

# Oral status and prosthetic factors related to residual ridge resorption in elderly subjects

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Our earlier studies on edentulous elderly subjects have shown associations of severe resorption in the mandibular residual ridge with female gender and systemic diseases. The aim of this study was to examine whether other factors also were related to residual ridge resorption (RRR). Among 177 edentulous elderly subjects effects on RRR were investigated with regard to history of edentulousness and denture-wearing, the condition of the dentures and soft tissues, dental status of the opposing jaw, and oral hygiene habits. No significant association was found between degree of resorption and duration of edentulousness in either the mandible or the maxilla. RRR was related to denture quality ( $P < 0.05$ ); however, severe resorption was not. In the maxilla previous use of removable partial dentures was a factor contributing to the resorption (odds ratio (OR), 2.4); flabby ridge was related to the severity of the resorption (OR, 2.4). This study showed local factors related to RRR more often in the maxilla than in the mandible, thus suggesting that severe resorption in the mandible is influenced more by systemic factors than by those investigated in this study. □ *Denture quality; edentulousness; flabby ridge; oral hygiene; partial denture*

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Great individual variation in the degree of residual ridge resorption (RRR) has been the reason for various studies on factors that may influence the progress of such resorption (1–14). Duration of edentulousness has been related to the severity of RRR, particularly in the mandible. Alveolar bone loss in the edentulous jaw is a continuous process that may proceed throughout the lifetime of the denture wearer (4–7). According to several cross-sectional studies, patients with a long period of edentulousness had lost a greater amount of the mandibular bone than had patients with a short period of edentulousness (11–13).

Wearing of dentures is one of the factors associated with degree of alveolar bone loss in an individual. The number of lower dentures worn is usually correlated with the number of a person's edentulous years and the severity of alveolar resorption (11, 12). Some studies have shown that persons wearing complete dentures day and night had lost more alveolar bone than those wearing their dentures only during the daytime (5, 15). However, in some other studies this finding was not confirmed (11, 16). The patients with natural lower teeth only in the anterior region have had a greater reduction in the anterior alveolar ridge of the edentulous maxilla than the patients with a lower complete denture or those with their own lower posterior teeth (6, 17, 18). A history of wearing removable partial dentures and neglected oral hygiene may also influence degree of RRR (19, 20).

Our earlier studies on edentulous elderly inhabitants in Helsinki have shown significant associations of severe resorption in the mandibular residual ridge with female gender and asthma (21, 22) and of resorption of the mandibular canal wall due to RRR with female gender, asthma, and thyroid disease (23). However, it has remained open whether factors other than gender and some general diseases also have influenced RRR in these elderly subjects. The aim of this present study was to examine RRR in terms of history of edentulousness and denture-wearing, the condition of current complete dentures and denture-bearing soft tissues, the dental status of the opposing jaw, and oral hygiene and denture-wearing habits.

## Materials and methods

### *Subjects*

The subjects studied were from a dental survey on 76-, 81-, and 86-year-olds, which had been performed during the years 1990–91 as a part of the longitudinal Helsinki Aging Study (HAS) (24). The study population consisted of 185 elderly people (46 men and 139 women), included in the present study on the basis of the following criteria: a) edentulousness in the maxilla and/or the mandible, b) participation in a questionnaire interview and an oral examination at the dental clinic of

Table 1. Distribution of the study group by age, gender, and jaw

Age	Mandible						Maxilla					
	Men		Women		Total		Men		Women		Total	
	n	%	n	%	n	%	n	%	n	%	n	%
76 years	14	24	44	76	58	100	29	37	49	63	78	100
81 years	14	36	25	64	39	100	15	27	40	73	55	100
86 years	3	10	26	90	29	100	5	14	30	86	35	100
Total	31	25	95	75	126	100	49	29	119	71	168	100

the Institute of Dentistry (24), c) a panoramic radiograph made as a part of the oral examination. Of these subjects, 124 were completely edentulous; 55 had only an edentulous maxilla, and 6 had only an edentulous mandible. All the subjects studied were denture wearers.

Panoramic radiographs were taken with the PM 2002 CC panoramic apparatus (Planmeca Co, Helsinki, Finland). Trimax T16 intensifying screens and Trimax GTU X-ray film (3M, St. Paul, Minn., USA) were used. All films were processed in an RP X-Omat processor (Eastman Kodak, Rochester, N.Y., USA).

Four radiographs of subjects with an edentulous mandible and 11 of subjects with an edentulous maxilla were excluded owing to image distortion or lack of radiologic images of anatomic landmarks; finally, 177 radiographs—126 edentulous mandibles and 168 edentulous maxillas—were measured by one investigator (Q. Xie) (Table 1).

#### Assessment of residual ridge resorption

Vertical measurements were made at five sites in each jaw. In the mandible a line was drawn tangential to the most inferior points at the mandibular angle and the lower border of the mandibular body on each side (Fig. 1) (Z = vertical distance from the alveolar crest to the lower border of the mandible in the midline; X = distances from the alveolar crest to the lower border of the mandible at 34% and 53% of the length of the mandibular body (representing the first premolar and first molar sites in the edentulous mandible (21)) and perpendicular to the tangent on both sides). In the maxilla a reference line (Lo) was drawn joining the inferior points of both the orbits (A = vertical distance from Lo to the alveolar crest in the midline and along the infraorbital vertical line and the zygomatic vertical line (representing the first premolar and first molar sites in edentulous maxilla (21)) on both sides).

Reductions in the heights of the mandible and maxilla were evaluated by comparison of heights of the residual ridges with average heights of the elderly dentate jaws and expressed as percentage reduction, separately for each sex and for measurement sites. The

methods for measuring residual ridge height and calculating percentages of reductions in the heights of edentulous mandible and maxilla and the results have been reported in our previous study (21). The average percentages of reductions in the edentulous mandible were 44% ( $s = 14$ ) including both the posterior and anterior regions, 46% ( $s = 16$ ) in the posterior regions, and 38% ( $s = 13$ ) in the anterior mandible. The corresponding figures for the edentulous maxilla were 14% ( $s = 12$ ), 12% ( $s = 11$ ), and 18% ( $s = 11$ ).

#### Interview and clinical examination

Subjects were interviewed with a structured questionnaire and clinically examined by four calibrated faculty members of the Department of Prosthetic Dentistry. The contents of the clinical examination have been described previously (25). Data on the history of edentulousness and denture-wearing, denture age, self-estimated current denture function, and on oral hygiene habits are from the structured questionnaire. Information on denture quality, dental status of the opposing jaw, and the condition of denture-bearing soft tissues were obtained from the clinical examination.

Denture quality was assessed for stability, retention, vertical dimension of occlusion, occlusion, and articulation, referring to the criteria used in the previous studies (26–28). Because of the aims of this study, only soft-tissue lesions in denture-bearing area were included. Inflammation, ulcers, and papillary and fibrotic hyperplasia were recorded by using the modified scheme recommended by the WHO (29). The presence of the displaceable ridge (flabby ridge) was recorded as well. Diagnosis was based on clinical observation; no biopsies were taken.

Residual ridge resorption was studied in terms of the following factors:

1. History of edentulousness: a) duration of edentulousness in years (7 time grades): 1 = 1–5 years, 2 = 6–10 years, 3 = 11–20 years, 4 = 21–30 years, 5 = 31–40 years, 6 = 41–50 years, 7 = >50 years; b) main reason for loss of teeth: caries, periodontitis, malocclusion, or trauma.

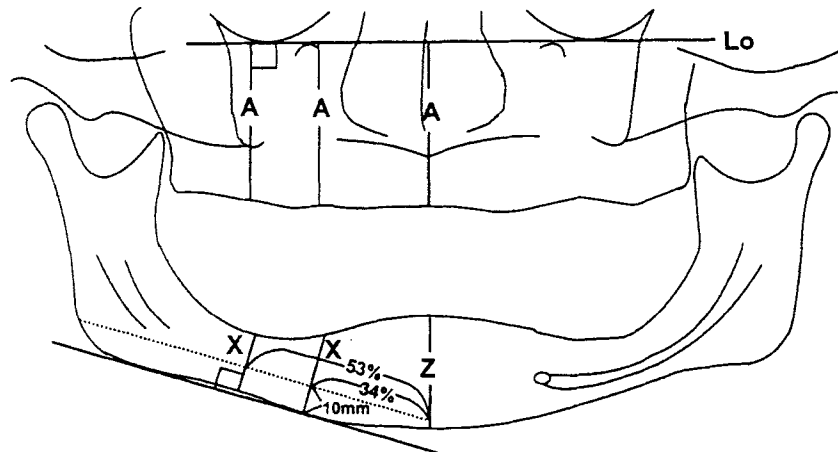


Fig. 1. Reference lines and measured heights and sites in edentulous jaws. In the mandible a dotted line shows mandibular length; X distances were measured at 34% and 53% of the length; the tangent, the dotted line, and X measurements were made on both sides. The Z measurement was recorded in the midline. In the maxilla the A measurement was made in the midline and along the infraorbital and zygomatic vertical lines on both sides.

2. Use of previous dentures: a) use of removable partial dentures: 0 = no, 1 = yes; b) number of complete dentures worn.

3. Use of current complete denture: a) age of the current complete denture (8 time grades): 1 = 0–1 years, 2 = 2–5 years, 3 = 6–10 years, 4 = 11–20 years, 5 = 21–30 years, 6 = 31–40 years, 7 = 41–50 years, 8 = >50 years; b) the quality of dentures (five characteristics): (1) stability: 0 = good, slight or no rocking on denture-supporting structures when under pressure; 1 = satisfactory, moderate rocking on supporting structures under pressure; 2 = poor, extreme rocking on supporting structures under pressure; (2) retention: 0 = good, good resistance to vertical pull, and sufficient resistance to lateral forces; 1 = satisfactory, slight to moderate resistance to vertical pull, and little or no resistance to lateral forces; 2 = poor, no resistance to vertical pull and lateral forces, so that the denture falls out of place; (3) occlusion: 0 = good, muscular and intercuspal positions coincide with only slight variation (up to 0.5 mm); 1 = poor, more than 0.5 mm error between muscular and intercuspal positions; (4) articulation: assessed by asking the subjects to do 5-mm lateral movements with the mandible from the midline habitual centric occlusion. If the dentures remained in place, articulation was considered good = 0, otherwise it was poor = 1; (5) vertical dimension of occlusion: 0 = good, the interocclusal rest space between 1 and 6 mm, 1 = poor, too low (the space more than 6 mm) or too high (the space less than 1 mm). The sum of five ratings was considered the score for denture quality (score 0–1 = good, 2–4 = moderate, 5–7 = poor); c) self-estimated current denture function:

0 = good, 1 = satisfactory, 2 = poor; d) wearing denture day and night: 0 = no, 1 = yes.

4. Denture-bearing soft-tissue lesions: a) denture-related mucosal lesions (local or general inflammation, ulcers, papillary hyperplasia, and fibrotic hyperplasia): 0 = no, 1 = yes (each of these disorders was recorded separately); b) flabby ridge (displaceable ridge): 0 = no (firm mucosa over bone), 1 = yes (top of ridge displaceable against the bone).

5. Dental status of opposing jaw: 0 = edentulous, 1 = natural teeth remaining in the anterior region of the jaw, 2 = natural teeth remaining in the anterior and posterior regions of the jaw.

6. Oral hygiene habits: a) denture-cleaning frequency: 0 = no cleaning, 1 = once daily, 2 = twice daily, 3 = >twice daily; b) cleaning mucosa under denture: 0 = no, 1 = yes.

All the variables were recorded separately for the mandible and maxilla, except the oral hygiene habits, occlusion, articulation, and vertical dimension of occlusion.

#### Statistical analysis

Statistical analyses were made with SPSS/PC+ Advanced Statistics software (version 5.0, SPSS Inc., Chicago, Ill., USA). The Mann–Whitney U test was used to examine the difference in duration of edentulousness between men and women. The self-estimated complete denture function and denture quality and the subjects' age and denture age were correlated using the Spearman rank correlation analysis. Linear regression analysis was performed to study whether the percentage

reduction in the residual ridge was related to each of the factors, with adjustment for confounding factors. In logistic regression analysis, residual ridge resorption was categorized into two groups by using cutoff points. In the mandible equal to or less than 53% reduction in vertical bone height was considered slight or moderate resorption (0), and more than 53% reduction severe resorption (1). In the maxilla, equal to or less than 15% reduction in vertical bone height was considered slight or moderate resorption (0), and more than 15% reduction severe resorption (1). The cutoff points were determined on the basis of the distribution of the percentage reduction (mean and standard deviation) and the number of subjects in each subgroup, so that the most significant factors could be obtained. The cutoff points were the same as used in our previous study (22). Logistic regression analysis was fitted to study the association of severe resorption in the residual ridge in terms of history of edentulousness and denture wearing, the condition of current dentures and denture-bearing soft tissues, dental status of the opposing jaw, and the subjects' oral/denture hygiene habits. Differences at the 5% level were accepted as significant.

## Results

### Oral status and prosthetic factors

Duration of edentulousness is shown in Table 2. The median duration of edentulousness was 21–30 years for both the maxilla and mandible. The median duration of edentulousness of women (31–40 years) was significantly higher than that of men (21–30 years) in both jaws ( $P < 0.01$  for the maxilla,  $P < 0.05$  for the mandible). Loss of teeth had occurred mainly due to caries.

Before becoming edentulous, about two-fifths (42% in the mandible and 41% in the maxilla) of the subjects had worn at least one removable partial denture (RPD). Mean number of complete dentures worn was 2.1 ( $s = 1.0$ ) in the mandible and 2.3 ( $s = 1.1$ ) in the maxilla.

Table 2. Subjects in accordance with duration of edentulousness (years) by jaw

	Mandible		Maxilla	
	<i>n</i>	%	<i>n</i>	%
1–5 years	2	2	2	2
6–10 years	1	1	4	4
11–20 years	16	19	15	13
21–30 years	27	33	38	34
31–40 years	15	18	23	21
41–50 years	13	16	16	14
>50 years	9	11	14	12
Total	83	100	112	100

In 43 mandibles (34%) and 56 maxillas (33%) the duration was unclear.

Most of current upper and lower dentures were 6–10 years old, and the oldest dentures had been in use for more than 30 years. The subjects' age was positively related to denture age in the mandible ( $r = 0.224$ ,  $P < 0.05$ ) and in the maxilla ( $r = 0.204$ ,  $P < 0.05$ ). Two-thirds of the subjects wore their current dentures day and night.

About two-fifths (39%) of the subjects were satisfied with their lower denture function and three-fifths (58%) with their upper denture function. Only 21% of the lower dentures and 7% of the upper dentures were claimed by the subjects to function poorly. The denture quality as assessed by the examiners was good in only 10% of the lower dentures and in 36% of the upper dentures; 46% of the lower dentures and 17% of the upper dentures were judged as poor in quality. The self-estimated complete denture function was related to the upper denture quality as assessed by the examiners ( $r = 0.234$ ,  $P < 0.05$ ) but not to the lower denture quality.

Observation of the denture-bearing soft-tissue health showed mucosal lesions in 16% of the edentulous mandibles and 35% of the edentulous maxillas. The commonest mucosal lesion was inflammation, seen in 8% of the mandibles and 29% of the maxillas. Denture-related ulcer was found in 7% of the mandibles and 1% of the maxillas. Papillary and fibrotic hyperplasia were observed in 2% and 3% of the mandibles, respectively; the corresponding figures for the maxilla were 8% and 2%.

Flabby ridge was observed in 5% of the edentulous mandibles, 4% in the anterior region and 1% in the posterior. Flabby ridge was observed in 24% of the edentulous maxillas; 11% were found in the anterior region, 8% in the posterior, and 5% in both the anterior and posterior. The subjects with upper flabby ridge were younger than those without ( $P < 0.05$ ).

The mean number of remaining teeth was 6.7 ( $s = 4.4$ ) in the six opposing dentate maxillas and 5.9 ( $s = 3.1$ ) in the 50 opposing dentate mandibles. Of the subjects with dentate mandibles, 17 (34%) subjects had only the anterior teeth and 33 (66%) both the anterior and posterior teeth.

Most subjects had good oral hygiene habits; 146 (82%) cleaned their dentures twice a day or even more frequently, and 147 (83%) cleaned their edentulous ridges every day. Only 5 (3%) subjects did not clean their dentures, and 20 (11%) did not clean their edentulous ridges.

### Associations with the resorption

In the multiple linear regression analysis the percentages of ridge reductions were used as dependent variables. The percentage of ridge reduction was significantly related to denture quality in both the mandible and maxilla ( $P < 0.05$  for the mandible,  $P < 0.01$  for the maxilla). In the maxilla, with adjust-

Table 3. Effects of study variables on percentage reduction in residual ridges† (linear regression analysis), adjusted for age and gender

Independent variable	Mandible		Maxilla	
	Coefficient	<i>s<sub>e</sub></i>	Coefficient	<i>s<sub>e</sub></i>
History of edentulousness				
Duration of edentulousness: time grades (1-7)	1.6	1.1	0.4	0.8
Reason for extraction or loss of teeth: caries and others = 0, periodontitis = 1	1.5	2.9	-2.4	2.1
Use of previous dentures				
Previous use of removable partial dentures: no = 0, yes = 1	5.8‡	3.1	4.2‡*	2.0
No. of complete dentures used	2.9‡	1.5	-1.9‡*	0.9
Use of current complete denture				
Denture age: time grades (1-8)	-1.2	0.9	-0.2	0.6
Denture quality score (0-7)	1.4*	0.6	1.2**	0.4
Self-estimated denture function: good = 0, satisfactory = 1, poor = 2	1.9	1.9	2.0	1.5
Wearing denture day and night: no = 0, yes = 1	-0.6	3.1	1.7	2.0
Denture-bearing soft tissue				
Soft-tissue lesions: no. of lesions	-0.2	2.7	-2.5	1.4
Flabby ridge: no = 0, yes = 1	-1.7	6.3	4.7*	2.0
Dental status of opposing jaw§				
Edentulous = 0, natural anterior teeth = 1, natural anterior and posterior teeth = 2	—	—	-0.5	1.1
Oral hygiene habits				
Denture-cleaning frequency, times/day	1.0	1.6	0.4	1.1
Cleaning mucosa under denture: no = 0, yes = 1	-1.6	3.5	-2.2	2.7

\*  $P < 0.05$ , \*\*  $P < 0.01$ .

† Percentage of reduction in residual ridge was assessed in the anterior and posterior regions of the edentulous mandible and in the posterior regions of the edentulous maxilla. Because the vertical measurement in the midline of the maxilla from the panoramic radiograph was sensitive to the head positioning, percentage reduction in the anterior region of edentulous maxilla was not used.

‡ Adjusted for age, gender, and duration of edentulousness.

§ Analysis was not done for the edentulous mandible because there were only six subjects with a dentate maxilla opposing an edentulous mandible.

ment for age and gender or age, gender, and duration of edentulousness, significant positive associations were found between the percentage of ridge reduction and previous use of an RPD ( $P < 0.05$ ), few dentures worn ( $P < 0.05$ ), and presence of flabby ridge ( $P < 0.05$ ), respectively (Table 3). No association was found between the percentage of ridge reduction and either the duration of edentulousness or the dental status of the opposing jaw.

In the multiple logistic regression analyses the number of lower complete dentures worn and previous use of an upper RPD were significant factors for severe resorption with odds ratios of 2.3 and 2.4, respectively (Table 4). The flabby ridge was found in severely resorbed maxillas more often than in slightly or moderately resorbed maxillas (odds ratio, 2.4). The number of mucosa lesions under dentures was smaller in severely resorbed maxillas than in the slightly or moderately resorbed maxillas (odds ratio, 0.5). No

significant association was found between severe resorption and other variables in the mandible and maxilla.

## Discussion

According to previous studies (21, 30, 31), it is possible to make reliable measurements in both the upper and the lower jaws from panoramic radiographs. The differences in the heights of the mandibular body and the maxilla between the dentate and edentulous subjects were highly significant and much greater than the individual deviations (21). However, in this cross-sectional study the individual deviations could not be avoided and may affect, to some extent, the accuracy of the estimated percentage reductions in the edentulous jaws. Using the heights of the residual ridges for analysis of relationships between RRR and related factors is

Table 4. Effects of study variables on severe vertical reduction of residual ridge\* (logistic regression analysis, only significant ( $P < 0.05$ ) variables given), adjusted for age and gender

Independent variable	Mandible			Maxilla		
	Odds ratio	95% confidence interval	<i>P</i>	Odds ratio	95% confidence interval	<i>P</i>
Previous use of removable partial dentures						
No = 0						
Yes = 1				2.4†	1.1–5.5	0.037
No. of complete dentures used	2.3†	1.3–4.2	0.007			
No. of soft-tissue lesions				0.5	0.3–0.9	0.031
Flabby ridge						
No = 0						
Yes = 1				2.4	1.2–5.1	0.020

\* > 53% vertical reduction in mandibular residual ridge; > 15% vertical reduction in maxillary residual ridge.

† Adjusted for age, gender, and duration of edentulousness.

unable principally to determine whether the difference in the height of the residual ridge between men and women is due to the difference in the size of the jawbone or the various rates of resorption.

The duration of edentulousness has previously been found to be related to the degree of resorption of the mandibular residual ridge (11–13). In the present study no such association was found. Different methods for assessing residual ridge resorption and the inconsistent age groups may explain the differing findings. The rate of resorption in the anterior alveolar ridge is most rapid during the first year of denture-wearing (5, 8) and is moderately rapid during the first 7 years of denture-wearing. After that, the rate has been reported to decrease obviously (8). The studies of Kalk & de Baat (11) and Bairam & Miller (13) included young people and many more subjects with a duration of edentulousness less than 10 years than did our investigation. Thus, the result of their earlier finding cannot be compared directly with the result of our study.

In these previous studies (11, 13) the degree of resorption in the mandible was assessed by means of the method described by Wical & Swoope (32) or by a visual classification method whose reliability was confirmed by the method of Wical & Swoope. Because the lower margin of the mental foramen is a landmark for making a measurement on the basis of Wical & Swoope's ratio, the edentulous mandible in which the mental foramen is completely resorbed cannot be assessed by this method. In our population the complete resorption of the mental foramen and the partial resorption of the superior border of the mandibular canal were observed in 66 (27%) mandibular halves (23). In the present study the percentage reduction of ridge height in the anterior and posterior regions was used to assess the amount of bone loss, and the percentage reduction was calculated in accordance with the average height of the ridge of dentate subjects aged 52–81 years (21).

Residual ridge resorption is a cumulative effect of

many factors. In a previous longitudinal study of subjects wearing complete dentures for 21 years (33), great variation in RRR was found. Gender and systemic diseases may affect the degree of resorption during long-term edentulousness (12, 34–36). In our population we found associations between RRR and female gender and systemic diseases (22, 23). Thus, in our cross-sectional study of edentulous elderly subjects the most severe resorption in the edentulous mandible seems to be related to systemic factors rather than to duration of edentulousness, especially with regard to resorption involving the basal portion of the mandible.

Wearing an RPD before becoming edentulous results, to some extent, in increased loss of alveolar bone. This change is especially apparent in those who have used a distal extension partial denture previously (19). In our population no important systemic factor was found to influence the resorption in the edentulous maxillas (22), and thus, the effect of using partial dentures on resorption was barely perceptible in the maxilla. The finding that the percentage ridge reduction in the maxilla was related to fewer dentures worn is in agreement with the findings of de Baat et al. (12). This may have indicated increased resorption due to prolonged wearing of old dentures that might have been ill-fitting.

An association between the subject's age and denture age was found in the present study and in the investigation by Moskona & Kaplan (37). The ability to adapt to new dentures decreases with biologic aging (38). The elderly subjects appeared to prefer tolerating their old dentures rather than to have risk undergoing changes that might occur with a new denture (39). The elderly do not always correctly identify the problems of their inadequate dentures (40, 41). They may consider loose dentures among the expected detrimental handicaps in general health experienced during the process of aging (39). The consequences of continuous resorption in the residual ridge and lack of repair of dentures include poorly fitting and poorly functioning dentures.

Complete dentures of inferior quality may cause traumatic load in the residual ridge, increasing alveolar bone loss.

Hyperplasia of the denture-bearing soft tissues is a common pathologic finding in denture wearers (37). Histologic study shows that flabby tissue develops at the ridge crest and is made up of fibrous connective tissue, which is considered to be the result of prolonged trauma from the denture base and severe bone resorption (17, 38). Flabby ridge is more often observed clinically in the maxilla than in the mandible, especially in the anterior region of the maxilla when the upper complete denture has been opposing natural lower anterior teeth (17, 18, 37). Flabby ridge was also found in the elderly subjects who had dentures of poor quality (37). In the present study the displaceable ridge was found not only in the anterior region of the maxilla but also in the posterior maxilla, and an association was found between the presence of a flabby ridge and the severity of residual ridge resorption in the posterior maxilla. These findings may indicate that denture trauma or overload of occlusion had occurred in the maxillary residual ridge and had resulted in severe resorption.

In conclusion, after adjustment for age and gender no significant association was found between degree of resorption and duration of edentulousness in either the *mandible or the maxilla* among edentulous elderly subjects. RRR was related to the quality of the denture; however, severe resorption was not. In the maxilla previous use of removable partial dentures was a factor contributing to the resorption, and the presence of a flabby ridge was related to the severity of the resorption. The present study showed factors related to severe resorption more often in the maxilla than in the mandible, and thus, severe resorption in the mandible was influenced more by systemic factors than by oral status and the prosthetic factors investigated in the present study.

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