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Volume 32, Number 2

Proceedings of the 22th International Conference on Magnetic Applications in Dentistry

The Japanese Society of Magnetic Applications in Dentistry

The 22th International Conference on Magnetic Applications in Dentistry

The 22th International Conference on The Japanese Society of Magnetic Applications in Dentistry organized by JSMAD was held on the Internet as follows;

Meeting Dates:

Friday, February 24 to Tuesday, March 14, 2023

Location:

JSMAD web site

http://jsmad.jp/international/22/

General Chair:

Prof. Hideki Aita, Health Sciences University of Hokkaido

Subjects:

Researches and developments related to dentistry and magnetism such as:

- Magnetic attachments for dentures
- Orthodontic appliances using magnets
- Measurement of jaw movement using magnetic sensors
- Biological effects of magnetic fields
- Dental applications of MRI
- Others

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The 23rd International Conference on Magnetic Applications in Dentistry General Information

General Information

The Japanese Society of Magnetic Applications in Dentistry (President: Masayuki Hideshima, Tokyo Medical and Dental University) is a scientific association founded in 1991 and is devoted to furthering the application of magnetism in dentistry. The 23rd International Conference on Magnetic Applications in Dentistry organized by JSMAD will take place on the Internet as follows.

Meeting Dates:

Monday, February 26 to Friday, March 15, 2024

Location:

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Executive Committee Chair:

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Subjects:

Researches and developments related to dentistry and magnetism such as:

- Magnetic attachments for dentures
- Orthodontic appliances using magnets
- Measurement of jaw movement using magnetic sensors
- Biological effects of magnetic fields
- Dental applications of MRI
- Others

Registration Information

Registration:

Send e-mail titled "Registration for 23rd international conference" with your Name, University or Institution, Postal address, Phone, Fax and E-mail address to conference secretariat.

Registration Fees:

No registration fees. Anyone who is interested in magnetic applications in dentistry can participate in the conference via the Internet. Publishing Charge for Proceedings:

After the conference, the proceeding will be published. The publishing charge is 10,000 yen per page. (No charge for invited paper.)

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Deadlines:

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Poster submission: <u>February 12, 2024</u>

Entry:

Send Title and Abstract within 200 words with your Registration.

Paper submission:

Please send papers in Microsoft Word format to the conference secretariat by E-mail. All contents should be written in English. No multi-byte character, such as Japanese Kanji, should be contained. A template file can be obtained from the conference web site. Web presentations for the conference will be produced by the secretariat from the paper. The secretariat will not make any correction of the paper even miss-spelling, grammatical errors etc. Alternative format files are acceptable. Please contact to the secretariat for more detailed information.

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Contents

A case report of a removable partial denture using magnetic attachments of different designs on intermediate missing mandibular molars

M. SONE[1], D. MATSUMOTO[1], M. NUMAZAWA[1], S. UCHIDA[1], Y. INOYAMA[1], D. SAKAMOTO[1], K. OKAMOTO[1], and M FUJISAWA[2].

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[2]Division of Fixed Prosthodontics, Department of Restorative and Biomaterials Sciences, Meikai University School of Dentistry

Abstract

In this presentation, we report a case in which two dentures with different designs of magnetic attachments were attached to intermediate missing mandibular molars.

The patient, a 59-year-old male, complained of masticatory dysfunction. After the initial preparation, the distal root of the mandibular right second molar was fitted with a coping magnetic attachment in consideration of its load-bearing capacity as an abutment tooth, and we decided to fabricate an extracoronal magnetic attachment using an EC Keeper Tray (GC, Japan) for the mandibular right first and second premolars.

The definitive denture had the first molar as a homemade metal tooth and the second molar as a hard resin tooth (SR-Orthosit-PE; Ivoclar-Vivadent AG, Liechtenstein). In addition, GIGAUSS (GC) was used for a magnetic attachment (the coping type was the D400), and the D600 was applied to the extracoronal type. One year after the installation of the right denture, in response to the patient's request to use the same magnetic attachment as the right side, the first and second premolars on the left side were equipped with similar extra-crown attachments, and the dentures were made of the same material.

Introduction

In the partial denture design, when intermediate missing teeth are on the right and left sides, due to the patient's need for wearing comfort, we sometimes design two dentures without a major connector. In this presentation, we report a case in which two dentures with different designs of magnetic attachments were attached to intermediate missing mandibular molars.

Clinical History

Clinical History: The patient, a 59-year-old male, complained of masticatory dysfunction. He had a partially edentulous maxilla (Kennedy Class II) and a history of arrhythmia. He complained that he wanted

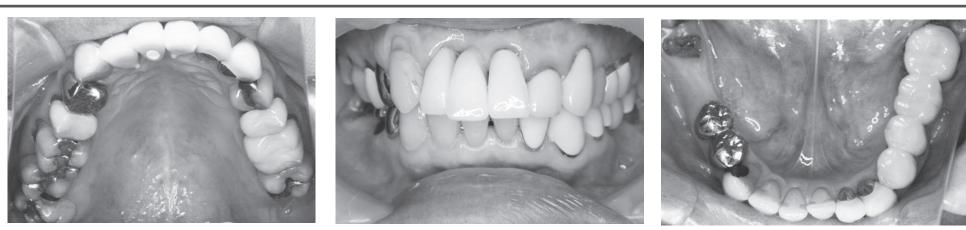

Fig. 1 Intraoral view at the first visit

to seat the denture firmly on his right jaw, but he did not want the implant treatment due to his current systemic history (Fig. 1).

Treatment Procedure: Based on dental X-ray photographs (Fig. 2) and periodontal disease examination (Fig. 3), the distal root of the mandibular right second molar was fitted with a coping type of magnetic attachment (Fig. 4) in consideration of its load-bearing capacity as an abutment tooth. We decided to fabricate an extracoronal magnetic attachment using an EC Keeper Tray (GC, Japan) for the mandibular right first and second premolars (Figs. 5 and 6).

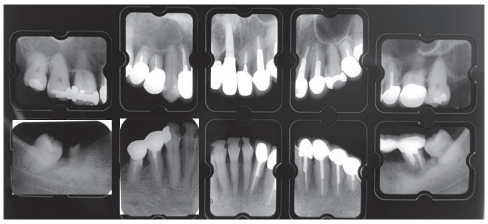

Fig. 2 X-ray photographs at the first visit

BOP																
Mobility	0	0	0	0	0	0	0		0	0	0	0	0	0	0	
PCR																
EPP	322	322	234	212	322	322	322		322	223	322	322	333	322	343	
(mm)	422	422	354	323	422	422	422		322	323	422	422	333	422	444	
Location	8	7	6	5	4	3	2	1	1	2	3	4	5	6	7	8
EPP	223	223		223	223	223	222	212	222	223	212	343	223		523	223
(mm)	333	333		333	333	333	212	111	222	333	322	323	333		543	333
PCR																
Mobility	0	0		0	0	0	0	0	0	0	0	0	0		0	0
BOP																

Fig. 3 Periodontal disease examination at the first visit

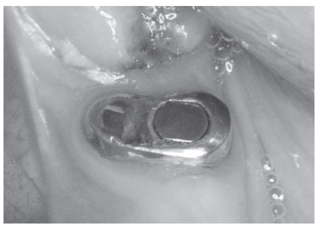

Fig. 4 Coping type of magnetic attachment

Fig. 5 Extracoronal magnetic attachment

Fig. 6 EC Keeper Tray

After fixing the coping type of magnetic attachment to the oral cavity, a pick-up impression was taken in the oral cavity for making a working model, and a framework of the denture was fabricated on it (Fig. 7). The definitive denture had the first molar as a homemade metal tooth, taking into account the space of the housing portion of the extracoronal magnetic attachment; the second molar was a hard resin tooth (SR-Orthosit-PE; Ivoclar-Vivadent AG, Liechtenstein) (Fig. 8). In addition, GIGAUSS (GC) was used for a magnetic attachment (the coping type was the D400), and the D600 was applied to the extracoronal attachment.

Fig. 7 Pick-up impression and denture framework (Right side)

Fig. 8 Definitive denture (Right side)

One year after the installation of the right denture, periodontal disease of the second molar on the left side of the mandible, which was the abutment of the left bridge, advanced, and the tooth was extracted. In response to the patient's request to use the same magnetic attachment as the right side for subsequent defect prostheses, the first and second premolars on the left side of the mandible were equipped with extra-crown attachments similar to the abutment teeth, and the dentures were made of the same material. As a support function to replace the root attachment on the right side, a mesial rest was added to the third molar on the left side of the mandible (Figs. 9 and 10).

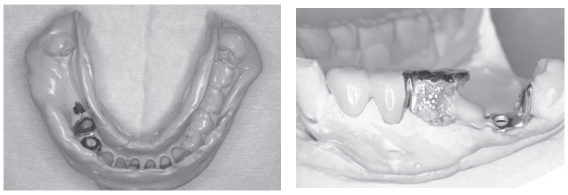

Fig. 9 Pick-up impression and denture framework (Left side)

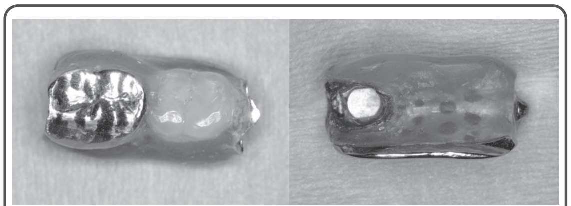

Fig. 10 Definitive denture (Left side)

Conclusion

Magnetic attachments can be used as support teeth by reducing the lateral pressure as coping types, even if the remaining teeth have problems with the crown-to-root ratio due to the absorption of alveolar bone. In addition, if the crown-to-root ratio is good, it is possible to produce highly stable dentures by having the abutment teeth carry the retention force and bracing force as an external type of crown (Fig. 11).[1,2] In this case, we applied these advantages and produced a denture. As a result, OHIP-14, which is related to QOL, was two points from the minimum value. By analyzing the amount of glucose discharge during gumi-jelly chewing, mandibular movements were quantitatively evaluated to be 188 mg/dl (right side) and 228 mg/dl (left side). We plan to confirm the postoperative course while performing regular maintenance in the future.

Fig. 11 Intraoral view of treatment procedures

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A pilot study on the fitness of a zirconia keeper coping fabricated by CAM system—Application of a high-precision scanner

D. MATSUMOTO, M. SONE, N. KOYAMA, Y. TANIUCHI, K. AOKI, T. MATSUKAWA, F. NARUMI, K. OKAMOTO and M. FUJISAWA[1)]

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Abstract

In this study, we report on the accuracy of matching of zirconia root plates fabricated using a high-precision laboratory scanner.

The abutment tooth was a preformed root plate–type epoxy artificial tooth (A50-359, NISSIN). The manufacturing procedure involves scanning the work model using a laboratory scanner (E3, 3Shape), modeling it using design software (Dental System, 3Shape), and then cutting it with a milling machine (CORiTEC 350i, Imes-Icore). Five specimens were tested, and the fitting accuracy of the zirconia root plates was evaluated using the cement replica method.

The measurement points are the labial margin at point a, the labial cervix at point b, the labial post at point c, the tip of the post at point d, the lingual post at point e, the lingual cervix at point f, and the lingual margin set as point g. The average gaps were 61.5±32.2 μm at point a, 73.5±32.4 μm at point b, 41.5±11.6 μm at point c, 148.5±19.1 μm at point d, 45.0±11.6 μm at point e, 81.5±27.8 μm at point f, and 46.0±13.3 μm at point g.

It was suggested that the zirconia root plate manufactured using a high-precision laboratory scanner could be applied clinically.

Introduction

The progress of dental CAD/CAM systems in recent years has been remarkable, and the further simplification of workflow and improvement in the compatibility of prosthetic devices are expected. At the 26th Annual Scientific Meeting, we examined the suitability of a zirconia root plate manufactured by supplementing the deep part of the model that was difficult to scan using a supplementary scanning post, and we reported that it was acceptable for clinical application. This time, we attempted to fabricate a zirconia root plate with a single system using a dental scanner for laboratory use, which has become more sophisticated and precise in recent years.

Materials and Methods

The abutment was an epoxy artificial tooth (A50-359, NISSIN) with a post part five mm deep, as recommended by this society. As for the manufacturing procedure, after taking an impression according to the standard method, a working model was made, it was scanned using a dental scanner for laboratory use (E3, 3Shape), and it was then scanned using design software (Dental System, 3Shape). After modeling, we cut it out using a milling machine (Figs. 1 and 2). The cement space was the specified value of the software, and the number of test samples was five.

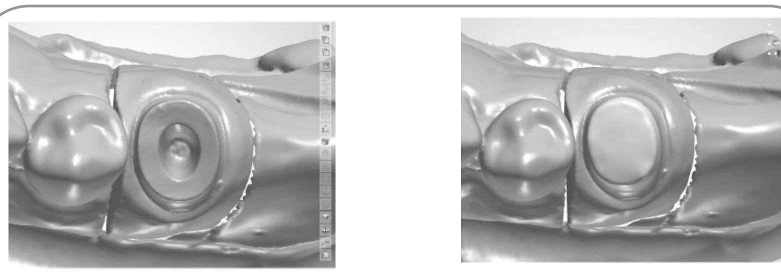

Fig. 1 Scanned model and designed keeper coping

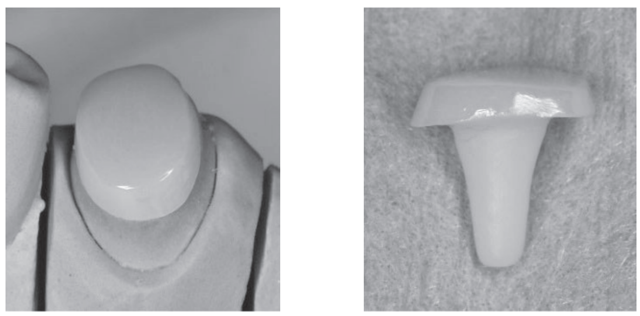

Fig. 2 Fabricated zirconia keeper coping

The fitting accuracy was evaluated using the cement replica method, which quantifies the gap between the model and the root plate based on the thickness of the silicone rubber coating (Fig. 3). In addition, the gap distance was measured by capturing a digital image of the cut surface of the silicone rubber together with a scale used as a reference and measuring it on a PC. In addition, seven measurement points were set as shown in Fig. 4.

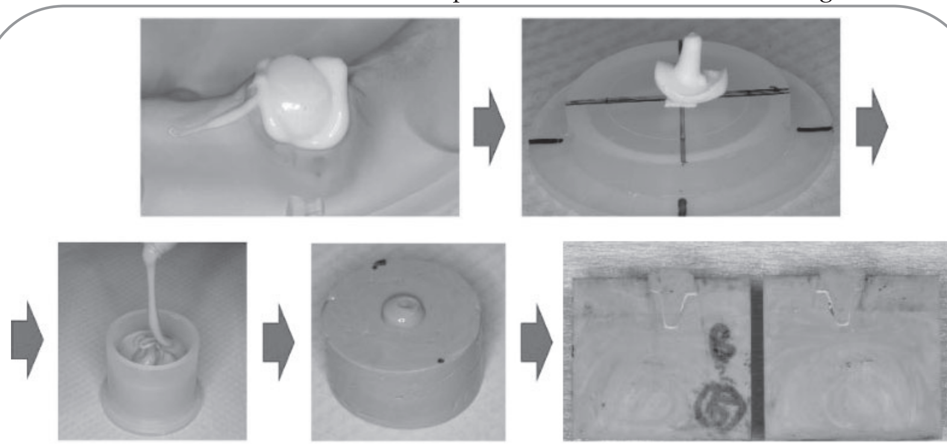

Fig. 3 Fabrication procedure of specimens (Cement-replica technique)

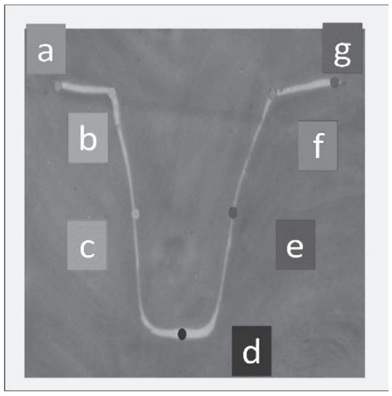

Fig. 4 Measuring points
(a:labial margin b:labial cervical c:labial center of post d: tip of the post e: lingual center of post f: lingual cervical g: lingual margin)

Results

The average gaps are 61.5±32.2 μm at point a, 73.5±32.4 μm at point b, 41.5±11.6 μm at point c, 148.5±19.1 μm at point d, 45.0±11.6 μm at point e, 81.5±27.8 μm at point f, and 46.0±13.3 μm at the g point (Fig. 5). Measurement points a, b, c, e, f, and g showed good compatibility as compared with the allowable range of compatibility for CAD/CAM prostheses reported by Suto et al.,[1] which is 100 μm.

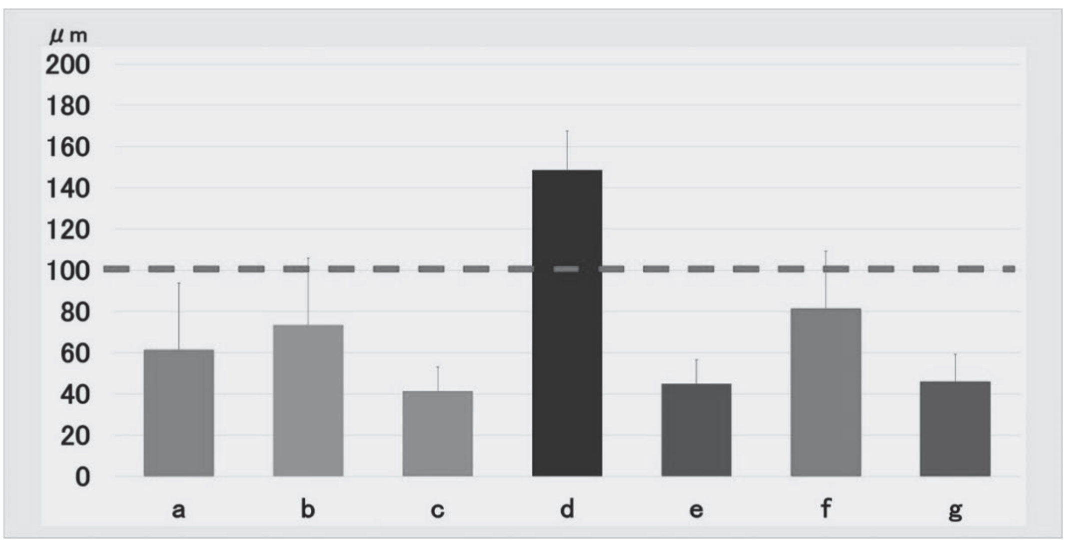

Fig. 5 Average gap volume

Conclusion

The reason compatibility was generally good was thought to be the influence of smooth and highly accurate modeling of the model due to the improved measurement accuracy of the camera and the corresponding software. In addition, the reason the value of point d did not meet the standard was considered to be that the setting value of the cement space was high as compared to those of other points, and that scanning and milling were somewhat difficult due to the morphology.

In the future, we plan to verify the fitting accuracy with a post length of 5 mm or more and also to investigate whether it is possible to set the anti-rotation groove and the keeper housing.

References

1. N. Suto, S. Miura, R. Inagaki, Y. Kaneta, M. Yoda and K. Kimura: A Basic Study on Fitness of All-ceramic Crown Fabricated by CAD/CAM System, Ann Jpn Prosthodont Soc, 1, 21–28, 2009.

Report of a hands-on seminar on magnetic attachment skills

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Department of Removable Prosthodontics, Tsurumi University School of Dental Medicine

Introduction

Unlike conventional mechanical force-application mechanisms, magnetic attachments use magnetic force and have many advantages, such as their small size, simple shape, and their use of a less harmful lateral force. For clinical success with magnetic attachments, accurate positioning of the magnetic assembly on the keeper and its connection are very important, as inadequate attachment causes a gap between the contact surface and a significant reduction in retentive force. In order to acquire the needed skills, a hands-on seminar titled "Learning Magnetic Attachments—Laboratory and Clinical Procedures" was held at the 131st Annual Meeting of the Japanese Society of Prosthetic Dentistry in cooperation with the Japan Society of Magnetic Applications in Dentistry. In this paper, we will report on this seminar.

Objective

In the seminar, a 40-minute lecture on the characteristics of magnetic attachments and how to proceed with treatment, their application, design, treatment procedures, and possible problems was given. After the lecture, 50 minutes was provided to practice using a simulation model and overdenture and to train in the clinical procedure of fixing the magnetic assembly to the denture base using autopolymerized resin.

Lecture

1. Explanation of points to note when placing magnetic attachments

(1) Causes of significant decrease in retention

Failures in the attachment procedures include misalignment of the magnetic assembly, namely, air gaps due to the intrusion of the resin onto the keeper surface or polymerization shrinkage.

As for the misalignment of the magnetic assembly and the keeper, it has been reported that the attractive force decreased by about 1/3 when an air gap of 0.1 mm was vertically created and by about 2/3 when the magnetic assembly was horizontally displaced by 0.5 mm (Figs. 1, 2)[1] .

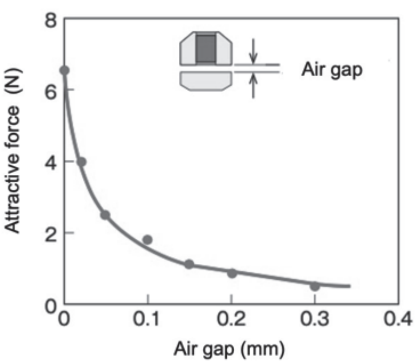

Fig. 1 Effect of vertical gaps between the magnetic assembly and the keeper on attraction force[1]

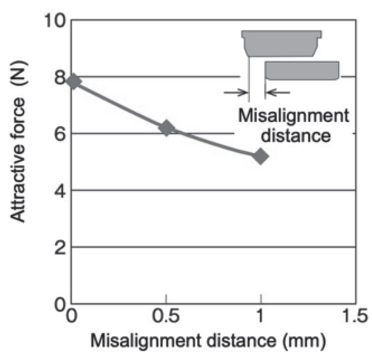

Fig. 2 Effect of horizontal deisplacement of the magnetic assembly on the keeper on the attractive force[1]

(2) Polymerization shrinkage of autopolymerized resins

(i) As the amount of autopolymerized resin used when fixing the magnetic assembly was increased, shrinkage of the autopolymerized resins also increased, and the air gap grew.

(ii) The brush-on technique showed lower polymerization shrinkage and better dimensional accuracy as compared to the mixing technique (Fig. 3)[2].
(iii) The brush-on technique can control the amount of resin on the inner surface of the denture base by the placement of a spillway. The results include the prevention of misfitting dentures and dentures that are difficult to remove due to resin that has penetrated into the undercut around the keeper coping (Fig. 4).
(iv) Holding the denture until the resin is polymerized and the timing of denture removal are also important.

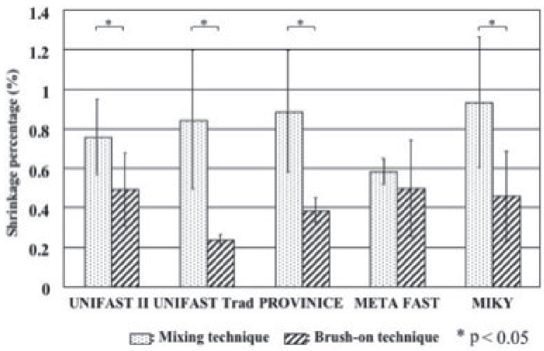

Fig. 3 Polymerization shrinkage of autopolymerized resin using the brush-on and mixing techniques[2]

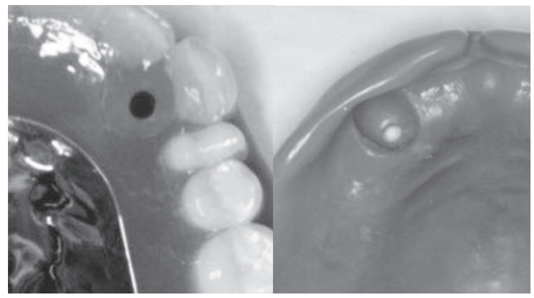

Fig. 4 Spillway provided to the denture base

(3) Placement of the magnetic assmbly
The magnetic assmbly should be placed after the denture is settled, considering the minimum shrinkage of the autopolymerized resin.

2. Movie explaining the clinical procedure of magnetic attachments (Fig. 5)

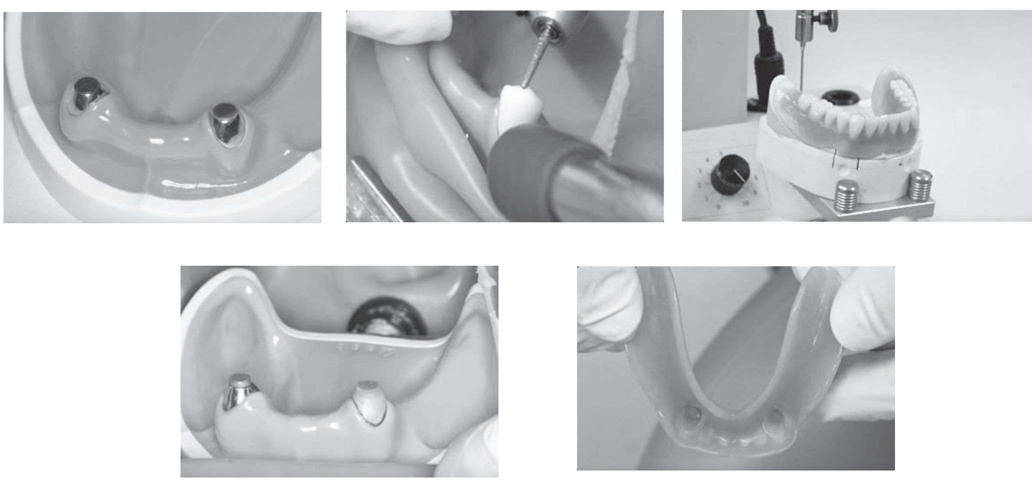

Fig. 5 Clinical procedure for applying a magnetic attachment

Practice

Placement of magnetic attachments (magnetic assembly) (Figs. 6-9)

Fig. 6 Jaw model of a partially edentulous mandible with left and right remaining canines, overdenture, and magnetic attachments (Physio Magnet, Kedika Corporation) used in the seminar.

Fig. 7 A space for magnetic attachments was created on the denture. The denture was placed on the jaw model, and a spillway was provided.

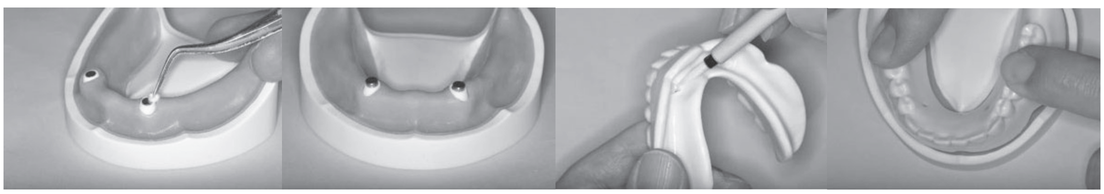

Fig. 8 After applying vaseline to the keeper coping and the residual ridge, the magnetic assembly was placed on the keeper. Using the brush-on technique, the magnetic assembly was fixed with autopolymerized resin using light pressure.

Fig. 9 After the resin was polymerized, the denture was removed and polished.

Results

The seminar was held twice, with a total of 40 participants (23 males and 17 females) divided into two groups of 20. There were 33 university and 7 non-university participants. Difficulties such as the detachment of the magnetic assembly and lack of retentive force were observed during the fixing procedures.

The results of the post-seminar questionnaire are shown in Figs. 10-12.

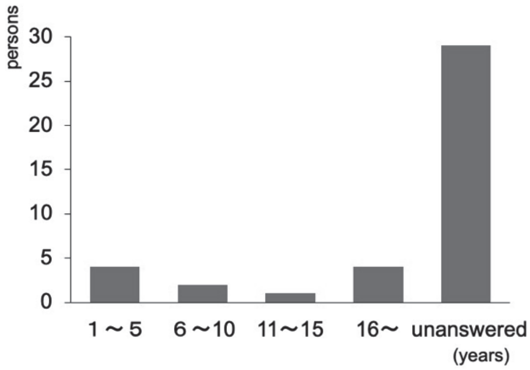

Fig. 10 Work years of participants

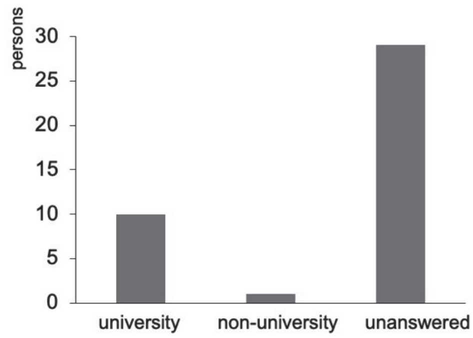

Fig. 11 Work place of participants

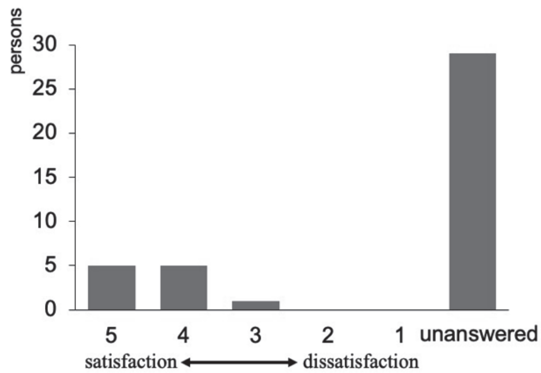

Fig. 12 Evaluation of the seminar

Discussion

Not using metal primers and the premature removal of the denture from the simulation model during the polymerization of the resin were considered to be reasons for the detachment. Insufficient retentive force may be due to misalignment of the magnetic assembly, namely, an air gap caused by the intrusion of the resin onto the keeper surface.

Conclusion

From a post-seminar questionnaire, most of participants learned well the clinical and laboratory procedures for magnetic attachments and were satisfied with the seminar.

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Acknowledgments

We would like to thank the Morita Corporation, the Kedika Corporation, and the Kikutani Corporation for their support of this seminar, as well as the teacing staff in our department for their cooperation in organizing the seminar.

A case report of a removable partial denture with magnetic attachments on the proximal surfaces of abutment teeth

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Introduction

Overdentures with magnetic attachments are a prosthetic approach that can restore masticatory ability and provide a highly aesthetic appearance, but they are difficult to apply to vital teeth. We will report a case of a removable partial denture (RPD) with magnetic attachments applied to the proximal surfaces of the abutment teeth to minimize invasion of the tooth structure.

Case report

1. Patient Information

The patient is an 80-year-old female with remaining mandible teeth #48, #42～#34, and #38. She was suffering from mastication difficulty and poor aesthetics due to metal clasps on the anterior teeth, and she requested the least invasive prosthetic treatment. Radiographic findings showed #24 root fracture.

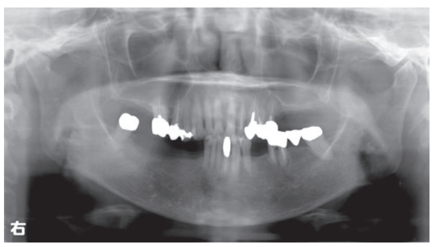

Fig. 1 Panoramic radiograph at the first examination

Fig. 2 Intraoral photograph at the first examination

Fig. 3 Placement of existing removable partial denture

2. Repair of additional teeth to existing denture

The existing RPD could not be used because the metal crowns (#24, #25) were detached. After #24 was extracted due to root fracture, the maxillary existing RPD was repaired with additional resin teeth (Fig. 4).

Fig. 4 Existing maxillary RPD after repair with additional resin teeth

3. Treatment plans

3.1 Delivery of maxillary titanium RPD with magnetic attachment with cast metal coping

A magnetic attachment with a cast metal coping was placed on the root of #25 where the Cr had become detached with the core. A titanium RPD with a half clasp on #23 and a cast clasp on #14～#16 was fabricated (Figs. 5–7).

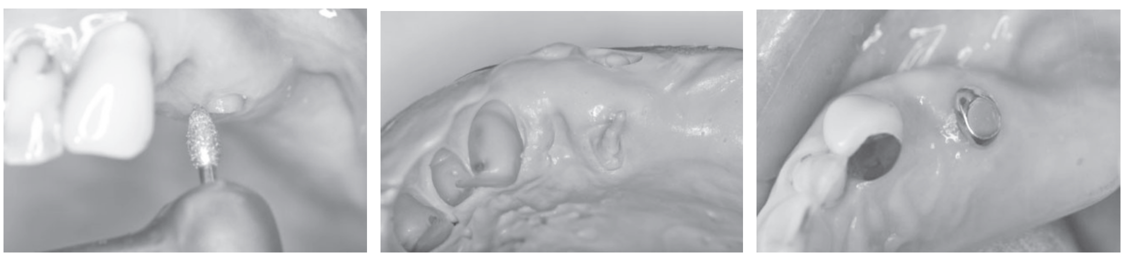

Fig. 5 #25 Tooth preparation, impression taking, placed magnetic attachment with coping

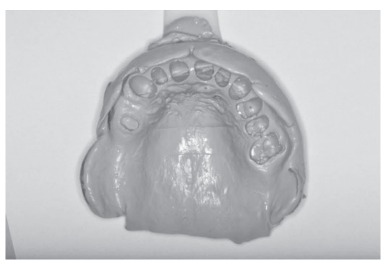

Fig. 6 Difinitive impression of the maxilla

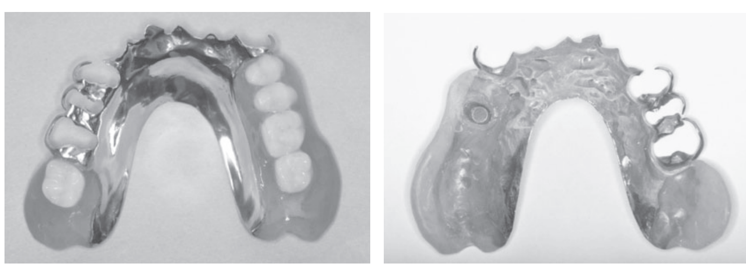

Fig. 7 Definitive maxillary titanium RPD

3.2 Magnetic attachments placed on the proximal surfaces of the abutment teeth in the mandible

To avoid a non-aesthetic metal clasp on the anterior teeth, the keepers were fixed to the proximal surfaces of the abutment teeth (#34 and #42) using composite resin. A keeper fixation part was fabricated on the working model using optical transparency composite resin (Fig. 8).

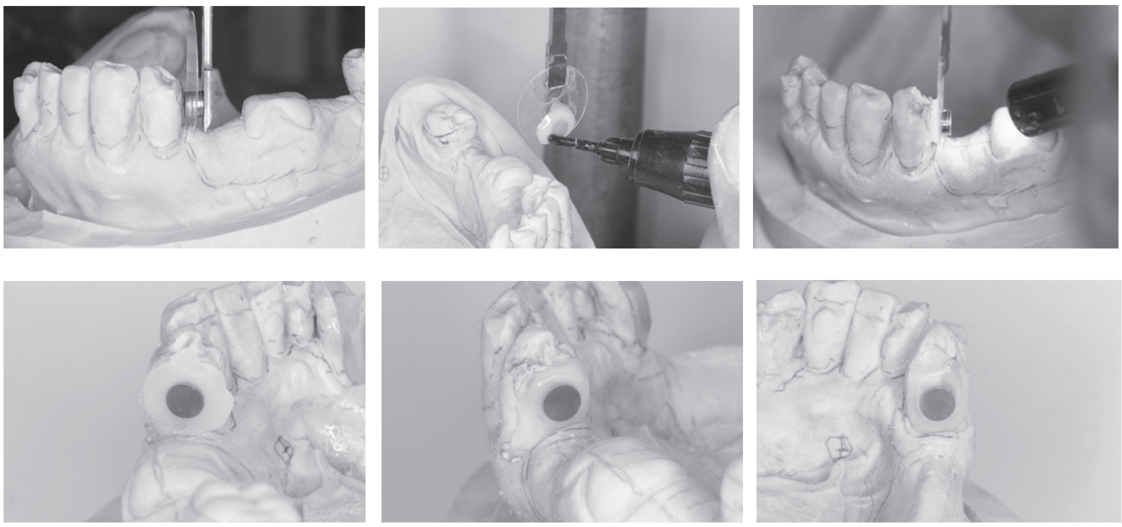

Fig. 8 Fabrication of composite resin parts for keeper fixation

3.3 Abutment teeth preparation using a preparation guide

Figure 9 shows the retentive forces when the magnetic attachments were applied to the proximal surfaces of the teeth with various angles of both keepers. The preparation guide was made on the model in advance, pre-treatment of the abutment tooth were performed for forming surfaces (Fig. 10).

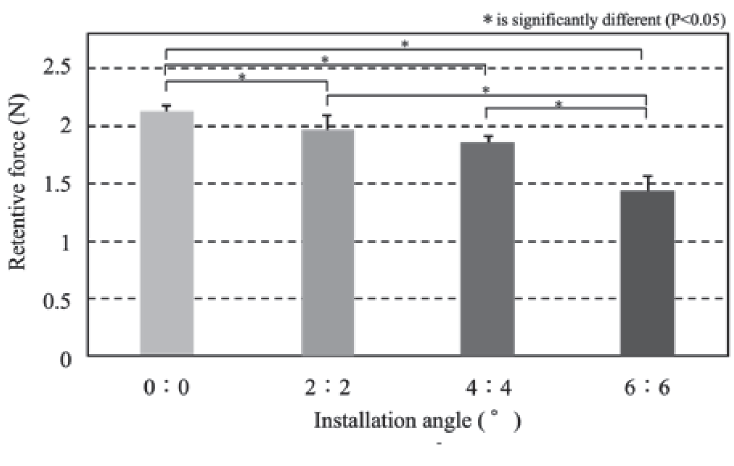

Fig. 9 Retentive forces when the magnetic attachments were applied to the proximal surfaces of the teeth with various angles of both keepers[1]

Fig. 10 Preparation of the abutment teeth using a preparation guide

3.4 Keepers were attached to the proximal surfaces

Two keepers were attached to the proximal surfaces of #34 and #42 using composite resin (Fig. 11).

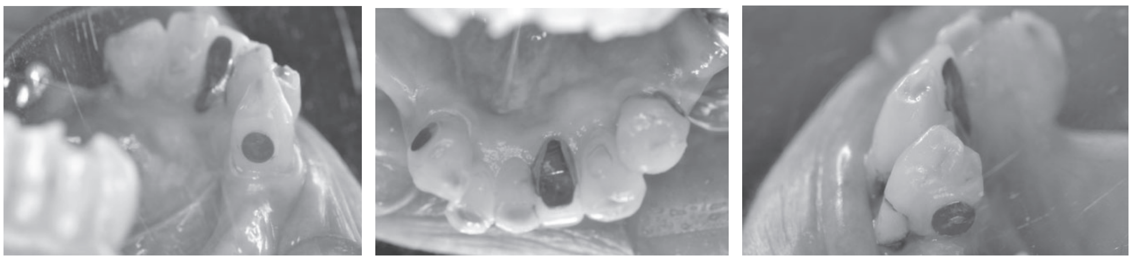

Fig. 11 Keepers attached with composite resin

3.5 Fabrication of a mandibular RPD framework

The mandibular denture framework was conventionally fabricated with a lingual plate. A cap clasp and a ring clasp were placed on #48 and #38, respectively (Fig. 12).

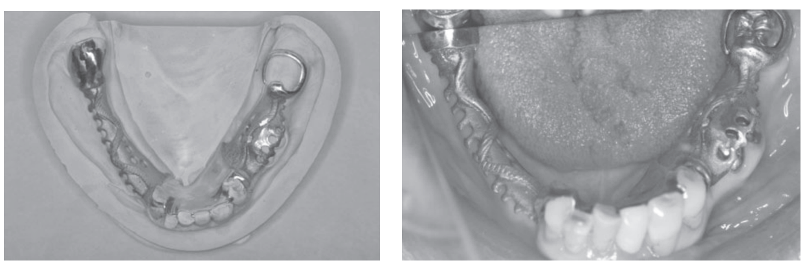

Fig. 12 The completed RPD framework

3.6 Completed definitive mandibular RPD (Figs. 13–14)

Fig. 13 Occlusal view of the definitive RPD

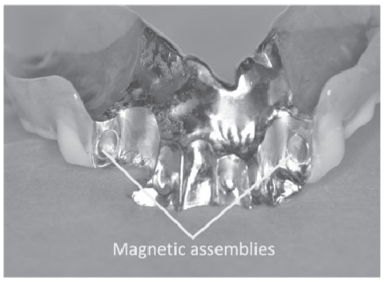

Fig. 14 Magnetic assemblies were placed in the proximal plates of the RPD.

3.7 Delivery of the definitive mandiblar RPD (Figs. 15–16)

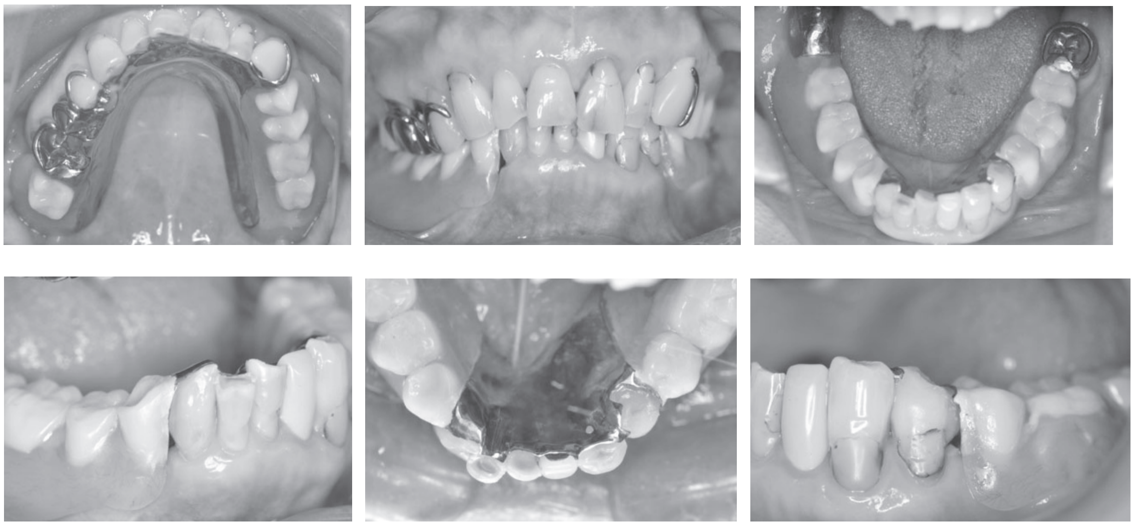

Fig. 15 Intraoral view of definitive maxillary and mandiblar RPDs

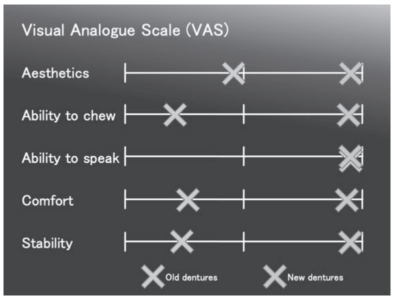

Fig. 16 Assessment of previous and definitive dentures by VAS

Discussion/conclusion

Magnetic attachments were applied to the proximal surfaces of the anterior teeth to improve the aesthetics with a minimally invasive treatment. The patient was fully satisfied with the aesthetics and the assurance of adequate retentive force.

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Retentive force of combined sandwich-type magnetic assemblies

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Abstract

Dental magnetic attachments are mostly paired combinations of magnetic assembly and keeper or two magnets. A combination of two magnetic assemblies is rare. In this study, we investigated retentive force characteristics of a set of two sandwich-type magnetic assemblies. Mating surfaces of two oval-shaped magnetic assemblies (Magfit EX600W) were placed in contact with different polarities facing each other. The pair was mounted on a measuring device and retentive force experiments conducted as specified in ISO 13017. The measurements were done with the two magnetic assemblies aligned and when one magnetic assembly was displaced along the long axis then short axis direction. The retentive force of a pair of magnetic assemblies was higher than that of magnetic assembly combined with keeper. There was a decline in retentive force measured upon separation of mating faces. It was more gradual in the case of two magnetic assemblies compared to assembly and keeper. Displacement along the minor axis, caused a decline in retentive force which was more in a pair of magnetic assembly compared to a magnetic assembly paired with keeper. Furthermore, a pair of combined magnetic assemblies generated a large restoring force against displacement. It was established advantageous to combine two magnetic assemblies.

Introduction

Dental magnetic attachments are often used as retentive elements in partial and complete dentures. They can also be utilized in implant overdentures such as 2-IOD and 4-IOD. From 2021, the Japanese insurance system committed to cater for cost of dental magnetic supported appliances[1)]. Its usage is therefore expected to rise in future. Magnetic attachments manufactured in Japan are predominantly a combination of magnetic assembly and keeper. A magnetic assembly exhibits closed magnetic circuit which is characterized by high retentive force despite its small size. Leakage of magnetic field associated with the closed circuit is minimal. On the other hand, products made in other countries utilize both closed and open magnetic circuit type magnets. To overcome poor corrosion resistance of rare–earth magnets, magnets used in dentistry are covered with stainless steel or titanium[2)]. A magnet is simple and easy to manufacture compared to magnetic assembly. However, its open magnetic circuit feature is associated with high leakage of magnetic field, and low retentive force relative to its size. In order to compensate for the weak retentive force of magnet-keeper combination, it may be beneficial to combine two magnets. In practice, there are three possible combinations of dental magnetic attachments: magnetic assembly to keeper, magnet to keeper, and magnet to magnet.

The magnet to magnet combination exhibits a retentive force greater than that of magnet-keeper combination. It is therefore postulated that two magnetic assemblies combined would also yield higher retentive force than magnetic assembly to keeper. However, there is no research on retentive force when combining two magnetic assemblies.

The two types of magnetic assemblies for application as dental magnetic attachments which exist are cup-yoke and sandwich type[3)]. It is difficult to combine two cup-yoke type of magnetic assemblies because the contact mating faces are of similar polarity causing repulsion (Fig. 1). Sandwich types are easy to combine due to the attraction force exhibited by the unlike poles which make up mating faces (Fig. 2). This study explored the possibility and characteristics of a new combination that involves two sandwich-types of magnetic assemblies.

Objective

The aim of this study was to explore possibility of combining two sandwich-type magnetic assemblies and investigate the retentive force characteristics. A combination of magnetic assembly and keeper, which forms the ordinary magnetic attachment, was used for comparison.

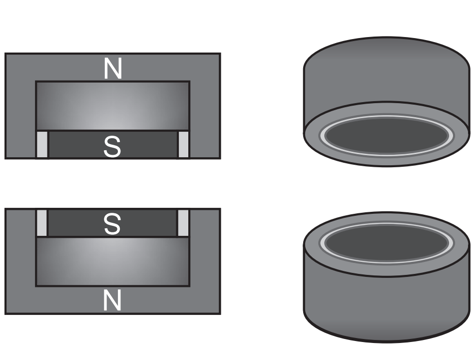


Fig. 1 Combination of cup-yoke type of magnetic assemblies

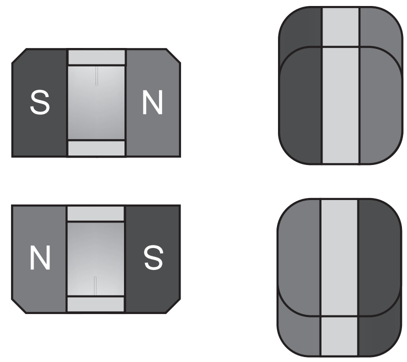


Fig. 2 Combination of sandwich type of magnetic assemblies

Materials and Methods

1. Dental magnetic attachment

Oval sandwich-type dental magnetic attachments (MAGFITEX600W, 3.8 mm major axis and 2.8 mm minor axis length, Aichi steel Corp.) were used in this study. The magnetic assembly was either combined with a keeper or another magnetic assembly. The mating faces were placed in contact with different polarities across each other (Fig. 2). Magnetic keeper was paired up with magnetic assembly to represent the ordinary magnetic attachment.

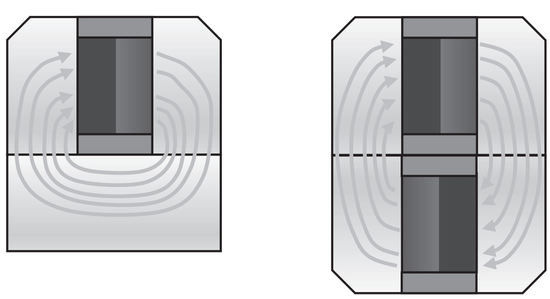
2. Procedure of retentive force measurement

The retentive force measuring device used in this study matches the description in ISO 13017:2020[3]. The device was connected to a digital force gauge (ZPS, Imada) and retentive force measured at crosshead speed of 2 mm/min. recording was done at a sampling rate of 1 kHz. Applying the known time and speed values, distance was calculated then a retentive force curve generated. The experiment begins when the magnetic assembly has its center aligned to that of keeper or second magnetic assembly. The measurements were done at intervals of 100 μm horizontal displacement, along the major and minor axis direction, of keeper or second magnetic assembly. The measurement is terminated when the magnetic assembly completely separates from its keeper or second magnetic assembly.

Results and Discussion

1. Retentive force of aligned magnetic attachments

The retentive force of a magnetic assembly paired with keeper or second magnetic assembly was 5.26 N and 6.45 N, respectively. Therefore use of a second magnetic assembly instead of keeper raised the retentive force by 1.23 times. This is attributed to the shorter distance between the magnetic poles of two magnetic assemblies (Fig. 3b) compared to magnetic assembly and its keeper (Fig. 3a). Additionally, the volume of the magnet is doubled, and the energy of the magnet increased causing an enhanced effect. However, due to saturation of the cup yoke's magnetic flux density, the retentive force is not doubled. Magnets whose design involves closed magnetic circuit are characterized by small size and relatively large retentive force. The force can be further enhanced through combination of two magnetic assemblies.



(a) (b)

Fig. 3 Schematic diagram of magnetic flux flow in the magnetic attachments (a) combination of magnetic assembly and keeper, (b) a pair of magnetic assemblies

2. Decline of retentive force upon complete separation of mating face

Retentive force curves for the two set up combinations are shown in Fig. 4. The displacement position at a time when the mating faces separate is denoted as 0 mm. For both scenarios, the retentive force values decreased with increasing distance which corresponds to displacement of the magnetic assembly away from keeper or second assembly. However, the rate of decline was moderate when two magnetic assemblies were paired up compared to the one with keeper. Although magnetic flux volume emitted from the assembly yokes is same, magnetic field lines are concentrated more towards the second magnetic assembly yoke than those that flow solely within the first assembly as shown in Fig 5. A combination of two magnetic assemblies offers a wider range of influence on the attractive force and is stable against air gap.

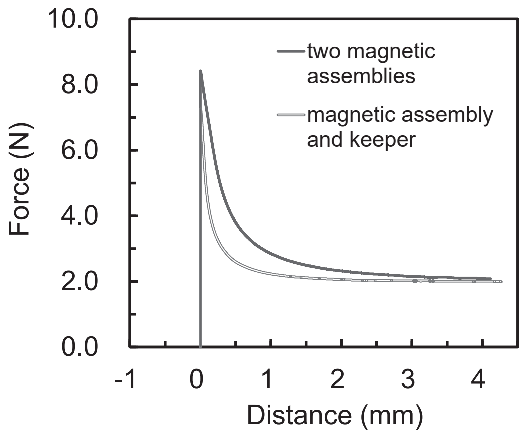
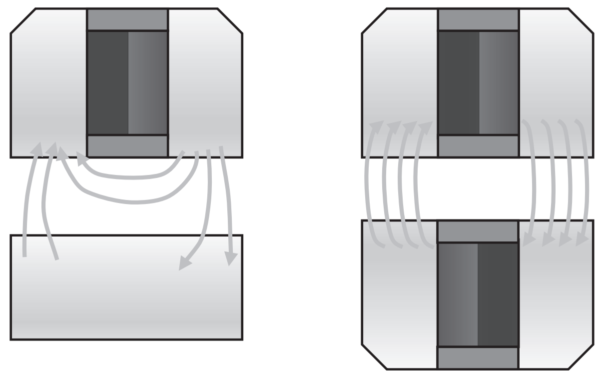


Fig. 4 Retentive force curve



(a) (b)

Fig. 5 Images of magnetic flux flow after separation of mating faces. (a) magnetic assembly and keeper combination, (b) pair of magnetic assemblies

3. Changes in retentive force against lateral displacement

Fig. 6 shows the change in retentive force when the second magnetic assembly was shifted in the major axis direction. The retentive force decreased gradually with increasing displacement. The loss in retentive force was linear at a displacement of 1.2 to 2.5 mm. This pattern was similar to that of the combination of the magnetic assembly and the keeper[4)]. The retentive force is therefore dependent on the contact surface area between the two magnetic assemblies upon displacement along the major axis direction.

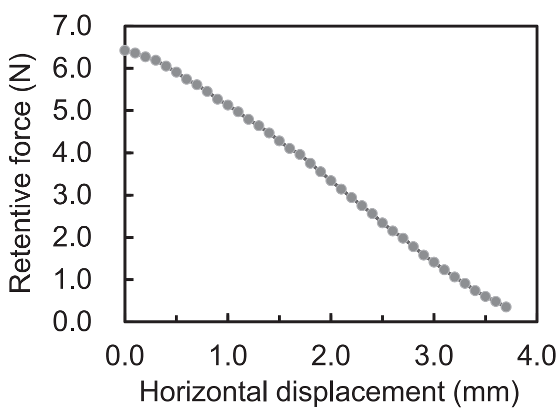


Fig. 6 Retentive force against displacement along major axis direction

Fig. 7 shows the changes in retentive force when displacement occurs along the minor axis direction. The retentive force decreased sharply upon displacement to reach 0 N at 1.5mm. Further displacement generated negative values which imply a repulsion of magnetic assemblies. This phenomenon was not observed in the magnetic assembly and keeper set up[4)].

As illustrated in Fig. 3, congruently matched magnetic assemblies have unlike poles in contact thereby producing an attractive force. Displacement along the minor axis direction, as shown in Fig. 8, creates varying scenarios in which some parts of magnetic assemblies are in attraction whereas others are in repulsion. The resultant force acting in a direction perpendicular to the mating face is measured and represents the retentive force. At the initial stages of displacement, the attractive force exceeds the repulsive force. At about 1.5 mm displacement, the two forces are equal resulting into 0 N retentive force. Further displacement yields a higher repulsive force compared to attractive force.

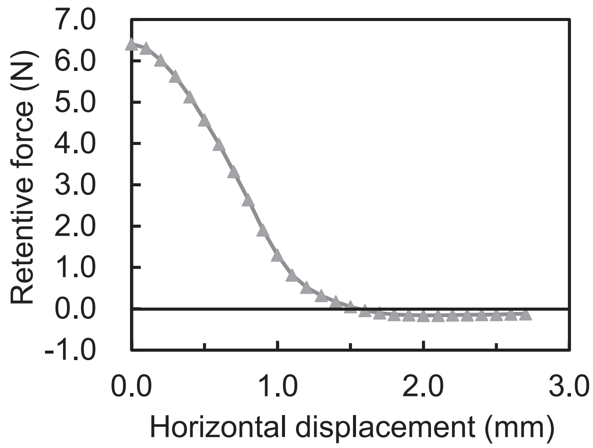


Fig.7 Retentive force against displacement along minor axis direction

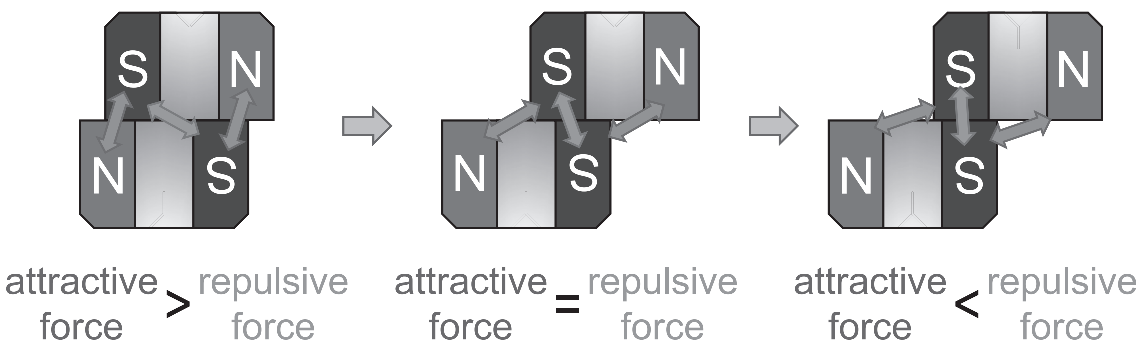


Fig.8 Images of forces between two magnetic assemblies in response to displacement along the minor axis direction

Besides the attractive and repulsive forces explained above; there also exists (lateral) forces that act in a direction parallel to the mating faces. Fig 9 demonstrates how attraction and repulsion forces act in a manner similar to closed and open coil springs respectively. A slight displacement (a→b) is accompanied by restoring force which acts like springs taking the set up back to the original position (b→a). Therefore, combining two magnetic assemblies yields a "restoring force" which counters the effect of minor lateral displacement.

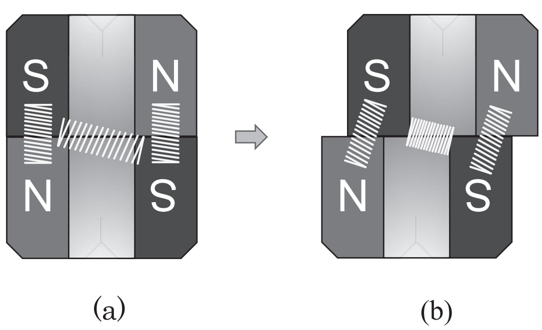


Fig. 9 Schematic drawing to illustrate spring effect of repulsion and attraction forces (a) well aligned, (b) slight displacement

4. Clinical application of combined magnetic assemblies

Dental magnetic attachment set up that involves two magnetic assemblies provides salient features which have meaningful applications in dentistry especially complete dentures. The spring like action by restoring force acts as a guide in proper alignment of magnetic attachments. It eases the procedure of incorporating magnetic assembly into denture. Higher retentive forces associated with magnetic assemblies compared to keeper of the same size offers improved denture stability. Erroneous inclusion of air gap has minimal effect as the consequent decrease in retentive force is gradual. The restoring force further promotes denture stability as minor denture displacement during function is automatically corrected. Major displacement of the magnetic attachment against abutment tooth in a horizontal direction triggers the repulsion forces which aid in removal of denture from the oral cavity. The concept of combining two magnetic assemblies is advantageous compared to use of assembly and keeper in terms of retentive force and stability.

Conclusion

The retentive force of a pair of magnetic assemblies was higher than that of magnetic assembly combined with keeper. The decline in retentive force was more gradual for the set up involving two magnetic assemblies compared to assembly and keeper. A pair of combined magnetic assemblies generates a restoring and repulsive force upon small and large displacements along the minor axis, respectively. It was established advantageous to combine two magnetic assemblies.

Acknowledgments

The authors greatly acknowledge Aichi steel Corp. for providing the MAGFIT EX600W.

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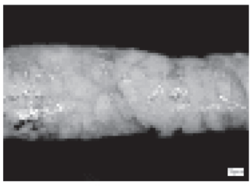

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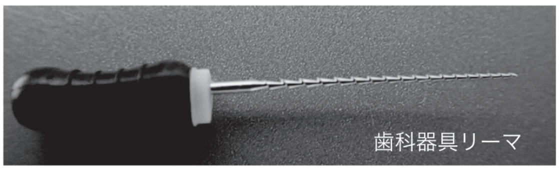

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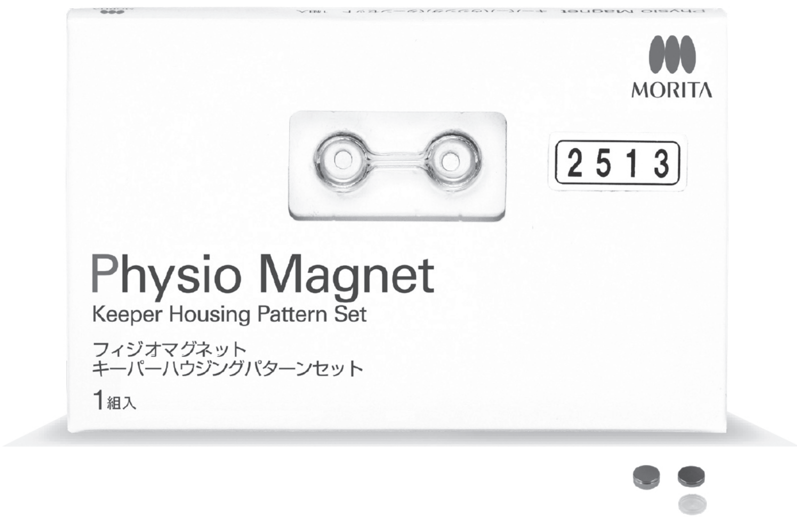
2021年9月1日より保険適用(2023年7月現在)



歯科用精密磁性アタッチメント

フィジオマグネット キーパーハウジングパターン セット

サ イ ズ　25、30、35、40、45、48、52、55
内　　容　マグネット 1個、キーパー 1個、キーパーハウジングパターン 1個、MRIカード 1枚
標準価格　各10,100円

製品紹介ページ

https://www.dental-plaza.com/qr/787

販売名　フィジオマグネット キーパーハウジングパターン セット　一般的名称　歯科用精密磁性アタッチメント　医療機器の分類　管理医療機器(クラスⅡ)　医療機器認証番号　221ACBZX00092A01
製造発売　株式会社ケディカ　宮城県仙台市泉区明通3-20　〒981-3206　T 022.777 1351
販　　売　株式会社 モリタ 大阪本社: 大阪府吹田市垂水町3-33-18　〒564-8650　T 06.6380 2525　東京本社: 東京都台東区上野2-11-15　〒110-8513　T 03.3834 6161
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www.dental-plaza.com