as a favourable insertion site for MI especially in the second molar region especially in Class-III patients [19-23]. Vertical and sagittal skeletal patterns have been reported to affect the anatomy of various structures such as the pterygomaxillary region, mandibular symphysis, and the alveolar cortical bone [8,19]. This anatomic and bone-width variability can also affect the stability of MIs during orthodontic treatment [8,18,20]. Studies conducted on MBS in different skeletal patterns have reported an increase in the alveolar bone thickness in Class-III and hypodivergent subjects [7,19,21].

The primary determining factor for the success of MI is the surrounding bone, therefore, it is essential to assess the site of insertion of the MI in the field of Orthodontics. To the best of the knowledge there is scarcity of literature in assessing the anatomical variations in the MBS region in South Indian population [25]. Therefore, aim of this study was to evaluate the angulation, bone width and bone depth of the MBS using CBCT in different skeletal patterns among South Indian population.

MATERIALS AND METHODS

This retrospective CBCT based study was done at Saveetha Dental College, Chennai in the Department of Orthodontics from January 2022 to June 2022. Prior approval from the Institutional

Review Board was obtained (Approval number- HEC/SDC/ORTHO-1903/22/380).

Sample size calculation: Sample size calculation was performed using G*Power 3.1 software. The descriptive data for power calculation was collected from published literature. The analysis revealed a total sample size of 45 to achieve a power of 95% at 5% significance level.

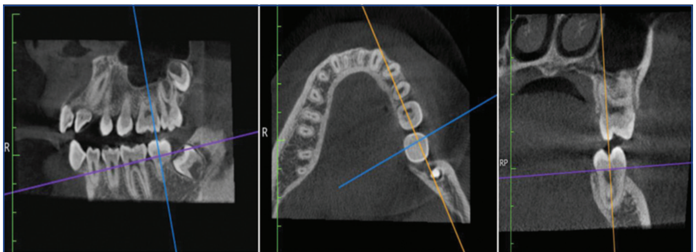
Inclusion and Exclusion criteria: A total of 250 CBCTs from patients from the Radiology Department were obtained which were further screened for the eligibility criteria. CBCTs of subjects in the age range of 13 to 30 years irrespective of gender and malocclusion with all mandibular premolars and molars present were included. CBCTs with artifacts or poor-quality images, CBCTs of subjects with oral pathologies, periradicular pathologies and alveolar bone loss in the MBS region were excluded from the study.

Digital lateral cephalometric views were generated from the CBCTs for all the samples and based on the ANB angle, a total of 15 CBCTs in each sagittal skeletal malocclusion were selected. A total of 45 CBCTs were divided equally into three groups based on sagittal growth patterns:

- Group A- skeletal Class-I;
- Group B- skeletal Class-II;
- Group C- skeletal Class-III.

The vertical skeletal pattern was deduced using the GoGn-SN angle from Steiners analysis [26,27]. Subjects with angular values more than 36° were defined as hyperdivergent, those with less than 28° were defined as hypodivergent, and those with values between 28° and 36° as normodivergent [28].

All CBCT images were collected in DICOM format and were assessed using OSIRIX LITE software version 12.0.3 by the investigator (RM). Each mandibular posterior quadrant was visualised in the multiplanar view (coronal, axial, sagittal planes) with three times magnification. The first and second mandibular molars' furcation marked the location of the axial plane [Table/Fig-1a]. The sagittal plane orientation was located at the center of the alveolar process from the mesial root of first mandibular molar to the distal root of second mandibular molar [Table/Fig-1b]. The coronal plane was oriented at the long axis of the roots being examined (the distal root of first mandibular molar, and mesial and distal roots of second mandibular molar) [Table/Fig-1c].



[Table/Fig-1]: Orientation of reference planes in the second molar region: (a)Axial plane (Purple line); (b) Sagittal plane (Blue line); (c) Coronal plane (Orange line).

Parameters Assessed

The parameters assessed for MBS in the present study were as per a study conducted by Escobar-Correa N et al., [26]:

1) **Angulation of MBS:** The angle between the long axis of the molar teeth and a tangent drawn to the outer surface of the MBS [Table/Fig-2a].
2) **Apico-coronal depth:** Horizontal reference lines were drawn from the CEJ, one at 4 mm and the other at 6 mm parallel to the Y-axis, the perpendicular distance from these lines to the outer surface of the cortex gave the apico-coronal depth of MBS [Table/Fig-2b].
3) **Width:** Vertical reference lines were drawn from the CEJ, one at 6 mm and other at 11 mm perpendicular to the Y-axis; the perpendicular distance from these lines to the outer surface of the cortex gave the width [Table/Fig-2c].

All these parameters were assessed at various locations (distal root of the first molar and mesial-distal root of the second molar) and were compared with age, gender, side of the arch, root location, and sagittal and vertical skeletal growth patterns.

STATISTICAL ANALYSIS

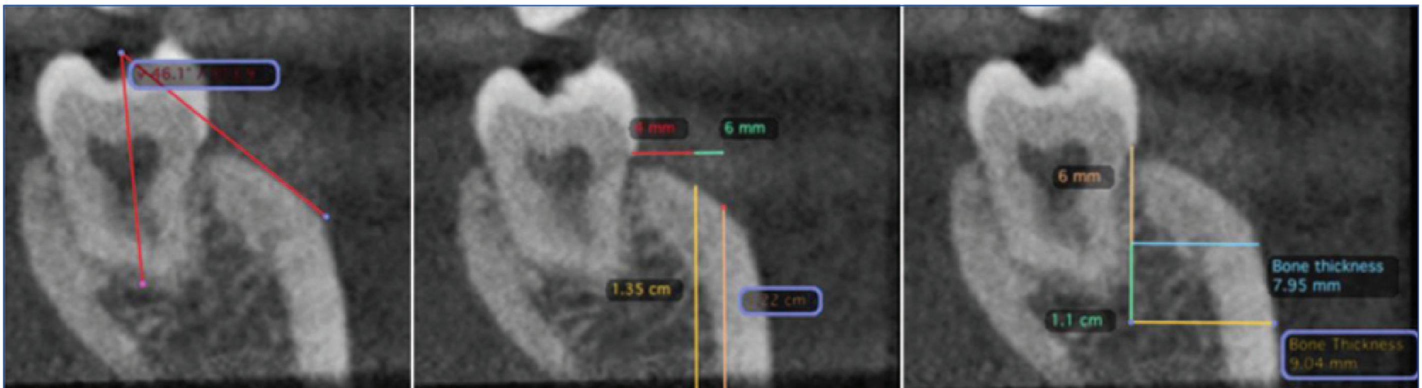
SPSS software version 23.0 was used to conduct the statistical tests. The reliability of the measurements were assessed by repetition of the measurements on 10 CBCT scans selected randomly after 2 weeks by the same investigator. The intraexaminer reliability was estimated by computing the Intraclass Correlation Coefficient (ICC). The normality distribution was assessed using the Kolmogorov-Smirnov test. Descriptive statistics were done for all three parameters of MBS studied. Mann-Whitney U test was performed to compare the values for the angulation, depth and width of MBS for both genders and involved sides (right and left). To compare the measurements on different locations (distal root of the first molar and mesial-distal root of the second molar) and between different skeletal patterns (both sagittal and vertical), Kruskal-Wallis one-way analysis of variance was performed. A p-value of <0.05 was considered statistically significant.

RESULTS

The ICC values for intraexaminer reliability were between 0.95 and 0.97 showing a high reliability between all the re-evaluated measurements.

In [Table/Fig-3], group C subjects showed more angulation of the molars (33.49±5.32) as compared to groups A (25.29±3.50) and B (25.91±3.39). Group C subjects had larger buccal bone depth at both 4 mm (17.29±4.88) and 6 mm (11.29±4.88) compared to other groups. On comparing the buccal bone width, group C showed higher width at 6 mm (3.11±1.86) and 11 mm (6.37±2.27) [Table/Fig-3].

MBS dimensions in different age groups, genders and sides: On comparing all measured parameters of MBS between age



[Table/Fig-2]: Mandibular Buccal Shelf (MBS) area parameters: a) Angulation {angle formed by red line}; b) Apico-coronal depth {at 4 mm distance-yellow line and at 6 mm-pink line}; c) Bone width {at 6 mm-blue line and at 11 mm-yellow line}.

Groups (N=45)	Angulation	Depth		Width	
		4 mm	6 mm	6 mm	11 mm
Group A (n=15)	25.29±3.50	10.17±1.71	7.81±1.60	3.04±1.14	5.50±1.59
Group B (n=15)	25.91±3.39	9.86±1.93	8.79±1.39	2.60±0.52	6.02±2.16
Group C (n=15)	33.49±5.32	17.29±4.88	11.29±4.88	3.11±1.86	6.37±2.27

[Table/Fig-3]: Measurements of Mandibular Buccal Shelf (MBS) area bone angulation, apico-coronal depth and bone width in the three groups.

groups, it was revealed that all the parameters were increased in adults compared to adolescents with significant differences in angulation (p-value=0.002), and width of MBS at 11 mm (p-value=0.01). Comparison between genders revealed the bone depth was greater in males and bone width was greater in females, but this was not significant statistically (p-value >0.05) [Table/Fig-4]. On comparison of all parameters between the right and left sides, no significant difference was noted (p-value >0.05) [Table/Fig-5]. MBS dimensions at various root locations [Table/Fig-6].

Characteristic	Angulation	Depth		Width	
		4 mm	6 mm	6 mm	11 mm
Age					
<18 years (n=17)	27.02±5.16	12.5±5.86	10.29±4.52	2.91±1.23	5.98±1.94
>18-30 years (n=28)	28.81±5.7	15.07±6.54	11.78±5.51	2.92±1.35	5.96±2.11
p-value	0.002**	0.07	0.97	0.73	0.01**
Gender					
Male (n=23)	28.03±5.48	14.48±6.72	11.68±5.4	2.9±1.23	5.93±2.1
Female (n=22)	28.44±5.71	13.99±6.12	10.9±5.07	2.95±1.4	5.99±2.02
p-value	0.48	0.14	0.98	0.73	0.25

[Table/Fig-4]: Comparison of various Mandibular Buccal Shelf (MBS) area dimensions with age and gender.
Mann Whitney's U test for comparison of means; *p-value <0.05; **p-value <0.01; ***p-value <0.001; n=sample size

Characteristic	Angulation	Depth		Width	
		4 mm	6 mm	6 mm	11 mm
Hemi-arch					
Right (n=45)	27.44±4.54	14.47±7.25	11.68±5.70	2.87±1.31	5.67±2.05
Left (n=45)	29.01±6.38	13.80±5.66	10.92±4.74	2.97±1.31	5.96±2.08
p-value	0.57	0.78	0.33	0.29	0.18

[Table/Fig-5]: Comparison of various Mandibular Buccal Shelf (MBS) area dimensions with two sides of the arch.
Mann Whitney's U test for comparison of means: n=sample size

Characteristic	Angulation	Depth		Width	
		4 mm	6 mm	6 mm	11 mm
Root					
1D (n=45)	23.29±3.46	12.48±5.61	8.97±2.73	1.92±0.56	4.14±0.95
2M (n=45)	30.7±4.76	15.02±6.01	12.20±5.02	2.77±0.65	5.53±1.30
2D (n=45)	30.69±4.75	15.23±7.25	12.90±6.39	4.09±1.42	8.22±1.21
p-value	<0.01**	<0.01**	<0.01**	<0.01**	<0.01**

[Table/Fig-6]: Comparison of Mandibular Buccal Shelf (MBS) area dimensions at different locations.
Kruskal-Wallis one-way analysis test for comparison of means; *p-value <0.05; **p-value <0.01; n=sample size; 1=first molar; 2=second molar; D=Distal; M=mesial

The values of all parameters were significantly lower at the distal root of the first mandibular molar and greater at the distal root of the second mandibular molar (p-value <0.05). At both the first and second mandibular molar region, the alveolar bone depth was greater at 4 mm and width was greater at 11 mm.

MBS dimensions in sagittal skeletal pattern [Table/Fig-7]: All parameters were significantly higher in subjects with skeletal Class-III than both Class-I and II (p-value <0.05) except for bone depth at 6 mm (p-value >0.05).

Characteristic	Angulation	Depth		Width	
		4 mm	6 mm	6 mm	11 mm
Skeletal pattern					
Class I (n=15)	25.29±3.50	10.17±1.71	7.81±1.60	3.04±1.14	5.50±1.59
Class II (n=15)	25.91±3.39	9.86±1.93	8.79±1.39	2.60±0.52	6.02±2.16
Class III (n=15)	33.49±5.32	17.29±4.88	11.29±4.88	3.11±1.86	6.37±2.27
p-value	<0.01**	<0.01**	0.18	0.05*	<0.01**

[Table/Fig-7]: Comparison of Mandibular Buccal Shelf (MBS) area dimensions among various sagittal skeletal patterns.
Kruskal-Wallis one-way analysis test for comparison of means; *p-value <0.05, **p-value <0.01, n=sample size

MBS dimensions in vertical skeletal pattern [Table/Fig-8]: Hypodivergent subjects presented with statistically significant increases in apico-coronal bone depth at 4 mm and 6 mm compared to normodivergent and hyperdivergent subjects (p-value <0.01).

Characteristic	Angulation	Depth		Width	
		4 mm	6 mm	6 mm	11 mm
Growth pattern					
Normodivergence (n=18)	25.32±4.90	12.34±5.72	9.98±4.54	2.90±1.11	5.91±1.91
Hypodivergence (n=15)	28.85±5.72	17.55±6.40	13.46±6.01	2.96±1.42	6.04±2.08
Hyperdivergence (n=12)	27.19±5.65	12.97±5.90	10.57±4.36	2.91±1.45	5.97±2.21
p-value	<0.01**	<0.01**	<0.01**	0.66	0.92

[Table/Fig-8]: Comparison of Mandibular Buccal Shelf (MBS) area dimensions among various vertical skeletal patterns.
Kruskal-Wallis one-way analysis test for comparison of means; *p-value <0.05, **p-value <0.01, n=sample size

DISCUSSION

The Mandibular Buccal Shelf area (MBS) area is a common extra alveolar site for the insertion of MI as it provides enough clearance to prevent root contact during implant placement [29]. The MBS extends buccally with a considerable amount of bone which allows practitioners to insert MIs in a direction parallel to the long axis of the molar roots and eliminating the need to relocate the MI during orthodontic treatment [6,24,30]. The current study was conducted to evaluate the dimensions of the MBS region in South Indian subjects. The variations in MBS of subjects in various age groups, genders and growth patterns were also evaluated. In the present study, it was noted that MBS dimensions were not different between genders. It was also observed that adults had increased bone depth and width than adolescents which was significantly higher at a distance of 11 mm apical to the CEJ. The depth and width of the MBS area were reduced at the distal root of the first mandibular molar and increased gradually posterior to the first molar and was greatest at the distal root of the mandibular second molar. Skeletal Class-III subjects reported higher values as compared to skeletal Class-I and Class-II subjects in terms of angulation, depth and width of buccal bone in the MBS region. Similarly, hypodivergent subjects presented with higher values for angulation and bone depth in the MBS region when compared to normodivergent and hyperdivergent subjects.

Similar results were reported by Farnsworth D et al., who had observed significant differences between adults and adolescents and the cortical bone was thicker in adults [31]. In contrast to this, Escobar-Correa N et al., reported higher values for the same parameters of MBS area as measured in this study in younger patients between 16-24 years [26].

An increased risk of Mini implant failure is often reported with thin buccal cortices [28,29]. The buccal bone width of the MBS area has been reported to increase gradually towards the posterior regions. The bone width was highest at the site distal to the root of mandibular second molar when compared to other sites and this finding was in consensus with the results reported in various studies [7,18,20,26,32]. In the current study, the alveolar bone depth was reported to be higher in the mesial and distal aspect of the mandibular second molar compared to the distal aspect of the mandibular first molar. Similar results were reported by Nucera R et al., Elshebiny T et al., and Escobar-Correa N et al., suggesting that average bone depth for MI placement was found at these sites [18,20,26]. However, Aleluia RB et al., reported higher bone depth in the mesial region as compared to the distal region of the second mandibular molar [7]. The bone depth of MBS area near to the second mandibular molar [mesial or distal] evaluated in the current study was sufficient for placement of 10-12 mm long MIs. Previous studies [7,18] have also reported that MIs of 10-12 mm length engaging 5-6 mm bone were found to be successful.

In the present study, subjects with Class-III skeletal pattern were observed to have higher values in relation to angulation, depth and width of MBS area with statistical significance at all areas except at alveolar bone depth of 6 mm. The findings of the present study were in consensus with the results obtained by Aleluia RB et al., and Escobar-Correa N et al., who have reported greater bone width in Class-III subjects [7,26]. However, Coşkun I and Kaya B who evaluated buccal bone width in different sagittal skeletal malocclusions found no significant differences between them [33].

Masticatory forces and biological adaptations can influence the mandibular structure in different skeletal patterns [7,34]. Several studies have described that the mandibular plane angle was associated with the buccal bone width in the MBS area [8,25-28]. They have reported that smaller gonial and mandibular plane angles are associated with thicker buccal cortical bone in the MBS area. This is in conjunction with the findings of the present study suggesting that hypodivergent subjects have greater cortical bone depth and width as compared to normodivergent and hyperdivergent subjects. Gandhi V et al., has reported that patients with hypodivergent growth pattern presented with greater buccal alveolar width than their hyperdivergent counterparts [19]. Trivedi K et al., observed that the hyperdivergent subjects have a slender buccal shelf area compared to hypodivergent subjects [21]. Similar results were noted in the study conducted by Aleluia RB et al., [7].

The present study can be used as a reference for planning orthodontic anchorage in the MBS region. With regard to site of insertion of MI, it has been observed that the width and depth of the alveolar bone was more in the second mandibular molar region compared to the first molar. Insertion of MI in regions with insufficient thickness must be avoided. Class-III subjects and hypodivergent subjects showed greater bone width and depth. The possibility of the MI contacting the roots of the teeth and of the buccal bone board being fenestrated would require a more cautious assessment in case of the other subjects.

Limitation(s)

Retrospective design, inclusion of a specific population from a single centre was the major limitations of this study. Further studies with a larger population can be conducted in future.

CONCLUSION(S)

The MBS dimensions progressively increased from distal of first mandibular molar to distal of second mandibular molar teeth. Hypodivergent subjects had significantly higher angulation and apico coronal cortical bone depth than normodivergent and hyperdivergent subjects. Subjects with sagittal Class-III skeletal pattern were observed to have higher MBS bony dimensions than Class-I and II subjects. The above-mentioned findings should be considered while placing MIs in the MBS area.

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