Content available at: https://www.ipinnovative.com/open-access-journals

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

Shweta Hinduja[1]*, Shweta Vasavi Hinduja[2], Mandavi Waghmare[2]

[1] *Neocare Orofacial Pain Relief Centre, Mumbai, Maharashtra, India*
[2] *D Y Patil University School of Dentistry, Navi Mumbai, Maharashtra, India*

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.

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.

* *Corresponding author*.
E-mail address: shwetahinduja19@gmail.com (S. Hinduja).

https://doi.org/10.18231/j.ijmi.2024.005

The thickness of buccal wall should be at least 1 mm to prevent gingival recession and improvise 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).

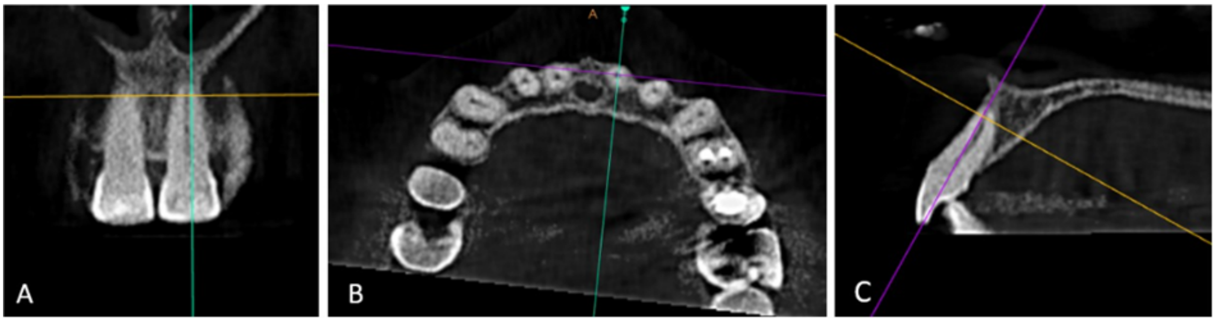

Figure 1: A): Axial section of CBCT. **B):** Coronal section used for orientation of tooth axis; **C)**: Paraxial section used for measurements of ABH at 4 different levels (a, b, c, d)

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	
	Male	44	7.7341	0.88342	7.4655	8.0027	
CI	**Female**	56	7.3357	0.76001	7.1322	7.5392	5.866, 0.017
	Total	100	7.5110	0.83629	7.3451	7.6769	
	Male	44	7.5045	0.70446	7.2904	7.7187	
LI	**Female**	56	7.1286	1.69895	6.6736	7.5836	1.895, 0.172
	Total	100	7.2940	1.36173	7.0238	7.5642	
	Male	44	9.0273	0.83981	8.7719	9.2826	
CN	**Female**	56	7.7018	0.67595	7.5208	7.8828	76.500, 0.00
	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 type1 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 al[8] and Uner D et al.[9] However, Farahamnd A et al[10] 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 al[11] where the palatal thickness of bone was higher in males than in females and Sheerah et al[12] and Linjawi A et al[13] 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 al[15] 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 al[16] 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 al[18] 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 al[5] reported significant differences in the alveolar dimensions at the mid-root level and at 3 mm below CEJ among the different AAFs. Costa et al[19] and Gaffuri F et al[20] 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 al[5] 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.

References

1. Buser D, Martin W, Belser UC. Optimizing esthetics for implant restorations in the anterior maxilla: anatomic and surgical considerations. *Int J Oral Maxillofac Implants*. 2004;19:43–61.
2. Obiechina N. Treatment Planning of Dental Implants in the Anterior Maxilla; Risk assessment and Review of Soft Tissue along with Bone Preservation and augmentation Techniques for Successful Clinical Outcomes. *Oral Health Dent Manag*. 2019;18(2). doi:10.35248/2247-2452.19.18.1071.
3. Spray JR, Black CG, Morris HF, Ochi S. The influence of bone thickness on facial marginal bone response: stage 1 placement through stage 2 uncovering. *Ann Periodontol*. 2000;5(1):119–28.
4. Misch CE. Treatment plans related to key implant positions and implant numbers. In: Contemporary implant dentistry. St. Louis: Mosby; 2008. p. 147–59.
5. Bulyalert A, Pimkhaokham A. A novel classification of anterior alveolar arch forms and alveolar bone thickness: A cone-beam computed tomography study. *Imaging Sci Dent*. 2018;48(3):191–9.
6. Behnia H, Motamedian SR, Kiani MT, Morad G, Khojasteh A. Accuracy and reliability of cone beam computed tomographic measurements of the bone labial and palatal to the maxillary anterior teeth. *Int J Oral Maxillofac Implants*. 2015;30(6):1249–55.
7. Chappuis V, Araújo MG, Buser D. Clinical relevance of dimensional bone and soft tissue alterations post-extraction in esthetic sites. *Periodontol 2000*. 2017;73(1):73–83.
8. Lee JE, Jung C, Kim Y, Kook YA, Ko Y, Par JB. Analysis of Alveolar Bone Morphology of the Maxillary Central and Lateral Incisors with Normal Occlusion. *Medicina (Kaunas)*. 2019;55(9):565.
9. Uner DD, Izol BS, Gorus Z. Correlation between buccal and alveolar bone widths at the central incisors according to cone-beam-computed tomography. *Niger J Clin Pract*. 2019;22(1):79–84.
10. Farahamnd A, Sarlati F, Eslami S, Ghassemian M, Youssefi N, Esfahani BJ. Evaluation of Impacting Factors on Facial Bone Thickness in the Anterior Maxillary Region. *J Craniofac Surg*. 2017;28(3):700–5.
11. Do TA, Shen YW, Fuh LJ, Huang HL. Clinical assessment of the palatal alveolar bone thickness and its correlation with the buccolingual angulation of maxillary incisors for immediate implant placement. *Clin Implant Dent Relat Res*. 2019;21(5):1080–6.
12. Sheerah H, Othman B, Jaafar A, Alsharif A. Alveolar bone plate measurements of maxillary anterior teeth: A retrospective Cone Beam Computed Tomography study, AlMadianh, Saudi Arabia. *Saudi Dent J*. 2019;31(4):437–44.
13. Linjawi A. Predictive Factors Affecting the Maxillary Alveolar Bone Thickness: A Cone-Beam Computed Tomography Study. Clin Cosmet Investig Dent. *Clin Cosmet Investig Dent*. 2020;12:359–65.
14. Ozdemir F, Tozlu M, Germec-Cakan D. Cortical bone thickness of the alveolar process measured with cone-beam computed tomography in patients with different facial types. *Am J Orthod Dentofacial Orthop*. 2013;143(2):190–6.
15. Gakonyo J, Mohamedali AJ, Mungure EK. Cone Beam Computed Tomography Assessment of the Buccal Bone Thickness in Anterior Maxillary Teeth: Relevance to Immediate Implant Placement. *Int J Oral Maxillofac Implants*. 2018;33(4):880–7.
16. Shrestha R, Liu X, Chen S, Li Z, Chen Z, Pow EHN, et al. Correlation of anterior overbite with root position and buccal bone thickness of maxillary anterior teeth: a CBCT study. *Surg Radiol Anat*. 2019;41(8):935–42.
17. Wang HM, Shen JW, Yu MF, Chen XY, Jiang QH, He FM. Analysis of facial bone wall dimensions and sagittal root position in the maxillary esthetic zone: a retrospective study using cone beam computed tomography. *Int J Oral Maxillofac Implants*. 2014;29(5):1123–9.
18. Jia XS, Zhang QX, Xu MJ, Wang M, Zhang P. The labial and palatal bone thickness in 67 young adults with normal occlusion at the maxillary anterior teeth measured by cone-beam computed tomography. *Shanghai Kou Qiang Yi Xue*. 2015;24(2):199–205.
19. Costa ED, Peyneau PD, Ambrosano G, Oliveira ML. Influence of cone beam CT volume orientation on alveolar bone measurements in patients with different facial profiles. *Dentomaxillofac Radioll*. 2019;48(6):20180330.
20. Gaffuri F, Cossellu G, Maspero C, Lanteri V, Ugolini A, Rasperini G, et al. Correlation between facial growth patterns and cortical bone thickness assessed with cone-beam computed tomography in young adult untreated patients. *Saudi Dent J*. 2021;33(3):161–7.

Author biography

Shweta Hinduja, Independent Researcher https://orcid.org/0000-0003-1446-9099

Shweta Vasavi Hinduja, Professor

Mandavi Waghmare, Professor and Head

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.