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IP International Journal of Maxillofacial Imaging

Journal homepage: <https://www.ijmi.in/>

Original Research Article

Evaluation of alveolar bone housing of maxillary anterior teeth and its influence on anterior alveolar arch form: A cross-sectional analytical CBCT study

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ARTICLE INFO

Article history:

Received 25-04-2024

Accepted 02-05-2024

Available online 14-05-2024

Keywords:

Cone beam computer tomography

Implant planning

Dentoalveolar bone

Alveolar arch form

Indian population

ABSTRACT

Background: Implant placement in the maxillary anterior region is most challenging due to demands of high aesthetics and biomechanical requirements with a prejudice of thin alveolar bone and fast resorption. Alveolar bone housing (ABH) of teeth in this area becomes an important parameter for successful implant planning. Alveolar bone thickness also exhibit significant differences among different arch forms. The present study was designed to provide baseline data of ABH of maxillary anterior teeth in different alveolar arch forms for the Indian population.

Aim & Objective: This study was conducted with the aim to generate baseline data of ABH in the maxillary anterior region in a sample of Indian population using CBCT. A further hypothesis was made that the ABH varies in different AAFs.

Materials and Methods: 100 CBCT scans were analysed for ABH as the mean of dimension at three different root levels and apical region for normal maxillary anterior teeth. Anterior alveolar arch form (AAF) was classified as ratio of inter-canine width and inter-canine depth. Paired t-test and ANOVA was used for evaluating mean ABH amongst the CIs, LIs, and CNs and across gender. Bonferroni post hoc test was carried out for comparative analysis between ABH and AAF.

Results: Significant difference was seen between mean ABH of CNs and CIs and CNs and LIs ($p=0.00$). Males had higher mean ABH than females in CNs ($p=0.00$) and CIs ($p=0.017$). No significant difference was seen between mean ABH and AAFs.

Conclusion: This study generates a baseline data of alveolar bone morphology of normal maxillary anterior teeth in Indian population to aid the clinicians in predictably planning placement of implants.

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1. Introduction

Dental implants are one of the most reliable treatment options for the replacement of missing teeth, owing to their ability of osseointegration. However, despite being the nearest equivalents of the natural teeth, implants are inadvertently associated with surgical and prosthetic complications. Implants cannot be placed with the mere thought of greatest amount of bone present, with no

consideration of the final definitive restoration. Thus, pre-surgical planning is the most definitive part of implant positioning.¹ The maxillary anterior region is a challenging site for implant placement due to high aesthetic demands, biomechanical requirement, thin alveolar bone, and fast bone resorption. Therefore, proper positioning of implant in all three dimensions, with correct angulation, implant size, and adequate soft tissue contours and inter-proximal papilla plays a vital role in successful treatment.²

Implants placed close to the buccal cortex have an increased likelihood of gingival recession and dehiscence.

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The thickness of buccal wall should be at least 1 mm to prevent gingival recession and improve aesthetics. Implants placed close to palatal cortex should have a ridge-lap prosthesis to accommodate the excessive buccal contours.¹ Spray et al. have reported that when the thickness of bone approached 1.8–2 mm, bone loss gradually decreased.³

Hence, alveolar bone housing (ABH) is an important parameter to be assessed during the planning of implant placement. Cone-beam computed tomography (CBCT), a three-dimensional imaging technique has been widely employed for the purpose with the advantages of convenience, accuracy, and relatively low dosage of radiation.

Studies suggest that the most favourable implant number and position are determined by the arch forms at the levels of both the dental and alveolar bone. Thus, anterior alveolar arch forms (AAF) play an important role in implant treatment planning and success.⁴ It is found that buccolingual alveolar bone thickness exhibited significant differences among the arch forms.⁵

Number of studies evaluating ABH in maxillary anterior teeth are carried out in different ethnic populations contributing to a baseline data for other than Indian population. Race and ethnicity influence the form of human dentofacial complex, morphological characteristics, size of the dentition, and arrangement of teeth.

This study was conducted with the aim to generate baseline data of ABH in the maxillary anterior region in a sample of Indian population using CBCT. A further hypothesis was made that the ABH varies in different AAFs.

2. Materials and Methods

CBCT scans of the anterior maxilla were obtained from the secondary database of the department and were carefully evaluated for the presence of all six maxillary anterior teeth. The study was approved by the institutional ethical committee. (Letter No.IREB/2021/OMDR/03)

Around 220 CBCT scans were evaluated to be included in the study. Of these 120 scans were discarded as the images were either of poor diagnostic quality or showed teeth with periodontal, periapical lesions, restorations, presence of supernumerary teeth, bone abnormalities due to systemic diseases, or evidence of infection, root resorption, or surgical treatment in the anterior maxillary dentition. Finally, 100 CBCT scans with good contrast showing all six healthy maxillary anterior teeth with their surrounding alveolar bone, of subjects above 21 years of age were included in the study.

The scans were made using CS 9000 3D unit (Carestream Health, Rochester, NY 14608, USA), according to the manufacturer's recommended parameters. The subject's head position for each scan was oriented with axial plane set parallel to the floor, the sagittal plane perpendicular to

the floor, and the coronal plane perpendicular to both the axial and sagittal planes.

DICOM datasets were analysed using CS imaging software (CS 3D; Carestream Healthinc., 2011) on a 21 inch HP Windows Desktop with a resolution of 1,440 x 900 pixels. The contrast function was regulated, and magnifying device activated when required.

The X and Y cursors were used for horizontal and vertical orientation of CBCT images of the bone. To survey the morphology of the bone width and height from the axial plane, the Z cursor was moved slowly in the cervico-apical direction. Arch form was drawn by joining the mid-points of the pulp chambers of the teeth.

2.1. Measurement of ABH

From the coronal section (Figure 1 B), paraxial section was selected by aligning the section parallel to the root axis through the centre of each tooth. Buccopalatal bone dimensions were measured in the paraxial section (Figure 1 C) for all the six anterior teeth at:

1. From the cemento-enamel junction (CEJ "a"
2. The mid-root level "b"
3. The apical level "c"
4. The apical height from apex to the nasal floor "d"

The ABH was calculated as the mean of all the above bone dimensions.

$$ABH = (a + b + c + d)/4.$$

Measurements were taken for all six anterior teeth; the right maxillary central incisor (CI 1), left maxillary central incisor (CI 2), right maxillary lateral incisor (LI 1), left maxillary lateral incisor (LI 2), right maxillary canine (CN 1), and left maxillary canine (CN 2).

The alveolar arch form (AAF) was analysed on axial section and classified as type 1 for inter-canine width and inter-canine depth ratio (ICW/ICD) <4.5, type 2 for ICW/ICD between 4.5 and 6, and type 3 for ICW/ICD >6.

2.2. Statistical analysis

Paired t-test was used for evaluating mean ABH amongst the CIs, LIs, and CNs and one-way ANOVA test to correlate the mean ABH across gender. Bonferroni post hoc test was carried out for comparative analysis between ABH and AAF.

3. Results

A total of 600 maxillary anterior teeth were evaluated in the 100 CBCT scans and the mean values of the ABH of all six maxillary anterior teeth is depicted in Table 1. Paired t-test indicates statistically significant differences between the mean ABH of CIs and CNs ($p = 0.00$) and of LIs and CNs ($p = 0.00$) (Table 2).

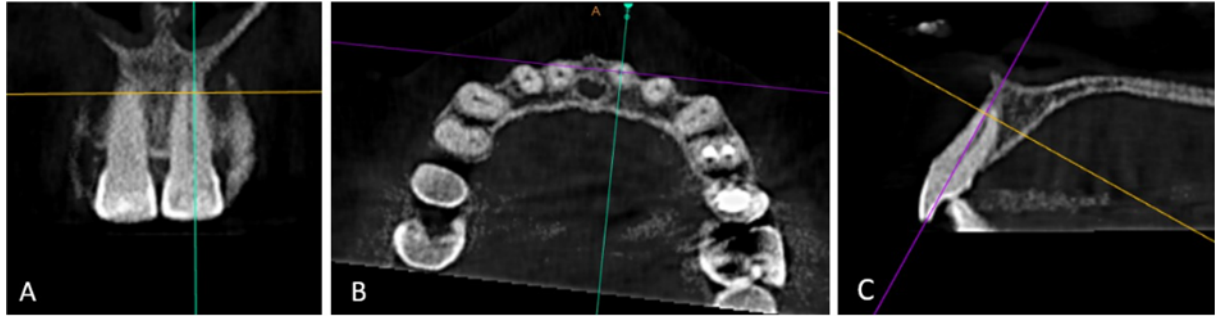


Figure 1: A): Axial section of CBCT. B): Coronal section used for orientation of tooth axis; C): Paraxial section used for measurements of ABH at 4 different levels (a, b, c, d)

Table 1: Mean alveolar bone housing (ABH) of maxillary anterior teeth

	N	Minimum	Maximum	Mean	Std. Deviation
CI 1	100	6.00	10.40	7.4700	0.88243
CI 2	100	5.70	9.80	7.5720	0.92158
LI 1	100	6.00	8.60	7.2260	0.62694
LI 2	100	4.80	30.80	7.3880	2.53291
CN 1	100	5.90	11.50	8.3000	1.09581
CN 2	100	6.30	11.60	8.2790	1.01676
CI	200	6.10	10.00	7.5110	0.83629
LI	200	5.60	18.80	7.2940	1.36173
CN	200	6.50	11.50	8.2850	0.99872
Total	600				

Table 2: Comparison of mean ABH amongst CIs, LIs, and CNs

		Paired Differences					T	Df	p
		Mean	SD	SEM	95% CI				
					Lower	Upper			
Pair 1	CI-LI	0.21700	1.34675	0.13468	-0.05023	0.48423	1.611	99	0.110
Pair 2	CI-CN	-0.77400	0.96699	0.09670	-0.96587	-0.58213	-8.004	99	0.000
Pair 3	LI-CN	-0.99100	1.51711	0.15171	-1.29203	-0.68997	-6.532	99	0.000

Table 3: ANOVA correlation of ABH across gender

		N	Mean	Std. Deviation	95% Confidence Interval for Mean		ANOVA (F, p)
					Lower Bound	Upper Bound	
CI	Male	44	7.7341	0.88342	7.4655	8.0027	5.866, 0.017
	Female	56	7.3357	0.76001	7.1322	7.5392	
	Total	100	7.5110	0.83629	7.3451	7.6769	
LI	Male	44	7.5045	0.70446	7.2904	7.7187	1.895, 0.172
	Female	56	7.1286	1.69895	6.6736	7.5836	
	Total	100	7.2940	1.36173	7.0238	7.5642	
CN	Male	44	9.0273	0.83981	8.7719	9.2826	76.500, 0.00
	Female	56	7.7018	0.67595	7.5208	7.8828	
	Total	100	8.2850	0.99872	8.0868	8.4832	

Table 4: Bonferroni test for association of mean ABH of teeth with the type of AAF

Dependent Variable	Arch form	Arch form	Mean Difference	Sig.(p)	95% Confidence Interval	
					Lower Bound	Upper Bound
CI	Type 1	Type 2	.15167	1.000	-.3176	.6210
		Type 3	.19167	1.000	-.5158	.8992
	Type 2	Type 1	-.15167	1.000	-.6210	.3176
		Type 3	.04000	1.000	-.6084	.6884
	Type 3	Type 1	-.19167	1.000	-.8992	.5158
		Type 2	-.04000	1.000	-.6884	.6084
LI	Type 1	Type 2	-.13095	1.000	-.8958	.6339
		Type 3	.16905	1.000	-.9841	1.3222
	Type 2	Type 1	.13095	1.000	-.6339	.8958
		Type 3	.30000	1.000	-.7568	1.3568
	Type 3	Type 1	-.16905	1.000	-1.3222	.9841
		Type 2	-.30000	1.000	-1.3568	.7568
CN	Type 1	Type 2	.20167	1.000	-.3529	.7562
		Type 3	.57500	.291	-.2610	1.4110
	Type 2	Type 1	-.20167	1.000	-.7562	.3529
		Type 3	.37333	.714	-.3929	1.1395
	Type 3	Type 1	-.57500	.291	-1.4110	.2610
		Type 2	-.37333	.714	-1.1395	.3929

One way ANOVA for correlation of ABH across gender revealed statistically significant difference in CNs ($p = 0.00$) and CIs ($p = 0.017$) with higher values in males than in females (Table 3).

Of the 100 scans, 28 were categorized as type 1 AAF, 60 as type 2, and 12 as type 3. There was no significant correlation between ABH of the anterior teeth (CI, LI, CN) and between the three types of AAF (p value ranged from 0.291 to 1.0) (Table 4).

4. Discussion

Peri-implant bone foundation is one of the most important factors that affects the ideal aesthetic and functional restoration for both immediate and delayed implant placement. In immediate placement, primary implant stability relies on engaging the implant with the palatal wall and the bone beyond the root apex.⁶

It has been established that tooth extraction is followed by a reduction of the buccolingual (29%-63%) as well as the apico-coronal (11%-22%) dimension of the alveolar ridge. The extent of bone loss following extraction depends on factors such as facial bone wall thickness, angulation of the tooth, and other differences in anatomy at the various tooth sites.⁷

This study aimed at generating a primary baseline data of the bony architecture in the maxillary anterior region in different AAFs for Indian population. It will also aid in further understanding of the bone changes that occur following tooth extractions.

In the study, there were no statistically significant difference in the mean ABH of the 6 teeth on the right and left sides. This observation was in concurrence with

the findings of Ji-Eun et al⁸ and Uner D et al.⁹ However, Farahamnd A et al¹⁰ reported significant difference in the dimensions of the crestal bone on the right and the left side.

Males had significantly higher mean ABH in the CIs and CNs as compared to those in females. Similar observations were reported by Do et al¹¹ where the palatal thickness of bone was higher in males than in females and Sheerah et al¹² and Linjawi A et al¹³ reported facial bone thickness to be higher in males than in females. However, some studies found no difference in the mean ABH between the genders.^{14,15}

Mean ABH was found to be maximum for the CNs (8.28mm), followed by the CIs (7.51mm) and LIs (7.29mm). These findings were similar to that of Gakonya J et al¹⁵ where the measured alveolar width at different levels of the root were significantly less around the LIs (8.30 mm) as compared to other anterior teeth (CIs -9.55 mm and CNs - 9.62 mm) and they concluded that it could be due to presence of lateral fossa.

Most studies have determined the facial bone width and have suggested <1 mm of facial bone for the anterior teeth to be a critical point. Shrestha et al¹⁶ found that 80% of the measured sites in Nepalese adults had <1 mm of the facial bone. The authors considered 1–2 mm facial bone thickness as thick facial bone and >2 mm as very thick facial bone. Authors have reported almost 80% of anterior teeth and 40% of premolars to exhibit thin facial bone wall (<1 mm) and nearly 30% of the sites with a bone wall thinner than 0.5 mm.¹⁷ Jia X S et al¹⁸ concluded that the labial bone was thinner than the palatal bone. Thin facial alveolar bone (<2 mm) may contribute to the risk of facial bone fenestration, dehiscence, and soft tissue recession after immediate implant therapy. In this study we did not analyse

the buccal bone separately.

Although statistically no significant difference were found in the mean ABH of the teeth across the three AAFs, maximum value of mean ABH of CI and CN was found in type 1 AAF, followed by types 2 and 3 AAF. The highest mean ABH was found for LI in type 2 AAF. Bulyalert et al⁵ reported significant differences in the alveolar dimensions at the mid-root level and at 3 mm below CEJ among the different AAFs. Costa et al¹⁹ and Gaffuri F et al²⁰ found thicker alveolar bone width in dolicocephalic individuals as compared to mesofacial and brachyfacial, These differences could be attributed to heterogeneous distribution of samples in the three types of AAFs in our study. Furthermore, we considered the mean values of the alveolar bone dimensions, whereas Bulyalert et al⁵ found differences in alveolar bone at two individual levels.

5. Conclusion

Mean value of ABH was highest for the CNs, followed by the CIs and LIs, with no significant difference in the mean values on right and left side. However, there was a significantly higher mean ABH in CNs and CIs in males than in females. Mean ABH was not statistically significant for the anterior teeth in the three types of AAF. This study generates a baseline data of the bone morphology in the maxillary anterior region in the Indian population and shall aid the clinicians in predictably planning the placement of implants in this region.

6. Limitations

In this study the AAFs were heterogeneously distributed.

7. Source of Funding

None.


8. Conflict of Interest

None.

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Cite this article: Hinduja S, Hinduja SV, Waghmare M. Evaluation of alveolar bone housing of maxillary anterior teeth and its influence on anterior alveolar arch form: A cross-sectional analytical CBCT study. *IP Int J Maxillofac Imaging* 2024;10(1):20-25.