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Cone beam computed tomography evaluation of bone height and width in 7 different tooth regions of totally edentulous maxilla

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ABSTRACT

Aims: The aim of this study was to evaluate the residual alveolar bone height and bone width at different depths from the central tooth region to the second molar tooth region in maxillary totally edentulous individuals.

Methods: This retrospective observational radiographic study was performed on cone beam computed tomography images of patients who presented to the department of oral and maxillofacial surgery for dental implant evaluation between January 2010 and March 2023. Horizontal measurements were taken on sagittal cross-sectional images at vertical depths of 1 mm, 3 mm, 5 mm and 7 mm from the alveolar crest. Vertical measurements were made by measuring the distance between the crest of the alveolar ridge and the base of the nose or the base of the maxillary sinus. The results were evaluated with 95% confidence interval and significance at p<0.05 level.

Results: Of the 104 patients included in the study, 42 were male and 62 were female and their age ranged from 36 to 90 years with a mean age of 50.88±10.28 years. The mean change of 0.46±1.83 units in the vertical measurements on the left side compared to the right side in the lateral region was statistically significant (p<0.05). Bone height was greater in the right and left central regions than in the 2nd premolar, 1st molar and 2nd molar regions (p<0.05). Bone width was greater in the 2nd premolar, 1st molar and 2nd molar regions and on the left side at depths of 1, 3 and 5 mm (p<0.05).

Conclusion: This study was the first to compare residual bone height and width at 1, 3, 5 and 7 mm depth from the central region to the second molar region in individuals with complete maxillary edentulism. The study showed that the loss of horizontal bone width as a result of alveolar crest resorption in edentulous patients was advanced and the need for horizontal augmentation was very high in this group of patients being considered for dental implant surgery.

Keywords: Dental implant, maxilla, edentulous maxilla, bone width, bone height

INTRODUCTION

The close relationship between the tooth and the alveolar crest continues throughout life. According to Wolff's law, the bone is remodeled in response to the applied forces. During function, changes occur in the internal and external structure of the alveolar bone. Alveolar crest resorption (ACR) is a chronic, progressive and irreversible process. ACR begins after tooth extraction and is associated with factors such as gender, hormones, metabolism, parafunction and inappropriate dentures. The duration of edentulism is one of the most important factors in ACR.[1-4]

It has been shown that 6 months after tooth extraction, bone width loss is between 29-63% and bone height loss is between 11-22%, and the resorption rate is highest in the first 6 months.[5] After tooth loss, atrophic edentulous ridges can form due to remodelling of the adjacent alveolar bone.[5,6]

As the alveolar crest volume has a direct effect on retention, stability and support of the prosthesis, it plays an important role in success of the prosthesis.[7] ACR is the major cause of stability and retention problems in removable dentures.[8]

Today, implant supported dentures are the first choice in the rehabilitation of edentulous jaws.[3] In individuals with complete edentulism, the effects of ACR increase with the duration of edentulism and rehabilitation of this patient group can be complicated. The width and height of the residual bone are critical in implant-supported prosthetic planning.[9] In cases of complete edentulism, bone width and height should be assessed prior to implant surgery. These assessments should identify areas of adequate and inadequate bone, and planning should be made accordingly.[5] The routine use of cone beam computed tomography (CBCT) is recommended to assess

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the width and height of edentulous ridges.[10] CBCT provides a three-dimensional assessment of the alveolar bone. Implant surgery planned without CBCT is likely to be problematic. Three-dimensional evaluation of the bone allows detection of cases with inadequate bone width and height, allowing modification of the planned implant site(s) or planned bone augmentation in the relevant areas. Preoperative knowledge of the available residual alveolar bone width and height prevents the clinician from encountering an unexpected situation during implant surgery and possible patient compromise.[11,12]

It is clear that radiological accuracy in implant planning is only possible with CBCT. However, despite its widespread use today, the use of CBCT is still limited.[13,14] Therefore, it is important to determine the bone height and width at different depths from the crestal level in different tooth regions for implant planning in the rehabilitation of edentulous patients. There are no studies in the literature that have evaluated edentulous jaws in this regard. In edentulous jaws, it is not known in which tooth(s) the bone width and height are sufficient and insufficient, and the determination of these regions will contribute to implant planning. The aim of this study was to evaluate the residual alveolar bone height and bone width at different depths from the central tooth region to the second molar tooth region in maxillary totally edentulous individuals.

METHODS

This retrospective observational radiographic study was performed on CBCT images of patients who presented to Van Yüzüncü Yıl University Faculty of Dentistry, Department of Oral and Maxillofacial Surgery for dental implant evaluation between January 2010 and March 2023. The study was approved by the Non-interventional Ethics Committee of Van Yüzüncü Yıl University (Date: 17.03.2023, Decision No: 2023/03-09). All procedures followed were in accordance with the ethical standards of the committee responsible for human experimentation (institutional and national) and the Helsinki Declaration of 1975, as revised in 2008.

Individuals aged 18 years and older, individuals with ASA1 and ASA2 systemic status, individuals who had been totally edentulous for at least 1 year, and individuals with CBCT images of sufficient resolution and showing the entire maxilla were included in the study. Individuals with cleft lip and palate, a history of nasal or maxillary sinus disease, a history of maxillary surgery, jaw pathology or fracture, image artefacts, and poor-quality images were excluded. The CBCT images used in this study were acquired with a Kavo 3D exam (KaVo Dental, Biberach, Germany) tomography unit (image characteristics as follows 0.2-0.4 mm voxel size, 18.54 mAs, 120 kVp, 8.9 seconds scan time and 160×60-130 field of view). CBCT images were analysed using examvision software (KaVo Dental, Biberach, Germany).

All measurements and assessments were performed by an oral and maxillofacial radiologist with 6 years of experience in CBCT image interpretation. Measurements were repeated by the same examiner at two different times, 3 weeks apart, and intraobserver agreement was calculated as 0.95. In the axial section, central points representing the position of each tooth were determined based on the average mesio-distal widths of the right and left maxillary central, lateral, canine, premolar and molar teeth. Crown widths were considered to be 8.87 mm for central, 6.96 mm for lateral, 7.77 mm for canine, 7.08 mm for first premolar, 6.77 mm for second premolar, 10.31 mm for first molar and 9.76 mm for second molar.[15,16] Using the CBCT midline as a reference, the points where the central teeth should be located on the right and left were first determined. The position of each tooth was then determined by calculating the distance from the midline and the midpoint of the previous tooth. Horizontal measurements (bone width measurements) were taken on sagittal cross-sectional images at vertical depths of 1 mm, 3 mm, 5 mm and 7 mm from the alveolar crest. Right and left central (R1), lateral (R2), canine (R3), 1st premolar (R4), 2nd premolar (R5), 1st molar (R6) and 2nd molar (R7) teeth were measured using the same protocol. A total of 56 bone width measurements were taken from 14 points. Width measurements corresponding to the nasal and maxillary sinuses were accepted as "0". Vertical (bone height) measurements were also taken for each tooth from the points where the horizontal measurements were taken. Vertical measurements were made by measuring the distance between the crest of the alveolar ridge (where horizontal measurements were taken at a depth of 1 mm) and the base of the nose or the base of the maxillary sinus (Figure). Power analysis was performed using G*Power (v3.1.9.2) to determine sample size. Based on the study by Katsoulis et al.,[17] the differences between the groups were examined and as a result of the calculation, the effect size was calculated as d=1.0338 and it was calculated that a total of at least 42 patients should be studied to achieve 99% power at α=0.01 level. Between March 2023 and January 2024, when the study was conducted, 104 patients were found to meet the inclusion criteria and all 104 patients were included in the study.

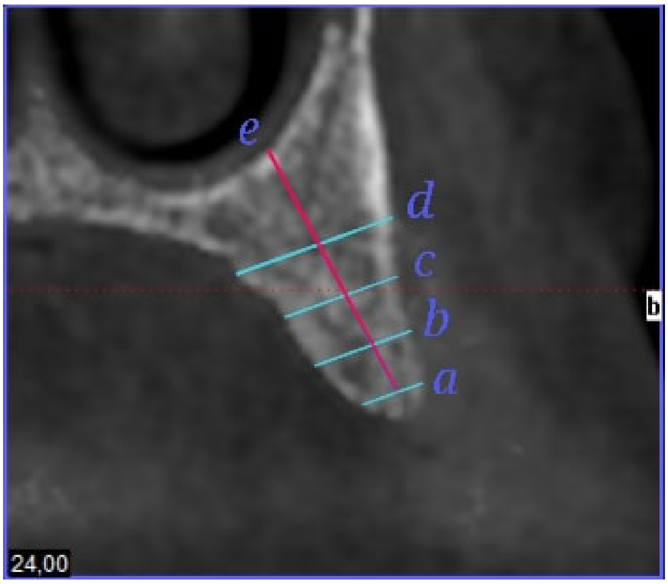

Figure. (a) Horizontal measurement at vertical depth of 1 mm; (b) Horizontal measurement at vertical depth of 3 mm; (c) Horizontal measurement at vertical depth of 5 mm; (d) Horizontal measurement at vertical depth of 7 mm; (e) Vertical measurement which is the distance between the crest of the alveolar ridge (where horizontal measurements were made at a depth of 1 mm) and the base of the nose or the base of the maxillary sinus

Statistical Analysis

NCSS 2020 (Kaysville, Utah, USA) was used for statistical analysis. When evaluating the study data, quantitative variables were presented using mean, standard deviation, median, Q1 and Q3 values, and qualitative variables were presented using descriptive statistical methods such as frequencies and percentages. The Shapiro-Wilks test and box plots were used to assess the suitability of the data for normal distribution. Student's t-test was used to assess two quantitative groups with normal distribution, and paired sample t-test was used for within-group assessments. Pearson correlation analysis was used to assess relationships between variables according to distribution. The results were evaluated with 95% confidence interval and significance at $p<0.05$ level.

RESULTS

Of the 104 patients included in the study, 40.4% (n=42) were male and 59.6% (n=62) were female and their age ranged from 36 to 90 years with a mean age of 50.88±10.28 years (Table 1).

Table 1. Distribution of descriptive characteristics

		n (%)
Gender	Male	42 (40.4)
	Female	62 (59.6)
Age	*Mean±SD*	50.88±10.28
	Median (min-max)	59 (36-90)

SD: Standart deviation, Min: Minimum, Max: Maximum

Evaluation of Vertical Measurements

There was a statistically significant difference in the mean vertical measurements on the left side compared to the right side in the lateral region ($p=0.011$; $p<0.05$). In other regions, the changes in the vertical measurements on the left side compared to the right side were not statistically significant ($p>0.05$) (Table 2).

Table 2. Comparison of vertical measurements in the regions by side

	Right maxilla		Left maxilla			
Vertical	Mean±SD	Median(IQR)	Mean±SD	Median(IQR)	Change	^{a}p
R1	15.15±3.58	15.3 (12.7-17.6)	15.64±3.82	16.1 (13.7-18.2)	-0.48±2.67	0.065
R2	14.42±3.44	14.7 (12.5-16.6)	14.89±3.55	15.5 (12.6-17.1)	-0.46±1.83	0.011*
R3	14.57±3.60	14.4 (12.5-17)	14.46±3.61	14.5 (12.1-16.6)	0.10±2.19	0.626
R4	13.41±4.52	13.7 (10.5-16.2)	13.73±4.23	14 (10.6-16.7)	-0.31±3.75	0.393
R5	10.39±5.10	10 (7.2-13.6)	10.83±5.02	11 (7.4-14.2)	-0.44±5.13	0.377
R6	7.05±4.40	6.8 (3.6-9.6)	7.32±4.35	6.8 (4-10)	-0.26±3.90	0.489
R7	7.12±4.41	6.8 (3.6-9.2)	7.47±4.40	7.1 (4.4-10)	-0.35±3.85	0.354
p	^{b}0.001**		^{b}0.001**			
	Mean±SD	p	Mean±SD	p		
R1-R2	-0.73±2.10	^{bb}1.000	-0.76±2.21	^{bb}1.000		
R1-R3	-0.59±2.83	^{bb}1.000	-1.18±2.79	^{bb}0.807		
R1-R4	-1.74±3.88	^{bb}0.906	-1.92±3.69	^{bb}0.236		
R1-R5	-4.77±5.39	^{bb}0.001**	-4.81±4.84	^{bb}0.001**		
R1-R6	-8.10±5.07	^{bb}0.001**	-8.32±5.08	^{bb}0.001**		
R1-R7	-8.04±4.88	^{bb}0.001**	-8.17±5.52	^{bb}0.001**		

^{a}: Paired Samples-t test, ^{b}: Repeated Mesaures test, ^{bb}: Dunn-Bonferroni test, $^{**}p<0,01$, $^{*}p<0.05$, SD: Standart deviation, R1: Central tooth region, R2: Lateral tooth region, R3: Canine tooth region, R4: First premolar tooth region, R5: Second premolar tooth region, R6: First molar tooth region, R7: Second molar tooth region

Right and Left Side

The difference between R1-R5, R1-R6 and R1-R7 bone heights was statistically significant ($p<0,01$). No significant difference was found in the other region comparisons ($p>0.05$) (Table 2).

Evaluation of Horizontal Measurements

Horizontal measurements at 1 mm depth: There was a statistically significant difference in the mean horizontal measurements on the left side compared to the right side in the R1 ($p=0.005$; $p<0.01$). In other regions, the changes in the horizontal measurements on the left side compared to the right side were not statistically significant ($p>0.05$) (Table 3).

Right side: The difference between R1-R5, R1-R6 and R1-R7 bone widths was statistically significant ($p<0.01$). No significant difference was found in other region comparisons ($p>0.05$) (Table 3).

Left side: The difference between R1-R6 and R1-R7 bone widths was statistically significant ($p<0.01$). No significant difference was found when comparing other regions ($p>0.05$) (Table 3).

Horizontal measurements at 3 mm depth: There was a statistically significant difference in the mean horizontal measurements on the left side compared to the right side in the R1 and R6 ($p=0.001$; $p<0.01$). In other regions, the changes in the horizontal measurements on the left side compared to the right side were not statistically significant ($p>0.05$) (Table 3).

Right side: The difference between R1-R5, R1-R6 and R1-R7 bone widths was statistically significant ($p<0.01$). No significant difference was found when comparing other regions ($p>0.05$) (Table 3).

Left side: The difference between R1-R6 and R1-R7 bone widths was statistically significant ($p=0.001$; $p<0.01$). No significant difference was found when comparing other regions ($p>0.05$) (Table 3).

Horizontal measurements at 5 mm depth: There was a statistically significant difference in the mean horizontal measurements on the left side compared to the right side in the R1 ($p=0.005$; $p<0.01$). In other regions, the changes in the horizontal measurements on the left side compared to the right side were not statistically significant ($p>0.05$) (Table 3).

Right side: The difference between R1-R7 bone widths was statistically significant ($p=0.004$; $p<0.01$). No significant difference was found when comparing other regions ($p>0.05$) (Table 3).

Left side: The difference between R1-R2 bone widths was statistically significant ($p=0,007$; $p<0.01$). No significant difference was found when comparing other regions ($p>0.05$) (Table 3).

Horizontal measurements at 7 mm depth: No statistically significant difference was found in the horizontal measurements of the left side compared to the right side in the regions ($p>0.05$) (Table 3).

Right side: No statistically significant difference was found between the horizontal measurements in the regions. ($p>0.05$) (Table 3).

Left side: The difference between R1-R2 bone widths was statistically significant ($p=0.020$; $p<0.05$). No significant difference was found in the other region comparisons ($p>0.05$) (Table 3).

Table 3. Comparison of horizontal measurements at 1, 3, 5 and 7 mm depth by party

Horizontal	Right maxilla		Left maxilla		Change	^{a}p
	Mean±SD	Median (IQR)	Mean±SD	Median (IQR)		
1 mm						
R1	3.38±1.36	3.1 (2.3-4)	3.77±1.47	3.4 (2.7-4.4)	-0.39±1.39	0.005**
R2	3.23±1.34	2.9 (2.3-3.8)	3.37±1.21	3.2 (2.6-4)	-0.14±1.12	0.204
R3	3.65±1.22	3.5 (2.7-4.3)	3.75±1.43	3.6 (2.8-4.5)	-0.10±1.19	0.375
R4	3.61±1.34	3.4 (2.9-4.3)	3.83±1.45	3.8 (2.8-4.8)	-0.21±1.26	0.086
R5	3.88±1.51	3.7 (2.8-4.9)	4.29±1.38	4 (3.4-5.1)	-0.42±1.48	0.005
R6	4.76±2.10	4.4 (3.3-6)	4.95±1.84	5 (4-6.1)	-0.19±2.22	0.380
R7	5.42±2.29	5.2 (4-6.8)	5.41±2.26	5.2 (4.2-6.4)	0.01±2.24	0.975
p	^{b}0.001**		^{b}0.001**			
	Mean±SD	p	*Mean±SD*	p		
R1-R2	-0.16±0.98	^{bb}1.000	-0.41±1.20	bb0.258		
R1-R3	0.27±1.22	^{bb}0.419	-0.02±1.41	^{bb}1.000		
R1-R4	0.23±1.40	^{bb}1.000	0.05±1.64	^{bb}1.000		
R1-R5	0.49±1.65	^{bb}0.037*	0.52±1.67	^{bb}0.081		
R1-R6	1.38±2.07	^{bb}0.001**	1.18±2.17	^{bb}0.001**		
R1-R7	2.04±2.37	^{bb}0.001**	1.64±2.46	^{bb}0.001**		
3 mm						
R1	4.26±1.57	3.9 (3.1-5.1)	4.74±1.54	4.5 (3.8-5.4)	-0.48±1.34	0.001**
R2	4.17±1.50	4 (3.1-5)	4.26±1.51	4 (3.2-5.3)	-0.09±1.09	0.410
R3	4.59±1.48	4.5 (3.4-5.6)	4.62±1.60	4.3 (3.4-5.6)	-0.03±1.27	0.835
R4	4.69±1.62	4.5 (3.6-5.8)	4.89±1.72	4.6 (3.7-6.1)	-0.20±1.34	0.133
R5	5.09±2.04	5 (3.7-6.4)	5.13±2.16	5.1 (4.1-6.4)	-0.04±1.87	0.834
R6	5.43±3.34	5.6 (4.1-7.6)	6.56±2.73	6.9 (5.6-8)	-1.13±3.24	0.001**
R7	6.64±3.48	7.3 (4.8-8.8)	6.83±3.21	7.6 (5.6-8.7)	-0.19±3.85	0.611
p	0.001**		0.001**			
	Mean±SD	**p**	**Mean±SD**	**p**		
R1-R2	-0.09±1.18	^{bb}1.000	-0.48±1.12	^{bb}0.140		
R1-R3	0.33±1.35	^{bb}1.000	-0.12±1.40	^{bb}1.000		
R1-R4	0.43±1.59	^{bb}1.000	0.15±1.89	^{bb}1.000		
R1-R5	0.83±2.08	^{bb}0.002**	0.39±2.25	^{bb}0.353		
R1-R6	1.17±3.28	^{bb}0.001**	1.83±2.83	^{bb}0.001**		
R1-R7	2.38±3.48	^{bb}0.001**	2.09±3.28	^{bb}0.001**		
5 mm						
R1	5.26±1.77	5.1 (4-6.1)	5.66±1.85	5.4 (4.5-6.8)	-0.40±1.56	0.010*
R2	4.87±1.79	4.6 (3.7-5.8)	4.98±1.85	4.7 (3.6-6.2)	-0.11±1.21	0.353
R3	5.27±1.61	5.2 (4.2-6.4)	5.46±1.77	5.2 (4-6.7)	-0.19±1.32	0.148
R4	5.41±2.02	5.5 (4-7)	5.70±1.93	5.4 (4.5-7)	-0.29±1.77	0.096
R5	5.33±2.90	5.4 (3.8-7.2)	5.47±2.98	5.8 (4-7)	-0.14±2.90	0.615
R6	5.39±4.28	6.6 (0-8.8)	5.40±4.21	7.2 (0-8.4)	-0.01±5.04	0.989
R7	5.72±4.56	7.1 (0-9.3)	6.16±4.43	7.6 (0-9.6)	-0.44±4.98	0.369
p	^{b}0.001**		^{b}0.001**			
	Mean±SD	**p**				
R1-R2	-0.39±1.35	^{bb}1.000	-0.69±1.26	^{bb}0.007**		
R1-R3	0.01±1.59	^{bb}1.000	-0.20±1.62	^{bb}1.000		
R1-R4	0.15±2.02	^{bb}1.000	0.04±1.94	^{bb}1.000		
R1-R5	0.07±2.90	^{bb}1.000	-0.19±3.23	^{bb}1.000		
R1-R6	0.13±4.33	^{bb}0.402	-0.26±4.46	^{bb}0.807		
R1-R7	0.46±4.67	^{bb}0.004**	0.50±4.41	^{bb}0.090		
7 mm						
R1	6.32±2.41	6.3 (4.8-7.6)	7.28±6.71	6.5 (5.3-8.2)	-0.96±6.38	0.127
R2	5.95±2.40	5.8 (4.4-7.2)	6.06±2.24	5.9 (4.6-7.3)	-0.11±1.97	0.566
R3	6.28±1.96	6.2 (4.8-7.6)	6.35±2.30	6.1 (5-7.8)	-0.07±1.48	0.615
R4	6.28±2.59	6.4 (4.9-8)	6.56±2.50	6.7 (5.2-8.1)	-0.28±2.73	0.303
R5	6.19±3.71	6.8 (4.6-8.6)	5.95±3.90	6.8 (3.9-8.4)	0.24±4.15	0.551
R6	4.79±5.00	4.8 (0-9)	4.61±4.87	2.4 (0-9.2)	0.18±5.95	0.757
R7	4.74±5.00	2.8 (0-9.2)	4.86±4.91	5.4 (0-10)	-0.12±4.59	0.783
p	^{b}0.105		^{b}0.038*			
	Mean±SD	**p**	**Mean±SD**	**p**		
R1-R2	-0.37±1.78	^{bb}1.000	-1.22±6.40	^{bb}0.020*		
R1-R3	-0.04±2.08	^{bb}1.000	-0.93±6.63	^{bb}1.000		
R1-R4	-0.04±3.00	^{bb}1.000	-0.72±6.64	^{bb}1.000		
R1-R5	-0.13±3.88	^{bb}1.000	-1.33±8.11	^{bb}1.000		
R1-R6	-1.53±5.15	^{bb}1.000	-2.67±8.53	^{bb}1.000		
R1-R7	-1.59±5.48	^{bb}1.000	-2.42±8.61	^{bb}1.000		

SD: Standart deviation, ^{a}: Paired samples-t test, ^{b}: Repeated mesaures test, ^{bb}:Dunn-Bonferroni test, *p<0.05, **p<0.01

Evaluation by Gender

The mean horizontal measurements of males at 3 mm depth were statistically significantly higher than those of females ($p=0.006$; $p<0.01$). The mean horizontal measurements of males at 7 mm depth were statistically significantly higher than those of females ($p=0.014$; $p<0.05$). Other horizontal and vertical measurements did not show statistically significant differences between the genders ($p>0.05$) (Table 4).

Evaluation by Age

There was a negative and weakly statistically significant correlation between patient age and mean vertical measurements ($r=-0.300$; $p=0.002$; $p<0.01$). There was no statistically significant correlation between patient age and mean horizontal measurements at 1, 3, 5 and 7 mm depth ($p>0.05$) (Table 5).

Table 4. Comparison of vertical and horizontal measures in regions by gender

		Male (n=42)	Female (n=62)	ᵃp
Vertical	Mean±SD	11.82±2.79	11.94±3.04	0.850
	Median (min-max)	12.3 (6.2-16.3)	11.6 (4.4-22.8)	
Horizontal 1 mm	Mean±SD	4.44±1.18	4.22±2.89	0.647
	Median (min-max)	4.4 (2.7-7.6)	3.8 (1.9-25.5)	
Horizontal 3 mm	Mean±SD	5.60±1.61	4.82±1.22	0.006*
	Median (min-max)	5.7 (2.8-9)	4.7 (2.4-8)	
Horizontal 5 mm	Mean±SD	5.83±2.03	5.16±1.48	0.055
	Median (min-max)	6.1 (2-10)	5.2 (2.1-8.6)	
Horizontal 7 mm	Mean±SD	6.45±2.18	5.48±1.77	0.014**
	Median (min-max)	7 (2.7-10.8)	5.7 (0.4-9)	

ᵃ:Sudent-t test, SD: Standart deviation, Min: Minimum, Max: Maximum, *: $p<0.05$, **: $p<0.01$

Table 5. Relationship between vertical and horizontal measurements in regions by age

	Age	
	r	p
Vertical	-0.300	0.002*
Horizontal 1 mm	-0.025	0.800
Horizontal 3 mm	-0.088	0.374
Horizontal 5 mm	-0.032	0.748
Horizontal 7 mm	0.041	0.678

r: Pearson correlation test, *: $p<0.05$

DISCUSSION

In this study, the residual alveolar bone heights and widths of patients with complete maxillary edentulism were evaluated in 7 different tooth regions from anterior to posterior, from the central tooth region to the second molar tooth region. It was found that the bone height in the central tooth region was greater than that in the 2nd premolar, 1st molar and 2nd molar tooth regions. Farina et al.[18] determined the vertical bone resorption in the posterior aspect of the edentulous maxilla and found that the bone height was lower in the 2nd premolar, 1st molar and 2nd molar regions, similar to our study. Lekovic et al.,[19] Camargo et al.,[20] Pelegrine et al.[21] reported that vertical bone resorption after extraction varied between 11-22%. Similarly, Iasella et al.,[22] Barone et al.[23] and Aimetti et al.[10] showed that vertical bone resorption was greater in the buccal aspect of the socket at an average of 6 months after extraction. D'Souza,[16] Cawood and Howell[24] reported that alveolar bone resorption occurring one year after extraction was greater in the horizontal than in the vertical direction. These studies show that alveolar bone resorption continues actively during the first year after extraction. Studies have shown that bone resorption is faster and more extensive in the horizontal direction than in the vertical direction. When the results of the present study were evaluated in terms of the minimum bone height and width required for implant surgery, it was observed that horizontal bone resorption was higher than vertical resorption and, as a result, horizontal insufficiency was higher. In addition to physiologic bone resorption after extraction, this may have occurred as a result of traumatic or complicated tooth extraction in the patients included in the study. When the right and left sides were compared in this study, the regions with differences were the lateral region in terms of bone height, the central region at 1, 3 and 5 mm, and the first molar region at 3 mm in terms of bone width. Bone height and width were greater on the left side in these regions. In the study by Katsoulis et al.,[17] it was shown that there was no difference between the right and left side in terms of bone width measurements in different regions of the edentulous maxilla.[17] In the study by Katsoulis et al.,[17] measurements were taken at 3 and 8 mm, whereas in this study measurements were taken at 1, 3, 5 and 7 mm, and we believe that this is the reason for the difference. In addition, Katsoulis et al.[17] found that there was no difference in bone width between the genders in their study, whereas this study found that bone width was greater in males at 3 and 7 mm depth. The difference between sides in this study suggests that patients generally use their right side in these regions and resorption is more common. In addition, the right-sided teeth in these regions may have been lost earlier or tooth extractions in these regions may have been traumatic. Among the possible reasons, the possibility that patients use one side more when chewing suggests the negative effect of unilateral chewing on alveolar bone resorption as well as temporomandibular joint disorders. In addition, we think that the fact that people use their right side more when chewing may also be related to being right-handed and is a topic that needs to be investigated.

Ulm et al.[25] found that bone height in the edentulous posterior maxilla ranged from 3.23 to 9.3 mm. In this study, the mean bone height in the edentulous posterior maxilla between the 1st premolar and 2nd molar ranged from 7.05-13.73 mm. In contrast to the study by Ulm et al.,[25] the bone height in this study was higher. We believe that the reason for this difference is that the patients in this study had less resorption in the vertical direction and the mean age of the patients in this study was lower. There was also a negative relationship between age and bone height was found in this study. The fact that the mean age was higher and the bone heights were lower in the Ulm et al.'s[25] study compared to this study supports the negative relationship between age and bone height.

Padhye and Bhatavadekar[26] evaluated bone width in the edentulous posterior maxilla and reported that the incidence of bone width less than 6 mm was 55.03%. de Souza Nunes et al.[27] found this rate to be 16.3%. Both studies stated that horizontal bone augmentation is required for alveolar ridges less than 6 mm, taking into account 1-2 mm of healthy bone around dental implants. In contrast to these studies, when the average widths from the 1st to the 7th region at a depth of 1 mm are evaluated in this study, they vary between 3.23-5.42 mm and the average widths are 100% below 6 mm. This indicates that horizontal resorption was particularly severe in the patients included in the study and that the patients required a high rate of horizontal bone augmentation. Padhye and Bhatavadekar[26] found that bone widths in the edentulous maxillary premolar and molar regions were similar. In support of Padhye and Bhatavadekar's findings, this study found no difference between the bone widths of the edentulous premolar and molar regions. Pramstraller et al.[28] showed that the mean bone widths of edentulous sites at 1 mm depth were 4.9 mm for the 1st premolar, 4.8 mm for the 2nd premolar, 5.7 for the 1st molar and 6.6 mm for the 2nd molar. In this study, these widths were 3.61, 3.88, 4.76 and 5.41, respectively, and were found to be lower than in the study by Pramstraller et al.[28] Although the mean age in this study (50.88±10.28) was similar to that of Pramstraller et al.[28] (55.2±10.1), we believe that the main reason for the lower bone widths was early tooth loss and increased duration of edentulism. Systemic deficiencies of which the patients were unaware, duration of complete edentulism, traumatic or complicated tooth extractions, dietary and chewing habits that may affect resorption, occlusion and bite conditions, and the use of removable dentures may have influenced the results. In addition, the mesiodistal widths of the teeth used as reference in the study may not be appropriate for each patient. The points determined for the patients' teeth may have deviated from their original positions. These were the limitations of the study.

CONCLUSION

This study was the first to compare residual bone height and width at 1, 3, 5 and 7 mm depth from the central region to the second molar region in individuals with complete maxillary edentulism. It was found that the regions with the least bone width were the central and lateral regions and the region with the least bone height was the first molar region. It was observed that the bone height was higher on the left side in the lateral region and the bone width at the 1st, 3rd and 5th mm in the central region was higher on the left side. These results showed that the loss of horizontal bone width as a result of ACR in edentulous patients was advanced and the need for horizontal augmentation was very high in this group of patients considered for dental implant surgery. We recommend that atraumatic extraction and socket protection methods, which are among the main factors causing this situation, should be popularised and that clinicians should be made aware of this issue.

ETHICAL DECLARATIONS

Ethical Committee Approval

The study was approved by the Non-interventional Ethics Committee of Van Yüzüncü Yıl University (Date: 17.03.2023, Decision No: 2023/03-09).

Informed Consent

Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process

Externally peer-reviewed.

Conflicts of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, conduct and analysis of the work, and that they have approved the final version.

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