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Bone Resorption Evaluation According to Measurements' Panoramic Radiographs: A Tunisian Cross-Sectional Study

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Abstract

Panoramic radiographs are the first and most efficient method, used to examine and evaluate the heights of residual alveolar ridges of edentulous patients. After tooth extraction, wound healing of the extraction socket is associated with modeling processes leading to dimensional alterations of the residual ridge. Besides, alterations in the size and shape of the jawbones have been observed to occur throughout adult life and it continues further. Most of the bone loss occurs in the early stage of the atrophic process. The rate and the amount of bone loss may be influenced by various factors such as gender, hormones, metabolism, and parafunction. This study aimed to determine and compare differences in the vertical measurements of jawbones in both edentulous and dentate subjects. The study sample included the diagnostic panoramic radiographs of 53 randomly selected edentulous and dentate patients without systemic diseases affecting bone.
-The radiographic selection criteria included the absence of obvious facial asymmetry, clearly visible anatomic structure, neither surgical nor fracture history.
-The sample was divided into 3 groups:
Groupe1: 29 edentulous patients
Groupe2: 14 edentulous upper maxilla patients
Groupe 3: 10 mandibular edentulous patients
The height of the residual bone was measured at 18 predetermined sites. ***Results:*** The differences between elderly men and women in percentages of reductions in heights of the maxilla were not significant. The reduction of the anterior ridge height was greater in the maxilla than in the mandible for both sexes. Moreover, we found a significant correlation between age and bone height in both genders. ***Conclusion:*** The outcomes in the present study would contribute to better understanding of RRR in dentate and edentulous subjects.

Keywords: edentulism, panoramic radiography, resorption, residual ridge, dentate, bone height.

I-INTRODUCTION

Residual ridge is one of the most crucial factors affecting removable denture stability, retention, masticatory function, and planning implant insertion areas.

The non-compensated loss of teeth causes resorption and atrophy of the surrounding alveolar bone by the lack of physiologic stimulation.

This is how human bone inevitably decreases in quantity and quality with aging. The rate and amount of bone loss may be influenced by gender, age, hormones, metabolism, parafunction and it can be evaluated clinically by the mean of radiographic examination particularly panoramic radiography which is used in large institutional practices as the sole method of screening edentulous and dentate patients [1].

Guler and al defined it; as a curved plane tomographic radiographic technique used to depict the body of the mandible, maxilla, and the lower half of the maxillary sinuses on a single image and it is the first and most efficient method, used to examine and evaluate the heights of residual alveolar ridges of edentulous patients [2].

However, in the literature, few are those who exposed and evaluated these ridge resorption etiologies.

By conducting this study, both dentate and edentulous subjects were evaluated and compared for residual ridge resorption (RRR) of jawbones only by panoramic radiography, and our aims were to:

- Determine and compare the vertical height of the jawbones in elderly dentate and edentulous study subjects (intergroup comparison)
- Assess the variations of the vertical height measurements in the maxilla and mandible in both study groups (intragroup comparison)
- Evaluate the differences in vertical measurements in study subjects when compared to age and gender.

II-MATERIALS AND METHODS

The study was led in the Department of Complete Removable Denture of the Dental Clinic of Monastir, Tunisia for a period of seven months. This sectional cross survey included a total of 53 patients divided into 3groups. Patient's inclusion Criteria were as follow:

- Patient with no history of systemic diseases impacting on bone metabolism.
- Edentulous, maxillary dentate and mandibular dentate patients.

All the edentulous and dentate subjects had complete oral and medical examination records to ensure that they are free from any disease affecting bone.

Patients with severe attrition of the incisal and occlusal surface of the teeth, gross facial asymmetry, fractures, and severe periodontal disease, were excluded from the study.

The Criteria for selecting the radiographs were as follow:

- Only clear radiographs with high quality
- Radiographs with distinct images of anatomical landmarks such as most inferior points of both infraorbital margins of zygomatic processes, and the infraorbital foramen visible at least on one side;
- Radiographs with clear images of the inferior and posterior borders of the mandible.

Each radiograph was viewed on a standard lightbox. One investigator was responsible for selecting the panoramic radiographs and performing the measurements manually, marking all the points and lines with a pencil.

Linear vertical measurements for jawbones were done at 10 sites on each radiograph, five in each jaw as midline, at the distal surface of the first premolar, and at the distal surface of the first molar on both sides; for each group.

Vertical measurements for the elderly dentate subjects

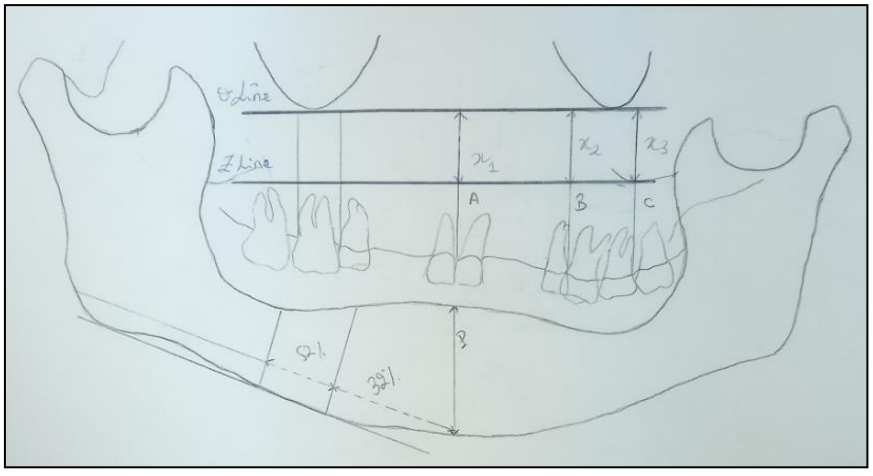

Fig-1: Measurements sites and reference lines on the jaw bones in edentulous subjects

At first, the inferior most points of infraorbital ridges and inferior margins of the zygomatic processes of the maxilla were marked on both the right and left side (Figures).

O line: a first reference line drawn to join the inferior points on the infraorbital ridges.

Z line: a line joining the inferior margins of the zygomatic processes of the maxilla as shown in Figures 1and 2.

X: corresponding to the vertical distance between O line and Z line measured at midline.

X 1, X 2,X 3: distances between O line and Z line measured at the distal surface of the first premolar and at the distal surface of the first molar.

The "X" distance at various locations was taken to develop the maxillary ratio.

A: vertical distance from the O line to the alveolar crest at 1.2 mm from the cementoenamel junction measured at midline.

B: vertical distance from the O line to the alveolar crest at 1.2 mm from the cementoenamel junction measured at the distal surface of the first premolar.

C: vertical distance from the O line to the alveolar crest at 1.2 mm from the cementoenamel junction measured at the distal surface of the first molar, as shown in Figure 1.

For mandible, a line was drawn tangential to the most inferior points of the lower border of the mandibular body. The vertical lines were drawn at measurement sites along the tangent, and the vertical distances from the alveolar crest at 1.2 mm from the cementoenamel junction to the lower border of the mandible were measured at midline (P), at the distal surface of the first premolar (Q) and at the distal surface of the first molar (R) as shown in Figure 1.

Another line was drawn parallel to the tangent at 10 mm above the lower border of the mandible. The horizontal lengths up to the distal surface of first premolars and first molars from the midline were measured along this line in the dentate mandible as shown in Figure 1, and these proportions were taken as a guide drawing the vertical lines in the edentulous mandible corresponding to the locations of first premolar and first molar.

According to the estimates from the dentate subjects, the first premolar and the first molar were located at proportions of 32% and 52% respectively, of the total length of the mandibular body from the midline.

The Formula for calculation of locations of first premolar and first molar =

(Length up to distal surface of lower first premolar /molar from midline) × 100. Length of mandibular body from the midline to the posterior border of the ramus **[3].**

Vertical measurements for the edentulous subjects

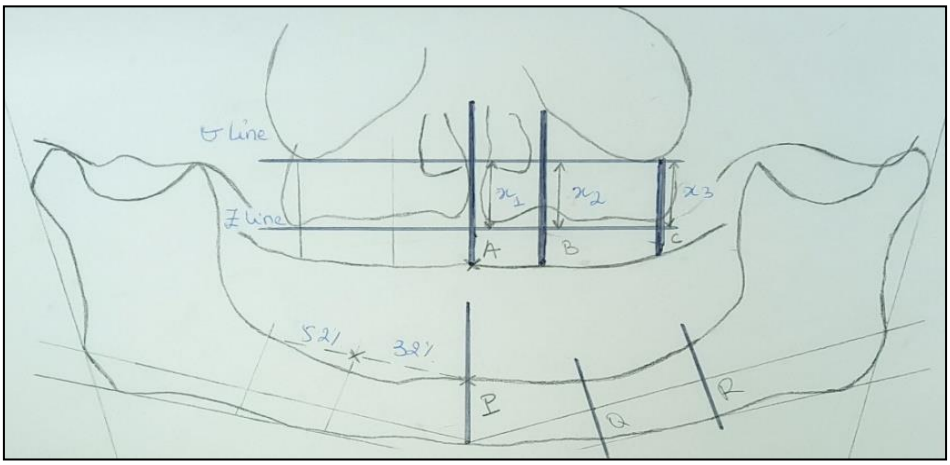

Fig-2: Measurements sites and reference lines on the jaw bones in edentulous subjects.

For maxilla as similar to that in dentate subjects, the O line and Z line were drawn and the measurements were done. To determine the measurement sites in the edentulous maxilla, the vertical line was drawn through the mesial margin of the infraorbital foramen from the O line to the alveolar crest and another vertical line was drawn through the inferior margin of the zygomatic process of the maxilla from the O line to the alveolar crest as shown in Figure 2.

The infraorbital vertical line and zygomatic vertical line were approximate to the locations of maxillary first premolar and the maxillary first molar, respectively.

The midline was determined by taking images of the anterior nasal spine, nasal septum, and the nasopalatine foramen as a guide.

A: vertical distances from O line to the crest of jawbone were measured at midline,
B: at the distal surface of the first premolar,
C: at the distal surface of the first molar.

For mandible, the vertical measurements were done as similar to that in dentate mandibles (Figure2). As derived from the dentate mandible, the horizontal locations of first premolars and first molars were determined at a proportion of 32% and 52%, respectively (Figure 2). The midline was determined by taking images of genial tubercles and lingual foramen as a guide.

P: The vertical distances from the crest of jaw bone to the lower border of the mandible were measured at midline,
Q: at the distal surface of the first premolar,
R: at the distal surface of the first molar as shown in Figure2

III-STATISTICAL ANALYSIS AND RESULTS

- Statistics were obtained by processing informations with the statistical package SPSS.
- The test used to investigate differences between groups was the Chi-square test performed by a statistician.
- Means (M), Standard deviation (SD), Odds ratios (ORS), 95%confidence intervals (CIs), and p values were estimated.
- p values< 0.05 were considered statistically significant and analyses were performed using the Japanese edition of SPSS20.0.

A-Descriptive results
Study Population

The Population consisted of fifty-three patients, 49% were males. The average age of our sample was under 65 years, which is about 40% of the study subjects. The percentage of edentulous patients is about 55%.

Fig-3: Patients distribution according to edentulism

The results of the detailed measurements according to the parameters, were summarized in tables (1,2,3,4,5,6).

***Maxilla:**

Table-1: Means (mm) of radiologic vertical heights in mandibular dentate, maxillary dentate and edentulous subjects according to the different measurement maxillary sites and gender

Gender		Sites measurements																	
		X1			X2			X3			A			B			C		
		G1	G2	G3	G1	G2	G3	G1	G2	G3	G1	G2	G3	G1	G2	G3	G1	G2	3
Male	*N*	*13*	*8*	*5*	*13*	*8*	*5*	*13*	*8*	*5*	*13*	*8*	*5*	*13*	*8*	*5*	*13*	*8*	*5*
	Mean	*2,9*	*2,98*	*3,26*	*2,85*	*3*	*3,26*	*2,89*	*3,02*	*3,2*	*3,95*	*4,11*	*3,56*	*3,88*	*4,02*	*3,92*	*3,81*	*3,95*	*4,02*
	Standard deviation	*,63*	*0,40*	*0,20*	*0,61*	*0,42*	*0,30*	*0,63*	*0,39*	*0,23*	*0,90*	*0,45*	*0,48*	*0,71*	*0,35*	*0,58*	*0,69*	*0,50*	*0,33*
	Minimum	*1,7*	*2,4*	*3*	*1,7*	*2,5*	*2,9*	*1,6*	*2,6*	*2,9*	*2,1*	*3,6*	*3*	*2,5*	*3,6*	*3,1*	*2*	*3,5*	*3,5*
	Maximum	*3,8*	*3,7*	*3,4*	*3,7*	*3,7*	*3,6*	*3,6*	*3,7*	*3,4*	*4,8*	*4,8*	*4,1*	*4,9*	*4,5*	*4,5*	*4,6*	*4,9*	*4,3*
Female	*N*	*16*	*6*	*5*	*16*	*6*	*5*	*16*	*6*	*5*	*16*	*6*	*5*	*16*	*6*	*5*	*16*	*6*	*5*
	Mean	*2,34*	*2,67*	*3,02*	*2,36*	*2,68*	*2,98*	*2,41*	*2,67*	*3*	*3,3*	*3,8*	*3,34*	*3,28*	*3,77*	*3,66*	*3,11*	*3,6*	*3,78*
	Standard deviation	*0,74*	*0,25*	*0,15*	*0,72*	*0,23*	*0,26*	*0,74*	*0,23*	*0,25*	*0,86*	*0,49*	*0,46*	*0,82*	*0,39*	*0,49*	*0,71*	*0,34*	*0,35*
	Minimum	*1,2*	*2,3*	*2,8*	*1,2*	*2,4*	*2,7*	*1,1*	*2,4*	*2,7*	*1,9*	*3,4*	*2,9*	*2*	*3,4*	*3*	*1,7*	*3,3*	*3,2*
	Maximum	*3,6*	*2,9*	*3,2*	*3,5*	*2,9*	*3,3*	*3,4*	*3*	*3,3*	*4,5*	*4,5*	*4*	*4,3*	*4,3*	*4,2*	*4,2*	*4,2*	*4,1*
Total	*N*	*29*	*14*	*10*	*29*	*14*	*10*	*29*	*14*	*10*	*29*	*14*	*10*	*29*	*14*	*10*	*29*	*14*	*10*
	Mean	*2,59*	*2,84*	*3,14*	*2,58*	*2,86*	*3,12*	*2,62*	*2,86*	*3,1*	*3,59*	*3,98*	*3,45*	*3,55*	*3,91*	*3,79*	*3,43*	*3,8*	*3,9*
	Standard deviation	*0,73*	*0,39*	*0,201*	*0,71*	*0,38*	*0,31*	*0,73*	*0,37*	*0,25*	*0,92*	*0,48*	*0,46*	*0,82*	*0,38*	*0,53*	*0,77*	*0,46*	*0,34*
	Minimum	*1,2*	*2,3*	*2,8*	*1,2*	*2,4*	*2,7*	*1,1*	*2,4*	*2,7*	*1,9*	*3,4*	*2,9*	*2*	*3,4*	*3*	*1,7*	*3,3*	*3,2*
	Maximum	*3,8*	*3,7*	*3,4*	*3,7*	*3,7*	*3,6*	*3,6*	*3,7*	*3,4*	*4,8*	*4,8*	*4,1*	*4,9*	*4,5*	*4,5*	*4,6*	*4,9*	*4,3*

1-For the Edentulous group
2-For the Maxillary Dentate Group
3-For the Mandibular Dentate Group

For males
The measurement X1 value was the highest in the edentulous group
The measurement X2 value was the highest in the edentulous group and the maxillary dentate group
The measurement X3 value was the highest in the mandibular dentate group

***Mandible:**

Table-2: Means (mm) of radiologic vertical mandibular heights in edentulous group, maxillary dentate and mandibular dentate group according to gender

Gender		Sites measurements								
		P			Q			R		
		G1	G2	G3	G1	G2	G3	G1	G2	G3
Male	*N*	*13*	*8*	*5*	*13*	*8*	*5*	*13*	*8*	*5*
	Mean	*3,24*	*3,21*	*3,44*	*3,47*	*3,21*	*3,68*	*2,98*	*2,92*	*2,98*
	Standard Deviation	*0,42*	*0,41*	*0,30*	*0,59*	*0,65*	*0,28*	*0,70*	*0,58*	*0,16*
	Minimum	*2,6*	*2,8*	*3,1*	*2,6*	*2,2*	*3,2*	*1,9*	*2,1*	*2,8*
	Maximum	*3,8*	*4,1*	*3,8*	*4,5*	*4,3*	*3,9*	*4,1*	*3,8*	*3,2*
Female	*N*	*16*	*6*	*5*	*16*	*6*	*5*	*16*	*6*	*5*
	Mean	*2,61*	*2,72*	*3,22*	*2,57*	*2,72*	*3,54*	*2,39*	*2,45*	*2,84*
	Standard Deviation	*0,55*	*0,71*	*0,31*	*0,85*	*0,79*	*0,21*	*0,79*	*0,64*	*0,27*
	Minimum	*1,6*	*2*	*3*	*1,4*	*1,8*	*3,2*	*1,3*	*1,8*	*2,4*
	Maximum	*3,2*	*3,9*	*3,6*	*4*	*4,1*	*3,7*	*4,1*	*3,6*	*3*
Total	*N*	*29*	*14*	*10*	*29*	*14*	*10*	*29*	*14*	*10*
	Mean	*2,9*	*3*	*3,33*	*2,97*	*3*	*3,61*	*2,65*	*2,72*	*2,91*
	Standard Deviation	*0,58*	*0,60*	*0,31*	*0,86*	*0,73*	*0,24*	*0,8*	*0,63*	*0,29*
	Minimum	*1,6*	*2*	*3*	*1,4*	*1,8*	*3,2*	*1,3*	*1,8*	*2,4*
	Maximum	*3,8*	*4,1*	*3,8*	*4,5*	*4,3*	*3,9*	*4,1*	*3,8*	*3,2*

For males
- The measurement **P** value was the highest in the maxillary dentate group.
- The measurement **Q** and **R** values were the highest in the edentulous group.

For females
The measurement **P** and **Q** values were the highest in the maxillary dentate group.

The measurement A value was the highest in the maxillary dentate group and edentulous group.
The measurement B value was the highest in the edentulous group.
The measurement **C** value was the highest in the maxillary dentate group.

For females
All the measurement values were the highest in the edentulous group.

The measurement **R** value was the highest in the edentulous group.

*For Age: In the present study, we chose to estimate the height of the anterior region in both maxilla and mandible (Measurement site A and P) in two groups according to age(subjects younger and older than 65 years) to possibly find a significant difference not relative to gender but age, as it is shown in Table3.

Table-3: Means (mm) of radiologic vertical heights in subjects older and young than 65 years in maxillary and mandibular anterior region

Gender		Sites measurements			
		P		A	
		Ga	Gb	Ga	Gb
Male	*N*	*11*	*15*	*10*	*15*
	Mean	*3,31*	*3,25*	*2,74*	*3,72*
	Standard Deviation	*0,36*	*0,43*	*0,77*	*0,80*
	Minimum	*2,9*	*2,6*	*1,6*	*2,1*
	Maximum	*4,1*	*3,8*	*3,9*	*4,8*
Female	*N*	*10*	*17*	*10*	*17*
	Mean	*2,74*	*2,75*	*3,59*	*3,39*

	Standard Deviation	*0,77*	*0,47*	*0,73*	*0,75*
	Minimum	*1,6*	*1,8*	*2,1*	*1,9*
	Maximum	*3,9*	*3,5*	*4,5*	*4,5*
Total	*N*	*21*	*32*	*21*	*32*
	Mean	*3,04*	*2,99*	*3,88*	*3,54*
	Standard Deviation	*0,64*	*0,60*	*0,70*	*0,80*
	Minimum	*1,6*	*1,8*	*2,1*	*1,9*
	Maximum	*4,1*	*3,8*	*4,8*	*4,8*

younger than 65 years
older than 65 years

For the measurement site **P**: the residual ridge resorption was higher for subjects younger than 65 years for males and females.

For the measurement site **A**: the residual ridge resorption was higher for subjects older than 65 years for males and subjects younger than 65 years for females.

B-Analytic Results

Comparison between Males and Females

Table-4: Comparison of means (mm) of radiologic vertical heights of maxillary measurements in edentulous, maxillary dentate and mandibular dentate subjects.

Site measurements		Dof			Sum of squares			p value		
		G1	G2	G3	G1	G2	G3	G1	G2	G3
X1	*Intergroup*	*1*	*0,33*	*1*	*2,16*	*0,33*	*0,14*	*0,04*	*0,15*	*0,05*
	Total	*28*	*1,97*	*9*	*15,15*	*1,97*	*0,38*			
X2	*Intergroup*	*1*	*1*	*1*	*1,68*	*0,34*	*0,20*	*0,066*	*0,12*	*0,16*
	Total	*28*	*13*	*9*	*14,05*	*1,85*	*0,83*			
X3	*Intergroup*	*1*	*1*	*1*	*1,64*	*0,41*	*0,1*	*0,077*	*0,08*	*0,23*
	Total	*28*	*13*	*9*	*14,77*	*1,79*	*0,58*			
A	*Intergroup*	*1*	*1*	*0,12*	*3,07*	*0,33*	*1*	*0,05*	*0,24*	*0,48*
	Total	*28*	*13*	*1,88*	*23,78*	*2,98*	*9*			
B	*Intergroup*	*1*	*1*	*1*	*2,61*	*0,23*	*0,17*	*0,05*	*0,22*	*0,47*
	Total	*28*	*12*	*9*	*18,71*	*1,63*	*2,49*			
C	*Intergroup*	*1*	*1*	*1*	*3,54*	*0,42*	*0,14*	*0,012*	*0,17*	*0,30*
	Total	*28*	*13*	*9*	*16,79*	*2,76*	*1,06*			

1-For The Edentulous group

2-For The Maxillary Dentate Group

3-For The Mandibular Dentate Group

For the measurements sites **X1, A, B, C**, there were significant correlation between gender and resorption **(p<0.05),** in the edentulous study groups.

However, there was not statistically significant difference between men and women in the distances X2 **(p=0.66)** and X3 **(p=0.77).**

No significant differences were observed between males and females, in the maxillary dentate group in all the measurements sites **(p>0.05).**

Comparison between males and females

Table-5: Comparison of means (mm) of radiologic vertical heights of mandibular measurements in edentulous, maxillary dentate and mandibular dentate subjects.

Site measurements		Dof			Sum of squares			p value		
		G1	G2	G3	G1	G2	G3	G1	G2	G3
P	*Intergroup*	*1*	*1*	*1*	*2,95*	*0,843*	*0,121*	*0,002*	*0,12*	*0,28*
	Total	*28*	*13*	*9*	*9,58*	*4,54*	*0,84*			
Q	*Intergroup*	*1*	*1*	*1*	*5,75*	*0,84*	*0,05*	*0,003*	*0,221*	*0,393*
	Totals	*28*	*13*	*9*	*20,64*	*6,9*	*0,53*			
R	*Intergroup*	*1*	*1*	*1*	*2,56*	*0,78*	*0,05*	*0,042*	*0,084*	*0,34*
	Total	*28*	*13*	*9*	*17,71*	*5,21*	*0,43*			

There was a statistically significant correlation between gender and RRR for all the study groups.

Table-6: Comparison of means (mm) of radiologic vertical heights of the maxillary and mandibular anterior region in subjects older and younger than 65 years.

ANOVA[a]						
		Sum of squares	**dof**	**Mean square**	**F**	**Sig.**
P	*Intergroup*	*1,69*	*1*	*1,696*	*4,90*	*,039*
	Total	*8,27*	*20*			
A	*Intergroup*	*1,46*	*1*	*1,461*	*3,42*	*,080*
	Total	*9,57*	*20*			
P	*Intergroup*	*1,99*	*1*	*1,995*	*9,91*	*,004*
	Total	*8,03*	*31*			
A	*Intergroup*	*1,75*	*1*	*1,753*	*2,93*	*,097*
	Total	*19,69*	*31*			

There was a significant correlation between vertical height of the anterior maxillary region and age.

IV-DISCUSSION

Bone resorption was analyzed in our study relating to many factors:

1-Gender: Male versus Female

The differences between elderly men and women in percentages of reductions in heights of the maxilla were not, significant.

In agreement with our results, previous studies published Arati. S and Al [3], K.BALTO and al [4], SOIKKONEN and al [15] and Qiufei X and al [15] reported that mandibular alveolar atrophy was more severe in woman than men.

Besides, A.U Güler and al [6] found, in a study focused on 'the evaluation of vertical heights of maxillary mandibular bones and the location of anatomic landmarks in panoramic radiographs of edentulous patients for implant dentistry', that there were statistically significant differences between edentulous men and edentulous women for the vertical distances from the upper border of the mandibular canal to the alveolar crest in the first molar area.

It was also demonstrated, in a study published by Jeon-ki J and al [11] that the influence of edentulism on the gonial angle was more pronounced in women than men.

Al-Jabrah and Al-Shumailan 2014 [2], Liang *et al*., 2014 [13] reported greater bone resorption in women than men. Vaishnav and al 2010 [19] also reported resorption of the wall of the mandibular canal that was more in edentulous women than men due to hormonal reasons.

All these findings may be mainly related to hormonal influences such as postmenopausal depletion of estrogens or secondary or primary hyperparathyroidism and resulting in calcium metabolism, but also to the fact that men have greater masticatory forces and cortical bone thickness than women [11].

However, this difference between the genders may lie in different bone quantities between the mandible and maxilla, the trabecular bone is more often looser in the maxilla than in the mandible.

2-Resorption sites: Anterior region in the maxilla Vs in the mandible

- The reduction of the anterior ridge height was greater in the maxilla than in the mandible for both sexes.
- These findings are similar to the previous studies published by Q. XIE and al 1997[15], Guler .AU2005 [6] and Ulm C 1992[18].
- It could be explained by several factors such as the inner aspect of the anterior area of the mandible which provides attachment for the genial muscles. These attachments, because of the functional forces of the genial muscles, probably protect this area from extreme alveolar bone loss and reduction in vertical height, on the other hand, the lower position of the reversal line in the posterior region leads to rapid ridge resorption in the posterior region.

3-Age

In our study, we found a significant correlation between age and bone height in both genders.

- In a study published by Imirzalioglu and al 2012 [8], Residual ridge resorption was observed less frequently in patients <49 years of age than in patients 50–69 and >70 years of age ($p < 0.001$).
- Moreover, Al AlSheikh and al 2019 [1] proved that as age increased, the mandibular bone height significantly decreased. This finding was expected as was reported by previous studies [15, 2, 7, 9, 10].
- Findings of our study were supported by previous studies which reported that the duration of edentulism had the most significant impact on resorption followed by age and then gender [2,10]
- Gerken and al 2020 performed a correlation analysis revealing a weak but yet significant (p values < 0.0001 for all classes) positive correlation of Class value (I–IV) and age for all regions [5]

V-CONCLUSION

The outcomes in the present study would contribute to better understanding of RRR in dentate and edentulous subjects and other possible factors associated with residual ridge resorption will be analysed in continuing studies.

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