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Proceedings of the 14th International Conference on Magnetic Applications in Dentistry

The Japanese Society of Magnetic applications in Dentistry

The 14th International Conference on Magnetic Applications in Dentistry

The 14th International Conference on The Japanese Society of Magnetic Applications in Dentistry organized by JSMAD was held on the Internet as follows;

Meeting Dates:

March 2 to March 20, 2015

Location:

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http://www.jsmad.jp/international-e.shtml

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Prof. Chikahiro Ohkubo, Tsurumi University

Conference Secretariat:

Dr. Yasunori Suzuki, Tsurumi University

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 15th International Conference on Magnetic Applications in Dentistry General Information

General Information

The Japanese Society of Magnetic Applications in Dentistry (President: Shinichi Masumi, Kyusyu Dental University) is a scientific association founded in 1991 and is devoted to furthering the application of magnetism in dentistry. The 15th International Conference on Magnetic Applications in Dentistry organized by JSMAD will take place on the Internet as follows.

Meeting Dates:
Monday, February 29 to Friday, March 18, 2016

Location:
JSMAD web site:
http://www.jsmad.jp/international-e.shtml

General Chair:
Prof. Shunsuke Minakuchi, Tokyo Medical and Dental University

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
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Registration Information

Registration:
Send e-mail titled "registration for 15th 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.)

Guidelines for Presentation

Deadlines:
Entry: January 29, 2016
Poster submission: February 19, 2016

Entry:
Send Title and Abstract within 200 words with your Registration.

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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 of lower removable partial denture with intracoronal and extracoronal dental magnetic attachments

S. Tsuda, S. Masumi, E. Makihara, T. Kawano, M. Yagi, and M. Arita

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Abstract

A 67-year-old female patient was provided a non-metal clasp lower partial denture for the edentulous region of Nos. 34, 35, 36, 46, and 47 from a certain dental clinic. She could not wear it, however, because the gingival inflammation that was caused by the clasps of the denture cut into her gingiva. She visited our clinic on April 17, 2014, for the fabrication of another esthetic removable partial denture.

As Nos. 45 and 37 were non-vital direct abutment teeth, a magnotelescopic crown was designed for No. 37, and a root cap of short coping type was designed for No. 45. As No. 33 was a vital direct abutment tooth, this tooth was designed as a resin-facing crown with an extracoronal dental magnetic attachment. A dental magnetic attachment (GIGAUS C600; GC Corporation, Tokyo, Japan) was used as retainer in all three abutments.

After fixing an inner crown of No. 37 and a root cap of No. 45 with adhesive resin cement, a removable partial denture was fabricated by the conventional method.

Because the finished denture was good esthetically and easy for the patient to put on, remove, and clean, the patient was satisfied. From the post evaluation, we were able to confirm improvement in her oral QOL.

Introduction

Dental magnetic attachments are very useful for the retention of removable partial dentures. At this time, we report on a clinical case of a lower removable partial denture with intracoronal and extracoronal dental magnetic attachments.

Clinical history

The patient was a 67-year-old female who had visited our clinic 15 years earlier for the treatment of her TMD problem. One of the presenters (S.M.) treated of her problem. After resolving the TMD problem, she was provided with a removable partial denture.

Last year, she was provided with a non-metal clasp lower partial denture for the edentulous region of Nos. 34, 35, 36, 46, and 47 from a certain dental clinic. However, she could not wear it because the gingival inflammation caused by the clasps of the denture cut into her gingiva.

She visited our clinic on April 17, 2014 for the fabrication of another esthetic removable partial denture (Figs.1,2).

Fig.1 A removable partial denture fabricated 15 years ago

Fig.2 Intraoral findings (May 15, 2014)

Treatment procedure

As Nos. 45 and 37 were non-vital direct abutment teeth, a magnotelescopic crown was designed for No. 37 (Figs.3,4). As No. 33 was a vital direct abutment tooth, a resin-facing crown with an extracoronal dental magnetic attachment was designed for this tooth (Fig.5). Dental magnetic attachments (GIGAUS C600®; GC Corporation, Tokyo, Japan) were used as retainers in all three abutments. After fixing an inner crown of No. 37 and a root cap of No. 45 with adhesive resin cement, a removable partial denture was fabricated by the conventional method (Figs.6,7).

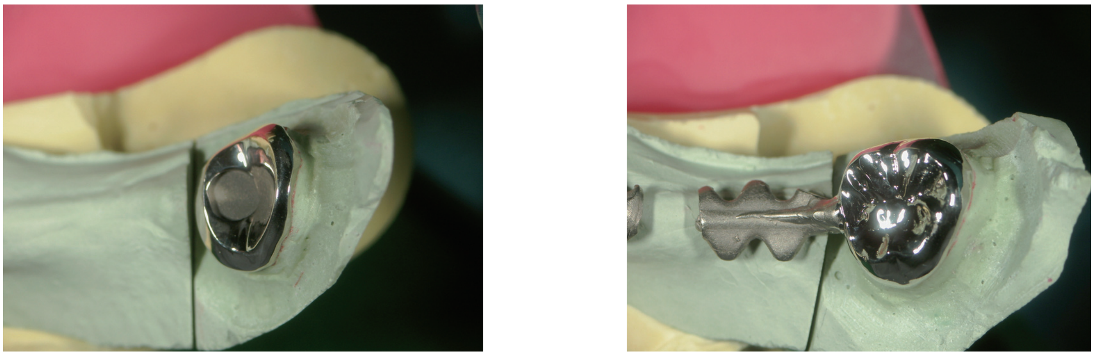

Fig.3 A magnotelescopic inner crown and a full metal outer crown on No. 37

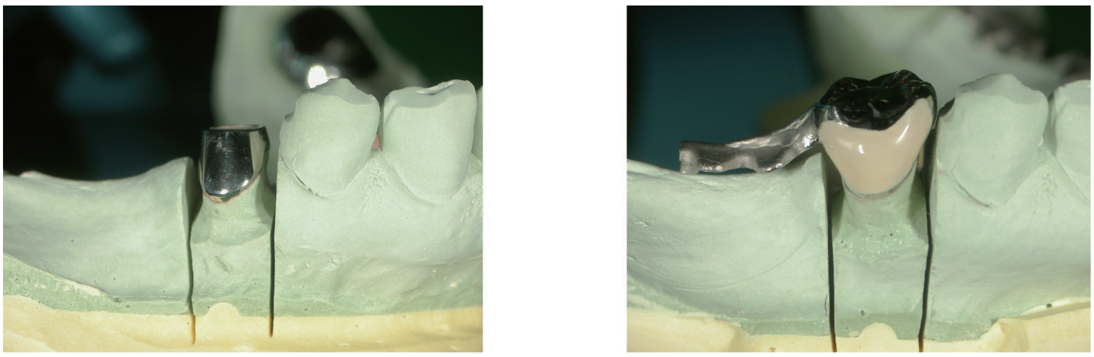

Fig.4 A magnotelescopic inner crown and a resin-facing outer crown on No. 45

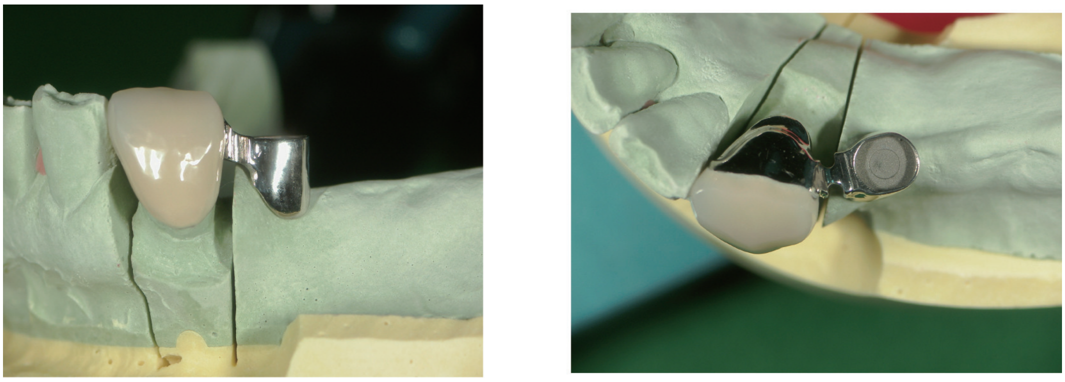

Fig.5 A resin-facing crown with an extracoronal dental magnetic attachment on No. 33

Fig.6 Finished crowns

Fig.7 Wax denture

At the try-in of these crowns and a wax denture, the patient complained about the outer crown of No. 45. She refused to see the metal color of the occlusal surface.

Therefore, we decided to use the inner crown of No. 45 as the root cap of an overdenture (Fig.8).

Fig.8 Finished denture (August 12, 2014)

Evaluation

We made several evaluations of the patient's oral QOL (Table 1).

Table 1 Pre- and post-evaluation

Items	Pre	Post
Occlusal force (N)	221.5	268.3
Masticatory ability (glucose: mg/dL)	147	180
Score of mastication foods	39.7	39.6
POMS (mental function) (TMD)	55	29
OHIP14	30	26
GOHAI	29	36

Conclusion

Because the finished denture was good esthetically and easy for the patient to put on, remove, and clean, the patient was satisfied.

From the post-evaluation, we were able to confirm improvement in her oral QOL.

Acknowledgement

We express our special thanks to Katsuhiro Nagatomi, who contributed to fabricating the prosthesis in this case.

Conflict of interest

The presenters declare no conflict of interest for this study.

Immediately loaded mandibular two-implant overdentures retained by magnetic attachments: Marginal bone loss and survival rates

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Abstract

[Purpose]

The aim of this 1-year study was to evaluate and compare marginal bone loss and survival rates of immediate and conventional loading of two-implant mandibular overdentures with magnetic attachments.

[Material and methods]

Nineteen mandibular edentulous patients were allocated into 2 groups. Implants were loaded by mandibular overdentures either 3 months after (conventional loading group) or the same day as (immediate loading group) implant surgery. Marginal bone loss was recorded at the time of the implant surgery and 3, 6, and 12 months after implant placement using standardized radiographs. The t-test was used for marginal bone loss analyses, and the log-rank test was used to determine survival rates.

[Results and discussion]

Marginal bone loss was highest for the immediate loading group, while there was no statistically significant difference between the 2 groups. The survival rate of the 2 implants immediately loaded using magnetic attachment-retained mandibular overdentures was 100%, while that with conventional loading was 89%. In addition, survival rates of the 2 groups do not differ significantly.

BACKGROUND

Mandibular 2-implant overdentures (2-IOD) are the first choice standard of care for edentulous patients.[1] The monitoring of marginal bone loss around implants has been regarded by numerous authors (Albrektsson et al. 1986; Roos et al. 1997; Zarb and Albrektsson 1998) as the most important criterion in determining the success of implants.[2] The magnetic attachment is a clinically useful device; however, the introduction of implant-retained overdenture prostheses has led to a paradigm shift in the management of complete edentulism. Therefore, a survival rate with the immediate loading of 2-IOD using magnetic attachment-retained mandibular overdentures of 86% has been recorded.[3]

OBJECTIVE

The aim of this 1-year study was to evaluate and compare marginal bone loss and survival rates of immediate and conventional loading of two-implant mandibular overdentures with magnetic attachments.

METHODS

1. This clinical study was a randomized controlled clinical trial.

2. Twenty mandibular edentulous patients were allocated into 2 groups, either the same day as surgery (immediate loading group) or after 3 months of healing (conventional loading group) (Fig.1).
3. Each patient received 2 implants (NobelSpeedy Groovy, Nobel Biocare) with magnetic attachments (Magfit IP, Aichi Japan) (Figs.2, 3). [Note: In some cases you give the location of companies while you don't in others. It is better to choose one style and be consistent throughout.]
4. Marginal bone loss was recorded at the time of implant surgery as well as 3, 6, and 12 months after implant placement using standardized radiographs (Figs.4, 5, and 6).
5. Marginal bone losses of the 2 groups were compared by Student's t-test, and the log-rank test was used for survival rates.

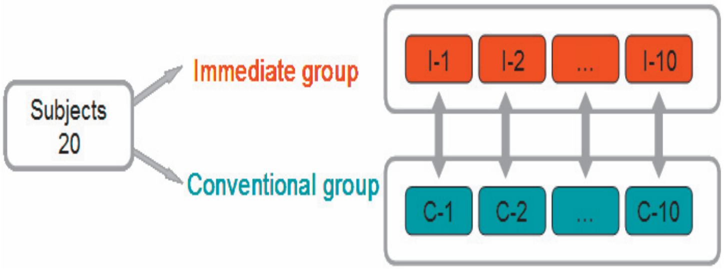

Fig.1 Allocation to the immediate group or the conventional group

Each patient received 2-IOD with magnetic attachments used in flapless surgery.

Fig.2 Placing a magnet on the implants

Fig.3 Picking up the magnets

In addition, peri-implant vertical and horizontal marginal bone loss was assessed in both groups at the time of the implant surgery and 3, 6, and 12 months after implant placement using the intra-oral long-cone paralleling technique. Clinical and radiographic evaluations were performed at distal and mesial peri-implant sites. T-tests were performed in the immediate and conventional groups at T3, T6, and T12.

Fig.4 Intra-oral long-cone paralleling technique

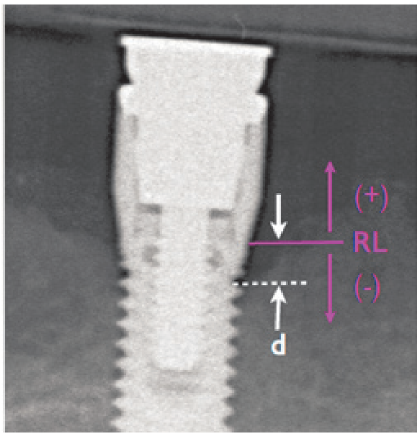

Fig.5 RL: Implant-abutment junction
d: Marginal bone loss

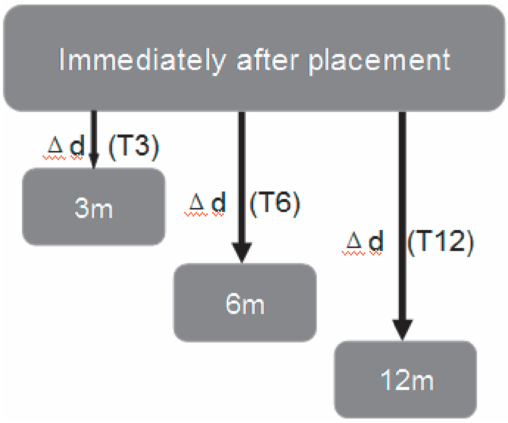

Fig.6 Recorded at the time of implant surgery, 3, 6, and 12 months after implant

RESULTS AND DISCUSSION

Marginal bone loss: The average radiographic bone level change after 12 months of functioning was -1.02±0.87 mm and - 1.76±1.16 mm for the conventional loading and the immediate loading implants, respectively. The immediate group is more apical than the conventional group (Fig.7).

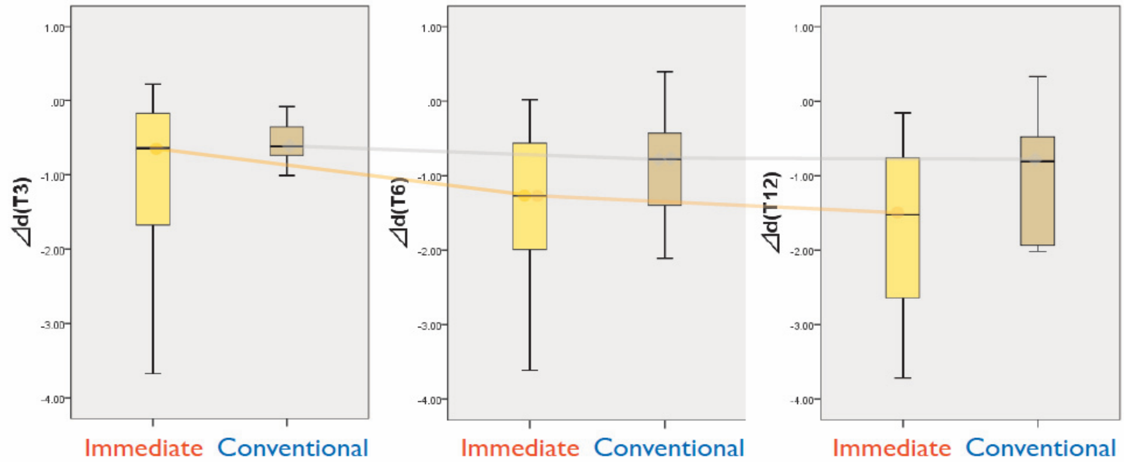

Fig.7 Marginal bone loss

Marginal bone loss in the immediate loading group was higher when compared with conventionally loaded implants after 1 year; there was no significant difference in the radiographic bone-level change between the 2 groups (Fig.7).

The survival rate with the immediate loading of 2 implants using magnetic attachment-retained mandibular overdentures was 100% (20/20 implants); that with conventional loading was 89% (20/18 implants) (Fig.9).
One patient in the conventional loading group lost both implants within 1 month of implant placement (Fig.8).

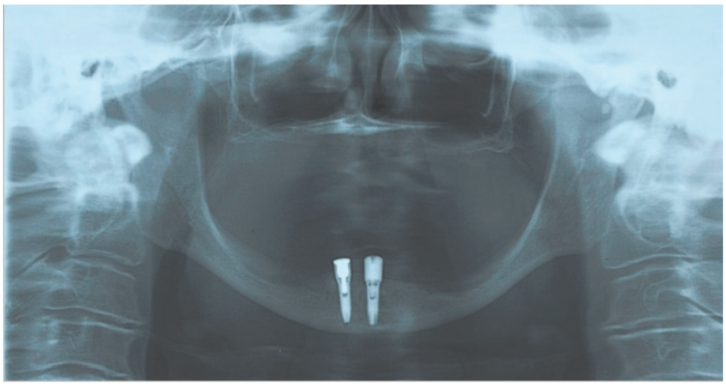

Fig.8 Lost implant

In the conventional loading group, one patient lost 2 implants within 1 month of implant surgery. This might be because of harmful stress due to their positioning between implants and dentures or the difficulty in brushing around a healing abutment.

At a 12-month follow-up, survival rates tested by log-rank testing recorded that there was no significant difference in the implant survival rates of the 2 groups (Fig.9).

		Immediate group	Conventional group
Implant length (mm)	10	0	1
	11.5	2	3
	13	2	5*
	15	14	7
	18	2	2
Insertion torque (Ncm)	45>	20	18*
Survival rates at 1 year		100% (20/20)	88.9% (18/20)

*2 implants were lost

Fig.9 Survival rates

CONCLUSION

Marginal bone loss was the highest for the immediate loading group, while no statistically significant difference was found between the 2 groups. The survival rate with the immediate loading of 2 implants using magnetic attachment-retained mandibular overdentures was 100%; that with conventional loading was 89%. In addition, there was no significant difference between survival rates of the 2 groups.

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A case report of a removable denture using magnetic attachments for a missing mandibular molar with a decreased occlusal vertical dimension followed up for 3 years

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Abstract

This case report describes our establishment of an appropriate OVD for a patient with a decreased OVD to restore aesthetics and function by using magnetic attachments.

As the definitive prosthesis, a maxillary removable overlay denture with coping-type magnetic attachments and a horseshoe plate as the major connector was fabricated, and a mandibular removable partial denture with an extracoronal-type magnetic attachment was also fabricated.

Three years after the denture setting, the definitive prosthesis has been used without any problems, and the magnetic attachment has had no clinically significant loss of retention.

Introduction

To maintain a harmonious craniofacial system, it is essential to establish an appropriate occlusal vertical dimension (OVD).[1] This case report describes our establishment of an appropriate OVD for a patient (Eichner B3: missing mandibular molar) with a decreased OVD to restore aesthetics and function by using magnetic attachments.

Clinical History

The patient, a 59-year-old female, complained of aesthetic dissatisfaction and masticatory dysfunction. The patient had a partially edentulous maxilla (Eichner B3: missing mandibular molar). All fixed prostheses were failed restorations with a marginal discrepancy that had been damaged by caries and periodontal disease. The patient refused to wear a mandibular removable partial denture because of dissatisfaction with a visible metal clasp on the anterior teeth. She was diagnosed with infraocclusion by analysis of her OVD (Fig.1). We suggested that a mandibular removable overlay denture with coping-type magnetic attachments and a maxillary removable partial denture with extracoronal-type magnetic attachments and porcelain fused to metal crowns should be fabricated that would be acceptable to the patient.

Fig.1 Intraoral view at the initial examination

Treatment Procedure

First, the prostheses with marginal discrepancies were removed (Fig.2), and temporary restorations were placed. The 3 and 12 teeth were extracted because of severe caries. After pre-prosthetic treatment, the OVD was increased using a treatment denture, and the patient obtained an adequate occlusal relationship (Fig.3).

Fig.2 Intraoral views of removing the prostheses with marginal discrepancies

Fig.3 Intraoral views of inserted temporary restorations and treatment denture

As definitive prostheses, a maxillary removable overlay denture with coping-type magnetic attachments and a horseshoe plate as the major connector was fabricated (Fig.4), and a mandibular removable partial denture with an extracoronal-type magnetic attachment was also fabricated (Fig.5). The magnetic attachments used in this case report were GIGAUSS C400® (GC, Japan). The keepers of the magnetic attachments and magnetic assemblies were fixed with adhesive resin cement (Multilink® Automix, Ivoclar Vivadent AG, Liechtenstein) (Figs.6 and 7). Figure 8 shows an intraoral view of the definitive prostheses.

Fig.4 Maxillary removable overlay denture

Fig.5 Mandibular removable denture

Fig.6 Occlusal view of abutment teeth

Fig.7 Extracoronal-type magnetic attachments

Fig.8 Intraoral view of definitive prostheses

Outcome of Treatment

Three years after the denture setting, the definitive prostheses have been used without any problems, and the magnetic attachments have had no clinically significant loss of retention (Fig.9).

In the interval, the remaining dentition, periodontal condition, and retentive forces of the prostheses have been examined as part of a maintenance program (Fig.10).

Fig.9 Intraoral view of
the definitive prostheses 3 years after treatment

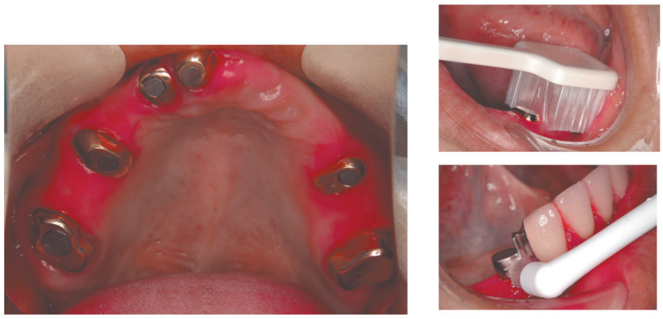

Fig.10 Maintenance program

Oral hygiene efficiency was evaluated using the Plaque Control Record (PCR) method. In this case, the PCR was 88.5% at the first visit and had improved to 20.8% (Fig.11) 3 years after treatment.

The Oral Health Impact Profile (OHIP) questionnaire is one of the most technically sophisticated instruments for assessing oral health–related quality of life (OHRQoL). Additionally, the OHIP-14, a short version of the OHIP, is considered most appropriate for edentulous patients.[2)] The OHIP-14 total score in this case was 41 at the patient's first visit and, 3 years after setting the removable denture with magnetic attachments, had improved to a score of 21 (Fig.12).

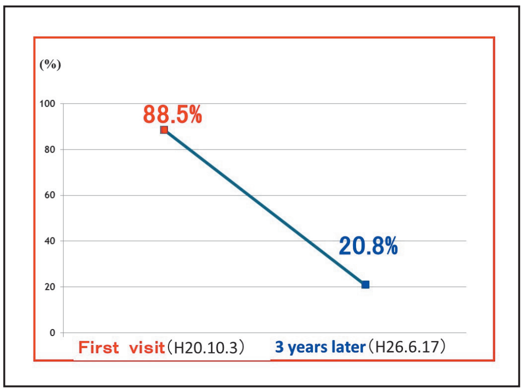

Fig.11 Plaque Control Record

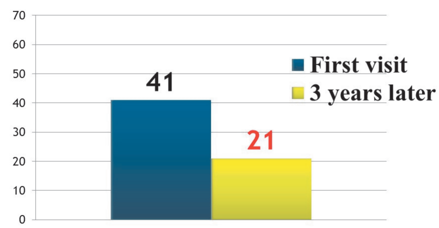

Fig.12 Japanese Oral Health Impact Profile-14

Conclusion

A magnetic attachment could be provided as a useful retentive appliance for alleviating patient complaints regarding aesthetics and function. It is difficult to maintain an ideal combination of aesthetics and functionality because the design of a final prosthesis is complex. Therefore, continuous follow-up is necessary with occlusal adjustment and relining of the denture base to prevent any OVD reduction.

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Denture base strength influence of its thickness surrounding magnetic assembly: Examination by model experiments

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Abstract

Long-term use of a magnetic overdenture often requires repair of the resin denture base on the coping due to fracture. This may result in a thin denture base surrounding the magnetic assembly, and the magnetic assembly works as a fulcrum or supporting point. Therefore, we evaluate how the thickness of the denture base surrounding a magnetic assembly affects its strength.

Specimens made of heat curing resin, two coping models (cone and spherical), were evaluated. Each coping model was then made in thicknesses of 2.5, 3.0, and 3.5 mm. Bending strengths with three- and four-point bending of the specimens were measured at a crosshead speed of 5 mm/min in a universal testing machine.

Although there were significant differences in the thickness of specimens, there were not significant differences in the coping shapes.

This result indicates that improvement of the denture base requires thick resin surrounding the magnetic assembly.

Introduction

Denture fractures are frequently reported with long-term use of a magnetic overdenture. There have been few studies about the effect of various thicknesses of the denture base resin around the magnetic assembly on fracturing.[1)] In this study, the correlation between thickness and strength of the denture base in overdentures was examined.

Objective

Experiments were performed using two types of bending tests (modified 3-point bending test and modified 4-point bending test) on simplified overdenture models.

Materials and Methods

1. Materials

a. Coping models

Figure 1 shows the coping models made of stainless steel (TOKYO GIKEN, Inc.). The coping models have two different shapes. Model A has a dome shape (dome), and model B has a trapezoidal shape (trapezoidal).

The dome is 6.0 mm in diameter and 2.0 mm in height. The trapezoid is 6.0 mm in diameter at the bottom, 4.5 mm in diameter at the surface, and 2.0 mm in height.

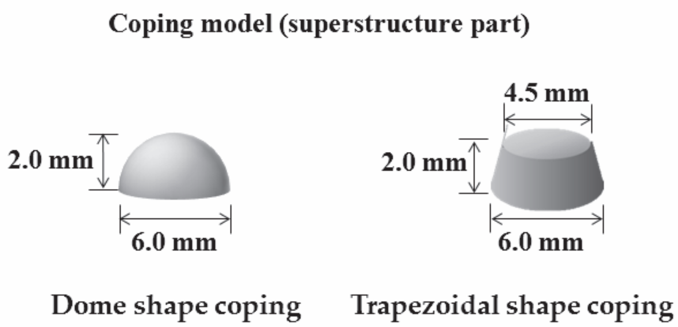

Fig. 1

b. Bending specimens

Rectangular solid bending specimens were fabricated with heat-curing resin (GC ACRON). Specimens were 64.0 mm wide; 10.0 mm long; and 2.5, 3.0, and 3.5 mm thick (Figs. 2,3).[2] Polymerized resin blocks were shaped using a semi-automatic polishing machine (Doctor Lap ML180, NARUTO) and silicon carbide paper.

According to the shape and the number of concave portions, four specimen groups were fabricated and named types A, B, C, and D. Five specimens were randomly assigned to each group.

Type A had one concave hemisphere part in the center. Type B had one concave frustum of a circular cone in the center. Type C had two concave hemisphere surfaces 9.5 mm and 39.5 mm from the left end of the major axis. Type D had two concave surfaces of circular cones in the same positions as type C.

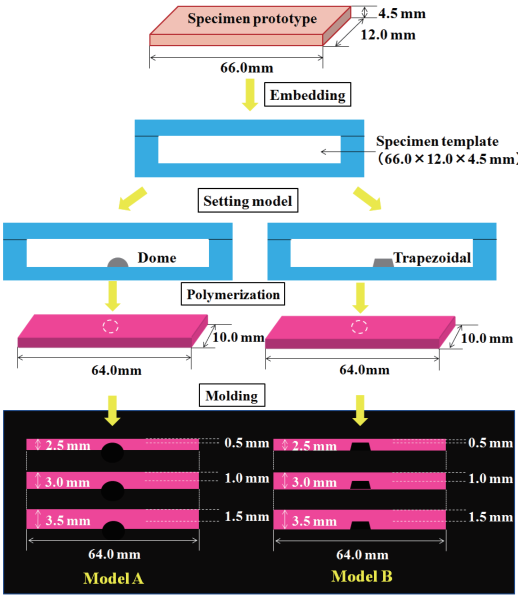

Fig. 2

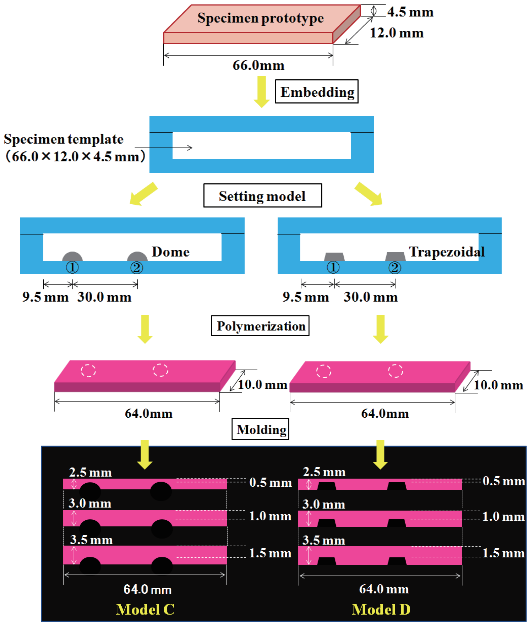

Fig. 3

2. Methods

Each specimen used for the experiments was soaked in 37℃ water for 48 hours. The bending test utilized a universal testing machine (EZ Test, SHIMADZU). For the experiments, a loading plunger was used in accordance with the specifications of JIS T6501.[3] The experiments were conducted with two kinds of tests (modified three-point bending and modified four-point bending tests). The modified three-point bending test (3PB) was used in experiment 1, and the modified four-point bending test (4PB) was used in experiment 2.

a. Modified three-point bending test (3PB)

Type A or B was loaded on a coping model until both sides fractured (Fig. 4). The coping model was attached to the under part in the EZ Test. Type A was on top in the dome model. Similarly, type B was on the top of the trapezoidal model. A loading plunger attached the crossing head part in the EZ Test at a distance of 30.0 mm between fulcrums. Bending tests were conducted using a crosshead speed of 5.0 mm/min. The bending strength of the specimen was measured at the maximum loading point, and the average value was calculated.

Acquired data was analyzed statistically by critical regions of 5% of the whole. It was used for statistical analysis using a two-way ANOVA and the Tukey-Kramer test.

b. Modified four-point bending test (4PB)

Type C or D was loaded until fracturing on the same two kinds of coping models (Fig. 5). The right-coping model in Fig. 5 was loaded from both sides, and the left-coping model was loaded from one side only. A unilateral free end was assumed in this state. The bending test was conducted at a distance between fulcrums of 30.0 mm and a crosshead speed of 5.0 mm/min. The statistical analysis was similar to that in experiment 1.

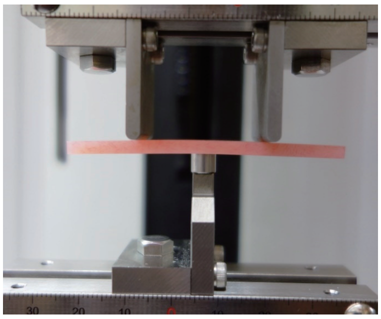

Fig. 4

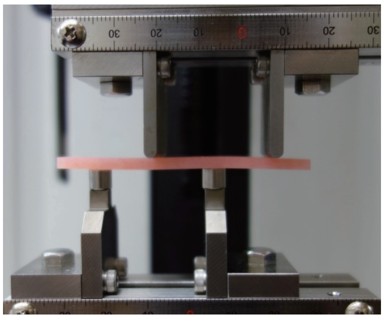

Fig. 5

Results

Figure 6 shows the results of experiment 1. The bending strength increased intentionally in both type A and B models whenever the thickness of the specimen increased. As a result of two-way ANOVA, it was not admitted for alternating cropping. Moreover, the different coping shapes did not cause a significant difference.

Figure 7 shows the results of experiment 2. In the loading areas of the EZ Test, types C and D did not fracture at 1.5 mm. Therefore, we were not able to calculate the value. In comparing thicknesses of 0.5 mm and 1.0 mm (types C and D), there were significant differences in the bending strength: more thickness brought more strength. As a result of two-way ANOVA, it was not admitted to the interaction. Moreover, there were significant differences between the coping shapes.

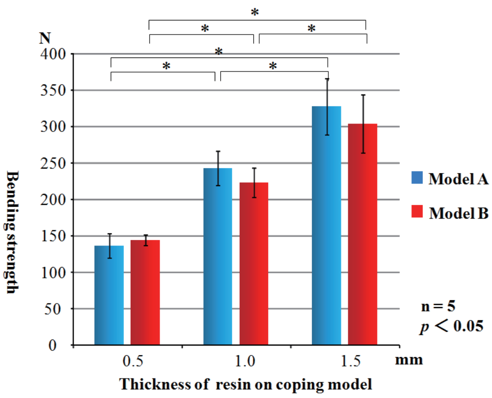

Fig. 6

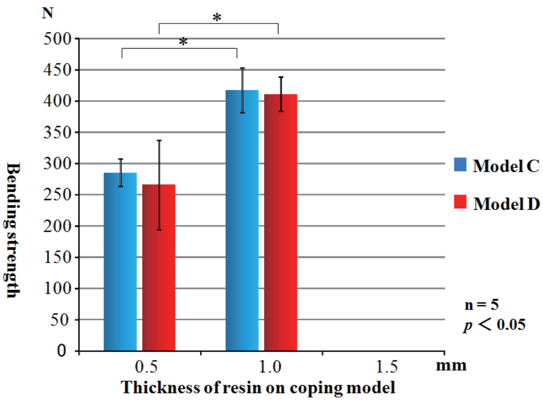

Fig. 7

Figure 8 shows the appearance of fracture from the underside in the 1.0-mm specimen (types A, B, C, and D). In type A, much of the fracture showed from the slight position displacement to one side from the deepest concave portion. In type B, much of the fracture occurred from the position that hit near the edge of the concave portion. In types C and D, much of the fracture occurred from the middle in both coping models. This corresponds to part of the left indenter of the loading plunger.

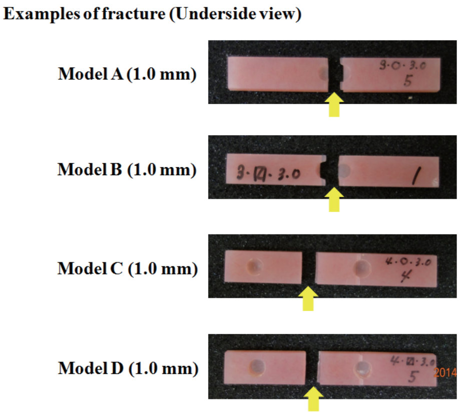

Fig. 8

Discussion

In these bending tests, the thickness of the resin plate increased the flexural strength; the different copings had no effect. In the case of one coping, many specimens were fractured in the coping mount portion. In the case of two copings, many of the specimens were fractured at the midpoint of the coping. This result is different from clinical reports in which the coping mount portion often fractures.

Conclusions

This experiment was to consider using also three-dimensional finite element methods. The shape of the specimen was simplified. Based on this review using model experiments and three-dimensional finite element methods, it will be necessary in the future to consider the experiment in line with more clinical testing. To avoid fractures of the coping resin base, thickness studies are needed.

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The thickness of the resin base needed for the top of copings: Examination by the three-dimensional finite element method

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Abstract

Denture fracture is a common complication in overdentures because the thickness of the denture base is often not sufficient above the copings. The thickness of the denture base should be sufficient for the prevention of denture fractures. However, how thick the denture base must be has not been clear. In this study, the correlation between the thickness of the resin and the stress concentration above the root cap was assessed using the three-dimensional finite element (FE) method. The three-dimensional FE models consisted of a plunger, a resin plate, and copings for the FE method. A 3-point bending test and a 4-point bending test (cantilever model) were examined using both the FE method and model testing. The part that fractured in the model testing was similar to the part highly stressed in the FE method. Increasing the thickness of the resin reduced the stress concentration and displacement of the resin plate. This result suggests that increasing the thickness of the denture base reduces the risk of denture fracture. Further experimentation is warranted to identify the thickness of the denture base required.

Introduction

Denture fracture is a common complication in overdentures because the thickness of the denture base is often not sufficient above the copings, and the copings become a fulcrum.[1)] Very few attempts have been made to study this. In this study, the correlation between the thickness of the resin base and the stress concentration above the copings was assessed using the three-dimensional finite element (FE) method in addition to model testing.

Materials and Methods

1. Model

The outline of a plunger, resin plate, and coping were modeled using three-dimensional data from ANSYS (Rel. 15.0, ANSYS Inc., USA) and SpaceClaim Direct Modeler (SpaceClaim Corp., USA). The maximum principal stress and displacement of these models were evaluated using ANSYS. Table 1 shows the Young's modulus and Poisson's ratio.[2)]

Material		Young's modulus (MPa)	Poisson's ratio
Plunger	Stainless SUS400C	1.930×10^5	0.31
Denture base	ACRON	1.896×10^3	0.30
Coping	Stainless SUS400C	1.930×10^5	0.31

Table 1: Material Properties

Figure 1 shows the plunger, resin plate, and coping models. The plunger that pressed the resin plate was a column with a radius of 1.6 mm, in accordance with the JIS T6501.[3)] The resin plate was 10 mm long; 64 mm wide; and 2.5, 3.0, and 3.5 mm high. It was hollowed in accordance with the shape of the copings. Its diameter was 6.0 mm, while the part of thrusting into resin plate had a height of 2.0 mm.[4)]

Two types bending test models, a modified 3-point bending test (3PB) and a modified 4-point bending test (4PB) model, were constructed for assessing the thick of a resin plate. Model A is a 3PB of a dome-shaped coping and resin plates of 3 different thicknesses. Model B is a 3PB of a trapezoid-shaped coping and resin plates of 3 different thicknesses. Model C is a 4PB of a dome-shaped coping and resin plates of 3 different thicknesses. Model D is a 4PB of a trapezoid-shaped coping and resin plates of 3 different thicknesses.

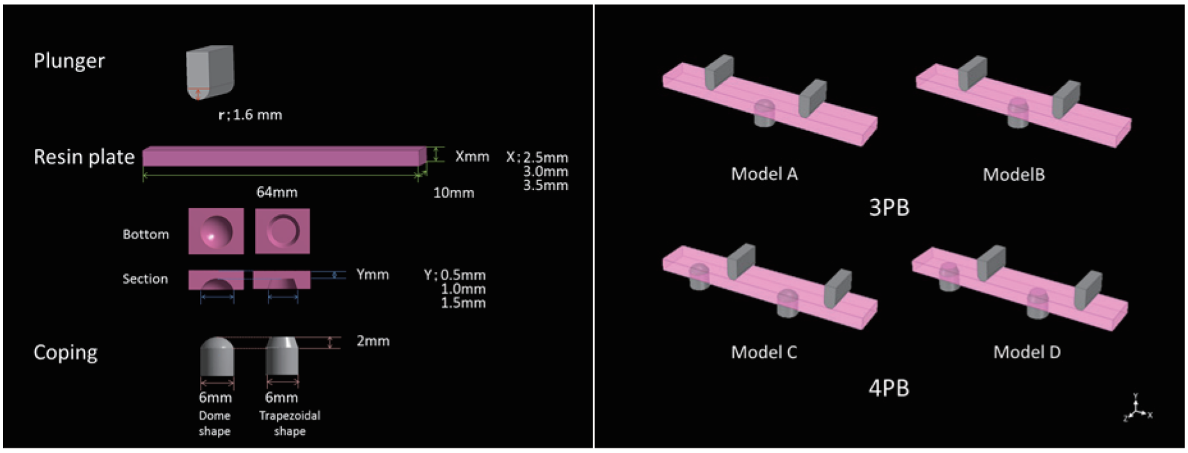

Fig.1: Analysis Model

2. Loading and Boundary Conditions

Figure 2 shows loadings and boundary conditions. The loading amount is 110N, according to the bending strength of ACRON. The surface of each plunger was loaded 55N, 110N in total. A complete constraint was applied to the bottom of the copings in all degrees of freedom.

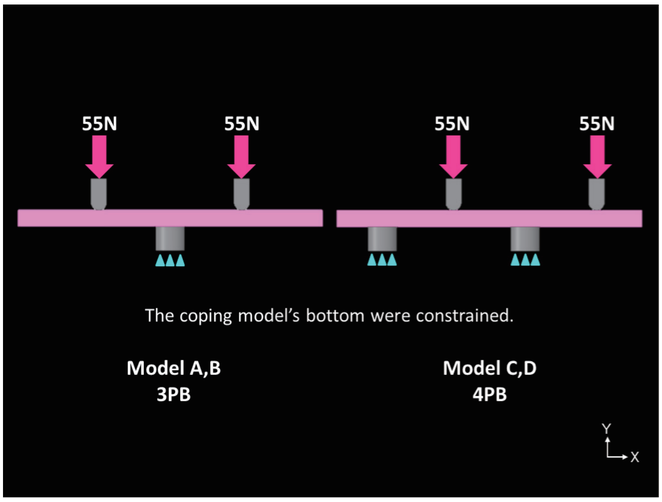

Fig.2: Loading and Constraint Conditions

3. Displacement

The measuring point was set on the surface of the resin plate, and the displacement was analyzed vertically.

Results

Figure 3 shows the maximum principal stress of the section with 3BP and 4BP. The stress was concentrated on the resin plate's surface corresponding to the top of the dome-shaped copings. The stress was concentrated on the resin plate's surface corresponding to the corner of the trapezoid-shaped copings. Increasing the thickness of the resin plate reduced the stress concentration. The part fractured in the model testing was similar to the result with the FE method.

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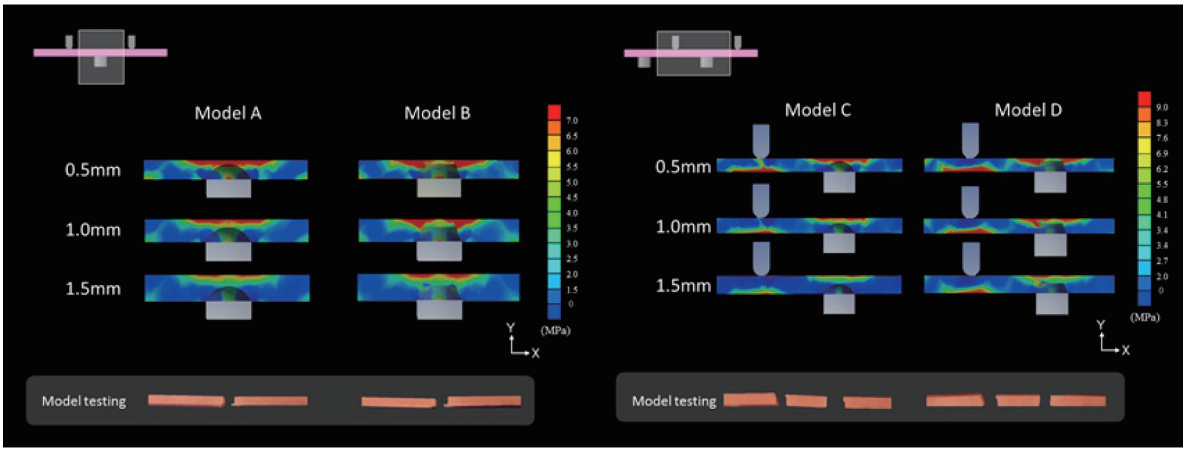

Fig.3: 3BP and 4BP Maximum Principal Stress

Figure 4 shows the maximum value of the maximum principal stress of the 3PB and 4PB. Resin plates of 3 different thicknesses were investigated to find the maximum value of the maximum principal stress in 4 models. Increasing the thickness of the resin plate reduced the maximum value of the maximum principal stress. The stress was no different between the dome-shaped and trapezoid-shaped copings.
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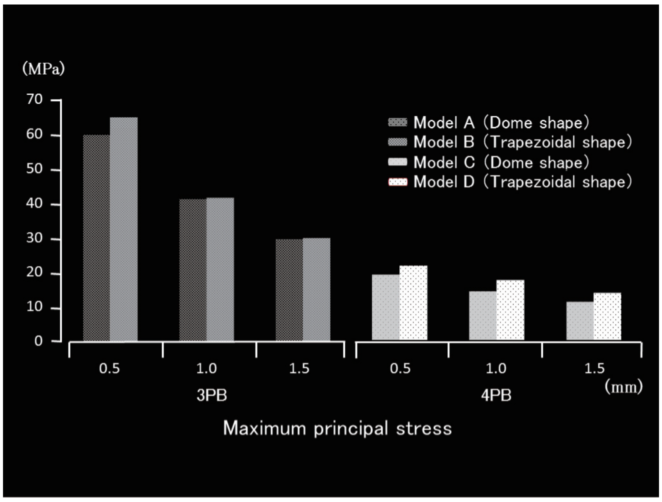

Fig.4: Maximum Value of the Maximum Principal Stress

Figure 5 shows the displacement of the resin plate with 3PB and 4BP testing. The arrows are plungers. The figure is the coping. The resin plate was displaced equally on both sides, starting from the coping, in both models A and B. Increasing the thickness of the resin plate reduced the displacement in all models.

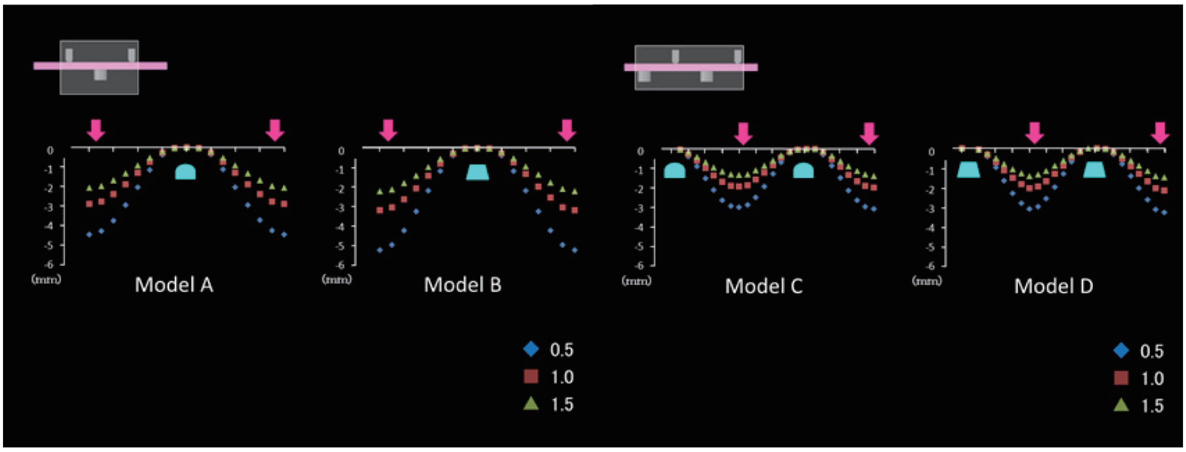

Fig.5: Displacement of 3PB and 4BP Tests

Discussion

We found that increasing the thickness of the resin plate reduced the maximum principal stress and the displacement with both 3PB and 4PB tests.

We found that the stress was concentrated at the center of the resin plate in models A and C. Additionally, the stress was concentrated at the corner of the copings in models B and D.

This tendency of denture fractures is suggested by the FE method, as model testing by Kanazawa[5)] returned the same results.

Conclusions

These results suggest that increasing the thickness of the resin plate reduces the risk of fracture just as with a model test; it also showed the invisible effect of the coping shape in the model test. Further experimentation is warranted to identify the denture base thickness required to avoid fracturing.

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Fixation of a modified magnet assembly to the denture base using alternative resins

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Abstract

Introduction:

Special care must be taken during the fixation of a magnetic assembly because the denture may become impossible to remove from the abutment teeth or implant due to the PMMA resin's hardening within the undercut around the keeper. The aim of this study has been to investigate the fixation strengths of magnetic assemblies to denture bases using alternative resins similar to conventional resin.

Materials and Methods:

Magnetic assemblies with three different undercuts and three resins as materials for fixation to magnetic assembly were prepared in this study. Tensile testing was performed to evaluate the fixation strength and the attractive force of the magnetic assembly using resins after repeated insertion/removal testing. The data of fixation strengths and attractive forces were analyzed using a two-way ANOVA, Tukey's multiple comparison, and a t-test (α=0.05).

Results and Discussion:

By adding undercut wings to the magnetic assembly, fixation strengths tended to increase when temporary fixation materials were used. Temporary filling resin and conventional PMMA resin demonstrated a constant attractive force without removing the magnetic assembly. Temporary filling resin showed comparable fixation strength to conventional resin.

Introduction

Magnetic attachments have been widely used as stud attachments for root- and implant-retained overdenture rehabilitation. In general, the magnetic assembly has been directly fixed to the denture base with autopolymerized polymethyl methacrylate (PMMA) resin using the brush-on technique after the magnetic assembly is placed on the keeper of the abutment tooth or implant. However, special care must be taken during the fixation because the denture may become impossible to remove from the abutment teeth or implant due to the PMMA resin's hardening within the undercut around the keeper. In this study, the magnetic assembly was modified to add several undercuts to improve mechanical retention.

Objective

The aim of this study was to investigate the fixation strengths of magnetic assemblies to denture bases using alternative resins rather than conventional PMMA autopolymerized resin without housing.

Materials and Methods

To evaluate the effectiveness of mechanical retention in this study, a commercially available magnetic assembly (PHYSIO MAGNET 35, Neomax, Gunma, Japan; diameter: 3.5 mm; thickness: 0.8 mm; attractive force: approximately 5.5 N) was modified by adding three different undercut wings (wing diameter [undercut]: 4.5 mm [0.5 mm], 4.8 mm [0.65 mm], and 5.5 mm [1.0 mm]). A conventional magnetic attachment (PHYSIO MAGNET 35, Neomax, Gunma, Japan) of the same size without undercut wings was compared as a control (Fig. 1).

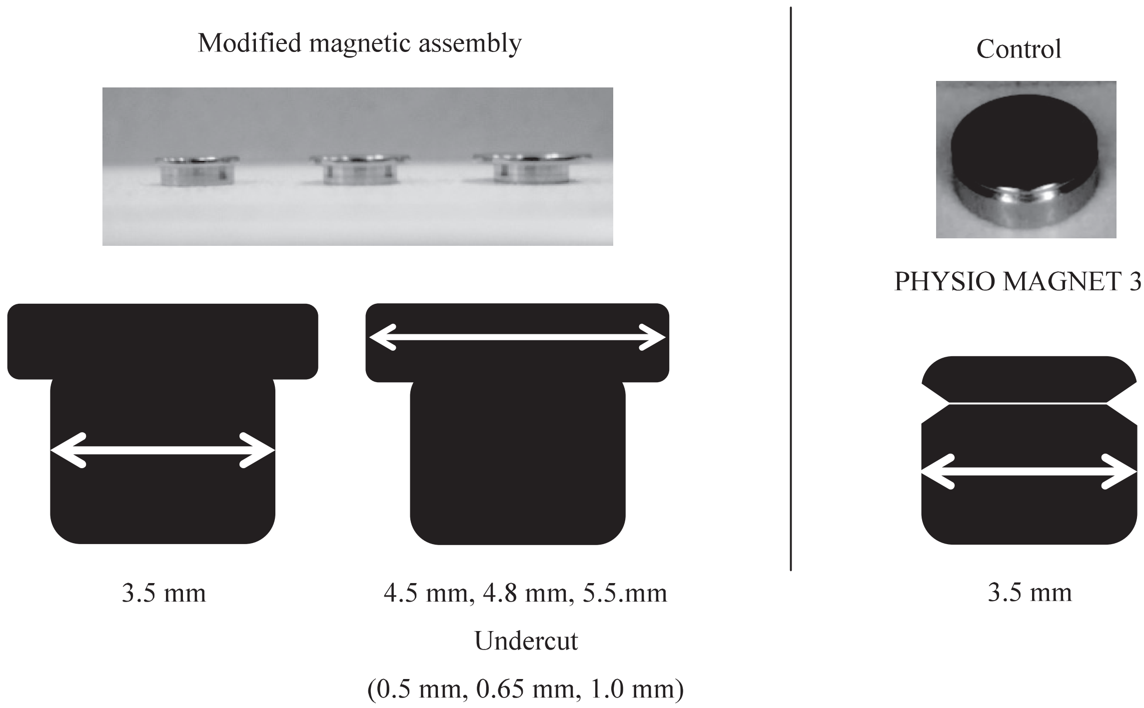

Fig. 1 Magnetic assemblies modified by adding three different undercut wings (wing diameter [undercut]: 4.5 mm [0.5 mm], 4.8 mm [0.65 mm], and 5.5 mm [1.0 mm])

The materials selected for the retaining magnet as fixation material were an experimental resin (70% polyethylene glycol dimethacrylate 23G and 30% MMA in the monomer, 20% polybuthylmethacrylate and 80% PMMA in the polymer), a temporary filling resin (DuraSeal, Reliance Dental Mfg. Co., Worth, IL, USA), and an autopolymerized PMMA resin (UNIFAST III, GC Corp., Ltd., Tokyo, Japan). Magnetic assemblies were bonded to the lower jig using a cyanoacrylate adhesive (ARON ALPHA, Toagosei Co., Ltd., Tokyo, Japan) for tensile testing. For testing repeated insertion/removal, the keeper was mounted in the lower jig, and the magnetic assembly was placed on the keeper without a cyanoacrylate adhesive. After the polymers and monomers of the fixation materials were mixed, they were applied to the magnetic assembly and poured into the housing in the upper jig (Fig. 2). Tensile testing was performed to evaluate the fixation strength and the attractive force of the magnetic assembly using resins after repeated insertion/removal testing up to 10,000 cycles (Figs. 3, 4). Tensile strengths were measured using an autography at a crosshead speed of 1.0 mm/min. The data of fixation strengths and attractive forces were analyzed using a two-way ANOVA, Tukey’s multiple comparison, and a t-test (α=0.05).

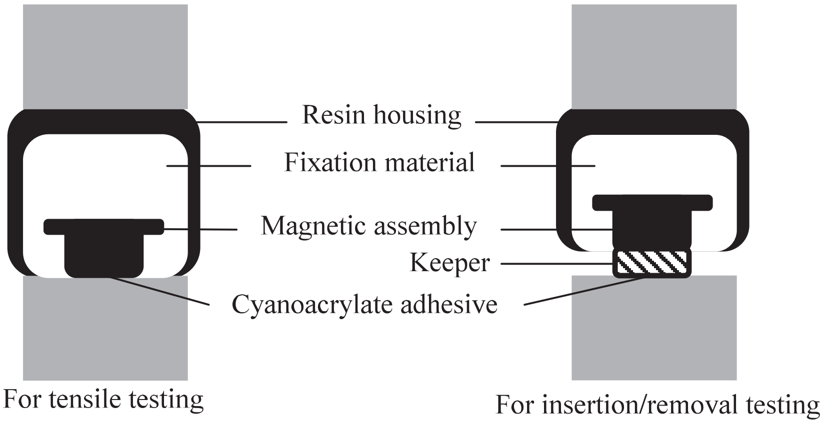

Fig. 2 Fixation of the magnetic assembly for each test

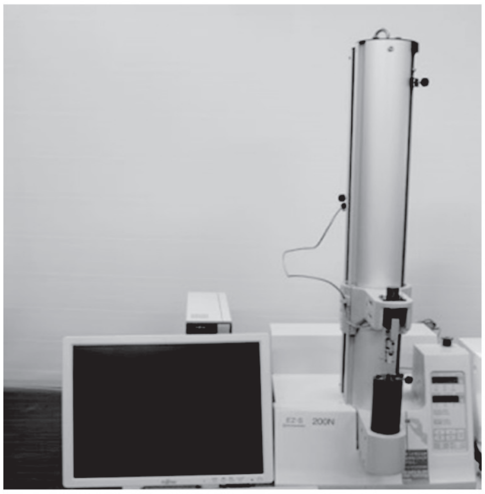

Fig. 3 Autography used for tensile testing

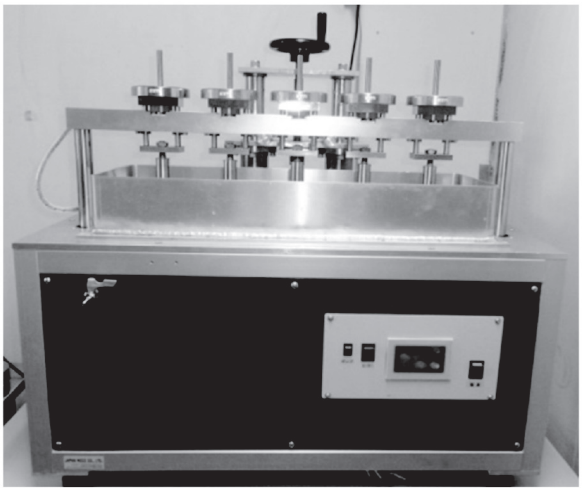

Fig. 4 Insertion/removal testing machine

Results

Figure 5 shows the fixation strengths of magnetic assemblies using permanent fixation material, both initially and after 10,000 cycles. The fixation strengths of a temporary filling resin (DuraSeal) with a 4.5-mm undercut wing and conventional PMMA resin could not be measured because the magnetic assembly was separated from the lower jig without failure between the magnetic assembly and the fixation resin.

Figures 6 and 7 show the changes in the attractive forces of the magnetic attachments when using fixation materials with and without the undercut wing, respectively. Without the undercut wing, the magnetic assembly was removed in one of the 5 experimental resin specimens. There were no significant differences in the attractive forces with and without undercuts (p>0.05). Although the initial attractive force of the experimental resin was similar to the others, both with and without the undercut wing, a remarkable decrease was shown at 1,000 cycles, keeping constant attractive forces at 2,000 cycles.

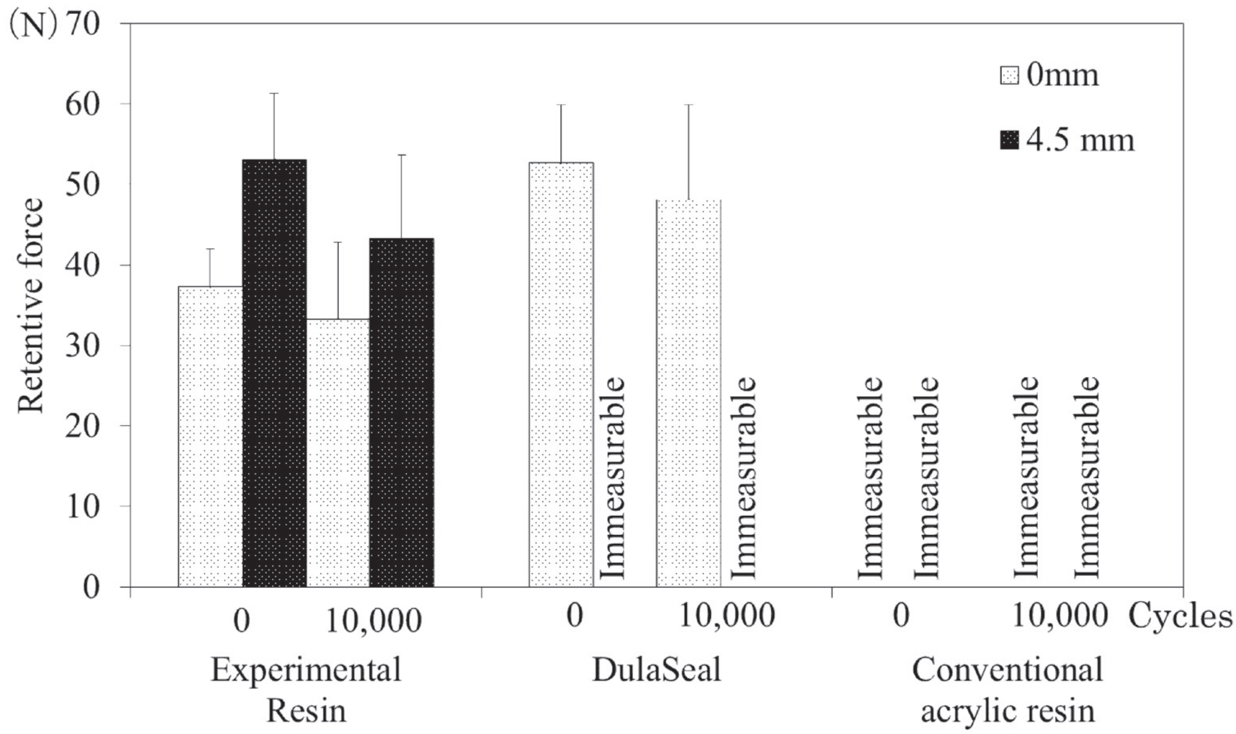

Fig. 5 Fixation strengths of magnetic assemblies using fixation materials

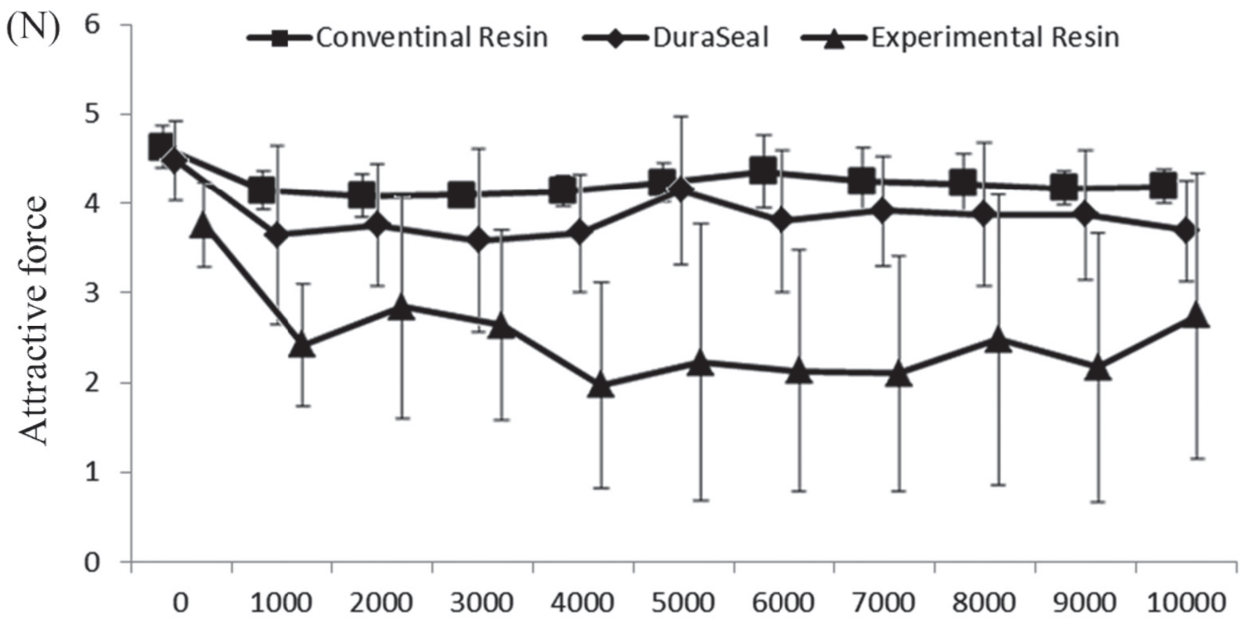

Fig. 6 Changes of attractive forces to the magnetic assembly without using fixation materials on the undercut

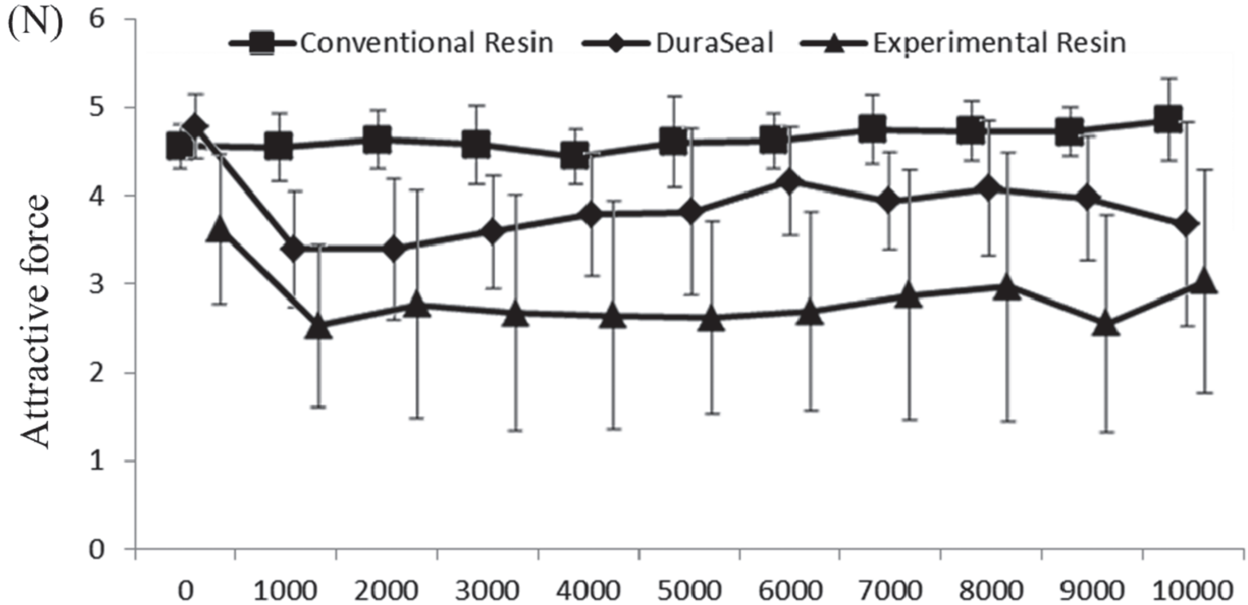

Fig. 7 Changes of attractive forces to the magnetic assembly with a 4.5-mm undercut using fixation materials

Discussion

Regarding the experimental resin, polyethylene glycol (PEG) dimethacrylate 23G and polybuthylmethacrylate were prepared for flexibility and expanded the polymerization time. The magnetic assembly was removed from the housing in one of five specimens that used the experimental resin during up to 10,000 insertion/removal cycles. Thus, the mechanical property of the experimental resin should be improved for rigid fixation if the experimental resin is used as a permanent fixation material. The fixation strengths of magnetic assemblies using temporary filling resin, even without undercuts, showed approximately 50 N even after 10,000 insertion/removal motions. Until 10,000 insertion/removal motions, temporary filling resin and conventional PMMA resin demonstrate a constant attractive force (approximately 4 to 5 N) without removing the magnetic assembly. In conclusion, using a temporary filling resin can be recommended as a permanent fixation material similar to conventional PMMA resin.

Conclusions

By adding undercut wings to the magnetic assembly, fixation strengths tended to be increased when fixation materials were used. Although the experimental resins demonstrated satisfactory fixation strengths, improving their mechanical strengths is necessary because the magnetic assembly was removed from the housing in one of five specimens. Temporary filling resins showed comparable fixation strengths to conventional resins; thus, they could be used as permanent fixation materials for magnetic attachments as used in this study.

Retentive forces and displacement of new stress-breaking magnetic attachments

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Abstract

Numerous studies with reliable results on attachment systems for implant overdentures in the mandible and maxilla have been published. Most attachments allow for rotational change but cannot compensate for vertical displacement under functional forces. This study evaluated the retentive forces and displacement of stress-breaking attachments after repeated loads.

Seven types of stress-breaking attachments-a self-adjusting magnetic attachment, a cushioned type of magnetic attachment, a locator attachment, three types of SBB (Stress-Breaking Ball) attachments, and an SBM (Stress-Breaking Magnetic) attachment-were placed on the implants. To simulate chewing cycles, a load of 5 kgf was repeatedly applied up to 50,000 times using a loading apparatus. The retentive force was measured by tensile testing. The vertical displacement of each female was measured under 5 kgf. These measurements were repeated for 10,000 cycles. The mean values were analyzed using a one-way ANOVA followed by the Tukey's test at a significance level of $\alpha=0.05$.

There were no significant differences in the retentive forces of both magnetic and SBM attachments before and after loading ($p>0.05$).

The vertical displacement of the magnetic and SBM attachments showed a slight decrease after loading. On the other hand, the locator attachment had no vertical displacement, and the cushioned type of magnetic attachment decreased significantly ($p>0.05$).

Introduction

Numerous studies with reliable results on attachment systems for implant overdentures in the mandible and maxilla have been published. Most attachments allow for rotational excursion but cannot compensate for vertical displacement under functional forces. There are extraordinary differences in setting under a chewing load between the implant and mucosa under the denture base. In addition, horizontal forces and rotational excursion are also applied to the implants depending on the occlusal contact, location, and number of implants in the dental arch. Therefore, excessive and harmful occlusal forces are applied to implants. To protect implants from excessive forces, a few stress-breaking attachments have been manufactured.

Objective

This study evaluated the retentive forces and displacement of stress-breaking attachments after repeated loads simulating masticatory function.

Materials and Methods

Stress-Breaking Magnetic (SBM) attachments were placed on the implants (Fig. 1). An SBM attachment consists of a housing unit that includes a steel spring (SUS 304; height: 2 mm) and a magnetic assembly (Hyper Slim 3513, NEOMAX; diameter: 4 mm; undercut: 1 mm). The SBM attachments revised the amount of displacement to 0.5 mm.

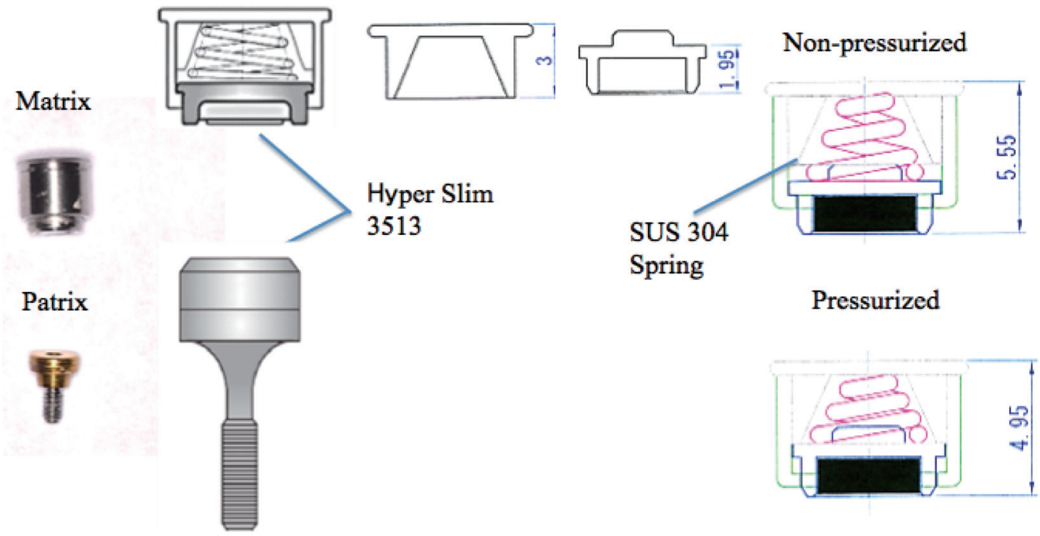

Fig. 1 Schema of an SBM attachment

Seven types of stress-breaking attachments (Fig. 2) -a self-adjustment type of magnetic attachment (Magfit SX, AICHI STEEL), a cushioned type of magnetic attachment (Magfit IPS, AICHI STEEL), a locator attachment (Locator, ZEST ANCHORS), and three types of Stress-Breaking Ball (SBB) attachments (amount of displacement: 0.3 mm, 0.5 mm, 0.7 mm; GC Corp.) -were placed on the implants. The implants were embedded in a resin block using autopolymerized resin (Fig. 3). To simulate chewing cycles, a load of 5 kgf was repeatedly applied up to 50,000 times using a loading apparatus (Fig. 4). The retentive force was measured by means of tensile testing at a crosshead speed of 5 mm/min. The vertical displacement of each female was measured under 5 kgf. These measurements were repeated for 10,000 cycles. The mean values were analyzed using a one-way ANOVA followed by the Tukey's test at a significance level of α=0.05.

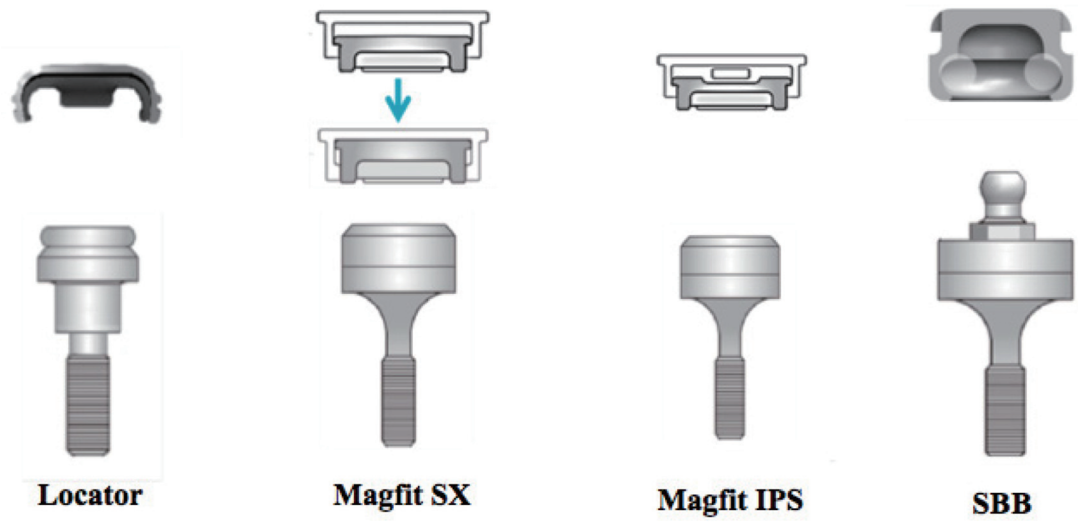

Fig. 2 Schema of stress-breaking attachments

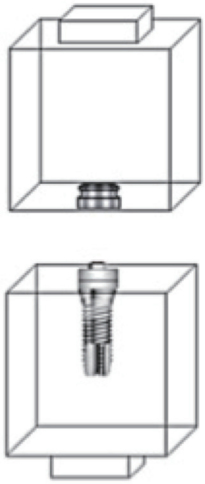

Fig. 3 Schematic drawing of specimens

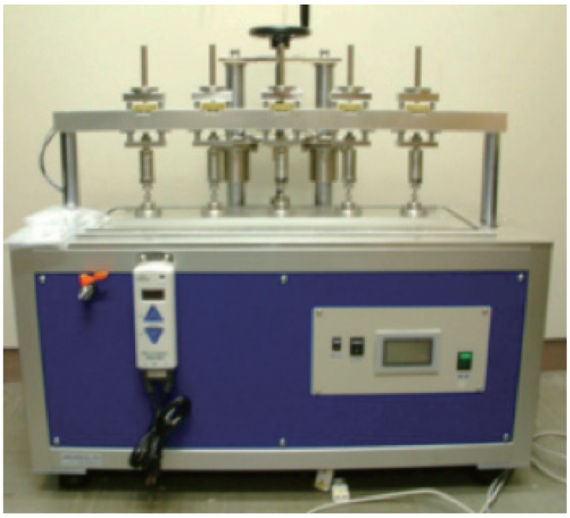

Fig. 4 Cyclic loading testing machine for tensile testing

Results

The initial retentive force of the locater attachment was significantly greater than that of any other attachment tested ($P<0.05$). After 10,000 cycles, the retentive force of the locator attachment decreased to two-thirds of the initial one. There were no significant differences in the retentive forces of both magnetic, SBB, and SBM attachments before and after loading ($P<0.05$) (Fig. 5). The vertical displacement of Magfit SX, SBB, and SBM attachments decreased slightly after loading. On the other hand, there was little vertical displacement of the locator attachment irrespective of the load applied. The vertical displacement of Magfit IPS decreased significantly after 20,000 cycles, and there was little vertical displacement after 40,000 cycles (Fig. 6).

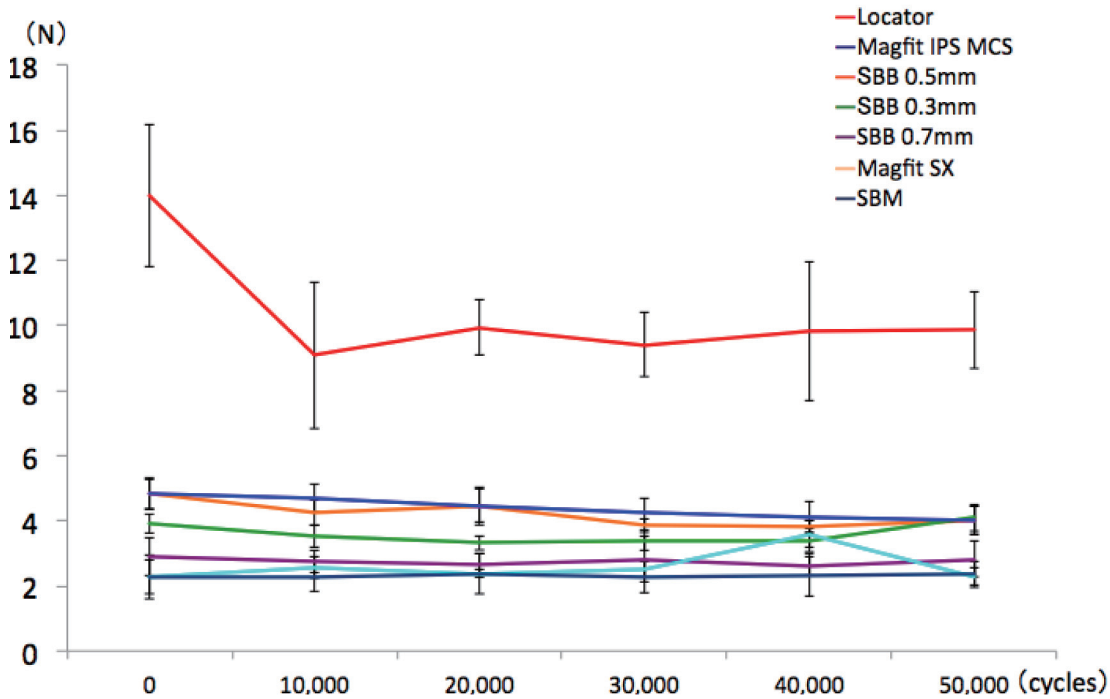

Fig. 5 Changes in the retentive forces of all attachments

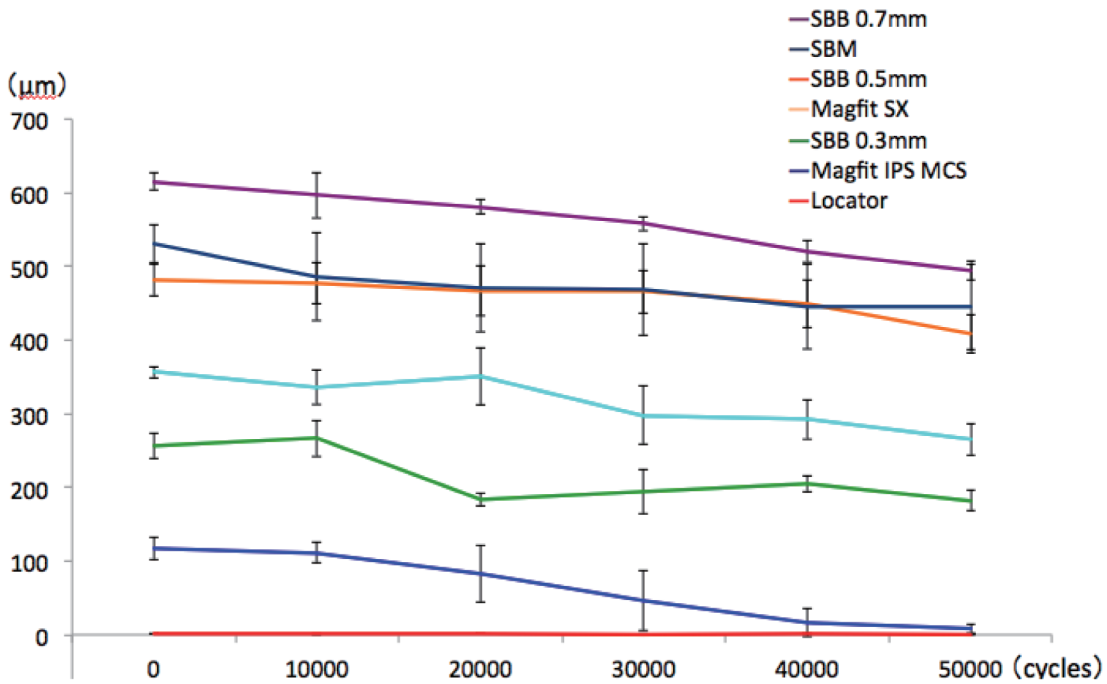

Fig. 6 Vertical displacements of all attachments

Discussion

It is very difficult to determine the most suitable retentive force for overdenture attachments. Generally, a single overdenture may require a retentive force of approximately 2 kg to withstand the chewing of sticky foods; simultaneously, it should be easily removable by wearers. One retainer may require a retentive force of approximately 300~1,000 g [1]. After 10,000 cycles, the retentive force of the locator attachment decreased to two-thirds of the initial one. However, with a retentive force after 10,000 cycles that was greater than that of other attachments, the locator attachment would be effective for use in clinical applications similar to those of other attachments. When a static load in the axial direction was applied to the implant superstructure and the alveolar mucosa, the displacements were less than 5 μm and 300 μm , respectively [2] [3]. A stress-breaking attachment may compensate for this difference in displacement accuracy. The vertical displacement of Magfit SX, SBB, and SBM attachments decreased slightly after repeated loading. However, these attachments may distribute occlusal force equally between the alveolar ridge and the implant. The possibility of clinical application suggested that the attachment could be improved and miniaturized hereafter.

Conclusion

The initial retentive force of the locater attachment was significantly greater than that of the other attachments; however, after 10,000 cycles, the retentive force of the locator attachment remarkably decreased. There were no significant differences in the retentive forces and vertical displacements of both magnetic, SBB, and SBM attachments before and after repeated loading.

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Investigation of an optimal magnetic attachment structure using three-dimensional finite element method -An influence of different magnetic assembly and keeper structure on attractive force-

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Abstract

Magnetic attachments are designed to exert an attractive force at clinically useful levels. However, more improvement is necessary considering strict clinical conditions. The present study analyzed and investigated magnetic attachments from the point of magnetic circuit using a three-dimensional finite element method to enhance the performance of magnetic attachments.

An analysis model was constructed based on a dental magnetic attachment (GIGAUSS D 600, GC). Round shaped non-magnetic body was embedded in the shield disk of a magnetic assembly and center of the attractive surface of a keeper in the analysis model. Analysis was performed by changing the diameter of a non-magnetic material by 0.05 mm. Magnetic flux density distribution and attractive force were evaluated by the analysis.

An increase in magnetic flux density on the attractive surface was confirmed by embedding a non-magnetic body to a magnetic assembly and a keeper. However, magnetic flux density was oversaturated when it exceeded a certain value. A similar tendency was confirmed in attractive force.

Introduction

Magnetic attachments have been continuing to improve. Various magnetic circuits have been designed so that the minimal size of magnetic attachment can exert high attractive force.

A magnetic attachment consists of a magnet assembly and a keeper. A magnet in the magnetic assembly is encapsulated by magnetic and non-magnetic bodies. Magnetic flux can penetrate a magnetic body, but cannot penetrate a non-magnetic body. Magnetic flux is the magnetic line of forces. It penetrates a magnetic body and forms the closed magnetic circuit that exerts attractive force when a magnetic assembly and a keeper come into contact[1)].

Attractive force is affected by attractive surface area of a magnetic assembly and a keeper, and magnetic flux density. Since the size of a magnetic attachment should be minimal, it is impossible to increase the attractive surface area of a magnetic assembly and a keeper[2)] . Attractive force of a magnetic attachment can be effectively increased by increasing magnetic flux density. A magnetic circuit changes by incorporating a non-magnetic body in the inner structure of a magnetic assembly and a keeper, and this may increase a magnetic flux density. In other words, clinically-feasible magnetic assemblies and keepers can be developed by introducing an optimal magnetic circuit. Finite element method is considered the most effective method to optimize the magnetic circuit as it can visualize the dynamic behavior of the magnetic circuit inside a magnet, and simulation can be performed by changing the conditions.

Objective

A non-magnetic body was embedded in the center of a magnetic assembly shield disk and center of the attractive surface of a keeper. Three-dimensional finite element method was performed to analyze the influence of a difference in the magnetic circuit on the attractive force, and to optimize the magnetic circuit.

Materials and Methods

1. *Analysis model*

The size of a magnetic assembly was 1.8 mm in radius and 1.3 mm in height, and a magnet inside the magnetic assembly was a round shape, and was 1.3 mm in radius and 0.5 mm in height. The size of a ring was 0.2 mm in width and 0.2 mm in height. A shield disk was 1.1 mm in radius and 0.2 mm in height. A keeper was a round sharp, and was 1.8 mm in radius and 0.7 mm in height. Considering the model was axial symmetry, 1/4 model was set as a basic model (Fig. 1).

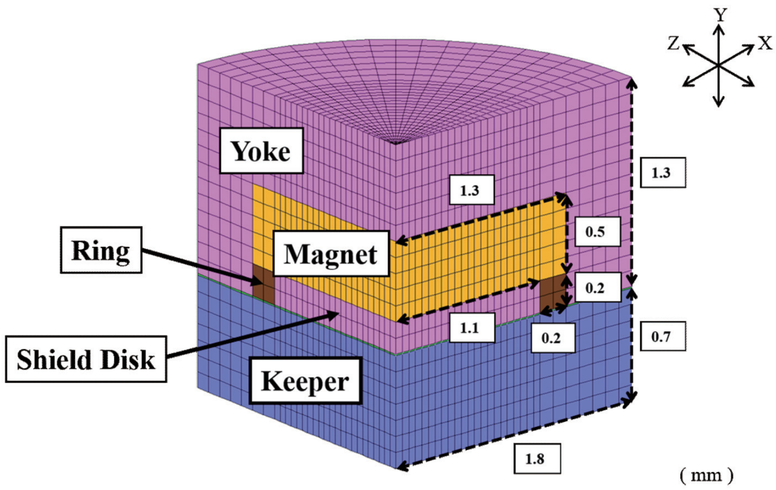


Fig .1 Basic model

Analysis range was 2 mm around a magnetic assembly and a keeper, and the analysis of the factor was performed. Marc mentat 2010 (Multi-Purpose Finite Element Pre and Post Processor, MSC) was used for model construction, and μ-MF (electromagnetical field analysis system, μ-TEC) analysis software was used. Element type was three-dimensional pentahedron and hexahedron elements. The element count was 53,802, and nodal point count was 57,784.

The components of a magnet were Ne-Fe-B (Neodymium, ferrum, boron), and its magnetic properties were calculated based on the thermal property of GIGAUSS D 600 and values provided by a manufacturer[3). The component of a yoke and a keeper was SUS447J1, and the B-H curve of the magnetic properties was calculated by the approximation formula (Table 1).

Table 1 Analysis conditions

Magnetic assembly		
	Nd-Fe-B	(BH) max = 46 MGOe
		Residual magnetic jnduction = 1.22 T
Keeper & Yoke		
	SUS447J1	Saturation magnetic induction = 1.35 T

B-H curve $B = Bs \{ 1 - \exp (-\mu_r \cdot \mu_0 \cdot H / Bs) \}$

2. *Analysis items*

A non-magnetic body was embedded in the center of the shield disk of a magnetic assembly and center of the attractive surface of a keeper. The radius of a non-magnetic body was changed by 0.05 mm increments from 0.05 mm to 0.5 mm in the center of a shield disk (10 patterns in total)(Fig. 2).

Magnetic assembly

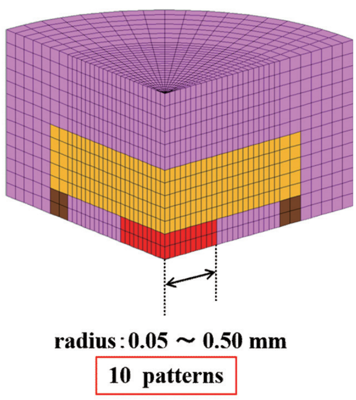


Fig.2 Analysis item of magnetic assembly

In the center of the attractive surface of a keeper, the radius of a magnetic body was changed by 0.05 mm increments from 0.05 mm to 1.0 mm, and the depth was changed by 0.1 mm from 0.1 mm to 0.6 mm (120 patterns in total)(Fig. 3).

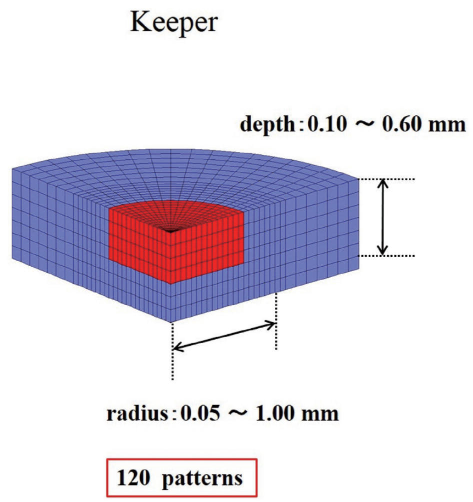


Fig.3 Analysis item of keeper

These patterns were combined, and a total of 1,200 patterns were analyzed (Fig. 2). Analysis result was evaluated as magnetic flux density and attractive force.

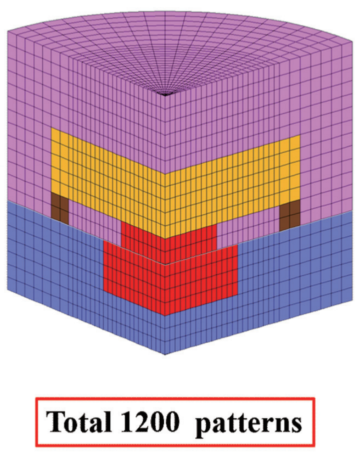
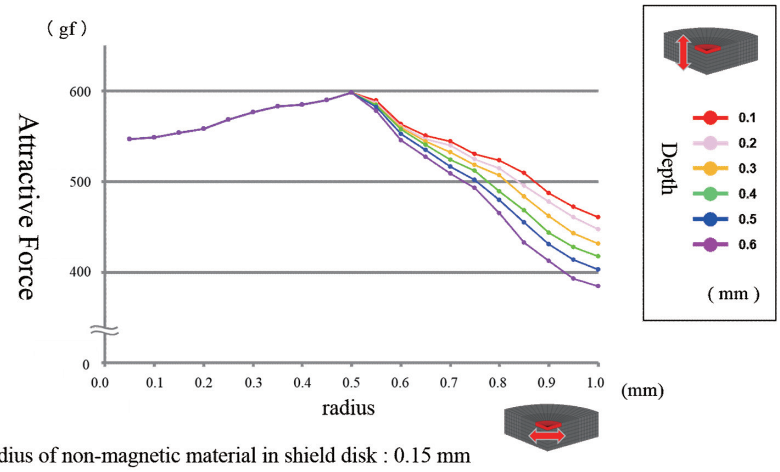


Fig.4 Total patterns

Results

1. *Attractive force*

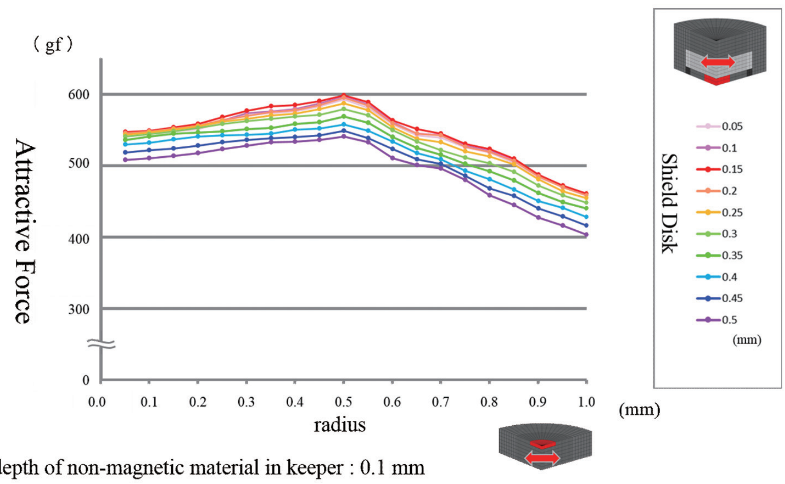
Fig. 3 shows the influence of the radius of a non-magnetic body embedded in the keeper attractive surface on the attractive force for the depth where the radius of a non-magnetic body in the center of a shield disk was 0.15 mm. There was no influence of depth until the radius of a non-magnetic body in the attractive surface of a keeper reached 0.5 mm. Attractive force was the highest at 0.5 mm in radius. When the radius exceeded 0.55 mm, attractive force started to decrease and was affected by the depth.



＊ radius of non-magnetic material in shield disk : 0.15 mm

Fig.5 Influence of the depth

Fig. 4 shows the influence of a change in radius of a non-magnetic body in the attractive surface of a keeper on attractive force for the radius of a non-magnetic body in the center of a shield disk. Since there was a little influence of the depth of a non-magnetic body until the radius of a non-magnetic body in the center of a keeper attractive surface reached 0.5 mm where attractive force continued to increase (Fig. 3), the depth of a non-magnetic body was set at 0.1 mm. Attractive force increased with an increase of a radius of the non-magnetic body in the center of a keeper attractive surface. The attractive force reached a maximum of 598 gf when a radius of a non-magnetic body in the center of a shield disk was 0.15 mm and that in the center of an attractive surface of a keeper was 0.5 mm, but decreased thereafter with an increase of a radius of a non-magnetic body on the attractive surface of a keeper. When attractive force of the basic model was defined as 100%, the attractive force was increased to approximately 110% at 0.15 mm radius of a non-magnetic body in the center of a shield disk and 0.5 mm radius of a non-magnetic body in the center of an attractive force of a keeper where attractive force reached the maximum.



＊depth of non-magnetic material in keeper : 0.1 mm

Fig.6 Influence of shield disk and keeper

2. *Magnetic flux density distribution*

Fig. 5 shows a typical magnetic flux density distribution of the analysis results. The radius of a non-magnetic body in the center of an attractive surface of a keeper was changed when the radius of a non-magnetic body in the center of a shield disk was 0.15 mm and the depth of a non-magnetic body in the center of an attractive surface of a keeper was 0.1 mm.

An increase in the magnetic density was confirmed in the magnetic assembly and attractive surface of a keeper. When the radius of a non-magnetic body in the center of an attractive surface of a keeper exceeded 0.75 mm, the magnetic flux density in the magnetic assembly and on the attractive surface of a keeper became oversaturated, and a decrease in the magnetic flux density in the magnetic assembly and inside a keeper was observed.

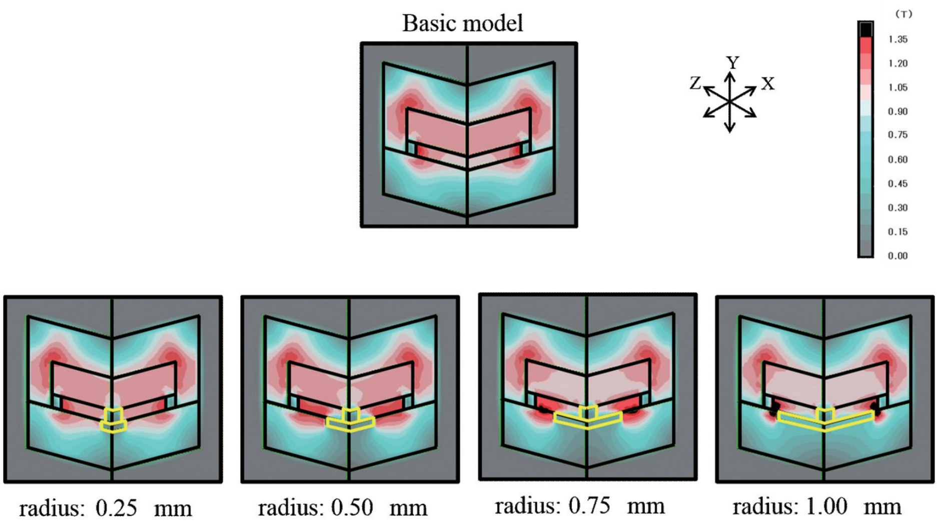


Fig.7 Magnetic flux density distribution

Discussion

1. *Efficiency of finite element method*

It is difficult to measure and observe the detail of behavior of attractive and repelling force created by a magnet. This is because the magnetic field has a gradient in all directions, and, therefore, simple calculation formula cannot be established. Although it is possible to measure magnetic force and magnetic field at specific location, it is difficult to design the magnetic circuit from the measurements that exerts the maximum attractive force and verify optimal magnetic circuit that minimizes magnetic field leakage. Finite element method is the only way to investigate the inner behavior of the magnetic circuit. Magnetic circuit compartments were considered as micro-compartment to solve the simultaneous equation. Finite element method allows visualization and simulation of the inner behavior of the magnetic circuit by adding various conditions. It is considered time-efficient and cost-effective to search optimal magnetic circuit using a finite element method.

2. Accurate of the analysis result of the present study

The magnetic field analysis was performed in the present study. Since there is a magnetic field distribution in the space, it is prerequisite that the paths of integration in the space around the analysis model and the interface between a magnetic assembly and a keeper are subdivided. Exploratory analysis was performed to calculate the value with the least effect. Therefore, the analysis result of the present study is considered highly accurate[4)].

3. The relationship between the attractive surface area and magnetic flux density

The attractive force of a magnet can be expressed as $F = (1/2\mu_0) \cdot S \cdot B^2$\{$\mu_0$: space permeability, S:attractive surface area, B: magnetic flux density\}[5)]. The attractive force of a magnetic attachment is affected more by magnetic flux density than attractive surface area. Therefore, attractive force can be increased efficiently by increasing the magnetic flux density. The magnetic circuit changes by replacing part of a keeper of a magnetic attachment with a non-magnetic body, resulting in an increase in the magnetic flux density on the attractive surface. The attractive force was affected more by an increase in the magnetic flux density than a decrease in the attractive surface area, resulting in an increase in the attractive force. However, there is a limit of magnetic flux density in the magnetic body called “saturated magnetic flux density”. When the magnetic body reaches that point, an increase in the magnetic flux density stops even with the continuous increase of the size of a non-magnetic body. As a result, the attractive force decreases due to an influence of the attractive surface area. The relationship between the attractive surface area and magnetic flux density is extremely important for the optimization of the magnetic circuit.

4. Inference of the depth

In the present study, a non-magnetic body was embedded in the center of a shield disk and attractive surface of a keeper. The magnetic circuit of a magnetic assembly and inside a keeper was changed by changing the radius of a non-magnetic body, resulting in an increase in the magnetic flux density distribution on the attractive surface. The attractive force is affected more by the magnetic flux density than a decrease in the attractive surface area, resulting in an increase in the attractive force. The attractive force reached its maximum at 0.15 mm radius of a non-magnetic body in the center of a shield disk and 0.5 mm radius of a non-magnetic body in the center of an attractive surface of a keeper. When the magnetic flux density on the attractive surface became oversaturated, attractive force decreased due to a decrease in the magnetic flux density and attractive surface area. When the radius of a non-magnetic body in the center of a shield disk is constant, the attractive force continued to increase until the radius of a non-magnetic body is increased to 0.5 mm. The attractive force is affected by an increase of the magnetic flux density on the attractive surface, and is rarely affected by the depth of a non-magnetic body. However, when the radius of a non-magnetic body in the center of an attractive surface of a keeper exceeds 0.5 mm, the magnetic flux density on the attractive surface becomes oversaturated. The magnetic flux that could not penetrate the attractive surface flows into the non-magnetic body. The magnetic flux is hard to penetrate a non-magnetic body, but a small amount of magnetic flux can flow. The deeper the non-magnetic body gets, the more difficult the magnetic flux can penetrate the non-magnetic body. It is considered that a decrease in the attractive force is caused by the depth of a non-magnetic body.

Further analyses are necessary to optimize the magnetic circuit.

Conclusion

The influence of a non-magnetic body in the center of a shield disk and attractive surface of a keeper was analyzed and investigated using a three-dimensional finite element method, and the following results were obtained:

1. In the present analysis model, the optimal inner structure of a magnetic attachment was 0.15 mm radius of the non-magnetic body in the center of a shield disk and 0.5 mm radius of the non-magnetic body in the center of an attractive surface of a keeper.
2. The attractive force increased until the optimal inner structure value was reached, and decreased thereafter with an increase of the radius.
3. The influence of the depth of a non-magnetic body in the center of an attractive surface of a keeper was small until the radius reached the value where the maximum attractive force was achieved.
4. When the radius of a non-magnetic body in the center of a shield disk and attractive surface of a keeper exceeded the value where the maximum attractive force was achieved, the magnetic flux density on the attractive surface became oversaturated.

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The Relining Method of Removable Denture with Magnetic Attachments

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Abstract

In a magnetic attachment denture, relining material is interposed between a keeper and magnetic assembly. It creates air gap, which results in a decrease in attachment force of a denture. The purpose of the present study was to investigate the proper relining method of a magnetic attachment denture.

Three relining methods were performed: Direct relining methods were performed by removing and not removing a magnetic assembly. In the indirect method, a functional impression was taken using the denture base as a tray. The denture was relieved and relined in the dental laboratory.

Selection criteria of direct and indirect relining method were different between resin-bonded and cement-bonded magnetic assemblies in the denture base. The level of difficulty in relining was different depending on the fitting condition and a size of a denture base, and the shape of keeper coping and metal denture base.

Further investigation is needed on the selection criteria for relining method of a magnetic attachment denture.

Introduction

If you use a denture for a long time, the denture will observe changes such as disharmonious occlusal relationships by attrition of artificial teeth, coloring and degradation of the denture base[1,2)]. In addition, incompatibility of the denture base is caused by changes in the jawbone through absorption of under floor mucosa, over time. The Japan Prosthodontic Society guidelines have been created for relining and rebase. With regards to these issues, we often encounter opportunities to treat relining based on the diagnosis of denture incompatibility at the clinical practice. The guidelines recommend the direct relining methods for mild denture nonconformity and the indirect method for more non-conforming cases. However, in a magnetic attachment denture, relining material is interposed between a keeper and magnetic assembly. It creates air gap, which results in a decrease in attachment force of a denture[3)]. The purpose of the present study was to investigate the proper relining method of a magnetic attachment denture.

Relining method

Three relining methods were performed for three different cases. In the first case, direct relining method was performed without removing a magnetic assembly. In the second case, a magnetic assembly was removed before direct relining, and was returned after relining. In the third case, indirect relining method was performed.

1. Direct relining method (without removing a magnetic assembly)

a. Case report

A patient was a 76-year-old female who presented to a clinic with a chief complaint of a discomfort in the upper left area. She was diagnosed with mastication disorder due to rampant caries and marginal periodontitis. The upper left canine and second premolar were extracted due to dental root fracture. Although secondary caries and bone resorption were observed in the upper left first molar, a root cap with a keeper was placed. An immediate overdenture was fabricated in the missing area. Fig. 1 shows the denture design.

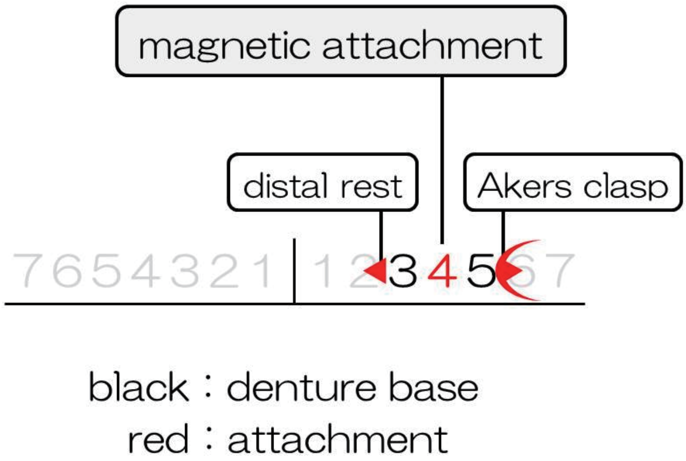

Fig. 1 the denture design

The upper left canine and second premolar were extracted, and an immediate denture was placed on the same day. Figures. 2-a and b show an intraoral image 7 months after the extraction and immediate denture placement. Figures. 2- c and d show the results of fitting test of the denture base using Fit Checker (GC, Japan).

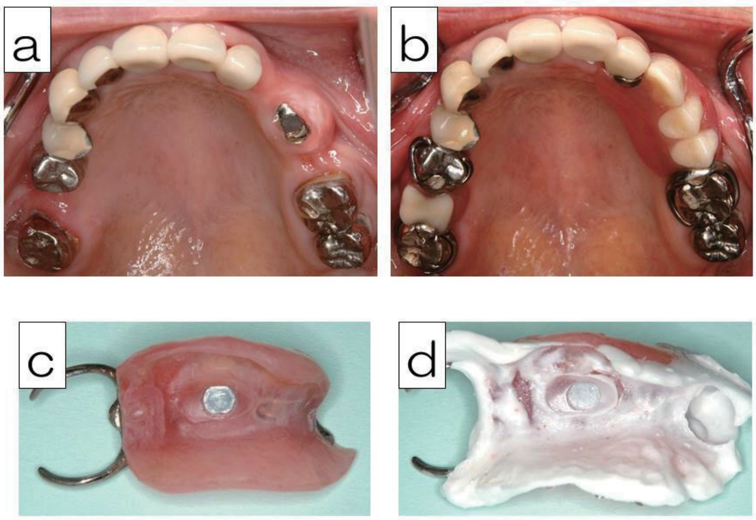

Fig. 2 the intraoral image and fitting test

There was an ill-fitting area in the denture base of the upper left canine and second premolar area. There was no problem in occlusal relationship.

In the present case, the denture base was small, and it was considered that appropriate relining material thickness could be obtained by supporting effect of a root cap and a rest. Therefore, direct relining method was performed without removing a magnetic assembly.

b. Treatment and Prognosis

Spillways were made in two locations around a magnetic assembly as a pretreatment (Fig. 3-a). The mucosal surface of the denture was slightly ground to create space for relining material (Fig. 3-b). Relining process was performed using an easy-to-handle light-cured denture base relining material (MILD REBARON LC., GC, Japan) (Figures. 3-c and d).

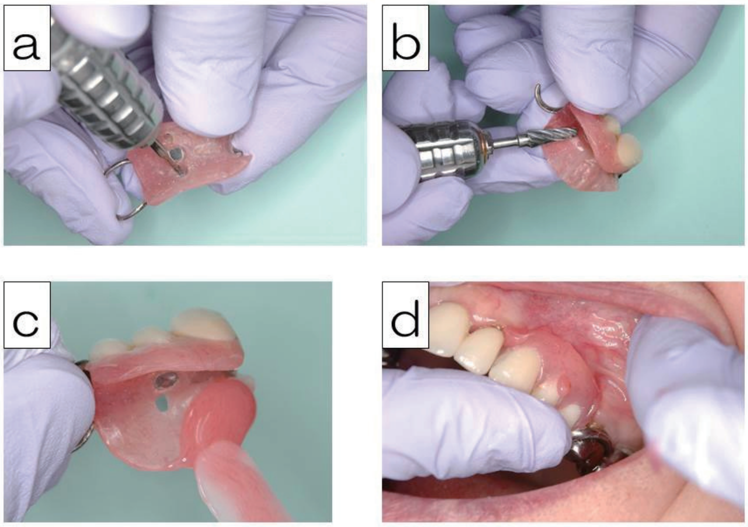

Fig. 3 processes of relining a denture material

It was confirmed that the denture was restored to the original place, and that relining material was pushed out from the spillways. Then, morphology modification and polishing of the denture were performed. Fig. 4 shows post-treatment denture and fitting test result. The fit of a denture was improved without changing retention force, and prognosis was uneventful.

Fig. 4 end of relining a denture material

2. Direct method (removing a magnetic assembly)

a. Case report

A patient was a 69-year-old female who has been using a lower magnetic attachment denture for approximately 6 years. A denture was a complete magnetic overdenture. Keepers were fixed in the root caps of the lower bilateral canines. Fig. 5 shows the denture design.

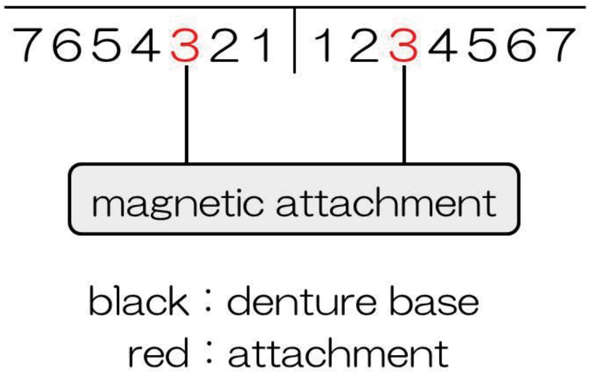

Fig. 5 the denture design

Regular check-ups had been conducted since the placement of a denture, and prognosis had been uneventful. However, the patient complained of food impaction on the mucosal surface of the denture at the regular check-up 6 years after the denture placement. Fitting test of the denture base showed ill-fitting area in the left molar area. There was no problem in occlusal relationship. Figures. 6-a and b show an intraoral image. Figures. 6-c and d show the result of fitting test of the denture base using Fit Checker.

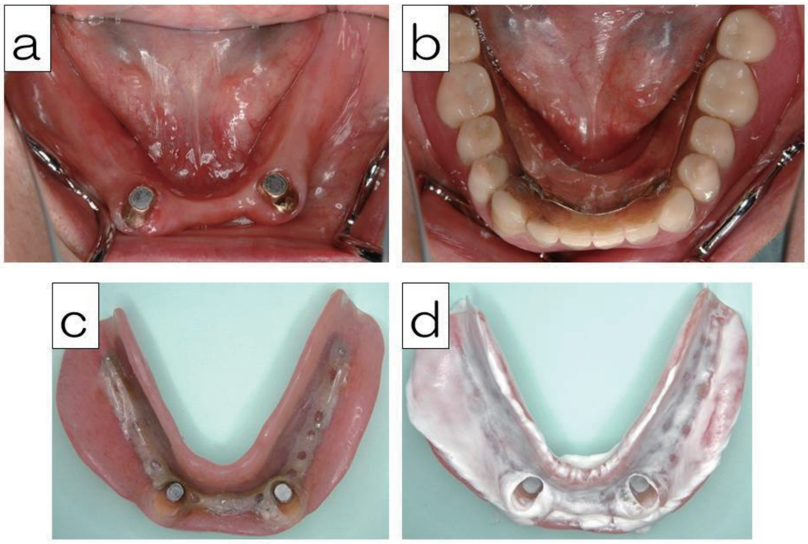

Fig. 6 the intraoral image and fitting test

A magnetic assembly was attached using autopolymer resin, and was removable. Therefore, a magnetic assembly was removed, and direct relining was performed.

b. Treatment and Prognosis

Figures. 7-a and b show the process of removing resin around a magnetic assembly as pretreatment to remove magnetic assembly. Careful attention was paid to minimize the grinding amount and not to damage a magnetic assembly. Figures. 7-c and d show the process of grinding a mucosal surface of a denture base and forming spillways.

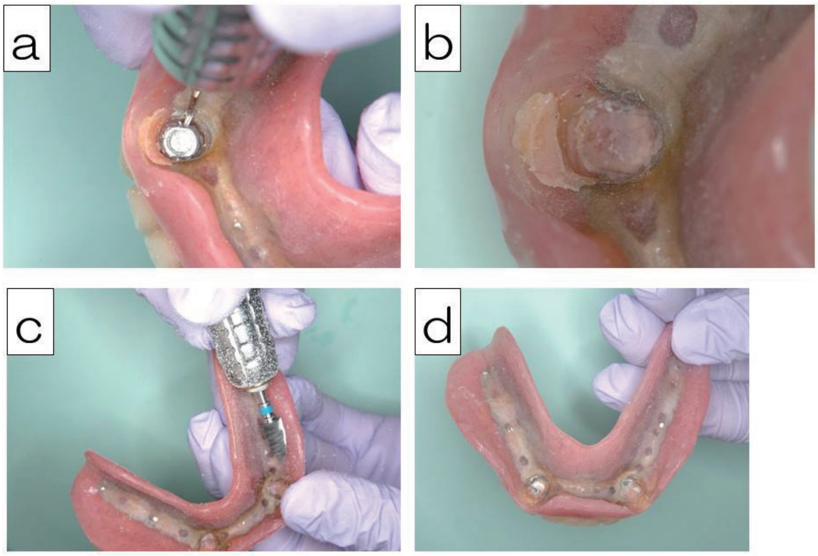

Fig. 7 processes of relining a denture material

Silicone impression material (EXAFINE, regular, GC, Japan) was used for impression taking, and the impression was trimmed. Relining was performed using a autopolymer denture base hard relining material (REBASE II, Tokuyama Dental) according to the manufacturer's instruction (Figures. 8-a, b, c, and d).

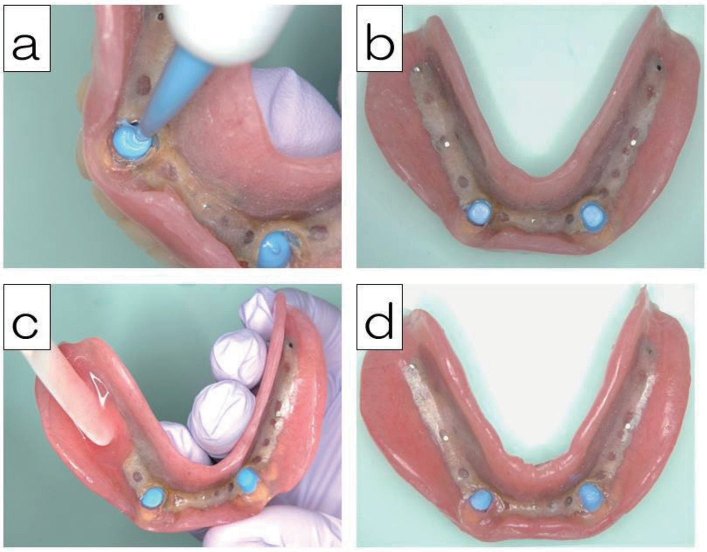

Fig. 8 processes of relining a denture material

A magnetic assembly was reattached. After silicone impression material was removed, a magnetic assembly was sandblasted, and dental metal adhesive (Metal Primer II, GC, Japan) was applied (Figures. 9-a and b). Undercut around a root cap with a keeper was confirmed, and Vaseline was applied. Autopolymer resin (UNIFAST III, GC, Japan) was used to attach a magnetic assembly to the denture according to the conventional method (Figures. 9-c and d).

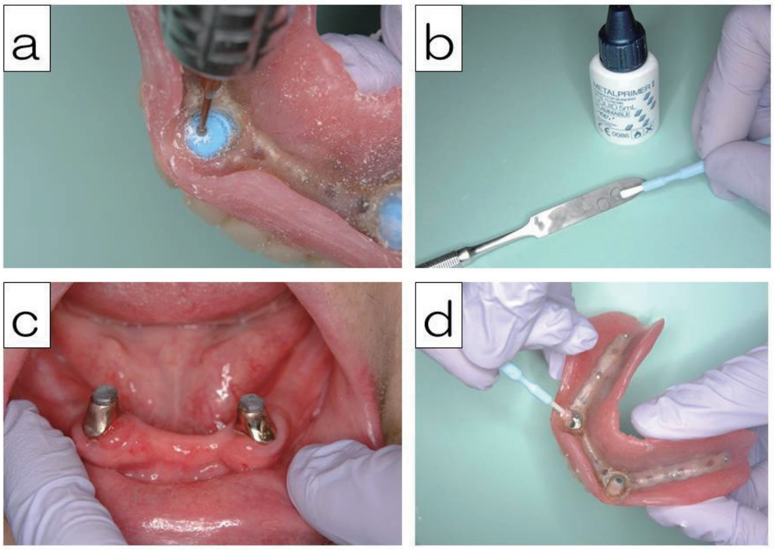

Fig. 9 processes of relining a denture material

Undercut is often observed in the subgingival area around the root cap with a keeper in relining cases. Therefore, careful attention is needed. Morphology modification and polishing of the denture were performed. Fig. 10 shows post-treatment denture and fitting test result. The fit of a denture was improved without changing retention force, and prognosis at 3 months was uneventful.

Fig. 10 end of relining a denture material

3. Indirect method

a. Case report

A patient was a 71-year-old female who has been using an upper magnetic denture for approximately 5 years. A denture was a complete overdenture with magnetic telescopes in the upper right canine and first premolar areas. Fig. 11 shows the denture design.

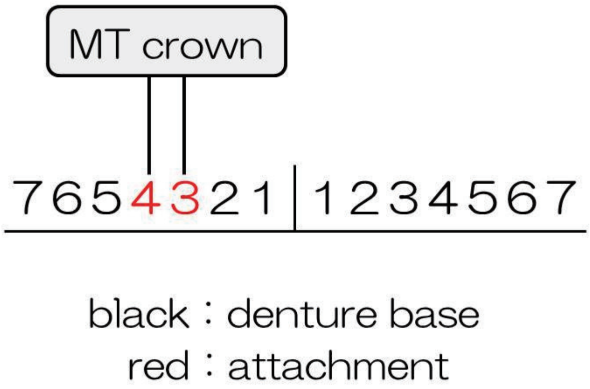

Fig. 11 the denture design

Regular check-ups had been conducted after denture placement, and prognosis had been uneventful. However, the patient complained of loose denture at check-up 5 years after denture placement. Fitting test of the denture base showed an ill-fitting denture base in the right molar area (Figures. 12-a and b). Figures. 12-c and d show the result of denture base fitting test using Fit Checker.

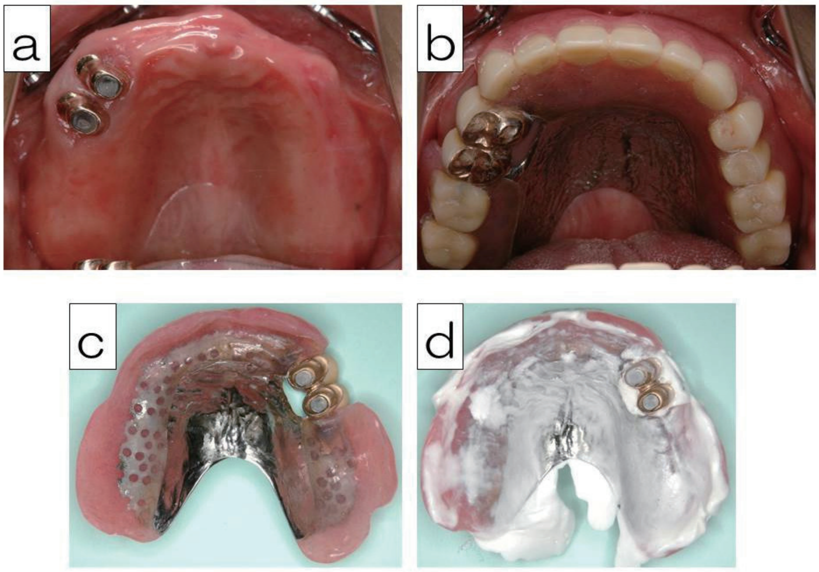

Fig. 12 the intraoral image and fitting test

There was no problem in occlusal relationship.

A magnetic assembly was cemented to the denture in the present case, and was unable to be detached. Therefore, indirect relining was performed. Although the fitting test also showed a slight lack of fit in the metal base, relining was performed only in the resin base considering advantages of metal base would be lost by relining materials.

b. Treatment and Prognosis

Functional impression was performed with wax using a denture as a tray. The mucosal surface and margin of the denture base were ground as a pretreatment (Fig. 13-a). The purposes of the pretreatment were to create the space for impression material and to remove undercuts before model fabrication. Spillways were created in the finish line to clearly identify the border between resin and metal (Fig. 13-b). Fit Checker was used to check if there is an appropriate space for impression material before impression taking.

Functional impression was performed with wax impression material (KORECTA WAX#4 ORANGE EXTRA SOFT, D-R Miner Dental., Japan). Impression taking with other impression materials such as silicone impression material may cause uplift of a denture due to a leakage of impression material into the metal base. Marginal formation was required since a denture base margin was ground as a pretreatment. Therefore, wax impression material was used in the present study. The process of functional impression taking is shown in Figures. 13-c and d.

After functional impression taking, wax and mucosal surface were settled in the mouth for approximately 10 minutes. The patient was then instructed to hold cold water in the mouth to prevent wax deformation.

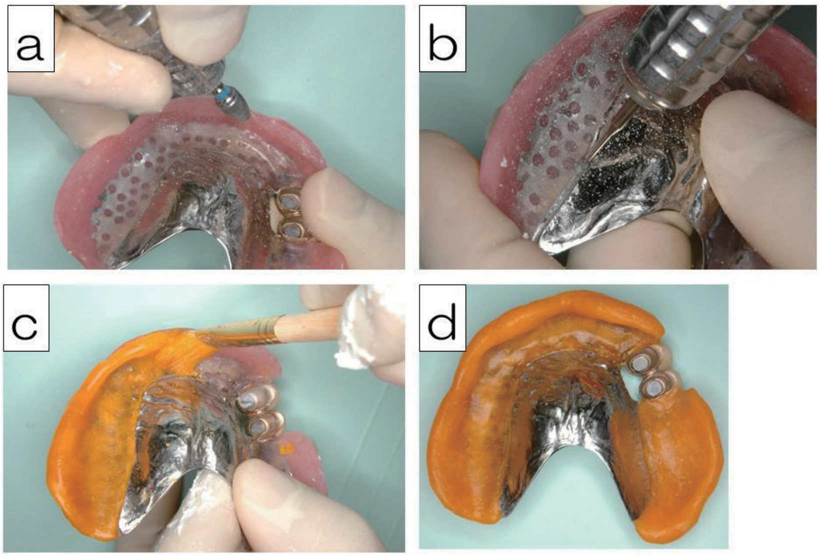

Fig. 13 processes of relining a denture material

Relining was performed in the dental laboratory. The denture was retrieved to fabricate the model in the laboratory. The model was mounted on the articulator to check occlusion before and after relining (Fig. 14-a). Margin was smoothly finished on the model to use pour-type resin, and a wax spruce was placed. Impression was taken using silicone putty (Fig. 14-b). Wax was then removed, and denture base acrylic resin (PROCAST DSP, GC, Japan) was packed. The model was remounted on the articulator, and confirmed that there is no uplift of a denture. The process was shown in Figures. 14-c and d.

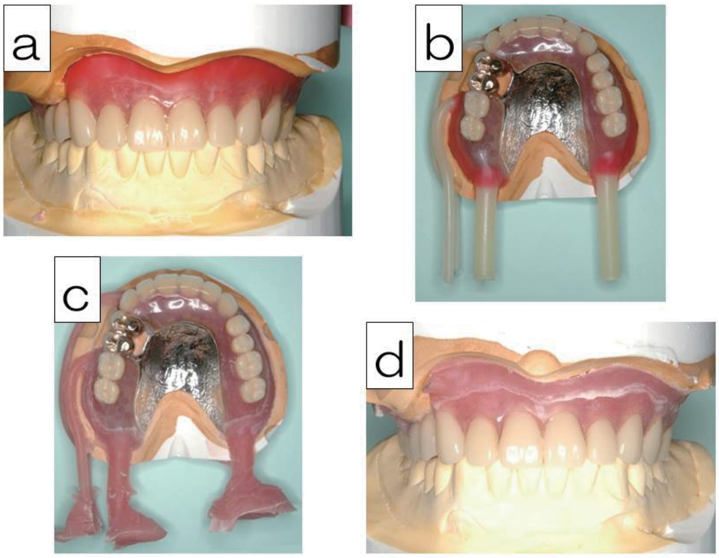

Fig. 14 processes of relining a denture material

Then, morphology modification and polishing of the denture were performed. Fig. 15 shows post-treatment denture and fitting test result.

The fit of a denture was improved without changing retention force, and the prognosis after 3 months was uneventful.

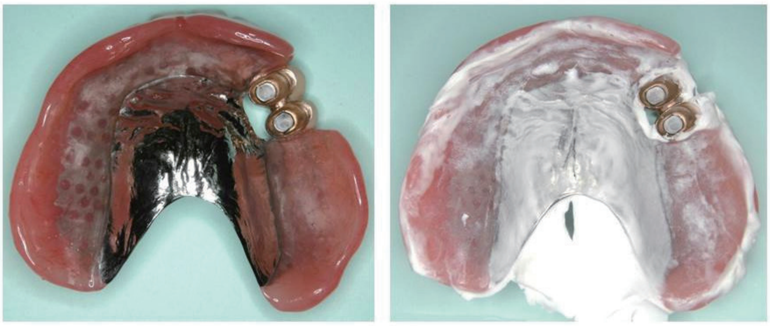

Fig. 15 end of relining a denture material

Conclusion

The present study reported 3 types of relining methods. It is important to choose relining method of the magnetic attachment denture depending on the case. Procedures are significantly different between a denture with a removable magnetic assembly and non-removable magnetic assembly. When a magnetic assembly is attached with resin, it is removable, and, there is a choice between direct and indirect relining methods. In contrast, when a magnetic assembly is cemented, it is not removable, and indirect method is recommended. Not only removability of a magnetic assembly but also a degree of ill-fitting of a denture, denture base material and size, the shape of root cap with a keeper, and the number of magnetic assemblies should be considered.

Further investigation is needed to objectively and quantitatively evaluate a change in retention force of a denture before and after relining, and to set the criteria for relining method selection.

References

1. Y. Tanaka . Dental Magnetic Attachment Q&A, Ishiyaku Publishers Inc, Tokyo, 126-127, 1995.
2. Y. Akagawa, Y. Igarashi, T. Ichikawa, S. Ohkawa, S. Kohno, K. Koyano. et al. Prosthetic Treatment for Edentulous Patients, Ishiyaku Publishers Inc, Tokyo, 236-244, 2004.
3. Y. Nakamura. Stress Analysis of an Overlay Denture and a Magnetic Attachment using Finite Element Method. Journal of Prosthodontics, 1998 ; 42 : 234-245.

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