

Report on establishing the base outline of mandibular complete denture obtained from measurements of denture base dislodging and retraction force (1st report): Discussion on retentive force from coverage difference with a denture base over the retromolar pad

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Summary

(Purpose) Establishing the base outline of complete denture is a vitally important factor to determine denture retention and stability. Especially in mandibular complete denture, the current situation is that establishing of the outlines differs among practitioners. So, a measurement experiment was designed to use a retracting device for the purpose of determining influence on retentive force from establishing the base outline in mandibular complete denture. As the first report of a serial study, a variety of retentive force depending on coverage difference with a denture base will be discussed.

(Method) A measurement experiment of denture base dislodging and retraction force was conducted by retracting an experimental tentative denture seated in the mouth with a digital force gauge in the process of reducing the coverage area of the posterior border of an experimental tentative denture in stages of reducing the posterior margin of the retromolar pad, the 2/3 area, the middle part and the anterior margin from the distal end dome of the retromolar pad. And comparative study of obtained results was made about influences of establishing the base outline of the posterior border on retention. Simultaneously, dimensional measurement was performed on the retromolar pad regions, and digitization was attempted regarding defined denture base outlines.

(Results) As the base outlines of the posterior border were positioned accordingly from the distal end dome of the retromolar pad to the more anterior direction, measurement values were found decreased. The measurement value was highest at the distal end dome of the retromolar pad, and it was statistically significant difference at $p < 0.01$ when compared with the value at the anterior margin of the retromolar pad.

(Conclusion) In order to secure the border seal in good stability at the retromolar pad, it was suggested that the denture posterior border should be defined at least more posteriorly than in the 2/3 coverage area of the retromolar pad (positioned posteriorly about 7mm from the anterior margin of the retromolar pad) and should be extended as much as possible to

the distal end dome of the retromolar pad (positioned posteriorly about 15mm from the anterior margin of the retromolar pad).

Key words : base outline of mandibular complete denture, retromolar pad, retention, suction, border seal

Introduction

Patients' complaints of mandibular complete denture about floating at the mouth opening as well as speech and mastication problems are unending. And daily practice is very frequently troubled with these complaints and problems.

However, the problem involved with floating of mandibular complete denture could be solved scientifically, only if cases are limited, according to the report of the border seal mechanism of mandibular complete denture ^{1,2)}. An inventor of this suction mechanism, Abe, states that complete denture suction will need effective peripheral seal over the denture base entirely whether or not throughout the maxillomandibular jaws. And even a single site of broken border seal is said to lose the suction effect.

Also another report has that most effective suction force should be under the condition of rich volume of sponge-like tissues that are present at the sublingual fold in the anterior region of the base of the mandible, reporting on the effective denture base extension in this area ³⁾.

Furthermore, Abe confirms that, in order to complete the posterior border seal of mandibular complete denture, close adaptation between the denture base internal surface and the mucosal surface of the retromolar pad should be essential together with the contact seal of buccal mucosa and tongue on the denture base in the retromolar pad region. It is stressed that, for that purpose, the retromolar pad should be covered on the whole with the denture base. Meanwhile, as far as the coverage area of the retromolar pad is concerned, views are scattered currently as to the whole area of the pad, the 2/3 area, the 1/2 area, the 1/3 area and the anterior marginal area. And it is not yet known how much the retromolar pad area should be covered from the viewpoint of denture retentive force ⁴⁻¹¹⁾.

This study, therefore, was designed to survey different retentive forces by changing the coverage area of denture base over the retromolar pad region among measurements of edentulous residual ridges for the purpose of defining how much influence on denture retention should be from different coverage area of the retromolar pad with the mandibular complete denture base. And also this survey was conducted for the purpose of defining where the denture base outline should be established clinically. As a result,

some interesting findings were obtained as in the following report.

Materials and Methods

I . Fabrication procedure of experimental tentative denture

The retromolar pad is presented in transition to the pterygomandibular fold in its posterior region (**Fig.1**) . A preliminary impression is taken including the distal end dome of the retromolar pad as the boundary region of the mandibular most posterior end. And the posterior border of a base plate is matched to the distal end dome of the retromolar pad and fixed with its lingual border in 2~3 mm inferiorly from the mylohyoid ridge, and a wax occlusion rim is made on this base plate. And this base plate is adjusted for fitness in the mouth, and then, a precision close mouth impression is taken with a dental silicone impression material (Genie, Sultan Healthcare) (**Fig.2**) . After an impression is taken, a boxing is made carefully for precise reproduction of peripheral border from this functional impression and a working cast is completed.

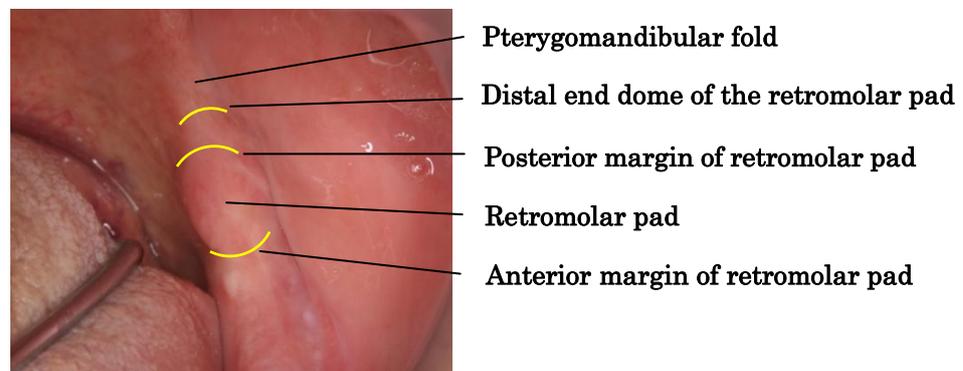


Fig.1 The retromolar pad surrounding areas. From anatomical shapes, the oval shaped eminence is called the retromolar pad, and its anterior margin, posterior margin and the boundary in transition to the pterygomandibular fold is called the distal end dome of the retromolar pad.

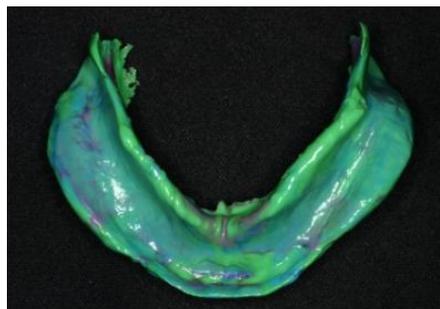


Fig.2 Precision close mouth impression taking, using a silicone impression material for

obtaining the mandibular complete denture suction: Three fold combined impression taking (heavy body type→regular body type→light body type).

Next, the working cast obtained is blocked out and relieved for damage protection of the cast, and an experimental tentative denture is made with the denture outline extended to the margin of the working cast using self cure acrylic resin for an impression tray (Ostron II, Clear pink, G-C Corp) (**Fig3**). The experimental tentative denture is provided for selective use with five retraction hooks respectively in the anterior teeth central region, right and left premolar teeth corresponding regions, and right and left molar teeth regions. But in this study, the retraction hook was used only with the anterior teeth central region.

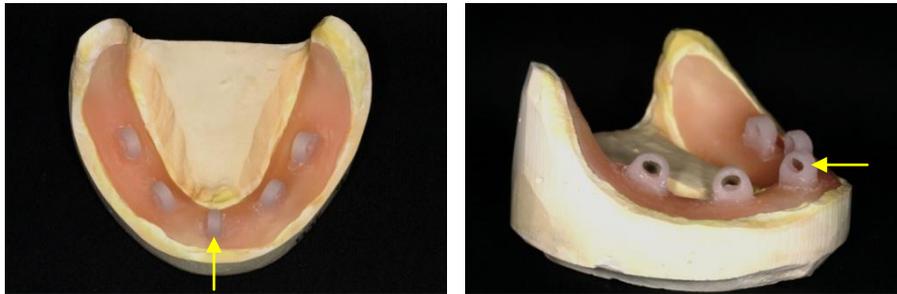


Fig.3 An experimental tentative denture made as the outline based on the peripheral margin of the working cast. Totaling five retraction hooks are given in the anterior teeth central region, right and left premolar teeth corresponding regions, and right and left molar teeth regions. But in this study, the retraction hook was used only with the anterior teeth central region (arrowed).

II. Survey 1. Survey on influence associated with denture retentive force from different denture coverage area of the retromolar pad with the denture base

1. Subjects

Subjects were 6 patients (2 males and 4 females at mean age of 80.17) who visited at our clinic wishing for new mandibular complete dentures and who consented of this study purpose that was explained orally.

2. A measurement experiment of denture base dislodging and retraction force

An experimental tentative denture was inserted in a subject's mouth, pressurized to the residual ridge with a practitioner's fingers, and retracted slowly with a thread of dental floss already tied with the retraction hook (**Fig.4**) and a measurement experiment was made to determine the retraction force at the dislodgment from the ridge.

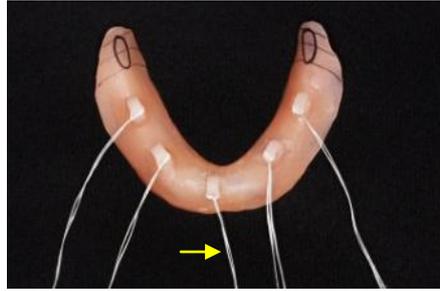


Fig.4 Threads of dental floss were tied with five individual hooks in the anterior teeth central region, right and left premolar teeth corresponding regions, and right and left molar teeth corresponding regions. But in this study, the dental floss on the retraction hook was used only with the anterior teeth central region (arrowed) for a measurement experiment of denture base dislodging and retraction force.

3. Measurement method

Retraction measurement was made by hooking the dental floss through the hook with the measuring device (Digital Force Gauge AD-4932A-50N, AND Co., Unit of measurement: N, Digital presentation to two places after the decimal point, Measurement presentation range: 0.03~50.00N, **Fig.5**)

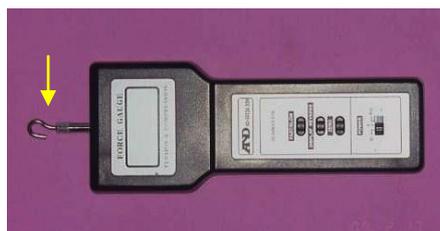


Fig.5 The measuring device in use. A hook for tension measurement (arrowed) is attached. Measurement values are displayed in digital presentation, and maximum value can be held in memory.

4. Retraction method

A subject's measuring posture is a seated posture without any tension of the perioral muscles, opening slightly in about 15~20mm (**Fig.6**), and the tongue position is held in natural posture. The retraction is made to the anterior median direction from the anterior teeth central retraction hook for a measurement experiment of denture base dislodging and retraction force.

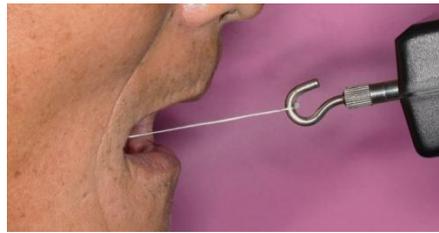


Fig.6 An experimental tentative denture seated in the mouth was retracted to the anterior median direction with the dental floss passing through the anterior teeth central retraction hook using a digital force gauge and opening the mouth slightly in about 15~20mm.

5. Survey content

The most posterior end of the working cast was taken as the distal end dome of the retromolar pad of the retromolar pad, and its anterior presence of the oval shaped eminence was taken as the retromolar pad, and its mesiodistal dimension was divided into the posterior margin of the retromolar pad, the middle, and the anterior margin from the order of distal region (**Fig.7**) .

And then, a single unit of experimental tentative denture was used to be reduced progressively from the distal end at totaling four different areas of the distal end dome of the retromolar pad, the posterior margin of the retromolar pad, the middle and the anterior margin for a measurement experiment of denture base dislodging and retraction force as to determining the denture outlines of the posterior border (**Fig.8**) . And influence was studied on measurement values from the changes of establishing the denture outlines of the posterior border.

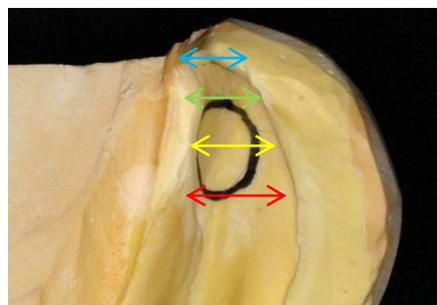


Fig.7 The distal end dome of the retromolar pad and the retromolar pad (oval shaped eminence) that are presented on the working cast. Four different areas are divided as the distal end dome of the retromolar pad (blue arrow), the posterior margin of the retromolar pad (green arrow), the middle part (yellow arrow) and the anterior margin (red arrow), and they are taken as experiment references of establishing the denture base outlines.



Fig.8 Established the denture outlines of the posterior border of a single unit of experimental tentative denture were studied on a measurement experiment of denture base dislodging and retraction force in each individual stage of reducing the posterior border progressively from the distal end dome of the retromolar pad (above left), the posterior margin of the retromolar pad (above right), the middle part (below left) and the anterior margin (below right).

6. Measurement number of times

On each subject, respectively five times basis of a measurement experiment of denture base dislodging and retraction force were conducted as to the established denture outlines of the posterior border at four areas above.

7. Statistical analysis

Measurement results of total number of subjects were counted on individual survey items, and F-test was performed through the software of Microsoft Excel and t-test was used. The significance level was set at 0.05 and 0.01.

III. Survey 2. (an additional survey) Survey on influence associated with denture retentive force from different denture coverage area as to the distal end dome of the retromolar pad and the 2/3 area of the retromolar pad

An additional survey was conducted on another 13 subjects (7 males and 6 females at mean age of 72.15) with similar method of Survey 1 only by changing of those surveyed.

In other words, this survey was conducted on influence associated with measurement values by changing the coverage area of denture posterior border from the distal end

dome of the retromolar pad to the 2/3 area coverage of the retromolar pad, while a measurement experiment of denture base dislodging and retraction force was performed as to the established denture outlines of the posterior border (Fig.9) before and after reducing the posterior border of a single unit of experimental tentative denture at those different coverage areas from the distal end dome of the retromolar pad to the 2/3 coverage area of the retromolar pad.

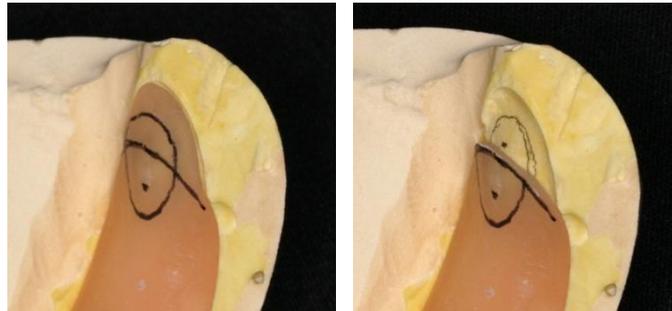


Fig.9 A measurement experiment of denture base dislodging and retraction force was performed before and after reducing the posterior border of a single unit of experimental tentative denture at those different coverage areas from the distal end dome of the retromolar pad (left) to the 2/3 coverage area of the retromolar pad (right).

IV. Survey 3. Dimensional measurement survey on the retromolar pad

For the purpose of determining anatomical morphology at the retromolar region, from the subjects of a measurement experiment of denture base dislodging and retraction force, randomly selected 19 subjects were measured on their working casts. The oval shaped eminence presented at the most posterior end on the working cast was taken as the retromolar pad, and the cast posterior end was taken as the distal end dome of the retromolar pad. And the mesiodistal dimension of the retromolar pad as well as distance from the posterior margin of the retromolar pad to the distal end dome of the retromolar pad were measured (Fig.10) with a dental caliper (KANON).

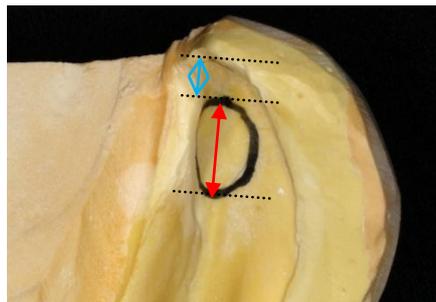


Fig.10 From subjects seated with experimental tentative dentures, randomly selected 19

subjects were measured on their working casts regarding distances of the mesiodistal dimension of the retromolar pad (red arrow) as well as distances from the posterior margin to the cast posterior end (clinical distal end dome of the retromolar pad) (blue arrow).

Research Results

I. Survey 1. Survey on influence associated with retentive force from different denture coverage area of the retromolar pad with the denture base

As for 6 subjects of all, counted results are shown in **Fig.11** as to a measurement experiment of denture base dislodging and retraction force that was conducted in reference to 4 regions, namely the distal end dome of the retromolar pad region, the posterior margin of the retromolar pad, the middle part and the anterior margin for determining the outline of the denture posterior border. Largest measurement values showed in the region of the distal end dome of the retromolar pad (total retraction measurement number of 27 times, mean value \pm SD : 7.87 ± 3.67 N), then in the region of the posterior margin of the retromolar pad (total retraction measurement number of 28 times, mean value \pm SD : 7.68 ± 3.45 N), next in the middle part (total retraction measurement number of 28 times, mean value \pm SD : 6.16 ± 3.54 N) and finally in the anterior margin (total retraction measurement number of 29 times, mean value \pm SD : 1.77 ± 0.59 N). As above, measured values decreased accordingly in the process of reducing the posterior border from the distal end dome of the retromolar pad to the anterior regions in stages.

As a result, in accordance with the distal end dome of the retromolar pad, measurement values decreased in significant difference only when reducing down to the anterior margin of the retromolar pad ($P < 0.01$).

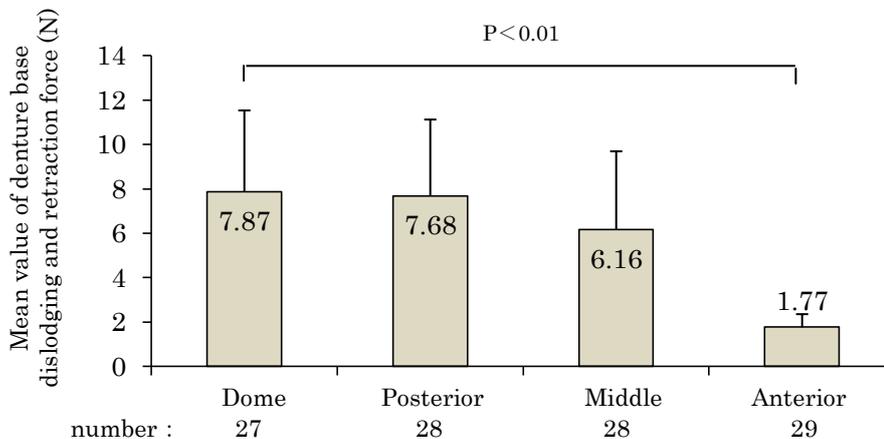


Fig.11 As for 6 subjects of all, counted results as to a measurement experiment of denture

base dislodging and retraction force conducted in reference of individual stages of reducing the established outline of the posterior border progressively (Unit N: Newton).

II. Survey 2. (an additional survey) Survey on influence associated with denture retentive force from different denture coverage area as to the distal end dome of the retromolar pad and the 2/3 coverage area of the retromolar pad

In another survey conducted on newly selected 13 subjects, counted results are shown in **Fig.12** as to a measurement experiment of denture base dislodging and retraction force in reference to the regions in the distal end dome of the retromolar pad and in the 2/3 coverage of the retromolar pad. Those measurement values of the distal end dome of the retromolar pad (total retraction measurement number of 86 times, mean value \pm SD : 7.88 ± 4.81 N) and of the 2/3 coverage of the retromolar pad (total retraction measurement number of 91 times, mean value \pm SD : 7.16 ± 3.81 N) showed slight decrease by reducing the posterior border from the distal end dome of the retromolar pad up to the 2/3 coverage of the retromolar pad, but there was no significant difference confirmed between both.

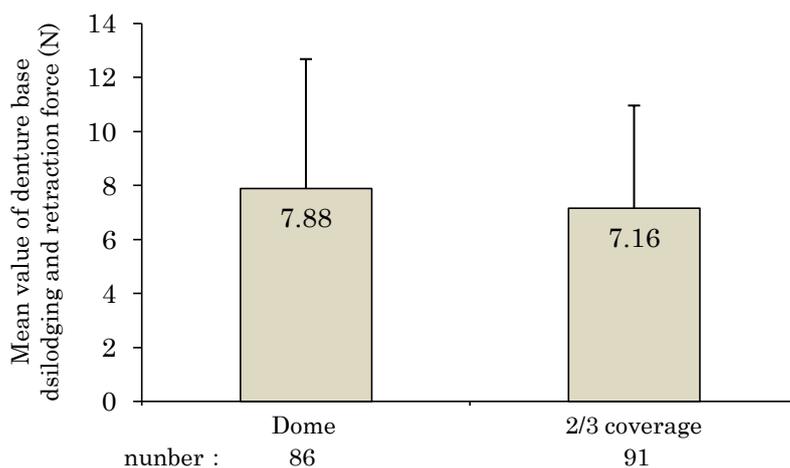


Fig.12 As for 13 subjects, counted results as to a measurement experiment of denture base dislodging and retraction force conducted before and after reducing the established denture outline of the posterior border from the distal end dome of the retromolar pad up to the 2/3 coverage of the retromolar pad (Unit N: Newton).

III. Dimensional measurement survey on the retromolar pad

As for randomly selected 19 subjects among subjects of a measurement experiment of denture base dislodging and retraction force, counted results are shown in **Table 1** as to

dimensional measurements of the retromolar pad on the working casts. And the mesiodistal dimension of the retromolar pad was about 10.6mm, and the distance up to the distal end dome of the retromolar pad that was developed on the working cast through the taken impression was about 4.4mm.

Retromolar pad morphology (Unit mm)	Right n=19	Left n=19	Right/Left combined n=38
Mesiodistal dimension Mean value \pm SD	10.37 \pm 1.20	10.79 \pm 1.10	10.58 \pm 1.15
Posterior margin~Dome distance Mean value \pm SD	4.26 \pm 0.95	4.50 \pm 0.96	4.38 \pm 0.95

Table 1. Counted results of Right and Left individual values and Right/Left combined values measured as for 19 subjects on the working cast about the mesiodistal dimension of the retromolar pad and the distance from the posterior margin of the retromolar pad up to the distal end dome of the retromolar pad.

Discussion

I. Purpose of Study

This study is an experimental survey in an object to determine objectively through numerical values of measurements as to what influence has on the denture retention according to the denture base coverage difference of the retromolar pad using an original method of a measurement experiment of denture base dislodging and retraction force about the posterior border of the mandibular complete denture which are understood as one of most difficult areas of obtaining denture peripheral seal ¹²⁾. And, this study was conducted majorly in an object to offer some help by way of reviewing an investigation for determining the outline of the denture base in this region where it is not yet defined fully.

Furthermore, for designing denture, factors that are involved with the right and wrong of retention will include denture base largeness, fitness to the mucous membrane of the mouth and effective peripheral seal, and most critical factor to retention is the peripheral seal ¹³⁾. And because the established outline of the denture base in the retromolar pad region is an important element to determine the peripheral seal of this denture posterior border, another additional object is to discuss over the peripheral seal mechanism of mandibular complete denture from empirical measures through an active performance of experimental survey.

II. Patient tasks for measurement

Measurement was based on 5 times as per each individual setting, and, because the measurement experiments were processed monitoring of subject's physical conditions, measurements were sometimes more than 5 times and sometimes less than 5 times.

In order to coordinate the measurement condition as consistently as possible, subject's measuring posture was defined as seated without any tension of the perioral muscles, opening the mouth slightly in about 15~20mm and the tongue position is held in natural posture without any guidance. But it looked rather protruded position at a slightly opened mouth.

A measurement experiment of denture base dislodging and retraction force throughout a single unit of experimental tentative denture was performed with only one chair time (for about 60 minutes). But even though with only one chair time, because the measurement values were seemingly inclined to decrease along with increased salivary excretion during measuring, the intraoral environment was tried to keep constant by the way of gargling or taking a brief interval.

III. Retraction direction and meaning of measurement values

In this study, the measurement method of retraction force exerted on dislodging the denture base from the residual ridge was taken by retracting an experimental tentative denture in the anterior median direction at an angle of almost parallel to the occlusal plane. Retention is defined as resistance to denture dislodging, and the right and wrong of retention can be verified through settling a denture firmly in the mouth, providing the rectangular directed force to the occlusal plane and trying to dislodge the denture¹³⁾. In this study, however, measurement values obtained by retracting in the anterior median direction cannot be replaced directly as retentive force.

But, in order to retract in the rectangular direction, any appropriate and bulky measuring device will be needed especially in the posterior teeth region¹⁴⁾. On the contrary, retraction in the anterior median direction is very simple and reproducible, and, therefore, this method was taken on a basis that this force might indicate retentive force indirectly although it is admitted that it is not retracted in the rectangular direction.

In addition, measurement values obtained in this study might indicate eventually retentive force indirectly of a finished denture during oral functions.

IV. Retracted regions

The experimental tentative denture in this study was provided with five retraction

hooks respectively in the anterior teeth central region, right and left premolar teeth corresponding regions, and right and left molar teeth corresponding regions, and a preliminary experiment was carried out for verifying influences of different hooks upon measured values.

As a result, the lower values were identified as in the more posteriorly positioned retraction regions and also the lower on the left side rather than on the right.

Contributing factors of these reasons were any torque force exerted from the retraction on the experimental tentative denture through the unilateral retraction in the premolar and molar regions. And also instability was attributed to directing this retraction because a practitioner stood usually on the subject's right side.

In order to prevent this instability from the unilateral retraction in the posterior region, the right-left simultaneous retraction on the molar teeth region was tested and compared with the anterior central region, but there was no significant difference among the measured values.

From above, in response to our major purpose of this study, retracting with the anterior central region was selected because the unilateral retraction in the posterior region was found instable and inadequate for reproducibility and because the bilateral retraction on the molar teeth region was not definitely needed for reasons of simple convenience.

V. Results of a measurement experiment of denture dislodging and retraction force

Accordingly as the posterior border of the experimental tentative denture was reduced, that is, in the sequence of the distal end dome of the retromolar pad → the posterior margin of the retromolar pad → the middle part of the retromolar pad → the anterior margin of the retromolar pad, measured values were found decreased. And, the significant difference of decreased measured values according to the distal end dome of the retromolar pad was confirmed with those of the anterior margin of the retromolar pad ($p < 0.01$) or in the anterior region on the boundary in the middle part of the retromolar pad.

It was suggested from above that retentive force should result in obvious decrease unless denture base should cover over the posterior part of the retromolar pad going beyond the middle area.

And then, in an object to determine how much is a proper coverage from the viewpoint of retentive force going beyond the middle part of the retromolar pad, as an additional experiment, a survey was conducted on the 2/3 coverage area of the retromolar pad that was frequently referred as the basic outline of the posterior border comparatively to be

investigated with the distal end dome of the retromolar pad. As a result, there was no significant difference concluded between both regions.

As an important factor of denture retention, suction is required with definite border seal over the denture peripheral entirely, but the denture suction on the whole has to be equivalent to the minimally weak border seal if any part of marginal seal is insufficiently weak¹⁵. In the past literature, as far as defining the outline of the denture posterior border is concerned, views are scattered as to the whole area of the pad, the 2/3 area, the 1/2 area, the 1/3 area and the anterior marginal area. In this study of retentive forces, the results indicate that retentive forces that are intrinsically retained in the retromolar pad region cannot be exerted successfully, unless the posterior border should be extended at least to the 2/3 coverage area going beyond over the middle part of the retromolar pad. And at the same time, it is recommended to extend the denture posterior border to the distal end dome of the retromolar pad going beyond over the retromolar pad for obtaining the maximum retentive force.

In daily practice, many cases are found with no denture base coverage of the retromolar pad, and so it was suggested that practitioners should be ready with fresh awareness of coverage issues of the retromolar pad.

VI. Results of dimensional measurement survey on the retromolar pad

The working casts in this study may possibly develop in a little deformed condition from pressures of impression materials or impression trays in the regions from the retromolar pads through the distal end dome of the retromolar pads. Therefore, this deformation can be said as a clinical shape which is different from a natural anatomical shape as observed in the mouth. With this in mind, results of measured dimension of the retromolar pad were about 10.6mm in the mesiodistal dimension of the retromolar pad, and about 4.4mm in the distance from the posterior margin of the retromolar pad to the distal end dome of the retromolar pad.

From these results, the posterior border of the working cast for making an appropriate denture should be taken in the impression of the area range of 11~15mm from the anterior margin of the retromolar pad to the posterior direction.

As combined with the study on denture retentive force, in order to provide effective retentive force to a denture in the retromolar pad, the denture posterior border should be established in the region posteriorly beyond over 7mm as a basis from the anterior margin of the retromolar pad. And also in order to obtain the maximum retentive force, the denture base should cover the region posteriorly beyond about 15mm as a basis from the anterior margin of the retromolar pad, namely up to the distal end dome of the

retromolar pad.

Conclusion

In this study, the following can be concluded from the survey of influence on denture retentive force depending on coverage difference of the retromolar pad regions with a denture base using a measurement experiment method of denture base dislodging and retraction force, and also from the dimensional measurement survey result of the retromolar pad on the working cast.

1. As to determining the outline of the denture base in the retromolar pad, a survey was performed on five different regions of the distal end dome of the retromolar pad, the posterior margin of the retromolar pad, the 2/3, the middle area, and the anterior margin, and retentive force was found decreased accordingly as the outline was established progressively to the anterior direction.

2. As a result of comparative tests on the distal end dome of the retromolar pad, decreased retentive force showed obviously in significant difference about the anterior margin of the retromolar pad. And stable retentive force showed in the regions more posteriorly from the 2/3 coverage of the retromolar pad.

3. As a result of dimensional measurement of the retromolar pad regions on the working cast, the mesiodistal dimension of the retromolar pad was about 10.6mm and the distance up to the distal end dome of the retromolar pad was about 4.4mm.

From above, it is found that, in order to obtain stable retentive force in the retromolar pad regions in every case, the denture posterior border should be established at least more posteriorly than in the 2/3 coverage of the retromolar pad. And also it was suggested that, in order to obtain the maximum retentive force, the denture base should be extended to cover the region of the distal end dome of the retromolar pad. Because of this, as a requisite condition of the working cast, the impression should be taken in the area range of 11~15mm from the anterior margin of the retromolar pad to the posterior direction.

Through this study on the retromolar pad regions, it is known about the importance of rules of the border seal “the denture peripheral should be ended in soft-natured tissues” . And also it is known objectively about the numerical values of influence of border seal on denture retention with the retromolar pad.

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This research publication is dedicated to my mother who passed away during this survey study without finishing her renewed dentures.

Reference

- 1) Abe J: Color Atlas, Lower Complete Denture Suction that Anyone Can Get, 1st ed.:17-74, Hyoron Publ., Tokyo, 2004 (Japanese)
- 2) Abe J: Finished in 4-Steps, Lower suction denture and BPS Perfect Manual, - Responding to whole edentulous cases -, 1st ed.: 56-78, Quintessence, Tokyo 2011 (Japanese)
- 3) Jia-Jin Chang, DDS, MDS / Jen-Hao Chen, DDS, MDS, / Huey-Er Lee, DMD, PhD / Hong-Po Chang, DMD, PhD, et,al : Maximizing Mandibular Denture Retention in the Sublingual Space. Int J Prosthodont ; Vol24, No.5 : 460-464, 2011.
- 4) Kawabe S: Practice of Kawabe's Complete Denture, 1st ed: 47, Ishiyaku, Tokyo, 1989 (Japanese)
- 5) Toyota S: Complete denture practice atlas - Focusing on Flange Technique -, GC Practical Series 61: 9, 1982 (Japanese)
- 6) Hosoi N, Hayakawa I, Hirai T, Nagaoka E, Akagawa Y, et al.: Complete Denture Technique, 5 th ed.: 3, Ishiyaku, Tokyo, 2006 (Japanese)
- 7) Gonda Y, Hanyu T, Fujii H, Fujii T, Yagyu Y: Latest Complete Denture Prosthodontics, 2nd ed.: 33, 159-160, Ishiyaku, Tokyo 2008 (Japanese)
- 8) Kato T: Complete denture practice using a treatment denture – What requires from complete denture, 1st ed.: 64, Ishiyaku, Tokyo, 2002 (Japanese)
- 9) Hayakawa I, Theory and practice of complete denture – Imaging of complete denture, 26, Quintessence, Tokyo, 2004 (Japanese)
- 10) G.A.Zarb et al. (translation by Tanaka H, et al): Boucher's Prosthodontic Treatment for Edentulous Patients, (12th ed.), Ishiyaku, Tokyo, 2008 (Japanese)
- 11) Muraoka H: Answer by steps, Complete denture practice 120 points, 1st ed.: 26-27, Hyoron, Tokyo, 1993 (Japanese)
- 12) Someya S: Observing the oral form and denture border form for comfortable border seal, J Practice in Prosthodontics 30(1): 31 – 36, 1997 (Japanese)
- 13) Watt,D.M., MacGregor,A.R. (translation by Kobayashi Y, Tanaka T, Torii K) :

- Designing Complete Denture, 1st ed.: 72-89, Ishiyaku, Tokyo,1987. (Japanese)
- 14) Okino S: Complete denture dentistry – Theory -, 3rd ed.: 133-135, Ishiyaku, Tokyo, 1979 (Japanese)
 - 15) Someya S: Complete denture border seal and impression taking, J Nippon Dental Review 546: 83-91, 1988 (Japanese)