Journal of
Oral Health and Oral Epidemiology

https://johoe.kmu.ac.ir
doi:10.34172/johoe.2023.26
Vol. 12, No. 4, 2023, 150-155

Original Article

Sufficiency of residual alveolar bone in terms of regions, age and gender in patients who underwent CBCT evaluation

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Abstract

Background: Alveolar bone resorption may complicate dental implantation of the edentulous area. The quantity of residual bone depends on the region, and it is uncertain which region may present more difficulties before implantation. In this study, the alveolar bones of patients who had cone beam computed tomography (CBCT) before dental implantation were examined, and residual bone was evaluated based on age, gender, and the location of the missing tooth.

Methods: In this observational study, the patients with CBCT were divided into two age groups: 18 to 35 and 36 and older. Also, the edentulous regions were divided into incisor, premolar, and molar regions. Radiographic measurements were performed with a cross-sectional aspect in the single-tooth deficiency regions of the patients; bone height and width measurements were made.

Results: This study included 164 CBCT scans from individuals (99 females and 65 males). There was no statistically significant difference between the bone heights and between bone widths at the 1st, 3rd, 5th, and 7th mm according to age or gender ($P>0.05$). Bone height in the incisor tooth region (ITR) and bone width at the 1st, 3rd, 5th, and 7th mm in the molar tooth region (MTR) were significantly larger ($P<0.01$).

Conclusion: This study revealed that the bone width at the 1st mm of the ITR was insufficient for dental implant placement and that horizontal bone augmentation was needed.

Keywords: Alveolar ridge augmentation, Alveolar bone loss, Alveolar bone grafting, Dental implants, Cone-beam computed tomography

Citation: Orhan ZD, Ciğerim L, Öner Talmaç AG, Mızrak YR, Çınarsoy Ciğerim S, Kahraman NH. Sufficiency of residual alveolar bone in terms of regions, age and gender in patients who underwent CBCT evaluation. *J Oral Health Oral Epidemiol*. 2023;12(4):150–155. doi: 10.34172/johoe.2023.26

Received: May 21, 2022, **Accepted:** October 24, 2023, **ePublished:** December 29, 2023

Introduction

Currently, implants are among the most popular choices for rehabilitating the oral region in patients with missing teeth.[1] Dental implants need to be of specific dimensions to handle enough force, so the alveolar bone must also be suitable for these dimensions for implant placement.[2,3] While the width and length of the bone vary from person to person, one thing that does not change is the resorption of the alveolar bone when it is edentulous.[4,5] Although this resorption is at its highest in the first year, it continues progressing as long as the bone is not in function.[6] The amount of bone must have specific conditions for the implant to be placed in the edentulous area. After the implant is placed, a distance of at least 1 mm of bone should be left on the buccal and lingual sides of the implant.[3,7] The longer the patients have been edentulous, the less likely the bone size will be sufficient for implant placement, making the operation more complicated; sometimes, this situation is enough to prevent implantation, and additional operations such as bone augmentation will be required.[8,9]

There are studies in the literature evaluating bone height and width before implantation, but no studies in the literature compare resorption differences between tooth regions. The main purpose of this study was to determine in which tooth region the height and width of the residual alveolar bone is smaller and which tooth region will more probably need augmentation. When evaluating the alveolar bone, there may be differences based on tooth region, gender, and age. Determining these is important regarding rehabilitation, implant planning, prognosis, and possible complications. Therefore, this study aimed to evaluate the width and height of the residual alveolar bone before dental implant surgery.

Materials and Methods

This observational cohort study was conducted on the cone beam computed tomography (CBCT) of patients

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who referred to Van Yüzüncü Yıl University, Faculty of Dentistry, Departments of Orthodontics and Oral and Maxillofacial Surgery between January 2010 and January 2019. The study was performed on 164 people who underwent CBCT to evaluate alveolar bone before dental implant surgery. Approval was obtained from Van Yüzüncü Yıl University Presidency Non-Interventional Research Ethics Committee for the study (2020/09-08). The sample size of this study was calculated as 51 samples, with a minimum of 17 samples in each group, using the G*Power statistical program (ver.3.1.9.7). The test power was 0.80, the effect size was 0.45, and the type-1 error (α) was 0.05.

The eligible subjects were individuals aged 18 years or older without systemic disease, who had had their tooth extraction one to five years prior to the study and whose edentulous area deficiency was restricted to one tooth; also, the demographic information of the individuals needed to be complete. Smokers, individuals whose radiographic records were missing or inaccessible, individuals with more than one tooth missing in the edentulous area, individuals with prosthetic restoration of the single tooth deficiency area, and those with errors in their films that prevented measurement were excluded from the study. In this study, regions with single missing teeth were examined. This was to minimize the effect of specific factors influencing resorption in areas with multiple missing teeth.

The patients were divided into two age groups: 18 to 35 years and 36 and older. Cross-sectional radiographic measurements were taken in the single-tooth deficiency regions of the patients; bone height measurements were taken as the mesiodistal distance from the midpoint of the space to the mandibular canal/sinus floor/nasal base; bone width measurements were taken as the bone width at the depths of 1, 3, 5 and 7 mm from the crest (Figures 1-3). Each measurement was repeated three times, and the mean values were recorded. Measurements were made on the acquired CBCT images at 0.2–0.25 mm^3 voxel size and were reconstructed with the KaVo eXamVision (KaVo Dental GmbH, Germany) program at 1 mm thickness. CBCT images were displayed on a 20-inch flat panel screen (EIZO Flexscan S2000 with 1920x1080 pixel resolution) and viewed in a low-light environment. Edentulous regions were divided into three areas: 1- The incisor tooth region (ITR), the lower and upper central, lateral, and canine teeth, 2- The premolar tooth region (PTR), the lower and upper 1st and 2nd premolar teeth, and 3- The molar tooth region (MTR), the lower and upper 1st and 2nd molar teeth.

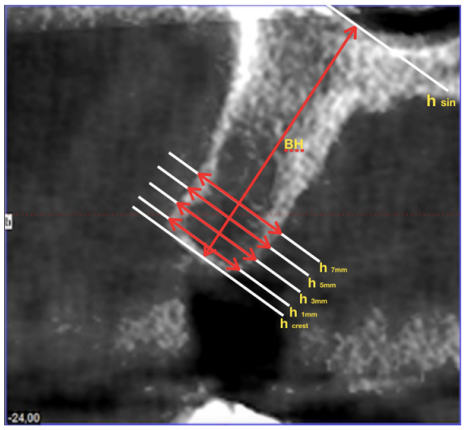

Figure 1. Reference lines of radiographic measurements of deficient right maxillary first premolar region. Bone width measurements were performed at depths of 1, 3, 5, and 7 mm from the crest. Bone height measurements were performed by measuring the distance between the most coronal point of the crest and the maxillary sinus or nasal floor

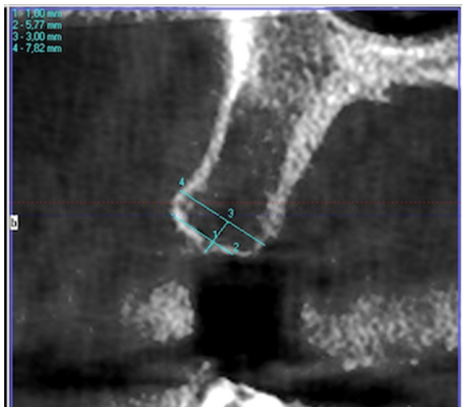

Figure 2. Figure shows bone width measurements at the 1st and 3rd mm depth

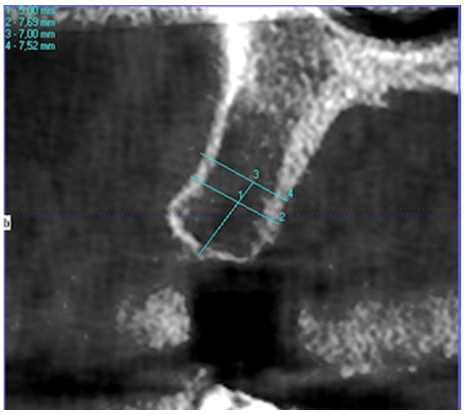

Figure 3. Figure shows bone width measurements at the 5th and 7th mm depth

Statistical analysis

The NCSS (Number Cruncher Statistical System) 2007 (Kaysville, Utah, USA) software was used for statistical analysis. A one-way ANOVA test was used to compare more than two groups of normal distribution of quantitative variables, and the Bonferroni and Games-Howell tests were used in paired comparisons. The Kruskal-Wallis and Dunn-Bonferroni tests were used to compare the difference between two independent groups of non-normally distributed quantitative variables. The paired samples test was used for intergroup comparison of quantitative variables with normal distribution. Statistical

significance was defined as $P<0.05$. An independent statistician reviewed the methodology.

Results

This study included 164 CBCT scans from individuals (99 females and 65 males) with an age range of 19 to 71 years and a mean age of 38.28 ± 10.71 years. Seventy-four individuals were between 18 and 35 years old, and 90 individuals were 36 and older. The deficient teeth were located in the 113 MTR (69%), 34 PTR (21%), and 17 ITR (10%) regions. The first molars (101 cases, 61%) were the most common deficient teeth (Table 1).

There was no statistically significant difference between the bone height and width according to age or gender ($P>0.05$) (Table 2).

The bone of the ITR was found to be significantly higher than that of the MTR ($P<0.01$; Table 3).

The bone width of the MTR was larger than the bone width of the ITR at 1 and 3 mm ($P<0.01$). The bone width of the MTR was larger than those of the ITR and PTR at the 5th mm ($P<0.01$). When the bone widths at 7 mm depth were compared, it was found that the bone width in the MTR and PTR region was greater than it was in the ITR region ($P<0.01$). In all three regions, bone widths at 3, 5, and 7 mm depths were found to be greater than it was at 1 mm depth, bone widths at 5 and 7 mm depth were greater than it was at 3 mm depth, and bone width at 7 mm depth was greater than it was at 5 mm depth ($P<0.01$; Table 3).

Discussion

Studies evaluating alveolar bone generally focus on age, gender, and time after extraction. Considering the clinical studies evaluating the relationship of residual bone size with the age and gender of the patients, Zhang et al stated that the bone height and width in the edentulous mandible were larger in males. However, there was no relationship between the age of the individuals and bone size.[10] Similarly, Saeed et al also stated that the residual bone height and width of the posterior mandible were larger in men, and there was no relationship between these values and age.[11] Yüzügüllü and colleagues' study on edentulous mandibles stated that bone height was affected by neither age nor gender.[12] We found no correlation between age and gender and the residual bone height and width.

No comparison has been found in the literature regarding which region is thinner or shorter in edentulous jaws. Considering the studies giving information about the bone size of different regions, the study of Zhang et al, which evaluated the edentulous mandibula in MTR,

Table 1. Distribution of descriptive features and distribution of teeth regions by vertical and horizontal bone distances

Characteristics	
Age	
Min-Max	19–71
Mean ±SD	38.28 ± 10.71
18–35 years	74 (45.1%)
≥36 years	90 (54.9%)
Gender	
Male	65 (39.6%)
Female	99 (60.4%)
Deficient tooth region	
Incisor tooth region	17 (10.4%)
Central	5 (3.0%)
Lateral	6 (3.6%)
Canine	6 (3.6%)
Premolar tooth region	34 (20.7%)
First premolar	19 (11.6%)
Second premolar	15 (9.1%)
Molar tooth region	113 (68.9%)
First molar	101 (61.6%)
Second molar	12 (7.3%)

Table 2. Bone width at the 1st, 3rd, 5th and 7th mm and bone height according to age and gender

		Age		Test value	Gender		Test value
		18–35 years (n = 74)	≥36 years (n = 90)	*P*	Male (n = 65)	Female (n = 99)	*P*
Bone width at 1 mm	Min-Max	0.89–13.16	1.48–11.9	t: 0.113	1.48–10.63	0.89–13.16	t: 0.219
	Mean ±SD	5.52 ± 2.15	5.49 ± 1.92	0.910[a]	5.55 ± 1.95	5.48 ± 2.07	0.827[a]
Bone width at 3 mm	Min-Max	2.15–14.56	0–12.7	t: 0.291	0–14.56	2.15–13.3	t: 1.121
	Mean ±SD	7.07 ± 2.35	6.97 ± 2.21	0.772[a]	7.26 ± 2.48	6.86 ± 2.12	0.264[a]
Bone width at 5 mm	Min-Max	3.05–14.56	0–12.9	t: 1.226	0–14.56	0–13.5	t: 0.549
	Mean ±SD	8.13 ± 2.54	7.63 ± 2.7	0.222[a]	8 ± 3.06	7.76 ± 2.32	0.584[a]
Bone Width At 7 mm	Min-Max	0–15	0–14.41	t: 1.014	0–15	0–13.8	t: 0.202
	Mean ±SD	8.71 ± 2.78	8.26 ± 2.82	0.312[a]	8.53 ± 3.4	8.43 ± 2.34	0.840[a]
Bone height (mm)	Min-Max	5–23.37	2.4–30.44	t: 0.609	2.4–30.4	4.8–27.2	t: 0.010
	Mean ±SD	15.97 ± 3.97	15.57 ± 4.44	0.544[a]	15.75 ± 4.88	15.75 ± 3.76	0.992[a]

[a] Student *t* test.

Table 3. Evaluation of bone height and width at the 1st, 3rd, 5th, and 7th mm according to deficient tooth region

		Deficient tooth region			Test value
		Incisor tooth region (n=17)	Premolar tooth region (n=3 4)	Molar tooth region (n=113)	*P*
Vertical bone distance	Min-Max	11.3–30.4	7.6–23.37	2.4–22.8	F: 7.428
	Mean±SD	18.77±4.99	16.69±3.63	15.02±4.04	0.001**,b
Horizontal bone distance					
1 mm	Min-Max	1.6–7	0.89–9.66	1.48–13.16	F: 5.532
	Mean±SD	4.37±1.54	5.22±1.6	5.76±2.13	0.007**,b
3 mm	Min-Max	1.6–7.9	2.15–10.06	0–14.56	F: 7.888
	Mean±SD	5.36±1.68	6.49±1.72	7.42±2.36	0.001**,b
5 mm	Min-Max	2–9.7	3.05–11.6	0–14.56	F: 11.577
	Mean±SD	6±1.71	7.25±1.84	8.32±2.8	0.001**,b
7 mm	Min-Max	3–10.6	4.5–12.9	0–15	F: 12.173
	Mean±SD	6.48±1.67	7.93±1.89	8.93±3.01	0.001**,b
1–3 mm	Difference	0.99±1.03	1.27±0.96	1.66±1.35	χ^2: 8.947
	P[a]	0.001**	0.001**	0.001**	0.011*,c
1–5 mm	Difference	1.63±1.23	2.03±1.33	2.56±2.31	χ^2: 11.967
	P[a]	0.001**	0.001**	0.001**	0.003**,c
1–7 mm	Difference	2.11±1.35	2.70±1.63	3.17±2.72	χ^2: 10.124
	P[a]	0.001**	0.001**	0.001**	0.006**,c
3–5 mm	Difference	0.64±0.70	0.76±0.70	0.90±1.67	χ^2: 7.429
	P[a]	0.002**	0.001**	0.001**	0.024*,c
3–7 mm	Difference	1.12±1.03	1.44±1.14	1.50±2.18	χ^2: 5.387
	P[a]	0.001**	0.001**	0.001**	0.068[c]
5–7 mm	Difference	0.48±0.41	0.68±0.71	0.61±1.13	χ^2: 1.906
	P[a]	0.001**	0.001**	0.001**	0.386[c]

[a]Paired samples test; [b]One-way ANOVA; [c]Kruskal Wallis test; *$P<0.05$;**$P<0.01$

showed that the alveolar bone was higher in the 1st molar region and the width of the alveolar bone was larger in the 2nd and 3rd molar regions.[10] In their study, Zhao et al evaluated posterior residual alveolar bone. As a result, they measured alveolar bone heights in the premolar and molar region regions as 11.5–15.8 mm and 6.6–12.9 mm, respectively. They showed that the width of the horizontal bone at the 1st, 3rd, and 6th mm ranged from 5.3 to 10.5 mm in the PTR and 6.6 and 13.6 mm in the MTR.[13] Pramstraller et al examined the residual alveolar bone in the posterior site of the mental foramen and found that the bone height of the crest was 14.37 mm in the PTR and varied between 12.43 and 13.41 mm in the MTR. Mean bone width was between 4.99 and 8.80 mm in the PTR and 5.99 and 12.87 mm in the MTR.[14] Unlike these studies, it was observed that the bone in the PTR (16.69 mm) and MTR (15.02 mm) was higher. Similar to the studies mentioned, the present study showed that bone height decreases towards the posterior. The bone widths of different depths varied between 5.22 and 7.93 mm in the PTR and 5.76 and 8.93 mm in the MTR, and in some instances, the bone width is narrower in the anterior of the jaws than in the posterior. We can consider two reasons for this. First of all, the chewing forces that differ according to the region of the tooth and the different forces resulting from the movements of the tongue, lip, and cheek, and maxillary sinus pneumatization may have increased or decreased the amount of resorption in the bone. Secondly, it is possible that the width of the bone was already narrower and the height of it longer in ITR than MTR, even before the teeth were extracted, which led to the observed difference even if the amount of resorption in the different regions were similar.

Zhang et al, Pramstraller et al, and Saeed et al showed that bone height on the dentate side was higher in the premolar or molar region than on the edentulous side.[10,11,14] Zhang et al showed in their study that the dentate site was wider in the coronal and middle third than the edentulous side, and the buccolingual decrease in the coronal third of the edentulous site was greater than in the middle and apical third.[10] Pramstraller et al showed that the dentate side at the 1st and 3rd mm

depth was wider than the edentulous side.[14] Araujo and colleagues' study showed that osteoclastic activity is most intense in the coronal region of the extraction socket in the early postoperative period.[15] The findings of this study support the findings of the previous studies, as the width of the alveolar bone was the lowest in the coronal site in all regions.

Our results show that ITR is riskier regarding bone width than other regions. It revealed the need for horizontal bone augmentation in most individuals with a single tooth deficiency in the ITR.

Strengths and Limitations

Differences between individuals may have affected the resorption amount, which is a study limitation. Also, it is not known whether a traumatic or atraumatic method was used during tooth extraction. Apart from these factors, chewing and tongue, lip, and cheek movements may have increased or decreased the amount of resorption, depending on the tooth region.

Conclusion

In conclusion, this study determined that approximately one out of every two patients with a single-tooth deficiency who planned to have dental implants needed horizontal bone augmentation, especially in the ITR. These results reveal the importance of evaluating the residual alveolar bone before dental implant surgery. In future studies, the effect of single tooth deficiency in different tooth regions should be evaluated in larger populations.

Acknowledgments

The authors thank Emire Bor for her assistance in the statistical evaluation of the data and methodology review.

Authors' Contribution

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Project administration: Levent Ciğerim.
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Software: Yusuf Rodi Mızrak.
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Validation: Zeynep Dilan Orhan.
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Writing–original draft: Zeynep Dilan Orhan.
Writing–review & editing: Levent Ciğerim, Zeynep Dilan Orhan.

Competing Interests

There is no conflict of interest to declare.

Consent for publication

A signed informed consent form was obtained from all study participants to use tomography images and data collection.

Data Availability Statement

The dataset supporting the conclusions of this article is included within the article.

Ethical Approval

The study protocol was approved by Van Yüzüncü Yıl University Non-Interventional Research Ethics Committee, Turkey (2020/09-08).

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

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