Morphological Investigation of Residual Ridge in Japanese Edentulous Elderly for Fabrication of Edentulous Stock Tray

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Abstract

The objective of this study was to determine the size of the residual ridge in edentulous elderly Japanese persons for preparation of edentulous stock trays and clarify any correlations among the items measured. The participants comprised 74 patients requesting construction of a complete denture for the maxilla, mandible, or both. The length, width, and anterior and posterior height of the maxillary and mandibular residual ridge was measured on a prepared working model using a caliper. For each of the maxillary and mandibular edentulous residual ridges, correlations among measurement items were analyzed employing Pearson’s correlation coefficient. In participants who were edentulous in both the maxilla and mandible, correlations between the maxillary and mandibular measurement items were analyzed employing Pearson’s correlation coefficient. The results revealed that the mean maxillary length of the residual ridge was 55.21 ± 4.07 mm, while mean mandibular length was 56.03 ± 4.04 mm. The mean posterior width of the maxillary jaw was 48.79 ± 4.14 mm, while that of the mandibular jaw was 57.33 ± 3.24 mm. A strong correlation was found between the length and width of the residual ridge in both the maxilla and mandible, but no strong correlation was detected between the height in the anterior tooth region and any other item measured. These findings suggest that the size of any given item can be estimated by measuring either the length or width of the residual ridge when selecting a stock tray. We also propose that it is necessary to prepare stock trays with several different heights in the anterior tooth region, regardless of the length and width of the tray, or to adjust the length of the tray.

Key words: Edentulous — Morphology — Residual ridge — Elderly

Introduction

Many countries have an aging population, as can be seen in the increasing number of elderly persons in those locations. The demand for large dentures, such as complete dentures, is likely to increase as this trend continues. Taking an impression of the eden-
tulous residual ridge is very important in securing retention and support when constructing a complete denture. Generally, obtaining a precise impression with an individual tray is performed after preliminary impression taking using a stock tray. The use of such an individual tray with its more appropriate morphology allows more accurate impression taking. Therefore, the role of the preliminary impression is also important due to the necessity of accurately reproducing the structure and landmarks of the residual ridge. To obtain the appropriate preliminary impression, it is desirable that the stock tray used fits the size and morphology of the residual ridge as much as possible. This means it is necessary to determine the size and morphology of the residual ridge in order to establish the required tray morphology.

When a natural tooth is lost, alveolar bone is resorbed and the maxillary and mandibular residual ridges show specific individual changes. This makes investigation of the morphological characteristics of the edentulous residual ridge important, and various investigations aimed at this were performed in the 1970s. After the 1990s, implant overdenture treatment in edentulous persons also became an option, necessitating reinvestigation of the morphology of edentulous residual ridges. Many of these earlier studies focused on the residual ridge in Caucasians. The residual ridge in many Japanese people is smaller, however, due to the brachycephalic head shape usually found in that population, compared to that in many Caucasians, who typically have a dolichocephalic head shape. Therefore, application of foreign-made stock trays in Japanese patients was shown to be inappropriate in some cases.

Some studies therefore investigated the morphology of the residual ridge in Japanese patients at that time, which led to the development of stock trays suitable for this particular population.

Recently, the aging of the Japanese population has been progressing quickly. At the same time, however, much effort has been put into promoting the conservation of natural teeth, which should limit the amount of alveolar bone resorption that accompanies the aging process. It has been reported that the width of the alveolar ridge decreases with aging in the natural dentition, however, and that the width and length of the dental arch decreased. Even among edentulous individuals, there are many cases of severe absorption of the residual ridge, which may result in change in its morphology. Therefore, it may be necessary to re-investigate the morphology of the residual ridge in edentulous individuals in the current super-aging society.

The objective of this study was to determine the size of the residual ridge in edentulous elderly Japanese persons for preparation of edentulous stock trays and clarify any correlations among the items measured.

Materials and Methods

1. Participants

The participants comprised 74 patients who visited the Department of Prosthodontics at Tokyo Dental College Suidobashi Hospital requesting construction of a complete denture for both the maxilla and mandible, or maxilla or mandible alone (37 men and 37 women; mean age, 77.9 ± 8.6 years). The protocol of this study was approved by the Ethics Committee of Tokyo Dental College (approval no: 890). All experiments were performed in accordance with the Edinburgh Revision of the Declaration of Helsinki. Written informed consent was obtained from all participants.

2. Preparation of working cast

Working casts obtained from the participants were used for measurements. The working casts were prepared as follows. Firstly, a preliminary impression was taken using a stock tray and alginate impression material. Dental plaster (Capstone DF, Shofu, Kyoto, Japan) was then poured to prepare the study cast. Each individual tray was prepared on the study cast and the final impression taken
using a silicone rubber impression material after border molding with an impression compound. The dental plaster was poured to prepare a working cast. Impression taking was performed by prosthodontists with 3 years or more experience.

3. Measurement of residual ridge

Measurement points were set on the prepared working cast. The measurement items on the residual ridge described below were measured using a caliper (YDM, Tokyo, Japan). Bilateral points were measured for items with bilateral measurement points. The following measurements were performed by 3 trained dentists:

Maxillary measurement items (Figs. 1a and 1b)

(a) Maxillary length: distance between the most anterior point of the incisive papilla and Hamular notch.
(b) Maxillary posterior width: distance between the bilateral Hamular notches.
(c) Maxillary maximum width: distance between the most buccal points of the bilateral maxillary tubercles.
(d) Maxillary anterior height: distance between the highest point of the incisive papilla and lowest point of the gingivolabial fold straight down from the incisive papilla.
(e) Maxillary posterior height: distance between the highest point of the maxillary tubercle and lowest point of the gingivolabial fold straight down from the maxillary tubercle.

Mandibular measurement items (Figs. 1c and 1d)

(f) Mandibular length: distance between the most anterior point of the residual ridge on the median line and the posterior margin of
the retromolar pad.

(g) Mandibular posterior width: distance between the centers of the bilateral retromolar pads.

(h) Mandibular anterior height: distance between the highest point of the residual ridge on the median line between the bilateral sides and lowest point of the gingivolabial fold straight down from the residual ridge.

(i) Mandibular posterior height: distance between the posterior margin of the retromolar pad and lowest point of the junction with the oral floor.

4. Statistical analysis

Bilateral differences in the maxillary/mandibular length and maxillary/mandibular posterior height were analyzed using the paired $t$-test. For each of the maxillary and mandibular edentulous residual ridges, correlations among the items measured were determined using Pearson’s correlation coefficient. In participants who were edentulous in both the maxilla and mandible, correlations between the maxillary and mandibular measurement items were determined using Pearson’s correlation coefficient. A level of 0.05 was considered significant. Statistical analysis was performed using SPSS software for Windows, version 25 (IBM Corp., Armonk, NY, USA).

Results

1. Results for measurement items

Among the total number of participants in whom measurements were made, 33 were edentulous in both the maxilla and mandible; 27 were edentulous in the maxilla alone; and 14 were edentulous in the mandible alone. The results for the items measured in the maxillary edentulous residual ridge obtained in 60 participants, and those in the mandibular edentulous residual ridge in 47 participants are shown in Table 1.

Bilateral differences in maxillary/mandibular length and maxillary/mandibular posterior height measured bilaterally were analyzed using the paired $t$-test, but no significant difference was found ($p = 0.108$, $p = 0.625$, $p = 0.385$, and $p = 0.353$, respectively). Thus, the value obtained on the right side for each measurement item was used in the analysis below.

Mean maxillary length was $55.21 \pm 4.07$ mm, while mean mandibular length was $56.03 \pm 4.04$ mm, which was almost the same.

| Measurement Item                     | Minimum (mm) | Maximum (mm) | Median (mm) | Mean (mm) | SD (mm) |
|-------------------------------------|--------------|--------------|-------------|-----------|---------|
| Maxillary length right              | 46.50        | 66.00        | 55.70       | 55.21     | 4.07    |
| Maxillary length left               | 46.00        | 64.00        | 54.75       | 54.80     | 3.91    |
| Maxillary posterior width           | 40.50        | 61.00        | 48.45       | 48.79     | 4.14    |
| Maxillary maximum width             | 49.10        | 77.00        | 60.60       | 61.11     | 6.59    |
| Maxillary anterior height           | 0.90         | 14.00        | 8.00        | 7.81      | 2.89    |
| Maxillary posterior height right    | 2.00         | 17.00        | 10.05       | 10.54     | 3.21    |
| Maxillary posterior height left     | 1.60         | 16.00        | 10.80       | 10.36     | 3.15    |
| Mandibular length right             | 47.70        | 65.00        | 56.00       | 56.03     | 4.04    |
| Mandibular length left              | 49.20        | 69.00        | 56.50       | 56.40     | 4.40    |
| Mandibular posterior width          | 50.00        | 64.00        | 57.00       | 57.33     | 3.24    |
| Mandibular anterior height          | 0.30         | 12.10        | 6.00        | 5.63      | 3.25    |
| Mandibular posterior height right   | 8.00         | 30.00        | 16.00       | 16.21     | 5.13    |
| Mandibular posterior height left    | 7.50         | 30.00        | 16.50       | 16.58     | 4.46    |
In contrast, mean maxillary posterior width was 48.79 ± 4.14 mm, while mean mandibular posterior width was 57.33 ± 3.24 mm, showing a larger value in the mandible.

2. Results of analysis of correlations among measured values

The results of the analysis of correlations among the measured items of the maxillary residual ridge are shown in Table 2. A significant positive correlation was found between maxillary length and maxillary posterior width ($r = 0.851$, $p = 0.000$) and between maxillary length and maxillary maximum width ($r = 0.873$, $p = 0.000$). Significant positive correlations were also found between maxillary posterior height and maxillary length; between maxillary posterior height and maxillary posterior width; and between maxillary posterior height and maxillary maximum width ($r = 0.404$, $p = 0.001$; $r = 0.345$, $p = 0.005$; and $r = 0.416$, $p = 0.001$, respectively). However, maxillary anterior height showed no significant correlation with maxillary length, maxillary posterior width, and maxillary maximum width ($r = 0.190$, $p = 0.129$; $r = 0.078$, $p = 0.535$; and $r = 0.127$, $p = 0.314$, respectively). A weak correlation was found between maxillary anterior height and maxillary posterior height ($r = 0.293$, $p = 0.018$).

The results of the analysis of correlations among the measured values in the mandibular residual ridge are shown in Table 3. Similar to in the maxilla, a significant positive correlation was found between mandibular length and mandibular posterior width ($r = 0.850$, $p = 0.000$). Significant positive correlations were also found between mandibular posterior height and mandibular length, and between mandibular posterior height and mandibular posterior width ($r = 0.470$, $p = 0.000$; and $r = 0.368$, $p = 0.007$, respectively). However, mandibular anterior height showed no significant correlation with mandibular length and mandibular posterior width ($r = 0.136$, $p = 0.335$; $r = 0.193$, $p = 0.169$, respectively). Additionally, no significant correlation was found between mandibular anterior height and mandibular posterior height ($r = 0.151$, $p = 0.284$).

The results of the analysis of correlations among the items measured in the maxilla and mandible in participants edentulous in both are shown in Table 4. Strong positive correlations were found between maxillary length and mandibular length or posterior width ($r = 0.909$, $p = 0.000$; and $r = 0.902$, $p = 0.000$, respectively); between maxillary posterior width and mandibular length or posterior width ($r = 0.869$, $p = 0.000$; and $r = 0.874$, $p = 0.000$, respectively); and between maxillary maximum width and mandibular length or posterior width ($r = 0.798$, $p = 0.000$; and

Table 2 Results of analysis of correlation among the measurement items of the maxillary residual ridge

|                              | Maxillary posterior width | Maxillary maximum width | Maxillary anterior height | Maxillary posterior height |
|------------------------------|---------------------------|-------------------------|---------------------------|----------------------------|
| Maxillary length             | Correlation coefficient (r) | 0.851**                 | 0.873**                  | 0.190                      | 0.404**                    |
|                              | p value                   | 0.000                   | 0.000                    | 0.129                      | 0.001                      |
| Maxillary posterior width    | Correlation coefficient (r) | 0.820**                 | 0.078                    | 0.345**                    | 0.005                      |
|                              | p value                   | 0.000                   | 0.535                    | 0.005                      |                            |
| Maxillary maximum width      | Correlation coefficient (r) |                         | 0.127                    | 0.416**                    | 0.001                      |
|                              | p value                   |                         | 0.314                    |                            |                            |
| Maxillary anterior height    | Correlation coefficient (r) |                         |                         | 0.293*                     |                            |
|                              | p value                   |                         |                         |                            | 0.018                      |

**: p < 0.01, *: p < 0.05, n = 60
In contrast, the correlations between the maxillary and mandibular anterior heights and between the maxillary and mandibular posterior heights

### Table 3: Results of analysis of correlation among the measurement items of the mandibular residual ridge

|                      | Mandibular posterior width | Mandibular anterior height | Mandibular posterior height |
|----------------------|---------------------------|---------------------------|---------------------------|
| Mandibular length    | Correlation coefficient (r) | 0.850**                   | 0.156                     | 0.470**                   |
|                      | p value                   | 0.000                     | 0.335                     | 0.000                     |
| Mandibular posterior width | Correlation coefficient (r) | 0.193                     | 0.368**                   |
|                      | p value                   | 0.169                     | 0.007                     |
| Mandibular anterior height | Correlation coefficient (r) | 0.151                     |
|                      | p value                   | 0.284                     |

**: p<0.01, n=47

### Table 4: Results of analysis of correlation among the measurement items in subjects edentulous on both maxillary and mandibular jaws

|                      | Maxillary posterior width | Maxillary maximum width | Maxillary anterior height | Mandibular posterior width | Mandibular anterior height | Mandibular posterior height |
|----------------------|---------------------------|-------------------------|--------------------------|---------------------------|---------------------------|---------------------------|
| Maxillary length     | Correlation coefficient (r) | 0.908**                 | 0.896**                 | 0.279                     | 0.476**                   | 0.909**                   | 0.902**                   | 0.164                     | 0.437**                   |
|                      | p value                   | 0.000                   | 0.000                   | 0.090                     | 0.003                     | 0.000                     | 0.324                     | 0.006                     |
| Maxillary posterior width | Correlation coefficient (r) | 0.852**                 | 0.179                     | 0.357*                    | 0.869**                   | 0.874**                   | 0.074                     | 0.376*                    |
|                      | p value                   | 0.000                   | 0.282                     | 0.028                     | 0.000                     | 0.659                     | 0.020                     |
| Maxillary maximum width | Correlation coefficient (r) | 0.216                   | 0.477**                   | 0.798**                   | 0.797**                   | 0.156                     | 0.379*                    |
|                      | p value                   | 0.193                   | 0.002                     | 0.000                     | 0.000                     | 0.351                     | 0.019                     |
| Maxillary anterior height | Correlation coefficient (r) | 0.420**                 | 0.358*                    | 0.318                     | 0.373*                    | 0.275                     |
|                      | p value                   | 0.009                   | 0.027                     | 0.051                     | 0.021                     | 0.095                     |
| Maxillary posterior height | Correlation coefficient (r) | 0.458**                 | 0.316                     | 0.096                     | 0.331*                    |
|                      | p value                   | 0.004                   | 0.053                     | 0.566                     | 0.031                     |
| Mandibular length     | Correlation coefficient (r) | 0.879**                 | 0.156                     | 0.464**                   |
|                      | p value                   | 0.000                   | 0.349                     | 0.003                     |
| Mandibular posterior width | Correlation coefficient (r) | 0.166                   | 0.391*                    |
|                      | p value                   | 0.321                     | 0.015                     |
| Mandibular anterior height | Correlation coefficient (r) | 0.258                     |
|                      | p value                   | 0.117                     |

**: p<0.01, *: p<0.05, n=33

$r = 0.797$, $p = 0.000$, respectively). In contrast,
were weak ($r = 0.373, p = 0.021$; and $r = 0.351$, $p = 0.031$, respectively).

**Discussion**

Border molding using individual trays was applied to the working casts used for measurement, as in clinical practice, which suggests that functional marginal positions and morphology were obtained. Border molding on the mandibular lingual side was performed in reference to the mylohyoid line. Mostly the same measurement points have been used to establish the width of the residual ridge in many previous studies, whereas the length of the median line has been used to measure the major axis.

However, the major axis is measured along the alveolar crest when a stock tray is selected in many cases. Therefore, in this study, the distance along the alveolar crest between the most anterior part of the incisive papilla and the origin of the Hamular notch was taken to represent maxillary length; and the distance between the most anterior part of the residual ridge on the median line between the bilateral sides and posterior margins of the retromolar pad was taken to represent mandibular length. The major axis cannot be simply compared with those in preceding studies because the measurement points used were slightly different. Regarding width, the measured values were smaller than those reported overseas in both the maxilla and mandible. In one Japanese study over 10 years ago, maxillary posterior width was $47.9 \pm 4.2$ mm, whereas it was $48.8 \pm 4.1$ mm in the present study. Mandibular posterior width was $55.7 \pm 3.3$ mm in the previous study, compared to $57.3 \pm 3.2$ mm in this study, showing a slightly higher value here. This apparent slight change in edentulous residual ridge morphology over the last 10 years suggests that re-investigation is necessary for fabrication of stock trays.

It has been clarified that the width, height, and palate plate area in an edentulous residual ridge are smaller than those in dentulous persons, and this has been suggested to be due to resorption of alveolar bone resulting in a decrease in height after tooth loss and the inward progression of maxillary bone resorption. In contrast, mandibular bone resorption progresses outward, suggesting that mandibular width increases in cases with advanced bone resorption. In the present study, the measured posterior width was larger in the mandible than in the maxilla, suggesting age-related bone resorption.

Regarding correlations among the items measured, a strong positive correlation was found between the length and width of the residual ridge in both the maxilla and mandible. Similar findings were reported in a preceding study, which suggested that the length or width could be estimated by measuring either the width or length of the residual ridge in selecting a stock tray. In contrast, although residual ridge height showed a correlation with the length and width of the residual ridge in the posterior region, no correlation was found in the anterior tooth region. This may be because residual ridge height in the anterior tooth region is likely to be influenced by bone resorption, while that in the molar region is markedly influenced by the original alveolar ridge size. In the participants who were edentulous in both the maxilla and mandible, a strong positive correlation was found between maxillary length and width and between mandibular length and width, suggesting that the tray size of the one can be estimated from that of the other in preliminary impression taking. However, measured height in the anterior tooth region varied greatly, and no strong correlation with any other item measured was found. Therefore, it may be necessary to prepare stock trays with several different heights in the anterior tooth region, regardless of the length and width of the tray, or to adjust the length of the tray by thoroughly confirming the fit of the anterior region during trial.

In conclusion, the mean maxillary length of the residual ridge was $55.21 \pm 4.07$ mm and mean mandibular length was $56.03 \pm 4.04$ mm, which was almost the same. In contrast, the mean posterior width in the maxilla
was 48.79 ± 4.14 mm, while that of the mandible was 57.33 ± 3.24 mm, showing a larger value in the latter.

A strong correlation was found between the length and width of the residual ridge in both the maxilla and mandible, but no strong correlation was found between the height in the anterior tooth region and any other item measured.

**Conflict of Interest**

The authors report no conflict of interest directly relevant to the content of this article.

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