Posterior Mandibular Residual Ridge Resorption in Patients with Conventional Dentures and Implant Overdentures

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Purpose: *This study investigated the effects of certain systemic and local factors on resorption of the posterior mandibular residual ridge under conventional dentures and overdentures supported by 2 implants.* ***Materials and Methods:*** *Proportional area measurements of the posterior mandible were made on rotational tomograms taken immediately before and 5 years after treatment. The area was bounded by a line joining gonion to the lowest point of the mental foramen and the crest of the residual ridge and was expressed as a proportion of an area that was not dependent on the ridge. The use of proportions rather than actual measurements minimized errors related to magnification and distortion.* ***Results:*** *The estimated average reduction in height was 1.25 mm in 5 years (1.63 mm for conventional denture groups and 0.69 mm for implant overdenture groups, ie, almost 1 mm less in the overdenture group).* ***Discussion and Conclusion:*** *Female gender was a risk factor for greater resorption. Other factors, such as the number of years a patient had been edentulous, initial height of the mandible, and the number of dentures used, failed to show an association with resorption of the residual posterior mandibular ridge, while the statistically significant effect of age was unlikely to be clinically significant.* (INT J ORAL MAXILLOFAC IMPLANTS 2003;18:447–452)

Key words: *alveolar process, bone resorption, complete denture, dental implants, endosseous dental implantation, mandible, overdenture*

A primary objective of prosthodontics is the preservation of remaining tissues. However, after the extraction of natural teeth, a phase of extensive remodeling follows, which usually results in some loss in the height of the residual ridge. Great individual variation in the degree of residual ridge resorption has been reported among different patients and even in the same person at different times and sites.[1–3]

The success of removable prostheses relies greatly on the quantity and architecture of the jawbones. Remodeling sometimes leads to a situation wherein there is no longer sufficient retention, stability, and support for the proper functioning of complete dentures. In addition, in the patient with extensive ridge atrophy, the dentist often has to cope with problems of appearance and habituation.[4,5] Residual ridge atrophy also has psychologic and economic effects that must be considered.[6]

Even when mandibular atrophy does not interfere with the potential for implant placement, a residual ridge with reasonable dimensions can be a significant advantage for the success of an implant overdenture. Implant stabilization of complete dentures is often employed on the basis of the improvement in retention, stability, and support provided for the patient. Consequently, the role of dental implants in the maintenance of remaining oral tissues needs to be confirmed. There has been considerable research on ridge resorption, which has implicated a number of local and systemic factors. In the present study, however, the significance of

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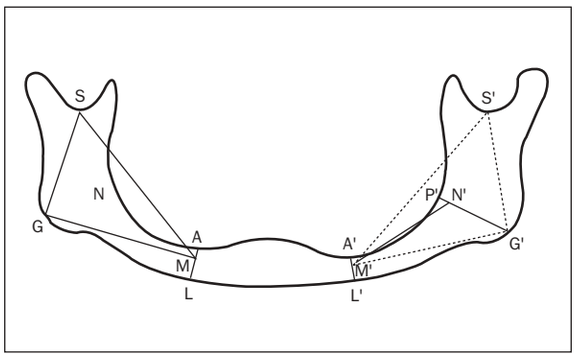

Fig 1 The anatomical landmarks M, M' (lower border of mental foramen); S, S' (sigmoid notch); and G, G' (gonion) were used to construct the triangles M-S-G and M'-S'-G' with centers N and N', respectively. Boundary lines were constructed as follows: M-G and M'-G', A-L and A'-L' (crest of residual ridge to lower border of mandible perpendicular to M-G and M'-G'), M-N and M'-N', and G-P and G'-P' (G-N and G'-N' extended to the crest of the residual ridge at P and P').

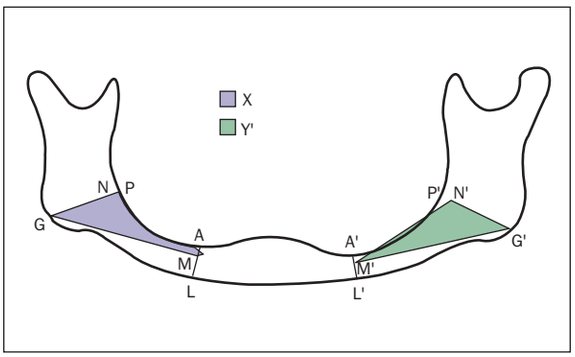

Fig 2 The areas were defined as follows: X and X' by the crest of the residual P-A and P'-A' and the boundary lines A-M and A'-M', M-G and M'-G', and G-P and G'-P', respectively; and Y and Y' by the triangles M-G-N and M'-G'-N', respectively. The Posterior Area Index was calculated from (X/Y + X'/Y')/2.

some factors is investigated using a large population and attempting to control some of the confounding factors. The working hypothesis was that patients treated with overdentures supported by 2 implants placed between the mental foramina presented less resorption of the posterior mandibular ridge in comparison with patients treated with conventional dentures.

MATERIALS AND METHODS

The study population consisted of approximately 150 edentulous patients who attended the Department of Oral and Maxillofacial Surgery and Maxillofacial Prosthodontics of University Hospital, Groningen, The Netherlands. Patients were divided into 5 groups (number of patients in each group differed) according to height of the edentulous mandibular ridge and the surgical and prosthetic treatment modalities employed for their rehabilitation. Rotational tomograms were obtained from all patients immediately before and 5 years after treatment. Mandibular ridge height was measured at the midline of the radiographs.

- Patients in group I had mandibular ridge height not exceeding 15 mm and were treated with 2 endosseous implants and an overdenture.
- Patients in group II had mandibular ridge height not exceeding 15 mm and were treated with a conventional complete denture.
- Patients in group III had mandibular ridge height between 15 and 25 mm and were treated with 2 endosseous implants and an overdenture.
- Patients in group IV had mandibular ridge height between 15 and 25 mm and were treated with labial vestibuloplasty and a conventional complete denture.
- Patients in group V had mandibular ridge height between 15 and 25 mm and were treated with a conventional complete denture.

The 2 implants were connected by a rigid bar, and the overdentures were connected to the bar with clips. Patients in groups II, IV, and V were given the option to change to an implant-retained prosthesis after 1 year if they were not satisfied with their conventional denture.

The method consisted of proportional area measurements of the posterior mandible similar to that used by Wright and Watson.[7] The areas were bounded by a line joining gonion to the lowest point of the mental foramen and the crest of the residual ridge and were expressed as a proportion of areas that are not dependent on the ridge. The use of proportions minimized errors related to magnification and distortion. The landmarks were traced from the radiographs and digitized (Figs 1 and 2).

To estimate the clinical significance of the results in the present study, because the values of the Posterior Area Index (PAI) at 0 years were always around 1, it was possible to approximately consider the values of the change as the percent reduction of the initial PAI. Taking into account that the posterior area at 0 years was on average 500 mm^2, the area difference could be estimated by multiplying the average initial area with the value of the change in PAI. Then approximate changes in height could be calculated by dividing the average initial area by the

Table 1 Descriptive Statistics of the Study Population

Group	No. of radiograph pairs	Gender (M/F)	Age		Years edentulous		No. of dentures worn	
			Mean	Range	Mean	Range	Mean	Range
I	18	2/16	52	36–72	23	5–38	3	1–7
II	8	2/6	60	49–69	29	19–36	2	1–4
III	21	11/10	55	31–76	18	1–36	2	1–5
IV	15	8/7	55	36–70	21	5–39	2	1–4
V	11	6/5	49	35–60	19	2–33	2	1–4
Total	73	29/44	54	31–76	22	1–39	2	1–7

average length of the posterior residual ridge, which was approximately 40 mm.

Before the main study was initiated, a pilot study was conducted to test the repeatability of results and the way they were affected by the quality of radiographs. Ten radiographs (1 pair from each group) were selected, as they were of varying quality and the visibility of the points involved in the study was not always clear. These radiographs were measured 10 times on 10 separate occasions using the method of the main study. For the repeatability error to be measured, the standard deviation and coefficient of variation were estimated for each set of repeated measurements. The coefficient of variation was found to range between 1.2% and 5%, with the smaller variation being associated with clear visibility of the points to be traced. It was concluded that for radiographs with clear visibility of all points, changes greater than the previously established threshold (± 0.04)[8,9] could be attributed to the change in height of the residual ridge. Therefore, before the main study all radiographs were examined carefully, and only those in which all the main points to be traced were clearly visible were selected. This resulted in 73 pairs of radiographs that were suitable for the study as shown in Table 1.

Data analysis included descriptive and analytic statistics.

RESULTS

The descriptive statistics of the study population are shown in Table 1.

The change in the PAI was calculated for each patient by subtracting the PAI at 5 years from the PAI at 0 years. Therefore, positive values indicated resorption, and negative values indicated an increase in the area of posterior residual ridge or the bone apposition. Results for the various groups are shown in Table 2. The value of the change in PAI that was previously established as the threshold for bone resorption was 0.04.[8,9] The means of the change in the PAI for the implant and the conventional denture patients were compared using a paired *t* test. The difference was highly significant ($P < .0001$).

Table 2 Change in Posterior Area Index (PAI) for Each Group

Group	Mean change in PAI	SD	Minimum PAI	Maximum PAI
I	0.06	0.09	–0.12	0.24
II	0.11	0.06	0.02	0.19
III	0.05	0.06	–0.03	0.16
IV	0.16	0.09	0.02	0.37
V	0.13	0.07	–0.02	0.22

The avereage change in the PAI in all groups was well above the value of 0.04 that was determined as the threshold for bone resorption. It is also obvious that the implant groups (I and III) demonstrated much less resorption (mean 0.055, range –0.12 to 0.24) compared with the conventional denture groups (II, IV, and V) (mean 0.135, range –0.02 to 0.37).

Multiple linear regression analysis was adopted. Results were adjusted for the potential confounding factors: gender, age, years edentulous, number of dentures worn, and initial ridge height of the mandible. The next step was to test for interaction between variables in the model. Since this showed there was no statistically significant interaction between gender, age, and initial ridge height of the mandible, the results were presented for the whole group (Table 3).

Calculations of the approximate changes in posterior mandibular residual ridge height resulted in an estimated loss of height of 1.25 mm in 5 years for all groups. Estimated loss was 1.63 mm for the conventional denture groups and 0.69 mm for the implant-stabilized overdenture groups, which was almost 1 mm less ($P < .001$).

Female patients presented more residual ridge resorption than male patients, regardless of their group. A male patient in this study was likely to lose 7.5% less bone (0.9 mm in 5 years) than a female

Table 3 Results of Linear Regression Analysis Over 5 Years

Variable	Coefficient	SE	*t*	*P*	95% CI
Age	–0.001	0.000	–2.029	.046	–0.003 to 0.000
Gender	0.071	0.017	3.996	.000	0.003 to 0.107
Time edentulous	–0.001	0.000	–1.224	.225	–0.003 to 0.000
No. of dentures worn	0.007	0.078	0.923	.360	–0.008 to 0.022
Small jaw height	–0.029	0.019	–1.502	.138	–0.067 to 0.009
Implant	–0.088	0.016	–5.229	.000	–0.122 to –0.054

SE = standard error; CI = confidence interval.

patient of the same age and implant status ($P < .0001$). Older age was also significantly associated with reduced resorption ($P < .05$). However, the very small reduction in resorption (0.1% in 5 years) would not be clinically significant. The number of years edentulous, the number of dentures worn, and the initial ridge height of the mandible failed to show a significant effect on the amount of posterior mandibular residual ridge resorption recorded.

DISCUSSION

The method used in the present study has been reported in other studies.[8,9] It was introduced by Wilding and coworkers,[9] who also estimated the error of the method. They compared the measurements taken from dry mandibles with the measurements taken from radiographs of the same mandibles. For radiographic measurements, the mandibles were repositioned so that extreme positions of the subject were simulated. They concluded that when differences between successive observations exceeded 4%, such differences could be attributed to bone resorption.

Jacobs and associates[8] investigated the variability of results when 2 separate examiners were employed. A paired *t* test revealed no significant difference between duplicate measurements. The authors established a threshold for detecting bone resorption that was identical to that proposed by Wilding and coworkers (0.04).

The values for resorption in the present study are in agreement with the classic studies of edentulism. Considering the fact that at the beginning of the study the average time that the patients had been edentulous was 22 years, the average reduction of 1.25 mm over 5 years is almost the same as the results found by Tallgren.[10]

One of the studies that can be directly compared with the present study is that of Jacobs and associates.[8] The authors used a similar method to measure resorption in patients who were similar to those examined in the present study. However, Jacobs and associates generally reported higher resorption rates for the similar overdenture patients, even though they had much shorter observation times (24 months for the overdenture patients and 12 months for the complete denture patients, on average). They also found higher resorption rates for the overdenture patients who had been edentulous for less than 10 years before implant placement, compared with conventional denture wearers.

The different results between the 2 studies may be explained by the differences in the groups of subjects employed for each. One difference was the status of the opposing arch. In the study by Jacobs and associates,[8] 14% of the patients had implant-supported maxillary prostheses or some natural maxillary teeth remaining, which may be associated with enhanced posterior bone loading and therefore greater resorption. In addition, Jacobs and associates reported "moderate bone quality and resorption," which is a very subjective phrase. However, in the present study there were patients with varying degrees of bone quality and resorption. Other parameters that may account for the above differences could be prosthetic factors and the philosophy of denture fabrication. The absence of relevant information did not permit identification of these parameters.

Another radiologic study that investigated the same problem was that of Sennerby and colleagues.[11] They used linear measurements at standard sites, along with area measurements, on cephalometric radiographs. Their results are generally in agreement with the results of the present study. For the complete denture group, they reported residual ridge resorption that was always statistically significant, although there was great individual variation. For the implant overdenture group, they reported small, statistically insignificant changes posterior to the most distal implants. Instead, resorption was reported to be higher in the symphysis region.

Sennerby and colleagues also reported on the effect of duration of edentulism on ridge resorption. For the patients with complete dentures, they found resorption to be more pronounced during the first 2 years after tooth extraction, with great individual variation. Resorption in all implant overdenture patients was reported to be minimal, so there seemed to be no effect of time. For patients with conventional dentures, the present study could not report on the resorption rates immediately after extraction of natural teeth, since most of the patients had been edentulous for many years (22 on average) before the study was conducted. As a result, the 2 studies are not directly comparable. However, the findings of the present study suggest that the time a patient has been edentulous is not associated with the amount of reduction of the posterior residual ridge. Even if resorption was more pronounced immediately after extraction, apparently after a few years and because of the action of other confounding factors, the effect of time was not significant. This is in agreement with other studies.[12,13]

For patients with implant-supported overdentures, both in this study and the study of Sennerby and colleagues,[11] it is suggested that their use reduced resorption of the posterior residual ridge. Sennerby and colleagues reported that all implant overdenture patients presented bone resorption that was minimal and not statistically significant. This was independent of time edentulous and denture-wearing experience, as well as the status of the opposing arch. In some of their implant overdenture patients, there were natural teeth in the opposing arch, but resorption was still not significant, even though their observation period was generally longer than in the present study (5 to 13 years). The difference from the present study was that Sennerby and colleagues reported almost no resorption distal to the implants.

Prosthetic factors could be responsible for the differences. However, it is not yet clear under which clinical conditions differences in loading of the ridge, frequency of relining, or occlusal parameters could account for differences between 2 studies measuring residual ridge resorption. The very small number of implant patients employed in the study of Sennerby and colleagues (7 implant patients for each group) may also account for the lack of significant findings.

One of the conclusions of the present study was that gender was a major factor influencing mandibular atrophy. Nevertheless, it is difficult to determine how critical this difference could be from a clinical standpoint in individual patients. Several authors have considered female gender a risk factor for greater residual ridge resorption.[14–16] Possible explanations for this include the longer life expectancy of women, as well as the influence of hormonal factors. However, the former could not account for the difference in this study, since female patients were not significantly older than male patients. In addition, an absence of information on the age of menopause prevented further investigation of the effect of hormonal factors. The significant effect of age on the amount of resorption is also unlikely to be clinically significant.

Another factor investigated in this study was the number of dentures used. Results suggested that a history of many dentures worn would not necessarily be associated with high rates of residual ridge resorption. This is in line with the results of Harrison.[17] This also implies that frequent denture replacement may be done for reasons other than discomfort and instability related to the atrophic ridge. Conversely, Xie and coworkers[2] reported that the number of mandibular dentures worn was a significant factor for severe resorption. However, there is still the question of whether frequent replacement was the cause or the result of severe resorption, since patients with mandibular atrophy are more likely to be unhappy with their dentures and seek new dentures more frequently.

To explain the differences in ridge resorption between conventional denture and implant overdenture patients, loading patterns for both designs must be considered. Surprisingly, little is known about the exact nature of force distribution under the conventional mandibular complete denture. Most studies are concerned with stress distribution around the implants, and the way in which the presence of implants affects loading patterns of the edentulous ridge is still not known. As yet there is no method to measure stresses in bone, and stress values that suggest bone "overloading" and "suboptimal" bone loading need to be defined. For skeletal bones, it is known[18] that preservation is better with dynamic events of short duration than with those that are applied over long periods. However, it is not clear whether these concepts could be related to the phenomenon of residual ridge reduction.

With implant overdentures, especially when implants have a vertical orientation, the generated stresses are apparently lower and symmetrically distributed around the implants. For this implant orientation, only when a posterior load is applied is there an increased proportion of the load distributed to the ridge.[19]

Also, depending on biomechanical factors,[20,21] bone areas adjacent to the implants might be more favored. One should expect that reduced resorption

rates with implant-supported overdentures could be attributed to the less unfavorable loading of bone adjacent to the implants and the protection of the residual posterior ridge from excessive loading, which is inversely proportional to the distance from the implant. This is in agreement with the study of Sennerby and colleagues,[11] which reported resorption to be minimal adjacent to the implants and more pronounced posteriorly. However, the mechanism of this favorable effect is still not well understood and becomes even more complicated if one considers that occlusal forces are higher in the case of implant overdentures. Although it is difficult to explain the lower resorption rates using current knowledge, it seems that excessive force is not unfavorably transferred to the posterior residual ridge. Further investigation is therefore required for this to be confirmed.

CONCLUSIONS

Under the conditions of this investigation it can be concluded that:

- The method successfully measured small changes in the area of the residual posterior mandibular ridge.
- Average ridge height reduction for complete denture wearers was 1.63 mm in 5 years.
- Average ridge height reduction for implant overdenture patients was 0.69 mm in 5 years, almost 1 mm less than that seen in the conventional denture patients.
- Female gender is a risk factor for greater residual posterior mandibular ridge resorption.
- Age showed a significant association with residual posterior mandibular ridge resorption, but the size of the effect was unlikely to be clinically relevant.
- The number of years a patient has been edentulous failed to show an association with resorption of the posterior residual mandibular ridge.
- The initial height of the mandibular ridge failed to show a significant association with resorption of the posterior mandibular ridge.
- The number of dentures a patient has worn failed to show a significant association with resorption of the residual posterior mandibular ridge.

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