

Association of residual ridge resorption with systemic factors in home-living elderly subjects

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Residual ridge resorption after loss of teeth is a multifactorial oral problem. To examine the association of residual ridge resorption with systemic factors, a cross-sectional study was made of 177 edentulous subjects (43 men and 134 women) aged 76, 81, and 86 years. Resorption in the mandibular and maxillary residual ridges was assessed from panoramic radiographs. The effects on residual ridge resorption of the age, gender, smoking, alcohol intake, body mass index, functioning in daily living, and certain systemic diseases of the subjects were investigated. After adjustment for age and duration of edentulousness, the elderly women had a greater amount of reduction in the mandibular residual ridge than the men ($P < 0.001$). When the resorption was classified into slight or moderate and severe resorptions, the elderly with asthma were at high risk of severe reduction in the edentulous mandible (odds ratio, 6.0; 95% confidence interval (CI), 1.3-28.2); the elderly women were at high risk of severe resorption in the edentulous mandible, with an odds ratio of 4.5 (95% CI, 1.2-17.1); an inverse association was found between alcohol intake and severe resorption in the edentulous maxilla (odds ratio, 0.4; 95% CI, 0.2-0.9). This study suggests that asthma due to corticosteroid treatment is to be considered a risk indicator for severe resorption of the edentulous mandible; alcohol intake in the elderly may be related to a lesser degree of resorption of the edentulous maxilla. Female gender is confirmed as a major factor resulting in mandibular atrophy. □ Alcohol intake; asthma; edentulousness; gender; risk factor

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Residual ridge resorption (RRR) after loss of teeth is a chronic, progressive, and cumulative disease of bone remodeling (1-5). The amount and rate of RRR vary both between patients and for a given patient at different times; both are affected by multiple factors (1, 5-7). A severely reduced residual ridge constitutes a serious problem complicating prosthetic rehabilitation whether by construction of a removable denture or by use of an implant prosthesis (8).

Factors associated with RRR are classified into two groups, local and systemic (6). Local factors consist of the condition of the alveolar process after the extraction of teeth (quality, size, and shape of ridge), duration of edentulousness, and bite stress on the edentulous alveolar ridge transmitted by the denture, all possibly resulting in various degrees of RRR among edentulous patients (1-3, 6, 9, 10). Systemic factors, such as high age, female gender, low calcium intake, and osteoporosis, have repeatedly been linked with mandibular atrophy (11-20).

Estrogen deficiency during and after menopause accelerates a generalized mineral loss from the skeleton (21). This loss of bone mass may affect the rate of RRR (22, 23). Resorption in the mandibular residual ridge has been found to be more pronounced in edentulous women than in edentulous men (17, 24). Compared with normal subjects (with no radiographic evidence of

vertebral compression fracture or of metabolic bone disease), patients with systemic osteoporosis had less mandibular bone mass, lower bone density, and a thinner cortex at the gonion (22). Certain systemic diseases (for example, hyperthyroidism, hyperparathyroidism, or diabetes) and certain medications (such as corticosteroids and thyroxine), which are risk factors of osteoporosis (7, 18, 25-28), may affect the degree of resorption in edentulous jaws.

Alcohol abuse is known to cause alcohol-related bone disease by means of a directly deleterious effect on bone structure or indirectly by such factors associated with alcohol abuse as nutritional deficiencies, hypogonadism, and hypercortisolemia (29). However, moderate alcohol consumption may have a beneficial effect on bone for postmenopausal women (30). Smoking is a major risk factor for bone loss and fracture (7, 31, 32). Association of smoking with periodontal disease has been demonstrated in several studies (33-36).

RRR may progress without apparent symptoms until the patient's dentures become loose. Therefore the ability to predict which patients are likely to lose a greater amount of bone is important both for prevention and for making a prosthetic plan. However, little knowledge is available about the effects of tobacco smoking, alcohol intake, and systemic diseases on RRR. The present study was designed to examine the

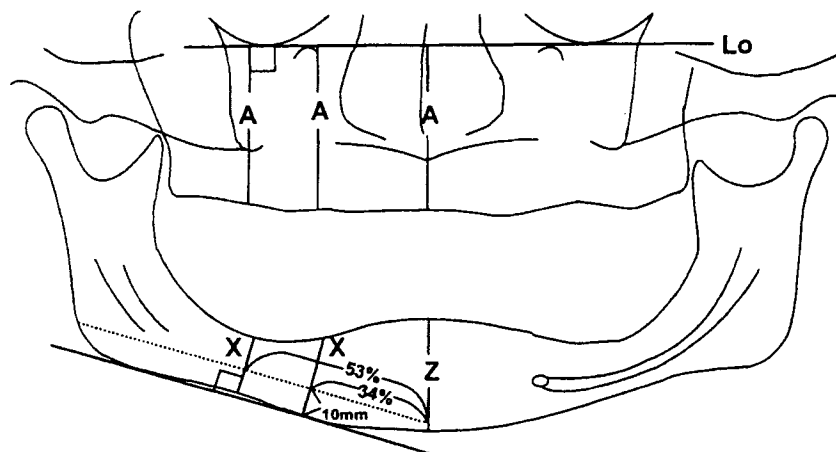


Fig. 1. Reference lines and measured heights and sites in edentulous jaws. In the mandible a dotted line shows mandibular length; X distances were measured at 34% and 53% of the length; the tangent, the dotted line, and X measurements were made on both sides. The Z measurement was recorded in the midline.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

association of RRR in the mandible and maxilla with age, gender, tobacco smoking, alcohol intake, body mass index, functioning in daily living, and certain systemic diseases and to identify the factors related to severe resorption of the residual ridge.

Materials and methods

Population

The subjects studied were from a dental survey on 76-, 81-, and 86-year-olds, which was performed from 1990 to 1991 as a part of the Helsinki Aging Study (HAS) (37). A total of 293 elderly people who were living at home came to the Institute of Dentistry, University of Helsinki, for a questionnaire interview and an oral examination by dentists calibrated for the dental survey and for a radiographic examination. Of these, 46 elderly men and 139 elderly women ($n = 185$) with 1 or 2 edentulous jaws were included in the present study; 124 were edentulous in both the mandible and maxilla; 55 had only an edentulous maxilla, and 6 only an edentulous mandible. The rest ($n = 108$) of these elderly people were dentate in both the mandible and maxilla. 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 automatically in an RP X-Omat (Eastman Kodak, Rochester, N.Y., USA).

Assessment of residual ridge resorption

Four radiographs of subjects with an edentulous mandible and 11 of subjects with an edentulous maxilla

were excluded due to distortion of image or lack of radiologic images of anatomic landmarks; thus 177 subjects' radiographs—126 edentulous mandibles and 168 edentulous maxillas—were measured.

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 (38)) 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 (38)) on both sides).

Reductions in the heights of the mandible and maxilla were evaluated by comparison of the heights of the residual ridges with the 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 have been reported in our previous study (38).

Collection of variables studied

Data on the subjects' general condition, such as weight, height, alcohol intake, functioning in daily

living, and systemic disorders (history of bone fracture, thyroid disease, diabetes, hyperparathyroidism, heart failure, hypertension, and asthma) were obtained from the records of the medical examination of the HAS, in which the elderly underwent a structured interview by public-health nurses and a clinical examination on diseases by physicians (39). Information on tobacco smoking was obtained from the records of the dental survey. Data on the subjects' general condition and smoking were missing for some subjects, and the number of subjects for whom data were missing varied from 1 to 37 in different variables.

Variables used in the present studied were as follows: 1) age: 76, 81, or 86 years; 2) gender: 0 = male, 1 = female; 3) body mass index (BMI = weight/height²), in kg/m²; 4) alcohol intake: 0 = none or less than once/week, 1 = once/week or more; 5) tobacco smoking: 0 = no, 1 = yes (current smoker or former smoker); 6) functioning in daily living: 0 = independent (does not need any help in housework), 1 = dependent (needs help in housework or needs help both in housework and in activity of daily living); 7) diseases in relation to bone metabolism or diseases for treatment of which the medications used influence bone metabolism: bone fracture, diabetes, thyroid disease, hyperparathyroidism, asthma, heart failure, hypertension: 0 = no, 1 = yes (data for each of these disorders recorded separately); 8) average percentage reduction in the anterior and posterior regions of the edentulous mandible (mean = 44%, *s* = 14); average percentage of reduction in the posterior regions of the maxilla (mean = 12%, *s* = 11); and 9) severe reduction in the residual ridge: 0 = ≤53% reduction in the mandible or ≤15% reduction in the posterior maxilla (slight or moderate reduction), 1 = >53% reduction in the mandible or >15% reduction in the posterior maxilla.

Because the A measurement in the midline of the maxilla is relatively sensitive to head positioning (38, 40), effects of systemic factors on percentage reduction were analyzed only in the posterior maxilla. The cut-off points were determined on the basis of the distribution of the percentages of reduction and the number of subjects in each subgroup, so that the most significant factors could be found.

Statistics

All analyses were made with SPSS/PC+ Advanced Statistics software (version 5.0, SPSS Inc., Chicago, Ill., USA). The chi-square test was used to compare frequencies of two or more groups of categorical variables and the *t* test for testing the difference in means between genders. Associations between percentages of residual ridge reductions in the mandible and maxilla and the systemic variables were analyzed by means of multiple linear regression. Multiple logistic regression was performed to examine the associations between severe reduction in residual ridge and systemic

Table 1. Distribution of edentulous subjects by age, alcohol intake, smoking, dependence in daily living, and systemic diseases in relation to gender

	Men (<i>n</i> = 43)		Women (<i>n</i> = 134)		Total (<i>n</i> = 177)	
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Age						
76 years	20	46	62	46	82	46
81 years	18	42	40	30	58	33
86 years	5	12	32	24	37	21
Alcohol intake	12	28	57	43	69	39
Tobacco smoking	20	47***	26	19	46	26
Dependence in daily living	9	21	57	43*	66	37
Systemic diseases						
Bone fracture	17	40	54	40	71	40
Diabetes	9	21	22	16	31	18
Thyroid disease	0	0	26	19**	26	15
Hyperparathyroidism	0	0	3	2	3	2
Heart failure	4	9	46	34**	50	28
Hypertension	11	26	59	44	70	40
Asthma	4	9	8	6	12	7

Asterisks denote difference between men and women: **P* < 0.05; ***P* < 0.01; ****P* < 0.001.

variables. Each of the independent variables analyzed was adjusted for gender and age in both the linear and logistic regressions. In the statistical evaluation of the estimated regression coefficients, the *t* test was used in the linear regression analysis, whereas the Wald statistic (chi-square) was applied in the logistic regression analysis.

Results

Table 1 shows the distribution of age, alcohol intake, tobacco smoking, dependence in daily living, and systemic diseases in relation to gender. Elderly women needed help in housework and suffered from heart failure more frequently than elderly men. Thyroid disease and hyperparathyroidism were found only in women. The percentage of smokers was greater among men than among women.

The mean body mass index was 25.7 kg/m² (*s* = 4.1), 26.1 kg/m² (*s* = 4.0) for men and 25.6 kg/m² (*s* = 4.0) for women. The difference between men and women was not statistically significant.

For the edentulous mandible, significant associations were found between percentage reduction in the residual ridge and female gender (*P* < 0.001) when adjusted for age and duration of edentulousness (Table 2). The other variables studied were not significantly related to percentage reduction. No significant variable for percentage reduction was found in the edentulous maxilla.

In multiple logistic regression analysis female gender was associated with severe reduction in the mandibular residual ridge, with an odds ratio of 4.5 (95%

Table 2. Multiple linear regression analysis of percentage of reduction in residual ridge† and systemic variables, adjusted for age and gender

Independent variable	Category	Edentulous mandible			Edentulous maxilla		
		n§	Coefficient	s _e	n§	Coefficient	s _e
Gender‡	Male = 0	31	11.0***	3.3	40	1.0	2.3
	Female = 1	95			128		
Body mass index	Kg/m ²	114	-0.5	0.3	149	0.1	0.2
Alcohol intake	<Once/week = 0	70	-4.8	2.7	88	-2.1	1.8
	≥Once/week = 1	46			67		
Tobacco smoking	No = 0	82	0.2	2.9	113	1.1	2.0
	Yes = 1	38			46		
Functioning in daily living	Independent = 0	75	-1.3	2.7	103	0.02	1.9
	Dependent = 1	50			61		
Bone fracture	No = 0	44	-1.4	2.8	66	0.9	1.8
	Yes = 1	57			68		
Diabetes	No = 0	106	0.3	3.5	135	3.1	2.6
	Yes = 1	19			31		
Thyroid disease	No = 0	97	-0.7	3.7	126	-2.1	2.5
	Yes = 1	18			26		
Hyperparathyroidism	No = 0	116	17.7	9.8	155	-3.1	6.6
	Yes = 1	2			3		
Heart failure	No = 0	89	-5.4	2.9	116	3.4	2.0
	Yes = 1	35			47		
Hypertension	No = 0	72	-4.2	2.6	100	-1.8	1.8
	Yes = 1	52			65		
Asthma	No = 0	116	6.4	5.0	152	-1.9	3.3
	Yes = 1	8			12		

† Percentage reduction in the anterior and posterior heights of the edentulous mandible: mean = 44%, s = 14, median = 45%; percentage reduction in the posterior heights of the edentulous maxilla: mean = 12%, s = 11, median = 13%.

‡ Adjusted for age and duration of edentulousness.

§ Total number varies due to missing values.

*** P < 0.001.

confidence interval (CI), 1.2–17.1) (Table 3). Asthma was the only systemic disease related to severe reduction in the mandibular residual ridge, with an odds ratio of 6.0 (95% CI, 1.3–28.2). In the maxilla severe reduction in the residual ridge was inversely related to alcohol intake (odds ratio, 0.4; 95% CI, 0.2–0.9, after adjustment for gender, age, and body mass index). Severe reduction in the maxillary residual ridge was more often found in the elderly who drank no alcohol or drank less than once per week than in those who drank once per week or more. No significant association was found between severe resorption and other variables in the mandible and maxilla.

In both the linear and logistic regression analyses female gender, after adjustment for all other variables, still showed significantly positive association with the mandibular resorption.

Discussion

The findings of this cross-sectional study showed that asthma was significantly related to a large amount of RRR in the mandible and that an inverse significant correlation existed between alcohol intake and severe reduction in the maxilla. Our findings on the association

of asthma and alcohol intake with residual ridge resorption appear to be the first such reported.

In asthmatic patients the prevalence of bone fracture and of bone mineral density has been investigated (41–43). Use of corticosteroids is an important approach in the treatment of asthma (42). It is well known that corticosteroids are implicated in bone loss (7, 26, 28). Adinoff & Hollister (41) found no evidence of rib or vertebral fractures in the non-steroid-treated asthmatic subjects, in contrast to a fracture prevalence of 11% in asthmatics who had received steroids for at least 1 year. Packe et al. (42) have used quantitatively computed tomography to study asthmatic patients. Compared with asthmatic patients who had never taken either inhaled or systemic corticosteroids, those patients who had taken high-dose inhaled corticosteroids and continued with low-dose systemic corticosteroids had a significant reduction in vertebral bone density. In a study on patients with chronic obstructive pulmonary disease, Napal et al. (43) found, by using double-energy X-ray absorptiometry, a 12% decrease in bone mineral density in the spine and a 7% decrease in the neck of the femur in patients treated with corticoids. Studies both of bone histomorphometry and of markers of bone metabolism showed glucocorticoids had suppressed bone formation (44).

Table 3. Multiple logistic regression analysis of severe reduction in residual ridge (SRRR)* and systemic variables (only significant ($P < 0.05$) variables given)

Independent variable	No. of subjects with SRRR	No. of subjects without SRRR	Odds ratio	95% confidence interval	<i>P</i>
Edentulous mandible					
Gender†					
Male = 0	4	27	—		
Female = 1	32	63	4.5	1.2–17.1	0.030
Asthma‡					
No = 0	41	85	—		
Yes = 1	5	3	6.0	1.3–28.2	0.025
Edentulous maxilla					
Alcohol intake§					
<Once/week = 0	46	42	—		
≥Once/week = 1	24	43	0.4	0.2–0.9	0.026

* >53% reduction in height of mandible; >15% reduction in height of maxilla.

† Adjusted for age and duration of edentulousness.

‡ Adjusted for age and gender.

§ Adjusted for age, gender, and body mass index.

In the present study a greater amount of resorption in the mandible was found in the elderly with asthma than in those without asthma, and therefore the asthmatic patients' records of medications used and duration of edentulousness were checked. All the asthmatic patients with an edentulous mandible were at present being treated with corticosteroids and had on average a 31- to 40-year experience of edentulousness. In subjects without asthma the average duration of edentulousness was 36–45 years. Use of corticosteroids was probably the factor that explains the association of asthma with severe resorption in the mandible. Bone mineral density of the buccal cortex in the edentulous mandible has been found to be related to the mineral density in the femoral neck and in the lumbar spine (19), and corticosteroid-induced bone loss may therefore involve the mandible (45). In addition to the general influence of corticosteroids on bones, it was suspected that the special administration in asthmatic patients, by means of inhaled corticosteroids, had resulted in a local effect on the jawbones. That bone cells have glucocorticoid receptors makes it possible that glucocorticoids act directly on osteoblasts and suppress bone formation (44).

Recent studies have indicated that alcohol use is not a risk factor for hip fracture in subjects who are more than 65 years old (46) or are postmenopausal women (47) and that moderate alcohol intake might even increase bone mass (30, 48, 49). In postmenopausal women the serum concentration of estradiol (synthesized presumably in peripheral tissues from estrone) has been found to correlate positively with alcohol intake (30). Alcohol increases circulating estrogens by inducing the adrenal

production of androstenedione and increasing peripheral conversion of androstenedione to estrone (50). That estrogens have the effect of suppressing bone resorption is well known (21). Furthermore, Rico (51) has shown that calcitonin secretion increases after acute alcohol intake. Calcitonin inhibits the function of osteoclasts and decreases bone resorption. Moderate alcohol intake with the effect of increasing circulating estrogens and increasing calcitonin secretion might to some extent protect the bone structure.

The lack of association of alcohol intake with RRR in the edentulous mandible might be due to the difference in bone structure from that of the maxilla. The maxilla has a thicker trabecular bone and a thinner cortex and a better blood supply than in the mandible. The mandible may thus be less sensitive to the effect of alcohol intake than the maxilla.

In the present study female gender was shown to be a major risk factor for mandibular atrophy and to affect residual ridge resorption in the mandible independently. The most likely explanation of this finding might be the effect of estrogen deficiency after menopause (12, 14–18). The rate of bone loss due to estrogen deficiency decreases 5–10 years after menopause, and bone loss continues slowly with increasing age (52). RRR is cumulative and irreversible, and the strong relationship between residual ridge resorption and female sex is therefore still obvious even in elderly subjects more than 75 years old. This finding is in agreement with the study of de Baat et al. (24).

Because of image distortion or lack of radiologic images of anatomic landmarks, 15 edentulous jaws were not measured on radiographs. Of four subjects with an edentulous mandible (one man and three women), one asthmatic patient had a severely resorbed mandible, the mandibular canal at the top of the crest of the residual ridge; one asthmatic patient and two subjects without the disease had the crest of the residual ridge above the mental foramen and the mandibular canal. In 11 subjects with an edentulous maxilla (6 men and 5 women), 2 drank alcohol once a week or more and 3 had asthma; 5 subjects had the crest of the residual ridge below the bottom of the maxillary sinus, and in 6 the crest was approximately at the level of the bottom of the maxillary sinus. If the dropped cases were included using the criteria for determining severe resorption (the crest of the residual ridge being approximately at the level of the mental foramen and the crest being approximately at the level of the bottom of the maxillary sinus), the results of logistic regression analyses were similar to those already presented. The systemic factors—female gender, asthma, and alcohol intake—were still significantly related to severe resorption of the residual ridge. Therefore, these dropped cases would not greatly influence the significant findings of this study.

The association of RRR with other factors (duration of edentulousness, number of complete dentures worn,

quality of current denture) will be reported in a separate article on the same series of elderly subjects.

We conclude that, in the edentulous elderly, asthma is a risk factor for severe resorption in the mandibular residual ridge due to use of corticosteroids for treatment of asthmatic patients; alcohol intake might be related to the lesser extent of resorption of the maxillary residual ridge; female gender is a major factor resulting in mandibular atrophy.

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