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ORIGINAL RESEARCH ARTICLE

Radiographic Examination of Alveolar Ridge Resorption Concerning Age in Kennedy Class II Edentulism

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Abstract

Purpose: After the loss of teeth, the alveolar bone begins to resorb due to the disappearance of the stimulus being applied by the teeth to the alveolar bone. This situation is termed residual ridge resorption. This study aims to determine the amount of alveolar bone resorption that occurred in the maxilla and mandible of patients having Kennedy Class II edentulousness and the distribution of it according to age groups.
Materials and Methods: The study was carried out on the panoramic radiographs of 122 individuals (60 mandibles, 62 maxilla). Vertical measurements were made at 10 sites (central incisors, first premolars, and molars at the left and right of both jaws). The difference in the measurements according to the group and demographic variables was analyzed with the independent groups independent-t and one-way ANOVA tests. Also, dentate and edentulous measurements according to the group and demographic characteristics in the group interaction were analyzed with the repeated ANOVA test.
Results: When the edentulous regions were considered, the vertical height values of the mandible were lower than the maxilla. Also, a statistically significant difference was detected in the maxillary premolar region of the edentulous regions. According to gender, women's vertical height results were found to be lower than men and the vertical heights of the 6-12 months group were higher than the 12-24 months group.
Conclusions: According to these results, we think that the patient should be directed to implant rehabilitation to prevent bone loss, especially in edentulous patients in the maxillary premolar region.

Keywords: Alveolar Bone Loss; Alveolar Resorption; Anatomy; Panoramic Radiography

Introduction

There is a relationship between tooth eruption and the development of alveolar structures. The subsequent development and eruption of deciduous and permanent dentition have a stimulating effect on the growth and development of alveolar structures. The part of the alveolar bone that supports the teeth is called the "alveolar ridge," and apart from various pathological conditions such as periodontitis and osteoporosis, the alveolar crest continues to exist as long as teeth are present. After the loss of teeth, the alveolar bone begins to resorb due to the disappearance of the stimulus applied by the teeth to the alveolar bone. This resorption is very rapid in the first year, with the fastest phase occurring in the first 3 months. This chronic, progressive, irreversible, and cumulative phenomenon is termed "residual ridge resorption (RRR)" and continues for life.[1–5]

RRR is a multifactorial process. These factors include anatomical (amount and quality of the bone), metabolic (physiological capacity of the bone), functional (forces on the bone), prosthetic (duration of prosthesis use, number of prostheses used, quality of prostheses), and systemic factors (advanced age, gender, diseases such as hyperparathyroidism, thyroid dysfunction, asthma, osteoporosis, diabetes).[6–9] According to various studies, the average annual rate of vertical resorption in the anterior maxilla has been determined to be approximately 0.1 mm (ranging from 0 to 0.7 mm), varying both among individuals and within the same individual at different times.[1,10,11] This rate of resorption is influenced by anatomical, biological, psychosocial, metabolic, functional, and prosthetic factors.[10,12] Cawood and Howell[13] propose that alveolar ridge resorption follows a predictable pattern, beginning with horizontal bone loss and subsequently progressing to vertical re-

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sorption. They further suggest that bone resorption occurs in the alveolar process of the jaw rather than in the palatine process.[10]

Panoramic radiographs, which are frequently used, especially for initial imaging, allow many morphometric measurements that assess the quality and quantity of bone.[14–18] This imaging technique is available for the evaluation of RRR and has been used by several investigators. Wical and Swoope[19] developed a method for the evaluation of RRR using panoramic radiography. According to this method, the reference point was the mental foramen, and it naturally included only the mandible. Packota et al.[15] introduced a technique that also evaluates the maxilla. In this technique, Wical and Swoope's method was used for the mandible. Later, Xie et al.[18] developed a technique, which we also used in our study, to make RRR assessment more accurate and sensitive in both the maxilla and mandible. Additionally, in most studies, age group classification was not evaluated, and this situation was stated as a limitation. Therefore, clear information about the effect of age on resorption was not reported in the literature.[8,20,21] We hypothesized that by dividing the age groups specified as limitations in other studies, and by determining which regions have more resorption in which age range, the time intervals important for patient orientation in prosthesis or implant rehabilitation for edentulous areas can be determined. For this reason, we investigated the amount of alveolar bone resorption seen in the maxilla and mandible and its distribution according to age groups in patients who were determined to be Kennedy Class II on panoramic radiographs.

Material and Methods

Participants

This clinical study was retrospectively conducted on 122 patients aged between 40 and 74 years who were admitted to the Department of Oral and Maxillofacial Radiology. The study was approved by the Local Ethics Committee (2020/243). The study protocol was carried out in accordance with the principles of the Declaration of Helsinki.

Inclusion criteria for panoramic radiographs;

- Anatomic landmarks such as the inferior points of the orbit and zygomatic process, the posterior and inferior border of the mandible, and the alveolar crest must be evident,
- No distortion in the maxilla and mandible images,
- Maxillary and mandibular crests should not be in contact,
- Images must be diagnostically sufficient, with no artifacts observed.

Individuals with systemic disorders affecting bone metabolism, such as hyperparathyroidism, osteoporosis, hypo- or hyperthyroidism, diabetes, chronic renal failure, malignancy, and those using drugs that affect bone metabolism, were excluded from the study. Since the prolongation of the edentulous period would cause changes in the bone structure and reduce the reliability of the measurements, the edentulous period was examined in two groups to standardize the measurements. One group consisted of patients with panoramic films taken between 6 and 12 months after becoming edentulous. The other group consisted of patients with a period of edentulism between 12 and 24 months. Each patient's dentate side was measured as a control group. Patients with bone destruction due to periodontal disease or any pathology in the control region were excluded from the study.

According to the power analysis performed while determining the groups, with alpha and power set at 0.05 and 0.90, respectively, there should be a minimum of 20 individuals in each group. Individuals with more than one missing tooth on the dentate sides were excluded from the groups. The absence of a third molar tooth was not considered missing.

Based on the limitations of previous studies in the literature, we formed a total of 6 groups in our study: mandible and maxilla over 3 age groups. Since our study involved Kennedy Class II patients, each patient's dentate side was measured as a control group. These groups are;

- Group 1: Mandible Kennedy Class II (ages 40-49): 20 individuals (8 men and 12 women) with a mean age of 42.3.
- Group 2: Maxilla Kennedy Class II (ages 40-49): 22 individuals (7 men and 15 women) with a mean age of 42.9.
- Group 3: Mandible Kennedy Class II (ages 50-59): 20 individuals (8 men and 12 women) with a mean age of 51.9.
- Group 4: Maxilla Kennedy Class II (ages 50-59): 20 individuals (10 men and 10 women) with a mean age of 51.7.
- Group 5: Mandible Kennedy Class II (ages 60-74): 20 individuals (9 men and 11 women) with a mean age of 65.6.
- Group 6: Maxilla Kennedy Class II (ages 60-74): 20 individuals (14 men and 6 women) with a mean age of 65.7.

Procedures

The radiographs used in the study were taken on the same panoramic machine, the Instrumentarium OP 200D (Instrumentarium Dental, Tuusula, Finland). The images were saved in Tagged Image File Format (TIFF), and reference drawings and measurements were made using ImageJ software version 1.52v (https://imagej.nih.gov/ij/). Measurements were made by one observer, and 20% of the measurements, randomly chosen from all groups, were repeated and recorded by the same observer one month later.

First, a line passing through the inferior borders of the two orbits (HO) in the maxilla and a second line joining the inferior borders of the zygomatic processes (HZ) were drawn. Next, a third line was drawn tangent to the body of the mandible and the mandibular angle (D1). A fourth line, parallel to D1, was drawn 10 mm above it (D2) in the mandible. The measurements were performed and recorded separately for the points determined based on these lines as dentate (control side) and edentulous areas. To determine the possible locations of the premolars and molars in the edentulous region, the distance from the midline to the outermost border of the ramus of the mandible was first measured on the D2 line in the mandible in the dentate regions. Then, on this line, the distance from the midline to the distal of the 1st premolar and the distance to the distal of the 1st molar was determined. (For this, the line that determines the horizontal length of the mandible (D2) was extended perpendicularly from the distal surfaces of the 1st premolar and 1st molar, and the points where they intersected the line were determined as the locations of the 1st premolar and 1st molar). Calculations from the dentate region showed that the 1st premolars are located at a point corresponding to approximately 35% of the horizontal length of the mandible from the midline, and the 1st molars at 53%. This ratio is consistent with the 34% and 53% ratios found by Xie et al.[18] Therefore, in the measurements to be performed in edentulous areas, the positions of the 1st premolar and 1st molar teeth were determined as percentages according to the above ratios.

The measurement points were determined as follows: the maxillary and mandibular midlines (in the maxilla, A1; in the mandible, C1); the distal surfaces of the first premolars (FP) on the left and right (in the maxilla, A2; in the mandible, C2); the distal surfaces of the first molars on the left and right (in the maxilla, A3; in the mandible, C3); and the distance between the zygoma and the orbit at the midlines (B) (Fig.1-Fig.2).

Statistical analysis

The data analysis was conducted using the SPSS 25 software, with a 95% confidence level. The kurtosis and skewness values ob-

Table 1. Demographic Properties of the study

		Mandible	Maxilla
		N (%)	N (%)
Age groups	40-50	20 (33.3)	22 (36.6)
	50-60	20 (33.3)	20 (33.2)
	60>	20 (33.3)	20 (32.2)
Gender	Men	25 (41.7)	31 (51.7)
	Women	35 (58.3)	29 (48.3)
Duration of Edentuloussness	6-12 months	11 (18.3)	9 (14.5)
	12-24 months	49 (81.6)	53 (75.5)

Table 2. Vertical Height Values According to Regions of Measurement

	Mandible	Maxilla	p
Edentulous premolar region	37.56±4.96	46.59±5.23	**0.000***
Edentulous molar region	28.91±4.83	42.06±5.66	**0.000***
Dentate anterior region	39.29±5.39	48.63±5.69	**0.000***
Dentate premolar region	39.03±4.65	49.21±5.03	**0.000***
Dentate molar region	32.8±4.77	46.55±4.99	**0.000***

* $p < 0.001$

tained from the measurements in both groups were between 3 and -3.[22–25] Accordingly, the measurements were considered to meet the assumption of normality, and parametric methods were used in the analysis. Frequency (n) and percentage (%) were provided for categorical (qualitative) variables, while the mean ($\bar{x}$), standard deviation (SD), minimum (min), and maximum (max) were provided for numeric (quantitative) variables. The differences in measurements according to the group and demographic variables were analyzed using independent t-tests and one-way ANOVA tests. The differences between the control and edentulous measurements according to the group and demographic characteristics in group interaction were analyzed using the repeated measures ANOVA test. The intra-class correlation coefficient (ICC) was used to assess intra-observer agreement.

Results

Measurements were performed on 122 radiographs (62 maxilla, 60 mandible). The results of the demographic data are shown in Table 1.

The results according to the regions are presented in Table 2. When the edentulous regions were considered, a statistically significant difference was detected between the mandible and maxilla in both regions ($p < 0.05$). The vertical height values of the mandible were lower than those of the maxilla. Additionally, a statistically significant difference was found in the measurements of the regions used as control ($p < 0.05$), and as with the edentulous regions, the results for the mandible were lower than those for the maxilla. The results were obtained based on vertical measurement coefficients of variation in dentate regions as shown in Table 3. The coefficients of variation in dentate regions were calculated using the formula "Coefficient of Variation = (Standard Deviation X 100) / Mean." The results ranged from 9% to 13%.

The results by age group are presented in Table 4. A statistically significant difference was detected in the maxillary premolar region of the edentulous regions ($p < 0.05$), with this result being driven by the higher vertical values in the 40-49 age group. In the dentate group, a similar result was obtained in the molar region. In the mandible, no statistically significant differences were detected in either the edentulous or dentate groups ($p > 0.05$).

The comparison of the maxilla and mandible according to gender is presented in Table 5. There was a statistically significant difference only in the mandible between the edentulous and dentate regions ($p < 0.05$). This difference was driven by the women's values, as their vertical height results were found to be lower than those of men. In contrast, no statistically significant difference was detected in the maxilla ($p > 0.05$).

The results according to the duration of edentulism are presented in Table 6. In the mandible, a statistically significant difference was found between the 6-12 months group and the 12-24 months group ($p < 0.05$). The vertical heights of the 6-12 months group were higher than those of the 12-24 months group. In the maxillary anterior region, no statistically significant difference was present ($p > 0.05$).

The intra-observer agreement results of the measurements performed at one-month intervals were calculated using the intra-class correlation coefficient. According to the results of this evaluation, the correlation coefficient was determined to be 0.916.

Discussion

When reviewing the bone structure of the jaws, it is observed that while most of the bone structure of the mandible consists of cortical bone in the basal part, the cortical and trabecular portions of the mandible seem to behave differently with age. The cortical bone mass diminishes considerably over the years, but the trabecular portion shows marked individual variation in all age groups. Additionally, trabecular bone constitutes the majority of the bone structure in the maxilla.[26] As mentioned in the introduction, although residual ridge resorption (RRR) has been reported to be very rapid during the first year after extraction and continues gradually throughout the patient's life, some inter-individual variabilities affect the resorption rate. Factors such as nutrition, physiological factors, the period of edentulism, prosthesis usage and duration, gender, and systemic diseases have been suggested as reasons for these variabilities.[8,9,20,21,27] Furthermore, Pietrokovski et al.[28] stated that the mylohyoid muscle attached to the mylohyoid ridges, the buccinator muscles attached to the buccal bone, and the additional muscles surrounding the mandible limit chronic bone resorption in the edentulous jaws. Other studies have similarly stated that these muscles provide physiological stimulation of the edentulous region, thereby preventing bone resorption.[29–31] Muscles like the genioglossus, attached to the genial tubercles in the anterior mandible, serve as examples of this phenomenon. The process of alveolar resorption occurs more slowly with the stimulation provided by muscle attachment.[32] In line with this information, Kurt et al.32 reported bone apposition in the mandibular angle region where muscle attachment occurs in their study.

On the other hand, it is evident that the use of prostheses also transmits functional forces to the bone structure. Supporting this, some studies have revealed that bone resorption increases with the use of prostheses. This situation highlights the importance of tooth-supported fixed prostheses.[8,21] RRR removes the supporting bone tissue that allows total dentures to function, occurring more in the mandible than in the maxilla, sometimes within a short period, such as 3 months.[18,33] Tallgren[11] stated that in the first year after extraction, a decrease of 4-6 mm occurs in the anterior mandible and 2-4 mm in the maxilla. Atwood and Coy[34] reported that annual bone loss was 0.4 mm in the mandible and 0.1 mm in the maxilla in a follow-up study on edentulous patients over 2.5 years. They proposed that RRR is a biomechanical problem, suggesting that by eliminating direct occlusal contact, the functional forces acting on the edentulous ridge are reduced, subsequently inducing RRR. Although this "disuse atrophy theory" has been blamed for RRR, the mechanistic aspect of this theory has never been confirmed.[34] Indeed, the mechanism of disuse atrophy in RRR remains questionable, and whether the local alveolar crest becomes functionally unloaded needs to be seriously investigated in detail. After tooth extraction, it has been reported that the buccolingual width of the residual alveolar bone undergoes a more pronounced reduction compared to its height.[4] The height reduction rate, expressed as the percentage decrease in vertical linear distance between the base

Table 3. Vertical Measurement Coefficients of Variation According to Gender in Dentate Regions

	Mandible				Maxilla			
	Men	VC*(%)	Women	VC*(%)	Men	VC*(%)	Women	VC*(%)
Dentate anterior region	42.23±5.19	12	37.19±4.52	11	49.37±5.12	10	47.84±6.25	13
Dentate premolar region	41.89±4.9	11	36.98±3.2	9	49.33±4.23	8	49.09±5.85	11
Dentate molar region	36.47±4.41	12	30.18±2.97	9	46.21±4.34	9	46.91±5.65	12

VC*: Coefficient Of Variation

Table 4. Vertical Height Values According to Regions of Measurement and Age Groups

	Mandible				Maxilla			
	40-50	50-60	60>	p	40-50	50-60	60>	p
Edentulous premolar region	38.32±5.08	37.41±5.31	36.96±4.63	0.684	49.27±5.72	45.08±3.76	45.43±5.18	**0.017***
Edentulous molar region	30.32±4.79	27.98±4.78	28.44±4.85	0.272	43.52±6.76	41.05±4.32	41.61±5.63	0.358
Dentate anterior region	40.69±4.94	39.11±5.79	38.07±5.35	0.308	50.81±5.79	48.24±4.35	46.85±6.3	0.081
Dentate premolar region	39.7±4.62	38.47±5.07	38.91±4.4	0.704	51.19±5.7	48.79±3.65	47.65±5.1	0.075
Dentate molar region	33.42±4.68	31.54±4.51	33.43±5.11	0.359	48.87±5.35	45.39±3.92	45.38±4.96	**0.036***

* p < 0.05

Table 5. The Comparison of Maxilla and Mandible According to the Gender

	Mandible			Maxilla		
	Men	Women	p	Men	Women	p
Edentulous premolar region	40.03±5.27	35.8±3.93	**0.001***	46.79±4.81	46.38±5.74	0.769
Edentulous molar region	31.04±4.88	27.39±4.25	**0.003***	42.29±4.62	41.81±6.67	0.746
Dentate anterior region	42.23±5.19	37.19±4.52	**0.000****	49.37±5.12	47.84±6.25	0.301
Dentate premolar region	41.89±4.9	36.98±3.2	**0.000****	49.33±4.23	49.09±5.85	0.856
Dentate molar region	36.47±4.41	30.18±2.97	**0.000****	46.21±4.34	46.91±5.65	0.587

** p < 0.001 * p < 0.05

Table 6. The Comparison of Maxilla and Mandible According to Edentuloussnes Duration

	Mandible			Maxilla		
	6-12 months	12-24 months	p	6-12 months	12-24 months	p
Edentulous premolar region	42.06±5.29	36.22±4.48	**0.001***	43.8±6.18	46.29±4.07	**0.004***
Edentulous molar region	33.19±4.31	27.65±4.33	**0.002***	38.68±6.9	41.84±4.52	**0.004***
Dentate anterior region	43.88±4.65	38.02±5.26	**0.004***	47.04±5.51	48.35±5.52	0.139
Dentate premolar region	42.21±5	38.06±4.49	**0.027***	46.49±4.53	48.95±4.59	**0.005***
Dentate molar region	36.54±5.29	31.9±4.34	**0.013***	44.35±2.71	46.09±4.71	**0.002***

* p < 0.05

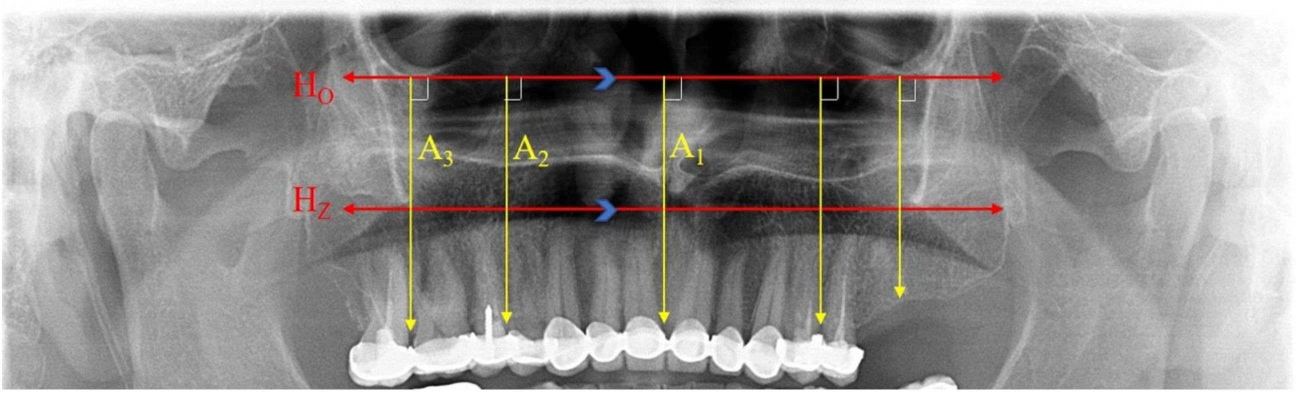

Figure 1. Reference lines and measured heights and sites in the maxilla. In the maxilla the A1 measurement was made in the midline, A2 and A3 measurement was made in the infraorbital and zygomatic vertical lines on both sides.

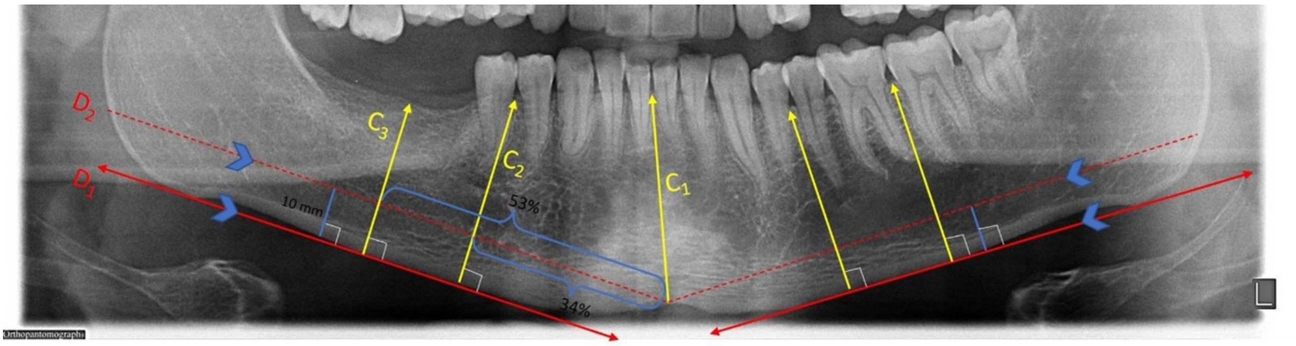

Figure 2. In the mandible a dotted line shows mandibular length; C2 and C3 distances were measured at 34% and 53% of the length; the tangent, the dotted line, and C2 and C3 measurements were made on both sides. The C1 measurement was recorded in the midline.

of the socket and the crest of the alveolar bone prior to extraction, was observed to be 15% at 3 months and between 11% and 22% at 6 months. Conversely, the reduction in buccolingual width, expressed as the percentage decrease in horizontal linear distance between the buccal and lingual borders of the alveolar bone before extraction, was reported to be 32% at 3 months and between 29% and 63% at 6 months.[35] Notably, the extent of height reduction varied depending on the specific region.[4,35] These clinical observations suggest that structural changes in the edentulous jawbone are predominantly unidirectional, primarily resulting from osteoclast-mediated resorption of the residual alveolar bone. Residual ridge reduction following tooth extraction has been studied extensively through the use of standardized lateral cephalographs[4,11] and panoramic radiographs[8,16], which have been employed to assess the structural changes occurring in the underlying jawbone.[4]

The first method for measuring residual ridge resorption on panoramic radiographs was developed by Wical and Swoope[19], and this method has been used in most studies. However, the mandibular ratio in this method can only indicate changes in bone height in the mental foramen region. A limitation of this method is that it cannot provide information on radiographs where the mental foramen cannot be clearly visualized, nor does it account for resorption occurring in other parts of the mandible or the maxilla.[8] Xie et al.[18], took the distance between the zygoma and orbit as the reference line in their study and improved the method we used in our study by altering only the measurement points and the ratio. They found a value varying between 9% and 10% in terms of maxillary ratio between toothed males and females, stating that this value is suitable for investigating vertical height changes. The values between 9% and 13% found in our study were close to these results. The differences are thought to be due to the selected groups or the magnification of the panoramic device. Using this method, we found that the edentulous maxilla and mandible had lower vertical heights than the toothed maxilla and mandible, consistent with the literature.[8,18,21,31] In our study, ridge resorption in the mandible was found to be higher than in the maxilla, with lower vertical heights measured in the mandible. The presence of trabecular bone and more bone marrow in the maxilla may delay bone loss, whereas the compact nature of the mandibular bone structure might contribute to rapid resorption when subjected to incoming forces.[18,31]

Although the results of our study align with similar studies in the literature.[8,18,21,26,31], it also had some particularities. For instance, the lack of division into age groups in the study by Ozan et al.[21], was noted as a limitation. Similarly, most studies did not classify age groups as restricted (under 65 and over 76).[8,20,21] In our study, patients were evaluated in three different age groups, which may provide clinically clearer information regarding which stages of these age groups experience more alveolar vertical loss and help guide patients toward dental or implant-supported prostheses. Indeed, in our results, a significantly lower vertical height was found with age progression in the maxillary premolar region of the edentulous regions when comparing age groups. No significant difference was found in other measurement regions in the maxilla and mandible. It has been reported in the literature that ridge resorption increases with age in edentulous areas. However, as a limitation, age ranges in the study by Ozan et al.[21] were not mentioned. Most existing studies in the literature used a wide age range to evaluate selected patients without dividing them into specific age ranges or groups. In contrast, in our study, individuals were grouped as 40-49, 50-59, and 60 and over. The age of 40 was selected as the initiation of investigation because it is accepted as the start of tooth loss. Therefore, we believe that by dividing the age groups specified as limitations in other studies and determining which regions have more resorption in which age ranges, we can identify the time intervals important for guiding patients in prosthesis or implant rehabilitation for edentulous areas. Narhi et al.[20] using the technique developed by Wical and Swoope[19], conducted a study on 96 individuals using total prostheses and found a significant relationship between the duration of toothlessness in women and RRR, but not in men, and stated that there was no relationship between patient age and resorption in both genders. Although we did not use the technique of Wical and Swoope[19], our study revealed that RRR gradually increased in the maxillary premolar edentulous region with each decade after the age of 40. Supporting this, RRR was shown to increase after menopause.[20] It has therefore been reported that RRR is higher in women than in men.[16,36] In our study, the vertical height in women was found to be significantly lower than in men in all regions of the mandible. This may be due to more common resorption in women than in men during the post-menopausal period due to bone destruction, as stated in the literature. There was no significant difference between both sexes in the maxilla. The width of the maxillary alveolar crest decreases more rapidly than its height. Prospective studies by Schroop et al.[37] evaluating changes in the extraction cavity over a 10-year period after single tooth extraction revealed that major changes occur within 12 months following extraction. Bone formation in the alveoli and a decrease in the vertical height of the alveolar bone crest occur simultaneously in the first three months, and bone formation continues in the second three months. The remodeling process continues for 6-12 months. Although the new level formed after the extraction cavity is filled with bone never rises to the level of the teeth located in the mesial and distal regions of the cavity, it was revealed through linear measurements that the bone level after 12 months coincides with the bone level after extraction.[38] For this reason, in our study, patients who had been edentulous for between 6-12 months and those who had been edentulous for between 12-24 months were classified. In these processes, the vertical height was found to be significantly lower in individuals who had been edentulous for between 6-12 months in all regions except the maxilla anterior toothed region compared to those who had been edentulous for between 12-24 months. We believe that the reason for this high value is the remodeling in the second six-month period in individuals who had been edentulous for 6-12 months, and the increase in osteoclastic activity due to the loss of stimulation in the edentulous area as time progresses. The lack of significant change in the maxillary anterior tooth region is due to the presence of teeth in the mouth, highlighting the importance of teeth in preventing the resorption of the alveolar bone structure. In our study, the changes in the Kennedy Class II classification with alveolar ridge resorption and prosthesis usage time in age and gender groups were revealed. The fact that there is no dramatic loss of alveolar bone due to the presence of teeth in this region once again underscores the importance of tooth-supported prostheses in patients.

As a limitation of the study, the edentulous period was restricted to two years, and the condition in other Kennedy classes and modifications was not evaluated. Further research that addresses these aspects could enhance the predictability of alveolar ridge resorption.

Conclusion

Firstly, teeth play a crucial role in preventing bone resorption, so prosthesis planning should take into account the resorption that will occur after tooth extraction. The literature reports that patients using removable and total prostheses experience more residual ridge resorption than those who do not use prostheses. This underscores the growing importance of implant-supported prostheses. The primary advantages of implants are that they function like natural teeth to prevent bone resorption and provide support to the superstructure prosthesis. Our study reveals that significant bone resorption occurs across the current age ranges, highlighting the need to minimize the duration of edentulism. Additionally, our findings show significant vertical bone loss in each decade in the maxillary premolar edentulous region, while no significant bone loss was observed in other edentulous regions over the decades. Based on these results, we recommend directing patients, particularly those who are edentulous in the maxillary premolar region, towards implant rehabilitation to prevent bone loss. Implant prostheses can be presented as an optimal solution in modern dentistry to meet the functional, phonetic, and aesthetic expectations of patients as they age.

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Author Contributions

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Investigation : S.Y.
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Data Curation : O.M.D.Y.
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Conflict of Interest

The authors declare no conflict of interest.

Ethics Approval

The study was approved by the Local Ethics Committee (2020/243). The study protocol was carried out in accordance with the principles of the Declaration of Helsinki.

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