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The Japanese Society of Magnetic applications in Dentistry

The 12th International Conference on Magnetic Applications in Dentistry

The 12th International Conference on The Japanese Society of Magnetic Applications in Dentistry organized by JSMAD was held on the Internet as follows;

Meeting Dates:

March 4 to March 22, 2013

Location:

JSMAD web site

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

General Chair:

Prof. Tetsuo Ichikawa, The University of Tokushima

Conference Secretariat:

Dr. Kan Nagao, The University of Tokushima

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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Department of Restorative and Biomaterials Sciences,
Meikai University School of Dentistry
1-1 Keyakidai, Sakado, Saitama 350-0283 JAPAN

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The 13th 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 13 th International Conference on Magnetic Applications in Dentistry organized by JSMAD will take place on the Internet as follows.

Meeting Dates:

Monday, March 3 to Friday, March 21, 2014

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

General 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 13th 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 8,000 yen per page. (No charge for invited paper.)

Guidelines for Presentation

Deadlines:

Entry: February 3, 2014
Poster submission: February 28, 2014

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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Notice to Contributors:

Freely-given informed consent from the subjects or patients must be obtained. Waivers must be obtained for photographs showing persons.

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Hideki Aita, Health Science University of Hokkaido
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Session 4 ***Chair: Shogo Ozawa (Aichi Gakuin University)***

Appendix

Full mouth prosthetic case applying magnetic attachments in various shapes

Y. Nakamura, R. Kanbara, K. Shoji, M. Sakane, H. Konno, Y. Takada[1], S. Tanaka, Yu. Ohno and Y. Tanaka

Department of Removable Prosthodontics, School of Dentistry, Aichi-Gakuin University
[1] Division of Dental Biomaterials, Tohoku University Graduate School of Dentistry

Introduction

The patient was a 83-year-old female who lost her bilateral molar occlusion due to the bilateral upper free-end and multiple tooth loss. A X-ray image showed alveolar bone resorption due to advanced periodontal disease, malalignment, and the collapse of the occlusal plane. Stress-bearing ability and preservability of the upper and lower remaining teeth were examined, followed by a thorough consultation with a patient regarding the esthetic recovery based on the diagnostic wax-up. Provisional restoration was placed in the upper jaw to correct the occlusal plane and tooth alignment. The crowns of the lower remaining teeth were truncated, and treatment overdenture was placed. The patient was followed for several months, and final restoration was placed after confirming that there are no functional and esthetic problems. For the design of the final restoration, radicular attachments using magnetic attachment and MT crowns were chosen in the lower jaw, and porcelain-fused-to-metal crown and extracoronal magnetic attachment were chosen in the upper jaw.

The patient is satisfied with functional and esthetic results. Postoperative prognosis at 3 years and a half after the placement of new dentures is satisfactory.

Initial Situation

Fig. 1 shows the intraoral image at first visit. The patient was not using the lower denture due to poor fitting of a denture. Bilateral occlusal support was lost, and malalignment of anterior teeth due to advanced periodontal disease and the collapse of the occlusal plane were observed.

Fig. 1 The intraoral image at first visit

Fig. 2 shows a panoramic X-ray at first visit. Problems were extracted from the oral examination and X-ray image. Problems included mandibular alveolar bone resorption, the collapse of the upper and lower occlusal plane, poor prosthesis, poor root canal filling and remaining teeth.

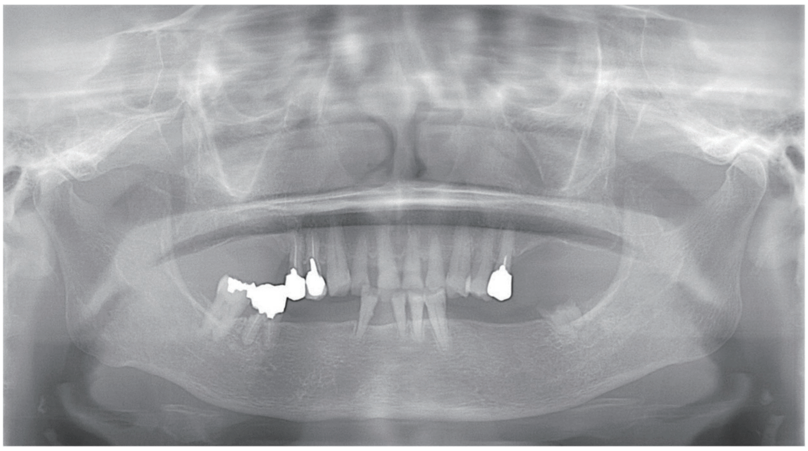

Fig. 2 Panoramic X-ray at first visit

Treatment Procedure

1. Exploration

1) Mandibular

Fig. 3 shows dental X-rays of the lower remaining teeth. Severe alveolar resorption in the anterior area, poor prosthesis in the right molar area, and the remaining teeth in the left molar area were observed in the mandible (Fig. 3). Treatment plans in the mandible were root canal treatment in the remaining teeth, followed by an overdenture for all the remaining teeth to improve the crown-root ratio.

2) Maxilla

Fig. 4 shows the frontal and occlusal views of the maxillary arch. The dental axis collapse and space were observed in the arch, and disharmony of the dental arch was observed in the occlusal view (Fig. 4). Treatment plans in the maxilla were prosthetic restoration of the remaining teeth for esthetic and functional recovery, and denture in the bilateral missing molar areas.

3) WAX-UP for exploration

A study model was mounted on an articulator using a face bow transfer (Fig. 5). For the maxillary dental arch, ideal dental arch and shape were fabricated using dental wax to use as a guide of final restoration for esthetic recovery. For the mandibular dental arch, prosthetic restoration of the lower right first and second molars and overdenture were simulated. Lower teeth were aligned to harmonize with upper teeth. The diagnostic wax-up is performed to examine if the present occlusal height is proper for the prosthetic treatment, and is used as an explanatory material.

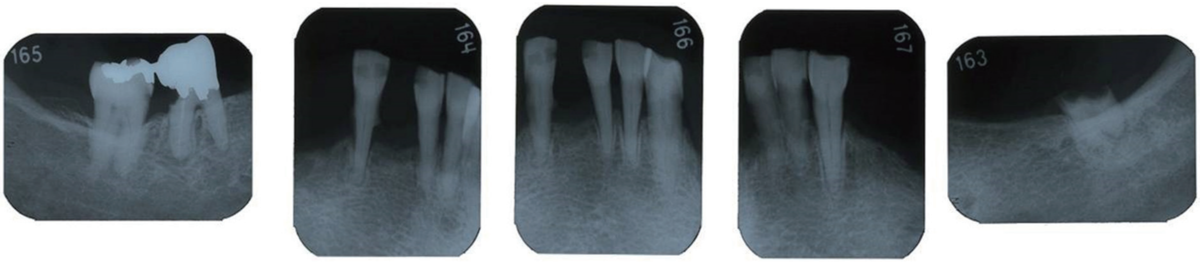

Fig. 3 Dental X-rays of the lower remaining teeth

Fig. 4 The frontal and occlusal views of the maxillary arch

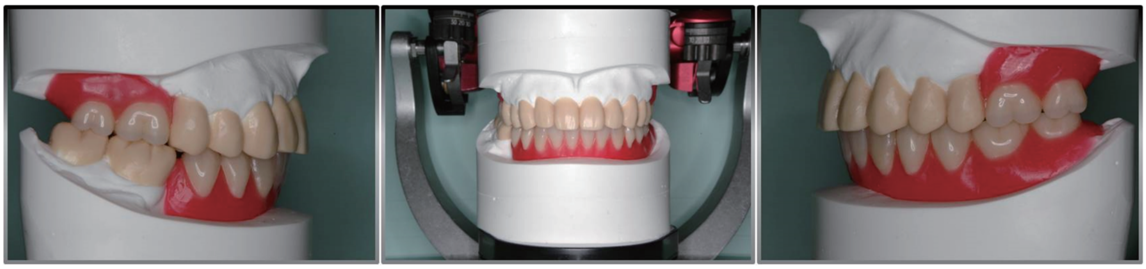

Fig. 5 WAX-UP for exploration

2. The Designs of Final Restoration

The designs of upper and lower restorations were determined based on the oral examination, X-ray image, and diagnostic wax-up. The designs of the mandibular restorations included radicular-type magnetic attachments in the lower anterior area between the right lateral incisor and the left canine, and attachment denture using MT crowns in the well-preserved lower right second molar (Fig. 6).

The upper prosthesis was also designed based on the oral examination, X-ray image, and diagnostic wax-up. The condition of the upper remaining teeth was fair without mobility. An extracoronal magnetic attachment was placed on the bilateral upper second premolars, and esthetic attachment denture without a clasp was placed on the bilateral molars. Three abutment teeth up to the canine were joined using porcelain-fused-to-metal crown (Fig. 7).

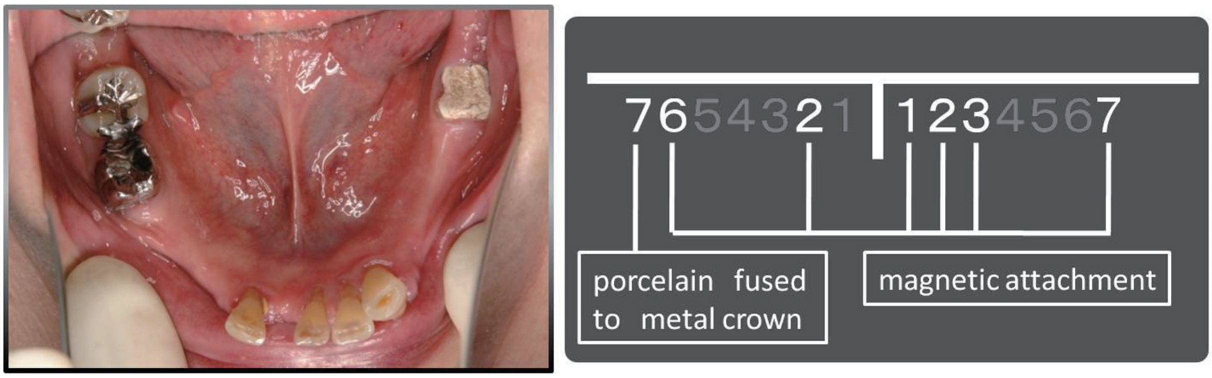

Fig. 6 The designs of lower restorations

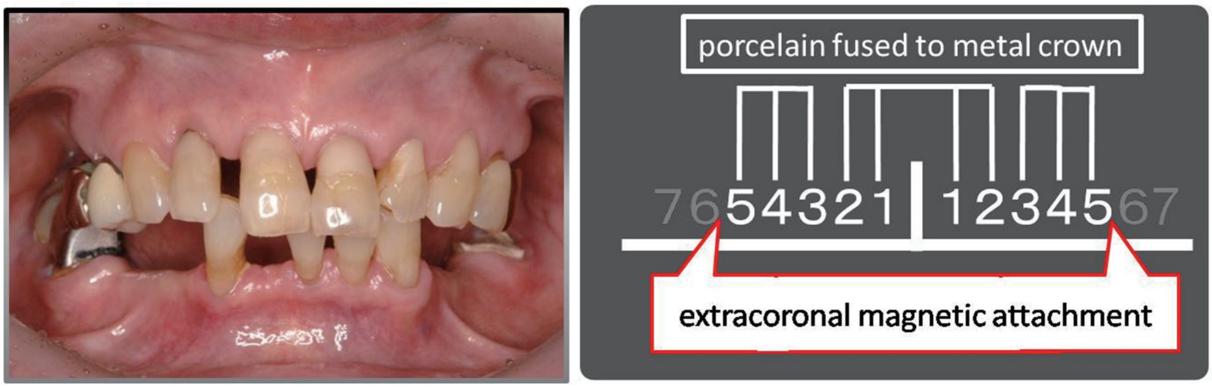

Fig. 7 The designs of upper restorations

3. Treatment Process (maxilla)

1) Temporary restoration

A temporary crown was placed to secure masticatory function, pronunciation, and esthetics (Fig. 8), and to facilitate initial periodontal and root canal treatment.

Fig. 8 Temporary restoration wearing

2) Change of the designs of maxilla prosthetic appliance

Root fracture of the upper left second premolar was confirmed during root canal treatment during initial treatment using temporary crown. Although the patient was followed for a certain period of time, the tooth extraction was indicated due to the lingering symptoms such as spontaneous pain. The maxillary restoration design was threofore altered to place an extracoronal magnetic attachment on the left first premolar instead of the second premolar. The canine and the first premolar were joined considering the condition of the periodontal tissue (Fig. 9).

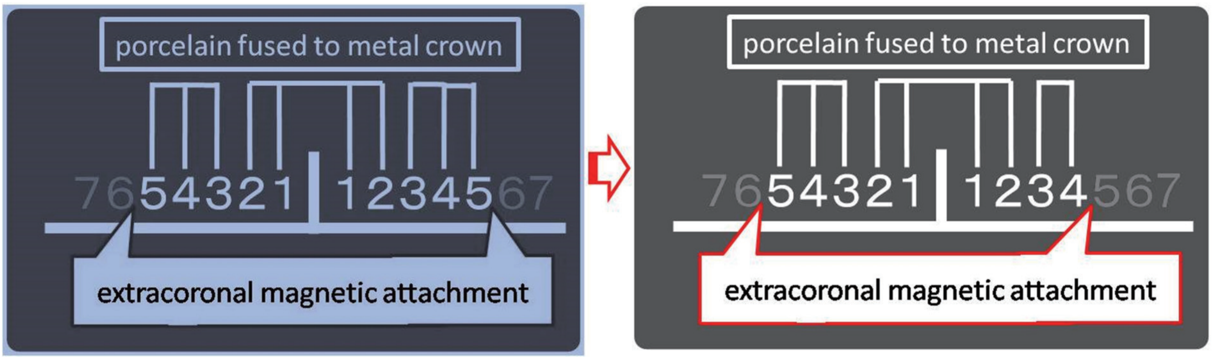

Fig. 9 Change of the designs of maxilla prosthetic appliance

3) Provisional restoration

A provisional restoration esthetically and functionally improved from a temporary crown was fabricated based on the diagnostic wax-up after the initial periodontal and root canal treatments, and placed.

4. Treatment Process (mandibular)

1) Root canal treatment and Keeper caps and MT-crown inner crown wearing

Fig. 10 shows an intraoral image and panoramic X-ray at the completion of the root canal treatment. A keeper caps and MT inner crown were placed according to the treatment plan and prosthetic design (Fig. 11).

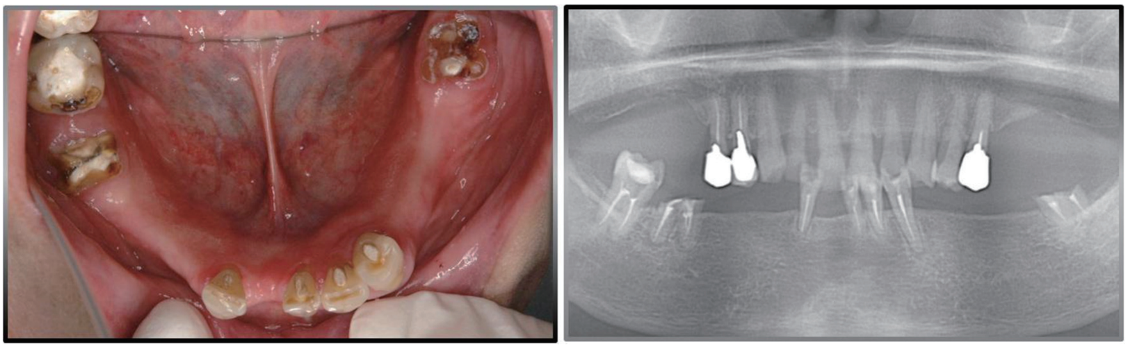

Fig. 10 Intraoral image and panoramic X-ray at the completion of the root canal treatment

Fig. 11 Keeper caps and MT inner crown wearing

5. Final Provisional Restoration and Treatment Denture wearing

Fig. 12 shows an intraoral image with upper final provisional restoration and upper and lower treatment dentures. Final provisional restoration was fabricated by making functional and morphological alterations of the previous provisional restoration. The occlusal plane, upper dental arch, and incisal overjet were improved compared with the initial visit (Fig. 12). The patient was followed for several months with the final provisional restoration. Since there was no problem in occlusal height and temporomandibular joint, final restoration was placed.

Fig. 12 Intraoral image with upper final provisional restoration and upper and lower treatment dentures

6. The Procedure of Final Restoration

1) *Bite taking*

Fig. 13 shows the bite taking of the final restoration. Bite taking was performed using a bite plate based on the occlusal height of the treatment denture. Occlusal height with upper provisional restoration was taken, followed by bite taking with the upper abutment teeth. For the bite taking between the abutment teeth and the bite plate, occlusal height between the obtained provisional restoration and bite plate was secured by an upper treatment denture, followed by the removal of provisional restorations in anterior teeth area and bite taking (Fig. 14). The upper denture was removed, and bite taking of the molar abutment teeth was performed using the same silicone bite (Fig. 15).

Since the bite plate was used for bite taking, obtained horizontal maxillomandibular relationship should be confirmed. Horizontal occlusal relationship was registered using Gothic arch to obtain horizontal jaw position according to the conventional method (Fig. 16).

Fig. 13 The bite taking of the final restoration

Fig. 14 Removing of provisional restorations in anterior teeth area and bite taking

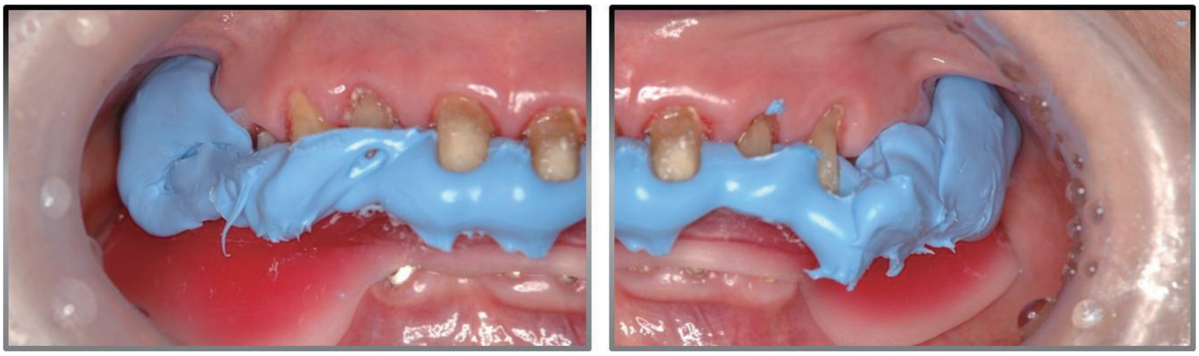

Fig. 15 Removing the upper denture and bite taking of the molar abutment teeth

Fig. 16 Using Gothic arch to obtain horizontal jaw

2） Try fitting

Fig. 17 shows the final restorations including upper and lower wax denture, upper porcelain-fused-to-metal crown, extracoronal magnetic attachment, and lower MT outer crown. These final restorations were tried in to verify occlusion and esthetics.

3） Final restoration

Fig. 18 shows upper and lower final dentures. The image on the left shows the occlusal view, and the right shows the mucosal surface of a denture base. The metal used for the metal base was gold platinum alloy.

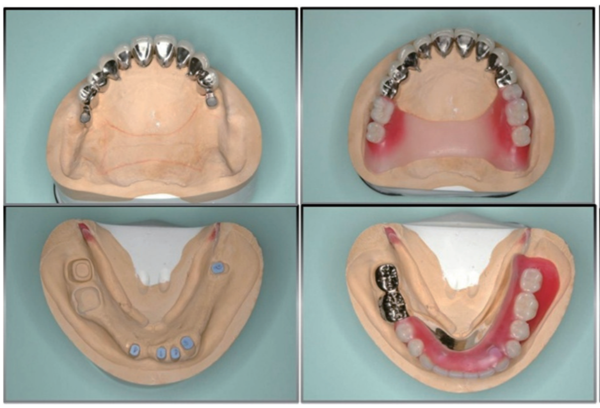

Fig. 17 Try fitting of the final restorations including upper and lower wax denture

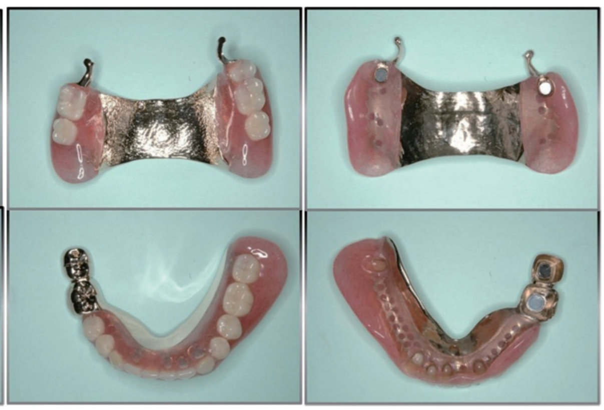

Fig. 18 Upper and lower final dentures

Discussions

Fig. 19 shows intraoral image of the patient with final restorations. The accurate intraoral position of a denture was determined by magnetic attachments. Magnetic attachments allowed easy placement and removal of a denture, and esthetics and function were markedly improved. The patient was satisfied with the results (Fig. 19).

Fig. 20 shows an intraoral image at 3 years after the placement of final restorations. Although mild redness in the gum around keeper caps and palatal indentation due to a denture were observed, the patient did not complain of pain, and there was no problem in masticatory function and esthetic appearance.

Fig. 21 shows the intraoral dental X-ray image of the first visit and present. Although the lower left second molar was hemisected, there was no clinical symptom in abutment teeth, and the prognosis was satisfactory. The results suggest the mechanical usefulness of magnetic attachments on abutment teeth. Although the designs of upper right second premolar and left first premolar with extracoronal magnetic attachments included cantilever structure, no alveolar resorption related to this design was observed. It is suggested that stress was distributed by the concomitant use of bracing arms and interlocks.

The results of the present study confirmed the effectiveness of magnetic attachments which can be applied in various shapes such as extracoronal attachment, MT crown, and root cap attachment depending on the clinical situations.

Regular follow-up and oral care by specialists will be continued for a favorable prognosis.

Fig. 19 Intraoral image of the patient with final restorations

Fig. 20 Intraoral image at 3 years after the placement of final restorations

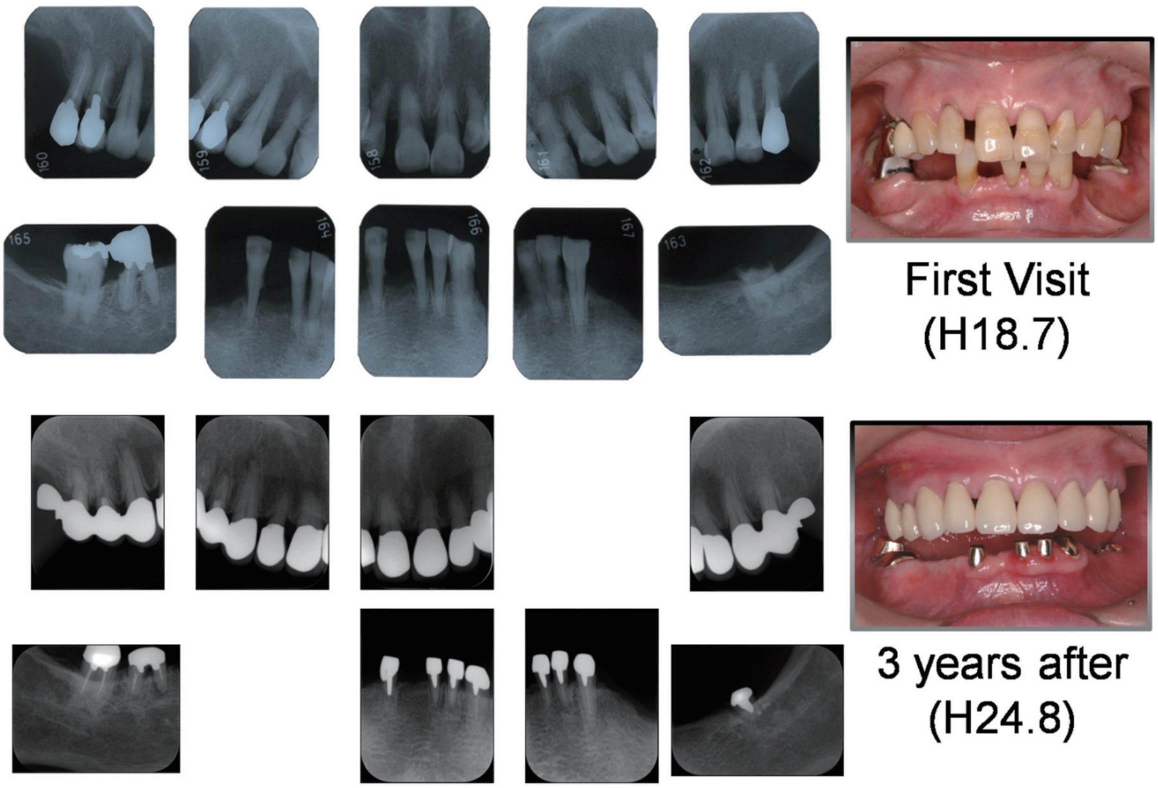

Fig. 21 The intraoral dental X-ray image of the first visit and present

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Long-term follow-up case reports on the use of magnetic attachment as intracoronal/extracoronal attachments

T. Goto, Y. Ishida, K. Nagao and T. Ichikawa

Department of Oral & Maxillofacial Prosthodontics, Institute of Health Biosciences, The University of Tokushima Graduate School

Introduction

In recent years, magnetic attachments have been applied to removable prostheses, such as bar attachments,intracoronal and extracoronal attachments. In this clinical report, three long-term follow-up cases of removable dentures using magnetic attachments are presented.

Case 1

The patient, a 79-year-old woman, was referred to the clinic with complaints of masticatory dysfunction and poor aesthetics caused by missing teeth. The missing teeth were 11–13, 15, 16, 21–23, 26 and 35–36. In this case, a removable bridge with intracoronal magnetic attachments at 17, 14, 24, 25 and 27 for the upper side and removable dentures for the lower side were applied. The patient was satisfied with these dentures. About three years later, 27 was extracted due to periodontal reasons, and then the removable bridge was repaired with the denture base at 26 and 27 (Fig.1-a). Twelve years later, the patient complained of pain at 14, and the denture base at the palatal region (Fig.1-b) was then placed to the removable bridge to increase the supporting zone (Fig.2).

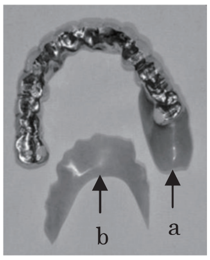

Fig.1 Removable bridge for the upper side
(a: Denture base at 26 and 27, b: Denture base at the palatal region)

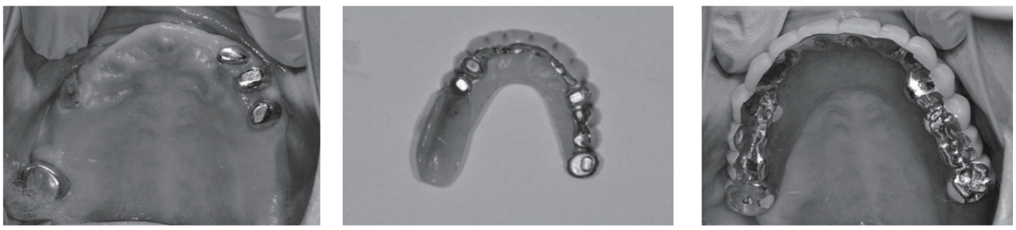

Fig.2 Views of the intraoral and removable bridge (left: Intraoral view without bridge, center: Removable bridge after repair, right: Intraoral view with bridge)

The patient has been recalled for fourteen years for scaling and checking the fit of the denture base. In this case with the magnetic attachment, when the abutment teeth were lost, the concept of increasing the supporting zone for the occlusal force was confirmed.

Case 2

This patient, an 81-year-old woman, complained of poor aesthetics of the lower denture and instability of the upper denture. The missing teeth were 11–16, 21–27, 35–37, 42 and 45–47. In this case, the removable partial denture with an extracoronal magnetic attachment at 34 and 44 for the lower side and removable dentures for the upper side were applied. Regarding mechanical stress in the extracoronal magnetic attachment, the remaining teeth of 31–34, 41, 43 and 44 were connected with a fixed bridge before the removable partial denture was set (Fig.3). Reasonable space was allocated between the extracoronal magnetic attachment and the residual ridge mucosa for easy cleaning by the patient. The patient regained masticatory function andpleasing aesthetics with these dentures (Fig.4).

Fig.3 Fixed bridge at the anterior region and the partial denture for the lower side

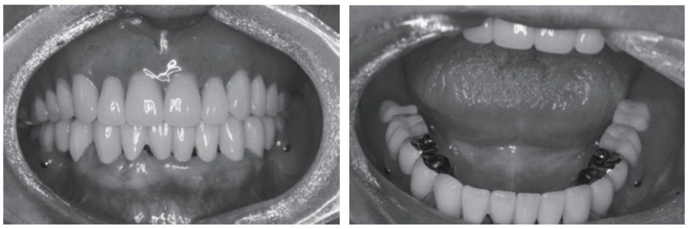

Fig.4 Oral view with removable dentures
(left: Frontal view with dentures, right: Intraoral view with dentures)

After about fifteen years, the removable denture for the upper side was refabricated with a titanium cast plate denture. This patient has undergoneclinical maintenance with scaling and occlusal adjustment for more than fifteen years (Fig.5). In such a case, with an extracoronal magnetic attachment, the mechanical problems with the cantilever effect of the extracoronal attachment and hygiene under the attachment should be considered. In this case, these problems were addressed with the fixed bridge at the anterior region and the appropriate morphology of the extracoronal attachment.

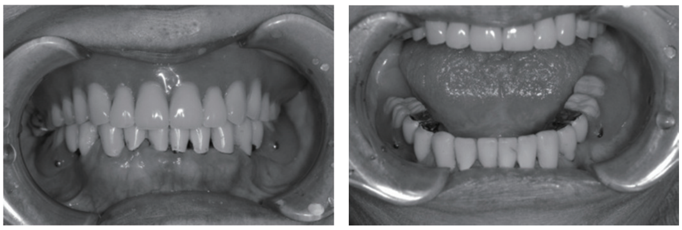

Fig.5 Oral view with removable dentures after about fifteen years
(left: Frontal view with dentures, right: Intraoral view with dentures)

Case 3

This patient, a 50-year-old man, complained of masticatory dysfunction caused by missing teeth. The missing teeth were 46 and 47. A removable bridge with extracoronal magnetic attachment at 45 and intracoronal magnetic attachment at 48 was applied to this patient. Reasonable space was allocated under the extracoronal magnetic attachment for easy cleaning as inCase 2. An extracoronal magnetic attachment was applied for reasons of poor aesthetics in the clasps and vital tooth 45 (Fig.6). This patient has been scheduled for occlusal adjustment and checking the fit ofthe removable prostheses for nine years (Fig.7). Comfortable mastication and good periodontal condition have been observed.

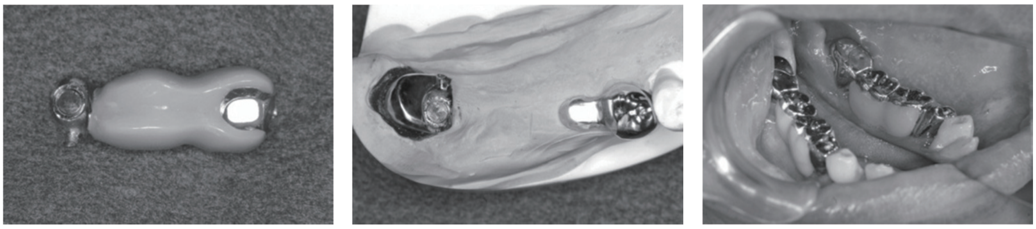

Fig.6 View of the removable bridge and keepers in a working cast at 45 and 48
(left: Bottom view of the removable bridge, center: Keepers in the abutment teeth, right: Oral view with removable dentures)

Fig.7 Oral view with removable dentures after nine years

Conclusions

To conclude, treatment with magnetic attachments applied for intracoronal and extracoronal attachments was a reliable plan. However, careful periodic examination and occlusal adjustment are essential for better long-term prognoses.

A Case Report of a Magnetic Attachment Denture by Use of an Immediate Denture to Maintain the Optimum Mandibular Position

M. Sone, F. Okutsu, T. Kusano, T. Matsukawa, Y. Toyota, R. Negoro, S. Yorichika,
A. Matsui, Y. Kawakami, S. Shimokawara, K. Okamoto and S. Ohkawa

Division of Removable Prosthodontics, Department of Restorative and Biomaterials Sciences,
Meikai University School of Dentistry

Introduction

To reconstruct a harmonious craniofacial system, it is essential to maintain an appropriate occlusal vertical dimension(OVD). This clinical report describes the use of a magnetic attachment denture that improved an immediate denture to maintain appropriate OVD and the optimum mandibular position.

Clinical History

The patient, a 63-year-old female, complained of masticatory dysfunction. The patient had received a maxillary fixed bridge from tooth #3 to tooth #11 in 1989, but the restoration failed, having a marginal discrepancy and damage by caries (Fig.1). We did not diagnose intraocclusion by analysis of OVD. Finally, we suggested that a removable maxillary overlay denture with a coping type of magnetic attachment as a definitive prosthesis by use of an immediate denture to maintain the optimum mandibular position was fabricated, which the patient found acceptable.

Fig.1 Intraoral view at the initial examination

Treatment Procedure

As the first therapy, the incompatible fixed bridge in a marginal portion was removed, and tooth #3 was extracted. Then an immediate maxillary denture was set on the portion of the missing teeth. With the immediate denture, the patient obtained an adequate occlusal relationship and maintained the optimum mandibular position (Fig.2).

Fig.2 Intraoral view with immediate denture

As a definitive prosthesis, the reinforcement structure of the framework for preventing denture base fracture was made to cover about three quarters of the circumference of the magnetic attachment, and protrusion of the labial side was avoided (Fig.3). The magnetic attachment in this case report was supplied by GIGAUSS C600® (GC, Japan) and applied to tooth #6. The keeper of the magnetic attachment and magnetic assembly were fixed with adhesive resin cement (Multilink® Automix, Ivoclar Vivadent, Liechtenstein) (Fig.4).

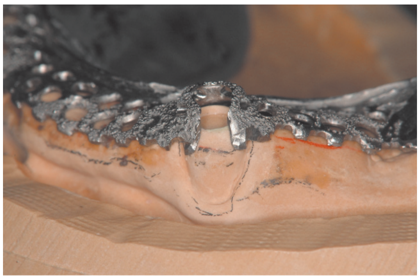

Fig.3 Reinforcement structure of framework

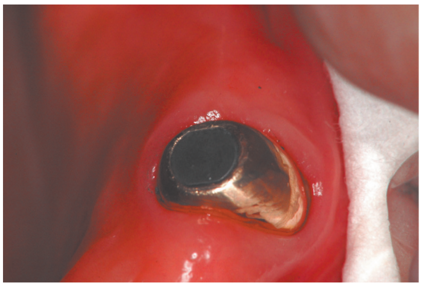

Fig.4 Keeper of the magnetic attachment

A removable maxillary overlay denture was fabricated and included a coping type of magnetic attachment, wire clasps, and a horseshoe plate as the major connector. This denture was fabricated with the existing occlusal height and the optimum mandibular position (Fig.5). Figure 6 is an intraoral view of the definitive prostheses.

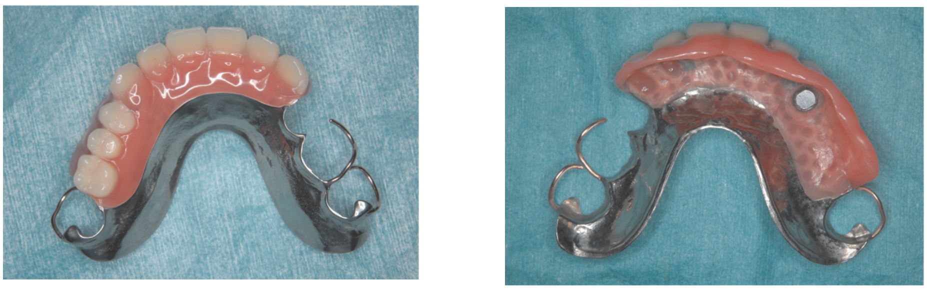

Fig.5 Removable maxillary overlay denture

Fig.6 Intraoral view with definitive prostheses

Conclusions

A removable overlay denture with a magnetic attachment was provided to maintain an OVD. The patient was satisfied and had comfortable mastication. It is difficult to maintain ideal hygiene and functionality because the design of a final prosthesis is complex. Therefore, continuous follow-up is necessary for occlusal adjustment and relining of the denture base to prevent reduction of the OVD. In addition, periodontal management and forced control of the remaining dentition should be evaluated during the maintenance program.

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Retentive forces and vertical displacements of stress breaking attachments for implant over dentures

D. Ozawa, Y. Suzuki[1], H. Osada, K. Kono and C. Ohkubo

Department of Removable Prosthodontics, Tsurumi University School of Dental Medicine.

[1]Division of Oral and Maxillofacial Implantlogy, Tsurumi University School of Dental Medicine.

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 excusion, but cannot compensate for vertical displacement under the 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 excusion are also applied to the implants depending on the occlusal contact, location, and numbers of implants in the dental arch. Therefore, excessive and harmful occlusal forces are applied to the 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

Four types of stress-breaking attachments (Fig.1), namely, a self-adjustment type magnet attachment (Magfit SX, Aichi Steel), a cushion type magnet attachment (Magfit IPS, Aichi steel), a locator attachment(Locator, ZEST anchors), and three types of Stress-Breaking Ball (SBB) attachments (amount of displacement:0.3mm, 0.5mm, 0.7mm,GC corp.), were placed on the implants. The implants were embedded in a resin block using autopolymerized resin (Fig.2). To simulate the chewing cycles, a load of 5 kgf was repeatedly applied up to 50,000 using a loading apparatus (Fig.3). 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 1-way ANOVA followed by the Tukey’s test at a significance level of $\alpha=0.05$. The contact surface of attachment female were examined using a microscope (SZX, OLYMPUS).

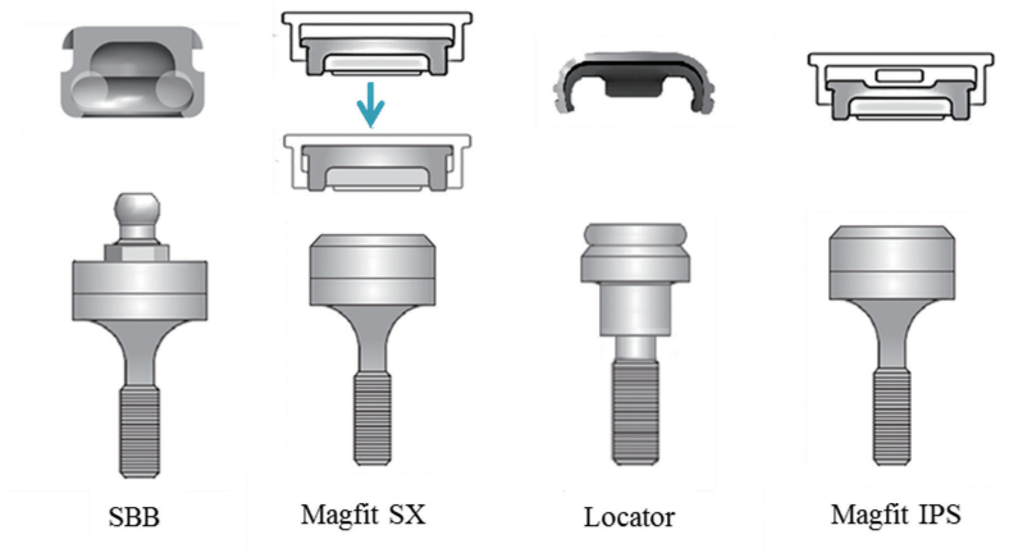


Fig. 1 Schema of stress breaking attachment

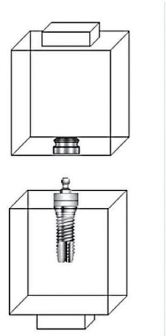


Fig. 2 Schematic drawing of Specimens

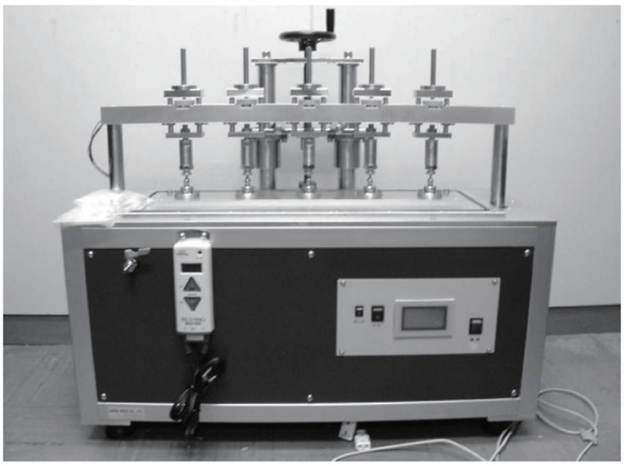


Fig. 3 Cyclic loading testing machine for tensile test

Results

The initial retentive force of the locater attachment was significantly greater than that of any other attachments 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 of the retentive forces of both magnet and SBB attachments before and after loading (P<0.05) (Fig4). The vertical displacement of MagfitSX and SBB attachments showed slight decrease after loading. On the other hand, there was little vertical displacement of the locator attachment irrespectively of the load applied. The vertical displacement of Magfit IPS was significantly decrease after 20,000 cycles, and there was little vertical displacement after 40,000 cycles (Fig.5). No crack and no deterioration were not observed in the O- ring rubber of the SBB attachment and these was no change of a diameter ratio compared between initial and 50,000cycles (Fig.6). Liner scratches to many directions were detected on the magnet and keeper surface of magnet attachments (Fig.7). The deformation was observed in the female silicone of the locator attachments (Fig.8). As for the Magfit IPS, built-in ball that made by silicon recognized the deformation. It caused displacement decrease. (Fig.9)

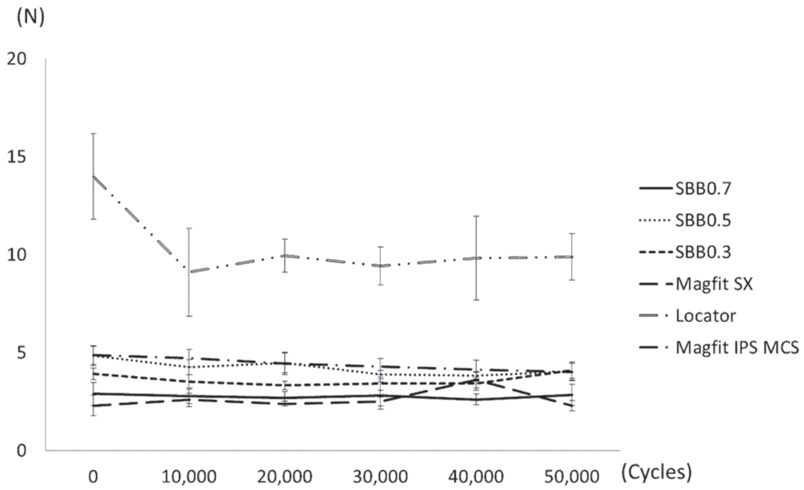


Fig. 4 Changes of retentive forces of each attachment

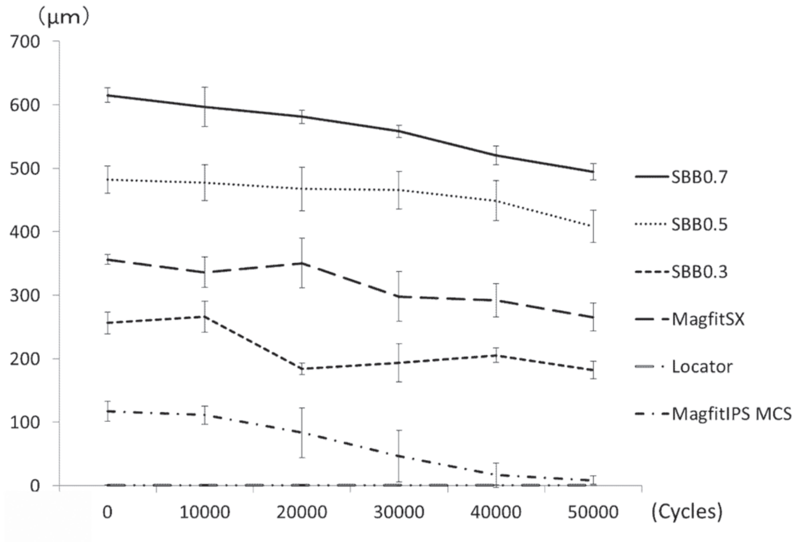
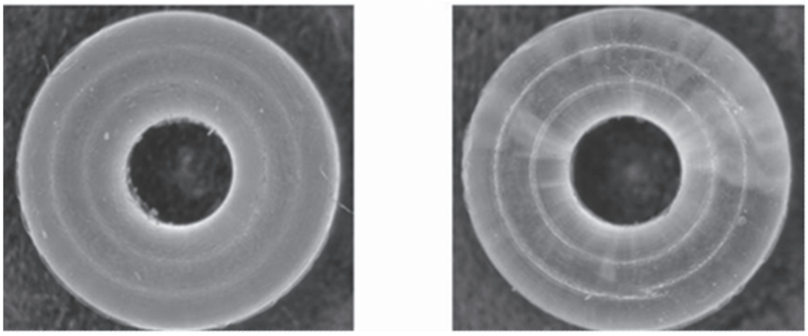
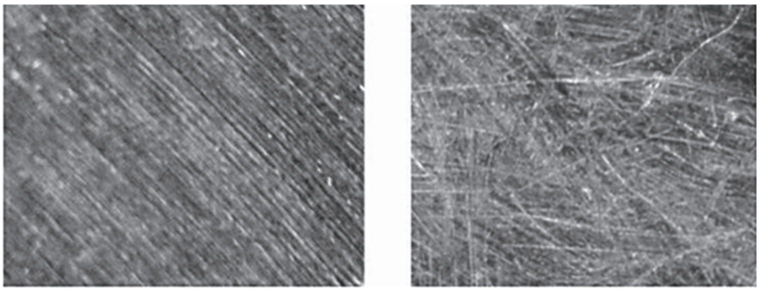


Fig. 5 Vertical displacement of each attachment



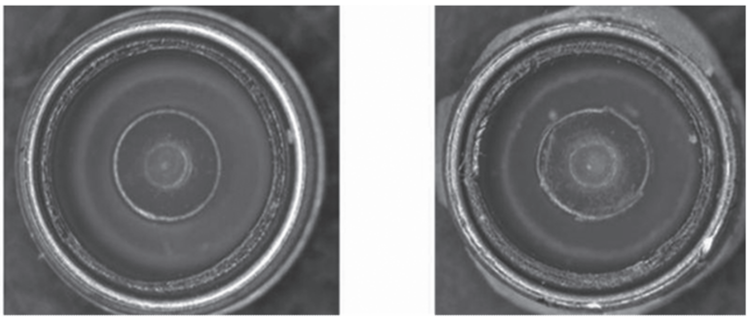
Before loading After loading

Fig. 6 Magnification of O-ring rubber in the SBB attachment (×10)



Before loading After loading

Fig. 7 Magnification of keeper surface of magnet attachment structure (×20)



Before loading After loading

Fig. 8 Magnification of female silicone in the locator attachment (×10)

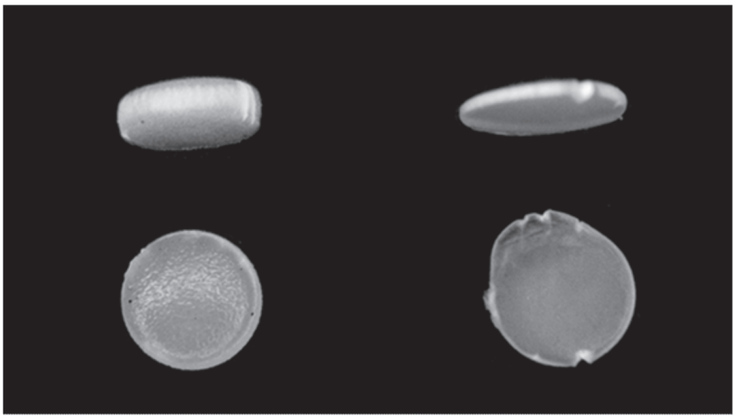


Fig.9 Magnification of the deformation built-in cushion of magnet attachment (×10)

Discussions

It is very difficult to determine the amount of the most suitable retentive force as the attachment for overdentures. Generally, a single overdenture may require a retentive force of approximately 2 kg to withstand the chewing of sticky foods, and simultaneously, it should be easily removable by the wearers. One retainer may require 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. But the retentive force after 10,000 cycles was greater than the other attachments, the locator attachment would be effective to use the clinical application similar to the other attachments.

When a static load of axial direction were applied to the implant superstructure and the alveolar mucosa, the displacement was approximately less than 5μm2)and 300μm3), respectively. The stress-breaking attachment may compensate for this displacement difference in accuracy. The vertical displacement of Magfit SX and SBB attachments showed slight decrease after repeated loading. But these attachments may distribute the occlusal force equally between the alveolar ridge and the implant.

Conclusions

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

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Development of Implant Magnetic Keepers

- Study on the screw loosening by repeated load -

Y. Nakamura, H. Nagai, T. Iwai, H. Kumano, M. Sakane, K. Hayashi, Y. Takada[1], S. Tanaka, Yu. Ohno and Y. Tanaka

Department of Removable Prosthodontics, School of Dentistry, Aichi-Gakuin University
[1]Division of Dental Biomaterials, Tohoku University Graduate School of Dentistry

Introduction

Implant materials and techniques have markedly improved in recent years. An implant overdenture with magnetic attachments has excellent retention mechanism, and has been drawing attention as one of the implant treatments.

We investigated attractive force and surface treatment methods to develop safe and practical magnetic implant system, and devised an ideal prototype keeper. Mechanical analysis was performed using three-dimensional finite element method to assess stress-bearing ability of this implant system for further optimization of a keeper.

A magnetic attachment is incorporated in the overdenture in the present implant system. External force is applied to an implant keeper during mastication due to the characteristics of an implant overdenture. The abutment was fixed to a fixture using an abutment screw, and the implant keeper was fixed on the top. The prototype implant keeper was fixed to an abutment by a screw structure of a keeper.

The axial force in the tensile direction in a bolt created by tightening the screw and compressive force in a tightened substance are combined and balanced when there is no external force. However, these forces decrease by the application of external force, resulting in loosening of a screw. Loosening of a keeper during functioning may cause impairment in function as an attachment, and increase a risk of accidental ingestion and aspiration of a keeper.

Objective

Repeated load was applied on a keeper of the implant to investigate loosening at the junction between a keeper and abutment during function.

Materials and Methods

1.Materials

An abutment and a keeper that fit into the fixture of commercially-available implant system (GENESIO, GC, Tokyo) were devised. Magnetic stainless steel SUSXM 27 was used for a prototype implant keeper, 6Al-4V-Ti alloy was used for a special jig, and pure titanium (JIS IV) was used for a fixture. The head of a GENESIO system abutment screw was shortened by the thickness of a keeper. A fixture and a special abutment were fixed with abutment screws according to the GENESIO system, and a special abutment and prototype implant keeper were fixed by a screw consisting of the inner part of the abutment and outer surface of a keeper. An implant keeper was designed to be completely stored in the abutment to avoid deformity and edge roll-off due to long-term use (Fig. 1).

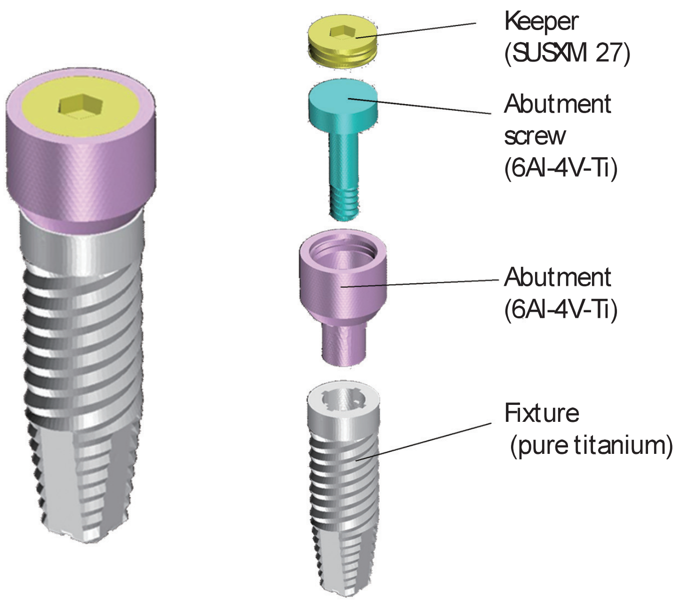

Fig.1. The structure of a prototype implant system

1) Prototype implant keeper

An implant keeper was designed in the cylindrical shape to match the size of a commercially-available magnetic attachment (GIGAUSS D600, GC, Tokyo). A keeper had a hexagonal screw hole with 1.3 mm in diameter and 0.8 mm in depth, and screw structure was added to the outer surface of a keeper. The hole center model of D 600 was designed 3.8 mm x 1.2 mm in diameter, and the standard of the screw structure was Class M 3.5 x 0.35 (Fig. 2).

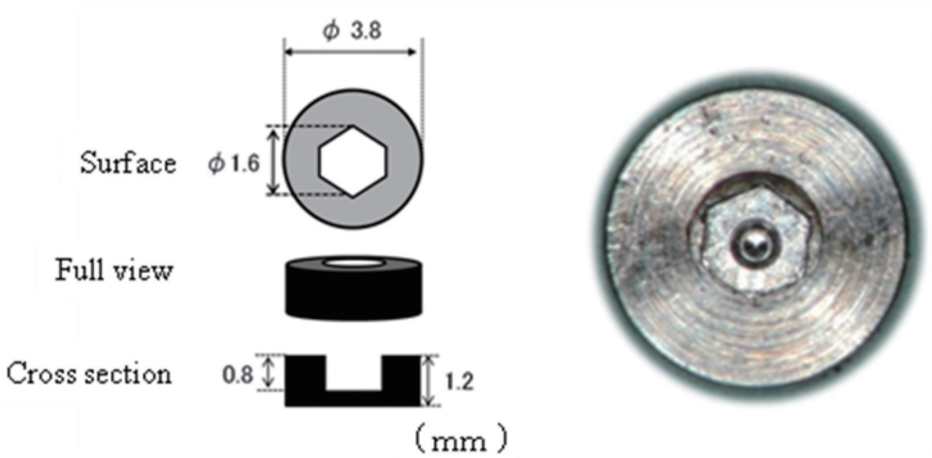

Fig.2. Prototype implant keeper

2) Experimental abutment

An abutment was designed to fit a prototype implant keeper. The size of a experimental abutment was 4.4 mm x 3.7 mm in diameter.

2.Methods

The lower plate simulating the environment that the prototype implant was placed into the bone, and the upper plate simulating an overdenture on the top were fabricated. The accelerated study was performed by applying repeated loads on the upper and lower plates to measure loosening of a keeper.

1) Lower plate

A square plate was fabricated using base resin (ACRON MC, GC, Tokyo), and 25 abutments were fixed concentrically from the center of the place using self-curing resin (UNIFAST, GC, Tokyo). The upper surfaces of abutments were adjusted to be on the same surface. Implant keepers were fixed on the abutments secured on the plate using a torque gauge (FTD50CN2-S, TOHNICHI, Tokyo). Torque value was changed to 1, 2, 3, 4, 5, 10, 15, 20, and 25 N, and 5 implant keepers were fixed at each torque value (Fig. 3 and 4).

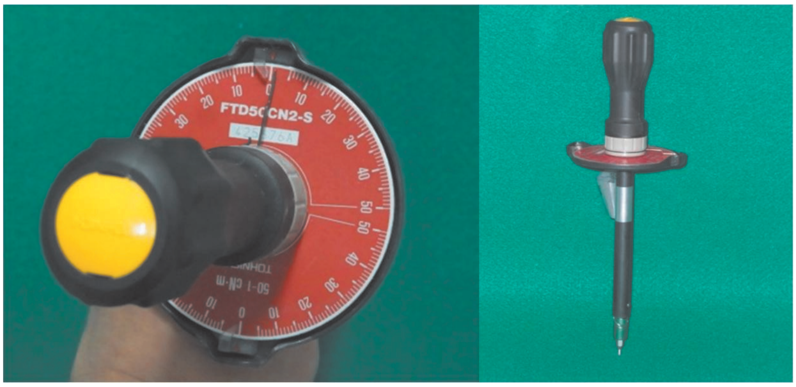

Fig.3. Torque gauge

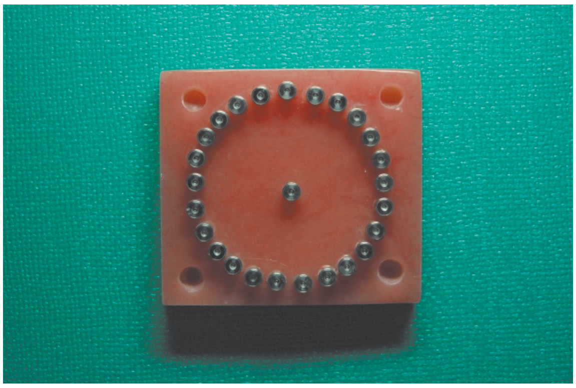

Fig.4. Lower plate

2) Upper plate

Although magnetic attachments were supposed to be incorporated into the upper plate reproducing an overdenture, keepers (GIGAUSS D600, GC, Tokyo) were conveniently used instead of magnetic structure in the present study. The upper plate was fixed to the lower plate to make a pair using the UNIFAST (Fig. 5).

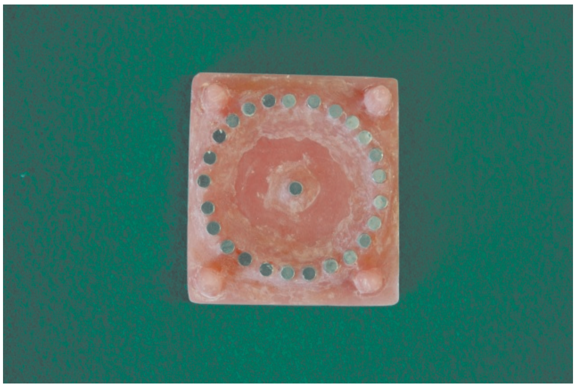

Fig.5. Upper plate

3) Repeated loads

(1) Loading

The upper plate was placed over the lower plate, and the load was applied to the upper plate so that repeated load was applied indirectly to the implant keeper. Only a keeper of the upper plate assuming a magnetic assembly was set to be in contact with an implant keeper fixed in the lower plate, followed by load application (Fig. 6, 7).

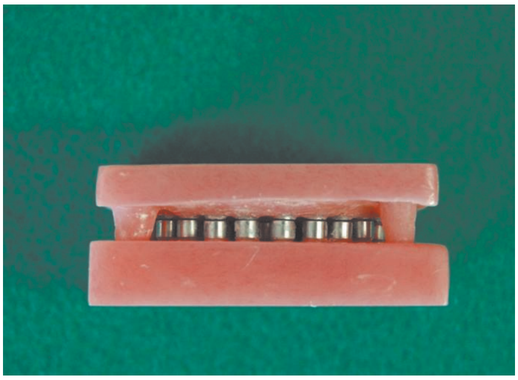

Fig.6. The upper plate was placed over the lower plate

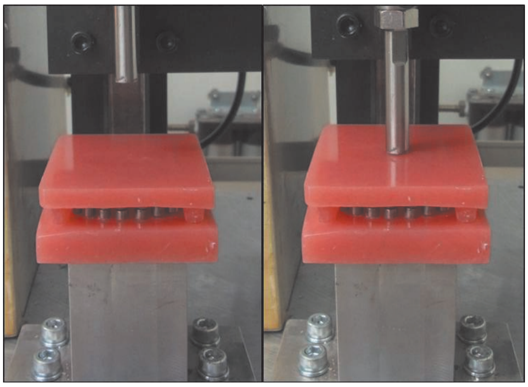

Fig.7. Repetition load

(2) Loading condition

A tap tester devised in our department was used for the load test (Fig. 8). A 20 kgf load was repeatedly applied 500,000 times at a cycle of 0.8 seconds.

Fig.8. Tap tester devised in our department

4) Measurement method

The torque values for fixing an implant keeper and for removing it after repeated loading were compared. The difference of the torque values for fixation and removal of an implant keeper was calculated, and it was set as the loosening value of a screw.

Results

Although there was no detachment of a keeper from the abutment after repeated loading of 500,000 times, loosening of a screw was confirmed in all samples. The torque value was decreased by 70.0% at 1N fixed torque value, 18.0% at 2N, 11.4% at 3N, 5.5% at 4N, 3.6% at 5.10N, 6.1% at 15N torque value before loading, 6.4% at 20N, and 9.8% at 25N (Table. 1).

Table 1. Loosening of a keeper after the load test

before loading	after loading		
torque value (N)	torque value (N)	standard deviation	decreasing rate (%)
1	0.30	0.20	70
2	1.6	0.15	18
3	2.7	0.17	11
4	3.8	0.15	5.5
5	4.8	0.42	3.6
10	9.6	0.52	3.6
15	14.0	0.82	6.1
20	18.0	0.70	6.4
25	22.0	0.48	9.8

Discussion

It is said that a screw has a proper torque. The proper torque value is a value when a screw is tightened with small rate of decrease in the torque value. The results of the present study showed that the rate of decrease in the torque value was the smallest when a keeper was fixed with 5 – 10 N torque value, suggesting that the proper torque value was around 5 – 10 N.

Some keepers fixed with over 20 N torque values showed surface bounce. It is considered that the margin of a screw hole bounced during fixation of a keeper to an abutment with the large torque value due to soft magnetic stainless-steel keeper. The adsorption face is distorted, resulting in a decrease in magnetic attraction of magnetic attachment.

The results of the present study suggested that the proper torque value to fix a prototype implant keeper with fine screw structure of M 3.5 x 0.35 using hexagonal screw hole (1.3 mm in diameter and 0.8 mm in depth) is 5 – 10 N.

Conclusion

Repeated load was applied to a prototype implant keeper 500,000 times, which is equivalent to the number of chewing strokes per year, to investigate loosening of a keeper screw, and the following results were obtained:

1.500,000 times repeated loading caused loosening of a screw in all samples despite the size of the torque value.

2.The proper torque value to fix a prototype implant keeper was 5.10 N.

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Development of a Simple Measuring Device of the Attractive Force with Magnetic Attachment

Y. Nakamura, K. Shoji, R. Kanbara, T. Iwai, M. Sakane, Y. Takada[1], S. Tanaka,
Yu. Ohno and Y. Tanaka

Department of Removable Prosthodontics School of Dentistry Aichi-Gakuin University
[1] Division of Dental Biomaterials, Tohoku University Graduate School of Dentistry

Introduction

The establishment of the attractive force measurement and measurement method is considered important to quantitatively describe the characteristics of dental magnetic attachment products. Various studies have been conducted to obtain accurate attractive force measurements since the development of magnetic attachments. The combination of Aichi-Gakuin testing jig and high-performance tensile tester is considered the most effective method of attractive force measurement of a dental magnetic attachment. The method meets ISO standards. Although Aichi-Gakuin testing jig allows high accuracy measurement, it lacks versatility due to its complicated biaxial structure and high cost.

An improved jig was devised by ISO task force of the Japanese Society of Magnetic Application in Dentistry to solve problems of Aichi-Gakuin testing jig. The improved jig expanded versatility by simplifying the structure from biaxial to uniaxial, and lowering the cost. Although the versatility of a jig was improved, it still requires a high-performance tensile tester. Since the ISO measurement system requires an expensive tensile tester, it lacks versatility due to difficulty in installing the device in institutions, introducing worldwide, and its difficult portability.

Objective

The purpose of the present study was to develop a simple measuring system of the attractive force introducing a tensile tester with a built-in jig to expand the versatility of the conventional ISO measurement system, and to evaluate the measurements using the system. The new system is designed to be cost effective, easily fabricated, and compatible with the round-robin test in each country.

Material and method

The following figures show a simple measuring system of the attractive force introducing a tensile tester with a built-in jig developed in the present study. The total weight of a device is 5 kg, and the size is 120 mm in width, 105 mm in length, and 370 mm in height (Fig. 1).

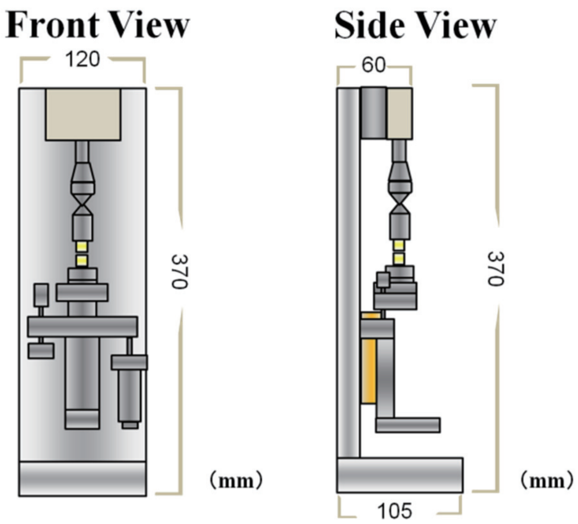

Fig.1 Simple measuring system of the attractive force

The measurement value was displayed by the Imada digital force measurement gauge up to 50 N with measurement accuracy of ±0.2% FS (Fig. 2).An uniaxial linear ball bearing is embedded in the device so that the friction resistance can move minimally in the longitudinal direction during measurement (Fig. 3). A magnetic assembly was embedded in the mold bonded with a digital force gauge by a movable joint in the upper part of a magnet assembly, and a keeper was installed in the lower mold with X-Y stage. The lower part of the device with a keeper starts free-fall movement by a measurement start screw (Fig. 4).

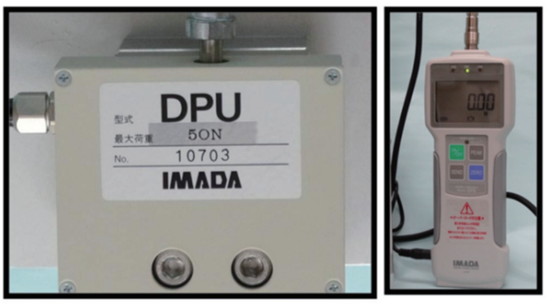

Fig.2 Digital Force Gauge (IMADA)

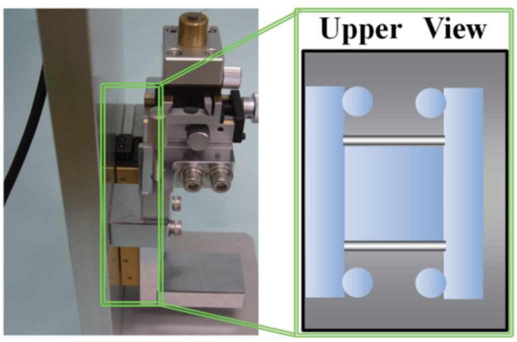

Fig. 3 Linear ball bearing

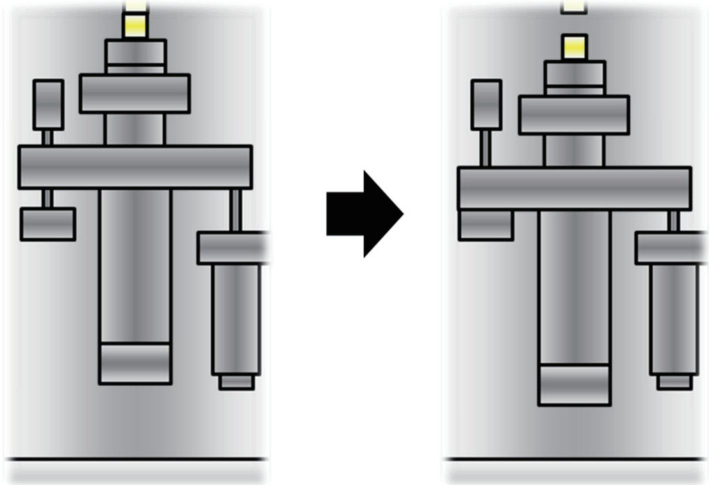

Fig. 4 Measurement system

The lower part of the device was supported using a dash-pot (KINECHECK, Meiyu Airmatic Co., LTD) to maintain a constant speed (Fig. 5).

The Fig. 6 shows the inner structure of a dash-pot. The falling velocity was maintained at a constant speed by oil pressure during indentation, and the piston was returned to the original position by the restoring force of the spring. The velocity can be changed by altering the size of oil aperture (Fig. 6).

Fig.5 Dashpot (KINECHEK, meiyu)

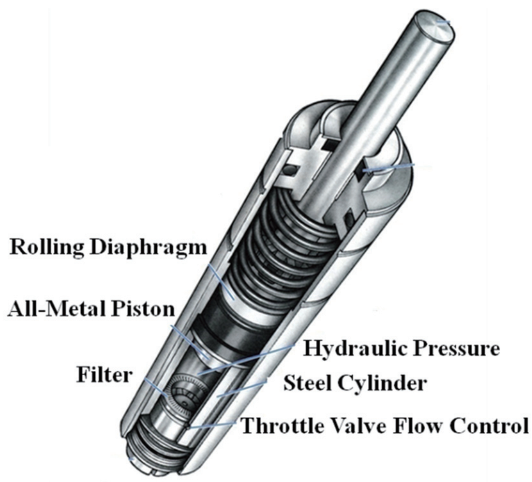

Fig.6 The inner structure of a dash-pot

Oil pressure of a dash-pot was controlled, and a scale at a cross head speed of 5 mm/min or less was confirmed in the preliminary experiment. The amount of time before the device sank by 5 mm was measured to calculate the measurement speed (mm / min).

The cross head speed was determined at 4.8 mm / min (13 on the scale) based on the measurement results of oil pressure scale (Table 1).

Table1 The cross head speed was determined by screw Hydraulic Control

Dashpot
Screw Hydraulic Control

Hydraulic Scale	Speed(mm/min)
5	90.0
10	10.0
15	3.3
20	1.4
25	0.8

Verification of ISO Standard(5mm/min or less)

Hydraulic Scale	Speed(mm/min)
11	7.5
12	6.0
13	4.8
14	4.0

The measurement results of a tensile tester with a built-in jig, a simple measuring device of attractive force, were compared with the results obtained by conventional two systems including the combination of Aichi-Gakuin testing jig and tensile tester and improved ISO jig and tensile tester (Fig. 7). Measurement samples were (GC) (Fig. 8).

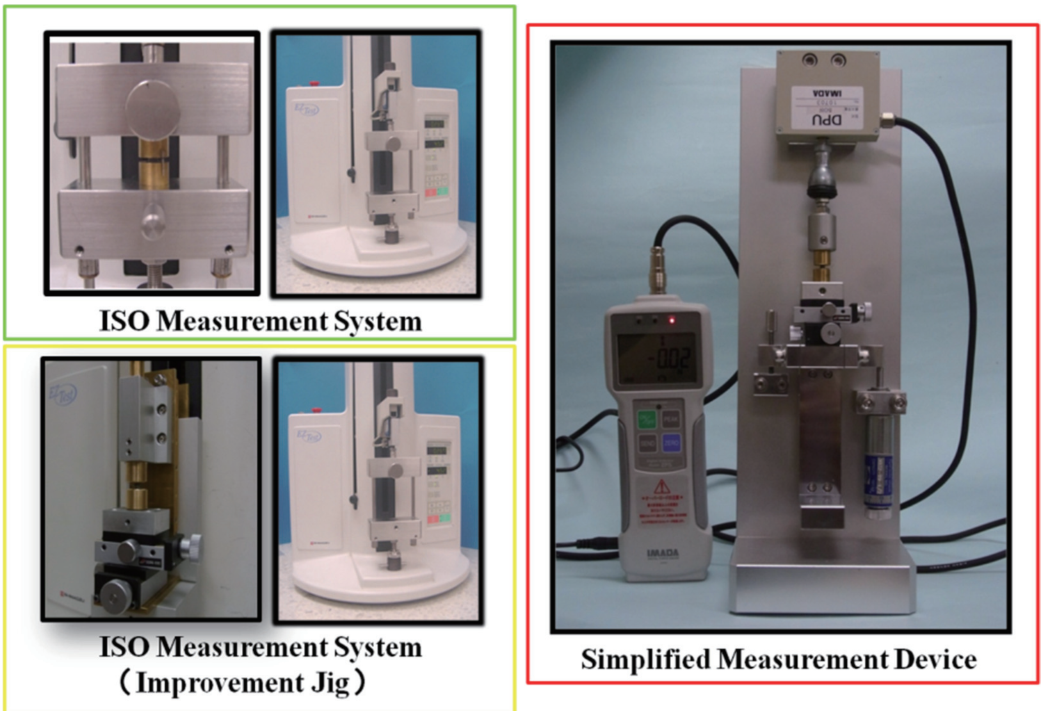

Fig.7 Comparison of measuring methods

Fig.8 Measurement samples(GIGAUSS D600 and C600)

Results

The attractive force measurement of GIGAUSS D600 using a simple measuring device was 4.04 N on average. The results showed significantly smaller attractive force compared with the other two measurement methods, and large standard deviation (Fig. 9).GIGAUSS C600 demonstrated the similar results with attractive force measurement of 4.57 on average (Fig. 10).

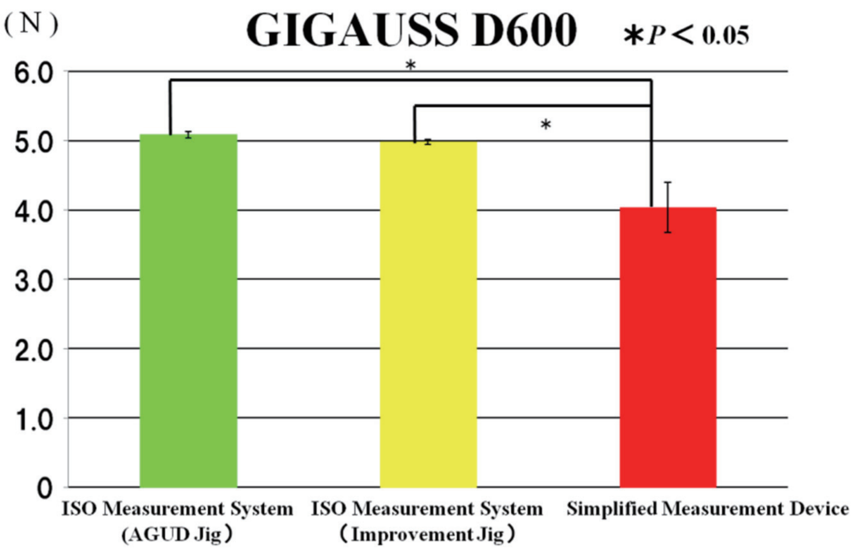

Fig. 9 Results GIGAUSS D600

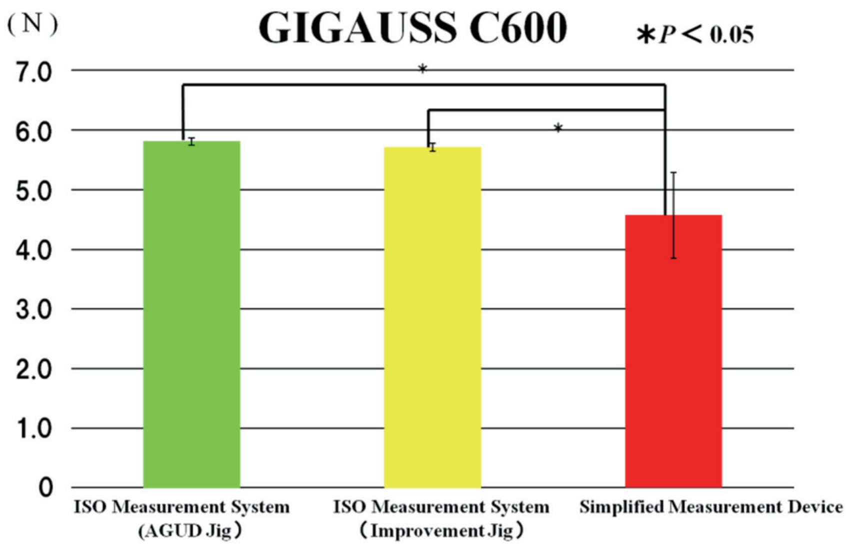

Fig.10 Results GIGAUSS D600

Discussions

The attractive force measurement using a tensile tester with a built-in jig confirmed that the crosshead speed during measurement can be controlled by a simple device. Fall velocity was controlled at a constant speed to avoid acceleration by a dash-pot, and vertical and horizontal directions were regulated by linear ball bearing. The crosshead speed under 5 mm/min (ISO standard) was accurately reproduced. The detaching movement between a magnetic assembly and a keeper, which is considered the most important element of attractive force measurement, was controlled. The previous studies showed that the most challenging part of attractive force measurement was to control the unique movement of magnets, and to transmit the attractive force to the load cell in the vertical direction. Therefore, overcoming these challenges was considered the biggest achievement of the present study. Although the simple measuring device used in the present study controlled the detaching movement between a magnetic assembly and a keeper, vertical and horizontal direction could not be controlled since the movable joint was used during accurate transmission of the attractive force to the load cell. As a result, measurement values were small, resulting in poor reproducibility. This problem is considered to be solved by incorporating ISO jig into the simple measuring device.

Another achievement of the present study was that the device is portable and mailable due to its size and weight. Therefore, the same device can be used for the measurement domestically and internationally to compare the results. The device can be fabricated at various institutions due to its simple structure and low cost, and the measurement procedure is simple.

Conclusion

The simple measuring device was designed and the prototype of the device was fabricated. The present study using the prototype device established the foundation of more cost-effective and versatile attractive force measurement system, and elucidated improvement points. Further improvements of the device are being pursued to increase availability of the present system.

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Mechanical Strength Analysis of Extracoronal Magnetic Attachment by Three-Dimensional Finite Element Method

-Report II Introduction of elasto-plastic analysis-

Y. Nakamura, A. Otoda, Yo. Ohno, K. Shiraishi, T. Masuda, M. Sakane, T. Itakura, Y. Takada[1], S. Tanaka,Yu. Ohno and Y. Tanaka.

Department of Removable Proshodontics, School of Dentistry Aichi-Gakuin University
[1]Division of Dental Biomaterials, Tohoku University Graduate School of Dentistry

Introduction

We have developed extracoronal magnetic attachments for vital teeth, and they are widely used in clinical practice. However, the mechanical strength of such magnetic attachments is not fully confirmed. Ohno from our department reported the mechanical strength analysis of an extracoronal magnetic attachment using Au-Ag-Pd alloy by three-dimensional finite element method in the 21st Conference on Magnetic Applications in Dentistry. However, platinum gold alloy is more frequently used than Au-Ag-Pd alloy in clinical practice.

In the present study, we focused on heat treatment of platinum gold alloy, and mechanical strength analysis of an extracoronal magnetic attachment was performed.

Objective

The purpose of the present study was to investigate mechanical strength of platinum gold extracoronal magnetic attachment up to the elastic limit.

Materials and Methods

As a preliminary experiment, the stress-strain curve of dental gold casting alloy (PGA-3, ISHIFUKU Metal Industry Co., Ltd(Fig.1) after heat treatment was calculated, followed by the elasto-plastic analysis of a simple-shaped sample based on the stress-strain curve. The finite element model of an extracoronal magnetic attachment was fabricated, and elasto-plastic analysis was performed to examine mechanical strength of extracoronal magnetic attachments.

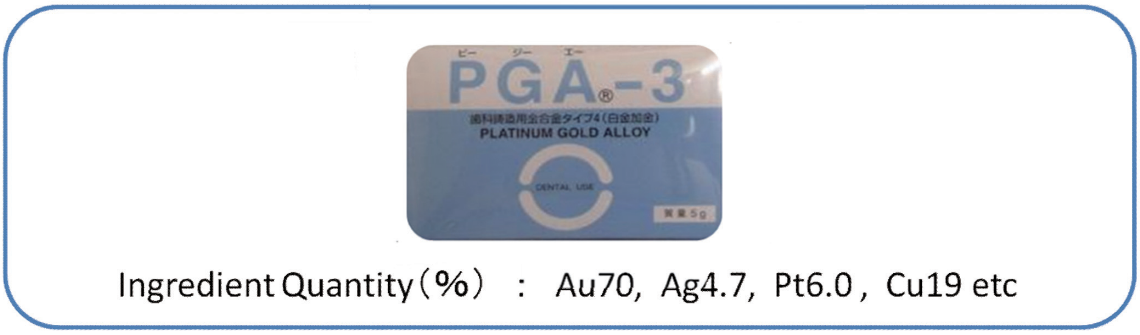


Fig. 1 Use metal:PGA-3(ISHIFUKU)

1. Preliminary experiment

1) Stress-strain curve

The size of a sample was 2 mm in diameter (parallel area), 25 mm in the distance between marks, and 55 mm in full length. PGA-3 (ISHIFUKU Metal Industry Co., Ltd) suitable for milling and applied to abutment teeth of extracoronal magnetic attachments in our university was used for the study (Fig. 2).

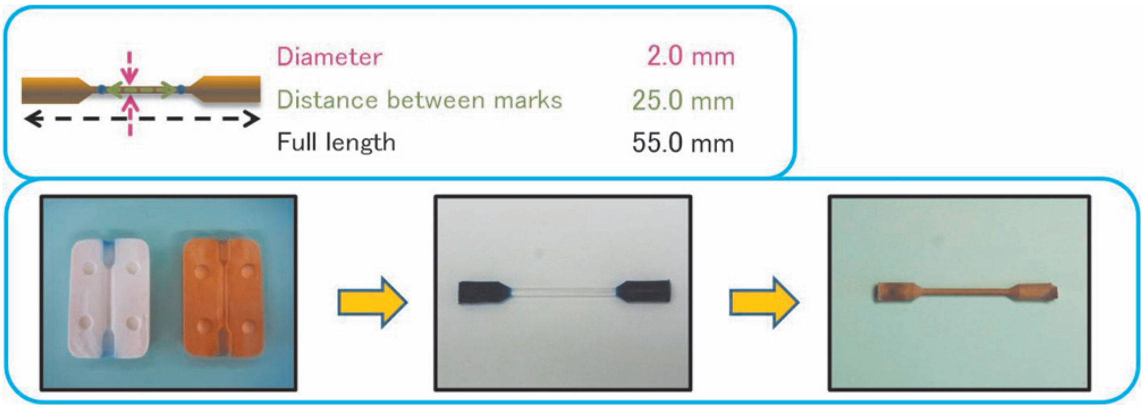


Fig. 2 Sample fabrication

Samples were invested, cast, and heat treated under the manufacturer's instructions. Samples with hardening heat treatment, no heat treatment, and softening heat treatment were prepared (7 each). Stress-strain measurement was performed using the Instron Universal Tester (Instron Japan) with a crosshead speed of 0.5 mm / min (Fig. 3).

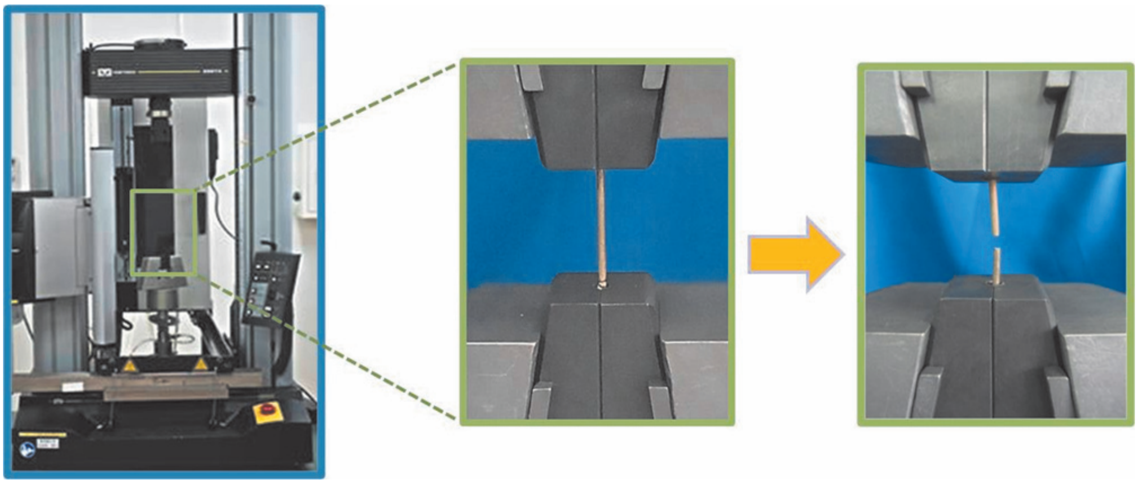


Fig. 3 Tensile test

The slopes of the strain amount in the elastic region were calculated. An inflection point and the following behavior in the plastic region were plotted to complete the stress-strain curve. The stress-strain curve was introduced to the exploratory analysis to examine the consistency of the elasto-plastic analysis.

2) Load displacement curve

The size of a sample was 7.0 mm in minor axis, 35.0 mm in diameter, and 1.6 mm in thickness (Fig. 4).

Fig. 4 Sample size and Sample

Samples were invested, cast, and heat treated under the manufacturer's instructions. Seven samples were prepared for each treatment. Load displacement was measured using the Instron Universal Tester with a crosshead speed of 0.5 mm / min.

2. Exploratory analysis

Fig. 5 shows the size of an exploratory analysis model.

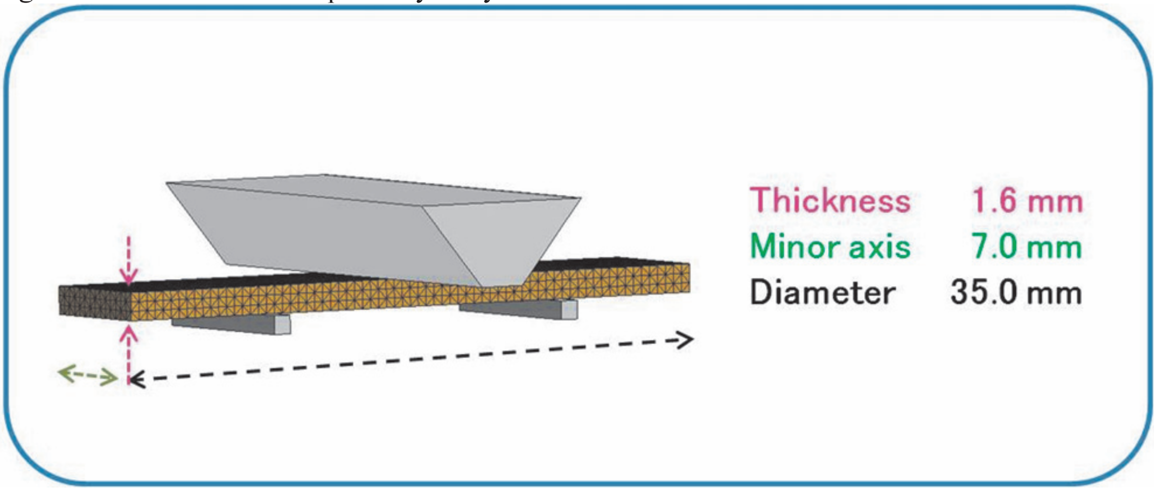


Fig. 5 Size of an exploratory analysis model

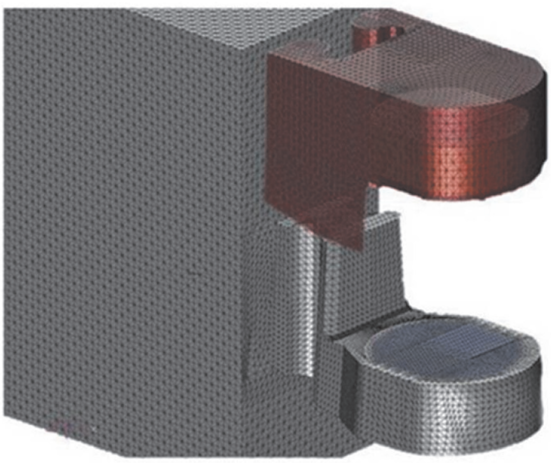
Elements and nodes were 5,164 and 23,288, respectively.

Constraint condition was applied in one direction to Z axis, and a rigid body simulating an indenter was placed at the center of a plate at 0.5 mm / min.

For material constants, the elastic coefficient of platinum gold alloy and material property in the plastic region were introduced from the stress-strain curve of the preliminary experiment for the analysis.

3. Actual analysis

Fig. 6 shows elements and nodes, and boundary condition of the present analysis.



elements : 690,844

nodes : 128,382

Material property

	Young's modulus (GPa)	Poisson's ratio
gold platinum alloy	80.0～100.0	0.30
SUSXM27	196.0	0.30
cement	8.8	0.30

Fig.6 Analysis model and boundary condition

The base and extracoronal model were fabricated together. A model was fabricated by cementing a keeper and attaching a housing on top of it.

A complete constraint was applied to the top, bottom, and back surfaces in the X, Y, and Z directions.

A load was applied at the center of the extracoronal attachment in the Z axis direction for 5 minutes at a rate of 0.5 mm / min (Fig. 7).

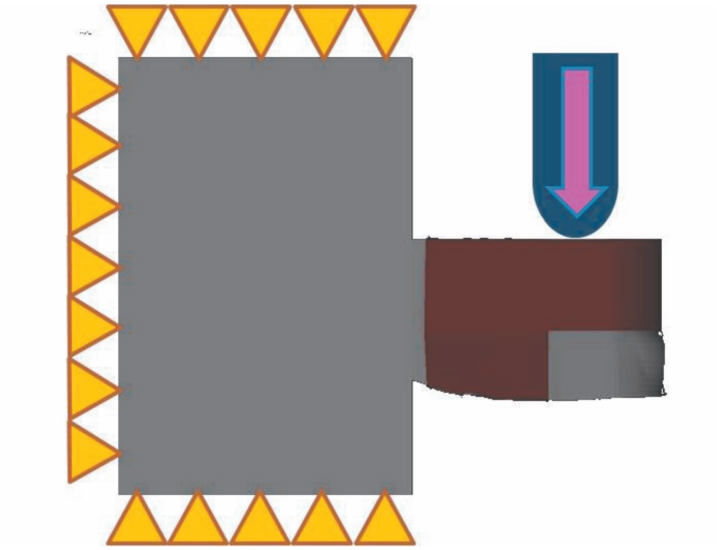


Fig. 7 Constraint condition of the present analysis model

The same method was employed for material constants, and the elastic coefficient of platinum gold alloy and material property in the plastic region were introduced from the stress-strain curve of the preliminary experiment for the analysis.

Patran, a general purpose pre/post processor and Mark, a general purpose finite element program, and MSC were used for explanatory and actual analyses.

Results

1. Preliminary experiment

1) Stress-strain curve

Fig. 8 shows the results of stress-strain curves.

A known value was substituted. Elastic coefficients were 82 G Pa in hardening heat treatment, 94 G Pa as cast, and 98 G Pa in softening heat treatment. Plastic region remain unchanged for all treatments.

A SEM image (Fig. 9) showed ductile fracture.

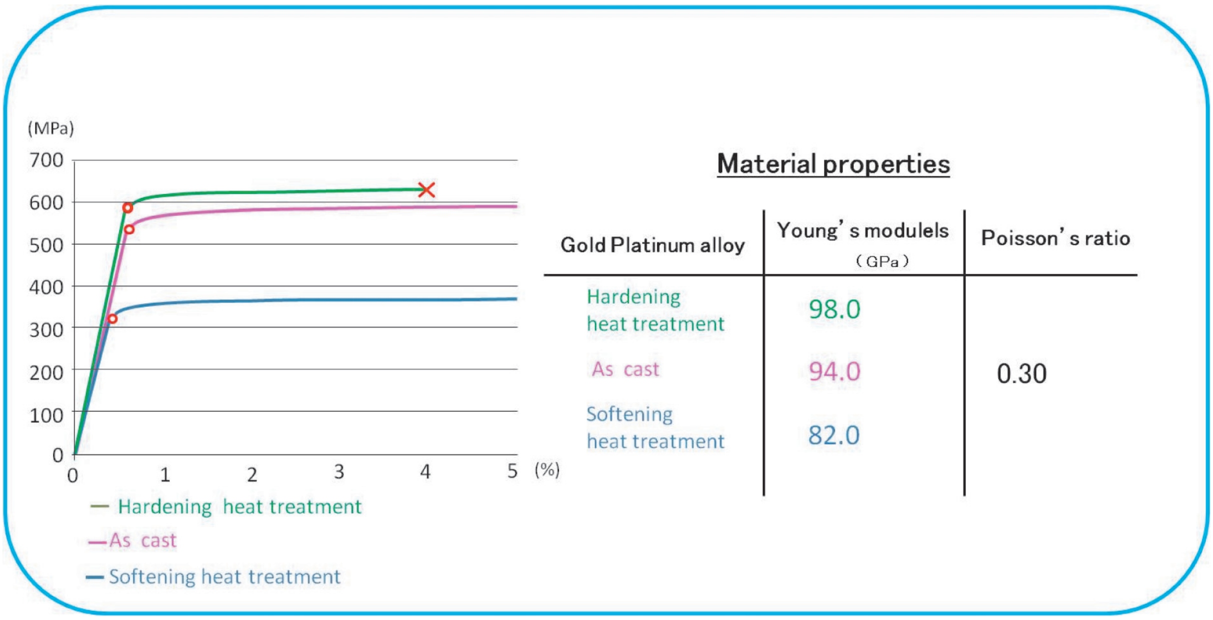


Fig. 8 Stress strain curves

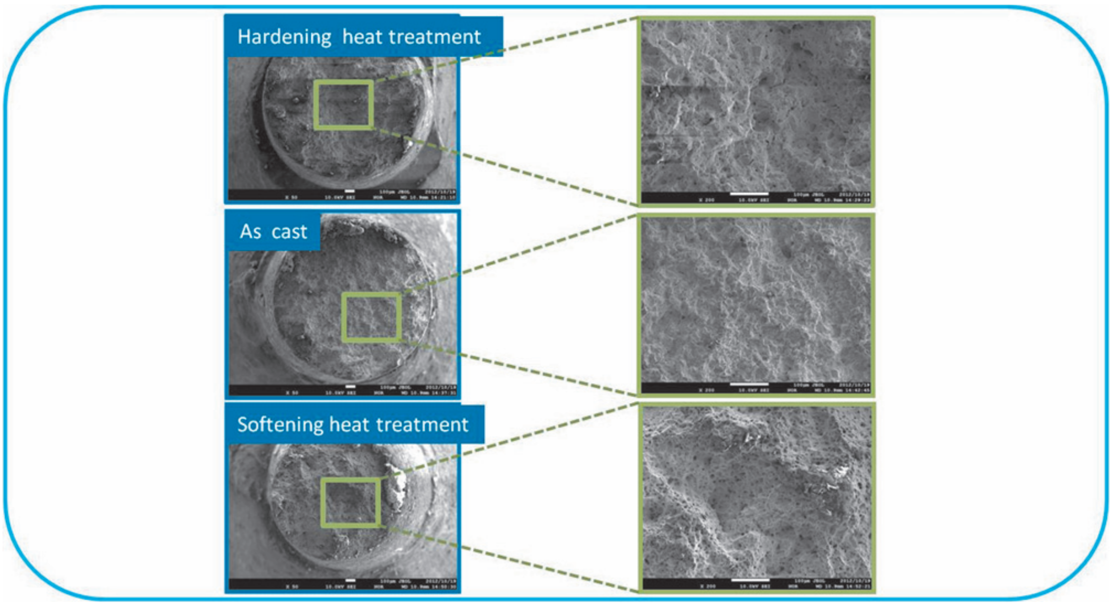


Fig. 9 SEM image

2) Load-displacement curve

Fig. 10 shows the results of load-displacement curves of measurement and analysis values.

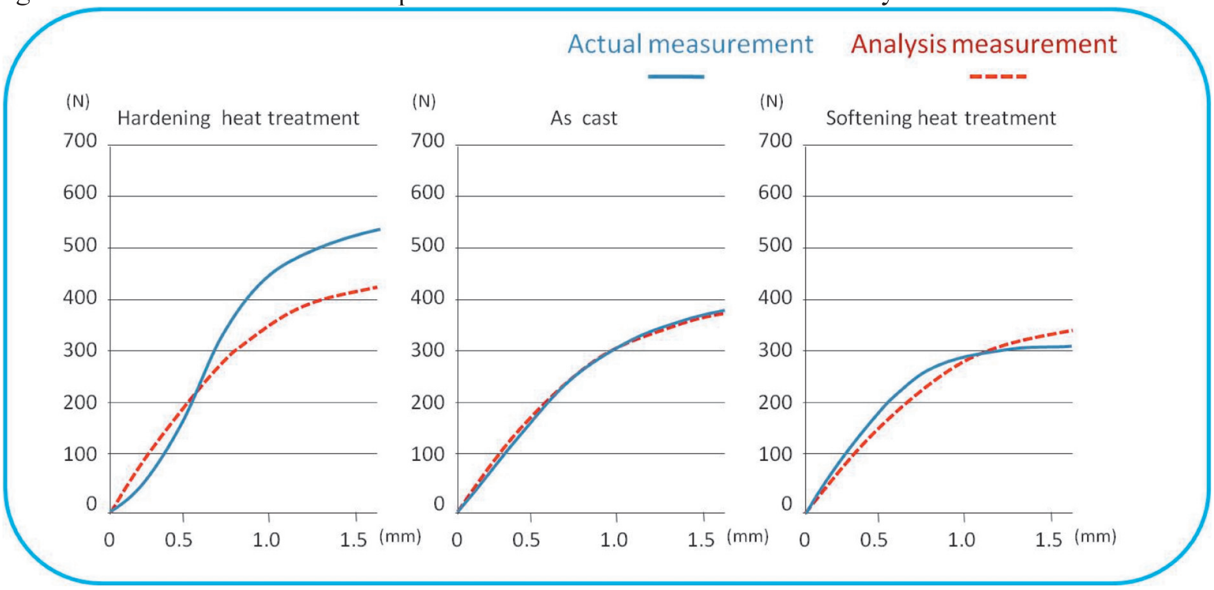


Fig. 10 Load-displacement curves

2. Explanatory analysis

The agreement rate between measurement and analysis values was the highest as cast, followed by softening heat treatment and hardening heat treatment.

3. Actual analysis

Fig. 11 shows the von Mises stress distribution chart of the present analysis.

The stress distribution chart indicated stress concentration of the stress applied on the top surface of an attachment on the neck part of an attachment.

Fig. 12 shows the load-displacement curves of the present analysis.

Elastic limit was 1.5 mm at 1100 N loading for hardening heat treatment, 1.3 mm at 800 N as cast, and 1.1 mm at 600 N loading for soft heat treatment.

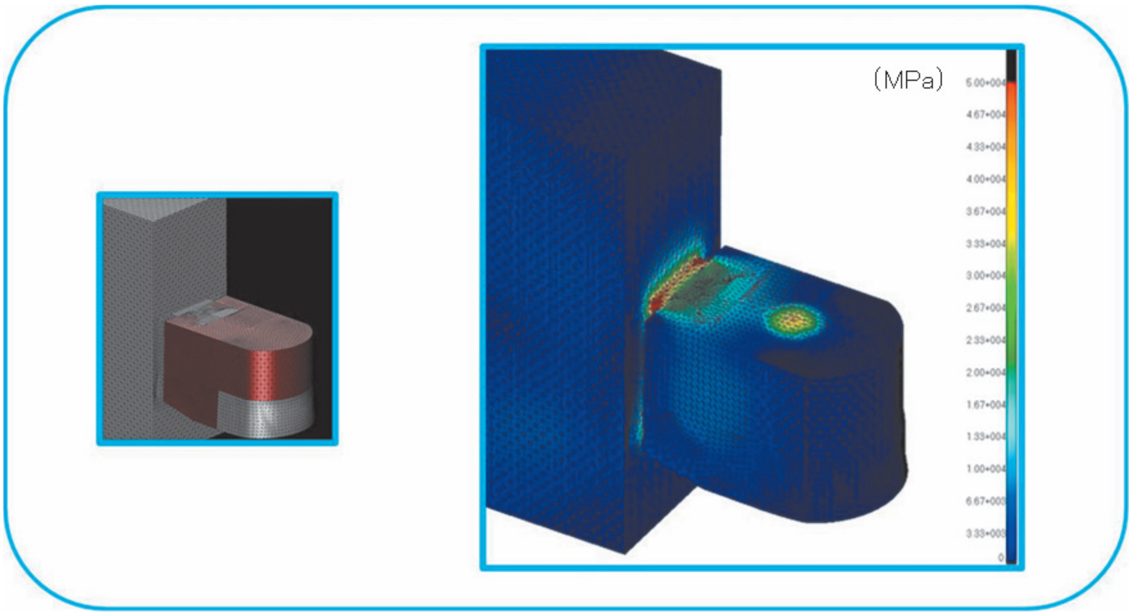


Fig. 11 von Mises stress distribution chart

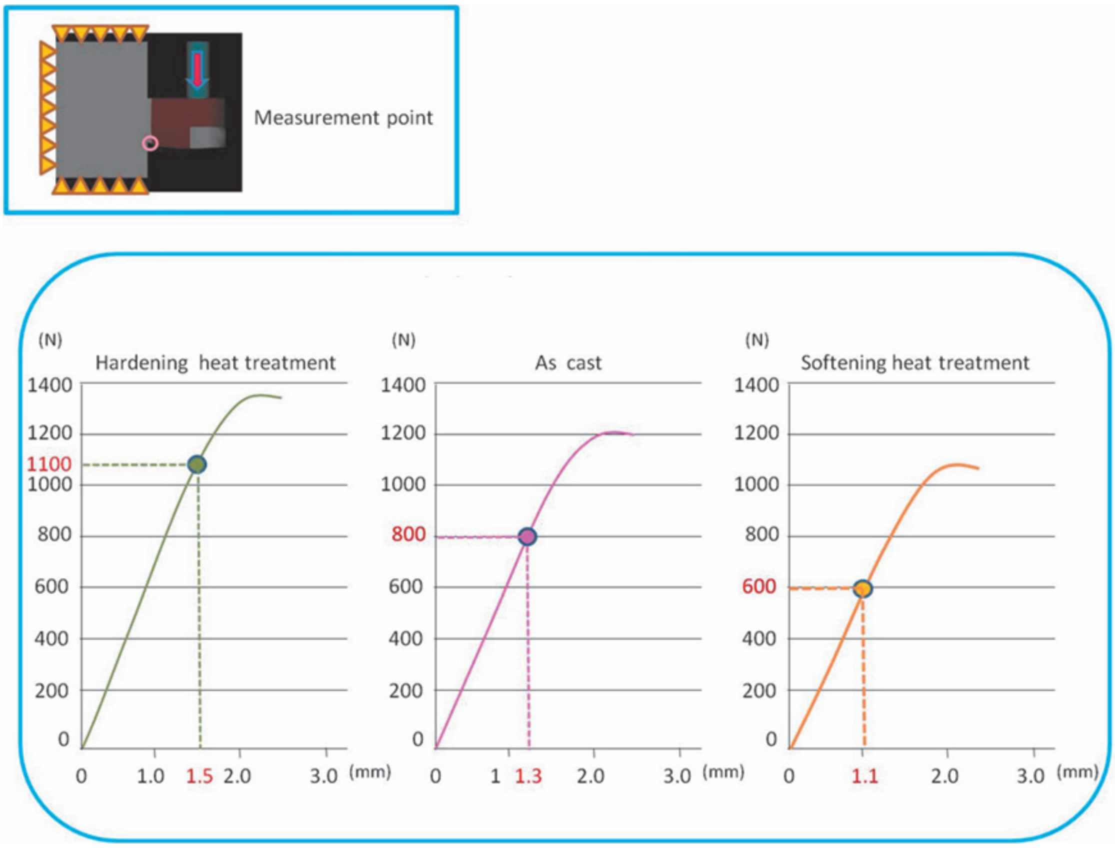


Fig. 12 Load-displacement curves

Discussion

1. Stress-strain curve

Stress-strain curves were measured using finite element analysis to investigate mechanical strength of an extracoronal magnetic attachment. Actual measurement allowed to know material properties specific to the metal, and to introduce proper mechanical properties to the finite element model. The fracture cross-section after the tensile test was observed by SEM. The images indicated that samples were fractured in a ductile manner, not due to twist or strain by a machine.

2. Preliminary experiment

Although the elasto-plastic analysis is rarely introduced in the medical field, it is actively introduced in the industrial field and its credibility has been established. In the present study, actual measurement of the preliminary experiment and comparison with the explanatory analysis were performed before the analysis of an extracoronal magnetic attachment to confirm practicality and credibility. The results of the preliminary experiment and explanatory analysis showed approximate values in extracoronal magnetic attachments with hardening and softening heat treatment. Errors were confirmed in the actual measurement and analysis values of samples with hardening heat treatment. It is considered that measurement error increased with each heat treatment.

3. Analysis model

A finite element model of the present study was fabricated by constructing an extracoronal attachment model based on the commercialized and normalized CAD data. A housing and the base were fabricated to fit the model. The size of the model was meticulously reproduced.

A model with tetrahedral elements was fabricated. Although it is said that calculation accuracy decreases in tetrahedral elements compared with hexahedral elements, the present model was subdivided to make all elements approximately the same shape, and, therefore, inaccurate stress concentration and reaction force due to the insufficient elements could be avoided.

Stress distribution was evaluated using von Mises stress. Although compression and tensile properties cannot be evaluated in von Mises stress, this method can easily exhibit stress concentration. The results showed stress concentration at the superior margin of an extracoronal magnetic attachment groove, and stress transmission in the upper and lower parts of the base. The similar results were obtained in the break test. Crowns and abutment teeth were simulated for the base. It was pointed out that high stress concentration may arise at the margin line by applying stress to an extracoronal magnetic attachment.

Conclusions

Practicality and credibility were reconfirmed by performing preliminary experiment of elasto-plastic analysis.

Three-dimensional finite element analysis showed that the elastic limit of an extracoronal magnetic attachment fabricated with platinum gold alloy exists around 1,000 N.

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Should Occlusal Pressure be Applied in Fixing Magnet Assemblies to Denture? An Evaluation using the Delphi Technique

K. Nagao, T. Goto, Y. Ishida, T. Ichikawa, M. Hideshima[1], H. Koshino[1], K. Hoshiai[1] and Y. Umekawa[1]

Department of Oral & Maxillofacial Prosthodontics, Institute of Health Biosciences,
The University of Tokushima Graduate School
[1]Dental Care Council, the Japanese Society of Magnetic Applications in Dentistry

Introduction

It is important to distribute occlusal force to the mucosa and abutments efficiently in magnet-retained overdentures. The difference in tissue displacement between the tooth and the mucosa is the most common precipitating factor of overstressing the abutment tooth. However, there are few articles related to the subject of how to fix the magnet assembly to the denture base in magnet-retained overdentures. Thus, it is difficult to build consensus if we have only insufficient and/or poor clinical evidence.

The consensus method, utilizing questionnaires for experts, has been occasionally used to build consensus. The Delphi technique is typical of the consensus method. A questionnaire survey is administered to experts, and the grade of the consent to questions is investigated. This questionnaire survey is administered repeatedly until consensus is built.

Objective

Should occlusal pressure be applied in fixing magnet assemblies to denture bases? The purpose of this study was to build consensus using the Delphi technique with reference to the experts' opinions. This presentation describes the outline of the Delphi technique used effectively to draw up clinical practice guidelines for magnetic attachments for which there has been insufficient evidence.

Materials and Methods

◆ Process of the questionnaires using the Delphi technique

The process used in administering the questionnaire survey was as follows:

1. Selecting experts and making the questionnaire
   Dental Care Council, the Japanese Society of Magnetic Applications in Dentistry, picked 71 prosthodontists who were familiar with magnetic attachments as the experts.
2. Distributing the questionnaire to the experts, collecting and tallying up the answer sheets
3. Distributing the questionnaire with the outcomes of previous answers and collecting the answer sheets again (Table 1)

◆ Decision of consent level

Consent level was decided by convergence level and median (Table 2). Convergence level was determined as follows: high—distribution of 3 or less, medium—distribution of 4 to 6, and low—distribution of 7 or more, excluding frequencies of 2 or less. Consent level was defined as PP—strong positive agreement, P—light positive agreement, N—light negative agreement, NN—strong negative agreement, and U—unidentified.

Table 1 Second questionnaire

The number below is outcomes of first answer.

Clinical Question (CQ):
How is it harmful when the magnet assembly is fixed to denture by no occlusal pressure?

Completely oppose : −5 neutral: 0 completely agree: 5

	-5	-4	-3	-2	-1	0	1	2	3	4	5
➢Effective in retentive force of prostheses	4	0	6	5	3	6	3	3	4	0	1
➢Effective in masticatory function	4	2	6	5	3	9	1	2	2	1	1
➢Effective in phonetic function	3	0	3	2	2	23	0	0	2	1	0
➢Effective in aesthetic	4	1	1	1	1	25	0	0	1	2	0
➢Effective in comfortableness	4	1	4	6	6	11	2	0	1	1	0
➢Effective in management of prostheses	4	1	4	2	4	17	1	1	0	1	0
➢Effective in permanence of abutment teeth and/or denture	7	3	8	6	3	7	0	1	0	0	1
➢Effective in health of periodontal tissue	4	5	9	4	2	9	1	0	1	0	0
➢Task body of patient/dentist and loss of time	1	0	3	8	0	20	0	2	1	1	0
➢Harmful to abutment teeth and patient(e.g. tooth preparation, pain)	1	0	2	4	2	22	1	0	4	0	0
➢Effective in reduction of cost	4	1	1	1	0	28	0	0	1	0	0

Table 2 Decision of consent level

Concent level was decided by convergence level and median.

	median ≦ -2	-2 < median < 2	2 ≦ median
convergence level : high	**NN**	U	**PP**
convergence level : medium	**N**	U	**P**
convergence level : low	U	U	U

convergence level: high 3 or less distributions exclude 2 or less frequency
convergence level: medium 4 to 6 distributions exclude 2 or less frequency
convergence level: low 7 or more distributions exclude 2 or less frequency

Consent level

PP : strong positive agreement
P : light positive agreement
N : light negative agreement
NN : strong negative agreement
U : unidentified

Results

Answers were obtained from 38 experts: 25 dental implant specialists and 13 prosthodontics specialists.

Figure 1 shows the frequency distribution concerning the questions: “Effective in permanence of abutment teeth and/or denture” and “Effective in health of periodontal tissue.” When the magnet assembly is fixed to the denture with no occlusal pressure, the consent level toward these two questions was N—of light negative agreement.

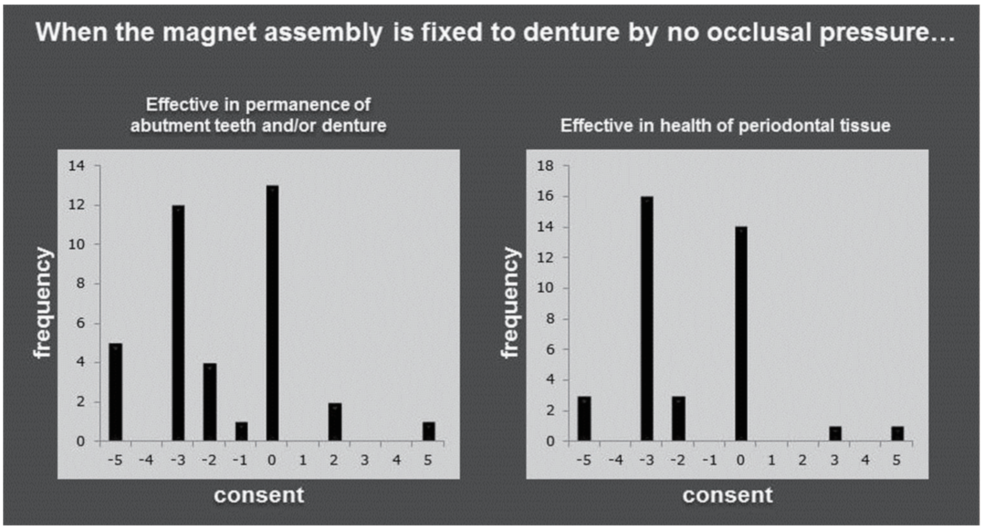

Figure 1 Frequency distribution
median: -2
convergence level : medium
Consent level N: light negative agreement

Table 3 shows the consent level for each question and the recommendation level. Convergence levels toward "Effective in phonetic function," "Effective in comfortableness," "Task body of patient/dentist and loss of time," and "Harmful to abutment teeth and patient" were "high" with medians of 0. In other words, phonetic function, comfortableness, suffering to patients and/or dentists, and harm were not affected by occlusal pressure when the magnet assembly was fixed to the denture. The recommendation level toward this CQ: "How is it harmful when the magnet assembly is fixed to the denture with no occlusal pressure?" was N—of light negative agreement synthetically.

Table 3 Consent level of each question and recommendation level

When the magnet assembly is fixed to denture by no occlusal pressure…

Questions	Median	Convergence level	Concent level
Effective in retentive force of prostheses	**-2**	low	U
Effective in masticatory function	0	low	U
Effective in phonetic function	0	**high**	U
Effective in aesthetic	0	medium	U
Effective in comfortableness	0	**high**	U
Effective in management of prostheses	0	medium	U
Effective in permanence of abutment teeth and/or denture	**-2**	medium	**N**
Effective in health of periodontal tissue	**-2**	medium	**N**
Task body of patient/dentist and loss of time	0	**high**	U
Harmful to abutment teeth and patient(e.g. tooth preparation, pain)	0	**high**	U
Effective in reduction of cost	0	medium	U
Recommendation level	**N: light negative agreement**		

Discussion

When the magnet assembly is fixed to the denture with no occlusal pressure, it is harmful to the health of periodontal tissue in abutment teeth; however, no clinical evidence about the quantity of occlusal pressure was shown. Furthermore, it is important for the prognosis of abutment teeth to know how much pressure there was from the impression material to the tissue under denture base when the denture was fabricated. Building clinical evidence and consensus on these subjects is necessary.

Conclusions

Evaluation using the Delphi technique suggests that it is harmful to the health of the periodontal tissue of abutment teeth when the magnet assembly is fixed to the denture with no occlusal pressure. Moreover, moderate occlusal pressure to the tissue under the denture is recommended when the magnet assembly is fixed to the denture.

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Formulating Clinical Practice Guidelines for Magnetic Attachment Applications: The Process and Results of a Survey Using the Delphi Method

M. Hideshima, T. Ichikawa, H. Koshino, K. Hoshiai, J. Tanaka, S. Ozawa, Y. Suzuki, Y. Umekawa, T. Ishigami, K. Nagao[1], M. Sone[1], M. Kono[1], J. Wada[1], J. Wadachi[1] and A. Nishiyama[1]

Dental Care Council and [1]Special Committee for the Japanese Society of Magnetic Applications in Dentistry

In the era of evidence-based medicine, clinical practice guidelines (CPG) have become an integral task of each academic society. The council for the dental care of the Japanese Society of Magnetic Applications in Dentistry (JSMAD) also performed a questionnaire survey for the purpose of preparing CPGs for magnetic attachments. A total of 147 clinical questions (CQs) were returned and divided into 5 categories according to their applications. Categories dealt with implants, type of defect, occlusion and periodontics, arrangement and configuration, management, etc. Fourteen typical CQs for CPGs were selected. For each CQ, the committee asked the prosthodontic departments of several universities to conduct a literature search and to write thorough, systematic reviews. However, related literature for each CQ was lacking, and formulating CPGs according to the GRADE group system was quite complicated. Therefore, the committee asked 71 clinical experts, referred to as our "consensus group," to reply to the same questionnaire twice, presenting the former results and analyzing the effect for each outcome according to the Delphi method.

Objective

The objective of this survey was to analyze the opinions of clinical experts of MAs and to develop a consensus of opinion for CQs in the absence of evidence providing guidance on topics that have not been studied in randomized controlled trials (RCTs).

Materials and Methods

The council for the dental care of JSMAD performed a questionnaire survey for the purpose of preparing CPGs for the magnetic attachments. A total of 147 clinical questions (CQs) were divided into 5 categories according to their applications, and 14 typical CQs shown below were selected.

1. Implant

1) In the case of implant-supported overlay dentures, are magnetic attachments (MAs) more effective than other types of retainers?
2) In case of implant-supported overlay dentures, is the application of MAs to implant abutments superior to applying them to natural teeth?
3) When applying magnetic MAs to implant-supported overlay dentures, are maxillary applications superior to mandibular applications?
4) When applying magnetic MAs to implant-supported overlay dentures, are multiple abutments with MAs more effective than single abutments?

2. Defects
5) In cases in which individuals have few mandibular teeth, is the application of MAs more effective than the use of other types of retainers?
6) In cases involving removable partial dentures with a free-end saddle, is the application of MAs more effective than the use of other types of retainers?
7) In cases involving overlay dentures, is the application of MAs more effective than the use of other types of retainers?

3. Occlusion/Periodontics
8) In cases of partially edentulous patients without occlusal contact, are MAs superior to other type of retainers?
9) In cases of partially edentulous patients with undulating occlusal planes, is the application of MAs more effective than the use of other types of retainers?
10) When periodontal disease is affecting remaining abutments, is the application of MAs superior to the use of other types of retainers?

4. Arrangement/Form
11) When applying MAs to multiple abutment teeth, are symmetrical arrangements more effective than asymmetrical ones?
12) When applying MAs to remaining abutment teeth, are flat-type keepers more effective than dome-shaped keepers for stability of the denture?

5. Management/etc.
13) When undergoing MRI examinations, are there more artifacts in the images with MAs than in those with other types of retainers?
14) When applying MAs to removable partial dentures, is the applied pressure method superior to minimum pressure methods?

For each CQ, the committee asked the prosthodontic departments of several universities in which staff belong to JSMAD to conduct literature searches and summarize systematic reviews. However corresponding literature or high-quality clinical data for each CQ were limited in number or entirely absent. Therefore, the committee selected 71 clinical experts of MAs, our "consensus group," including 36 members and 35 non-members of JSMAD, and asked them to reply to the questionnaire according to the Delphi method in order to achieve a consensus of clinical opinions.

In the absence of evidence from all 14 CQs above, 10 CQs were selected for the Delphi questionnaire. The questionnaire was framed with 11 outcomes, which were affected or not affected by applying MAs in each CQ (Table 5). The effect of each outcome was rated on a scale from -5 to +5.

The first questionnaire (round 1) contained questions regarding the experts' clinical experience with MAs and implants (Tables 1–4).

The committee sent similar questionnaires twice; in the second questionnaire, the committee provided anonymous statistical summaries of round 1 responses so that the responders could compare them with their own opinions (Table 5).

Results

Thirty-eight experts from the consensus group replied to the questionnaire regarding 11 outcomes in 10 CQs.

The tables below show the clinical experience of the experts (consensus group).

Clinical experience of the consensus group

Years of clinical experience	Number of persons
10y～	34
5～10y	3
2～5y	1
～2y	0

Table 1: Participants classified by years of clinical experience (N=38)

Number of MA cases	Number of persons
10～	35
5～9	2
1～4	1
None	0

Table 2: Participants classified by number of MA cases (N=38)

Years of clinical experience of implant cases	Number of persons
10y～	17
5～10y	9
～5y	2
None	10

Table 3: Participants classified by years of clinical experience with implant cases (N=38)

Number of MA cases in implant	Number of persons
10～	13
5～9	4
1～4	7
None	14

Table 4: Participants classified by number of cases of MA applied to implant (N=38)

Results of the Delphi method

The results of this 2-round survey showed convergence of noneffective (0) or bimodal distributions.

The tables below show the results of CQ6. The upper value of each column shows the rating scale from -5 to +5, and the lower value of each column shows the distribution of the number of experts. Red bold values show the results of round 2 that are different from those of round 1.

【CQ6 : In cases involving removable partial dentures with a free-end saddle, is the application of MAs more effective than the use of other types of retainers?】

・**Please select the number below according to the effect on each outcome when you apply MAs on removable partial dentures with a free-end saddle** (suppose the case was in maxillary

Kennedy class Ⅰ and abutments were bilateral premolars or canines).

← opposite effective noneffective effective →

	-5	-4	-3	-2	-1	0	1	2	3	4	5
1. Effective for the retentive force of denture retainers	0	0	0	1	**0**	4	**0**	**3**	**21**	**6**	**3**
2. Effective for masticatory function	0	0	**0**	0	0	**17**	**0**	2	**10**	**5**	**4**
3. Effective for pronunciation	0	0	0	**0**	0	**21**	**0**	**1**	**10**	**3**	**3**
4. Effective for esthetics	0	0	0	0	0	**7**	**0**	**2**	**3**	**10**	**16**
5. Effective for comfort (or discomfort, wearing sensation)	0	0	0	0	0	**1**	**1**	**2**	**20**	**8**	6
6. Effective for adaptability (management or repair)	0	**0**	**2**	**1**	**0**	**6**	**0**	**2**	**20**	**4**	3
7. Effective for durability (longevity of abutments or dentures against periodontal disease/dental caries)	0	**0**	0	**0**	**0**	**19**	**1**	**3**	**10**	**2**	**3**
8. Effective for maintaining sound periodontal tissue	0	**0**	1	**0**	0	**17**	1	**9**	**3**	**3**	4
9. Effect on imposition (physical and time-consuming strain on patients or doctors)	**1**	**1**	1	3	0	**26**	**1**	**1**	4	0	**0**
10. Effect on harm (damage from tooth reduction or pain)	**1**	**1**	4	**0**	**0**	**27**	**1**	**0**	**4**	**0**	**0**
11. Effective in reducing cost	**6**	**1**	4	**4**	0	**21**	**0**	1	**1**	**0**	0

(Upper value: rating scale, lower value: number of persons, (red) bold: round 2 results different from round 1)

Discussion

Most of the prosthodontic issues including MAs do not yield to randomized clinical trials or to stepwise quantitative data analysis. In such cases, experts use their training and personal anecdotal experience to help them make decisions in a variety of practical contexts. In these circumstances, the consensus opinion of experts provides a formal structured process for decision support.

The Delphi method provides anonymity for study participants and has been found to produce more frequent and stable consensus than do other methods. Delphi is described as a structured group communication process that allows a clinical decision-making group to resolve complex problems with the goal of producing useful guidance and opinions for decision makers. The Delphi technique refines expert opinion data through consideration of anonymous input from other peer experts and, over repeated applications, generates a considered consensus.

An open-ended survey should be sent to experts who, in turn, provide responses that allow the Delphi experimenter to frame items for subsequent surveys. In the first round of this survey, some experts mentioned indistinct clinical situations for each MA CQ. Therefore, detailed clinical situations were added to each CQ in the second round so that responders could consider similar cases that would lead to converging opinion and consensus.

The results of this survey tended to converge toward noneffective (0) in each outcome, which showed diverging distribution in the first round. Also, the distribution of the second round tended to converge to a certain value as compared to the first round, which represents more effective or opposite effective.

Conclusion

- A total of 14 typical CQs—Implant, 4; Defects, 3; Occlusion/Periodontics, 3; Arrangement/Form, 2; Management/etc., 2—were selected.
- The Delphi questionnaire survey was administered to 71 experts for 10 CQs in the absence of evidence.
- Eleven outcomes that were affected by MAs in each CQ were selected and were evaluated with a rating scale from -5 to +5.
- Thirty-eight experts replied; more than 10 had no clinical experience in applying MAs to implants.
- The distribution of the effect of MAs on each outcome tended to converge in the second survey.

Acknowledgements

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