Assessment of Anterior Maxillary Alveolar Ridge Dimension and Morphology - A Retrospective Analysis of Cone Beam Computed Tomography Images in South Indian Population

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Abstract

Purpose: Rehabilitation of missing maxillary anterior teeth with implants is very challenging as aesthetics dominates the outcome, CBCT is an invaluable tool aiding in radiographic assessment.

Materials and Methods: A retrospective assessment of 84 CBCT scans of maxillary central, lateral incisors and canines (252 teeth) was done to evaluate alveolar height, width, buccal undercut location. Gender comparison was done for the above mentioned parameters.

Results: The average alveolar height and width at maxillary anterior region ranged between 17.47 and 11.12 mm, respectively. Alveolar width was more for centrals and canines. The lateral incisors had deep buccal undercut. There was no significant difference in parameters among genders.

Conclusion: The study adds to the ridge dimensions data and throws light on the precautions needed for implant planning. Lateral incisors need special precautions. Alveolar dimension assessment will have a direct influence on aesthetic outcome and stability of implants. The study adds emphasises detailing of essential precautions and thorough radiographic evaluation for successful outcome.

Keywords: Alveolar Height Assessment; Buccal Undercut Depth; CBCT; Maxillary Anteriors; Implants

Introduction

Rehabilitation of missing teeth is an important aspect of restorative dental practice. Use of implants for rehabilitation for either single or multiple teeth has been the most sought after treatment options. Meticulous pre-treatment assessment planning decides the success of implant treatment. The assessment of bone height and width, morphology and anatomical variations, presence of important anatomical structures in the vicinity of implant site are all crucial factors deciding the successful outcome of implant treatment. Radiographic investigations have been important prerequistes for any of the restorative procedures and more appropriately for implant treatment planning [1]. The maxillary anterior region being the forefront of esthetic zone is a major concern in treatment planning. Regardless the purpose of implant placement, either for orthodontic concern or teeth rehabilitation the morphology of the alveolar bone is of great importance [2,3]. Alveolar morphology alters according to regional and ethnic differences and is influenced by various factors like occlusion, facial skeletal types and periodontal biotypes.

Implant planning has different challenges in different regions, the esthetic zones has its own weakness and the load bearing molar region poses different set of difficulties.

It has been suggested by previous reports that as the bone thickness was nearing 1.8 to 2 mm, bone loss decreased drastically [4]. Also, the relatively thin buccal alveolar bone in addition to thin peri-implant mucosa, and probably unsuitable angulations of implants would invariably induce soft tissue recession, even fenestration and perforation at the buccal side. As a measure to preclude fenestration and perforation during implant placement, thicknesses of alveolar bone should be detected [5]. Over the time it has been emphasized that the pre-operative assessment of maxillary anterior region is very crucial because alveolar dimension and morphology will have a direct influence on aesthetic outcome and stability of implant placement [6]. Also most studies have shown that adequate alveolar height is not the only prerequisite but should also be substantiated by meticulous planning [6].

Sectional imaging has now formed an inevitable part of pre-implant planning. They are proven to be far superior compared to conventional intra oral films. The American Academy of Oral and Maxillofacial Radiology (AAOMR) has recommended CBCT as the imaging modality of choice for implant treatment planning [7,8].

In this view the present study was designed to assess alveolar ridge dimensions of maxillary anterior teeth to obtain the morphology and ridge dimensions in the regional population.

Materials and Methods

The present study was retrospective analysis of CBCT (Kodak 9000C) images of anterior maxillary region. The images were selected from the database of oral radiology section.

The objectives of the study were

- To measure alveolar ridge dimensions of central incisor, lateral incisor, canine.

- To evaluate presence and size of buccal undercut in the above mentioned teeth region.

- To compare alveolar ridge dimensions between central incisors, lateral incisors, canines.

- To compare alveolar ridge dimensions of central incisors, lateral incisor and canines between quadrants.

- Age wise correlation of the ridge height and ridge width of central incisor, lateral incisor and canine.

A single calibrated observer assessed the images and recorded the measurements.

Inclusion criteria:

1. Images available in the age range of 18 - 40 years were selected.

2. Images of quadrants with both incisors and canines being present were selected.

3. Images with full dentition.

Exclusion criteria:

1. Images displaying severe bone loss/periodontal disease.

2. Images with dentoalveolar fractures/or any missing teeth.

3. Images with metal artifacts/distorted images/already implants placed.

84 CBCT images with 252 teeth were analyzed in the study for the assessment of following measurements.

Measurements: The following are the details of assessments:

a. **Alveolar height:** The distance from alveolar crest to the floor of nasal fossa was outlined as alveolar height this was measured as a line drawn from alveolar crest paralleling with the long axis of alveolar ridge. Furthermore, alveolar height was divided into coronal, middle, and apical third (Figure 1a-1d).

b. **Alveolar width:** The width was measured at aforementioned coronal, middle and apical regions. This was accomplished by drawing a line perpendicular to the long axis of alveolar ridge in the middle of each third. The distance between buccal and palatal cortical plate was defined as alveolar width. Also, the overall alveolar width for each tooth was the average of three above mentioned alveolar width measurements (Figure 1e).

c. **Buccal undercut position:** For a given tooth, buccal undercut was defined as, a line extending from alveolar crest (perpendicular to the long axis of the alveolar ridge). Buccal undercut was located at a distance from where the buccal cortical plate started dipping to the above-mentioned perpendicular line. This value was the display of extent of proximity of the buccal undercut to the alveolar crest (Figure 2a-2d).

d. **Depth of the buccal undercut:** For a given tooth, a line tangent to buccal cortical plate and parallel to the long axis of alveolar ridge was drawn. The distance from the deepest point of the buccal undercut to the above-defined line was designated as the buccal undercut depth (Figure 2e).

Statistical analysis

Kolmogorov-Smirnov test was used to assess the normality of the data. The data followed non normal distribution. Kruskal-Wallis test was used to detect statistical difference in quantitative measures among different class of anterior teeth. Mann Whitney u test was used to determine the difference quantitative measures among males and females. Spearman correlation was done to assess the relationship between alveolar height and buccal width. Data were reported as means ± standard deviation (SD) and median (Q1, Q3). The statistical difference was set at a p value less than 0.05. All of the statistical analyses were run with SPSS version 20.
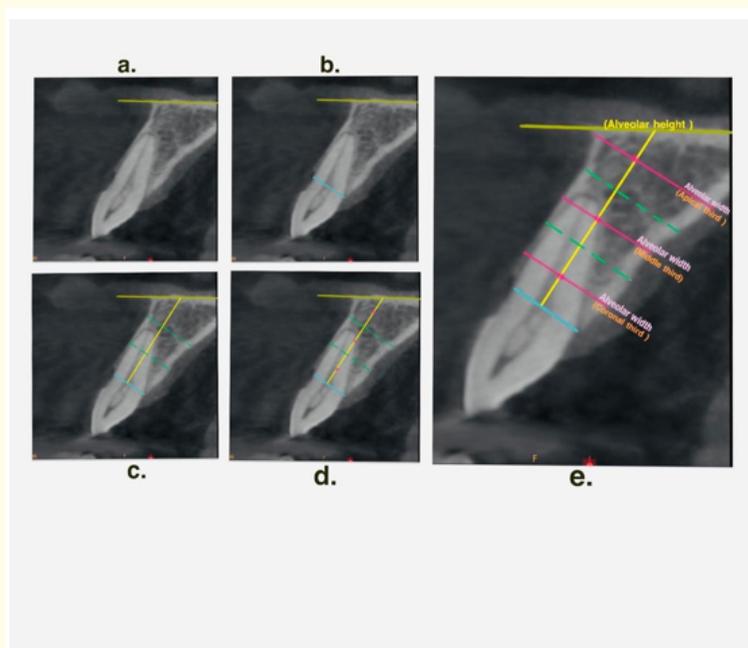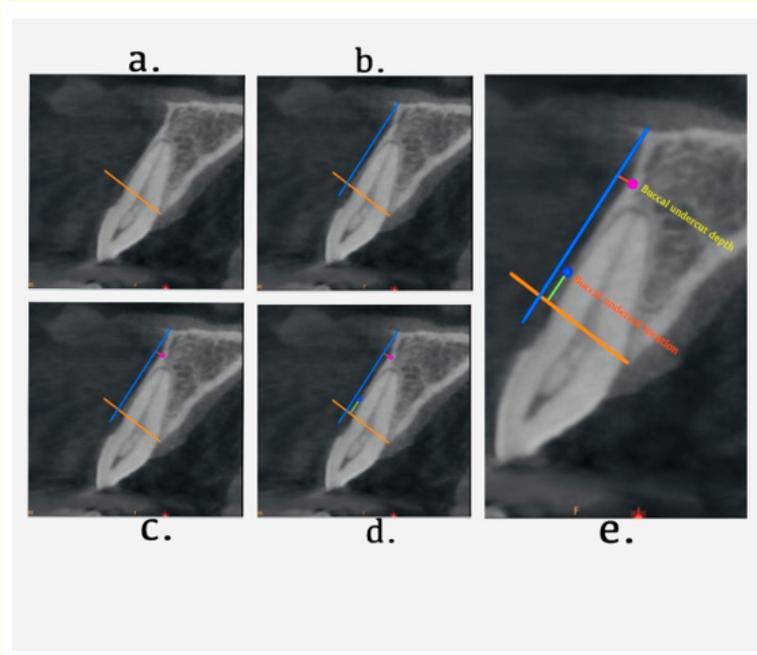

Figure 1

Figure 2

Results

The mean alveolar height for central incisors, lateral incisors and canines were 17.14 ± 2.29, 18.32 ± 2.27, 18.14 ± 2.35 respectively. The coronal, middle and apical alveolar width was 8.18 ± 1.82, 9.43 ± 1.57, 11.57 ± 2.12 for central incisors respectively. For lateral incisors the coronal, middle and apical alveolar width was 8.54 ± 1.55, 9.18 ± 1.68, 11.68 ± 2.04 respectively. Whereas for canines, the coronal, middle and apical alveolar width was 9.82 ± 1.22, 10.75 ± 1.46, 13.32 ± 2.17 respectively (Figure 3).
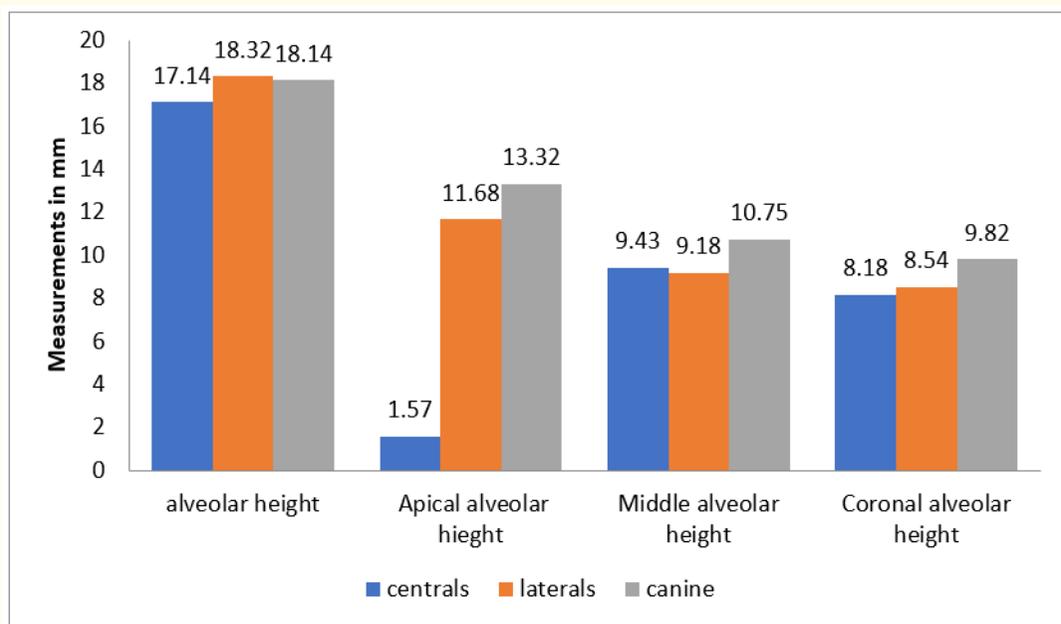

Figure 3: Comparison of alveolar height and width measurements among the three teeth.

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When the values were compared between the teeth it was evident that the values were statistically significant for canines.

The buccal undercut depth for central incisors, lateral incisors and canines was 1.75 ± 0.75, 2.57 ± 1.03, 1.96 ± 0.64 respectively. It was significantly deep for lateral incisor. Buccal undercut location for central incisors, lateral incisors and canines was 3.36 ± 1.5, 3.43 ± 0.91,3.68 ± 0.86 (Figure 4).
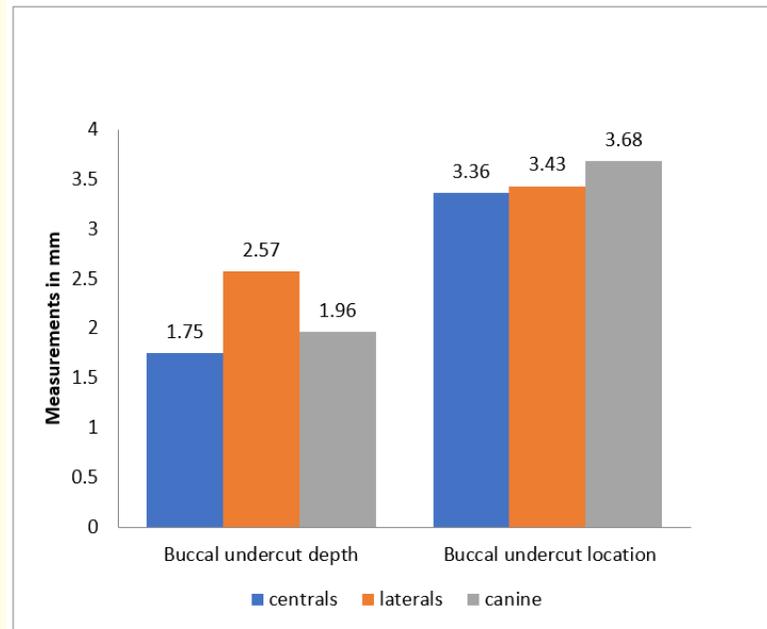

Figure 4: Comparison of buccal undercut location and depth among the three teeth.

Comparison of the parameters among males and females revealed that there was no statistically significant difference among males and females (Table 1).

Parameters	Centrals		Laterals		Canines		Kruskal Wallis test statistics	P value	Significant pairs
	Mean (sd)	Median (Q1, Q3)	Mean (sd)	Median (Q1, Q3)	Mean (sd)	Median (Q1, Q3)			
Alveolar height	17.14 mm (2.289)	17 mm (16,19)	18.32 mm (2.262)	18 mm (17,19)	18.14 mm (2.353)	19 mm (16.25,20)	3.877	0.144	
Apical alveolar width	11.57 mm (2.116)	11.5 mm (10,13)	11.68 mm (2.038)	12 mm (11.25,12)	13.32 mm (2.161)	13 mm (13,14.75)	12.107	0.002**	-Centrals and canines -Laterals and canines
Middle alveolar width	9.43 mm (1.574)	10 mm (8,10)	9.18 mm (1.679)	10 mm (8,10)	10.75 mm (1.456)	11 mm (10,12)	15.106	0.001**	-Centrals and canines -Laterals and canines
Coronal alveolar width	8.18 mm (1.827)	8 mm (7,9)	8.54 mm (1.551)	8 mm (8,10)	9.82 mm (1.219)	10 mm (9,10)	15.94	<0.001**	-Centrals and canines -Laterals and canines

Table 1: Comparison of Alveolar height and width measurements among the incisors and canines.

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Discussion

The resorption of alveolar process, following teeth extractions pose challenges in treatment planning. Hence the assessment of alveolar dimension prior to extractions may contribute in understanding the available alveolar volume for implant placement, and will also add to frame an appropriate treatment strategy and additional procedures if any required. These include measures to preserve the adjacent anatomical structures, or determining the length of implants to be placed based on the available ridge length [9]. Anterior maxilla remains a vulnerable zone presenting more challenges as esthetics plays a major role in the successful outcome [10,11].

Previous researchers have also emphasized that height of the bone wall influences the position of the mucosal margin on the facial aspect and the thickness determines the facial convexity of the alveolar process [12]. All of this research imply a need for assessment for the alveolar bone dimensions for successful implant treatment. In this regard the present study was planned to determine the alveolar bone dimensions to add to the existing literature for the selected population group.

Earlier researches have emphasized that a minimal 2 mm in thickness is ideal for an optimal biological and esthetic outcome [13,14]. And many researches have supported the fact that, the overall alveolar dimension and morphology at anterior maxilla adds clarity to implant planning. In the present study, the average alveolar height and width at maxillary anterior region ranged between 17.47 and 11.12 mm, respectively, for the selected subjects.

The central incisors had the thinnest alveolar ridge compared with the lateral incisors and canines. For all the three anterior teeth the alveolar width increased from the coronal to apical direction. There was no significant difference gender distribution in ridge dimensions. To exclude the influence of alveolar atrophy due to edentulism all the images selected included in the study had full dentition at maxillary anterior region.

In the current study, the buccal undercut was deepest for lateral incisors. This was in accordance with the findings of Chung P., *et al.* [6] which states that the deepest buccal bone concavity was found at the lateral incisors, although labial concavity is present in all anterior tooth. Their report also emphasizes that the size of the buccal bone concavity is related to buccal alveolar bone fenestration, which may directly influence the primary stability of implants placed.

Review of existing literature supports the fact that this study is one of its kind to have assessed the alveolar length, width and buccal undercut location and measurements in the regional population. There have been studies measuring crestal bone widths at different levels [15].

The data from the present study supports the fact that the bone dimension measured even in dentulous subjects adds to the facts that additional grafting procedures, may be required during implant placement especially in the lateral incisor region and less likely in the canine region. These findings are in accordance with reports of Zhang., *et al.* [2] but in contrast to the findings of Sheerah., *et al* [16]. Also, for the lateral incisor the alveolar ridge was thinnest and had deepest of buccal undercut located. This finding was also in accordance with Zhang., *et al* [2]. In addition, the undercut for lateral incisor was positioned most coronally among the three anterior teeth. Also, reports have emphasized that predominantly thin facial bone overlying the six maxillary anterior teeth calls for thorough preoperative evaluation of anterior maxilla [17,18].

These data call for a careful, especially of the lateral incisor region, which will contribute for the optimal treatment approach and reducing surgical complications. In addition, CBCT qualifies as a valuable tool to contribute not only for analysis but also to suggest sites for bone augmentation [19,20].

Study Limitations and Conclusion

The present study is limited in providing large data on the anatomical aspects owing to small sample size inclusion. Also, since the data was inclusive of pre-existing radiographs inclusion equal number of males and females for analysis was not possible. The authors would suggest inclusion of larger sample size for future investigation. The present study is the maiden efforts towards improving our understanding of the alveolar bone dimensions, which was lacking the present population. The data adds information regarding the ridge dimensions and throws light on the precautions needed for implant planning. There was, no significant differences in the assessed parameters with age or gender. The knowledge of ridge anatomy like buccal undercut depth and location, crest height and width are aesthetically relevant to anterior maxillary regions and will pave the way for appropriate treatment approach, especially for immediate implant. It is also suggested that, CBCT is an invaluable tool recommended in the presurgical imaging and planning.

Acknowledgements

Bibliography

1. Chan H L., *et al*. "Dental Imaging in Implant Treatment Planning". *Implant Dentistry* 19 (2010): 288-294.

2. Zhang W., *et al*. "Anterior maxilla alveolar ridge dimension and morphology measurement by cone beam computerized tomography (CBCT) for immediate implant treatment planning". *BMC Oral Health* 15 (2015): 65.

3. Eufinger H., *et al*. "Significance of the height and width of the alveolar ridge in implantology in the edentulous maxilla. Analysis of 95 cadaver jaws and 24 consecutive patients]". *Mund Kiefer Gesichtschir* 3.1 (1999): S14-S18.

4. Demircan S and Demircan E. "Dental Cone Beam Computed Tomography Analyses of the Anterior Maxillary Bone Thickness for Immediate Implant Placement". *Implant Dentistry* 24 (2015): 664-668.

5. Zhang S., *et al*. "Angulations of Anterior Teeth With Reference to the Alveolar Bone Measured by CBCT in a Chinese Population". *Implant Dentistry* 24 (2015): 397-401.

6. Chung M P., *et al*. "Evaluation of Buccal Bone Concavity in the Esthetic Zone: A Cadaver Study". *Implant Dentistry* 26 (2017): 751-755.

7. Tyndall DA., *et al*. "Position statement of the American academy of oral and maxillofacial radiology on selection criteria for the use of radiology in dental implantology with emphasis on cone beam computed tomography". *Oral Surgery, Oral Medicine, Oral Pathology and Oral Radiology* 113 (2012): 817-826.

8. Liu J., *et al*. "Efficacy of Cone-Beam Computed Tomography in Evaluating Bone Quality for Optimum Implant Treatment Planning". *Implant Dentistry* 26 (2017): 405-411.

9. Eufinger H., *et al*. "The role of alveolar ridge width in dental implantology". *Clinical Oral Investigations* 1.4 (1997): 169-177.

10. Braut V., *et al*. "Bone dimensions in the posterior mandible: a retrospective radiographic study using cone beam computed tomography. Part 1-analysis of dentate sites". *The International Journal of Periodontics and Restorative Dentistry* 32.2 (2012): 175-184.

11. Belser UC., *et al*. "Aesthetic implant restorations in partially edentulous patients - a critical appraisal". *Periodontology 2000* 17 (1998): 132-150.

12. Buser D., *et al.* "Optimizing esthetics for implant restorations in the anterior maxilla: anatomic and surgical considerations". *The International Journal of Oral and Maxillofacial Implants* 19 (2004): 43-61.

13. Braut V., *et al.* "Thickness of the Anterior Maxillary Facial Bone Wall-A Retrospective Radiographic Study Using Cone Beam Computed Tomography". *The International Journal of Periodontics and Restorative Dentistry* 31 (2011): 125-131.

14. Huynh-Ba G., *et al.* "Analysis of the socket bone wall dimensions in the upper maxilla in relation to immediate implant placement". *Clinical Oral Implants Research* 21 (2010): 37-42.

15. Kolte AP., *et al.* "Assessment of buccal and lingual alveolar bone width in the posterior region at dentate and edentulous sites: A cone-beam computed tomography study". *Journal of Indian Society of Periodontology* 24 (2020): 26-31.

16. Sheerah H., *et al.* "Alveolar bone plate measurements of maxillary anterior teeth: A retrospective Cone Beam Computed Tomography study, Al Madianh, Saudi Arabia". *Saudi Dental Journal* 31 (2019): 437-444.

17. Janua´ rio, A.L., *et al.* "Dimension of the facial bone wall in the anterior maxilla: a cone-beam computed tomography study". *Clinical Oral Implants Research* 22 (2011): 1168-1171.

18. Ghassemian, M., *et al.* "The thickness of facial alveolar bone overlying healthy maxillary anterior teeth". *Journal of Periodontology* 83 (2012): 187-197.

19. Benavides E., *et al.* "Use of Cone Beam Computed Tomography in Implant Dentistry: The International Congress of Oral Implantologists Consensus Report". *Implant Dentistry* 21 (2012): 78-86.

20. Worthington P., *et al.* "The role of cone-beam computed tomography in the planning and placement of implants". *The Journal of the American Dental Association* 141.10 (2010):19S-24S.