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Effect of magnetic attachment with stress breaker on lateral stress to abutment tooth under overdenture*

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SUMMARY **Recently, a newly developed magnetic attachment with stress breaker was used in retentive components in overdentures. Excessive lateral stress has a more harmful effect on natural teeth than axial stress, and the magnetic attachment with stress breaker is expected to reduce lateral forces on abutment teeth and protect it teeth from excessive stress. However, the properties of this retainer have not yet been determined experimentally. This study compares the lateral forces on abutment teeth for three retainers under loading on the denture base in a model study. A mandibular simulation model is constructed to measure lateral stress. Three types of retentive devices are attached to the canine root. These devices include the conventional root coping, the conventional magnetic attachment and the new magnetic attachment with stress breaker. For each retentive device, load is generated on the occlusal table of the model overdenture, and the lateral stress on the canine root and the displacement of the overdenture measured. The magnetic attachment with stress breaker does not displace the denture and exhibits lower lateral stress in the canine root than conventional root coping and magnetic attachments.**

KEYWORDS: **magnetic attachment, stress breaker, overdenture**

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Introduction

Over the last few decades, prosthodontic treatment by overdentures has become a common option for rehabilitating almost edentulous patients. One reason for this is that the few natural teeth that have lost periodontal bone support but are still in healthy condition to receive occlusal load may be preserved.

A number of different retention systems have been proposed and used, and one of these is magnetic retention.

Magnets have been used as retention devices for dental prostheses since the 1950s, with magnetic attachments widely used in both natural teeth and dental implants (1, 2). One of the greatest advantages of magnetic retention over mechanical retention is the reduced lateral force, which enables natural teeth with some degree of periodontal disease to be used as an abutment.

Although natural teeth and implants are affected by lateral stress (3, 4), only a few studies have examined bending effects, lateral stresses and retentive forces in magnetic attachments (5–7).

Recently, a newly developed magnetic attachment with stress breaker was used as a retainer in conventional or implant-supported overdentures in Japan (8). However, the stress-breaking effect of this retainer has not yet been determined.

The purpose of the present study was to quantitatively evaluate the magnetic attachment with the stress-breaker *in vitro*, to allow clinical indications to be determined more accurately.

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Materials and methods

Experimental model

An experimental model was designed to assess the magnitude of the force transmitted to the abutment during occlusal loading of an overdenture. The model was a replica of a commercially available mandibular model (G2-402L),† using acrylic resin. To simulate mucosa support, the model surface of the residual ridge was scraped out to a depth of 2 mm and substituted with silicone made by Fit Checker©.‡ The thickness of the mucous membrane was 2 mm (9, 10).

An artificial root was constructed on the left side of the canine position to simulate the abutment tooth of the overdenture. These were cemented to the model using temporary cement (HY-bond Temporary Cement Hard),§ with a keeper then built on top of this. The denture base was constructed of cold-curing resin (Palapress® vario).¶

A root analogue was fitted with four strain gauges (KFG-03-120-C1-11N30C2)** to produce a device for sensing lateral stress around an abutment tooth. The configuration of this sensing device is shown in Fig. 1. Strain gauges on the mesial and distal sides of the device measure lateral stress in the mesio-distal direction, and strain gauges on the buccal and lingual sides of the abutment tooth measure lateral stress in the bucco-lingual direction. Total lateral stress is then a combination of mesio-distal and bucco-lingual lateral stress. The device was calibrated to allow stresses to be determined from strain.

The device was embedded at the left canine position in the simulation model (Fig. 2) with retention devices attached to this sensing device during testing. Three types of retention devices were used in the study – conventional root coping (RC), conventional magnetic attachment (MD) (Trial product),†† and conventional magnetic attachment with stress breaker (MS) (Magsoft©)†† (Figs 3 and 4). The MD and MS magnets were embedded in the denture base and were replaced after each test. The attractive magnetic force of the MD magnet was 800 gf, and of the MS magnet was 750 gf.

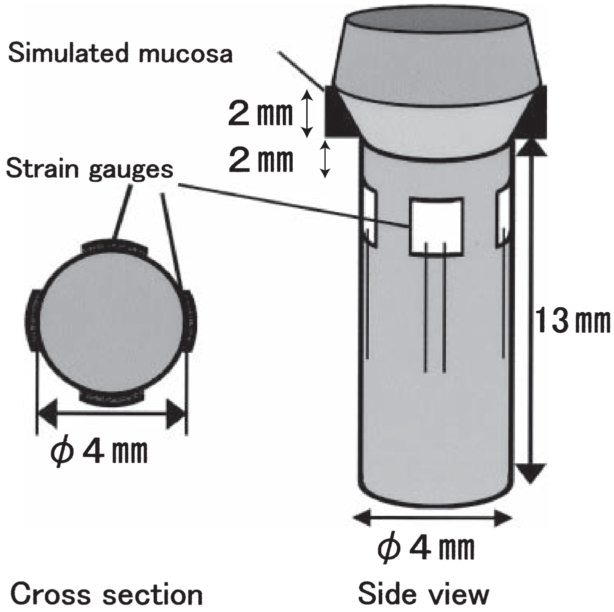

Fig. 1. Schematic of the root analogue including sensing devices that is used to determine lateral stresses in abutment teeth.

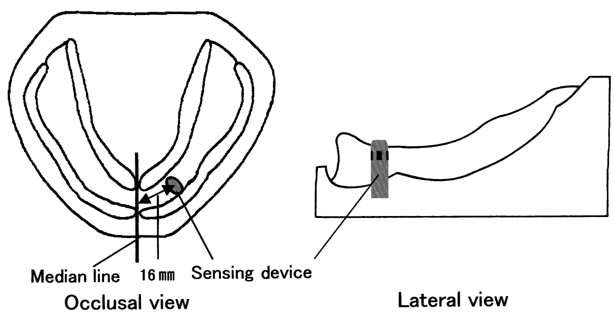

Fig. 2. Schematic of the mandibular simulation model.

Diameters of both attachments were 4·0 mm. The shape of each coping, with or without keeper, was a frustum of a cone having a height of 2 mm and a side taper of 6°. Five copings for each type of retainer were constructed.

For MD and MS attachments, the magnet was removed from the attachment and embedded in the denture base attached to the keeper. For the RC, the keeper was attached to the relined resin inside the denture base. The side of the keeper was relieved in each case via the spacer plate incorporated into the attachments.

Loading

Nine load application points were chosen (Fig. 5) with one in the median line position (C), and four bilateral

†Nisshin Dental Products Inc., Kyoto, Japan.
‡GC Corp., Tokyo, Japan.
§Shofu Corp., Kyoto, Japan.
¶Heraeus Kulzer, Wehrheim, Germany.
**Kyowa Electric Instruments Corp., Tokyo, Japan.
††Aichi Steel Corp., Nagoya, Japan.

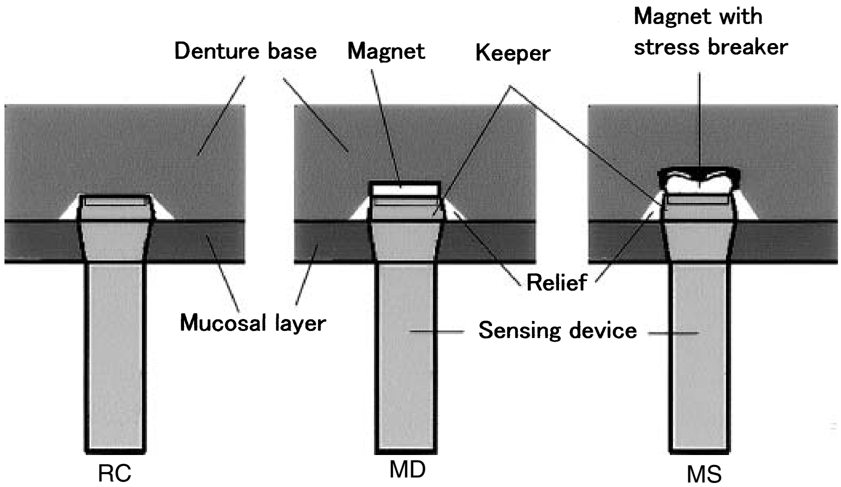

Fig. 3. Schematics of the three types of retentive devices considered, conventional root coping (RC), conventional magnetic attachment (MD), and magnetic attachment with stress breaker (MS), connected to the root analogue fitted with sensing devices.

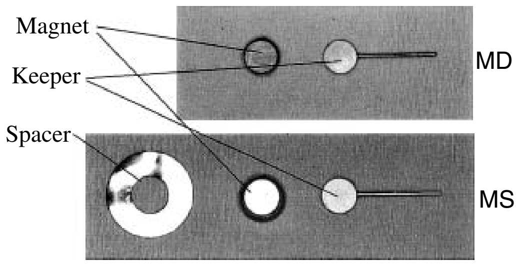

Fig. 4. Photographs of the components of the conventional magnetic attachment (MD), and magnetic attachment with stress breaker (MS).

points in the lateral incisor position (L), first premolar position (P1), first molar position (M1) and second molar position (M2). A vertical load of 49 N (5 kgf) was applied to each loading point using the loading apparatus shown in Fig. 6, with lateral stresses on the canine and displacement of the denture base measured.

Measurement

The three-dimensional, 6 degree of freedom displacement measurement system established by Nishida *et al.* (11) was used in measurements of denture base displacement. Six light-emitting diodes (LEDs)[‡‡] were placed at the first premolar and second molar positions of the left buccal side of the denture base (Figs 5 and 7). The position of LEDs was measured by a PSD camera (Fig. 6) and personal computer, and displacements of denture base were calculated. Denture base displacement was measured five times during each test.

[‡‡]Kyoto Semiconductor Corp., Kyoto, Japan.

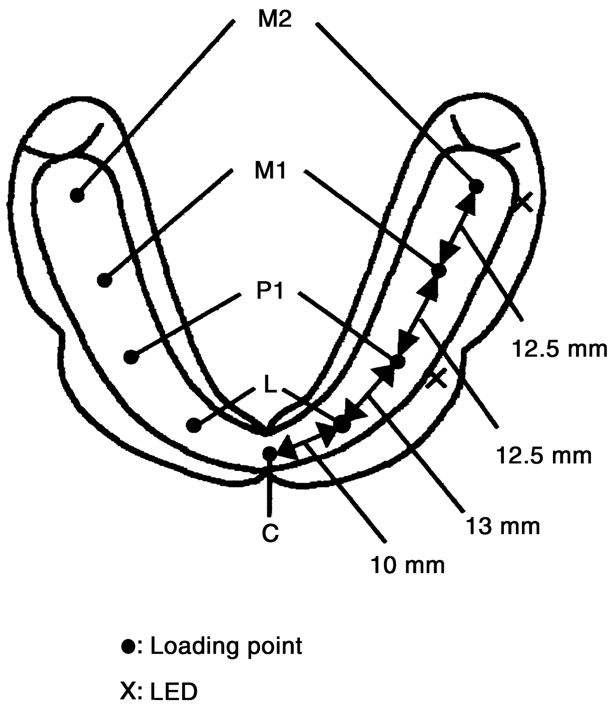

Fig. 5. Schematic of the denture used in experiments showing loading points and light-emitting diodes (LED) mounting locations.

Lateral stress was measured using the root analogue described earlier.

Statistical analysis

An analysis of variance (ANOVA) was conducted between the three retainers. *Post hoc* comparisons of mean values were performed via the Bonferroni method.

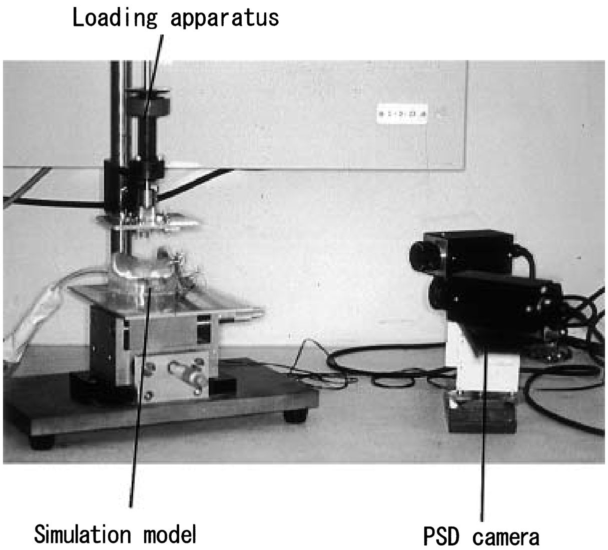

Fig. 6. Photographs of the loading apparatus, simulation model, and three-dimensional, 6 degree of freedom displacement measurement system.

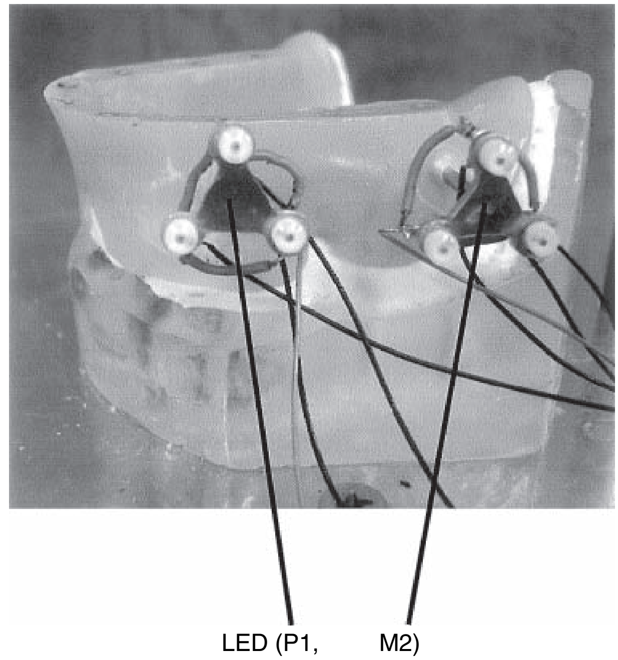

Fig. 7. Photograph of left side of the loading apparatus and six light-emitting diodes (LED).

Results

Lateral stress on the abutment tooth

The lateral stress ranged from 0·1 to 20 N. The lateral stress was significantly lower with MD and MS than with RC ($P < 0{\cdot}05$), when the loading point was the left lateral incisor. When the loading point was the left first premolar, lateral stress was significantly lower with MS than with MD and RC ($P < 0{\cdot}05$). For other loading points, there were no significant differences among these three retainers (Fig. 8).

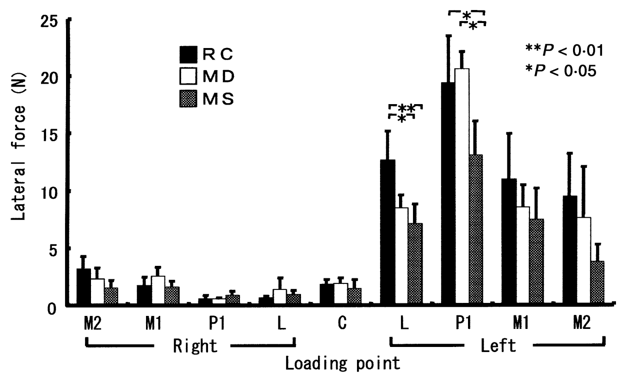

Fig. 8. Measured lateral stresses on the abutment tooth for root coping (RC), magnetic attachment (MD) and stress breaker (MS) retainers. Vertical bars show standard deviations, horizontal lines connect significantly different columns ($^{**}P < 0{\cdot}01$, $^{*}P < 0{\cdot}05$).

Displacement of the denture base

The displacement at the first premolar position ranged from 0·24 to 2·2 mm and the displacement at the second molar position ranged from 0·27 to 4·0 mm. No significant differences in the displacement of the denture base were observed among the three retainers (RC, MD, MS) in any of the loading points (Fig. 9).

Discussion

Studies on lateral and rotational stresses have drawn attention to magnetic attachment. Factors influencing the keeper have been investigated by Mensor (5) and Tanaka (6), while the relationship between the silicon rubber placed between the magnet and the denture base has been investigated by Ichikawa *et al.* (7). The authors reported that lateral stress and bending stress were reduced by these modifications. Among commercially available products, the Shiner System[§§] reduces lateral stress. The Shiner System is used for overdentures on both natural teeth root and on implants.

[§§]Preat Corporation, CA, USA.

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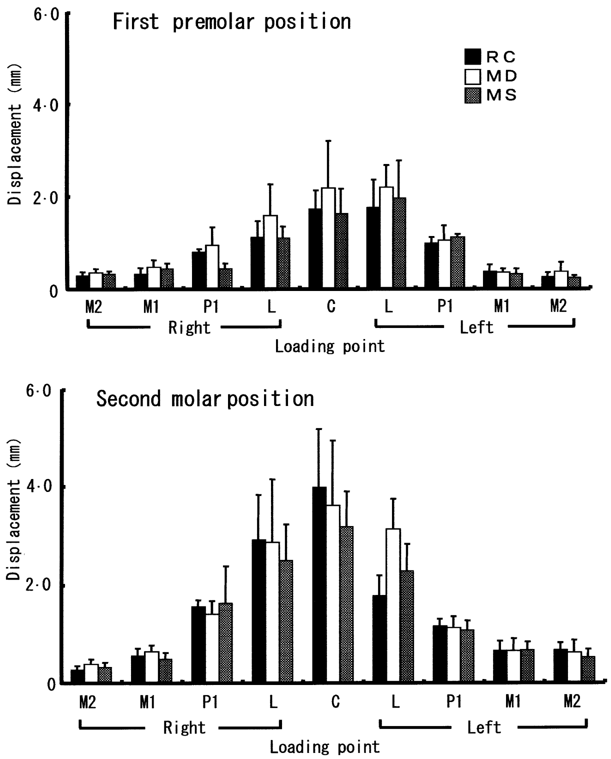

Fig. 9. Displacements of denture base in the first premolar and second molar positions of the left buccal side of the denture base for root coping (RC), magnetic attachment (MD) and stress breaker (MS) retainers. No significant differences were observed.

The magnetic attachment with stress breaker used in this study both allows rotation of the magnet and provides a vertical cushion. Vertical rotation of the denture is caused primarily by the difference in compressibility between the abutment tooth and the mucosa. Pitching movement is prevented if the vertical displacement of the abutment is similar to the mucosa. The magnetic attachment with stress breaker is designed with this in mind.

The periodontal ligament was assumed to be incompressible and was fixed in the model, because of the great difference in resilience between the periodontal ligament and mucosa support. To simplify the study and avoid variables that could introduce errors, all experiments were conducted on only one side of the mouth, despite this not being the clinically typical case.

As the largest occlusal force in removable partial dentures has been reported to be 100–200 N (12), the occlusal force on the denture during mastication was assumed to reach 49 N. For this reason, a vertical load of 49 N (5 kgf) was applied to each loading point.

When the loading point was on either the left lateral incisor or the left first premolar, lateral stress on the canine was significantly lower with MS than with RC or MD, which suggests that when the loading point is near the canine sensor, the stress-breaking ability of MS is more effective. However, for the other loading points, no significant differences were observed among the three retainers, because these loading points were distant from the abutment tooth. No significant differences in the displacement of the denture base were found among the measurement positions or among the loading points RC, MD and MS, indicating that the retainers examined in the present experiment did not influence the displacement of the denture base.

In this study, a conventional RC, conventional magnetic attachment (MD) and conventional magnetic attachment with stress breaker (MS) were compared on the simulation model. From the results of this study lateral stress of the abutment teeth and denture movement in the mouth can not be identified, but the characteristics of RC, MD and MS can be determined.

In conclusion, the magnetic attachment with stress breaker was found to have little affect on denture displacement, and to exhibit lower lateral stresses in the canine root than conventional RC or magnetic attachments.

This suggests that stress-breaking magnetic retainers are not as traumatic on abutment teeth as conventional retainers, and so this type of magnetic attachment should be clinically used in cases of periodontally compromised abutments.

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