

## Research Article

# Investigation of Methods for Measuring Mandibular Complete Denture Retention

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**Abstract**

**Purpose:** We aimed to clarify the effect of different measurement sites on the retention of maxillary complete dentures and to determine the optimal site and loading method for evaluating retention. The factors associated with mandibular complete denture retention are unclear; thus, a retention evaluation method has not been established. We investigated measurement methods and the optimal site by using a model to establish a retention measurement method for mandibular complete dentures.

**Method:** We manufactured complete resin dentures, based on normal methods used for edentulous mandibular models. We fabricated a covering splint to measure the denture surface. We set four points (A–D) for the measurement sites. We measured retention after filling the space between the denture mucosal surface and the model with four types of intervening saliva.

**Results:** All four types of intervening saliva could be measured only when measuring site A traction and the downward pressure on the fenestrations. Both conditions had a strong positive correlation ( $r = 0.94$ ,  $P < .01$ ). At site A, there was no significant difference in the measurement values with pressure exerted at  $45^\circ$  and at  $23^\circ$ , which indicated a positive correlation ( $r = 0.73$ ,  $P < .01$ ).

**Conclusion:** Mandibular complete denture retention can be measured by applying oblique downward pressure on the occlusal plane at the mandibular central incisor midpoint.

## INTRODUCTION

With the onset of a super aging society, the number of elderly people in Japan will increase and the number of years denture wearers live will increase. Therefore, the number of intractable cases which has difficulty in denture treatment is predicted to increase, including severe mandible bone resorption and age-related changes in mandibular position [1-3] and the onset of xerostomia [1,4-6]. Several factors reduce denture retention. High-quality complete denture treatment is needed because complete denture treatment significantly affects the quality of life of elderly people [1,2,7-10].

In the past, much research has focused on the factors that affect denture retention. Östlund [11,12] reported that denture retention conditions differ depending on the intervening saliva layer between the residual ridge and the mucosal surface of the denture base. Furthermore, several reports exist concerning the effect of saliva characteristics and oral moisturizers on denture retention [13-16]. In late years the new method of fabricating milled CAD-CAM dentures is established, and a study on retention is accomplished [17].

Therefore, we conducted research focusing on maxillary

complete denture retention. We developed a new retention measuring device for objectively assess ingretention [18], and we previously reported chair-side evaluation methods for the optimal sites and loading methods for measuring denture retention [19]. When we investigated the effect of the viscosity of oral moisturizers and the shape of the residual ridge on the retention of maxillary complete dentures, we found that denture retention increased as the viscosity of the oral moisturizer increased, and retention was correlated with the relative position of the anterior alveolar crest rather than the form of the molar residual ridge [20-22].

As indicated previously, information related to maxillary complete denture retention is just beginning to be clarified, but few reports exist on mandibular complete dentures. Furthermore, no gold standard method has been established for measuring the retention of mandibular complete dentures. We therefore investigated measurement methods and the optimal site for measurements by using a model to establish a method for measuring mandibular complete denture retention.

## MATERIAL AND METHODS

We assessed normal wearers of complete dentures

and manufactured a complete resin denture using an ideal arrangement and floor model, based on normal methods used in edentulous mandibular models for measurements. We fabricated a covering splint to measure the denture surface by hooks, filled the space between the mucosal surface of the denture and the model with intervening saliva, and recorded the measurements. The details of the measurement methods are described later.

### The retention measuring device

A digital force gauge (Digital Force Gauge RX Series; Aikoh Engineering, Tokyo, Japan) was used as the retention measuring device. Traction and pressure were measured by two methods using the digital force gauge. The pressurizing device was attached by fabricating a hook-shaped attachment (Figure 1).

### The mandibular complete denture covering splint

A mandibular edentulous jaw model (G10FE-402K; Nissin Dental Products, Inc., Kyoto, Japan) was used to ensure consistent measurement conditions. The experiment was conducted using resin mandibular complete dentures manufactured based on this model. We measured the retention of mandibular complete dentures fitted in patients. Thus, difficulty in directly attaching a hook for measuring retention was expected. We therefore fabricated a splint that covered the mandibular complete denture. The splint was a 3-mm thermoplastic resin for the denture base (Erkodur; Erkodent, Yokohama, Japan), which was manufactured with a heat-pressuring molding machine (Dual Former; Daiei Dental Product Co., Ltd., Osaka, Japan) and welded to a plaster model of the mandibular complete dentures. The splint configuration was set with the front teeth 2 mm from the cervical line and the molars 5 mm from the marginal side of the cervical line.

### Measurement sites

The following four points were set as the measurement sites:

Site A: Mandibular central incisor midpoint

This site was selected because it lifts when retention is measured in clinical practice.

Site B: Central fossa of the first molar on the right side of the mandible

This site reproduces the force added when chewing a highly viscous food.

Site C: Central fossa of the first molar on the left side of the mandible

This site was selected for the same reason as site B.

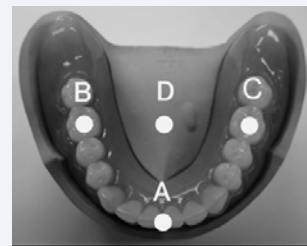
Site D: Extension of midpoint of first molar

The measurements were obtained at a similar location described in a previous study [23] (Figure 2).

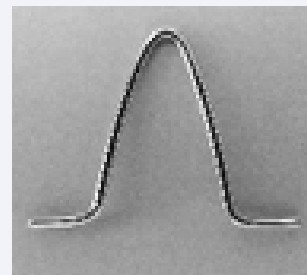
Hook 1 was attached to site A (Figure 3) and hook 2 was attached to site B and site C (Figure 4) with a room temperature curing resin (Unifast III; GC, Tokyo, Japan). Sites A, B, and C were measured with direct traction on the hooks. For site D, dental floss was attached to the hook at sites B and C and traction was applied at the midpoint. Hook 1 and hook 2 were curved 1.2-mm lines (Sun-Cobalt Wire; Dentsply Sankin, Tochigi, Japan).



**Figure 1** The digital force gauge. Measurements are obtained with the hooked apparatus attached.



**Figure 2** The measurement sites.



**Figure 3** Hook attached to site A.



**Figure 4** Hook attached to sites B and C.

The splint was fenestrated at site A and measurements were obtained by the retention measuring device by directly applying pressure downward at 45° and at 23° to the occlusal plane at the denture artificial tooth area. The splint fenestration diameter and thickness were within 8 mm (Figure 5).

### Intervening saliva

Measurements were obtained using four types of intervening

saliva between the mucosal surface of the mandibular complete dentures and the model. The intervening saliva used included the following: (1) artificial saliva (Saliveht; Teijin Pharma, Tokyo, Japan), (2) oral moisturizer spray (Wet Care; Kissei Pharmaceutical, Nagano, Japan), (3) liquid oral moisturizer (Oral Balance Liquid; T&K, Tokyo, Japan), and (4) geloral moisturizer (Biotene Oral Balance Gel; T&K, Tokyo, Japan). The viscosity was measured using a digital rotational viscometer (Brookfield Rotational Viscometer). The viscosity of two 500-mL samples from each patient was measured at 20°C. The average viscosity measurement was used.

**Measurement methods**

Each measurement was taken at the four measurement sites described previously. Retention was set as the amount of load when the denture separated from the residual ridge.

Retention measurements were obtained, as follows. First, each measurement was obtained five times with no intervening saliva. Second, each measurement was obtained six times with artificial saliva and with each of the three oral moisturizers. The very first measurement was excluded because the intervening saliva had not become attached to the denture and model. The amount of intervening saliva was set at the volume that covered the entire surface of the model mucosal surface of the denture. After bonding, measurements were obtained by applying approximately 20 N of hand pressure for 10 seconds to the denture.

A measurement was stopped when the splint separated from the denture or when the measurement value exceeded 20 N. These conditions were chosen because past research on maxillary complete dentures demonstrated that an intraoral pressure exceeding 20 N has a high risk of eliciting pain, thereby making it difficult to make measurements. If the aforementioned conditions for stopping measurement occurred twice, then subsequent measurements were stopped. To investigate the effect of angles on measurement conditions, the pressure measurements were obtained 10 times with artificial saliva intervention at site A only at 45° and 23° to the occlusal plane.

**Statistical analysis**

To test normality, Shapiro–Wilk tests were used for all measurement values. The Friedman test was used for the mean retention value under the five conditions (i.e., without intervening

saliva and with the four different moisturizers). The Bonferroni’s method was then used for multiple comparisons. Spearman’s rank correlation coefficient was used to assess the relationship between each site. The t-test was used for the angle relationship. Statistical software SPSS ver.19 (SPAW Statistics Base 19; IBM, Tokyo, Japan) was used for statistical processing.

**RESULTS**

**Retention under the five conditions and intervening saliva viscosity**

The results of the retention measurements are shown in Figure (6). The splint detached from the site with highly viscous intervening saliva such as liquids and gels, which made measurement impossible. If a measurement was impossible, it was marked with an x on the graph.

When the incisal edge of the central incisor was exposed to a 45° downward pressure, only two measurements were possible with each of the intervening saliva type when the incisal edge of the central incisor was tractioned upwards. When we compared the highly viscous geloral moisturizer with no intervening saliva, artificial saliva, and spray oral moisturizer, we found that retention tended to increase as the viscosity of the intervening saliva increased (Figure 7).

**The relationship between traction and pressure**

At site A, where measurements were possible for all

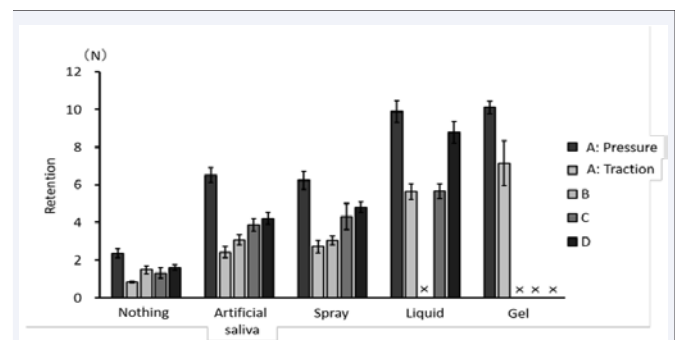


Figure 6 Retention for each site/moisturizer.



Figure 5 A drawing of the hook attached to the splint.

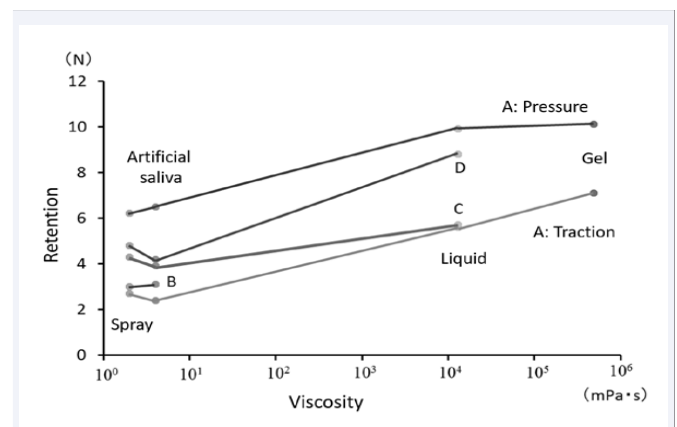


Figure 7 Retention for each type of intervening saliva.

intervening saliva types, there was a strong positive correlation between retention with traction on the incisal edge of the central incisor and retention with pressure at the incisal edge of the central incisor ( $r = 0.94$ ,  $P < .01$ ) (Figure 8).

### Angle relationship

There was no significant difference at site A when pressure was exerted at  $45^\circ$  and when it was exerted at  $23^\circ$  ( $P < .01$ ) (Figure 9). There was a correlation between both angles ( $r = 0.73$ ,  $P < .01$ ).

## DISCUSSION

### The mandibular complete denture covering splint

We fabricated a splint with a hook attached to determine the measurement site extra orally. However, when actually measuring inside a patient's mouth, a splint would not be fabricated. We instead wanted to measure the dentures currently used by the patient. In this study, we therefore created a fenestration and used a configuration that would enable direct pressure on site A. With this method, measurements were possible with a  $45^\circ$  direct downward pressure on the front teeth in the mouth.

### Intervening saliva

The volume of intervening saliva was determined by referencing previous reports. Kawazoe et al. [14], reported that retention was weakened by excess intervening saliva or insufficient intervening saliva between the base and the mucosal surface under the base [14]. They also observed that each person had an optimal volume of intervening saliva. Yamagaki et al., reported that obtaining stable measurements of retention was

possible if the test sample covered all surfaces of the model [24]. Therefore, we did not specify a set amount of intervening saliva; the amount was instead set as the amount that covered all mucosal surfaces of the denture base.

We selected four types of intervening saliva: artificial saliva and three types of oral moisturizers with different levels of viscosity. The reasons for this selection are stipulated later. The combination of inorganic electrolyte components in artificial saliva is nearly the same as in normal saliva. In several studies, Östlund et al., first reported that differences in the properties, composition, and outflow of saliva have a significant effect on retention [7,21]. Artificial saliva, which has a viscosity similar to that of human saliva, was used as the intervening saliva to eliminate differences in the salivary conditions of individual patients and to compare the effect on retention.

Yamagaki et al., demonstrated that retention increases as the viscosity of an oral moisturizer increases [24]. We therefore selected three types of oral moisturizers with different levels of viscosity to ascertain the effect of moisturizer viscosity on mandibular complete denture retention.

### Retention under the five conditions

Yamagaki et al., reported a positive correlation between retention and viscosity: when an oral moisturizer was used, retention increased with increasing viscosity of the oral moisturizer [24]. The current study used moisturizers with low viscosity, moderate viscosity, and high viscosity, based on this previous report. We also found that the regression line showed a positive correlation between retention and viscosity. On the basis of this information, we presumed that it would be sufficiently possible to use a developed retention measuring device for chair-side measurements. The reason measurements were possible at site A only where the splint did not detach may be because direct pressure was used and because the coverage on the front teeth was narrower than that in the molar region, which reduced retention.

### Correlation between traction and pressure

Based on statements in the denture examination and test methods advocated by the Japan Prosthodontic Society (Tokyo, Japan), an evaluator should attempt to remove artificial teeth with the fingers when evaluating whether denture retention is appropriate. This approach is consistent with traction at site A. However, pressure may be exerted in the direction of site A when upward traction is applied to the molar region. This is similar to the direction of force that pulls upward in the molar region and causes the dentures to detach when viscous food is chewed in the mouth. We therefore preferred exerting pressure to site A because measurements can be obtained as is and without using a splint when obtaining actual retention measurements in the mouth.

### Angle relationship

No significant difference was found when a  $45^\circ$  and  $23^\circ$  downward pressure was applied to site A. Because we found a correlation between both angles, we presumed that measurements obtained with either angle would produce virtually the same values. This finding therefore suggested that a detailed specification of an angle is unnecessary when measuring the actual retention force.

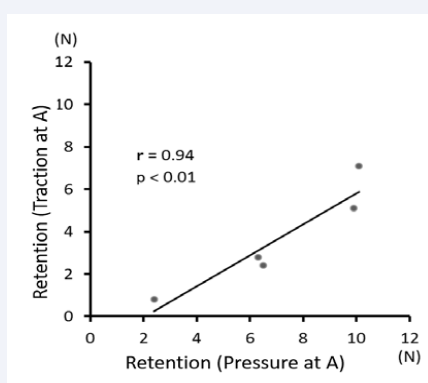


Figure 8 Withtraction and with pressure applied.

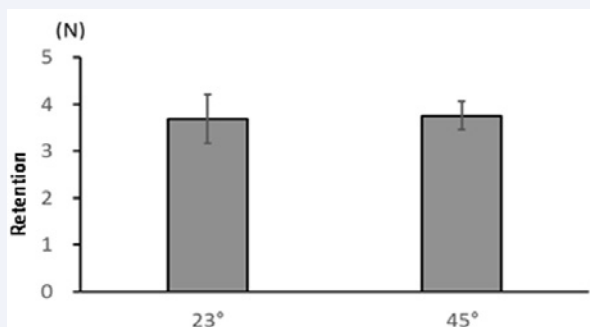


Figure 9 Differences in retention, based on the pressurization angle.

## CONCLUSION

This study suggests that mandibular complete dentures retention measurement may be possible with oblique downward pressure on the occlusal plane at the mandibular central incisor midpoint.

## FUTURE PROSPECTS

In the future, we want to obtain direct measurements of retention in the mouths of patients actually fitted with mandibular complete dentures, and to clarify the efficacy of these measurements. On conducting this measurement, it will be necessary to specify a patient's mouth opening capacity and to eliminate the effect of the buccal mucosa, lip pressure, and so forth. If it were clarified that the measurements in the patient's mouth are efficacious, it would be possible to investigate the relationship between retention and the shape of the residual ridge and the relationship between retention and the position of the anterior alveolar ridge. This will make it possible to determine intractable cases and to determine the therapeutic effect, based on pre- and post-treatment measurements. It will then be possible to provide better complete denture treatment and to contribute to improving the quality of life of elderly edentulous patients.

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