To evaluate the relationship between the complaints of complete denture wearers and alveolar bone resorption as well as the location of mental foramina, 96 patients were interviewed. All subjects had received new dentures at the University of Iowa between August 1985 and July 1990. Panoramic radiographs had been made for all the subjects before dentures were fabricated. The amount of estimated ridge resorption correlated significantly with the number of years females had been edentulous, but no correlation was found in males. The location of the mental foramen in relationship to the crest of residual ridge correlated negatively with the number of years both genders were edentulous. Subjective need for dental treatment, as expressed by “sore gums” or poor or fair chewing ability, were the most frequent complaints among the subjects. These complaints were more often recorded with the subjects who had lost more than 50% of their estimated original ridge height than with those with less than 50% resorption, but this difference was not significant. Int J Prosthodont 1997;10:183–189.
maxillary cysts, and maxillary sinus mucosal thickening were also recorded. All 335 patients who had received new complete maxillary and mandibular dentures between August 1985 and July 1990 were identified. It was found that 260 subjects were available for this investigation. The inclusion criteria for this study were that the subjects had a telephone, were cognitively able to answer questions over the telephone, and were willing to participate in the study. Fourteen subjects declined to participate, and four were dropped because they were hospitalized or cognitively impaired (Table 1). A pilot study was performed to develop and test the questionnaire, and 20 subjects participated in this two-phase part of the study. The structured questionnaire consisted of 40 questions about general and oral health, tooth loss, oral hygiene, and denture wear habits, as well as specific subjective complaints associated with the wearing of complete dentures. The questionnaire, which was given during a 20-minute telephone interview, was completed in 1995 by 135 subjects, 61% of all the available subjects.

Between 1985 and 1990, all subjects were screened with panoramic radiography before new dentures were fabricated. For this portion of the study, all subjects who had completed the interview and who had been clinically edentulous before fabrication of their complete dentures were identified. Persons who receive immediate dentures often require more adjustment appointments than experienced complete denture patients, and therefore all immediate denture patients were dropped from this study (n = 39). The remaining 96 persons were the subjects of this study, and their ages and gender are shown in Table 2.

It was found that 66% of the radiographs were made using an OP 10 (Siemens Medical Systems, Iselin, NJ), and 3% were made using a Panorex (S. S. White, Philadelphia, PA). The following radiographic findings were recorded: retained roots, unerupted teeth, abnormalities in the maxillary sinuses, and radiopacities including those suggestive of carotid calcifications. The height of the mandible in the mental foramen area (a) was measured. The distances between the lower border of the foramen to the residual ridge crest (b) and from the lower border of the mandible to the lower border of the foramen (c) were recorded on both the left and right sides of the radiographs. The measurements were made with a transparent plastic millimeter ruler in a darkened room over a light viewer. The ruler was placed across the image of the mandible, perpendicular to the horizontal axis of the body of the mandible. The ratio between the amount of bone above the mental foramen and the height of the mandible in the mental foramen area (b/a) was calculated to study the mental foramen location relative to the residual ridge crest (Fig 1). The amount of resorption was estimated according to the method described by Wical and Swoope. The original height of mandible was predicted to be three times the amount of bone below the lower border of mental foramen (3 × c). The amount of bone loss was calculated by subtracting the thickness of mandible from the predicted bone height (3 × c - a), after which the percentage of bone loss was calculated as:

\[(\frac{3 \times c - a}{3 \times c}) \times 100\%\]

All radiographs were examined at the same time by two investigators, one of whom was a trained oral and maxillofacial radiologist. All measurements were made by one examiner. To study intraexaminer reliability, the 18 radiographs that
were the most difficult to measure were reexamined after 1 week. The difficulties in measurement included the ability to locate the mental foramen or the residual ridge crest. It was possible to perfectly match 42% of the original measurements, and 36% of the readings differed by 1 mm. The remainder of the second readings differed by 2 to 3 mm from the original readings (one reading differed by 6 mm). The Kappa value of these repeated readings reached only 0.29. However, it should be remembered that only the most difficult radiographs were selected for reevaluation.

The amount of ridge resorption was studied in terms of gender, age, and the number of years since becoming edentulous. Subjects were categorized into three different groups according to the amount of bone loss: group 1 = bone loss < 30%; group 2 = bone loss between 30% and 50%; and group 3 = bone loss > 50%. Each group approximated one third of the subjects. The frequency of subjective complaints was analyzed between the subjects whose bone loss was more than 50% (n = 31) and those whose bone loss was less than 50% (n = 65).

The patients were further divided into one of the three groups according to the location of the mental foramen relative to the residual ridge crest expressed as a ratio: group 1 = ratio < .34 (n = 33); group 2 = ratio between .35 and .49 (n = 34); and group 3 = ratio > .50 (n = 29). Subjects in groups 2 and 3 were pooled (n = 63), and the frequency of their subjective complaints was compared to the frequencies of complaints among the subjects in group 1 (n = 33).

**Statistical Analysis**

Statistical analysis was performed using the SAS System (SAS Institute, Cary, NC). The Student's t test was used to evaluate the differences in mean values between two groups of subjects. The amount of resorption and the location of mental foramen were correlated with each other, with age, and with the number of years of edentulism using the Pearson correlation coefficient analysis. Chi-square analysis was used to study the association among several categorized independent variables.

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**Fig 1** Panoramic radiograph of a 72-year-old woman, edentulous for 10 years before the radiograph was made. During the interview she reported that her major complaints were "sore gums and poor chewing ability." The following measurements were made on all the radiographs and are presented here as vertical lines designated as: a = height of the mandible; b = amount of bone above the lower border of the mental foramen; and c = amount of bone below the lower border of mental foramen. 3 x c = predicted original bone height; and b/a = the location of mental foramen in relationship to the crest of the bone.
Table 3  Radiographic Findings Among the Study Population

<table>
<thead>
<tr>
<th>Finding</th>
<th>Men (n = 35)</th>
<th></th>
<th>Women (n = 61)</th>
<th></th>
<th>Total (n = 96)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>Percentage</td>
<td>n</td>
<td>Percentage</td>
<td>n</td>
<td>Percentage</td>
</tr>
<tr>
<td>Root fragments</td>
<td>3</td>
<td>9</td>
<td>8</td>
<td>13</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>Unerupted teeth</td>
<td>4</td>
<td>11</td>
<td>1</td>
<td>2</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Cysts (maxillary)</td>
<td>2</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Maxillary sinus mucosal</td>
<td>4</td>
<td>11</td>
<td>5</td>
<td>8</td>
<td>9</td>
<td>9</td>
</tr>
</tbody>
</table>

Table 4  Edentulous Years, Amount of Bone Resorption, and Location of Mental Foramina in the Study Population (Left and Right Sides Combined)

<table>
<thead>
<tr>
<th>Gender</th>
<th>Edentulous years</th>
<th>Amount of resorption</th>
<th>Location of mental foramina*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (±SD)</td>
<td>Mean % (±SD)</td>
<td>Mean (±SD)</td>
</tr>
<tr>
<td>Men</td>
<td>20.8 (±15.1)</td>
<td>39.5 (±16.9)*</td>
<td>0.41 (±0.15)*</td>
</tr>
<tr>
<td>Women</td>
<td>23.9 (±12.4)†‡</td>
<td>40.1 (±17.4)†‡</td>
<td>0.40 (±0.15)‡</td>
</tr>
</tbody>
</table>

* = Amount of bone above mental foramina/thickness of the mandible.
† = Significant negative correlation between the variables (r = -0.34, P < .05).
‡ = Significant negative correlation between the variables (r = -0.28, P < .03).
§ = Significant correlation between the variables (r = 0.34, P < .007).

Table 5  Subjective Complaints Related With Denture Wearing Among the Study Population

<table>
<thead>
<tr>
<th>Complaint</th>
<th>Men</th>
<th></th>
<th>Women</th>
<th></th>
<th>All</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>Percent</td>
<td>n</td>
<td>Percent</td>
<td>n</td>
<td>Percent</td>
</tr>
<tr>
<td>Needs treatment</td>
<td>16</td>
<td>48</td>
<td>17</td>
<td>28</td>
<td>33</td>
<td>34</td>
</tr>
<tr>
<td>Sore gums</td>
<td>12</td>
<td>34</td>
<td>16</td>
<td>26</td>
<td>28</td>
<td>29</td>
</tr>
<tr>
<td>Sore TMJ</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>5</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Mouth ulcers</td>
<td>3</td>
<td>9</td>
<td>4</td>
<td>7</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Chewing ability</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>fair</td>
<td>9</td>
<td>26</td>
<td>17</td>
<td>28</td>
<td>26</td>
<td>27</td>
</tr>
<tr>
<td>poor</td>
<td>3</td>
<td>9</td>
<td>3</td>
<td>5</td>
<td>6</td>
<td>6</td>
</tr>
</tbody>
</table>

Results

Root fragments were the most common radiographic finding and were present in 11% of the subjects. Maxillary sinus mucosal thickening was found in 9% of the subjects, maxillary mucous retention cysts in 2%, and unerupted teeth were found in 5% of the subjects (Table 3). The radiographic appearance of sinus mucosal thickening is suggestive of maxillary sinusitis. Unerupted teeth were more often found in men (11%) than in women (2%); however, this difference was not significant.

All radiographic measurements significantly correlated between the left and right sides of the mouth and were therefore grouped together for final analysis. The amount of resorption correlated significantly with the number of years women were edentulous (r = 0.34, P < .007), but no significant correlation was observed in men. The amount of resorption was not correlated with the age of the subjects. The ratio that described the location of mental foramen in relationship to the residual ridge crest was negatively correlated with the amount of bone resorption in both genders (in women: r = -0.28, P < .03; and in men: r = -0.34, P < .005) (Table 4).

A subjective need for dental treatment was reported by 46% of the men and 28% of the women. "Sore gums" was the most frequent subjective complaint among the participants (34% of men and 26% of women). All other complaints that are often associated with ill-fitting dentures were relatively uncommon among the present study population. The frequencies of different subjective complaints are presented in Table 5.

Frequency of subjective complaints in terms of the amount of bone resorption and the location of mental foramen are presented in Figs 2 and 3. The subjective need for treatment, soreness of the denture-bearing tissues, and poor or fair chewing ability were more frequently reported by the subjects with greater than 50% resorption than subjects with less than 50% resorption, but the difference was not significant. The same trend was observed when these symptoms were analyzed in terms of the location of mental foramen in relationship to the residual ridge crest.

The subjects whose bone loss was greater than 50% averaged 3.6 adjustment appointments after receiving new dentures. The corresponding figure was 2.9 for those with less than 50% bone loss. The difference was not significant.
Discussion

This study population consisted of patients who had been treated in the Department of Prosthodontics of the University of Iowa between August 1985 and July 1990. Therefore the study population can not be considered as a representative sample of complete denture patients in Iowa. In some of the patients, the time between the interview and fabrication of dentures was relatively long (10 years). The usual life of complete dentures is 5 to 10 years, and most of the denture wearers would be expected to have problems by the time of the interviews. It was not clear, however, how unsatisfactory anatomy (gross resorption and the location of mental foramen on the top of the alveolar ridge) affected dissatisfaction. Despite the long period of time between denture fabrication and the interview, the response rate in this study was high (61%), illustrating the stability of the population. Most of the subjects were elderly, however, one third of the patients were under 65 years of age at the time of treatment.

The radiographic findings were in agreement with the previous reports of edentulous patients in industrialized countries.\(^\text{10-12}\) The number of root fragments observed was higher in earlier radiographic studies compared to more recent ones.\(^\text{6,7}\) The use of panoramic radiographs as a part of diagnosis for dental patients has increased during the last two decades, making the diagnosis of root fragments much easier. This may explain the decreasing number of root fragments in the more recent studies.

However, the number of unerupted teeth has remained relatively constant over the years. Most unerupted teeth are third molars, and if they are asymptomatic and if no pathologic changes exist and the teeth are completely covered by bone, there is no indication for extraction. Thus, even if unerupted teeth are identified on radiographs, no effort may be made to remove them. This is obviously the reason why unerupted teeth are found as frequently in recent studies as they were a few decades ago.

The amount of residual ridge resorption was significantly correlated with the number of years females were edentulous, but this relationship was not found in males. Interestingly, in neither gender was the age of the subject significantly correlated with the amount of resorption. These findings are in agreement with previous reports.\(^\text{14-17}\) Ridge resorption has been found to increase after menopause.\(^\text{18,19}\) Most of the female subjects in the present study were past the usual age for menopause, and this may explain the gender-related difference observed in this study.

According to the interview, 34% of the subjects indicated that they needed dental treatment. The most common complaint was pain in the denture-bearing tissues, which was recorded for one third of the subjects, and one third of the subjects complained of poor or fair chewing ability. No significant associations were found between the subjects' complaints and radiographic findings. However, the subjects who had lost more than 50% of supporting bone more frequently reported a need for...
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Dental treatment than did those whose bone loss was less than 50%. Painful denture-bearing tissues and poor or fair chewing ability was also more often reported by the subjects with more extensive bone loss. The lack of statistical significance may have resulted from the small sample size.

In their study, Hirai and coworkers estimated bone loss with the same method used in this study. They also did not find any significant differences between the age of the subjects and the height of mandibular residual ridge. However, they concluded that the masticatory ability of complete denture wearers decreased significantly with increasing age.

The fit of complete dentures is determined by the size of the denture-supporting area, the anatomy and function of the craniofacial muscles, and the wearer's neuromuscular ability to cope with their dentures. The retention and stability of complete dentures are significantly improved if the denture-supporting area is increased (surgically, for example). Progressive ridge resorption decreases the denture-supporting area, but these changes are slow, and many persons who have worn complete dentures for a long period of time have become very skilled in manipulating their dentures. Therefore, some of these patients may not be aware of the poor fit of their dentures until the loss of supporting area is so great that subjective symptoms occur. This may be one reason the number of complaints was not significantly related to the loss of bone height in this study.

Although textbooks state that the location of the mental foramen on the top of the residual ridge can cause problems for persons wearing complete dentures, it was not possible to find any reports on the frequency of these symptoms. Among our study population the location of mental foramen in relationship to ridge crest at the time of denture fabrication was not significantly associated with the subjects’ complaints. However, the same trend was noted as was discussed above with alveolar bone resorption. Ridge resorption is reported to be very rapid during the first year after extraction and continues progressively throughout the patient’s life. There is, however, a very large interindividual difference in the rate of resorption, and several nutritional and physiologic factors may influence it. In most patients resorption progresses slowly, allowing enough time for the mental nerves and vessels to adapt to anatomic changes in the mental foramen area. Postmortem studies may give more information about how the soft tissue changes in relation to alveolar bone anatomy.

It has been reported previously that clinical variables are not related to patients’ satisfaction with their complete dentures. Also, according to the results of this study, it seems that the radiographic changes in bone quantity and the location of mental foramen prior to the denture fabrication are not very reliable predictive factors for the patients’ future subjective complaints. It should be borne in mind that the subjects in this study were not actively seeking treatment for their complaints, but were interviewed by telephone. It may be that the patients who did not want to participate were more dissatisfied with their dentures than were the participants. The findings in this study do not in any way question the diagnostic value of panoramic radiographs in planning prosthetic reconstruction for edentulous patients.

Conclusions

Ninety-six patients from an original group of 335 patients who had received complete maxillary and mandibular dentures between 1985 and 1990 were evaluated in an attempt to correlate residual ridge height relative to the mental foramen and patients’ denture complaints. Within the limitations of the number of subjects and the period of time between denture fabrication and the study, the following conclusions may be made:

1. Denture complaints increased with increased residual ridge resorption.
2. Increased ridge resorption was associated with the increased time of edentulousness in women but not in men.

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