Clinical, cephalometric, and densitometric study of reduction of residual ridges

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The reduction of residual ridges (RRR) is a major unsolved oral disease which causes physical, psychologic, and economic problems for millions of people all over the world. RRR is a chronic, progressive, irreversible, and disabling disease, probably of multifactorial origin. The relative importance of various cofactors is not known. Until more is known about its etiology, the ultimate goal of control or prevention of RRR will be delayed.

Certain characteristics of the reduction of residual ridges make research difficult. RRR is almost universal but with wide individual variations. Hence, what is important is the amount. However, since the amount is cumulative, a single examination does not reveal the current rate. Since the rate is slow, lengthy longitudinal studies are required. Since the rate can change, repeated readings at intervals are required to reveal changes in rate.

Research is made more complex by the facts that several cofactors seem to be of importance, not all cofactors are easily measured, and not all possible cofactors are even being considered at the present stage of knowledge.

As in many clinical studies, it is difficult to control all variables. This problem increases geometrically with the number of possible variables and human subjects.

SUBJECTS

Ambulatory clinic patients who were available and willing to return for follow-up examination were the subjects of this study. A standardized medical and dental history was taken on each subject; recording was done with a simple number code.

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Fig. 1. The numbers of patients subdivided both by order of maxillary ridge form and by the time period since the maxillary anterior teeth were extracted.

Fig. 2. The numbers of patients subdivided both by order of mandibular ridge form and by the time period since the mandibular anterior teeth were extracted.
In addition, maxillary and mandibular casts were constructed, and extraoral and intraoral photographs were made to record the clinical findings.

This report is on 76 subjects (44 women and 32 men) with a mean age of 65.2 years (S.D. 10.0; range 38 to 87 years). Patients were not selected to represent only one period of time postextraction and can be subdivided as follows:

<table>
<thead>
<tr>
<th>Time postextraction</th>
<th>Maxillary anterior</th>
<th>Mandibular anterior</th>
</tr>
</thead>
<tbody>
<tr>
<td>less than 6 months</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>½—2 years</td>
<td>17</td>
<td>10</td>
</tr>
<tr>
<td>2—10 years</td>
<td>19</td>
<td>16</td>
</tr>
<tr>
<td>10—20 years</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>over 20 years</td>
<td>25</td>
<td>18</td>
</tr>
</tbody>
</table>
The anterior ridge forms of these subjects as determined on the cephalometric radiographs can be classified as follows:

<table>
<thead>
<tr>
<th>Ridge order (cmx)</th>
<th>Maxillary anterior</th>
<th>Mandibular anterior</th>
</tr>
</thead>
<tbody>
<tr>
<td>III, high well-rounded</td>
<td>52</td>
<td>18</td>
</tr>
<tr>
<td>IV, knife-edge</td>
<td>16</td>
<td>42</td>
</tr>
<tr>
<td>V, low well-rounded</td>
<td>7</td>
<td>11</td>
</tr>
<tr>
<td>VI, depressed</td>
<td>1</td>
<td>5</td>
</tr>
</tbody>
</table>

If one correlates ridge order with time postextraction, it is observed that 68 per cent of the maxillary anterior ridges were Order III (high well-rounded) including 50 per cent of those over 20 years postextraction (Fig. 1). In contrast to this, 54 per
Fig. 5. A density curve is derived from plotting the optical density of the radiographic image of the thirteen steps of the aluminum penetrometer, and it is used to convert observed optical density readings to millimeters of aluminum.

percent of mandibular anterior ridges were Order IV (knife-edge) while only 24 percent were Order III; of these, 80 percent were 2 years or less postextraction (Fig. 2).

The reasons for extraction of the anterior teeth were given by each subject, and therefore, may be somewhat unreliable data but may be listed as follows:

<table>
<thead>
<tr>
<th>Reason for extraction</th>
<th>Maxillary anterior</th>
<th>Mandibular anterior</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caries</td>
<td>41</td>
<td>38</td>
</tr>
<tr>
<td>Periodontal disease</td>
<td>22</td>
<td>29</td>
</tr>
<tr>
<td>Unknown</td>
<td>9</td>
<td>3</td>
</tr>
<tr>
<td>Injury</td>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>

DENTURES

The dentures were made by undergraduate dental students under close supervision of the clinical staff to an acceptable level of quality. A standardized prosthetic
Fig. 6. Optical density was measured at 24 selected bony sites to obtain various measures of the bone density of each subject.

evaluation was recorded with a simple number code. The dentures had resin bases and zero-degree resin teeth. All subjects except one had an interocclusal distance when the mandible was in rest position. Retention and stability were rated "good" or "excellent" in most of the dentures. The occlusal plane was either flat or had a slight Monson curve. Most patients could be guided to a position that was more retruded than their habitual occlusal position. All patients except two were adapted to their dentures, and all but four wore their dentures at least eight hours per day.

CEPHALOMETRIC AND DENSITOMETRIC PROCEDURES

For each subject, two lateral cephalometric radiographs, one without dentures and one with dentures in occlusion, were made by using standard cephalometric equipment (Wehmer Cephalostat) and technique at approximately yearly intervals.

In addition, it was desirable to get some measure of the bone density of each subject. Radiographic densitometry requires strict adherence to standardized procedures of exposure, subject positioning, and film processing, all of which are standard procedures in cephalometric radiography. A method was devised for combining cephalometry and densitometry. On the lower right-hand face of the 8" x 10" cassette, a precision milled 12 step aluminum step wedge, 20 x 96 mm., was affixed with each step adding a 3 mm. increment in height for a total of 36 mm. (Fig. 3). A thirteenth step consisted of 2 mm. of lead supported by 2 mm. of alumi-
num. As a result, every cephalometric radiograph has an image of the step wedge (Fig. 4). This provides a standard for comparison of densitometric measurements made on each film, utilizing a Macbeth Quantalog Densitometer (EP-1000). By constructing a density curve for each film, it is possible to convert observed optical density readings of selected bony points to millimeters of aluminum (Fig. 5). This was done for each subject at 24 sites including the frontal bone, hard palate, maxillary and mandibular residual ridges, mandibular cortical bone, hyoid bone, and the body of the second vertebra—all of which appear on the cephalometric radiographs (Fig. 6).

The measure of RRR used in this study is anterior vertical bone loss. While it is possible to measure bone area with a planimeter, this technique has shown results similar to those obtained with anterior vertical bone loss.

Anterior vertical bone loss of the maxillary ridge plus that of the mandibular ridge give the total anterior vertical bone loss. For each subject, the bone loss is divided by the number of months and multiplied by 12 to give the rate of residual reduction in millimeters per year. In this study, the time lapse averaged 31 months or slightly over 2½ years, varying from 18 to 50 months.
FINDINGS

1. The rate of RRR varied between different individuals (Fig. 7). The rate of RRR was not measurable in 18 of the 76 individuals (23 per cent), while in 15 subjects (20 per cent) the rate of RRR was 1 mm. per year or more. The highest rate, which occurred in an individual studied over 3 years, was 2.2 mm. per year (0.1 mm. per year in the maxillae; 2.1 mm. per year in the mandible).

2. The rate of RRR varied between the upper and lower jaw (Fig. 8). For the maxillary anterior ridge, the mean RRR was 0.0079 mm. per month (S.D. 0.0134), or 0.1 mm. per year (range was 0 to 0.7 mm. per year). For the mandibular anterior ridge, the mean RRR was 0.0346 mm. per month (S.D. 0.035), or 0.4 mm. per year (range was 0 to 2.0 mm. per year). For the total of the maxillary and mandibular anterior ridges, the mean rate of RRR was 0.0425 mm. per month, or 0.5 mm. per year (range was 0 to 2.2 mm. per year).

Thus, the average rate of RRR for the 76 subjects was four times greater on the mandible than on the maxillae. While 67 per cent (51 subjects) had no measurable RRR in the maxillae, only 30 per cent (23 subjects) had none on the mandible. On the other hand, 9 per cent (7 subjects) had a higher rate on the maxillae than on the mandible, while the rate was the same on the upper and lower jaws in 26 per cent (20 subjects).

3. There was a low correlation between the rate of RRR and any one of several possible cofactors. As can be shown diagrammatically on distribution graphs, there was a wide generalized distribution for each factor following a pattern similar to
the over-all distribution (Fig. 7). For example, a distribution bar graph categorized by sex (Fig. 9) shows a wide generalized distribution for men and women above and below the over-all median line. Such wide generalized distribution is seen for (1) anatomic factors, such as the order of the anterior residual ridge, the height of the anterior part of the residual ridge, and the density of the anterior part of the residual ridge, (2) biologic factors, such as sex (Fig. 9), age (Fig. 10), relation to menopause (Fig. 11), mean density of 24 points (Fig. 12), and primary reason for the extraction of the teeth (Fig. 13), and (3) mechanical factors, such as average number of hours per day the dentures were worn, the interocclusal distance, retention, stability, and coincidence of centric occlusion and centric relation. No single factor was found to have a high correlation with the rate of RRR. However, there were some suggestive trends worthy of further study. For example: sex (slightly higher rate in men, Fig. 9); age (slightly higher rate in younger subjects, Fig. 10); time postextraction (slightly higher rate in those nearer extraction, Fig. 14); hours per day dentures were worn (slightly higher rate with longer wear, Fig. 15); interocclusal distance (slightly higher rate with larger distance); coincidence of centric occlusion with centric relation (slightly higher rate with lack of coincidence). None of these trends were strong, and there are notable exceptions in each direction with every characteristic.

Fig. 9. Rate of RRR (total) vs. sex.
DISCUSSION

Although this study is limited in scope, it illustrates certain premises about the reduction of residual ridges.

1. In this random group of clinic patients where there were varying times since extraction, a high proportion of maxillary ridges (68 per cent) were high and well rounded (Order III), including 50 per cent of those 20 years or more after extraction (Fig. 1). In contrast to this, only 24 per cent of the mandibular ridges were classified as high and well-rounded, and of these, 80 per cent were 2 years or less postextraction (Fig. 2). These findings are consistent with the findings of this study which indicated a rate of RRR fourfold greater on the mandible than that on the maxillae. There appears to be a more rapid progression from “high well-rounded” to “knife-edge” to “low well-rounded” to “depressed” on the mandible than on the maxillae.

2. The low correlation between the rate of RRR and several possible factors in this heterogeneous group does not prove that any of these factors may not be of importance in any one subject, for there may be many causes of RRR—one operating in some subjects, another in others, and so on. In a possibly analogous situation, osteoporosis may be caused by an excess of either thyroid hormone, parathyroid hormone, or cortisone (among other causes). In studying a heterogeneous group of patients with osteoporosis, a low correlation with excess thyroid would not prove that excess thyroid cannot cause osteoporosis. Research in RRR is at an early stage, and much more definitive studies than this will be necessary to determine the etiology of RRR.
3. A high correlation between the rate of RRR and any of these factors would not prove a causal relation. For example, any possible higher rate in younger subjects may not be due to age per se, but rather it might be related to time postextraction. Nor does a high correlation show which is cause and which is effect. For example, poor denture stability and/or retention could be either the cause or the effect of a high rate of RRR (Fig. 16). Because of the multiplicity of possible factors, elimination of controllable factors and multifactorial statistical analysis of a larger group of subjects would be desirable. Comparisons of such studies done in different parts of the world could well give epidemiologic data which would be helpful in determining the etiology of the reduction of the residual ridge.

4. No correlation was found between rate of RRR and bone density as determined by the method described—either for the average density of 24 points (Fig. 12) or for the density of any one point such as the crest of the mandibular ridge (Fig. 17). Although the validity of this method has been shown to be adequate, it is extremely time consuming, and meticulous care is necessary with many details. Newer and more sophisticated methods are promising and should be applied to the study of RRR.4
Study of reduction of residual ridges

Fig. 12. Rate of RRR (total) vs. mean density of 24 bony sites.

Fig. 13. Rate of RRR (mandible) vs. primary reason for extraction of mandibular anterior teeth.
Fig. 14. Rate of RRR (maxillae or mandible) vs. time postextraction.

Fig. 15. Rate of RRR (mandible) vs. average hours per day the mandibular denture was worn.
Study of reduction of residual ridges

Fig. 16. Rate of RRR (mandible) vs. retention and stability of mandibular dentures.

Fig. 17. Rate of RRR (mandible) vs. density of anterior mandibular ridges (site 14).
PRACTICAL SIGNIFICANCE

1. The average rate of anterior vertical RRR in these 76 subjects was 0.5 mm. per year. In ten years, this could represent an average loss of 5 mm. in anterior ridge height (considerably more in some patients) resulting in significant loss of occlusal vertical dimension, esthetics, and comfort. Such remarkable changes would inevitably necessitate repeated dental treatment in the average patient with complete maxillary and mandibular dentures.

2. Inasmuch as there are estimated to be 25 million totally edentulous people in America, chronic progressive RRR presents a staggering challenge to develop new methods of organizing the delivery of adequate prosthetic health care to all who need it. Because many of these patients are beyond 65 years of age and have limited income, the need far exceeds the demand.

3. New methods of prevention of RRR must be found, perhaps by seeking the research skills and experience of those from diverse disciplines who have never tackled the problem of RRR combined in a team approach with those who have.

4. However, until adequate preventive measures can be devised, new prosthetic materials and new methods of prosthetic treatment must be devised which will lower the unit cost yet maintain quality of service. For example, there is a great need for a biologically safe, esthetically pleasing, resilient denture relining material which will remain serviceable for at least five years and which can be professionally applied in the dentist's office in one visit at reasonable cost.

5. Because of the universality of oral diseases, many believe that the loss of teeth is the inevitable result of old age. However, modern dentistry is showing that the loss of teeth is the pathologic result of various oral diseases and trauma and that various treatment and preventive procedures can drastically reduce the loss of teeth. Similarly, many assume that RRR is an inevitable result of the loss of teeth. Yet this and other studies show that there is a wide variation in the amount and rate of RRR. Modern dentistry does not yet understand the causes of this major problem, nor has it performed research in this area with anywhere near the magnitude it has in other major areas. Much remains to be learned about this disease before adequate preventive and treatment procedures can be designed to attain the goal of control of this major oral disease.

SUMMARY

1. A clinical, cephalometric, and densitometric study of the reduction of residual ridges (RRR) was carried out on 76 edentulous clinic patients (44 women and 32 men) with a mean age 65.2 years (range of 38 to 87 years).

2. In this group of patients with varying periods of time since extraction, a high proportion of maxillary ridges were high and well rounded (Order III), including 50 per cent of those 20 years or more after extraction. In contrast, only 24 per cent of the mandibular ridges were classified as high and well rounded, and of these, 80 per cent were 2 years or less postextraction with 54 per cent classified as knife-edge (Order IV).

3. The rate of total anterior RRR varied between individuals, being immeasurable in 23 per cent and 1 mm. or more per year in 20 per cent. The highest rate
in one subject studied over 3 years was 2.2 mm. per year. The average rate was 0.5 mm. per year.

4. The rate of RRR varied between the upper and lower jaws averaging 0.1 mm. per year for the maxillae and 0.4 mm. per year for the mandible. Thus, the average rate for the lower jaw was four times that of the upper. Yet, 9 per cent of the subjects had a higher rate on the maxillae than on the mandible, while the rate was the same in 26 per cent.

5. There was a low correlation between the rate of RRR and several possible cofactors, including sex, age, and bone density.

6. An average rate of anterior vertical RRR of 0.5 mm. per year could represent an average loss of 5 mm. in anterior ridge height (considerably more in some patients) in 10 years, resulting in significant loss of vertical dimension, esthetics, and comfort. Such remarkable changes in millions of edentulous people represent a staggering need for prosthodontic care.

7. New methods of prevention and treatment of this disabling disease must be found.

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References