ASSESSMENT OF ALVEOLAR BONE HEIGHT AND WIDTH IN MAXILLARY ANTERIOR TEETH - A RADIOGRAPHIC STUDY USING CONE BEAM COMPUTED TOMOGRAPHY

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ABSTRACT

Cone beam computed tomography (CBCT) can be used for determining the height and width of alveolar bone surrounding the implant site which are important factors in implant planning. This study was done to evaluate and compare alveolar bone height and width in maxillary anterior teeth based on CBCT images from Nepalese population. This retrospective study included patients who had done CBCT scan between January 2019 to December 2020. Sagittal section views perpendicular to alveolar ridge were taken in the middle of maxillary left and right central incisor, lateral incisor, and canine regions and the linear measurements were done to measure alveolar height (between floor of nasal fossa and alveolar crest) and width (between buccal and palatal cortical plate). The result revealed no significant difference in alveolar height among maxillary anterior teeth. Mean alveolar width for maxillary right central incisor (11), lateral incisor (12), and canine (13) were 12.09 ± 2.36, 8.27 ± 1.37 and 9.99 ± 1.44 mm, respectively and for maxillary left central incisor (21), lateral incisor (22), and canine (23) were 9.51 ± 1.47, 8.27 ± 1.32 and 10.35 ± 1.85 mm, respectively. Lateral incisors have less width as compared to other maxillary anterior teeth. Pearson's correlation analysis for correlating alveolar height with width showed $p<0.05$ among 13, 12, 21 and 22. There is weaker correlation between the mean of alveolar height and width. The alveolar height as well as width was greater in male than female in all the six anterior teeth except for the alveolar width in relation to 11.

KEYWORDS

Cone beam computed tomography, extraction, implant, maxilla.

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INTRODUCTION

Implants are commonly used nowadays to replace one or more missing teeth in a way that is aesthetically pleasing, functional and long-lasting. However, lack of knowledge about the applied anatomy at anterior maxilla jeopardizes the clinical outcome of implant placement in this region.[1]

Proper treatment planning including height and width of alveolar bone surrounding the implant site are important factors in determining the implant size and prognosis and obtaining successful outcome.[1-4] Cone beam computed tomography (CBCT) has more advantages over conventional radiographic techniques as it creates high-resolution, accurate images without superimposition and distortion at low dosages of X-radiations, that can be used in implant planning.[1,5-6]

There is scarce information on the alveolar bone dimensions in anterior maxilla in Nepalese population. Therefore, the aim of study is to evaluate and compare alveolar bone height and width in anterior maxillary teeth and also to compare these dimensions among genders based on CBCT images of people attending a tertiary care hospital in Nepal.

MATERIALS AND METHODS

This was an observational retrospective radiographic study conducted in Department of Periodontology and Oral Implantology, Kathmandu University Teaching Hospital, Dhulikhel Hospital. Ethical clearance was obtained from institutional review committee, Kathmandu University School of Medical Sciences (KUSMS) (Ref: 21/2021). A total of 100 (52 male and 48 female) CBCT scans performed at the Department of Oral Medicine and Radiology, KUSMS from January 2019 to December 2020 were selected for study. The inclusion criteria were (1) patients' age at least 18 years of age at the time of the CBCT scan and (2) all maxillary anterior teeth were present. The exclusion criteria were: (1) patient with systemic or endocrine diseases that influence bone metabolism (e.g., diabetes, osteoporosis, etc.) that may be evident on the radiograph and (2) local conditions that affect the quality of the bone (e.g. cysts, tumors, prior orthodontics, trauma or surgical history). The CBCT images were obtained from subjects for dental purposes, such as orthodontic purpose, surgery, dental implant, etc. The sampling was done by convenient sampling method.

Rainbow TM Image Viewer (Dentium, Korea) software was used to collect and analyse CBCT views, and measurements were recorded in a table. The scans were acquired at 80 kVp peak voltage, 7 mA tube current, 17 seconds scan time, and a 300µm voxel size with Dentium rainbow CBCT unit. The linear measurements were taken using sagittal section views perpendicular to the alveolar ridge in the middle of the maxillary left and right central incisor, lateral incisor, and canine regions. Measurements were done by a single examiner. A line was drawn parallel to the long axis of the alveolar ridge from the alveolar crest. Alveolar height was defined as the distance between the alveolar crest and the floor of the nasal fossa. Alveolar height was divided into three sections. A line was drawn perpendicular to the long axis of the ridge in middle of each third, and the distance between the buccal and palatal cortical plates was referred as alveolar width at the apical third, middle third, and coronal third. Each tooth's overall alveolar width was the average of the coronal, middle, and apical thirds of alveolar width measurements (Fig. 1, 2).[1]

For statistical analysis, independent t-test was used for comparing alveolar height and width among gender. Correlation of alveolar height

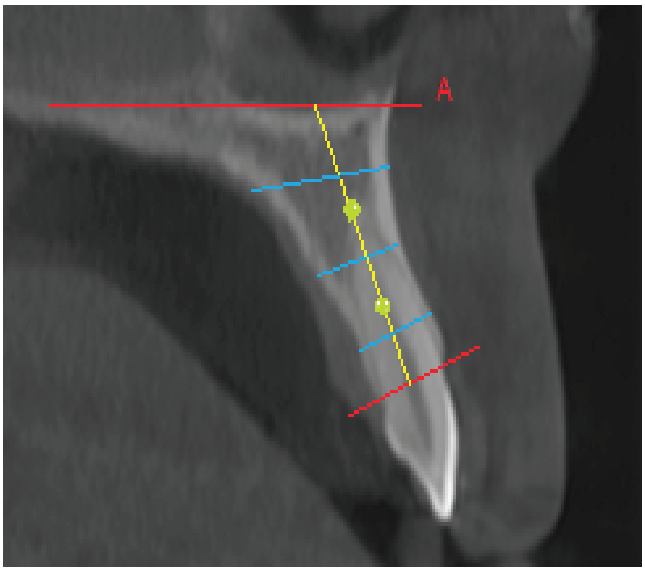

Fig. 1: Measurements of alveolar height and width: Line "A" represents nasal fossa's floor. Yellow line represents alveolar height (distance between the alveolar crest and the floor of nasal fossa). Alveolar height divided into three sections (by green dot). Blue lines (lines perpendicular to the long axis of the ridge in middle of each third) between buccal and palatal cortical plate represents alveolar width at the apical, middle, and coronal third.

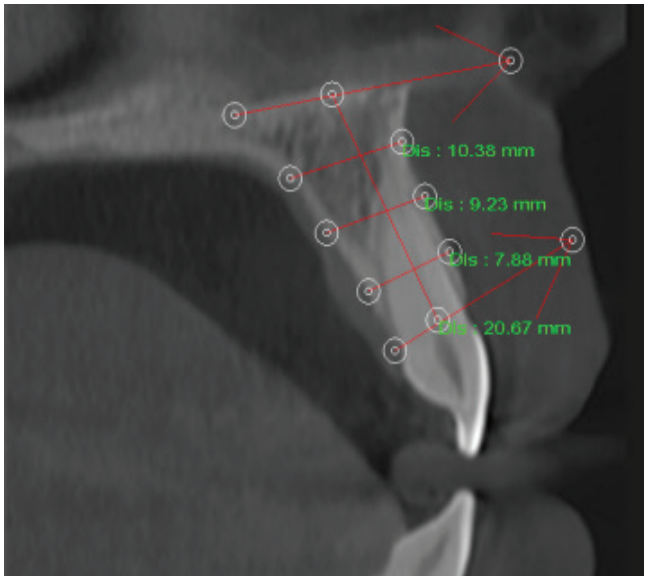

Fig. 2: Sagittal view of right maxillary central incisor with measurement of alveolar height and width.

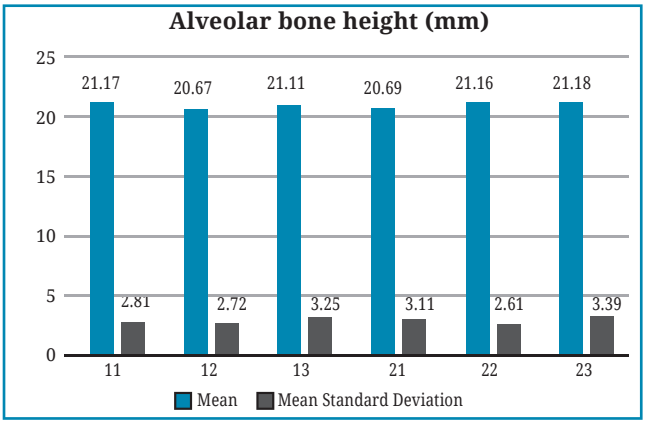

Fig. 3: Alveolar height measurements of maxillary anteriors.

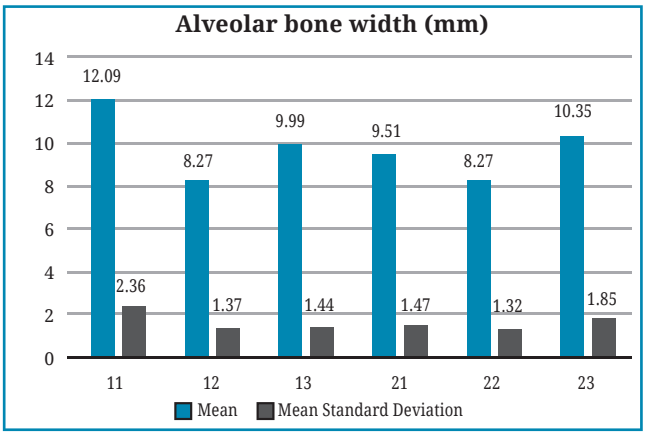

Fig. 4: Alveolar width measurements of maxillary anteriors.

with alveolar width was done by Pearson Correlation Analysis. Data were reported as means along with standard deviations (SD). The statistical difference was set at a p value <0.05. For Pearson Correlation Analysis, correlation was significant at the 0.05 level.

RESULTS

CBCT images of 100 subjects with 52 male and 48 female were selected according to the inclusion criteria. Mean alveolar height for the maxillary right central incisor (11), lateral incisor (12), and canine (13) were 21.17 ± 2.81, 20.67 ± 2.72 and 21.11 ± 3.25 mm, respectively and for maxillary left central incisor (21), lateral incisor (22), and canine (23) were 20.69 ± 3.11, 21.16 ± 2.61 and 21.18 ± 3.39 mm, respectively (Fig. 3). There was no significant difference in alveolar height among the teeth. Mean alveolar width for the 11, 12 and 13 were 12.09 ± 2.36,

Table 1: Independent t test Comparing Alveolar bone height among gender

Tooth	Gender	Alveolar height		"t"	Sig. (2-tailed) p-value
		Mean (mm)	Std. Deviation		
13	Male	21.87	3.17	2.474	.015*
	Female	20.30	3.17		
12	Male	21.51	2.93	3.420	.001*
	Female	19.76	2.15		
11	Male	22.11	3.19	3.790	.000*
	Female	20.14	1.90		
21	Male	22.04	3.45	5.195	.000*
	Female	19.21	1.78		
22	Male	21.94	2.83	3.252	.002*
	Female	20.32	2.07		
23	Male	22.03	3.56	2.704	.008*
	Female	20.25	2.98		

**Statistically significant (p-value<0.05)*

Table 2: Independent t-test Comparing Alveolar bone width among gender

Tooth	Gender	Alveolar width		"t"	Sig. (2-tailed) p-value
		Mean (mm)	Std. deviation		
13	Male	10.650	1.557	5.427	.000*
	Female	9.292	0.874		
12	Male	8.861	1.328	4.899	.000*
	Female	7.647	1.131		
11	Male	10.223	1.531	-.823	.413
	Female	14.120	34.138		
21	Male	10.058	1.546	4.101	.000*
	Female	8.931	1.156		
22	Male	8.783	1.339	4.305	.000*
	Female	7.728	1.084		
23	Male	10.755	2.256	2.324	.023*
	Female	9.927	1.181		

**Statistically significant* (p-value<0.05)*

Table 3: Pearson Correlation of alveolar height with alveolar width

		Alveolar width	
	n=100	Pearson Correlation	Sig. (2-tailed)
Alveolar Height	13	.235*	.018
	12	.201*	.045
	11	.098	.332
	21	.251*	.012
	22	.232*	.020
	23	-.049	.626

**Correlation is significant at the 0.05 level.*

8.27 ± 1.37 and 9.99 ± 1.44 mm respectively and for 21, 22 and 23 were 9.51 ± 1.47, 8.27 ± 1.32, 10.35 ± 1.85 respectively (Fig. 4). Lateral incisors had thinner width compared to other teeth.

When comparing alveolar height in male and female, the alveolar height was greater in male than female in all the six anterior teeth (Table 1). These parameters were statistically significant ($p<0.05$). When comparing alveolar width in male and female, the alveolar width was greater in male than female in all teeth except 11. These parameters were statistically significant ($p<0.05$) though, the alveolar width in female showed greater in 11, it was not statistically significant ($p>0.05$) (Table 2).

The overall correlation of alveolar height with alveolar width showed weaker correlation under Pearson's correlation analysis and showed $p<0.05$ among 13, 12, 21 and 22 (Table 3).

DISCUSSION

Dental implants are widely used today because of their functional and restorative success.[7] The success of implant depends upon various factors among which adequate amount of alveolar height and width are important ones for implant placement.[1-4] However, the alveolar ridge undergoes accelerated bone loss within first 6 months of extraction resulting in an eventual estimated 3.5-4 mm loss of ridge width and 1.5-2 mm loss of ridge height.[8] The facial bone wall in the anterior maxilla is frequently thin or absent as a result of the facial position of anterior teeth, and it undergoes significant resorption following tooth extraction.[2,9-10] It is very essential to assess the alveolar bone dimension in the maxillary anterior region because of its direct influence on stability of implant placement and aesthetic outcome.[11-12]

Because of the longer treatment time, conventional implants were less appealing

to both clinicians and patients.[13] Immediate implants are becoming increasingly popular because they shorten treatment time and increase patient comfort while preserving the natural shape of soft and hard tissues.[14] But, a systematic review and meta-analysis by Lee *et al.*[15] in 2014 revealed that bone dimensions of immediate implant sites demonstrated approximately 0.5-1.0 mm reduction in vertical and horizontal aspects 4-12 months after surgery. Many studies have also found that immediate implants are associated with mid-facial recession which may necessitate the use of an autogenous soft tissue graft such as connective tissue for correction.[16-17] As a result, prior to extraction, radiographic analysis of the alveolar dimensions using CBCT is critical for selecting an appropriate treatment approach and preserving adjacent anatomical structures, especially in cases requiring immediate implant placement.[1-2]

The current literature contains little information on the alveolar dimension in the maxillary anterior area, particularly in the Nepalese population. Several studies have measured the thickness of the buccal bone wall at the anterior maxilla and also reported that the facial wall can resorb significantly after tooth extraction.[18-19] Few studies have been done in Nepalese population as well for evaluating the buccal bone wall thickness. A study done by Shrestha *et al.*[20] in 2019 in Nepal, concluded that the labial bone in the anterior maxilla is mostly thin, with more than 80% of the sites showing less than 1 mm. However, the overall alveolar height and width in anterior maxillary teeth in the Nepalese population were yet to be fully evaluated.

In this study, the alveolar height had no significant difference among the teeth. Lateral incisors had thinner width compared to incisors and canines. Presence of a lateral fossa which creates the buccal concavity adjacent to lateral incisor could most likely be responsible for this.[1] Similar findings were observed in the study done by Zhang *et al*[1] in 2015 and Banu *et al*[4] in 2019. But in a study done by Ahmed and El Beshlawy[21] in 2019, the maxillary right canine had the highest alveolar bone height, followed by the right lateral incisor, and the right central incisor had the lowest values. The alveolar width increased from the coronal to apical direction for all anterior teeth in most of the samples. Similar finding was also reported by Zhang *et al.*[1]

For the correlation between gender and the alveolar height and width, there was a statistically significant difference between male and female. Male showed greater alveolar height and width than female in all anterior teeth except alveolar width in relation to right central incisor. This finding is in accordance to the other studies done by Zhang *et al*[1] in 2015, Banu *et al*[4] in 2019, Ahmed and El Beshlawy[21] in 2019 where greater height and width of alveolar bone were observed in male. According to Braun *et al*[22] and Usui *et al*[23] male impart more biting force than female by using stronger masticatory muscles.

We discovered no prior research linking alveolar width to alveolar height in the anterior maxilla. The overall correlation of alveolar height with alveolar width was seen to be weaker in this study under Pearson's correlation analysis. From this study we found that lateral incisors have higher risk of perforation of buccal plate compared to other teeth. So, additional grafting procedures or use of narrow diameter implant may be required for placing implant in this region.

The limitations of this study include relatively small sample size, heterogeneous population and small range of error due to CBCT. The errors have been reported in studies comparing calliper measurements on cadavers with measurements obtained from CBCT images.[24] Hence, we recommend a larger sample size with homogenous population would be required in future research to further validate current findings.

In conclusion, careful preoperative evaluation and planning with CBCT in anterior maxilla is strongly recommended, especially at the lateral incisor region due to limited availability of alveolar bone. The observation from this study would help clinicians to choose appropriate implant dimension and clinical approach. Bone augmentation procedures should be considered in implant site whenever there is an inadequate alveolar bone dimension.

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