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Original Research

Influence of Load on Retention during Placement of a Magnetic Attachment in an Overdenture

Gonda Tomoya, DDS, PhD, Igarashi Yuki, DDS, Umino Tetsuro, DDS, Dong Jian, DDS, PhD, Ikebe Kazunori, DDS, PhD and Nokubi Takashi, DDS, PhD

Division of Oromaxillofacial Regeneration, Osaka University Graduate School of Dentistry
(*Chief : Prof. Nokubi Takashi*)

Clinical significance
The retentive force of an overdenture with a magnetic attachment was measured with the goal of clarifying the influence of the load applied when placing the magnet. When loads of 26.4 or 29.4 N were applied, the attractive force of the overdenture was significantly less than with loads less than 23.5 N. These findings suggest that the use of a greater load results in insufficient retentive force.

ABSTRACT

Purpose : The purpose of the present research was to clarify the influence of load on the retention of the overdenture when placing a magnetic attachment.

Materials and Methods : A mandibular model with a root only in the left canine was fabricated. A root coping containing the keeper of a magnetic attachment was placed on the left canine. The thickness of the simulated mucosa in the residual ridge was 2 mm. The mucosa was fabricated using a fitness test material. A magnet was placed on the keeper and then embedded in the denture base with quick self-curing acrylic resin. A load ranging from 4.9 to 29.4 N was applied to the occlusal surface of the denture.

Results : When loads of 26.4 or 29.4 N were applied, the attractive force of the overdenture was less than 10 N ($p < 0.01$), which is significantly smaller than the attractive force obtained when a load of less than 23.5 N was used. These results are probably due to the rebound of the residual ridge membrane.

Conclusion : Although sufficient attractive force was obtained when a magnetic attachment was placed in the mouth and a small load was applied to the denture, the attractive force of the magnetic attachment may not be great enough under large loads, such as occlusal force. Care should be taken regarding the amount of load applied to the occlusal surface of the overdenture when placing magnetic attachments.

Key words

overdenture, magnetic attachment, retentive force

Corresponding author : Gonda Tomoya
1-8, Yamadaoka, Suita, Osaka 565-0871, Japan
Tel : +81-6-6879-2955, Fax : +81-6-6879-2957
E-mail : tgonda@dent.osaka-u.ac.jp
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INTRODUCTION

Magnetic attachments are composed of a magnet and a keeper. The attractive power between the magnet and the keeper is used as a means of retaining for removable dentures. Magnetic attachments provide a steady retentive force over a long period of time. In addition, an excessive load on the abutment tooth can be avoided, and the load distribution can be controlled according to the condition of the abutment tooth. Over the last few decades, prosthodontic treatment using overdentures with magnetic attachments has become a common option for rehabilitating nearly edentulous patients[1-7].

The magnet of a magnetic attachment is sometimes placed in the mouth with self-curing acrylic resin. Although it is recommended that the placement be performed with a suitable load on the denture, a thorough examination of the effect of the load on the denture has not yet been reported[1,4,5].

The purpose of the present *in vitro* study was to clarify the influence of load on retention while placing a magnetic attachment in an overdenture.

MATERIAL AND METHODS

Experimental Model (Figs. 1, 2)

The experimental model was a replica of a commercially available mandibular model (G 2-402 L, Nisshin Dental Products Inc., Kyoto, Japan) and was made using cold-curing resin (Palapress vario, Heraeus Kulzer, Wehrheim, Germany) (Fig. 1). In order to simulate mucosal support, the surface of the residual ridge on the model was thinned out to a depth of 2 mm and replaced with silicone (Fit Checker, GC, Tokyo, Japan). A 2-mm thickness was chosen for the mucous membrane in the residual ridge and a 4 mm thickness in the retromolar pad based on reports by Sakuma[8] and Terakura[9]. A denture base that fit the experimental model was constructed of cold-curing resin (Fig. 2).

An artificial root was constructed on the left side of the canine position to simulate the abutment tooth of the overdenture and was embedded in the model using self-curing acrylic resin. A keeper with an embedded magnet was placed on

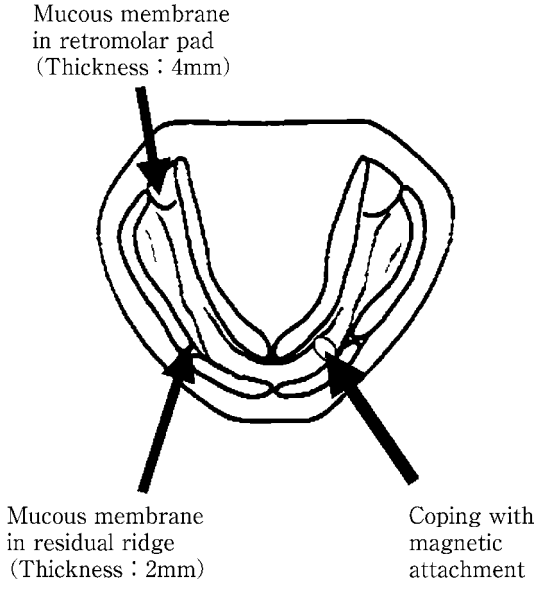

Fig. 1 Diagram of the mandibular experimental model

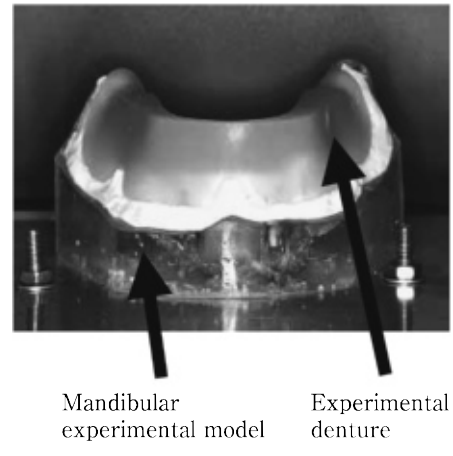

Fig. 2 Photograph of the mandibular experimental model and the experimental denture

the artificial canine root using temporary cement (HY-bond Temporary Cement Hard, Shofu, Kyoto, Japan). The magnetic attachment used in this study was a Magnedisc 800 (Aichi Steel, Aichi, Japan) (Fig. 3).

Placing the Magnet in the Denture Base

First, the inside of the denture base around the canine root was scraped out to place the magnet. The magnet was attached to the keeper on the canine root. Then, a wax seat (0.3 mm thick) was pressed onto the magnet as a spacer.

Next, the denture was fit to the spacer using self-curing acrylic resin (Unifast II, GC, Tokyo, Japan) by applying one of nine different vertical loads : 4.9, 9.8, 14.7, 19.6, 23.5, 24.5, 25.5, 26.4, or 29.4 N. After removing the spacer, the magnet was fixed in the denture base with one of nine vertical loads after placing a small amount of the self-curing acrylic resin in the gap between the magnet and the denture base.

Measuring the Retentive Force

Measurement of the breakaway retentive force was performed with a universal testing instrument (Autograph AGS-10 kNG, Shimadzu, Kyoto, Japan) (Fig. 4) at a speed of 1.0 mm/min. The overdenture was pulled up directly above the magnetic attachment.

Magnets were placed five times for each loading condition. Measurement of the retentive force was performed five times during each test, and the average value was assumed to be representative of the loading condition at placement. An analysis of variance (ANOVA) was conducted between the loads. A post hoc comparison of the mean values was performed according to the Bonferroni method.

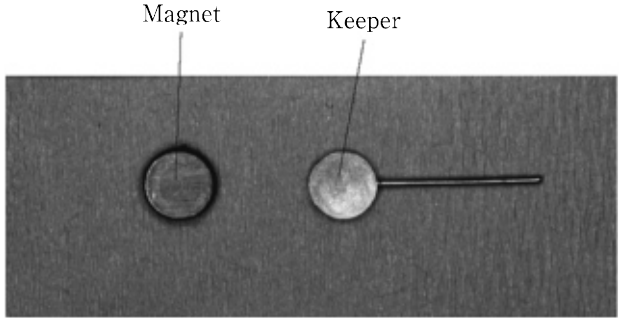

Fig. 3 Photograph of the magnetic attachment (Magnedisk 800, Aichi Steel)

RESULTS

The retentive force of the denture was 20 N or more for loads of 4.9, 9.8, 14.7, 19.6, and 23.5 N ; these results showed no significant differences. The retentive force of the denture was 10 N or less when the load was 26.4 or 29.4 N and was significantly less than the retentive force for loads of 23.5 N or less ($p<0.01$) (Fig. 5).

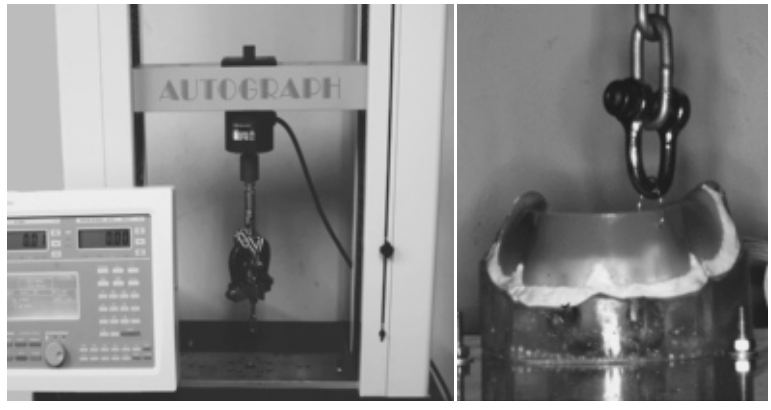

Fig. 4 Universal testing instrument (Autograph AGS-10 kNG, Shimadzu)

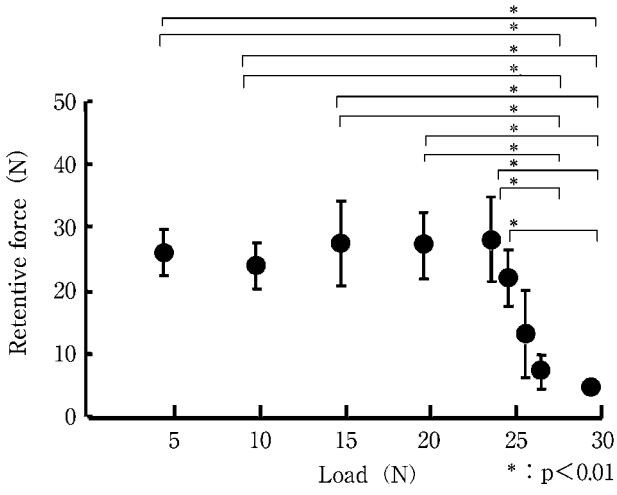

Fig. 5 Influence of load on retention while placing a magnetic attachment in an overdenture. Each point is the mean with the error bar showing the standard deviation

DISCUSSION

When constructing overdentures that include magnetic attachments, the magnet may be placed either when the denture is processed or after placement in the mouth[4,5]. Magnets are often placed in the denture approximately one week after delivery in the mouth in order to allow the mucous membrane to become accustomed to the denture[1,10].

Although an adequate load should be applied when the magnet is placed, studies have shown that the load may be inadequate[1,4,5]. Moreover, after placing the magnet, the retentive force may be insufficient due to the rebound of the mucous membrane, mistakes in placing the magnet, or shrinkage of the cold-curing resin. The focus of the present *in vitro* study was on the rebound of the mucous membrane and the influence of the load on retention while the magnetic attachments are placed.

A mandibular model was chosen for this experiment because mandibular cases more often involve insufficient retentive force compared to maxillary cases. The retentive force of a magnetic attachment in mandibular overdentures is expected to be stronger and more stable. The canine was chosen as the abutment tooth because it has the longest life among the natural teeth[11-13] and is suitable as an abutment for an overdenture[14]. Only the left canine was chosen in order to simplify the conditions of this experiment, although the canines on both sides are often used as abutment teeth for overdentures.

To simulate mucosal support in this study, the surface of the residual ridge on the model was replaced with silicone (Fit Checker), which has a degree of compression similar to that of the mucous membrane *in vivo*, as reported by Sakuma[8]. In addition, the mucous membrane thicknesses of 2 mm in the residual ridge and 4 mm in the retromolar pad were chosen, as reported by Sakuma[8] and Terakura[9].

Mucous membranes are viscoelastic but silicone is not. However, after pressure is applied to the membrane for several minutes, it acquires elastic behavior[8]. In this experiment, silicone simulated a mucous membrane after a period of "settling".

The retentive force was measured with a universal testing instrument. The overdenture was pulled up directly above the magnetic attachment vertical to the occlusal plane. The retentive force is defined as the maximum breakaway load and is affected by crosshead speed. The attachments in this experiment were loaded at a speed of 1 mm/min[1].

When a load of 26.5 N or more was applied, the retentive force of the denture was significantly less than with a load of 23.5 N or less ($p < 0.01$). This difference was caused by the deformation and rebound of the mucous membrane when the load was applied.

When the magnet was placed in the denture and the load applied, the mucous membrane of the residual ridge was deformed by the transmitted load. Thus, the magnet was placed in a

deformed mucous membrane. Because the mucous membrane has a degree of elasticity, it recovers its shape through a rebound force that forms after the load is removed. The gap between the keeper and the magnet that occurs when this rebound force increases is believed to cause insufficient retentive force of the denture. Therefore, the load at the placement of the magnetic structure is assumed to affect the retentive force of the denture.

When the magnet is placed using a small load, the retentive force is sufficient. However, the abutment tooth probably receives a large amount of load at the same time. When it receives an excessive load, there is a risk of occlusal trauma and tooth fracture. In this experiment, the retentive force and the applied load are of concern but the load on the abutment tooth is not. Further study is necessary to clarify the relationship between the load applied to the denture and load received by the abutment tooth.

The abutment tooth was assumed to be a natural tooth in this experiment. Similar results could be obtained in the case of an implant.

The results of the present experiment indicated that various factors caused the load to be insufficient when the magnet was placed in the denture. These results show the relationship between the load when the magnet was placed and the retentive force of the denture. An appropriate load that does not cause the mucous membrane to rebound will be examined in a future experiment.

CONCLUSIONS

The retentive force of dentures with magnetic attachments was measured to clarify the influence of the load applied on the retentive force of the denture while the magnet was placed in the denture.

The results indicated that the retentive force was insufficient when a large load was applied. Applying a large load using occlusal force may not be appropriate when a magnetic attachment is placed in the mouth.

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