

# Change in Retention Force and Angulation Limit of an Attachment System with Silicone Soft Relining Material for Implant-retained Complete Dentures

<sup>1</sup>Takayuki Ueda, <sup>2</sup>Keitaro Kubo, <sup>3</sup>Takashi Koike, <sup>4</sup>Tatsuyuki Kono, <sup>5</sup>Koichiro Ogami, <sup>6</sup>Kaoru Sakurai

## ABSTRACT

**Aim:** We investigated attenuation of the retention force on the female end (silicone soft relining material) with repeated mounting/removal and determined the allowable angle between the male ends for mounting/removal.

**Materials and methods:** Attachments consisting of metal ball anchors (diameter 2.5, 2.7, or 3.0 mm) for the male end and a silicone soft relining material for the female end were subjected to retention force measurement and allowable angle tests. The frequency of mounting/removal in 1 year was estimated assuming mounting/removal four times a day. The allowable angle test used two pairs of male ends with the between-male angle set at 0, 15, 30, or 45°, and the angle between the male ends joined with the female end was measured. The retention force at the initiation of the experiment and at each time-point was compared using one-way analysis of variance (ANOVA) followed by Dunnett's test ( $\alpha = 0.05$ ).

**Results:** The retention forces of the male ends with a diameter of 2.5, 2.7, or 3.0 mm at the initiation of the experiment were  $3.8 \pm 0.3$ ,  $5.2 \pm 0.2$ , and  $5.5 \pm 0.2$  N respectively. After repeated mounting and removal corresponding to use for 1 year, a significant decrease in retention force was noted in all male ends ( $3.3 \pm 0.1$ ,  $3.8 \pm 0.2$ , and  $4.3 \pm 0.1$  N respectively). It was also found that mounting/removal was possible up to a between-male-end angle of 45°.

**Conclusion:** Under the conditions of this experiment, the retention force decreased with repeated mounting and removal of the female end prepared with silicone soft relining material. Additionally, a large between-male angle for mounting/removal was allowable, and mounting/removal was possible up to 45°.

**Clinical significance:** This system may save time and expense and could be used to treat patients easily in their home or a nursing home.

**Keywords:** Attachment, Laboratory research, Overdenture, Prosthodontics, Removable denture, Soft relining material.

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**Conflict of interest:** None

## INTRODUCTION

Dental care for the elderly requiring long-term care at home is important for those unable to visit a dental clinic after implant treatment. Home treatment is difficult when the residual tooth condition is poor in a patient with partial attachment of fixed abutment retainers, and additional implant placement is necessary. In such a case, changing the fixed retainers to an implant bar denture may be a useful alternative treatment; therefore, attachments that can be simply incorporated and repaired are desirable.

Therefore, we focused on an implant overdenture system using a ball attachment for the male end and a silicone soft relining material for the female end, which may be applied to any implant system.<sup>1</sup>

We previously clarified the diameter of male ball anchors capable of exerting an appropriate retention force.<sup>1</sup> We also previously studied the reduction in retention force caused by repeated mounting/removal of a silicone soft relining material in relation to its use as the female end.<sup>2</sup> This system has been already applied in some clinical cases.<sup>3</sup>

One problem with general ball attachments is that the retention force decreases with repeated mounting and removal in existing implant overdenture systems.<sup>4</sup> The retention force may decrease as a result of wear, even when a silicone soft relining material is used for the female end.

To apply this system to patients with fixed abutment retainers, the superstructure and inserted ball attachments must be removed based on the fixture placement angle of the male end, because changing the angle of the fixture is rendered impossible because of the structure of the ball attachments.

When implants are placed with the assumption that fixed retainers are to be used, parallel implants are considered, and the angle is set within a range that allows impressions of the superstructure to be taken. Therefore, it is desirable that the allowable angle between each attachment is within the range that allows impressions to

<sup>1</sup>Associate Professor, <sup>2,4</sup>Special Course Student, <sup>3</sup>Lecturer  
<sup>5</sup>Senior Assistant Professor, <sup>6</sup>Professor and Chair

<sup>1-6</sup>Department of Removable Prosthodontics & Gerodontology  
Tokyo Dental College, Chiyoda-ku, Tokyo, Japan

**Corresponding Author:** Takayuki Ueda, Associate Professor  
Department of Removable Prosthodontics & Gerodontology  
Tokyo Dental College, Chiyoda-ku, Tokyo, Japan, Phone:  
+81363809201, e-mail: uedat@tdc.ac.jp

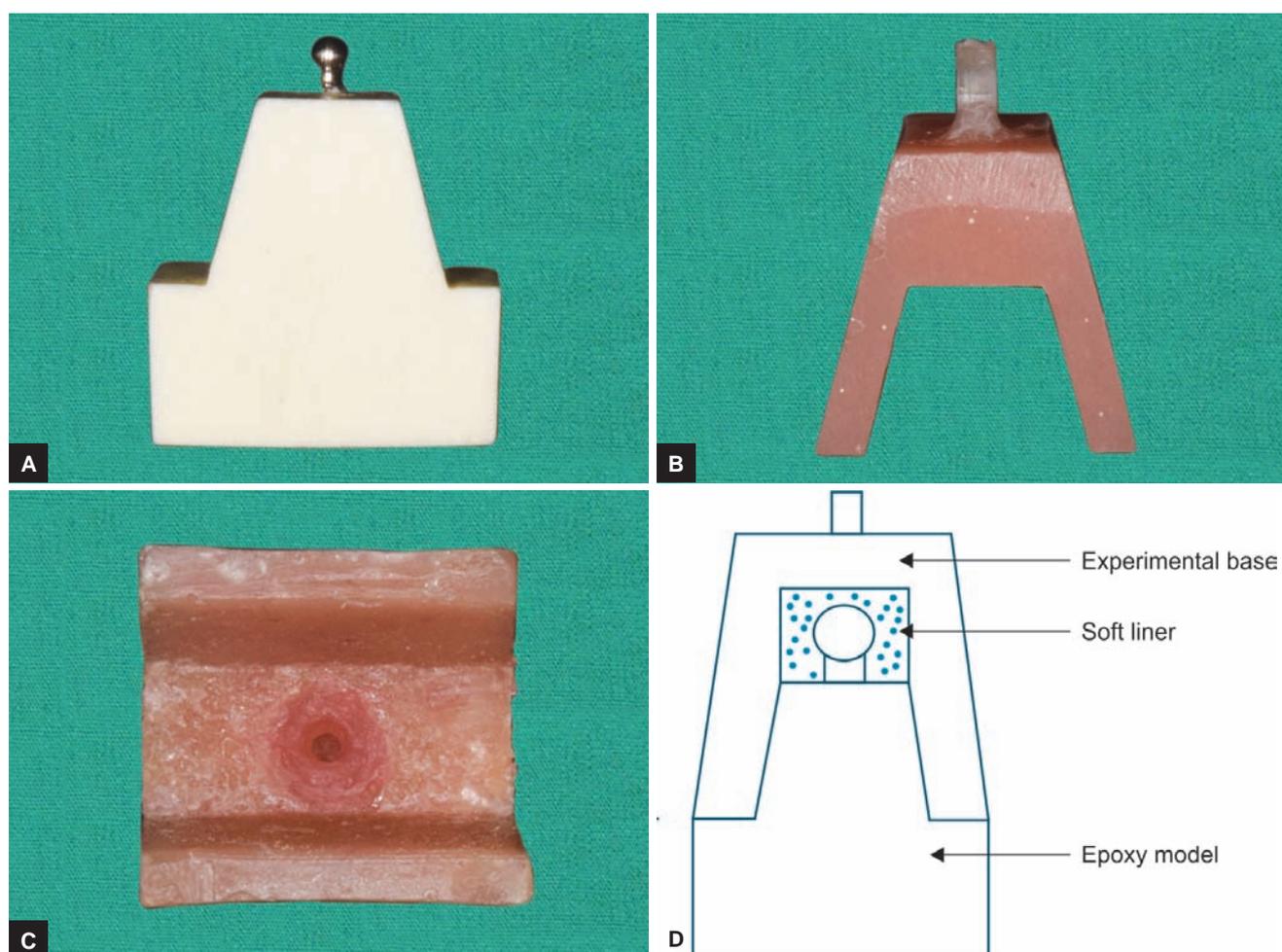
be taken of the fixture in the attachment system. Because the silicone soft relining material has high elasticity,<sup>5-7</sup> the allowable between-male angle for mounting/removal may be larger than that of the existing attachments, increasing the acceptable angle of the system.

The objective of this study was to investigate attenuation of the retention force of this system using silicone soft relining material after repeated mounting and removal, and to clarify the between-male angle for mounting/removal. We hypothesized that the attachment system with silicone soft relining material would maintain the necessary retention force after repeated mounting and removal corresponding to use for 1 year, and that its allowable angle would be greater than that of existing attachments.

## MATERIALS AND METHODS

Attachments were prepared using ball attachments with a diameter of 2.5, 2.7, or 3.0 mm for the male ends, and a silicone soft relining material (Sofreliner Tough Medium<sup>®</sup>, Tokuyama Dental, Tokyo, Japan) for the female end (Fig. 1). Retentive force measurements and allowable angle tests were subsequently performed.

For the retention force measurements, the initial retention force immediately after preparation of the attachment and changes in the retention force caused by repeated mounting/removal were investigated. Artificial saliva (10  $\mu$ L of 60% aqueous glycerin solution) was placed between the male and female ends.<sup>8</sup> The experimental base (self-curing resin: Tray Resin<sup>®</sup>, Shofu, Kyoto, Japan) and a cast were joined at a pressure of 5 N for 10 seconds. The experimental base was pulled from the cast at a crosshead speed of 25 mm/min,<sup>1</sup> the force required to detach was measured 10 times using a digital force gauge (MV-100; Imada Co., Ltd, Aichi, Japan), and the mean was adopted as the retention force. Assuming that the frequency of mounting/removal is four times per day, mounting/removal was repeated 1,488 times corresponding to the frequency per year. The retention force was measured after each cycle of 124 mountings/removals, which was assumed to be the frequency per month. For the allowable angle test, two pairs of male ends were used. The between-male ends angle was set at 0, 15, 30, or 45°, and the between-male angle with the corresponding female end (Fig. 2) was measured. Mounting



**Figs 1A to D:** Measuring device. (A) Epoxy resin model: residual ridge with ball anchor (patrix connector); (B) Experimental base; (C) Internal surface of combined resilient denture liner; (D) Sectional view of the measuring device



**Fig. 2:** Measurement of between-male angle [ $\theta$ : Between-male angle ( $\theta=0^\circ, 15^\circ, 30^\circ, 45^\circ$ )]

of the experimental base was judged to fit one of three states: A, mountable (monophasic); B, mountable (biphasic); and C, nonmountable. For the statistical analysis, the retention force at the initiation of the experiment was compared with the retention force at each time-point using one-way ANOVA followed by Dunnett’s test. Analysis was performed using IBM Statistical Package for the Social Sciences version 22 statistical analysis software (International Business Machines Corporation, New York, USA).

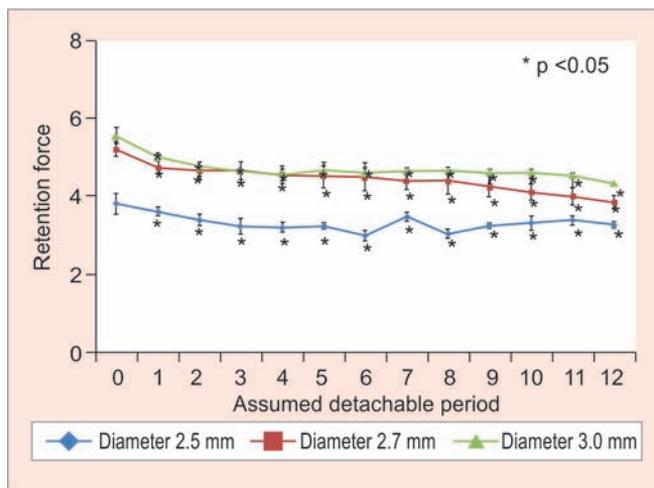
**RESULTS**

The initial retention forces of the male ends with a diameter of 2.5, 2.7, or 3.0 mm at the initiation of the experiment were  $3.8 \pm 0.3, 5.2 \pm 0.2,$  and  $5.5 \pm 0.2$  N respectively. After repeated mounting and removal corresponding to use for 1 year, the retention force decreased significantly to  $3.3 \pm 0.1, 3.8 \pm 0.2,$  and  $4.3 \pm 0.1$  N respectively (Graph 1). Mounting/removal of the male ends used in this experiment was possible up to an angle of  $45^\circ$ , although it was biphasic (Table 1).

**Table 1:** Possibility of mounting/removal of experimental base

	2.5 mm	2.7 mm	3.0 mm
0°	A	A	A
15°	A	A	A
30°	B	B	B
45°	B	B	B

A: The experimental base is mountable (monophasic), B: mountable (biphasic), or C: non-mountable (not observed in this study)



**Graph 1:** Reduction in the retention force between the female and male ends of three different diameters

**DISCUSSION**

Under the conditions of this experiment, the initial retention force decreased significantly after repeated mounting corresponding to use for 1 year for all male ends with a diameter of 2.5, 2.7, or 3.0 mm. However, the force was equivalent to or higher than that of a commercial OP anchor ( $2.9 \pm 0.2$  N),<sup>1</sup> suggesting that the silicone soft relining material maintains sufficient retention force over the period of 1 year despite repeated mounting and removal.

The timing for replacing the silicone soft relining material varies because the rate of deterioration varies according to denture management.<sup>9,10</sup> Therefore, the material should be replaced at every periodic check-up (every 3–4 months), so that the retention force is never compromised. However, patients requiring treatment at home may not receive check-ups for up to 1 year or longer. Therefore, the minimum required retention force is important for these patients, and measurement of changes in the retention force after repeated mounting/removal corresponding to use for 1 year is useful.

The method of exchanging the female end at the time of the periodic check-up is very simple. When self-curing resin is used where a normal O-ring is incorporated, detailed work is necessary and relief must be provided around the undercut of the male end in the patient’s oral cavity. In contrast, our system does not require such detailed work because the silicone soft relining material of the female end of the overdenture is removed by shaving using a carbide bur, and the relining material is injected. Even if the material enters the undercut, the denture can be removed without difficulty.

The allowable between-male angle for mounting/removal was as large as  $45^\circ$  in this experiment, which exceeds the allowable angle for taking impressions during the preparation of existing implant systems,<sup>11,12</sup> thus

raising no practical problems. Therefore, this system may be applicable for elderly patients in whom parallel implant placement is difficult because of marked bone resorption. This experiment also clarified the allowable angle.

Implants may not be parallel in many patients with partially fixed retainers when they are replaced with an implant bar denture. However, based on the results of this experiment, this attachment may be mounted by selecting several implants within the allowable angle range up to 45°.

For cleaning, a method that does not damage the silicone soft relining material is required. Dentures may be cleaned mechanically using a special brush, and cleaned chemically using denture cleanser. Denture brushes with hard bristles, based on ISO22254:2005,<sup>13</sup> were not found to roughen the surface more than denture brushes with soft bristles.<sup>14</sup> Chemical denture cleansers using enzymes and neutral peroxide do not damage the silicone soft relining material.<sup>14</sup> Combining these methods, sufficient cleaning is possible without damaging the surface of the relining material. Patients should be instructed on an appropriate cleaning method for this system.

Maryod et al<sup>15</sup> reported that the postoperative clinical outcomes and survival rate of tissue around fixtures were favorable when silicone soft relining material was used for the female end after application of an early load following fixture placement compared with those of implants with immediate loading. This was because micromotion of the fixtures was inhibited.

## CLINICAL SIGNIFICANCE

A simple attachment system for an overdenture is desirable, especially for older adults. We propose a system that focuses on a soft relining material for the female end of the attachment. This may save time and reduce costs and could be used to easily treat patients in their home or a nursing home.

## CONCLUSION

Under the conditions of this experiment, the retention force decreased with repeated mounting and removal of the female end prepared with silicone soft relining material; however, the reduced retention force was still clinically effective. Additionally, a large between-male angle for mounting/removal was allowable, and mounting/removal was possible up to 45°.

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