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March 7 to 25, 2011

The Japanese Society of Magnetic Applications in Dentistry

日本磁気歯科学会

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The Japanese Society of Magnetic applications in Dentistry

The 10th International Conference on Magnetic Applications in Dentistry

The 10th International Conference on The Japanese Society of Magnetic Applications in Dentistry organized by JSMAD was held on the Internet as follows;

Meeting Dates:

March 7 to March 25, 2011

Location:

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Conference Secretariat:

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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

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The 11th International Conference on Magnetic Applications in Dentistry General Information

The Japanese Society of Magnetic Applications in Dentistry (President: Tomohiko Ishigami, Nihon University) is a scientific association founded in 1991 and is devoted to furthering the application of magnetism in dentistry. The 9th International Conference on Magnetic Applications in Dentistry organized by JSMAD will take place on the Internet as follows.

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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

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Session 4 ***Chair: Masayuki Hideshima***

Session 5 ***Chair: Tatsuhiko Masuda***

Laser welding between magnetic stainless steels and titanium as a shield-ring and spacer material

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Division of Dental Biomaterials, Tohoku University Graduate School of Dentistry
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Introduction

The non-magnetic stainless steel, SUS316L, is used as a shield-ring or spacer material to form a magnetic circuit in closed magnetic circuit attachments, although it contains nickel. In view of the recent global movement against the use of nickel, it would be desirable to find nickel-free non-magnetic materials to substitute for SUS316L.

The requirements for shield-ring and spacer materials include many specifications, such as non-magnetism, excellent corrosion resistance, and good workability. The shield ring or spacer is usually welded to yokes made of magnetic stainless steels such as SUS444, SUSXM27, and SUS447J1 using a laser beam. Weldability is an important factor for magnetic attachments because a complete weld seals a corrosive rear earth magnet core and prevents saliva from leaking inside.

Objective

In this study, we focused on pure titanium as a nickel-free material used for the shield ring and the spacer and examined its weldability to magnetic stainless steels using laser welding.

Materials and Methods

1. Materials

SUS447J1, SUSXM27 and AUM20 (comparable to SUS444) were chosen as magnetic stainless steels used in commercially produced magnetic attachments. Pure titanium (Grade 1) and gold (>99.99 mass%) were also used. The composition of the stainless steels is shown in Table 1.

Table 1 Chemical compositions of each stainless steel

SUS	Cr	Ni	Mo	C	Si	Mn	P	S	Fe
444	18.9	-	2.1	0.01	0.01	0.02	0.003	0.003	Balance
XM27	26.02	0.011	1.34	0.007	0.11	0.07	0.008	0.005	Balance
447J1	30.38	-	1.82	0.004	0.11	0.11	0.02	0.005	Balance

Methods

1.1 Specimens

Each stainless steel and titanium sheet was cut and shaped to the size of 5 mm x 20 mm x 0.7 mm. The sheets were polished with #180-600-grid emery papers. In particular, the welded part of the edge was carefully polished at the right angle to the surface. Titanium was rolled to a thin sheet with a thickness of 0.3 mm and shaped to the size of 5 mm x 0.7 mm.

Two types of specimen were used, as shown in Fig. 1. The first type was a couple of stainless steel and titanium pieces (each 5 mm x 20 mm x 0.7 mm). Another type was a couple of stainless steel pieces that wedged the titanium thin ribbons between them.

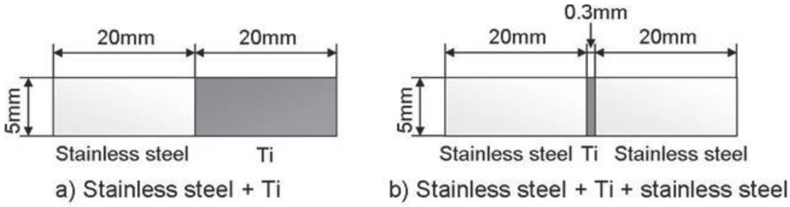


Fig. 1 Two types of specimen used for laser welding

1.2 Laser welding

The YAG laser machine (ALS100, ALPHA LASER GmbH, Germany) was used (Fig.2), and the automatic moving stage which was controlled by a computer, was equipped to keep a constant distance between beads (Fig.3).

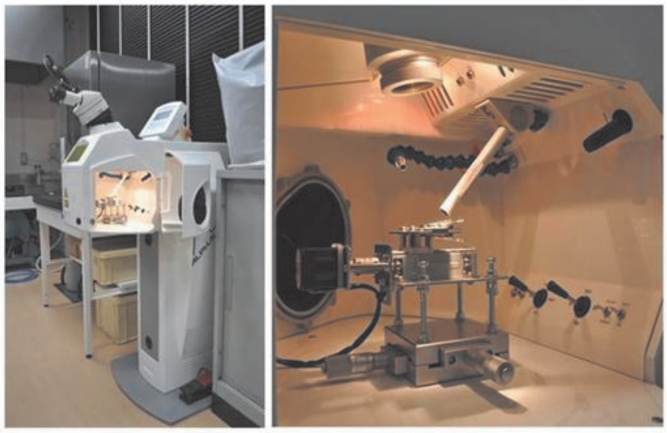


Fig. 2 YAG laser machine (ALS100)
(Crystal: Nd YAG, Wave length: 1064nm, Maximum power: 100W, Pulse energy: 95J)

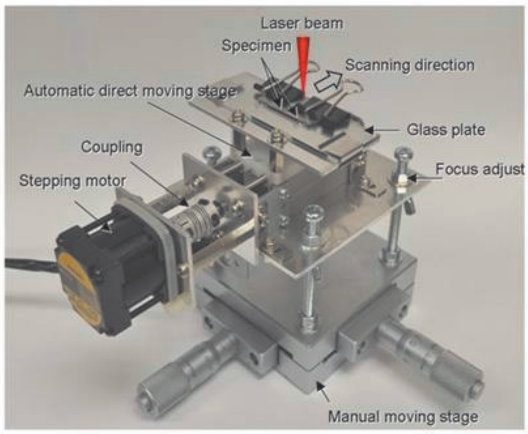


Fig. 3 The automatic moving stage controlled by a computer

The boundaries between each stainless steel and titanium piece were welded using the YAG laser machine (n=5) while spraying with Ar gas. In the case of the titanium thin ribbons that were wedged between a couple of stainless steel pieces, the sandwiched lines were also welded in the same way (n=5). The welding conditions are shown in Fig. 4.

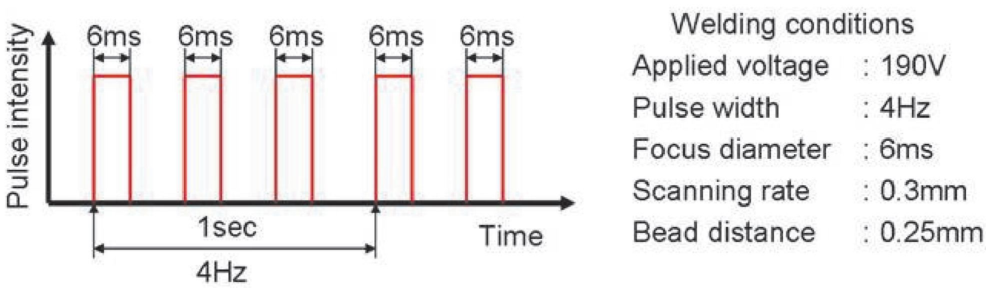


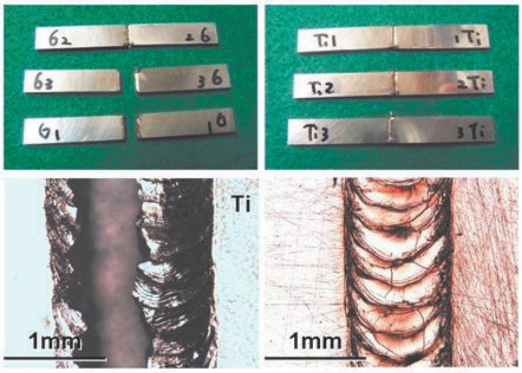
Fig.4 Welding conditions

1.3 Evaluation

Weldability between titanium and each stainless steel was evaluated using two simple methods: a bending test and observation of the welded zone using an optical microscope.

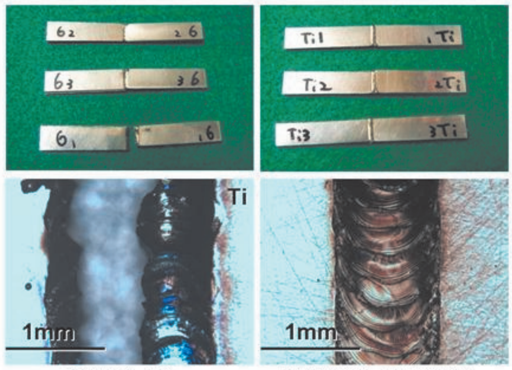
Results

The welded specimens and zones between titanium and each stainless steel were shown in Figs. 5-7. When titanium was welded with each stainless steel, some large cracks were observed on the beads. The running cracks extended to the inside of the beads as shown in the cross section of the beads between titanium and 447J1 stainless steels (Fig.7).



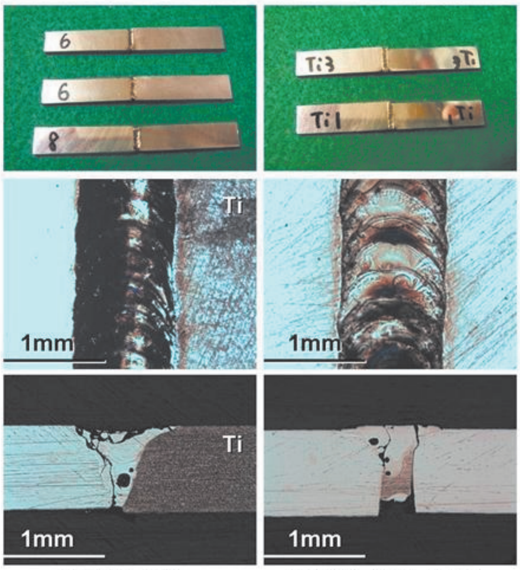
a) 444 + Ti　　b) 444 + Ti + 444

Fig. 5 The welded specimens and zones between titanium and SUS444(AUM20)



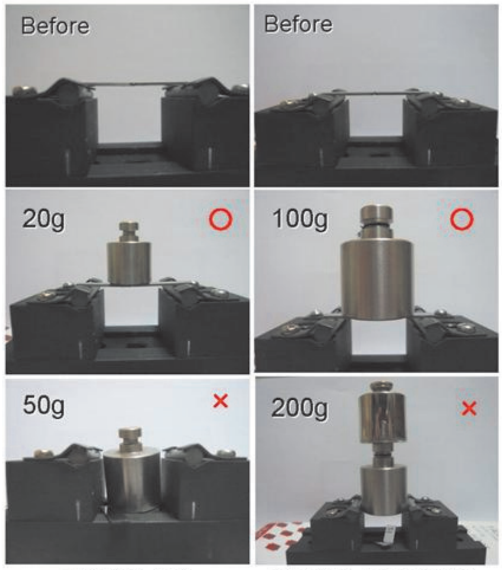
a) XM27 + Ti　　b) XM27 + Ti + XM27

Fig. 6 The welded specimens and zones between titanium and SUSXM27



a) 447J1 + Ti　　b) 447J1 + Ti + 447J1

Fig. 7 The welded specimens and zones between titanium and SUS447J1



a) 447J1 + Ti　　b) 447J1 + Ti + 447J1

Fig. 8 Weldability of SUS447J1 by the simple bending test

The results of the simple bending test are shown in fig.8. All of welded zones broke down easily. In the case of the thin titanium ribbon wedged between the stainless steels, the bending load below 200g also destroyed all of the sandwich line.

Discussion

According to the ternary phase diagram of the Fe-Cr-Ti system, [1] the formation of hard and brittle intermetallic compounds apparently caused large cracks and weakened the weld zone. Probably, a composition containing less titanium causes phases including the intermetallic compounds of $Cr_6Fe_{18}Ti_5$, Fe_2Ti, or Cr_2Ti. When we made alloys that were almost intermertallic compounds ($Cr_6Fe_{18}Ti_5$ and 33.3at%Ti-33.3at%Fe-33.3at%Cr alloys) and tapped them with a hammer, they broke easily (Fig.9). However, an alloy containing a significant amount of titanium, such as the 83at%Ti-11at%Fe-6at%Cr alloy, showed some ductility since it might have a meta-stable β phase because of β phase at high temperature (Fig.9).

Fig.9 The alloys whose composition was almost intermatallic compounds and the side containing much titanium

If a significant amount of titanium can melt into the bead, a meta-stable β phase possibly forms in the bead and adds ductility to the weld zone.

Conclusions

Although titanium has the hurdle to control the composition of the bead, the meta-stable β phase containing in the bead possibly improve weldability between titanium and magnetic stainless steels.

References

1. Villars A., Prince A. and Okamoto H., Handbook of Ternary Alloy Phase Diagrams, ASM International, 1997.

Questionnaire Survey for Formulating Clinical Practice Guidelines for Magnetic Attachment Applications - Analysis and Selection of the Clinical Questions (CQ) -

M. Hideshima, Y. Igarashi, T. Ichikawa, J. Tanaka, T. Kochi, T. Ishigami, T. Andoh[1] and A. Nishiyama[2]

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Introduction

Clinical practice guidelines (CPGs) are integral to evidence-based medicine among academic societies, and the Japanese Society of Magnetic Applications in Dentistry (JSMAD) has established a dental care council that has examined the CPGs as they relate to magnetic applications in dentistry and the directions of the Japanese Association for Dental Science.

The council developed a preliminary questionnaire survey dealing with the subject of magnetic attachments and distributed it to the board members in order to analyze the clinical questions (CQ) that they and their co-workers had.

According to the preliminary survey, the council distributed the questionnaire survey to attendees of the 19th annual meeting of JSMAD and general practitioners belonging to the academic section of dental associations who were not members of JSMAD.

As a result, 117 answers were returned, and a total of 147 clinical questions (CQs) were divided into 5 categories according to their applications. The numbers of CQs in each category dealing with implants were 21; with type of defect, 51; with occlusion and periodontics, 17; with arrangement and configuration, 27; and with management or others, 31. Fourteen typical CQs for CPGs were selected.

Objective

The objective of this survey was to analyze the variety of clinical questions asked by general practitioners with regard to the use of magnetic attachments and to encourage them to develop them and refer to them to formulate CPGs.

Materials and Methods

For a preliminary study, 30 present and former council members of the Japanese Society of Magnetic Applications in Dentistry (JSMAD) were surveyed by e-mail with a questionnaire attachment.

The recipients of the questionnaire were instructed to answer the survey and distribute it among the pertinent professional members of their offices. According to the preliminary survey, the council members distributed the survey among attendees of the 19th annual meeting of JSMAD at Morioka, Iwate Prefecture, and sent the survey by letter to general practitioners belonging to the academic section of the dental associations who were not members of JSMAD. The council members also published the questionnaire survey in the annual journal and on the JSMAD web homepage.

The survey contained questions regarding the clinical experience, work place, and affiliation of the individual answering the questions (Table 1). A procedure that we refer to as "PICO" was used to categorize the Clinical Questions (CQ). The acronym uses "P" to represent the "problem" or "patient," "I," "intervention," "C," "comparison," and "O," "outcome" (Table 2).

The completed questionnaires were returned by e-mail, FAX, or regular mail, and they were also hand-collected at the 19th annual meeting.

Q1.　How many years have you practiced clinical dentistry?
・resident　・2～4 years　・5～9 years　・over 10 years
Q2.　Where do you routinely work?
・university hospital　・general hospital　・private dental office
・general dental office (e.g.: dental office at a business company)　・other (__________)
Q3.　Are you a member (certified clinician) of the Japanese Society of Magnetic Applications in Dentistry (JSMAD)?
・non-member　・member（・certified clinician for magnetic dentistry）
Q4.　How many magnetic attachments have you used?
・none　・1～4　・5～9　・more than 10

Table 1: Contents of the questionnaire (Q1～4: clinical experience and affiliation)

Q5. Please write the questions below that occur most frequently in your practice regarding the application of magnetic attachments. Please write in fewer than 5 questions in the space provided below by reference to the example questions.

In case of ～ (patient or problem: P)	is ～ (intervention: I)	compared to～ (comparison: C)	effective? (outcome: O)
1) In case of few remaining mandibular teeth	is a magnetic attachment	compared to applying clasps	effective?
2) In case of implant-supported overlay dentures,	is a magnetic attachment	compared to other types of retainers	effective?
3) When applying a magnetic attachment to a remaining abutment tooth	is a flat-type keeper	compared to dome-shaped keepers	effective for stability of the denture?
①			
②			
③			
④			
⑤			

Table 2:　Questionnaire regarding clinical questions (Q5: CQ)

Results

A total of 117 participants completed the questionnaire, and 147 CQs were collected.
The tables below show the clinical experience and affiliation of the participants.

Clinical experience and affiliation

Years of clinical experience	Number of persons
10y～	77
5～10y	18
2～5y	21
Resident	1

Table 4: Q1. Participants classified by years of clinical experience (N=117)

Workplace	Number of persons
Dental Office	67
University Hospital	50

Table 5: Q2. Participants classified by workplace (N=117)

	Number of persons
Member	52
Non-member	65

Table 6: Q3. Participants classified as member or non-member of JSMAD (N=117)

Number of cases	Number of persons
10～	58
5～9	12
1～4	24
None	23

Table 7: Q4. Participants classified by number of cases of MA (N=117)

Clinical questions (CQ)

A total of 147 CQs were divided into 5 categories shown below according to their applications.

1) Applying MAs to abutments of dental implants
(Implant): 21CQs
2) Compared to other types of retainers when applying in individual type of defects (e.g. Kennedy class I mandibular defect)
(Defects): 51CQs
3) Compared to other types of retainers when applying in individual type of occlusion (e.g. partially edenturous cases without occlusal contacts) or concerning periodontal disease
(Occlusion/Periodontics): 17CQs
4) Arrangement of MAs in the remaining dentition or configuration of MA
(Arrange / Form): 27CQs
5) Management of MAs or others (Manage/etc.): 31CQs

The figures below show the distribution of each categorized CQ classified by workplace (Fig. 1) and member/non-member of JSMAD (Fig. 2).

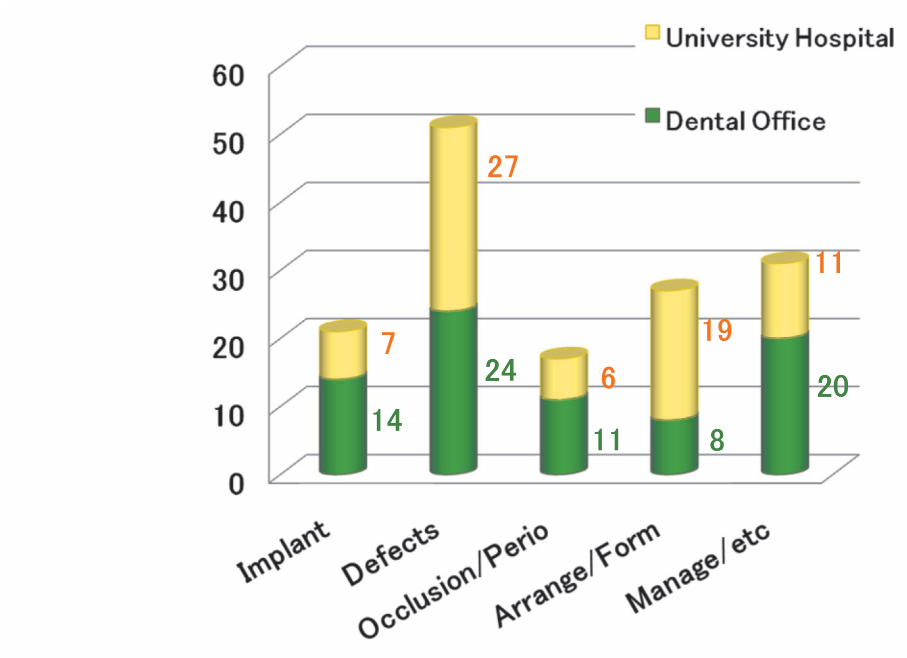

Fig. 1: Distribution of each categorized CQ classified by workplace

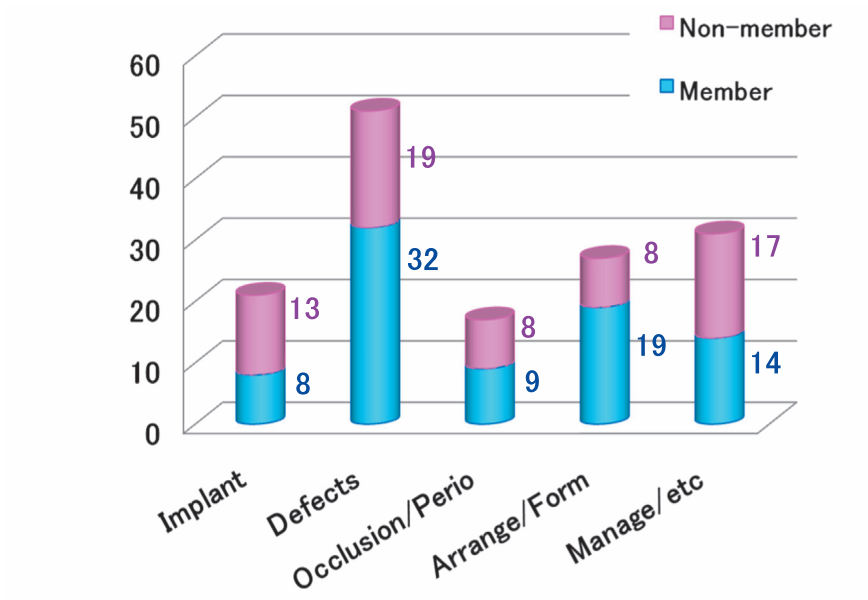

Fig. 2: Distribution of each categorized CQ classified by member/non-member of JSMAD

A total of 14 typical CQs in 5 categories were selected from the 147 CQs as follows.

1) Implant

(1) In 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 than mandibular ones?
(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 case of partially edentulous patients without occlusal contact, are MAs superior to other type of retainers?
(9) In cases of partially edentulous 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 there are in those with other types of retainers?
(14) When applying MAs to removable partial dentures, is the applied pressure method superior to minimum pressure ones?

Discussion

The results of this survey indicate that two-thirds of the participants had more than 10 years of clinical experience and one-half of them had used MAs at least 10 times. Fifty-eight percent of the participants were general clinicians at dental offices, and 56 percent of them were not members of the Japanese Society for Magnetic Applications in Dentistry (JSMAD). Although, in the preliminary survey, the ratio of dental office workers to non-members of JSMAD was quite low, it was still greater than 50 percent. To develop universal clinical guidelines, it would be valuable to seek a greater consensus and collect many CQs from individuals new to the clinical practice of dentistry, dental office workers, and those who are not members of JSMAD.

The PICO procedure is an effective way to answer clinical questions. First, the PICO question is formulated; next, the relevant domain (therapy/prevention, diagnosis, etiology/risk, or prognosis) is established, along with the type of research by means of which the question will have to be answered.

According to the GRADE (Grading of Recommendations Assessment, Development and Evaluation) group system, PICO format CQ and corresponding answers are synthetically recommended to formulate based on the balance with factors of evidence-based articles, doctors skill or speciality and patients demand. A thorough search of evidence-based articles for answers to some of the CQs would be a difficult task. However, it would be possible using another type of questionnaire survey addressing multiple expert clinicians, such as the Delphi Method.

Approximately one third of the 147 collected CQs were classified according to the type of defect, e.g., mandibular few remaining dentition or free-end saddle cases; 53% of them were from university hospital practitioners, and 62% from members. As for implants, 14% of the 147 CQs were accounted, and 62% of those were received from dental office practitioners, 50% of whom were members of JSMAD. Affiliation of the participants reflected differences in their clinical interest.

The 14 typical CQs were placed into 5 categories. A committee will seek expert advice for conducting a literature search related to the CQs, and the committee will write thorough systematic reviews.

This questionnaire survey additionally inquired opinions from individuals regarding whether social health insurance should cover treatment with magnetic attachments. Results of the distribution of agree, agree with reservations and disagree were dispersed and the committee could not develop a process of advanced medical care of MAs which the Japan Dental Society advocates.

The JSMAD currently lacks sufficient information required to make recommendations regarding health insurance coverage for MAs, and therefore, caution is required when referring to general practitioners expressing opinions on this subject concerning social health insurance.

Conclusion

- A questionnaire survey was conducted to collect Clinical Questions (CQs); 117 surveys were completed, and 147 CQs were collected.
- Half of the participants were clinicians with more than 10 years of experience, each averaging 10 cases involving MAs.
- CQs were classified into 5 categories: Applications to implants (Implant), 21; Comparison of MA among other retainers with individual type of defect (Defects), 51; Comparison of MA among other retainers with individual type of occlusion or with periodontal disease (Occlusion/Periodontics), 17; Arrangement with regard to dentition or configuration of MA (Arrange/Form), 27; and Management of MAs or others (Manage/etc.), 31.
- A total of 14 typical CQs; Implant, 4; Defects, 3; Occlusion/ Periodontics, 3; Arrange/Form, 2; Manage/etc., 2 were selected.

Acknowledgements

Members of the council are grateful to the participants for their cooperation with this study and hopeful that they will participate in the continuation of this effort.

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Retentive force and magnetic flux leakage of small sized keeper

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[2]Division of Clinical Research, Dental Research Center, Nihon University School of Dentistry
[3]GC Corporation

Introduction

Dental magnetic attachments of various types and sizes with a history of satisfactory retentive force and stability are now commercially available.[1,2] From among the various sizes of magnetic attachments available, the magnetic attachment is usually selected according to the size and shape of the cross section of the retained root.[3,4] In addition, it is difficult to apply circle-formed attachments to a shaped root with an elliptical cross section. To solve this clinical problem, GC produced a new magnetic attachment, GIGAUSS C800 (C800). The minor axis of the keeper is 0.2 mm smaller than the corresponding magnetic attachment.

Objective

This study sought to evaluate the retentive force and magnetic flux leakage of C800 in comparison with those of D800.

Materials and Methods

The magnetic attachments used in this study and the equipment are presented in Table 1. Two cylindrical magnetic assemblies, GIGAUSS C800 (C800; GC, Tokyo, Japan) and GIGAUSS D800 (C800), were assessed in this study. The size of the magnetic attachments is shown in Figure 1.

Material	Brand Name and Lot Number	Manufacturer
Magnetic attachment	GIGAUSS D800 1007261	GC Co,Tokyo,Japan
	GIGAUSS C800 100913	GC Co,Tokyo,Japan
Equipment	**Products**	**Manufacturer**
Universal testing machine	EZ-Test	Shimazu Co,Kyoto,Japan
Retentive force testing jig	K797-01	Tokyo Giken,Inc,Tokyo,Japan
Gaussmeter	5180	Sypris Test and Measurement,Orland,FL
Dedicated measuring probe	STB1X-0201	Sypris Test and Measurement,Orland,FL

Table1 Material used in this study

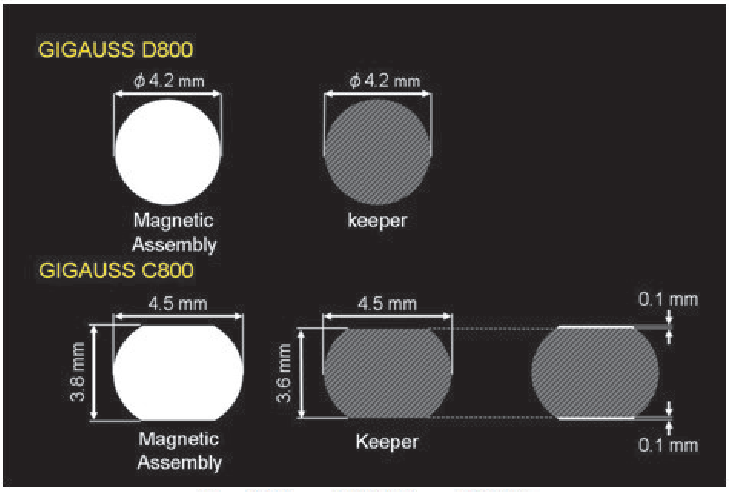

Fig.1 Size of D800 and C800

The retentive force was measured in a universal testing machine (EZ-TEST; SHIMADZU Co., Kyoto, Japan) using a retentive force testing jig (Nichidaigata; Tokyogiken), and C800 and D800 magnet-keeper combinations were tested at a crosshead speed of 5 mm/min. The vertical retentive force testing jig consisted of a linear ball slide (Linear Ball Slide; THK America, Inc., Schaumburg, Ill) and a universal joint to regulate traction in the perpendicular direction (Fig. 2). The jig was installed in a universal testing machine. Rectangular parallelepiped acrylic resin blocks (15 × 15 × 20 mm) were placed at the bottom and the traction side of the jig. The keeper and magnetic assembly were attached with cyanoacrylate adhesive (Aron Alpha; TOAGOSEI CO., Tokyo, Japan) in the center of the acrylic resin block. Without allowing for any space between the keeper and magnet assembly, the magnetic assembly was held in place by its force of attraction. The magnetic retentive force of each attachment was measured by attaching the magnetic assembly to the keeper and then dislodging it. Each magnet-keeper combination in a group was tested 5 times, and the mean values were compared.

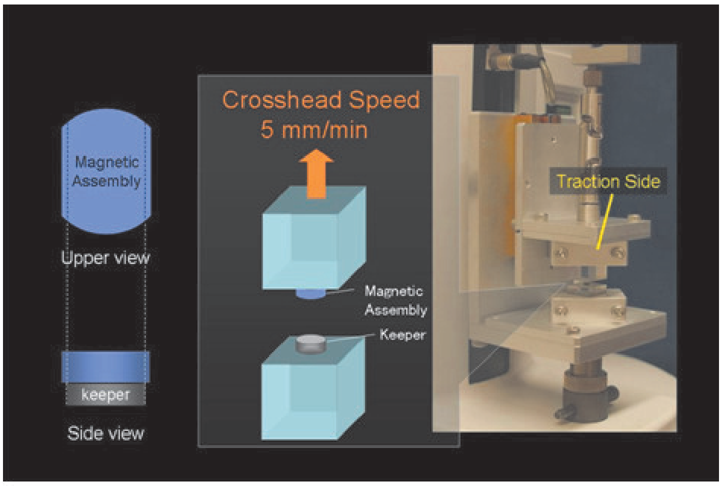

Fig.2 Universal testing machine using a retentive force testing jig

Magnetic flux leakage was measured using a Gaussmeter (F.W Bell 5180; Sypris Test and Measurement, Orlando, FL) and a dedicated measuring probe (Ultra Thin Transverse Probe STB1X-0201; Sypris Test and Measurement, Orlando, FL) (Table I). Ten measurements (2 groups × 5 measurements) were made at 3 points: A, at the outside interface of the keeper and magnetic assembly; B, beside the keeper; and C, at the bottom of the keeper. The probe has an active area that is located 0.3 mm from the tip surface, and the measurement was performed when the probe was in contact with the specimen (Fig. 3).

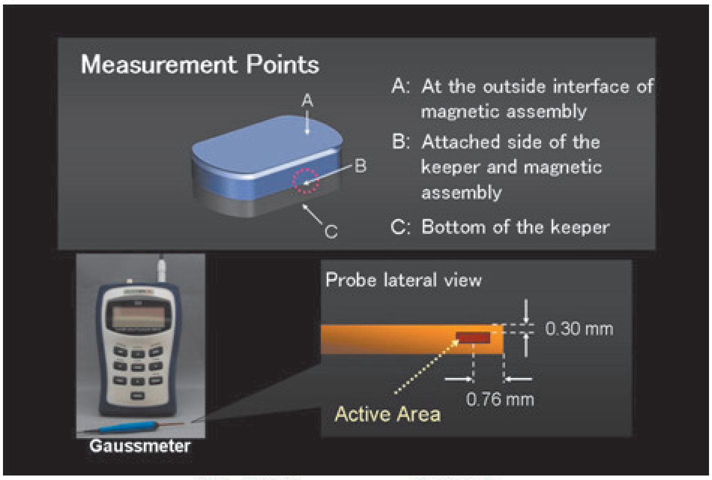

Fig.3 Measurement Points

Data were analyzed with a 1-way analysis of variance (ANOVA), and differences between the groups were analyzed with Tukey's Honestly Significant Difference (HSD) post hoc test (α = .05).

Results

The mean retentive force was 700.0 gf for D800 and 719.1 gf for C800. C800 was significantly higher than D800 (p <.05) (Fig. 4).

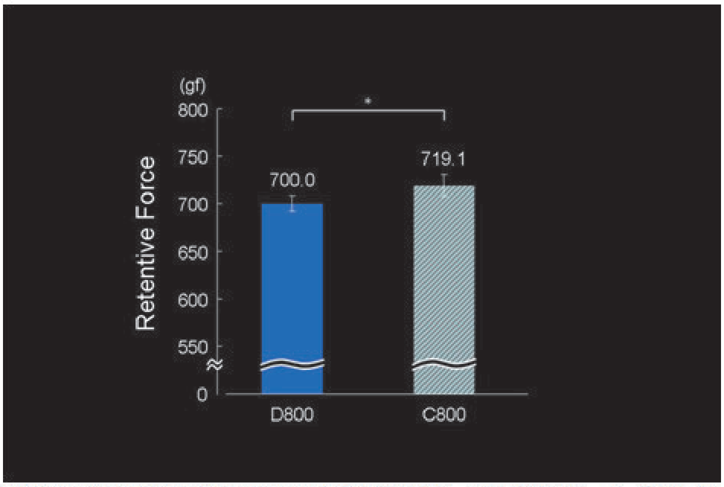

Fig.4 Mean retentive force result for D800 and C800　p <.05 (n = 5)

The results for magnetic flux leakage are shown in Figure 5. D800 of magnetic leakage was significantly higher at B than at A and C (p<.05). C800 of magnetic flux leakage was significantly higher at A than at B and C (p <.05). At measurement point A on D800, the mean magnetic flux leakage was 29.8 mT, and that at point A on C800 was 27.7 mT; there was no significant difference between D800 and C800 (p <.05). At measurement point B, the mean magnetic flux leakage was 32.0 mT for D800 and 14.6 mT for C800 (p<.05). C800 showed significantly lower magnetic flux leakage at measurement point B (p <.05).

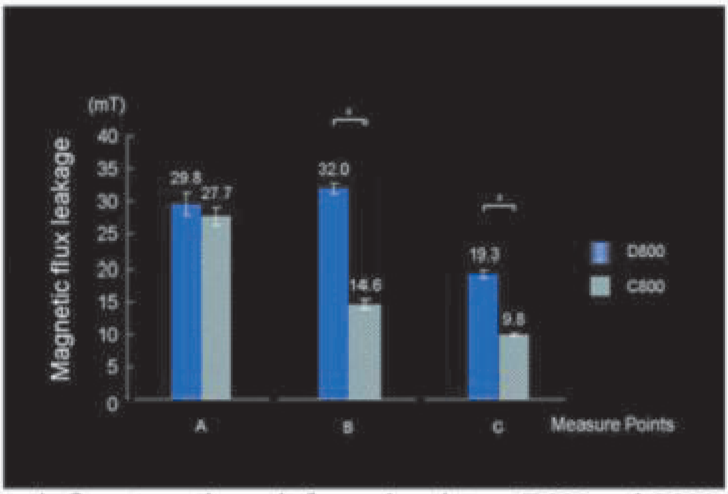

Fig.5Mean magnetic flux strength result for each point at D800 and C800 $p<.05$ (n = 5)

Discussion

No deleterious effects on marginal tissues have been reported; however, there is a need to clarify how the long-term use of magnetic attachments in the oral area might affect patients. The magnetic flux strength decreased in proportion to the square of the distance. As the magnetic attachment is not attached directly to oral tissue because the keeper is attached to a structure composed of metal dental materials, there is sufficient distance from the magnetic attachment to the marginal gingival tissue.

The results indicated that C800 has a stronger attractive force and C800 has a lower magnetic flux leakage than D800 at every measurement point; nevertheless, C800 has a smaller keeper than D800. A possible reason for the results in this study is the differences in the shapes of C800 and D800 magnetic assemblies. D800 and C800 have an undercut groove for retention. However, the circle-shaped D800 needs higher retention than the elliptically shaped C800. Therefore, the undercut of D800 is bigger than that of C800. This groove affects the magnetic circuit.

Furthermore, the tendency of the magnetic flux at C800 is large on the upper surface of the magnetic assembly; this is in contrast to those of C800 and D800, in which the magnetic flux is large on the attached side of the keeper and magnetic assembly in the marginal gingival tissue area. In this study, both C800 and D800 of magnetic field leakage at 0.03 mm from the magnetic assembly were not above 40 mT, and, therefore, its recommended usage should not adversely affect the human body. Because the 2009 the International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines for exposure to static magnetic fields state that the acute exposure limit for the general public for any part of the body is 400 millitesla (mT). Nevertheless, C800 had a lower magnetic flux leakage than D800 at every measurement point. The magnetic assembly has undercut areas for retention. The undercut area of D800 is larger than that of C800. It is suggested that the undercut area of C800 had a better magnetic circuit than that of D800; therefore, C800 has a lower magnetic flux and stronger attractive force.

In consideration of the retentive force and the magnetic flux leakage of C800, this new GUGAUSS C800 attachment has a great potential for clinical applications.

Conclusions

Within the limitations of this study, the following conclusions were drawn:

1. The retentive force of GIGAUSS C800 was higher than that of D800.
2. The magnetic flux strength of GIGAUSS C800 was lower than that of D800.

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Attractive Force Analysis of Implant Magnetic Keeper using Three-Dimensional Finite Element Method

― The effect of surface screw hole pattern design for magnetic attachments ―

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Introduction

The clinical applications of magnetic attachments with implant overdentures has become more common with progressive advances in implant materials and methods of use. The use of the magnetic attachments non-mechanical retentive design and an ease of concealment helps to reduce lateral forces and results in the controlled load transfer to a supporting abutment[1)] . The application and use of magnetic attachments with dental implants permits prosthetic flexibility in implant location and orientation, helping the overall esthetic outcome.

An implant magnetic attachment is secured to a implant fixture using a retaining screw. All screw designs require a superior surface access hole on the the magnetic keeper for placement and removal. These keeper screw access holes used may be of different dimensions depending upon the proprietary instrument size requirements for each design. Few studies are available regarding the influence of a screw hole on attractive force. The finite element method is an effective method for the solution of problems with non-linear material behaviors[2)] . The dynamics of a magnet interior is visualized by using this method, and permits simulation under changing conditions.

Objective

The purpose of the present study was to analyze the effects of differential screw access hole dimensions to an implant keeper upon attractive force and magnetic field using the three-dimensional (3D) finite element method.

Materials and Methods

1. Analysis model

Figure 1 shows a implant keeper prototype used as a reference of the analysis model. An abutment screw is made of magnetic stainless steel, and serves as an implant keeper. An abutment is fixed to the fixture with this screw. A screw hole is located in the center of a keeper. The magnetic assembly is designed to adhere to a magnetic attachment (GIGAUSS D 600; GC). Interior configuration of a magnetic assembly was measured prior to modeling procedures. Actual and proprietary measurements of an attachment were compared to estimate the external shape of the attachment. Internal configuration data was also required for modeling, but was not available. The sample attachment was embedded, sectioned using a diamond cutter, and then internally measured using VF-7510 to determine internal shape and measurement configurations. Figure 2 shows measurements of a magnetic assembly. The magnet embedded in the assembly was a round-shape configuration. Secondly, three keepers with different screw hole locations including a keeper without a screw hole, a keeper with a screw hole in the center, and a keeper with a screw hole in the edge were designed. Figure 3 shows a diagram and size of an implant keeper designed in the present study. An analysis model was constructed using Femap (UGS), and μ-MF (μ-TEC) was used for the

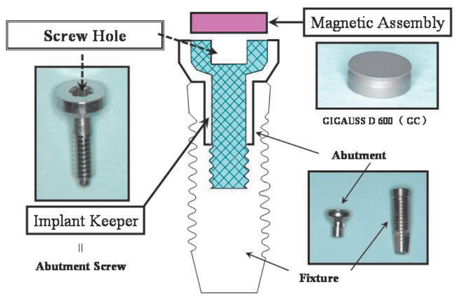

Fig1 : Implant keeper prototype

analysis. Identical element count and nodal point were used for all models. The element type designation was three-dimensional pentahedral and hexahedral elements. Figure 4 shows a constructed finite element model. A quarter model was created for the purpose of evaluating axial symmetry. Analysis range was peripheral 3 mm of a keeper and magnetic assembly. An element breakdown was conducted. A keeper without a screw hole,a keeper with center screw hole, and a keeper with a edge access screw hole are referred to as Models 1, 2, and 3, respectively.

2. Analysis condition

The magnetic property value was determined based on the thermal property of the test magnet (GIGAUSS D 600) obtained from a prior study and compared with proprietary information. (Miyata et al.[3)]) Although fabrication of the original yoke and keeper material is of SUSXM 27 alloy, the proprietary information is not released nor available. Similar steel property values were thus selected for functional similarity of magnetic properties. (SUS447J1 steel material) As the SUS447J1 steel material values were assigned, B-H

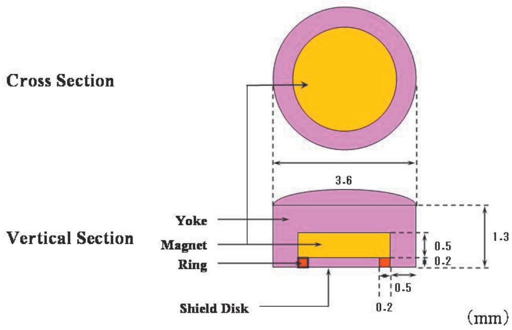

Fig2 : Size of the magnetic attachment

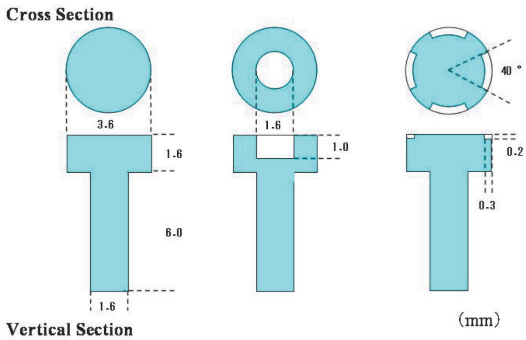

Fig3 : Diagram and size of the implant keeper

curve was then approximated and selected, for

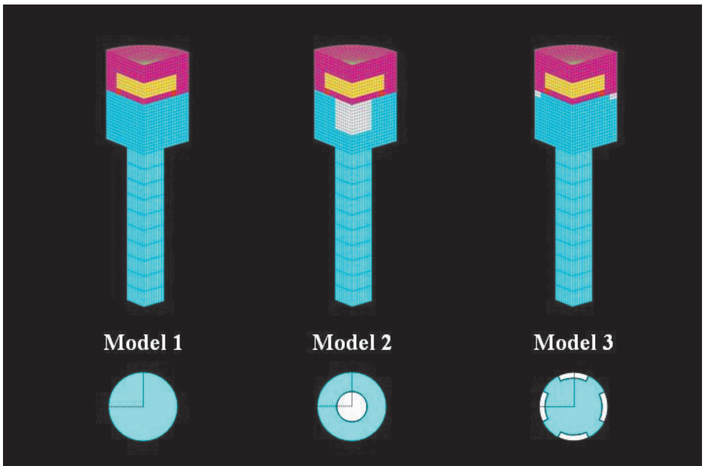

Fig4 : Analysis model

designation of magnetic properties (Table 1). Analysis results were evaluated in terms of magnetic flux density distribution and attractive force.

Table1 : Analysis conditions

- **Component**
  - Magnetic assembly — Magnet : Nd-Fe-B; Yoke : SUS447J1
  - Keeper : SUS447J1

- **Magnetic Characteristic**
  - Magnet — (BH) max = 46 MGOe; Residual magnetic induction = 1.22 T
  - Yoke — Saturation magnetic induction = 1.35 T

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

Results

1. Magnetic flux density distribution

Figure 5 shows the magnetic flux density distribution. No significant difference in the magnetic flux density distribution inside a magnetic assembly was observed. However, on the adhesive surface between a magnetic assembly and a keeper, a high magnetic flux density was observed around the Model 2 screw hole. As for a magnetic flux density inside a keeper, a magnetic flux distribution extended to the inferior part of a keeper in Models 1 and 3.

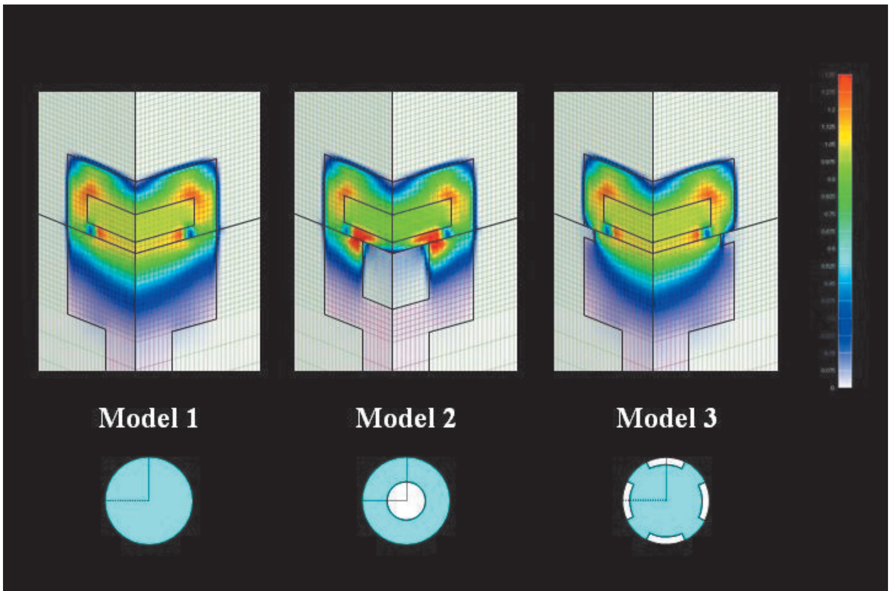

Fig5 : Magnetic flux density distribution

2. Attractive force

Figure 6 shows an attractive force of each model. An attractive force was the highest in Model 1 (520 gf), followed by Model 3 (490 gf), and Model 2 (440 gf). Attractive force decreased by 16% in the Model 2 with a screw hole in the middle, and 6% in the Model 3 with a screw hole in the edge compared to the Model 1 without a screw hole.

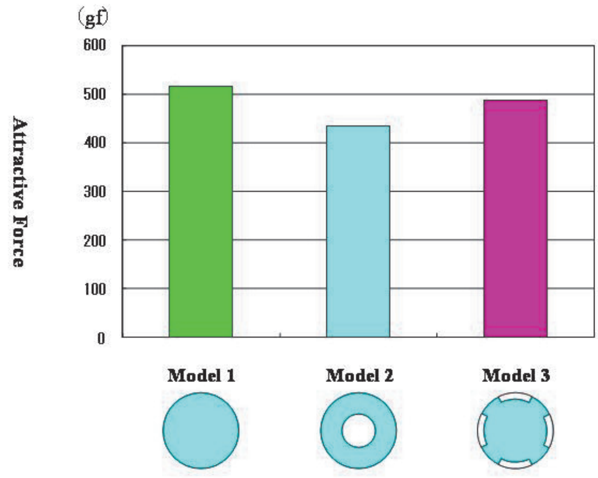

Fig6 : Attractive Force

Discussions

Although magnetic forces and magnetic fields can be measured using specialized measuring devices, it is difficult to design a magnet for maximum magnetic force based solely these values, and to also verify optimal properties with minimal field leakage. The finite element method is an effective way to examine some of these various issues.

Since the space has a magnetic distribution, an integration path of the space around the analysis model and also the interface between the magnetic assembly and keeper needs to be subdivided for evaluation. A preliminary analysis was performed to calculate figures with minimal influence. A subdivided analysis is considered very accurate for these purposes.

The magnetic properties of the magnetic stainless steel and magnet are important for the analysis. However, the detailed magnetic properties are unknown. Therefore, the SUS447J1 steel material values that have similar magnetic properties as SUSXM27 were assigned. The B-H curve was approximated from these values and used in the analysis. Future challenges lie in accurate value measurement and a search for materials with closer magnetic properties as SUSXM27.

The magnetic assembly used in the present analysis was cup yoke type. Magnetic flux density concentrates on the center of a keeper adsorption surface in this type of assembly. The air apace layer in the non-magnetic area screw hole blocks the magnetic flux, and creates high magnetic flux distribution in the surrounding area, resulting in the oversaturated magnetic flux density distribution of the keeper in the Model 2 compared to the Model 1. In the Model 3 which has a screw hole in the edge, magnetic flux was not blocked due to the side location of a screw hole. Therefore, the magnetic flux distribution of the Model 3 was the same as Model 1.

Attractive force is calculated by square magnetic flux density and facing area. The Model 2 with a screw hole in the center showed the biggest decrease in attractive force. This is considered to be due to a decrease in facing area and oversaturated magnetic flux density around a screw hole. In the Model 3 with a screw hole in the edge, a decrease in the attractive force was suppressed despite a decrease in the facing area. This is considered to be due to the small influence of the magnetic flux density inside the keeper. It has been reported that a decrease in attractive force can be prevented by making a screw hole smaller in the Model 2. Further analysis is required to obtain optimized implant keeper configuration.

Conclusions

An influence of the screw hole configuration on an implant abutment attachment magnetic keeper surface was analyzed using three-dimensional finite element method, and the following results were achieved.

1. Oversaturated magnetic flux density was observed inside a keeper around a screw hole in the model with a screw hole in the middle.
2. Attractive force decreased by 16% in the model with a screw hole in the center, and 6% in the model with a screw hole in the edge compared to the model without a hole.

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Introduction of Nonlinear Property into Three-Dimensional Finite Element Method

– Part 2 Mechanical Examination of R.P.D. with Extracoronal Attachment –

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Introduction

Extracoronal attachments are often utilized to eliminate visible clasp retainers for purposes of esthetics and improved comfort. While a bilaterally clasped partial denture is a common design for purposes of cross-arch stability, appropriately designed unilateral partial dentures may be of useful application. The intraoral dynamics of this denture design may be of significance for study.

The evaluation and realistic simulation of differential function of different of prosthetic designs has been previously reported using the finite element method (FEM). The finite element method (FEM) has traditionally evaluated the linear behavior of various materials. The incorporation of non-linear formulas and variables has resulted in improved in-vitro simulation of clinical prosthetic load conditions.

The analysis of periodontal ligament and oral mucosa soft tissues has been selected for evaluation and prosthetic load investigation. In the present study, the simulation of the complex behavior of these soft tissues was accomplished using an analysis program simulating the non-linear properties of these soft tissues.

Objective

The purpose of the present study was to introduce nonlinear tissue behavior properties into the periodontal ligament and oral mucosa analysis models for functional investigation of the different prosthetic designs using extracoronal magnetic attachments.

Materials and Methods

1. Analysis model

Figure 1 shows the analysis model used in the present study. The model was constructed by Ando using patient CT data and study model[1)]. An attachment denture design restoring missing mandibular left first and second molars was used. The lower left canine, first and second premolars were restoratively splinted with a fixed partial denture splint incorporating extracoronal magnetic attachments at the distal abutment.

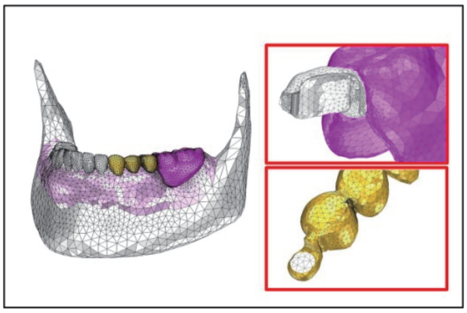

Fig.1 Analysis Model

2. Material non-linear analysis

A custom analysis program was developed to permit non-linear evaluative capacity to the FEM program used. (Fig. 2) The new analysis program automatically changes the material constants of the residual ridge and periodontal ligament in order to simulate material non-linear behavior in a three-dimensional finite element analysis model. The behaviors of the residual ridge and periodontal ligament were approximated to reported human tissue property values[2)]. Additional improvements are reported in this present study. Specified reported material non-linear properties were assigned to the residual ridge and periodontal ligament.

The non-linear tissue modeling capacity results in a test model that may show differential findings in response to a changing test load level. The model behavior response from low to high levels of response would not be accurately representative with linear tissue models of different supporting tissues and structures. The load behaviors of a partial denture, supporting abutments, the attachment behavior under varying load application were investigated.

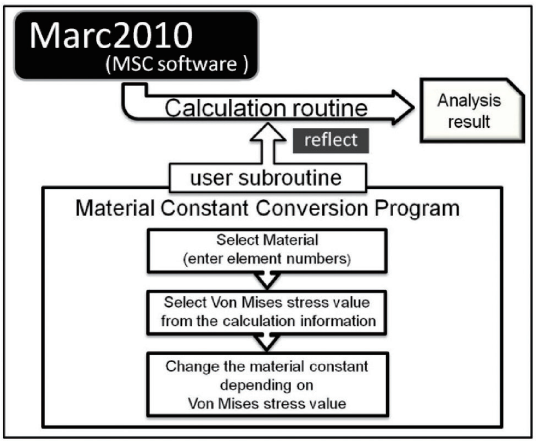

Fig.2 Analysis Method using user subroutine (Material Constant Conversion Point)

2.1 Material non-linear property of the soft tissue

Non-linear properties of the residual ridge and the previously reported human tissue behavior measurements. (Figures 3). Using these human tissue values, these measured were subdivided into 7 parts for the residual ridge, and 3 parts for the periodontal ligament. The load-displacement curves of the residual ridge mucosa and periodontal ligament are shown in Figures 4. Table 1 shows the material constants and stress values for the material constant conversion points.

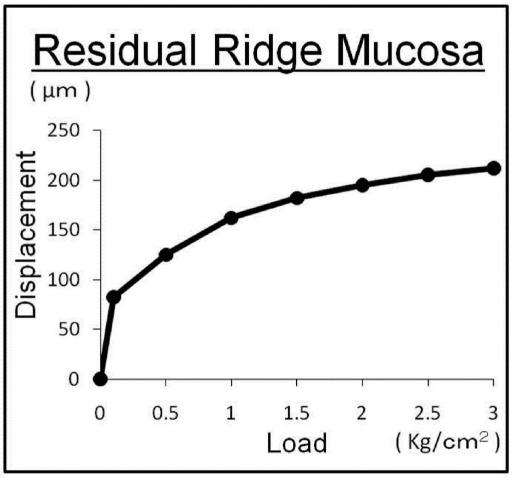

Fig.3 Actual Measurement Value (Residual Ridge Mucosa)

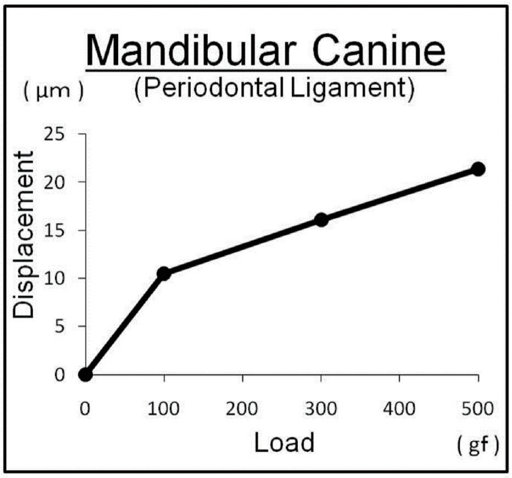

Fig.4 Actual Measurement Value (Mandibular Canine)

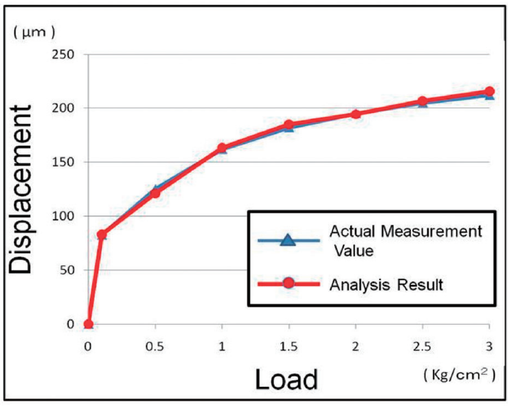

Fig.5 Load-Displacement Curve (Residual Ridge Mucosa)

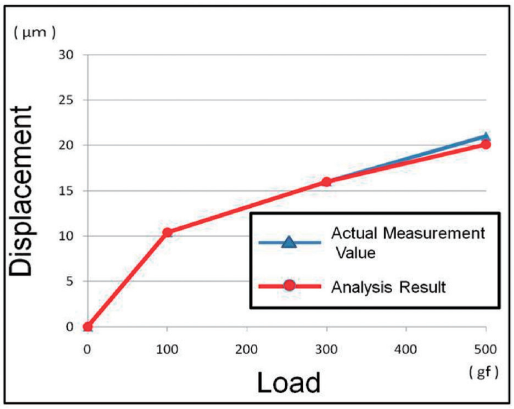

Fig.6 Load-Displacement Curve (Mandibular Canine)

Table 1　Material Properties and Conversion Point of Stress Value

Residual Ridge Mucosa

	Young Modulus (MPa)	Poisson ratio	Conversion Point Stress values (MPa)
1st	0.150	0.300	
			0.002114
2nd	0.700	0.350	
			0.006044
3rd	3.000	0.350	
			0.024457
4th	3.900	0.350	
			0.038255
5th	4.600	0.450	
			0.055987
6th	11.000	0.470	
			0.056688
7th	16.500	0.490	

Periodontal Ligament

	Young Modulus (MPa)	Poisson ratio	Conversion Point Stress values (MPa)
1st	0.070	0.250	
			0.002584
2nd	0.180	0.300	
			0.005648
3rd	0.200	0.350	

2.2　Analysis conditions

The analysis model was constructed using CT data input into CAE prepost for converted fabrication of the master finite element model with standard hardware (Patran 2010 windows 64bit, MSC software) (Dell Precision T7400Round Rock, Texas, USA). Modeling analysis conditions were set into tetrahedron and pentahedron elements. The analysis was set for elastic type stress analysis. An analysis software was used for evaluation.(marc 2010 - MSC). A complier was also used as a to introduce the program simulating non-linear soft tissue properties into the analysis. (Intel (R) visual fortran compiler 10.1)

2.2.1　Components and mechanical properties

Table 2 shows components and mechanical property values that define the material properties.

Table 2　Material Properties (Analysis Model)

	Young Modulus (MPa)	Poisson Rasio
Periodontal Ligament	Depend on the Stress Value	
Residual Ridge Mucosa	Depend on the Stress Value	
Cortical Bone	11,760	0.25
Sponge Bone	1,470	0.30
Dentin	11,760	0.35
Metal	94,080	0.30
Denture	2,450	0.30

	Young Modulus (MPa)	Poisson Rasio
Periodontal Ligament	0.070	0.250
	0.180	0.300
	0.200	0.350
Residual Ridge Mucosa	0.150	0.300
	0.700	0.350
	3.000	0.350
	3.900	0.350
	4.600	0.450
	11.000	0.470
	16.500	0.490

2.2.2　Boundary conditions

Figure 5 shows load conditions used in the present analysis.

Vertical loads from 5 N to 200 N (equivalent to occlusal force) were applied to the occlusal surfaces of the simulated test partial dentures.

Figure 6 shows constraint and contact conditions used in the present analysis.

A complete constraint was applied to the inferior border of the mandible in the X, Y, and Z directions.

Coulomb's friction coefficient (μ=0.01) was applied as the contact condition between the mucosal base of the denture and the corresponding residual ridge mucosa, abutment and extracoronal magnetic attachment, and adjacent magnetic attachment retainer and the different test dentures.

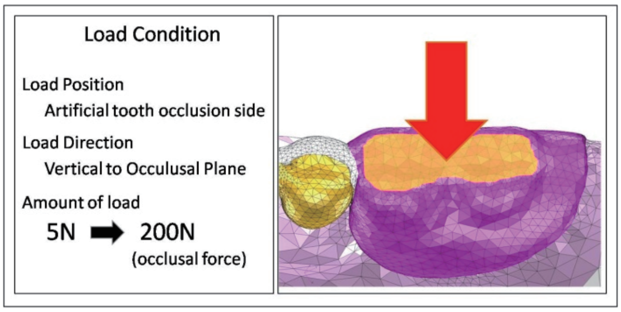

Fig.7 Load Condition

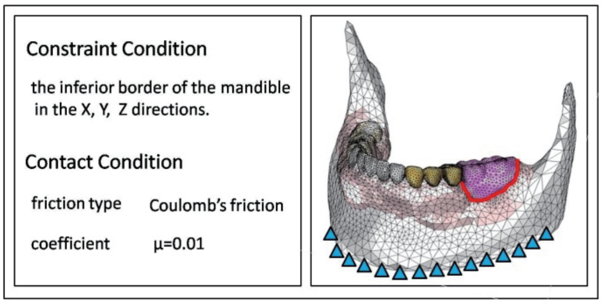

Fig.8 Constraint and Contact Condition

Results

1. Displacements related to different load applications (dentures and abutments)

1.1 Displacement of the anterior part of the denture

Figure 7 shows a change in displacement of the anterior part of the denture related to different load applications. The focal measurement point was the central pit of the lower left first molar of the denture.

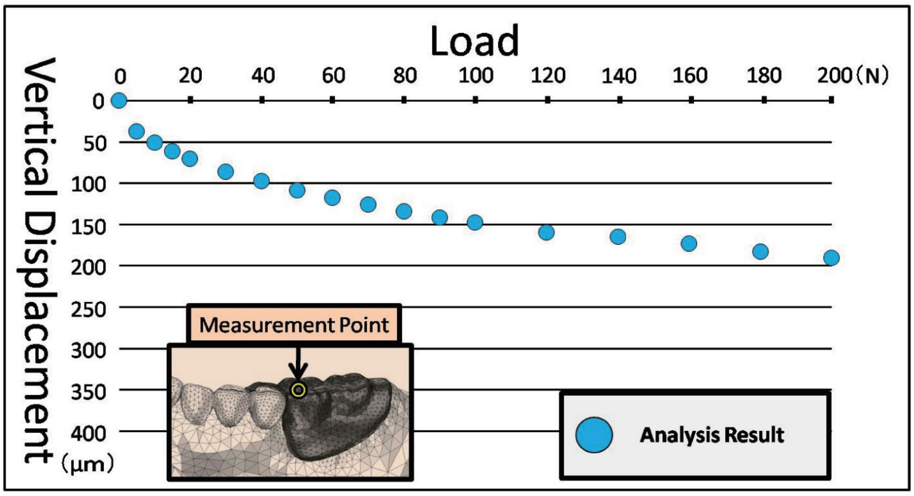

Fig.9 Displacement of the anterior part of the Denture

1.2　Displacement of the posterior part of the denture

Figure 8 shows a change in displacement of the posterior part of the denture related to different load applications. The focalized measurement point was a posterior margin of the denture base.

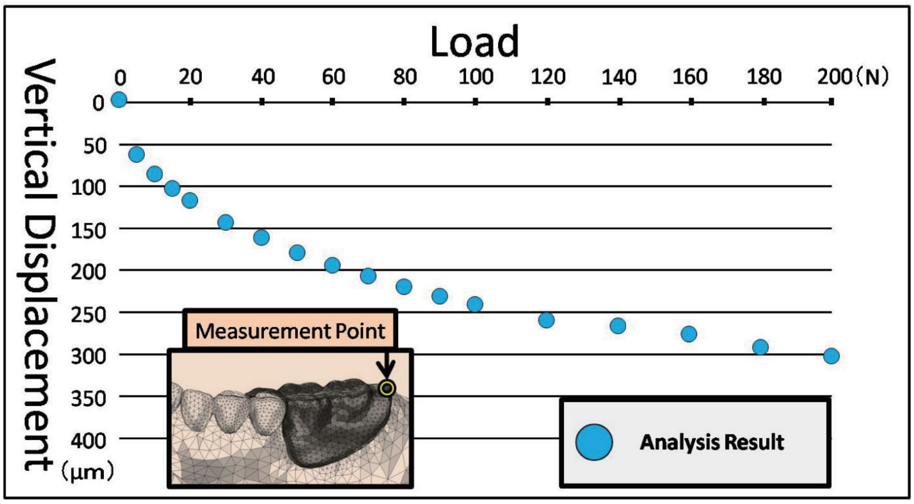

Fig.10　Displacement of the Posterior part of the Denture

1.3　Distal displacement of the abutment (lower left second premolar)

Figure 9 shows a change in distal displacement of the abutment related to different load applications. The focal measurement point was the buccal functional cusp tip of the lower left second premolar.

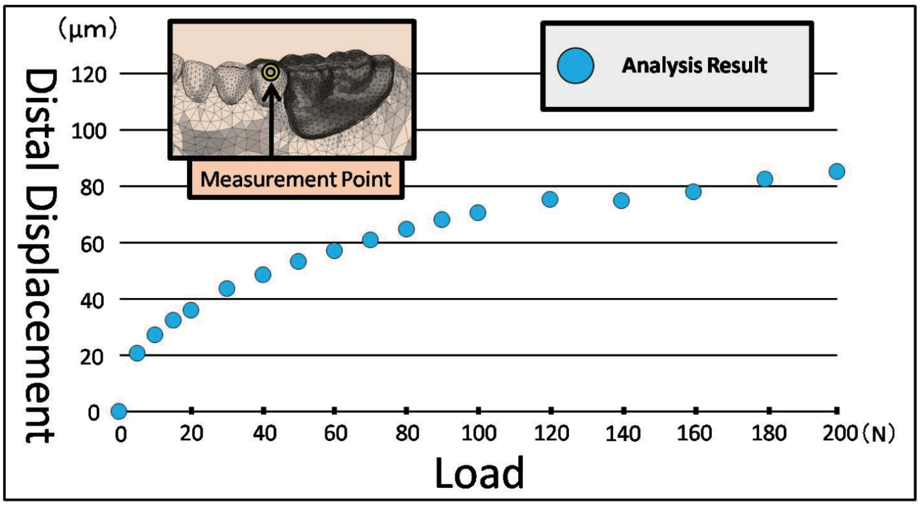

Fig.11　Distal Displacement of the Abutment (Lower Left Second Premolar)

2.　Displacement of an extracoronal magnetic attachment

Figure 10 shows a vertical displacement of the attachment when the maximum 200 N was applied, and actual strength measurement of an extracoronal attachment with identical designs as previously reported[3).

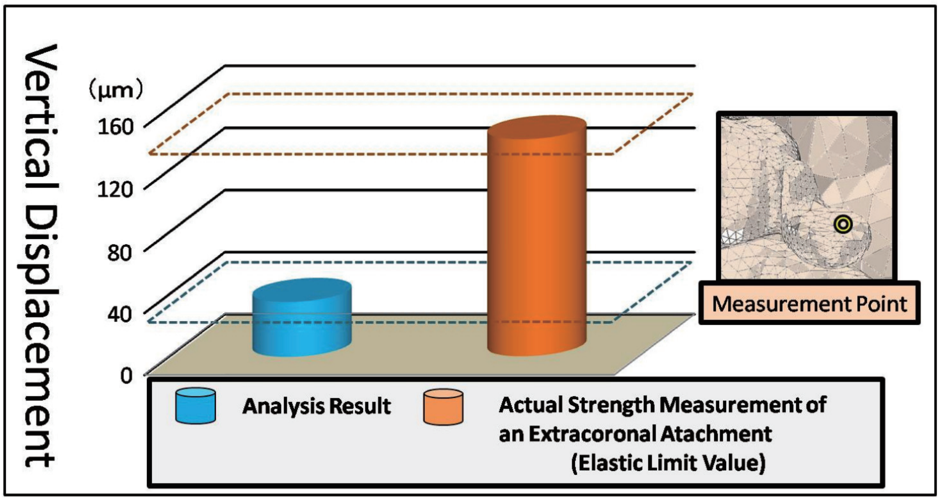

Fig.12 Displacement of an Extracoronal Magnetic Attachment

Discussions

1. Non-linear analysis

A program was developed that automatically changes material constants when the setup stress values exceed the von Mises stress value in order to simulate viscoelastic behavior of the residual ridge mucosa and periodontal ligament (Figures 2, 4). The non-linear tissue modeling technique enables applied prosthetic load evaluations to be more consistent with known reported in vivo conditions. The defined soft tissue behaviors had not previously been considered for modeling simulation.

2. Loading condition

When the opposing teeth are healthy, average occlusal force applied to the lower first molars of the partial denture is 14 kg in male and 11 kg in female.(you need a reference for this statement) The average occlusal forces for a periodontal ligament-borne single-tooth prosthesis, was 23 Kg in male and 17 Kg in female.

The prosthetic denture design of the present study was considered to be periodontal ligament-borne. It is considered that occlusal force applied to the denture base was higher than the reported values of the partial denture. Therefore, the maximum load was set close to the single-tooth denture occlusal value (200 N) assuming the occlusal force applied in the present denture design.

3. Analysis results

Miyashita[4)] reported that the displacement value of a free-end denture base demonstrated more rapid displacement at lower occlusal forces, and higher resistance to displacement at higher occlusal force loads. The results of the present study (Figures 7 and 8) demonstrated non-linear increasing strain of the posterior margin of the denture base with increased stress. These findings are consistent with those previously reported. Miyashita measured vertical displacements of a denture when the occlusal force up to 8.0 kgf was applied, and reported that vertical displacements range between 110 and 350 μm. The result of the present study was also within this previously reported displacement range.

The distal displacement of the lower left second premolar (Fig 9) demonstrated the material non-linear properties to the periodontal ligament, suggesting that the periodontal ligament of an abutment in the analysis model was non-linearly resistant to the distal displacement. These finding are consistent with reported in vivo findings[5)].

Nakashima et al.[3)] using a fabricated an extracoronal magnetic attachment with the identical form as the present analysis study, and reported the strength of an attachment with a keeper applied load. The report demonstrated an elastic deformation limit of an attachmentwas 140 µm at a 338 N load, followed by permanent deformation when that load level is exceeded. Stress concentrations at an attachment should be minimized since a minimal permanent deformation would significantly impairs the attachmentsfunctionality. The attachment fabrication alloy (Fig. 10) of the present model was Degudent Universal. (Densply Sankin). The displacement at the attachment was investigated for an occlusal force equivalent load simulation (200 N). A displacement of 35.3 µm was observed in the loading direction with a 200 N load application to the denture occlusal surface. Although the material composition of testing model extracoronal attachments values may be slightly different, the attachment's displacement is considered elastic at the test load equivalent of occlusal force application, thus suggesting an acceptable condition for anticipated clinical use.

Something will be happened.

Conclusions

The non-linear viscoelastic behavior of the residual ridge and periodontal ligament in the analysis model was determined using the finite element method to accurately simulate intraoral mechanical dynamics of a partial denture. The validities of the analysis results and material non-linear analysis were confirmed, and the following conclusions obtained.

1. The introduction of the material non-linear properties to the residual ridge and periodontal ligament enabled the application of load conditions not previously demonstrated.

2. The displacement values for abutments and denture demonstrated more rapid displacement at lower load application, and higher resistance to displacement at higher load applications, confirming non-linear behavior.

3. The elastic displacement of an attachment at occlusal force load equivalents was determined to be acceptable for the prosthetic designs tested.

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Examination of the sensor placement in the swallowing mensuration using a magneto-impedance sensor

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Introduction

The objective of this study is to develop a screening device for dysphagia (a swallowing difficulty) using a magneto-impedance (MI) sensor. Video fluorography (VF) or video endoscopy is used to diagnose dysphagia. On the other hand, the repetitive saliva swallowing test (RSST)[1)] is widely used as a simple test in some facilities that lack a VF apparatus.

The authors have developed a device to automate the RSST using an MI sensor. The availability of the proposed method was examined in a previous study.[2)] The experiments demonstrated that the movement of the laryngeal prominence could be measured using a small magnet and the MI sensor. However, it was difficult to measure the swallowing movement under specific situations. Movement of the body is one of such situations because the sensor measures the variation of geomagnetism simultaneously with the movement of the laryngeal prominence. In a previous study, we confirmed that the use of three-dimensional magnetic sensors was effective to reduce the influence of body movement. In this study, we examine the arrangement of the sensor and the magnet using a simple simulation.

Method

The proposed device consists of a neodymium magnet, an MI sensor (Aichi Micro Intelligent, AMI302), and a personal computer for data acquisition. The MI sensor is capable of measuring a three-dimensional magnetic field. The magnet is attached onto the laryngeal prominence, and the MI sensor is attached to the breastbone. The relative position between the magnet and the sensor changes as the subject swallows. The magnetic field at the sensor reflects the swallowing.

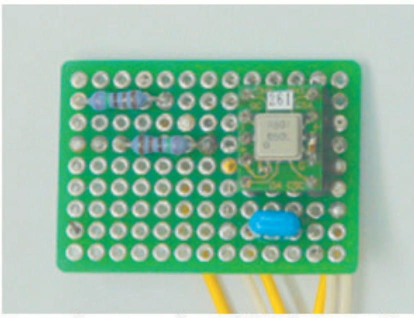
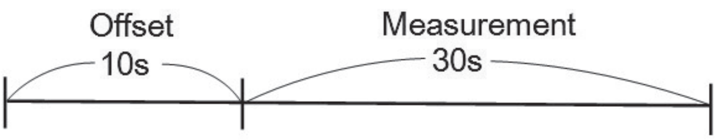


Fig.1 The magnetic sensor board implemented a MI sensor.

In the RSST, the subject is instructed to swallow saliva as fast as possible in 30 seconds. If the subject can swallow fewer than 3 times, he/she is suggested to need further investigation. In the proposed system, the basic procedure is same as that for the original RSST except for the 10 seconds preceding measurement to obtain the offset of the sensor output (Fig. 2). The offset is subtracted from the measured values.

Figure 2.　Measurement sequence

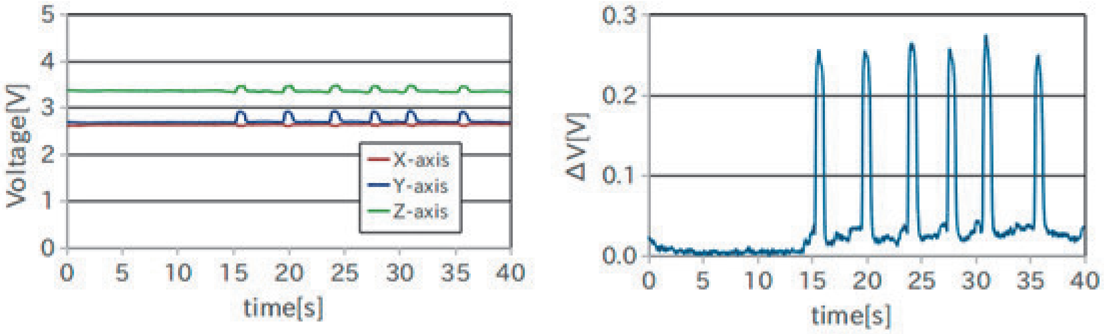


The change of the sensor output ΔV is described as

$$\Delta V = \sqrt{(V_x - V_{ox})^2 + (V_y - V_{oy})^2 + (V_z - V_{oz})^2} \qquad (1)$$
,

where V_x, V_y, and V_z are the sensor output of each axis and V_{ox}, V_{oy}, and V_{oz} are the offset of them. V_{ox}, V_{oy}, and V_{oz} are calculated as the average during the offset period. They consist of geomagnetism and the sensor offset.

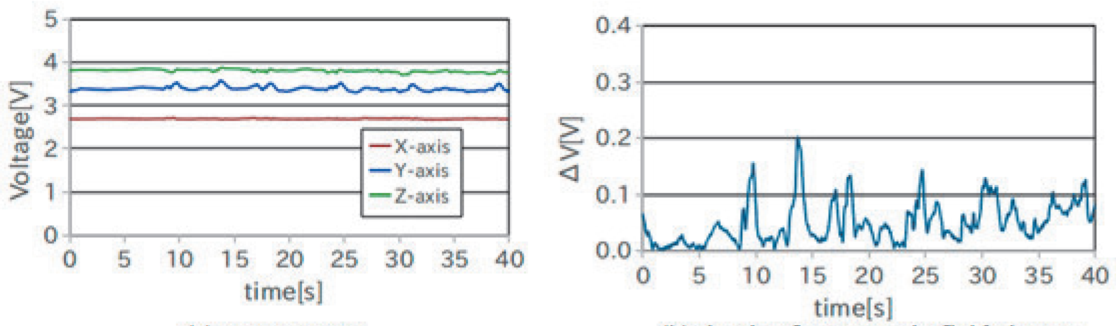
Results



(a) Outputs of the magnetic sensors　　(b) Change of the sensor output
Fig.3 The measurement result for healthy adult (22 years old)

It is possible to count the swallowing movements from both Fig. 3 (a) and (b). Especially, Fig. 3 (b) summarizes the variance of 3 magnetic sensors. It is convenient to count using a threshold.

Figure 4 shows the results of another healthy adult subject (23 years old, male). For this subject, the waveforms during swallowing are blurred. It is difficult to apply the threshold to count the occurrences of swallowing.



(a)measurement　　(b) the size for magnetic field change
Fig.4　the measurement result of healthy adult (23 years old)

The difference between the two subjects is the size of their laryngeal prominence. The movement of the first subject was visually distinguishable. On the other hand, that of the second subject was in a small range. It was also unclear by visual examination. This result means that the movement range of the laryngeal prominence has significant individuality and the magnet and the sensor need to be placed so that the variance of the magnetic field at the sensor is as large as possible.

Discussion

The results of the experiment demonstrate that it is important to place the magnet and the sensor properly. Another limitation of the placement is the distance between them. The magnetic field at the sensor is inversely proportional to the cube of the distance. This means that the range of the magnetic field near the magnet is too large to have the precision of an A/D converter. On the other hand, it is too small to measure the magnetic field when the distance is very large. For example, the magnetic field is smaller than the geomagnetism in the experimental system described above when the distance is more than about 5cm to 8cm. The appropriate distance is thought to be in that range. Another factor is the orientation of the magnet. The strength of the magnetic field is two times larger along the magnetic axis than the border of the magnetic poles (Fig. 5). Figure 5 represents the change of the magnetic field around the constant distance from a magnet (saturation magnetic field: 1T, height 6mm, diameter 7mm). The magnet is approximated as a magnetic dipole for ease of calculation. The magnet at the laryngeal prominence shows not only parallel movement but also rotation. The most appropriate angle to detect the rotation of the magnet is 45 and 135 degrees because the slope of the curve is at its maximum.

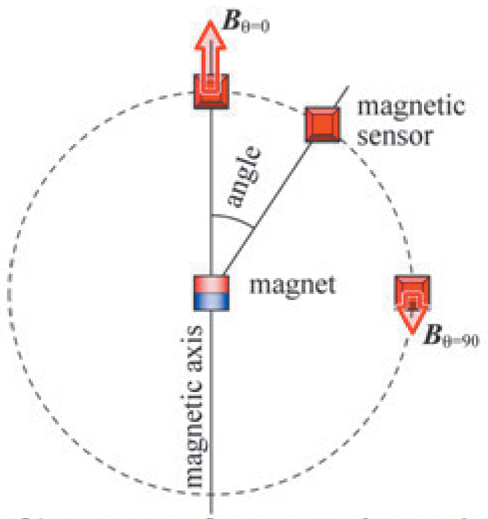


Fig.5Arrangement of a magnet and magnetic field.

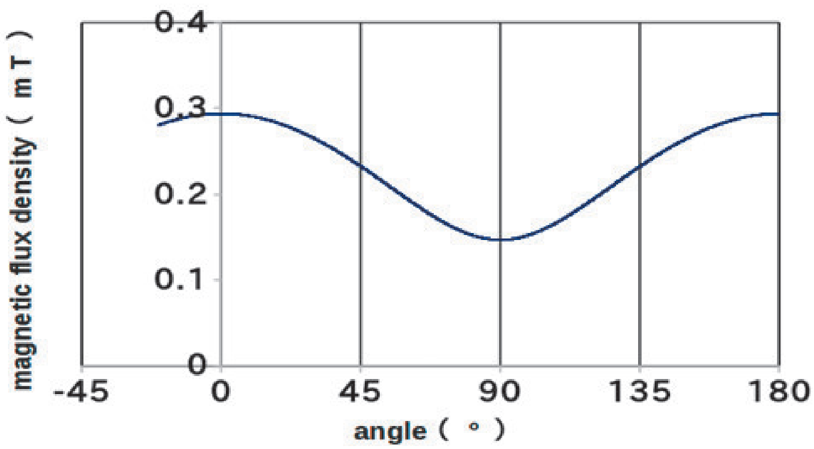


Fig.6. Relationship between the angle and magnetic flux density

Conclusion

An experimental device for automated RSST using a magnet and magnetic sensor is described. We confirm that the proposed device can measure the movement of the laryngeal prominence. However, it is difficult to count the number of swallowing occurrences for some subjects with a small laryngeal prominence. According to the calculation of the magnetic field distribution, the optimal position of the sensor is 45 degrees away from the magnetic axis of the magnet. The next task would be to measure the swallowing movement using derived arrangement.

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The Influence of the Screw Hole on the Implant Magnetic Keeper Attachment Surface

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Introduction

Restorative implant materials and techniques have continued to evolve and adapt to new design needs. The improved variety of magnetic attachments available for implant overdentures has also shown adaptive improvements in design.

A subtle but important difference in magnetic attachment design is the method of attachment of an implant magnetic keeper by cementation or screw retention. While cementation may not affect a magnetic keeper’s magnetic potential, the physical differences in keeper retaining screw designs may affect keeper surface magnetic attraction potentials.

A screw hole is located under the fixed keeper in one design method, and cementation may preclude retrievable access. A screw hole in the keeper method may permit retrievability and easy maintenance . However, the effect upon magnetic potential by the screw hole in the keeper center is unknown. of The screw hole keeper design may adversely affected the magnetic circuit thus resulting in a diminished magnetic force potential (Fig. 1).

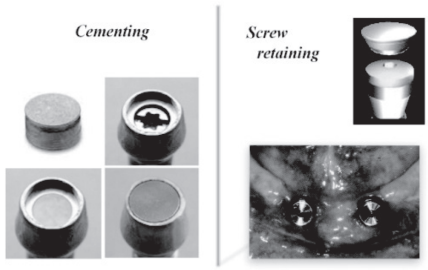

Fig. 1 Fixation method of Implant Keepr

Objective

A preliminary investigation was prepared. Custom designed test implant keepers with varying screw holes access dimensions were prepared based on commercially available keepers to investigate the influence and effect of the access screw hole on magnetic keeper attractive force.

Materials

GIGAUSS D 600 keeper samples with holes at different locations were prepared. (Figures 2 and 3). The locations of holes were the center (center-hole model) and the keeper lateral surface (side-hole model). The holes were round with ψ1.1, 1.3, and 1.6 mm in diameter and 1.0 mm in depth in the center-hole model. The lateral side-hole model has axially symmetrical 4 holes with 0.85 x 0.05 x 0.2 mm in size. A GIGAUSS D 600 keeper without a hole was used as a control. The total number of sample groups was five.

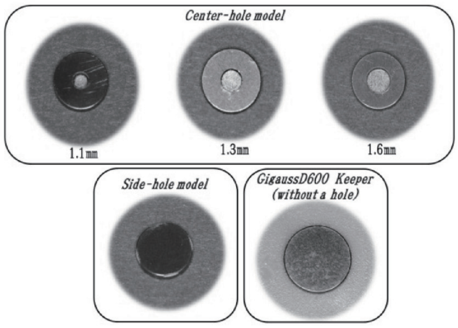

Fig. 2　Experimental samples

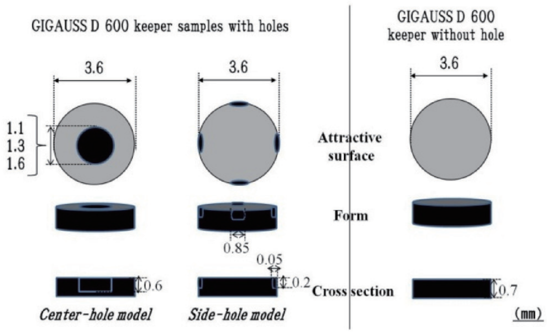

Fig. 3　Internal structure of Experimental samples

Methods

Attractive force measurements between sample keepers and GIGAUSS D 600 magnetic assemblies (Fig. 4) were performed, and results were compared. A custom-made jig and mold (Reference) were used to hold and support the samples during testing measurements. Pull tests were measured 10 times for each sample at 5 mm / min crosshead speed using a compact table-top universal testing machine (EZ test, SHIMAZU) (Fig. 5).

Average attractive forces of samples were calculated based on the obtained measurement at separation. One-way analysis of variance and multiple comparison using Sheffe's test were performed at the significance level of 5%. Statistical analysis software (Dr. SPSS II for Windows standard version, SPSS) was used for the analysis.

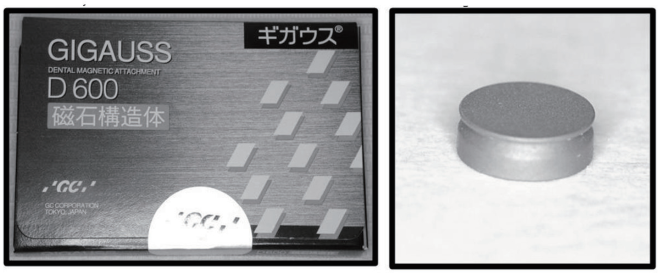

Fig. 4　Gigauss D 600　（GC ）

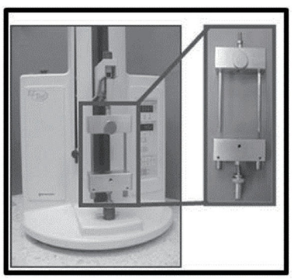

Fig. 5　A compact table-top universal tester machine

Results

Table 1 shows the results of measurement analysis. A decrease in the retention force was observed in the center-hole and side-hole models compared with the control model. A significant difference was observed between each sample.

A decrease in the retention force was also observed with increasing diameter screw hole size in the center-hole model. Attractive force of Gigauss D 600 without a hole was 500.1 gf. In contrast, the attractive force decreased by 13% (433.4 gf) at 1.1 mm screw hole, 15% (422.8 gf) at 1.3 mm screw hole, and 18% (409.6 gf) at 1.6 mm screw hole.

The attractive force of the side-hole model decreased by 10% (447.1 gf).

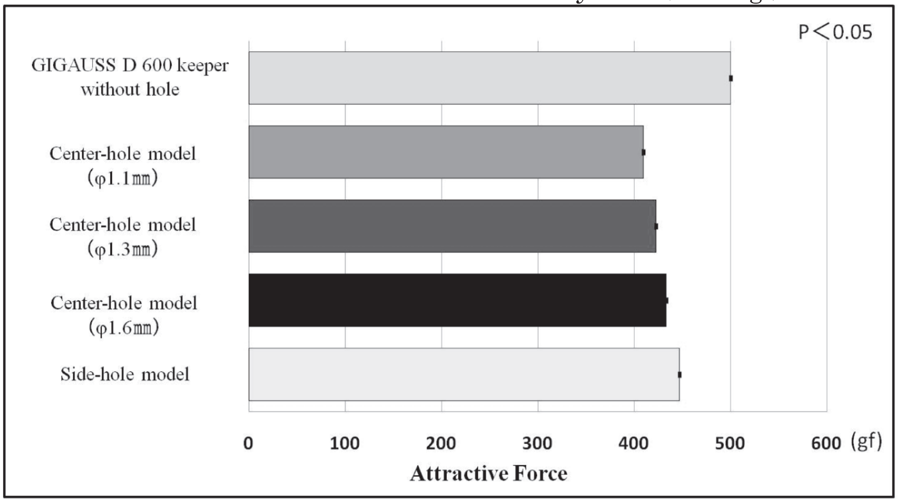

Fig. 6 The Influence of the Screw Hole on the Implant Magnetic Keeper Attachment Surface

Discussion

A decrease in the attractive force was confirmed in implant magnetic keepers with screw holes. The influence of screw hole location on attractive force was smaller when a screw hole was located aside from the center. However, a decrease in the attractive force in the center-hole model may be reduced to the same level as the side-hole model by decreasing the size of a hole.

Tanaka et al. reported a difficulty in obtaining required retentive force of a magnetic attachment. The ideal desired retention force level was 500 gf retentive force based on conventional mechanical retainers. The actual retentive force measurement of a prototype implant keeper based on GIGAUSS D 600 was 450 gf. This retention force level is considered insufficient for use as a denture retainer.

Screw retention of an implant keeper allows easy maintenance, and, therefore, considered feasible in clinical practice. Further studies are required to investigate optimal screw hole configuration and fixation method between a keeper and implant body, and to develop a prototype implant keeper with attractive force more than 500 gf.

Conclusion

Prototype implant keepers with different screw holes were prepared. Attractive force measurements and magnetic field analysis were performed using GIGAUSS D 600 to compare an influence of the screw hole configuration and location on attractive force, and the following results were obtained.

1. Screw holes of any shape affected the attractive force of a magnetic attachment.
2. The influence of screw hole location on attractive force was smaller when a screw hole was located aside from the center.
3. In the center-hole model, the influence of a screw hole decreased with decreased diameter size of the screw access hole.

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Influence of Re-casting on the Attractive Force of Attract P®

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Introduction

"Attract P" is a castable dental alloy with magnetic potential property for use with dental magnetic attachments. The casting properties of Attract P permit the application of the alloy for a wide variety of different configurations and uses as a cast magnetic keeper for the retention of prosthetic appliances. This material is ideal for customized fabrication of magnetic attachment keepers intended for space restricted clearance uses such as restricted occlusal clearance or the use with vital dentitions.[1)]

The casting procedure for castable dental alloys may require individual non-contaminated casting ingot use to prevent alloy contaminations that would impair the cast alloy physical properties. Another potential area of cast alloy physical property degradation may be the repeat casting of an alloy also causing changes in physical property. The effect of multiple melt and casting re-use upon magnetic attractive force for this specialized castable alloy has not been reported. No reports have been available regarding the influence of recasting on attractive force have been made.

Objective

Recasting was performed to fabricate a custom-made keeper using a new ingot and melting new alloy ingots. The influence of alloy recasting using a previously cast ingot and cruicible on attractive force was investigated.

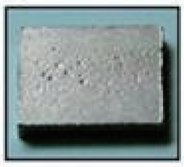
Materials and Methods

Ⅰ, Materials

Cast magnetic alloy Attract P® (TOKURIKI-HONTEN Co.) was used (Table 1).
Attract P is the only commercially available magnetic dental casting alloy.

table1:Attract P®(TOKURIKI HONTEN)

Ingredient	: Au:3% Pd:48% Ag:14% Co:32%(Others:Zn In)
Tone of color	: Silvery white
Melting poin	: 1148-1192℃
Castable temperature	: 1300℃
Specific gravity	: 10.5g/cm³
Strength	: 197HV
yield strength	: 300MPa
Elongation	: 13.5%



Ⅱ, Fabrication of samples

A custom-made jig was fabricated by molding a precast ingot formed during casting (Figures 1 and 2).

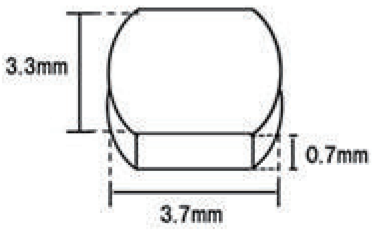


fig1: A custom-made jig

fig2: As cast

Table 2 shows five combination ratios of recycled and virgin metals, and 5 samples were prepared.

table2: combination ratios of recycled and virgin metals

Cntent of pre-cast ingot by percentage		0%	25%	50%	75%	100%
Total weight (g)	Virgin metal	10	7.5	5	2.5	0
	Pre-cast ingot	0	2.5	5	7.5	10

Sand blasting was performed after casting to remove oxide layers. The external morphology and surface areas of both marginal and non-attractive faces were adjusted to match the comparative sample keeper size (GIGAUSS C 600). Samples were embedded in epoxy resin, and attractive faces were mirror-polished using a polishing machine (ECOMET 3, BUEHLER) (Fig. 3).

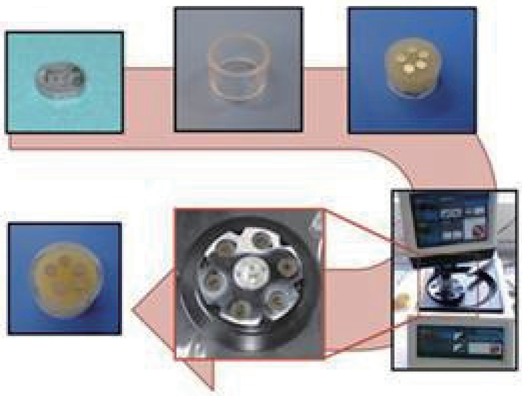


fig3: Methods of polish

Ⅲ, Attractive force measurement

Attractive force was measured using a compact table-top universal tester machine EZ test (SHIMAZU). A custom-made jig and mold (Reference) were used. Attractive force was measured 10 times for each sample at 5 mm / min crosshead speed (Figures 4 and 5).

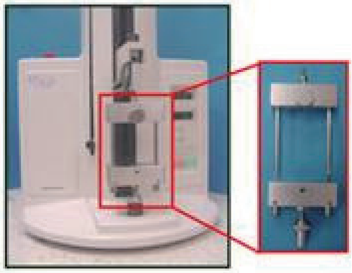


fig4: a cpmpact table-top universal tester machine EZ Test (SHIMAZU)

fig5:Acustom-made jig

Results

Attractive force of a magnetic assembly and a keeper decreased with an increase of pre-cast ingot content (Figure6).

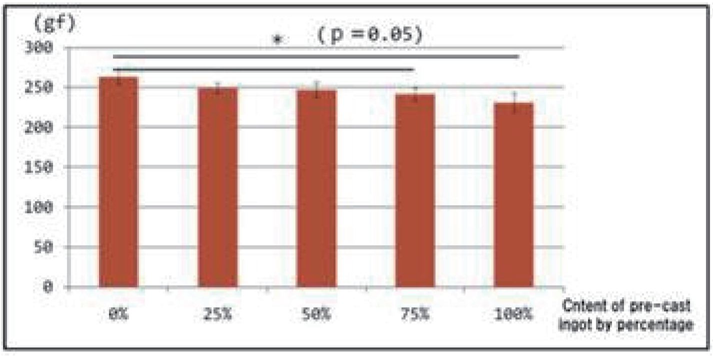


Fig6:Attractive force

Results were analyzed using one-way analysis of variance and Scheffe's multiple comparison test. A significant decrease in attractive force was observed in samples with 75% and 100% of ingot content compared to a virgin metal sample without pre-cast ingot metal.

Discussions

1, Dental cast magnetic alloy (Attract P)

Eda et al.[2] investigated castability, surface and mechanical properties, and texture observation of Attract P, and compared with those of commercially-available dental Au-Ag-Pd and gold alloys. The report stated that element distribution of a casting was relatively constant. However, casting using a pre-cast ingot has not been discussed. TOKURIKI-HONTEN, the manufacturer of Attract P reported that Attract P can be recast without any problems. However, no detailed conditions have been specified.

2, Fabrication of samples

Eda et al.[2] compared three different casting methods, centrifugal casting method using gas and oxygen blowpipe, high frequency and argon arc casting methods. The result showed that casting temperature increased by using a blowpipe, affecting the cast surface. In the present study, Cascom KDF, a casting apparatus that melts metal by a ceramic heater in an argon atmosphere was used. Casting with high precision was achieved by controlling the melting temperature and avoiding oxidation during casting with this machine.

3, Attractive force measurement

Vertical displacement control is important. Previous retention studies have demonstrated that a lateral displacement may not be well controlled and would advsersely affect any measurements. The magnetic assembly must not laterally slide on a keeper, and is pulled in a vertical direction perpendicular to the adhesive surface in order to ensure accurate measurements of maximum attractive force for a magnetic attachment. A custom-made jig with a vertical bearing control was used. A magnetic attachment was vertically displaced in a controlled manner and direction using this jig. The adherant attractive surfaces of the sample and magnetic attachment were pulled off in a vertical direction.

4, Results

Okamoto et al.[3),4)] reported that a magnetic force is exerted by addition of cobalt to Attract P. A magnetic attachment keeper was fabricated using ingot of castable dental alloy. An attractive force decreased with an increase of pre-cast ingot proportion increased to the virgin metal quantity. This finding was attributed to be due to increased content of cobalt in the cast alloy.

Although no increase in casting defects were observed by the repeat casting of an alloy, there is a potential of contamination with oxides attached to a cruicible.

Retentive force achieved in the present study was between 250 and 300 gf. Further studies are required to investigate additional designs and casting methods of Attract P that might achieve added attractive force. Further examination regarding surface properties and composition of the alloy is necessary in order to confirm the cause of the noted decrease in the attractive forces measured.

Conclusions

A magnetic attachment keeper was fabricated using a ingot of castable magnetic dental alloy (Attract P®, TOKURIKI-HONTEN Co.), and the following results were achieved.

A decrease in the attractive force was observed with a pre-cast ingot content of more than 75%.

There was no change in the cast defect with an increase of hearth content.

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Retentive Force and Magnetic Flux Leakage of A Magnetic Attachment in a Keeper and Castable Magnetic Alloy

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Introduction

A conventional magnetic attachment consists of a magnetic assembly and keeper; therefore, the prosthesis for an abutment has several size restrictions related to the size of the keepers. The use of Attract P (Tokuriki Honten Co., Ltd.), a new castable magnetic alloy for the fabrication of keepers, may allow for expanded applications of magnetic attachments (Fig. 1). However, the results about the retentive force of Attract P are not consistent because of differences in the test methods, and there is no report about magnetic flux leakage.

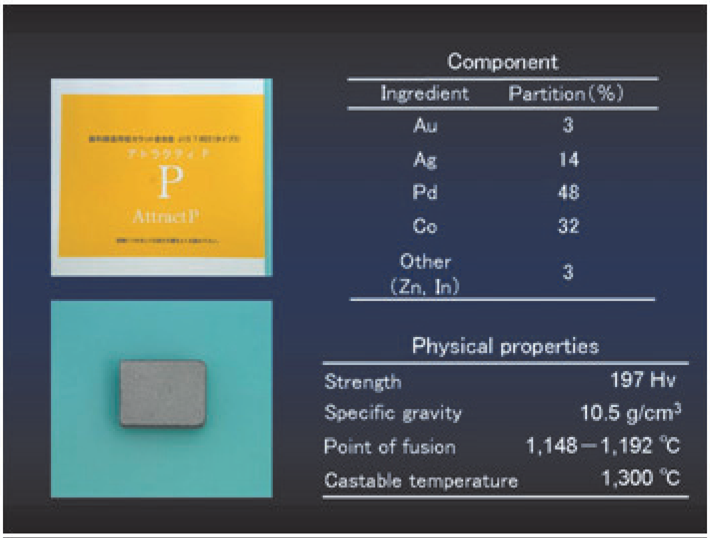

Fig.1: Attract P (Tokuriki-honten Co)

Objective

This study evaluated the retentive force and magnetic flux leakage of Attract P and compared the results to those of the keeper.

Materials and Methods

1. Production of samples

The wax patterns for samples were made with PLATE PARAFFIN WAX (Mutsumi Chemical Industries Co.) and SHEET WAX #24 (GC Co.) that was 6.0×6.0×2.0 mm in size. The wax patterns were invested with phosphate-bonded investment CERAVEST QUICK (GC Co.) and cast in a ceramic crucible at 1300 ℃ following the conventional method using a vacuum casting machine. To compare the influence of abrasion methods on the surface, one group of samples was polished with wet-dry sandpaper to # 2,000 until a mirror-like surface was obtained; another group of samples was hand-polished (Silicon point M2, M3: SHOFU, Inc.) in the same way as a method in clinical. The final dimension of the sample was 5.0x5.0x1.5 mm, and we manufactured it five pieces respectively. ssumed the clinical. GIGAUSS D600 (GC Co.) was then selected as a commercial ready-made keeper sample.

2. Measuring retentive force

Testing for retentive force was made using a linear ball slide (THK Co.) set on a universal testing machine (EZ-Test: Shimadzu Co.). A sample was attached to the acrylic prism of the jig fixation compartment, and the magnetic assembly was then adsorbed to the sample. The magnetic assembly was bonded to another acrylic prism of the jig traction compartment. Retentive forces were measured 5 times for each sample at 5.0 mm/min of crosshead speed (Fig. 2).

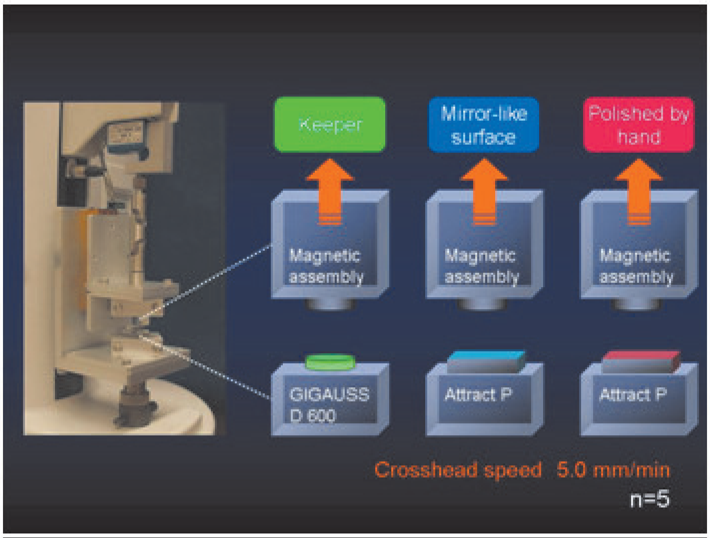

Fig.2: Testing for retentive force

3. Measuring magnetic flux leakage

The magnetic flux strength was measured using a Hall Effect Gaussmeter (F.W. Bell 5170: TOYO Co.) and a dedicated measuring probe (STB1X-0201: TOYO Co.). Magnetic flux leakage of the adsorbed magnetic attachment was measured at point where the greatest value was. (Fig. 3).

4. Statistical analysis

The data were statistically analyzed using the one-way ANOVA and Tukey's HSD post hoc test ($\alpha = 0.05$).

Results and Discussion

The retentive force for the keeper and castable magnetic alloy is shown in Fig. 4. The retentive force for the keeper was 505.1 gf, that for the mirror-like surface was 301.5 gf, and, when polished by hand, 281.7 gf. Significant differences were noted in the results among all groups of samples. We reasoned that Attract P had a lower saturation magnetic flux density than the keeper, which was made of stainless steel, and the adhesion between the magnetic assembly and sample had diminished.

The magnetic flux leakage for the keeper and castable magnetic alloy is shown in Fig. 5. Significant differences are noted in the results except for those between the mirror-like and hand-polished surfaces. Similarly, the results of the retentive force test showed that magnetic flux leakage was affected by the saturation magnetic flux density. However, since a significant difference was not seen at a result, the correlation of an adsorption surface quality and the magnetic flux leakage were not proved.

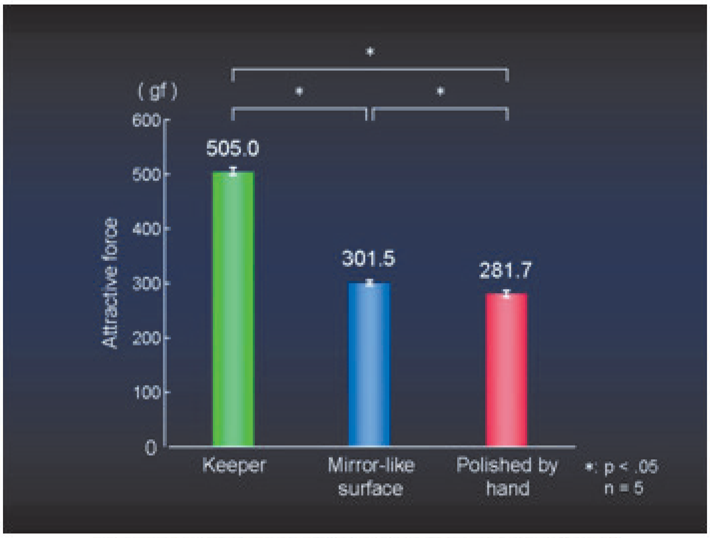

Fig.4: Retentive force of keeper and samples

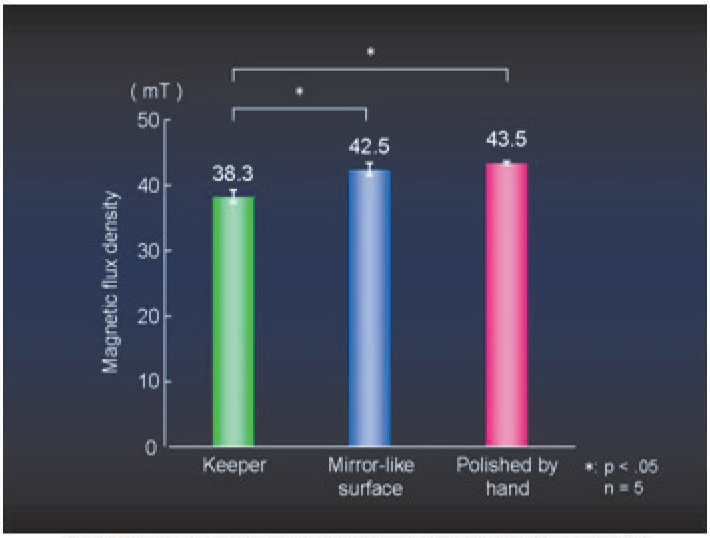

Fig.5: Magnetic flux leakage of keeper and samples

Conclusions

1. The retentive force of Attract P was 60 % of the original combination of GIGAUSS D600.
2. The polish method of a retentive side influences retentive force.
3. The magnetic flux leakage of Attract P was higher than that of the keeper.

The results obtained here show that this castable magnetic alloy does not produce great retentive force and, therefore, it is seldom expectable potential for clinical applications.

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Theoretical study of MRI artifacts caused by dental alloys - Three-dimensional analyses –

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Introduction

The metal artifact of MRI caused by dental alloys is one of the significant problems in clinical practice. A number of clinical and phantom studies have been performed to evaluate metal artifacts. Meanwhile few theoretical evaluations of the metal artifact are reported. A theoretical evaluation offers great flexibility regarding the conditions of imaging, such as the structures of (theoretical) phantoms, the strength of the static magnetic field, the size of the metal, and the magnetic gradient. The purpose of this study is to clarify the mechanism of the MRI metal artifacts and to evaluate the size of the region that is influenced by small ferromagnetic metal, such as a magnetic keeper. Computer simulations are performed to obtain the images.

Method

1. Magnetic dipole magnetic

A ferromagnetic metal is magnetized in an external magnetic field. From this characteristic, the metal distorts the magnetic field in the gantry of an MRI apparatus. The finite element method is a familiar method for calculating the magnetic field around magnets or metals. However, modification of a finite element model is necessary to calculate various conditions, e.g., to change the size and position of the metal. In this study, a magnetic dipole model is used to calculate the magnetic field. The precision of this approximation is sufficient except in the adjacent area of the metal or magnet.[1)] This modeling allows the use of a flexible configuration of the metal and fast calculation time.

Let us assume that a small ferromagnetic metal of volume V is placed in static magnetic field B_0. The metal is can be assumed as a magnetic dipole of magnetic moment $m = VB_0$. The direction of the magnetic moment is the same as the static magnetic field. Magnetic field $\boldsymbol{B}_{\mathrm{dp}}(\boldsymbol{r})$ at position $\boldsymbol{r}$ by the magnetic dipole is expressed as,

$$\boldsymbol{B}_{dp}(\boldsymbol{r}) = \frac{m}{4\pi|\boldsymbol{r}|}\left\{-\boldsymbol{i}_m + 3\left(\boldsymbol{i}_m \cdot \frac{\boldsymbol{r}}{|\boldsymbol{r}|}\right)\frac{\boldsymbol{r}}{|\boldsymbol{r}|}\right\} \tag{1}$$

where $\boldsymbol{i}_m$ is a unit directional vector of the magnetic moment.

2. Simulation of an MRI scan

A characteristic of the metal artifact depends on the sequences of an MRI scan. The spin echo sequence is used in this study. Parameter of TE and TR does not consider in order to simplify the calculation.

We examined the artifact by changing the strength of the static magnetic field, the gradient magnetic field, and the keeper volume. The conditions of our simulation are shown in Table 1.

Table 1: Parameter of the simulation

Keeper	Material	Soft magnetic stainless steel
	Saturation magnetic flux density	1.6T
	Height	1mm
	Diameter	4mm
MRI	Static magnetic field	1.5T
	Gradient magnetic field for slice selection	10 mT/m, 30 mT/m
	Gradient magnetic field for frequency encoding	10 mT/m, 30 mT/m
	Gradient magnetic field for phase encoding	10 mT/m, 30 mT/m
	Analytical domain	200 x 200 x 200 mm
	Image size	128 x 128 pixel

2.1 Artifact in the slice selection

The first step of an MRI scan is to activate the signal of the specific z position. This operation is carried out by changing the Lamor frequency for each z-position. The magnitude of the static magnetic field along the z-axis is gradually changed to control the Lamor frequency. When the magnetized metal is in the MRI gantry, the magnetic field in an arbitrary position is represented as the sum of the original magnetic field and that of the metal. Although the magnitude of the magnetic field is proportional to the z-position in a normal situation, this relation is broken. The relation of the z-position in a reconstructed image and original z-position is represented as

$$z' = z + \frac{B_{dp}(r)}{\Delta B_z} \qquad (2)$$

where z is the original z-position, z' is z-position in the reconstructed image, ΔB_z is a gradient of the slice selection magnetic field, and $B_{dp}(\boldsymbol{r})$ is the magnetic flux density by the magnetic dipole at the position of distance r, where described as Eq (1). In other words, Eq. (2) also represents the geometric distortion in the slice selection. By this distortion, the selected (or ``activated") surface is warped into a very complex shape, especially neighborhood of the metal.

3. Frequency and phase encoding

The following step is to obtain a density distribution in the xy-surface (transversal surface). This procedure is called a frequency (or phase) encoding. It is carried out in the activated surface. Although the signals received in this step come from a flat surface in a normal situation, the signal comes from a different z-position. In addition, the gradient magnetic field for the x and y direction is influenced by the metal.

The signal received without the metal is described as

$$S(t) = \iint \rho(x, y) e^{-i\gamma \Delta B_x x t_x} e^{-i\gamma \Delta B_y y T_p} dxdy \qquad (3)$$

On the other hand, the received signal with the metal is described as

$$S(t) = \iint \rho(x, y)\, e^{-i\gamma \Delta B_x x t} e^{-i\gamma \Delta B_y y T_p} e^{-i\gamma B_{dp}(x,y,z')(t+T_p)} dxdy \qquad (4)$$

where $\rho(x, y)$ is the spin density of position (x, y) and γ is the nucleus gyro-magnetic ratio.

B_x is the gradient magnetic field for frequency encoding. B_y is the gradient magnetic field for phase encoding. T_p is time to impress of B_y.

Equation (4) is different in the frequency of the received signal from the numerical Eq. (3) because of

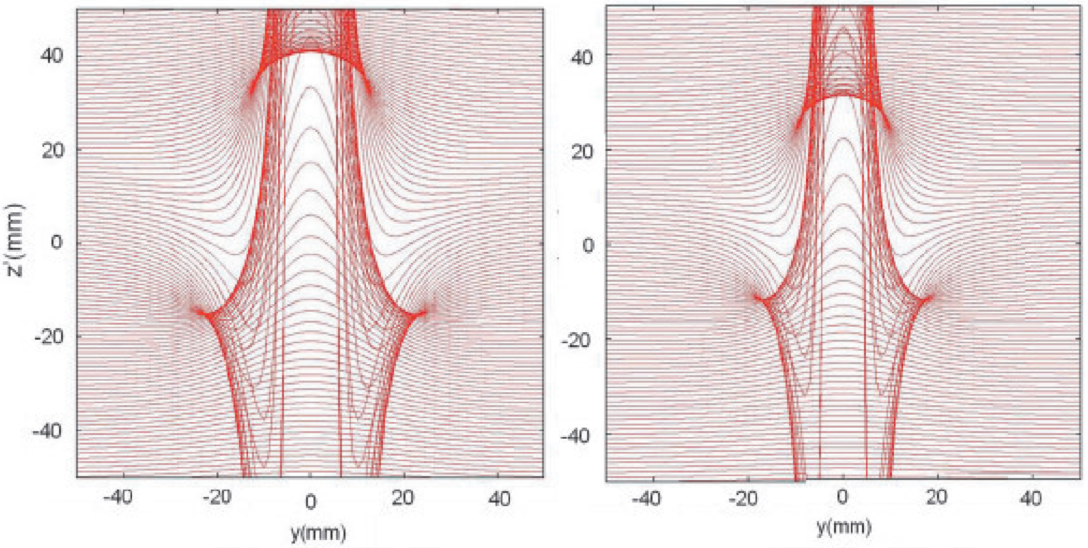
$B_{dp}(x, y, z')$.

The image in the transversal surface is obtained by 2D inverse Fourier transformation. This frequency and phase encoding receive the spin density and the magnetic flux density from the place that activated by slice selection.

Results

1. Distortion of slice selection

Figure 1 shows the geometric distortion of the slice surface.



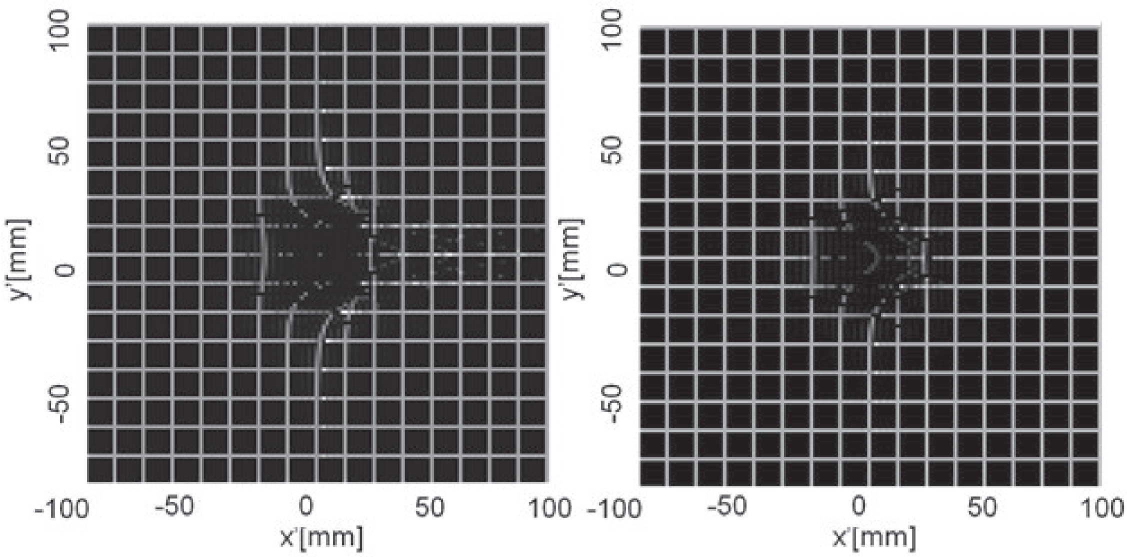
(a) $\Delta B_z = 10$mT/m (b) $\Delta B_z = 30$mT/m

Figure 1: Geometric distortion of the slice surface

The slice includes the signal of different z-positions and shows complex distortion. The range of the distortion is smaller (b) than (a).

2. Frequency and phase encoding

Figure 2 shows the reconstructed image for a grid pattern.



(a) $\Delta B_z = 30$mT/m, $\Delta B_x = \Delta B_y = 10$mT/m (b) $\Delta B_x = \Delta B_y = \Delta B_z = 10$mT/m

Figure 2: Geometric distortion in transversal surface

The range of the distortion is smaller (b) than (a).

Discussion and Conclusion

The result of this study shows a tendency similar to that in other clinical studies[2] and confirms that this study method is applicable. As a result of the computer simulation, we confirmed that the range of the artifact depends on the gradient of the magnetic field in the slice selection and frequency / phase encoding. The larger gradient shows the smaller range of an artifact.

This method is easy to consider with regard to the relationship between the artifact and various conditions of imaging. Nevertheless, it is important to confirm the simulated result using a practical MRI apparatus.

The relationship between the range of distortion and the shape or size of the magnetic keepers is an interesting problem. Described simulation method is expected to applied to these problems. It is well-known that a different tendency is observed using the other MRI sequence, and this tendency merits examination.

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The Effect Different Keeper Tray Materials Burn-out Incineration on Casting Investment during Burn-out Procedures.

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Introduction

Fabrication methods of the magnetic attachment keeper component for restorative placement have included casting or cementation procedures.[1-4] A cementation method, previously reported, utilizes a ready-made plastic pattern for investment burn-out and casting in a dental alloy. This technique does not subject the keeper surfaces to casting procedure roughness or deformations. The keeper is then directly cemented to the cast coping holder and is not subjected to casting procedure heat distortion and is thus a recommended method.Cast keeper coping housings require good casting accuracy as errors will prevent accurate positioning and seating of the keeper to the housing. Laboratory or chairside adjustment of these castings may be occasionally required (Fig. 1).

A new prototype keeper pattern using a keeper tray has been reported. The casting precision of these prototype keeper patterns has been found to be superior to available proprietary preformed keeper housing patterns (Fig. 2).

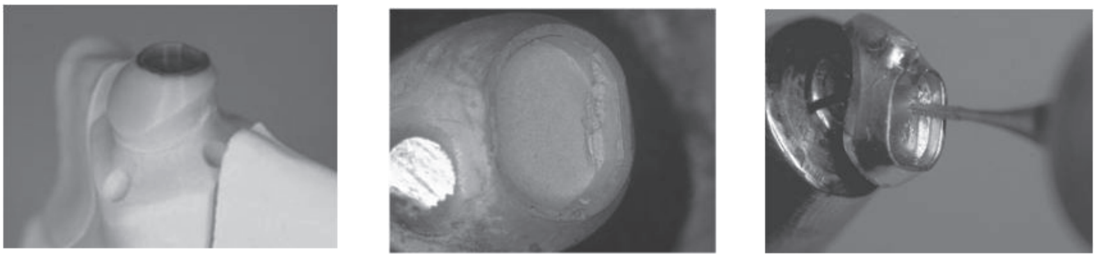

Fig.1　Adjustment of cast keeper

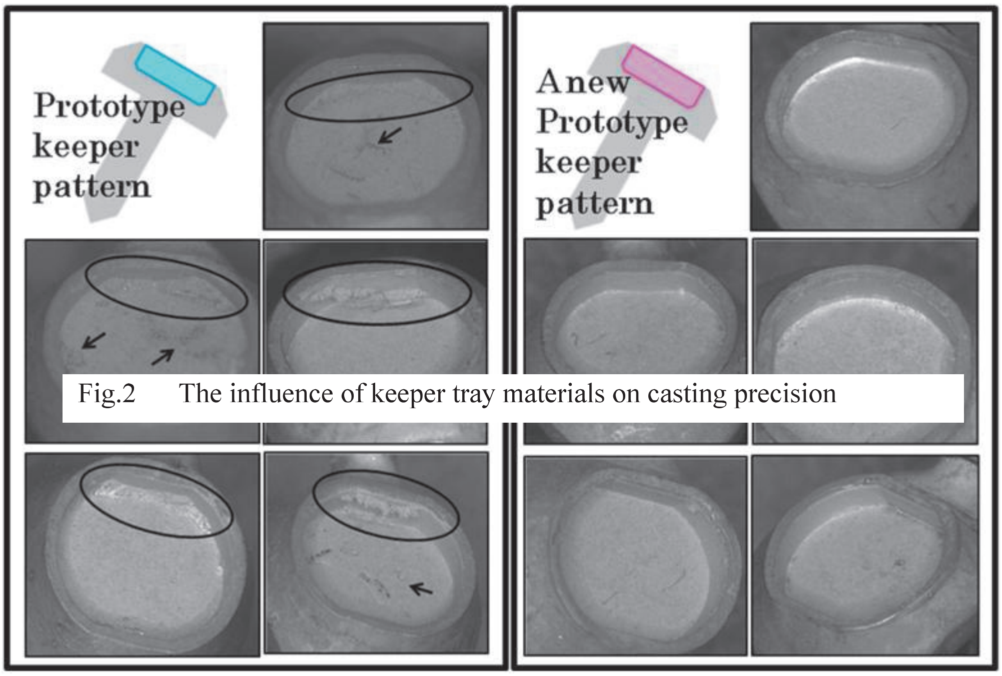

Fig.2　The influence of keeper tray materials on casting precision

Objective

The purpose of the present study was to compare investment material use and casting surface roughness for different samples of cast keeper housings from burn-out to casting, to elucidate the casting problems and error onset and to investigate casting defects different coping patterns.

Materials and Methods

1. Materials

Commercially-available ready-made pattern GIGAUSS C 600 KB (GC) was used. The chief component of GIGAUSS C 600 KB pattern is acrylic resin.

The prototype pattern had the same shape as GIGAUSS C 600 KB (Fig. 2), but the chief component was polyethylene resin.

2. Analysis items

1) The influence of incineration time on casting investment

Casting investments at 10, 20, and 30 minutes after sample incineration were observed, and surface roughness was measured.

2) The influence of wax application quantity on casting investment burn-out procedures.

Four samples with different quantity thickness of dental wax were fabricated. Each castinginvestment was qualitatively evaluated, and the surface roughness was measured.

3. Methods

1) Samples

The following 4 samples were fabricated for prototype and commercially-available patterns, respectively (n=5) (Figure 3)

(1) A plastic pattern without inlay wax (Wax 0)
(2) A plastic pattern with 1 mm inlay wax (Wax 1)
(3) A plastic pattern with 2 mm inlay wax (Wax 2)
(4) A plastic pattern with 3 mm inlay wax (Wax 3)

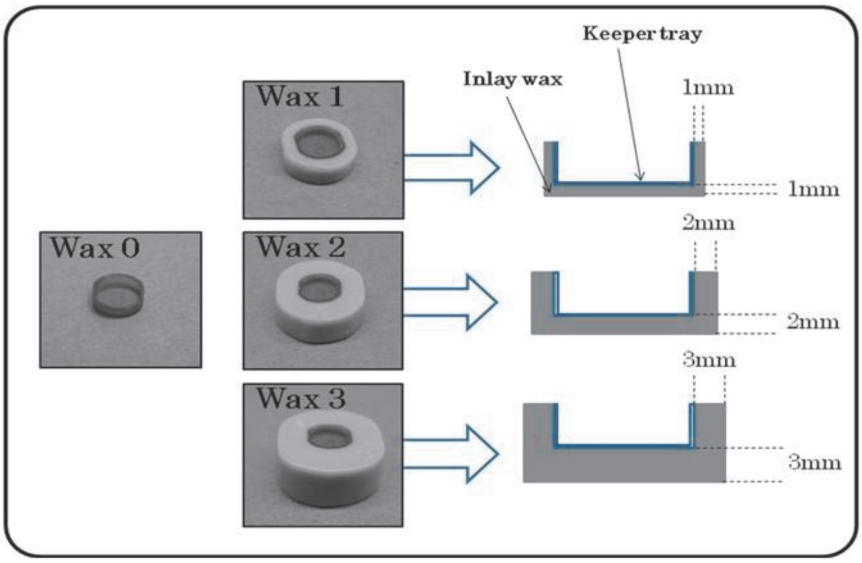

Fig.3　　4 Samples

2) Fabrication method

(1) The influence of incineration time on casting investment

The ratio of a keeper tray and wax thickness was 1 : 2 in the Wax 1. The sample was used to investigate the influence of incineration time on casting investment.

(2) The influence of wax application quantity on casting investment

①Investing procedure

The four samples were sprued with ready casting wax R 15 (GC), and placed on the investing ring base, and invested following manufacturer instructions using Cristobalite investment material (Cristoquick II, GC) (Fig. 4).

②Casting investment incineration

Four samples were transferred to a furnace, and removed after 30 minutes.

③Casting investment section

Casting investment removed from the furnace was air cooled, and the base was trimmed to expose the investment mold inner surface of the keeper tray mold(Fig. 5).

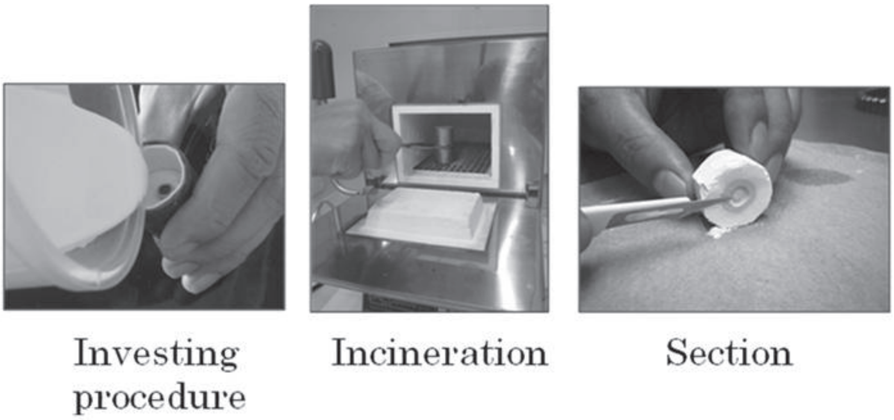

Fig.4 Investing procedure

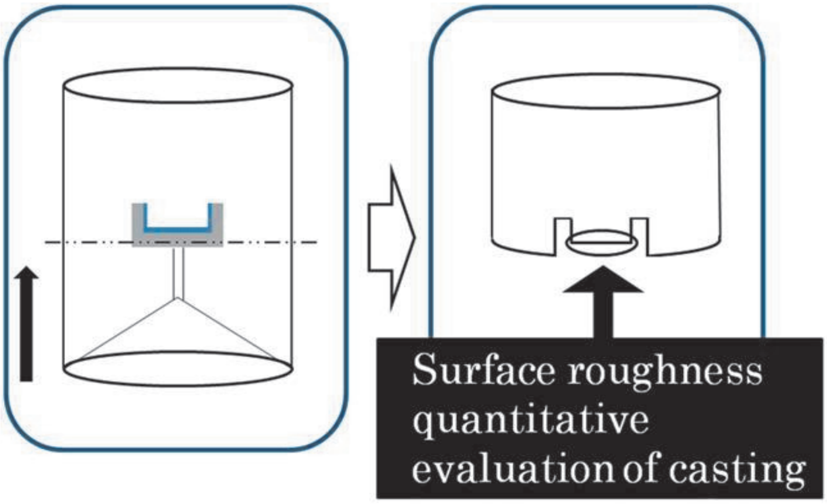

Fig.5 Casting investment section

3) Evaluation items

(1) Qualitative evaluation of investment casting mold surfaces using stereoscopic microscopy.

Casting investment mold surface (Keeper tray) inner surface mold of each sample was evaluated.

(2) Surface roughness quantitative evaluation of casting investment surface.

Surface roughness of casting investment was measured using a digital microscope VHX 500 (KEYENCE), and then observed three-dimensionally. Vertical interval of the surface was defined as surface roughness. One-way analysis of variance and Turkey test were performed at 5% significance level.

Results

1. The influence of incineration time on casting investment

1) Evaluation using a stereoscopic microscopy

Corner casting investment demonstrated surface degradations at 10, 20, and 30 minutes periods after incineration in the acrylic resin. In contrast, no surface degradations were seen for all post incineration time periods for the polyethylene resin samples (Fig. 6).

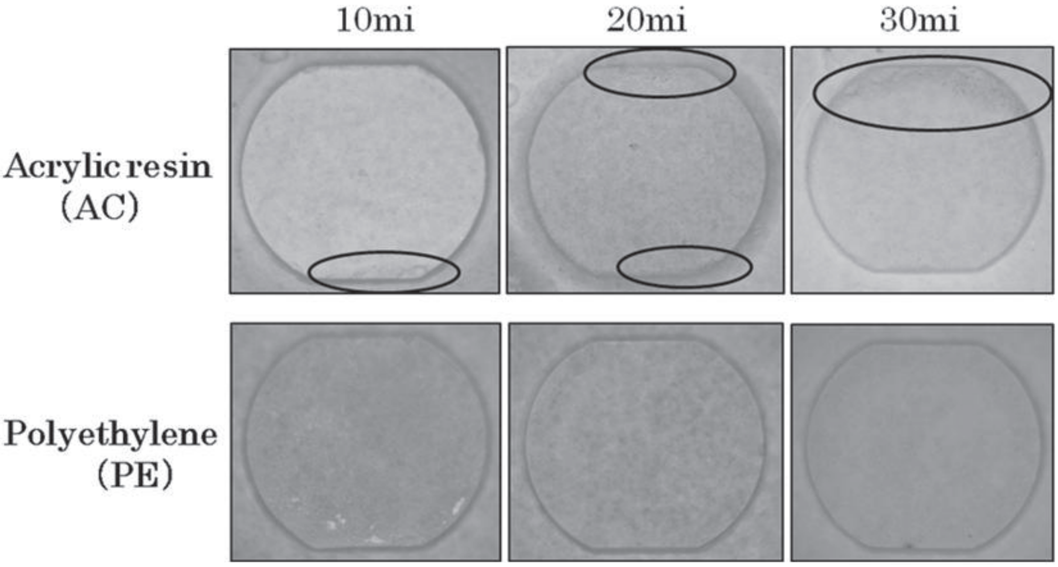

Fig.6　Evaluation using a stereoscopic microscopy

2) Surface roughness measurement

There was a significant difference in measured surface roughness between acrylic samples tested and the polyethylene resin samples at the 10, 20, and 30 minutes periods. No significant difference was observed between 10 and 30 minutes for the acrylic resin samples (Fig. 7).

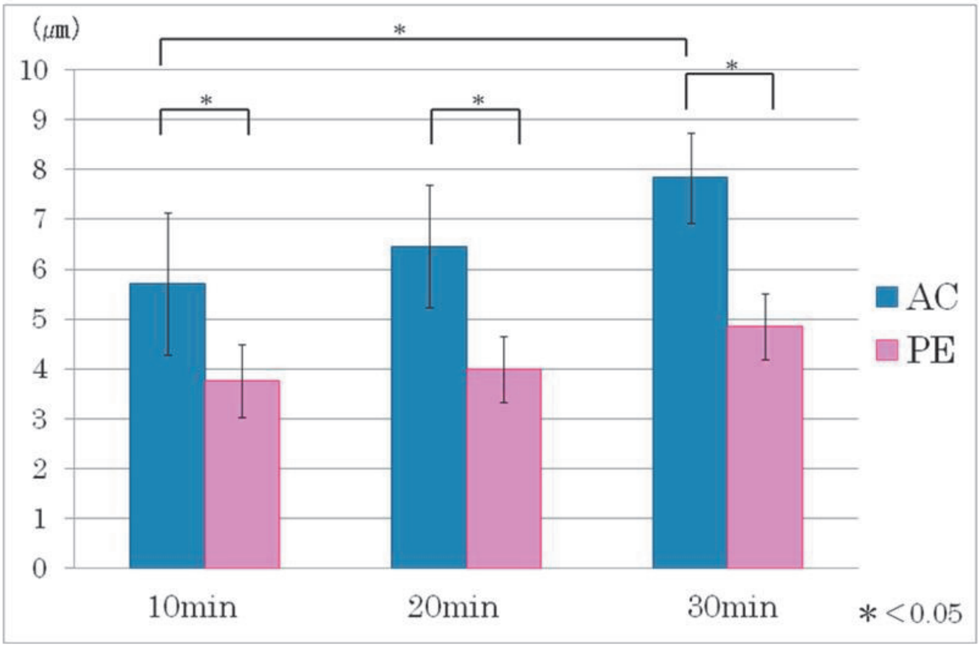

Fig.7　Surface roughness measurement

2. The influence of wax amount on casting investment

1) Observations of casting investment using a stereoscopic microscope

Distortions and degradations of the corner casting investment was observed for all samples with additive wax in the acrylic resin. In contrast, no destruction of the casting investment was observed for in the polyethylene resin/wax samples. There was no degradations of the casting investment both in the acrylic and polyethylene resins without additive wax (Wax 0) (Fig. 8)

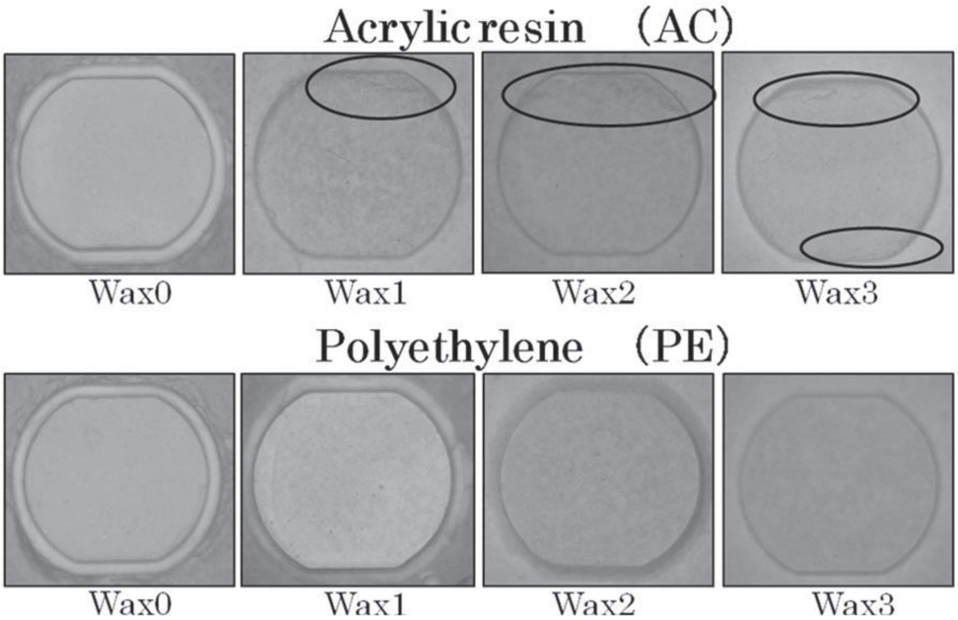

Fig.8　Evaluation using a stereoscopic microscopy

2) Surface roughness measurement

A significant difference was observed between acrylic and polyethylene resins of Wax 1 and 3. There was a significant difference between Wax 1, 2, and 3 in the acrylic resin. No significant difference was found both in the acrylic and polyethylene resins of Wax 1, 2, and 3. (Fig. 9)

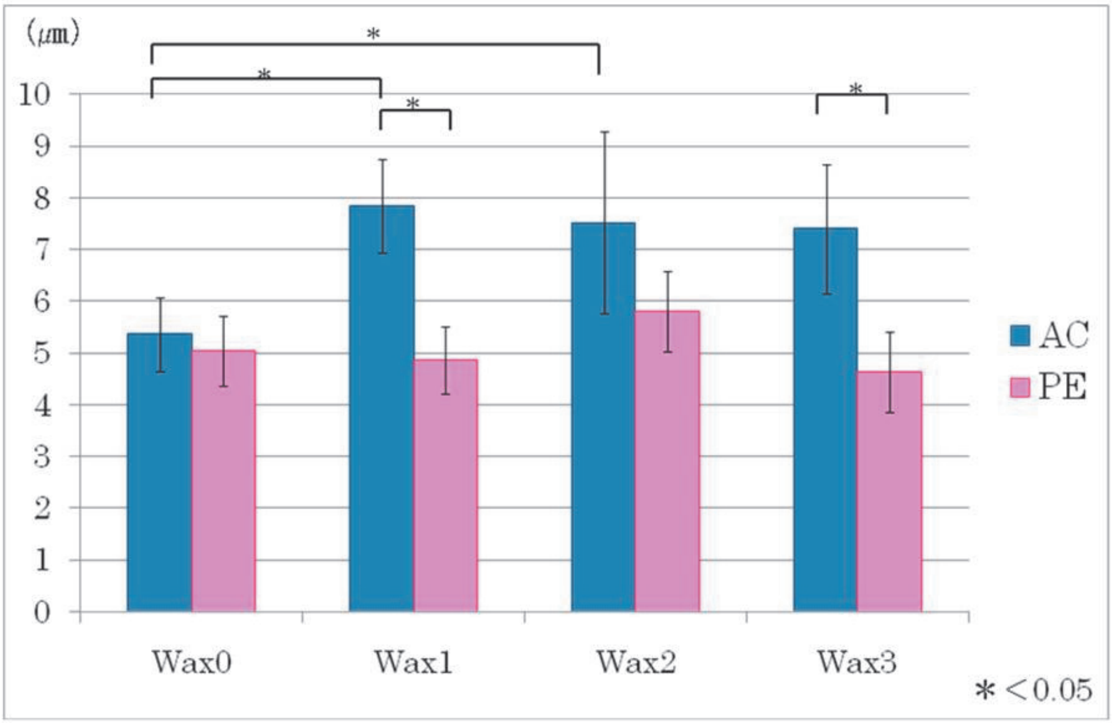

Fig.9　Surface roughness measurement

Discussion

1.　Keeper tray

The magnetic attachment keeper coping fabrication methods and the magnetic attachment keeper abutment fixation technique was developed by Toyota et al. The original recommended method proposed was a casting technique. A ready-made keeper pattern was incorporated into the wax pattern, and cast. This method has been widely adopted in the clinical setting due to ease and availability. However, several problems with this technique have been pointed out in clinical and basic experimental evaluations. The problems include the excess formation of an oxide film on the mirror-polished keeper surface due to casting investment exposure and high temperatures required. Also, other problems associated with high casting burn-out heat exposure are casting shrinkage keeper deformation, and alteration of magnetic properties and decreased corrosion resistance[5,6,7]. These problems may result in a overall decrease in the actual and potential attractive force of a magnetic attachment and therefore cannot be ignored.

Tanaka et al. developed a cementing technique method. In this technique, a separate coping housing excluding the actual keeper was cast, to be followed by the cementing of an unaltered keeper to the cast coping housing[1)-4)]. Keeper space is required on a coping surface. A ready-made plastic pattern (Keeper Tray@) was developed to facilitate wax build-up procedures. The plastic pattern is made of castable acrylic resin with 0.3 mm thickness, leaving a space for the cement after casting. The cast coping holder used to fix a keeper to the casting investment is not necessary in this method. Therefore, the mirror-polished adsorption face can be used without removing a holder[7)].

2. Prototype plastic pattern

Acrylic resin is readily used due to its thermal plasticity. This resin can be compression molded above 150 °C, and offers a greater cost performance[8)]. It is used for commercially-available ready-made patterns. However, casting defects caused by the combined use with other materials has been pointed out. The general properties of acrylic resin, the major component of this proprietary ready-made pattern, include resistance to deformation, insulation properties, and water resistance, but poor chemical resistance. [9)] It was speculated that chemical interaction may occur when acrylic resin is incinerated with dental wax. To avoid such problems, a preliminary experiment was performed to evaluate substitute plastic materials for the acrylic resin. Polyethylene (PE), polypropylene (PP), polyacetal (POM), and ABS resin were used as samples. PE presented the highest surface accuracy after casting. General properties of PE include milky-white translucency, lighter than water, physical properties similar to dissolved paraffin wax at incineration with a low melting temperature of 130 °C, and acid and alkali resistance related to higher molecule structure[8)]. PE is thus considered to have the least potential adverse influence on casting precision when in combination with dental wax. Polyethylene was therefore selected as the test sample material for use in this preliminary study.

3. Cast observation

Observation using a magnifying microscope demonstrated burnout degradation of the corner casting investment of acrylic resin at 10, 20, and 30 minutes after incineration. In contrast, no burnout degradation in the casting investment was observed. The surface roughness became coarser with time, demonstrating a significant difference between acrylic resin and PE.

There was no surface roughness influence caused by the wax quantity used with acrylic resin and PE samples.

The results suggested that casting defects found in the fabrication of a keeper coping using a conventional acrylic plastic pattern are not likely caused by the casting process itself, but by casting investment degradation during burnout incineration. The wax amount is not relevant to the casting surface degradations seen. Plastic patterns are incinerated completely at 10 minutes, and the investment mold surfaces becomes coarser with greater burnout time.

The single use of acrylic resin and PE presents great heat plasticity, and high casting precision can be expected.

A casting burr is caused by a crack of a mold. In a single wax-pattern casting, a crack of a mold is formed by an impact to the mold, and rapid and overheating after investment[9)]. However, rapid heating casting investment is used in the present study, and there were no such casting defects found as described above. Therefore, it is considered that the cast defect is caused by the simultaneous incineration of wax-pattern and plastic materials.

PE has great acid and alkali resistance, and melts at 130°C, lower than acrylic resin. PE is incinerated and permeated to the casting investment at wax boiling temperature, suggesting no blocking of airflow. On the other hand, acrylic resin demonstrates heat plasticity at 150°C. It was suggested that acrylic resin softened around wax boiling point blocks the airflow, and evaporated wax destructed the mold.

Conclusion

The casting investment procedures of a prototype keeper mold and commercially-available keeper trays mold at burn-out incineration process were compared. The following conclusions were drawn:

1. The observation of a casting investment using a stereoscopic microscope showed corner degradations inside the keeper tray surfaces of the acrylic resin mold samples tested. No destruction of the casting investment was observed in PE samples molds.
2. The surface showed more surface irregularities with increased time of burn-out.
3. There was no difference in the observed surface roughness for both the acrylic resin and PE samples with amounts of additive wax.
4. Surface roughness was decreased and lower for the PE samples than acrylic resin samples for all conditions.

The results suggested that the use of a polyethylene mold pattern results in a superior result compared to acrylic resin patterns use for attachment keeper castings.

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Retentive force of a magnetic attachments applied to the proximal surface–Part 2–

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Introduction

A clinical technique in which magnetic attachments are applied to the proximal surface of the abutment teeth of removable partial dentures is employed at Tsurumi University Dental Hospital.[1,2] The advantages of this technique are that it can be used for vital teeth without preparation and the results are esthetically pleasing. It is more effective if multiple magnetic attachments are applied or when combined with other retainers (Fig. 1).

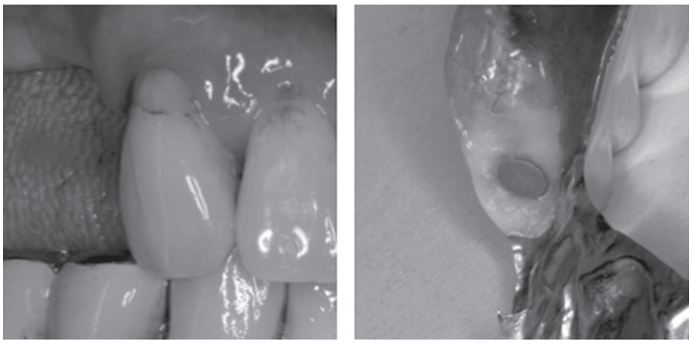

Fig. 1 A clinical case with a magnetic attachment applied to the proximal surface of the abutment tooth of a removable partial denture. A keeper was adhered to the distal surface of canine and the magnetic assembly was fixed to the mesial surface of artificial tooth.

Objective

The efficiency of magnetic attachments applied to the proximal surface of abutment teeth has been evaluated.[3] The purpose of this study was to investigate the effects of the fixation angle of the keepers and the location of the loading points on the retentive force.

Materials and Methods

A free-end saddle model, which was made of acrylic resin, was used with the mandibular first premolar as the abutment tooth. The mesio-distal width of the abutment tooth was 7.1 mm, according to the average size of natural teeth. The size referred to Fujita's textbook of anatomy. The framework was made of a cobalt-chromium alloy. A space of approximately 0.5 mm was left between the abutment tooth and the bracing arm of the framework. Therefore, the framework was in contact with the model only at the rests and rest seats, and lateral force was not generated during the tensile test (Figs. 2 and 3).

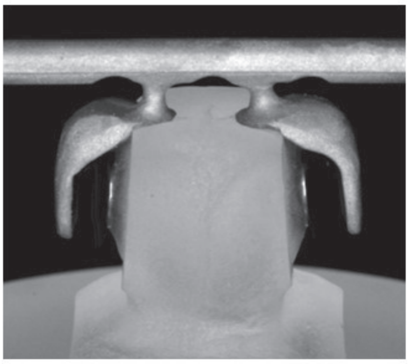

Fig. 2 Framework placed on the abutment tooth model (buccal view)

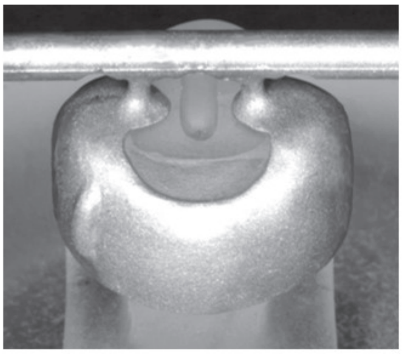

Fig. 3 Framework placed on the abutment tooth model (lingual view)

The PHYSIO MAGNET 35 (Nissin Co., Ltd., Kyoto, Japan) was used in this study (Table 1). Keepers were fixed to both mesial and distal surfaces of the abutment tooth. The fixation angles of both keepers were 2°, 4°, or 6° to the direction of removal. Small, flat planes were prepared on both proximal surfaces of the abutment tooth by a milling machine, and keepers were fixed using PATTERN RESIN (GC Co., Ltd., Tokyo, Japan) (Fig. 4).

Table 1. Magnetic attachment characteristics

Name	Manufacturer	Magnetic assembly		Keeper		Attractive force
		Diameter	Thickness	Diameter	Thickness	
PHYSIO MAGNET 35	Nissin Co.,Ltd,,　Kyoto, Japan	3.5 mm	1.3 mm	3.5 mm	0.8 mm	5.50 N

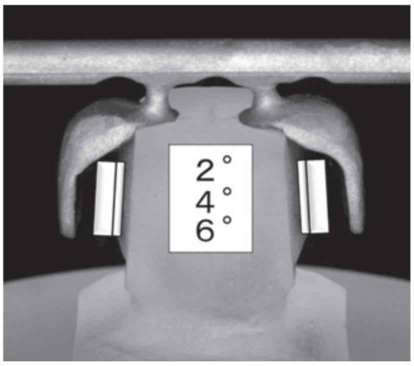

Fig. 4 Fixation angles of magnetic attachments

The retentive force was measured under two conditions. In Condition 1, magnetic attachments were applied to both the mesial and distal surfaces of the abutment tooth. In Condition 2, a magnetic attachment was applied only to the distal surface of the abutment tooth. On the mesial surface, a keeper was fixed to the framework to simulate the relationship between the guiding plane and the proximal plate.

The retentive force was measured by tensile testing conducted with a digital force gauge (FGC-1, NIDEC-SHIMPO Co., Kyoto, Japan) at a crosshead speed of 5 mm/min. The maximum load (N) was recorded. Tensile testing was conducted at five points, namely, the central and distal points of the abutment tooth, the second premolar, and the first and second molar regions. The testing points and the locations are shown in Table 2 and Fig. 5. The distance between points B and C was 5.0 mm, between points B and D, 10.5 mm, and between points B and E, 20.0 mm.

Table 2. Locations for tensile testing of the framework

Points	
A	Central points of the abutment tooth
B	Distal points of the abutment tooth
C	Second premolar region
D	First molar region
E	Second molar region

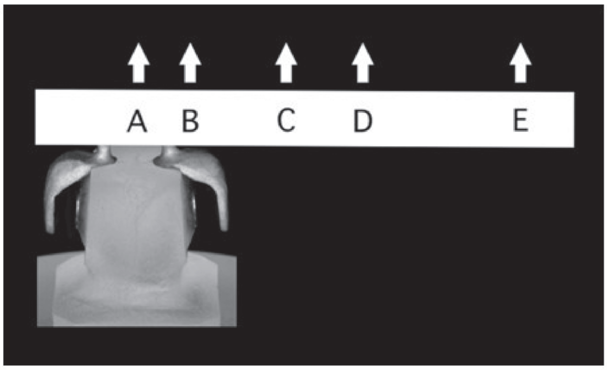

Fig. 5 Tensile testing was conducted at five points.

Measurements were repeated five times under each condition. Statistical analysis was performed using the Student's *t*-test and Scheffés test (SPSS ver. 12, SPSS Japan Inc., Tokyo, Japan) at a significance level of $\alpha = 0.05$.

Results

The results of Condition 1 are shown in Fig. 6.

When the fixation angle of the keeper was 2°, the retentive force was 1.97 N at point A and 1.65 N at point B. Tensile testing could not be conducted at point C, D, or E. Following the tensile testing, the framework tended to tilt, and a mechanical interlocking action occurred. When the fixation angle of the keeper was 4°, the same action occurred at point E.

As the fixation angle increased or the loading points moved distally, the retentive force tended to decrease. There was a significant difference between 2° and 4° at point A and between 4°and 6° at point D. There was a significant difference between points A and E when the fixation angles were 6°.

The results of Condition 2 are shown in Fig. 7.

When the fixation angle of the keeper was 2°, the retentive force was 0.89 N at point A and 0.85 N at point B. A mechanical interlocking action occurred at point C, D, or E, and the tensile testing could not be conducted. The same action occurred at point E when the fixation angles were 4°.

As in Condition 1, the retentive force tended to decrease as the fixation angle increased or the testing points moved distally. There was a significant difference between points A and D when the fixation angle was 4° and between points C and E when the fixation angle was 6°.

Comparing Condition 1 with Condition 2, the effects of the fixation angles or the location of the testing points on the retentive force showed a similar tendency. The retentive force in Condition 1 was approximately two times that of Condition 2. When magnetic assemblies were applied on both proximal surfaces of the abutment tooth, the retentive force seemed adequate.

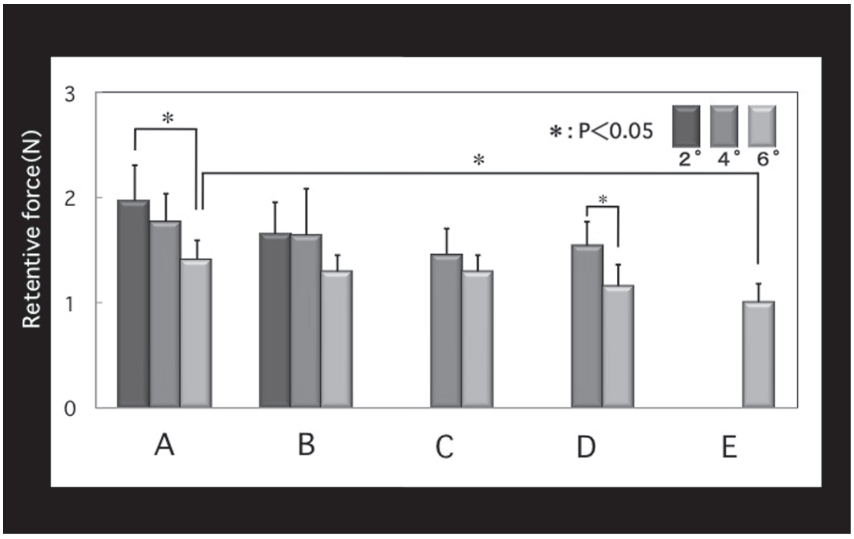

Fig. 6 Results of Condition 1. Magnetic assemblies were applied on both mesial and distal surfaces.

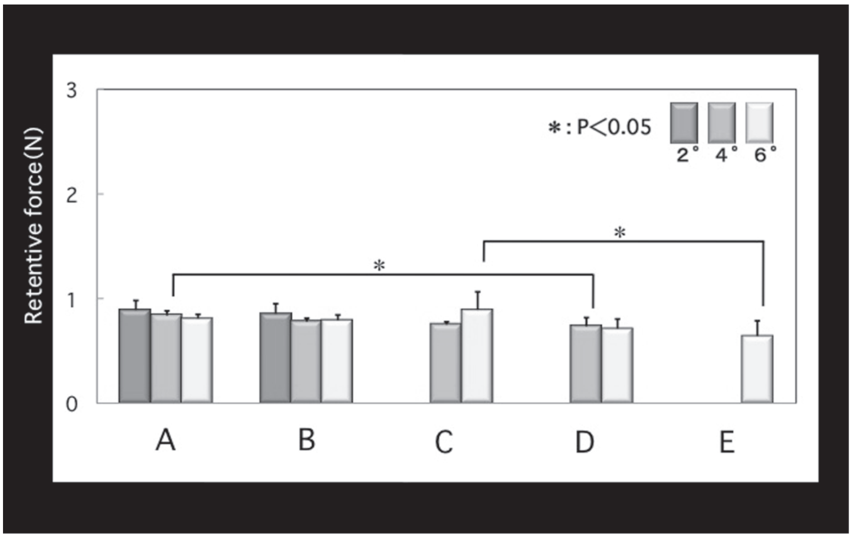

Fig. 7 Results of Condition 2. Magnetic assembly was applied only on the distal surface.

Conclusion

When magnetic assemblies were applied to both proximal surfaces of the abutment tooth and the fixation angle was 2° or 4°, the retentive force was adequate. Mechanical interlocking was observed when the fixation angles of the keepers were small, which would be effective for the retention of removable partial dentures.

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How to brush an attachment?
Oral hygiene instructions to attachment denture patients for dental hygienists

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Introduction

Dental hygienists in the Prosthodontic Department are in charge of the oral hygiene instructions provided to patients who complete prosthodontic treatment. Patients with specialized attachments are frequently encountered in a normal hygiene practice. Patients using partial dentures with special magnetic attachments are satisfied with esthetic result of treatment and their improved chewing ability.

The shape of these magnetic attachments varies from the simple to the complex. While the basic shape of a magnetic attachment keeper or MT crownsappears simple, they are actually completely different from natural teeth. The specialized shaping of an extracoronal magnetic attachment include the complex features of a groove and interlock.

Patients using attachment dentures often complain of difficulty in their oral hygiene and self-cleaning of the keeper attachment.

Objective

The present paper reports on the choice of magnetic attachment brushing materials and brushing methods.

Case Report

The patient was a 42-year-old female with several chief complaints including: poor esthetics, difficulty in chewing, and malocclusion. Figure. 1 shows the patient's image at first visit.

Fig.1　Patient's image at first visit

A magnetic attachment was used for the retaining abutment and final restoration. The chief complaints were addressed and reported improved upon. The patient stated satisfaction with prosthetic result and outcome. The present case was previously reported[1)] A MT crown and groove design prosthetic treatment was placed in the maxilla, and an extracoronal magnetic attachment and MT crown prosthetic treatment was completed for the mandible (Fig.2).

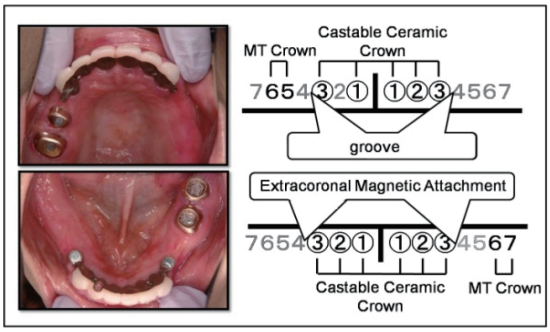

Fig.2　prosthetic treatment for Maxilla and Mandible

Oral hygiene instruction was given to the patient during prosthodontic treatment, and the patient maintained excellent plaque control. However, the first PCR after the attachment denture placement was 60%. Dental plaque was observed in a groove and attachment base. It was difficult to remove plaque using toothbrush alone due to thetight complexity of prosthetic design structure. Dental plaque was also observed on the mesial and distal surfaces of the maxillary MT inner crown. The problem of hygiene access is related to the contour, position and access of the the long and isolated MT crown structure and the patient awareness of the problem. (Fig. 3). Retained plaque was noted at the cervical and concave areas of the mandibular MT inner crown (Fig. 4). A denture plaque disclosing agent additionally identified dental plaque in these unbrushed areas. The patient lack of awareness was significantly noted in the cleaning her denture (Fig. 5).

A scrubbing and brushing technique was taught at the first appointment oral hygiene instruction. The extracoronal attachment brushing method was taught at the second lesson. Specifically, a

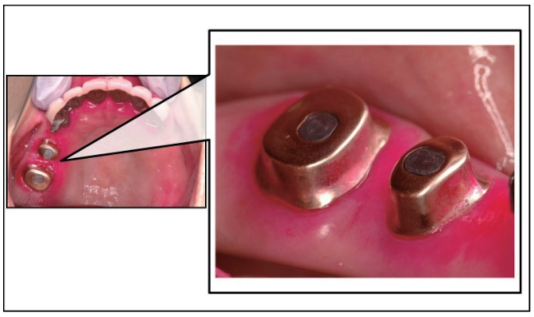

Fig.3　Dental plaque of the maxillary MT inner crown

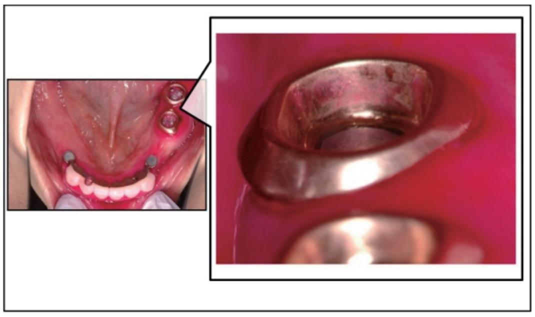

Fig.4　Dental plaque of the mandibular MT inner crown

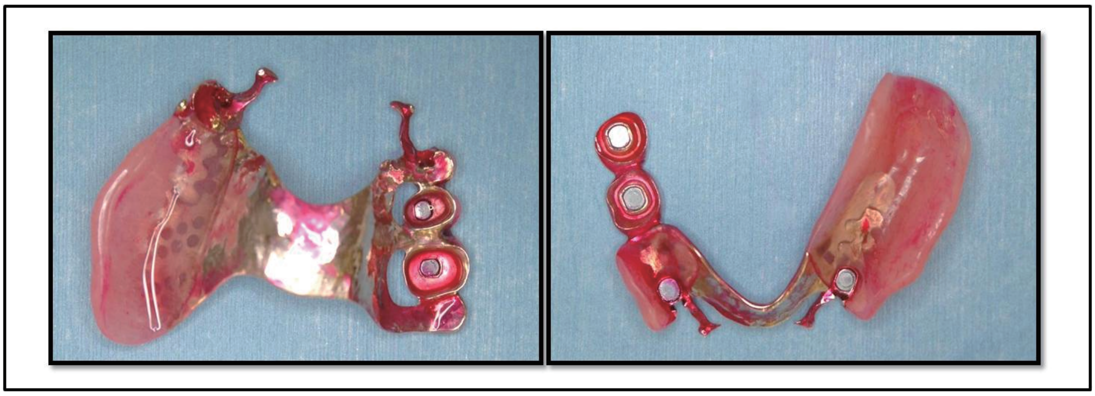

Fig.5　Dental plaque of the maxillary and mandibular dentures

thick-type abrasive floss thread (Superfloss, GC) was inserted along with the attachment base and groove (Fig. 6). A one tuft brush tip was then used to brush the interlock area (Fig. 7). The PCR gradually declined as the patient's motivation and improvedof brushing skills to an increase in. The brushing of the MT inner crown was taught at the fourth appointment. The angle, stability, and grip of the one tuft brush was additionaly demonstrated for cleaning of the long maxillary MT crown. An attachment brush was used to clean the mandibular MT crown as access is difficult due a low relativeprofile hight (Fig. 8). A evaluated PCR score showed a 5th measurement below 20%. (Fig. 9). Figure 10 demonstrates stained remaining teeth with a plaque disclosing agent after brushing. The visualization of uncleaned areas improves patient awareness and stresses othe importance of denture cleaning.

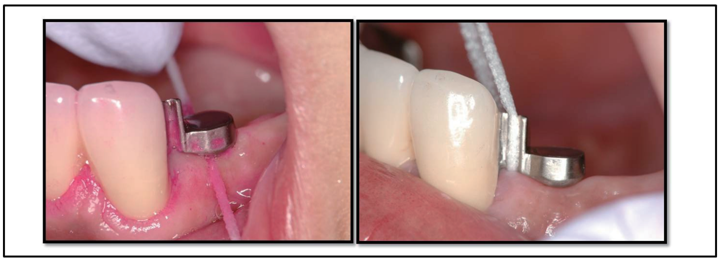

Fig.6　Scrubbing and brushing technique for attachment base and groove

PMTC is performed regularly at every 3-month checkup.

Fig.7　Scrubbing and brushing technique for interlock area

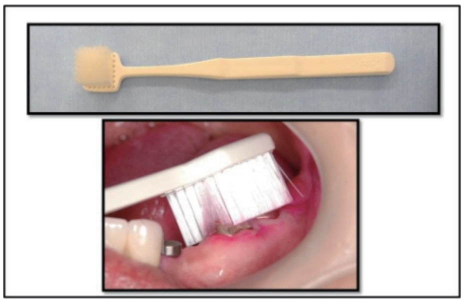

Fig.8　Attachment brush (GC)

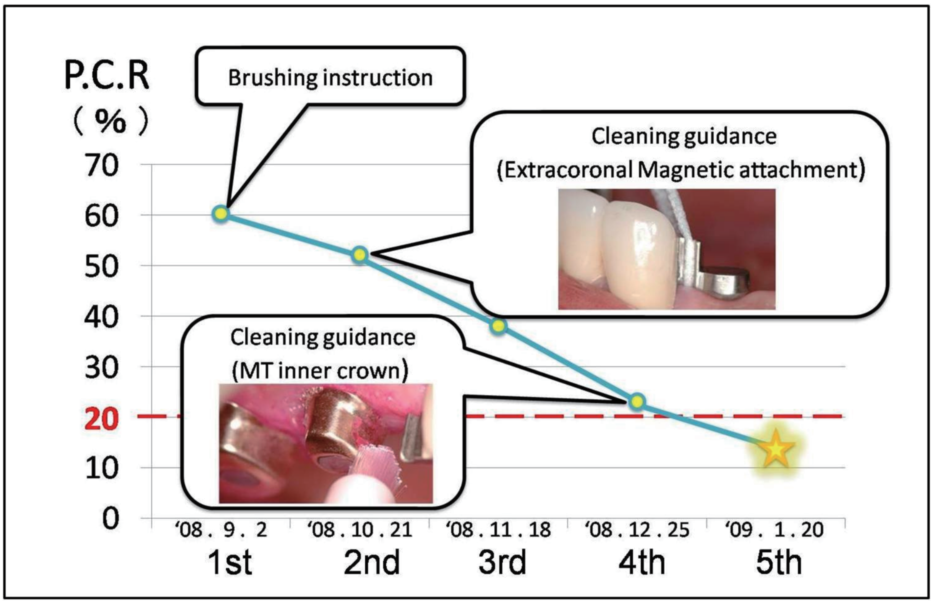

Fig.9　Plaque control instruction (1st – 5th)

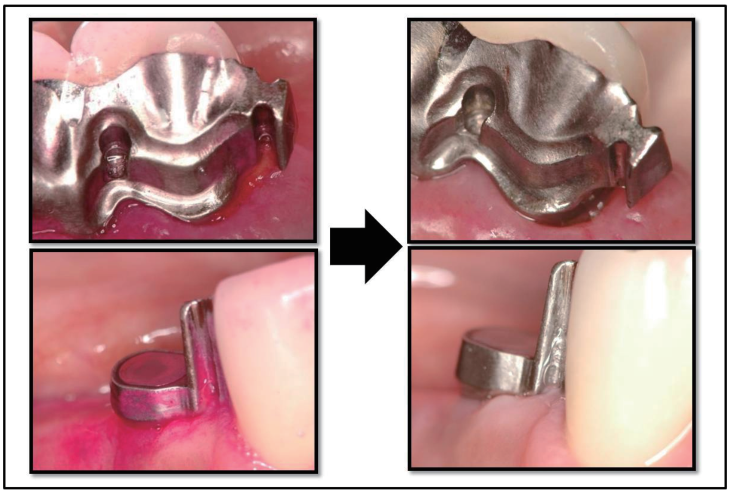

Fig.10　After plaque control instruction

Discussions

Although the patient showed an excellent plaque control during the prosthodontic phases of treatment, post treatment evaluation of multiple unbrushed areas was observed after attachment denture delivery. The visualization of hygiene problem areas is very important for patient awareness of the importance of denture and oral hygiene. Magnetic attachment designs of varying profiles and shapes are cleaned by appropriate use of adjunctive brush designs and hygiene tools.

Conclusions

Although the present patient achieved a satisfactory PCR result, identical brushing methods cannot be used for all patients. The brushing methods may be changed in response to a patient's dexterity. The importance of prostheses plaque control and complex restorative attachment structures are confirmed. It is important for doctors and dental technicians to not only seek functional and esthetic results but also provide for hygienic maintainability. Dental hygienists should give appropriate advice to each patient for correct tooth brush selection and recommended techniques considering the patient's age, dexterity, and individual awareness.

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Effect of Placement of Magnetic Attachment on Retentive Force of Overdenture

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Introduction

Complete mandibular dentures for edentulous patients become loose when their border seals loosen with precipitous tongue movements or when the mouth is opened. Implants with attachments are useful for retaining an overdenture. Good results have been reported in many cases in which magnetic overdentures are used. However, most of these reports dealt with experiments in which retentive force was achieved with the use of independent magnetic attachments. There have been few reports of experiments involving the retentive force of magnetic overdentures clinical situation.

Objective

The aim of this study is to evaluate the retentive force of a mandibular overdenture with various layouts of implants with magnetic attachments using a universal testing machine.

Materials and Methods

1. Experimental model

A mandibular model (H3-402L, Nissin) was used as a master model. Mandibular bone and overdenture models were made with acrylic resin (Acron, GC), and a residual mucous membrane model was made with a silicone impression material (Exahiflex Regular, GC). Artificial saliva was made with moisturizing gel (Oralbalance, Laclede). Magnetic attachments (Gigauss D600, GC) were placed on a median mandible, a canine, and a molar (Fig. 1).

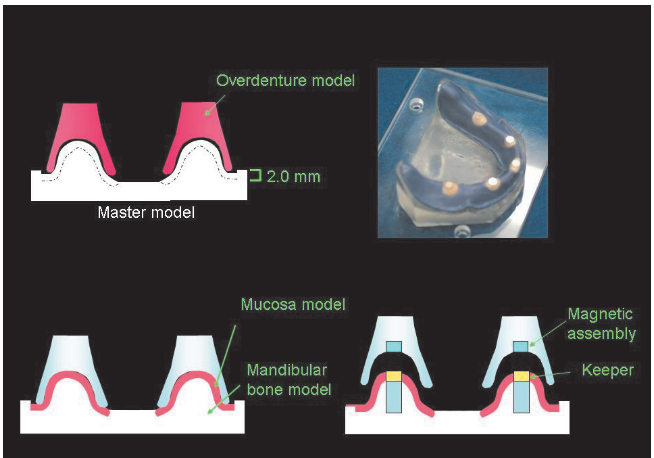

Fig.1 Experimental Model

2. Tensile tests

Tensile tests were performed at the incisor point (A), left second molar (B), and center of the second molar (C) of the overdenture model with an original testing jig[1)] and a universal testing machine at 5.0 mm/min of crosshead speed.[2)] The test was repeated five times under each condition, and the results were averaged (Figs. 2 and 3).

Statistical analysis

Statistical analysis was performed using SPSS ver.12 software. A statistical comparison was performed using Tukey's test (P<.05).

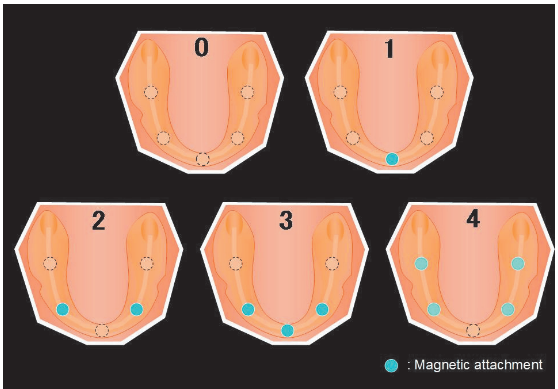

Fig.2 Experiment Design

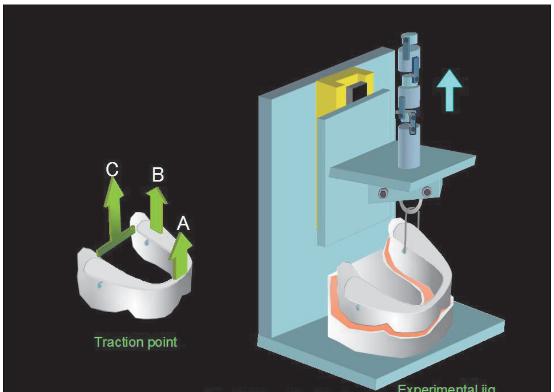

Fig.3 Tensile Test

Results

The largest retentive force at point A was observed with design 3 (6.3N), at point B, with design 4 (5.0N), and at point C, with design 4 (4.9N) (Figs. 3-6). The largest retentive force was observed at traction point C with design 0 (Fig. 7). No significant difference was found between traction points with design 1 and design 4. The largest retentive force was found at traction point A with designs 2 and 3.

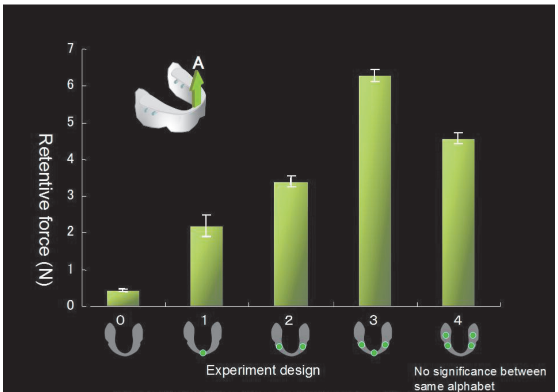

Fig.4 Retentive Force of Traction Point A

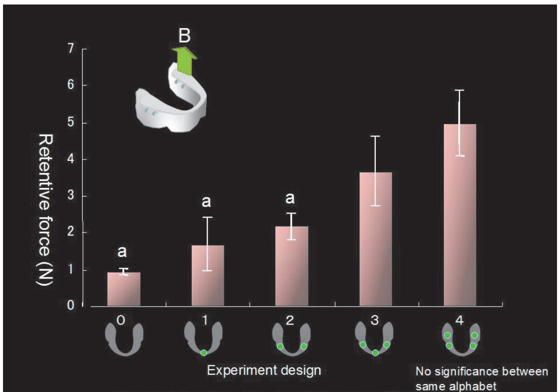

Fig.5 Retentive Force of Traction Point B

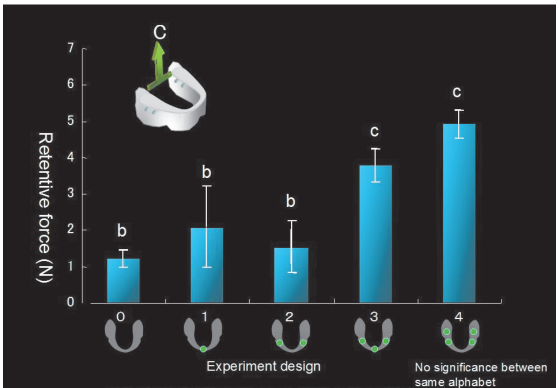

Fig.6 Retentive Force of Traction Point C

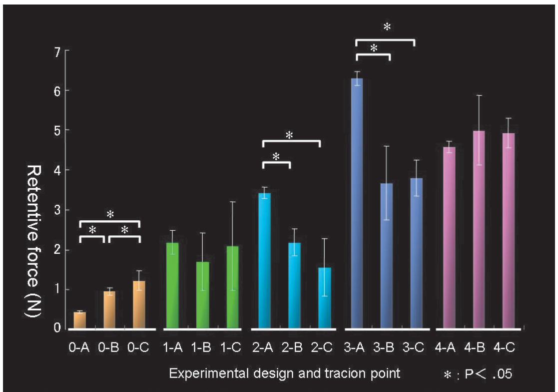

Fig.7 Retentive Force of Experimental Design and Traction Point

Conclusions

1. Magnetic attachments significantly increase the retentive force of a mandibular overdenture.
2. A median mandibular magnetic attachment significantly increases the retentive force, preventing anterior dislodgment of the overdenture.
3. Three front placement or four square placement of magnetic attachment increases retentive forces against posterior dislodgement of overdenture.

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Effect of Magnetic Fields on Osteoblasts and Fibroblasts *in vitro*

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Introduction

The effects of magnetic fields on bone biology have been of interest to researchers; however, the specificity and mechanism of the magnetic fields on bone have not been revealed yet.[1-2] The purpose of this study is to compare osteoblasts, which are responsible for bone formation, with fibroblasts, which do not make bone, and explore the mechanism of accelerated bone formation by magnetic field exposure.

Materials and Methods

In this study, MC3T3-E1 cells, established as an osteoblast cell strain from mouse calvaria, and L929, a standard fibroblast cell strain, were used.Those cells were inoculated into 12-well plates by 1 x 10^4 cells per well and incubated in a 37˚C, 5%CO_2 atmosphere. A time-varying electro-magnetic power unit generated a maximum 1T magnetic field in the culture area of 120mm x 120mm (Fig. 1). The frequency of the magnetic field could also be changed from 0 to 1Hz. This unit was equipped with a cell culture chamber fitted to the magnetic field exposure area. The chamber could carry a culture plate inside the slot. The strength and frequency of extremely low magnetic fields (ELMF) were set to 0.4T and 0.17Hz, respectively, and the ELMF was exposed to semi-confluent culture plates for 6 hours.

Cell proliferation was assessed using a colorimetric proliferation assay (WST-8 Cell counting kit, Dojindo, Kumamoto, Japan) on days 1, 3, 7, and 10 after ELMF exposure. We determined the hormazan content in the samples by measuring the absorbance at 450 nm. The alkaline phosphatase (ALP) activities of MC3T3-E1 cells were measured on days 3, 7, and 10 after ELMF exposure to evaluate osteoblast differentiation. ALP activities were standardized by the total protein content, which was measured by the Bradford method. Statistical calculations were performed by the student t-test at a significant level of 5%.

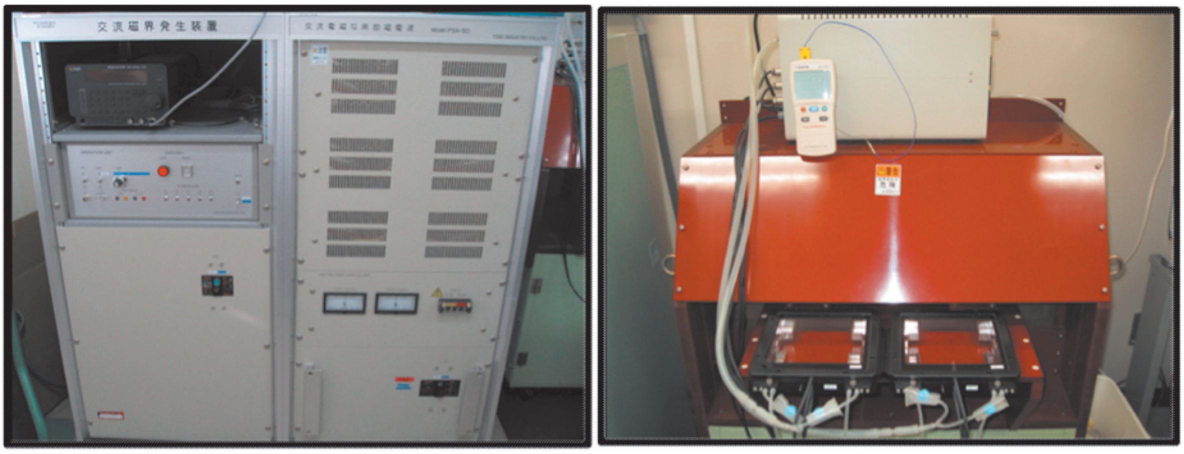

Fig .1: Electromagnetic power unit and special incubator fitted to the exposure slot

Results

The proliferation of MC3T3-E1 cells was promoted at day 3 after ELMF exposure, although day 1, day 7, and day 10 cultures did not show significant differences between the control and the exposed groups. Regarding the proliferation of L929 cells, the exposed culture did not show any differences at any time points compared with the control cultures. ALP activity in MC3T3-E1 cell significantly increased on day 7 and day 10 relative to that of the controls (Figs. 2-4).

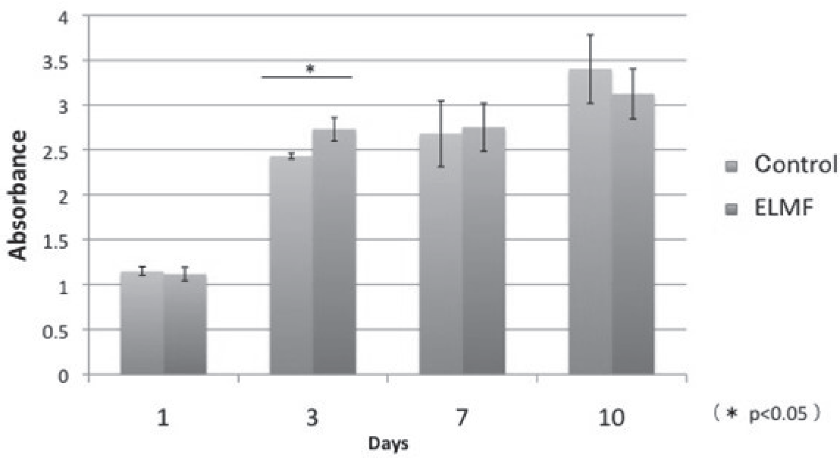

Fig. 2　MC3T3-E1 proliferation

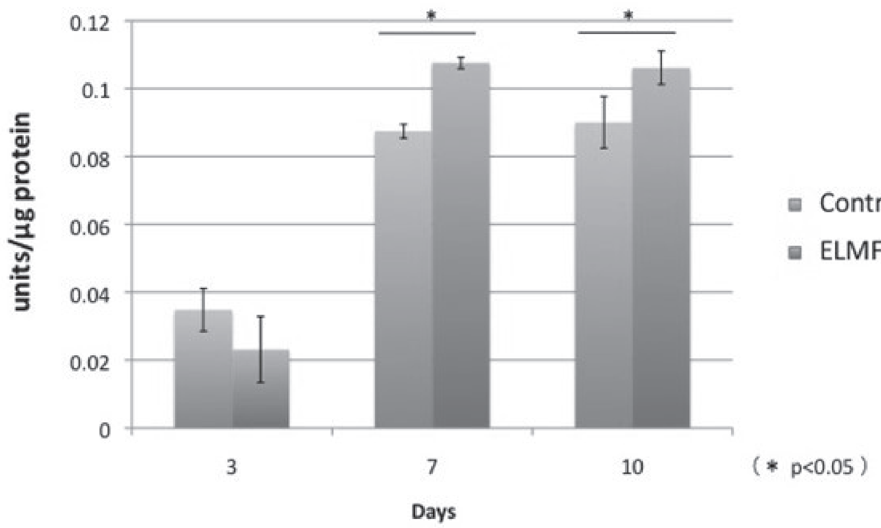

Fig. 3　MC3T3-E1 ALP activities

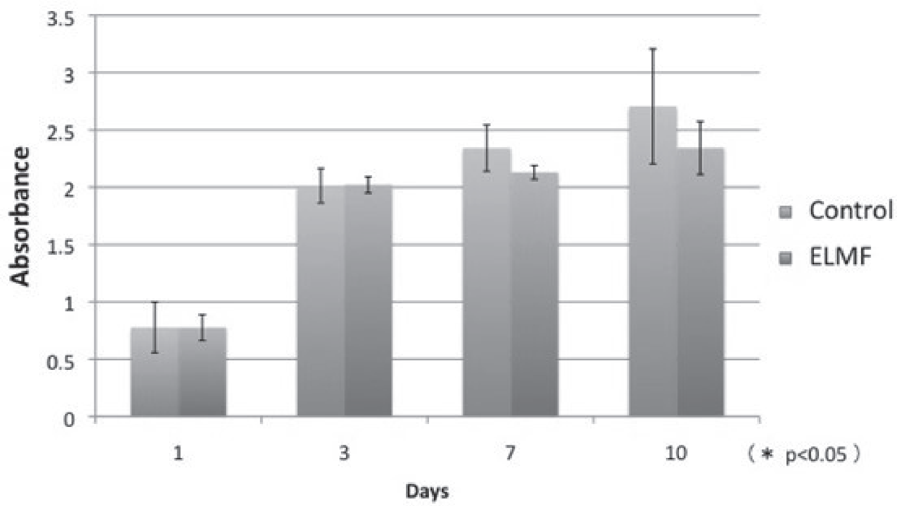

Fig. 4　L929 proliferation

Discussion

This study revealed that ELMF stimulated the proliferation of MC3T3-E1 osteoblast-like cells in the early stage and then promoted osteoblastic differentiation at a later stage. On the other hand, ELMF did not have significant effects on the proliferation of L929 fibroblastic cells.

Soda et al. reported that collagen synthesis stimulated by ELMF could be mediated by the p38 MARK pathway and suppressed the collagen synthesis by the PI3K pathway.[3)] Moreover, Nakano suggested that ELMF induced the differentiation of osteoblasts but did not act like Tri-iodothyronine (T3), a regulator of osteoblastic differentiation.[4)] Since various studies related to the biological effects of the magnetic field have been conducted, the mechanism of bone formation and that of magnetic field stimulation have not been elucidated yet. Further study is needed to understand ELMF effects on osteoblastic cells by molecular biological methods.

Conclusion

ELMF of 0.4T and 0.17Hz stimulated mouse osteoblast-like cell proliferation at the early stage and differentiation into mature osteoblasts, whereas fibroblasts did not show significant differences in proliferation by the exposure. These results suggested that osteoblasts have a specific response to the magnetic fields.

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Longitudinal Study of Magnetic attachments –Investigation of Probing Depth on Abutment Teeth Part.3-

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Introduction

At present, magnetic attachments have been applied clinically in various treatment plans. It's useful to carry out postoperative investigations and to confirm results, as it shows the criterion of the clinical application. [1)] Thus , magnetic attachments can be used safely.

Prospective investigation of magnetic attachments has been carried out since 2003 at the Japanese Society of Magnetic Applications in Dentistry.（JSMAD）

Comparison by condition of abutment teeth was reported earlier. [2)] This time, the comparison by tooth classification is reported.

Methods

The transition in probing depth (PD) of the abutment teeth was measured and the changes in the conditions of periodontal tissue were evaluated.

Immediately after cementation, oral conditions were recorded by use of an original questionnaire, and PD were measured by the 6 points method.

Patients were recalled after 5 years and PD was measured. 5 departments participated in earlier study. In this study, 7 departments participated .

Results

Fig.1 shows the transition of PD by Kennedy's classification. Significant difference were found in Class Ⅱ and Ⅲ.

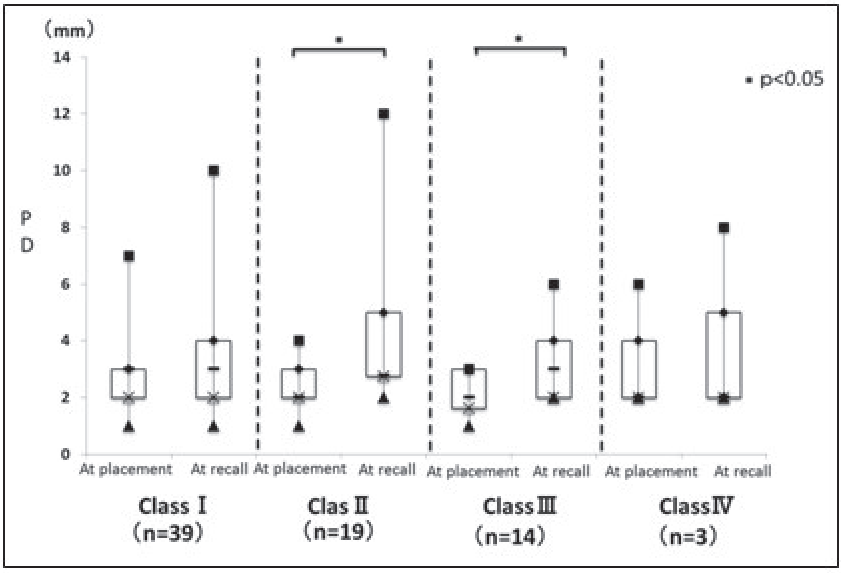

Fig.1 Transition of Probing Depth (Kennedy classification)

Fig.2 shows the transition of PD by Eichner's classification. The number of abutment teeth of class A is only one. So statistical analysis could not be used.
Significant difference were found in Class B.

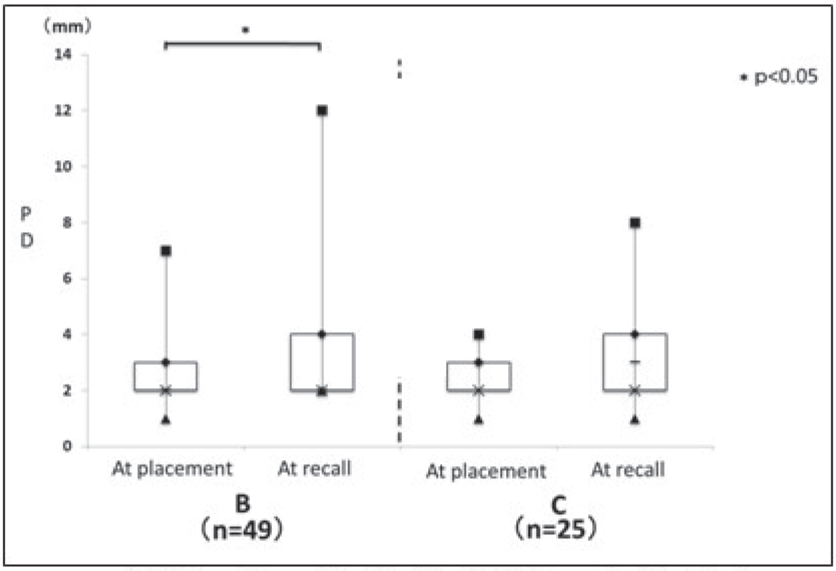

Fig.2 Transition of Probing Depth (Eichner classification)

Table.1 shows the position between abutment teeth and defect.
The white circle mean abutment tooth, the black circle mean another tooth and the black line mean missing.
Abutment teeth were classified into 4 types.

(1) Abutment teeth adjacent to distal extension defect.
(2) Abutment teeth adjacent to intermediary defect.
(3) Abutment teeth adjacent to distal extension and intermediary defect.
(4) Abutment teeth adjacent to no defect.

In addition,(1) and (2) were further classified into two types.
Type one is abutment teeth adjacent to one sided defect and type two is adjacent to both sided defect. The code of (1)-1 is α and the number of teeth is
21. There is no abutment tooth adjacent to both sided distal extension defect. The code of 2-(1) is β and the number of teeth is 20. The code of 2-(2) is γ and the number of teeth is 11. The code of 3 is δ and the number of teeth is 21. The number of abutment teeth adjacent to no defect is few and so statistical analysis had not been used.

Table.1 The Position between Abutment teeth and Defect

	number of abutment teeth	code
1. adjacent to distal extension defect		
・one side — ○ ● ●	21	<α>
・both side — ○ —	0	
2. adjacent to intermediary defect		
・one side ● ○ — ●	20	<β>
・both side ● — ○ — ●	11	<γ>
3. adjacent to distal extension and intermediary defect — ○ — ● ●	21	<δ>
4. adjacent to no defect. ● ● ○ ● ●	2	

○ abutment tooth ● another tooth — defect

Fig. 3 shows the transition of PD by classification of the position of abutment teeth. Significant difference were found in β.

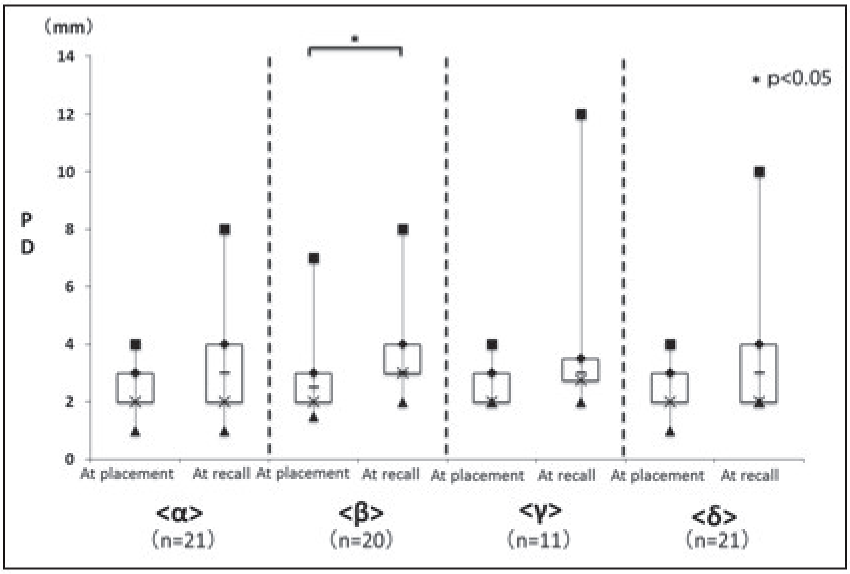

Fig.3 Transition of Probing Depth (classification of the position of abutment teeth)

Table.2 shows the result of the transition by tooth classification and the position of abutment teeth. Significant difference were found between in Kennedy class Ⅱ,Ⅲ, Eichner B and abutment teeth adjacent to one sided intermediary defect.

Table.2 Classification of Removable Partial Denture and position of Abutment Teeth

			* p<0.05
・Kennedy	Ⅰ (lateral distal extension defect)		
	Ⅱ (unilateral distal extension defect)		*
	Ⅲ (unilateral intermediary defect)		*
・Eichner	A (the case have 4 occlusal support)		
	B (the case lose one of 4 occclusal support)		*
	C (the case have no occlusal support)		
・classification of the position of abutment teeth		<α>	
		<β>	*
		<γ>	
		<δ>	

Fig.4 shows the details of treatment and troubles. The types of magnetic attachments are Magfit (48 teeth), GIGAUS (7 teeth), Hycolex (14 teeth), Hyper Slim (6 teeth).

The types of metal are gold-silver-palladium-alloy (64 teeth) platinum-gold-alloy (7 teeth) and unknown (4 teeth). The materials of cementation are resin adhesive (62 teeth), glass ionomer (8 teeth) and unknown (5 teeth). The troubles of dentures are reproduction (4 cases), omission of magnet from the dentures (6 cases), repair (2 cases) and broken of magnet (1 case).

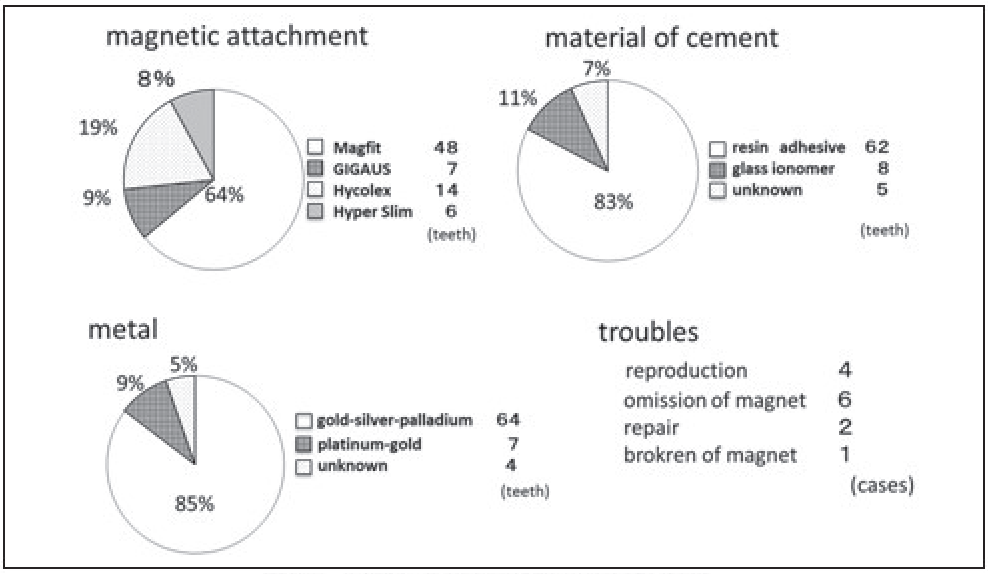

Fig.4　Details of Treatment and Troubles

Discussion

Significant difference were found between initial PD and PD 5 years later in Kennedy class Ⅱ,Ⅲ、Eichner B and abutment teeth adjacent to one sided intermediary defect. Kennedy class Ⅱ that mean unilateral distal extension defect, Kennedy class Ⅲ that mean unilateral intermediary defect, Eichner B that lose one of occlusal support and abutment teeth adjoining one-sided intermediary defect. This result corresponds with a retrospective cohort study that the survival rate of the abutment teeth that have many occlusal support is low. [3] The reason is if the denture has many occlusal supports, large occlusal force are added to the abutment teeth.

Conclusion

The result of prospective observation of magnetic attachments from the point of the transition of PD for 5 years is below.

・ PD of abutment teeth of unilateral distal extension defect and unilateral intermediary defect were increased over 5 years period.
・ PD of abutment teeth that lose one of 4 occlusal support were increased over 5 years.
・ PD of abutment teeth adjoining one-sided intermediary defect were increased over 5 years.

References

Literature references should be listed at the end of the paper in the same order that they appear in the text, and in accordance with the following examples.

1. K. Hoshiai, Y. Tanaka, M. Kawakita, W. Fujinami, K. Wakayama, Y. Imaizumi, T. Matumoto and M. Sakane: Longitudinal Study on Metal Plate Denture with Magnetic Attachments-Part 4, J J Mag Dent, 13(2), 26-29, 2004.
2. R. Ito, K. Hoshiai, Y. Tanaka, T. Ishigami, K. Ishibashi, E. Bando and H, Sasaki: Longitudinal Study of Magnetic Attachments -Investigation of Probing Depth on Abutment teeth-, J J Mag Dent, 19(2), 35-39, 2010.
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Longitudinal Study of Magnetic Attachments –Investigation of Probing Depth on Abutment Teeth Part.2-

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Introduction

Magnetic attachments have been applied clinically in various cases. It's useful to carry out postoperative investigations and to confirm results, as it shows the criterion of the clinical application[1)]. Thus, magnetic attachments can be used safely. The present paper reports in an investigation of prospective magnetic attachments that has been carried out since 2003 at the Japanese Society of Magnetic Applications in Dentistry.[2)]（JSMAD）

Methods

The transition of probing depth (PD) of abutment teeth was measured, and the changes of the conditions of periodontal tissue were evaluated. Immediately after cementation, oral conditions were recorded by use of an original questionnaire, and PD was measured using a 6- points method. After 5 years, patients were recalled and PD was measured once again. This time, 7departments of the JSMAD, represented by the authors of this paper, participated in this study. At the beginning of the study, there were 70 patients participants.
However, 28 patients were censored, leaving 42 patients to participate in the study.

Results

Table. 1 details of the cases which were able to participate in the study.
The dentures included 24 maxillary plates and 21 mandibular plates .
The abutment teeth included 12 incisor teeth, 29 cuspid teeth, 25 premolar teeth and 9 molar teeth. The denture plate materials of the dentures were 23 resin plates and 22 metal plates.
The results were statistically analyzed using Willcoxon signed rank test and Mann-Whitney's U test. The significance level was set at 0.05.

Table1.Construction of Abutment teeth

・Start cases　70 cases
Censored cases　28 cases
Extracted teeth　18 teeth

・Total Cases ：42 cases（75 teeth ）
Maxillary : 24 plates（45 teeth）　Mandiblular ：21 plates（30 teeth ）
Incisor ：12 teeth　Cuspid : 29 teeth　Premolar : 25 teeth
Molar : 9 teeth
Metal plate ：22 plates　Resin plate ：23 plates

・Statistical analysis
Wilcoxon signed-ranks test
Mann-Whitney's U test　SPSS Statistics 17.0 : SPSS Japan Inc

Fig 1 shows the transition with Median value and quartile deviation of PD of surviving teeth for 5 years.
A significant difference was found between initial PD and PD after 5 years of all methods (max point of olar unit, six point of olar unit, max point of all abutment teeth, six point of all abutment teeth).

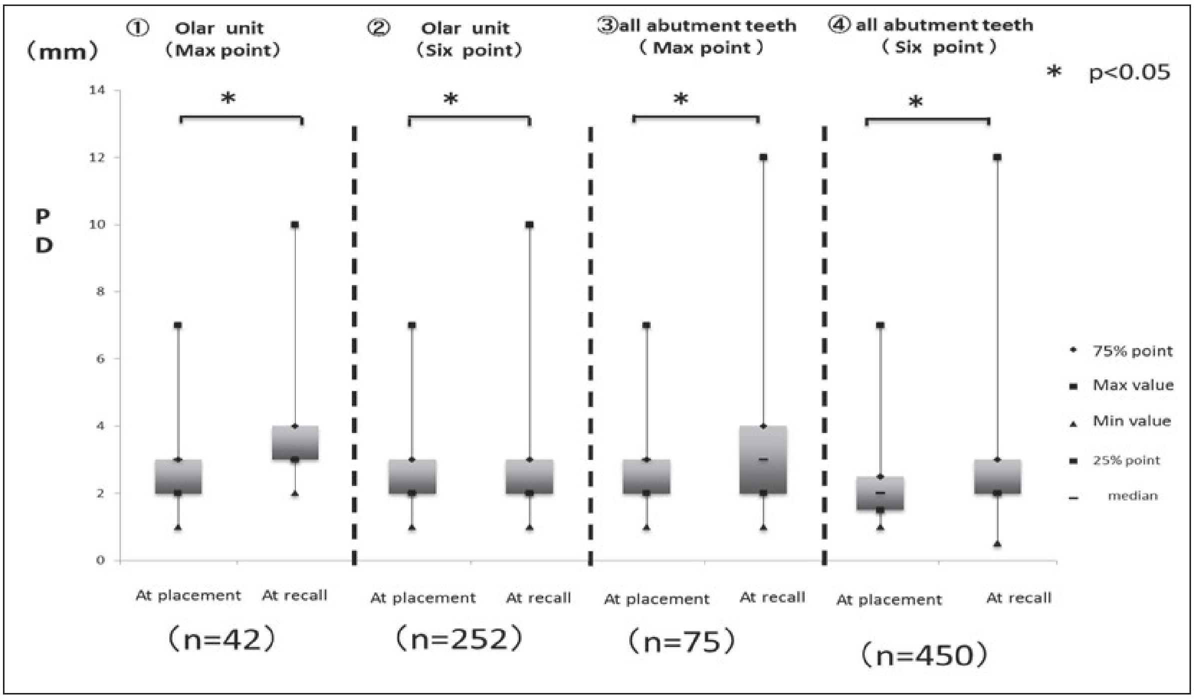

Fig1.Transition of Pocket Depth (deliberation of comparison)

Fig 2 shows the comparison of PD between residual teeth and extracted teeth at placement.
Significant difference was found between residual teeth and extracted teeth at placement.

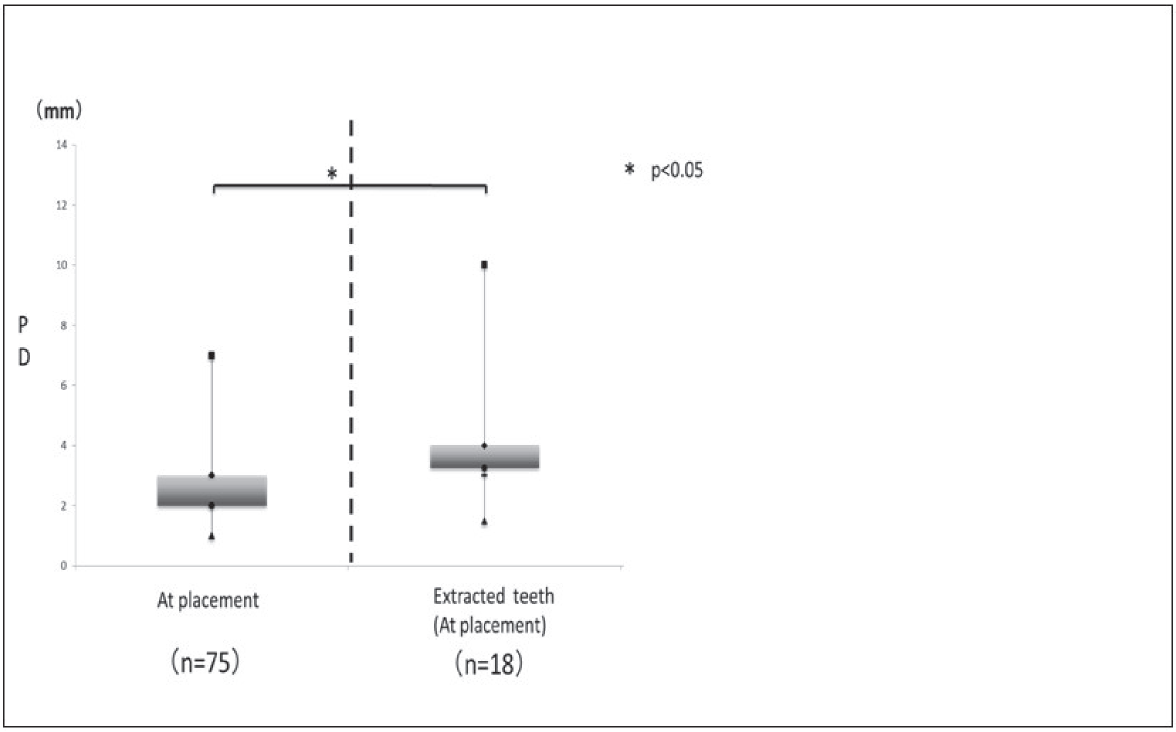

Fig2. .Transition of Pocket Depth (comparison of wearing)

Fig 3 shows the transition of PD of maxillary and mandibular plates. Significant differences were found in the maxillary plates.

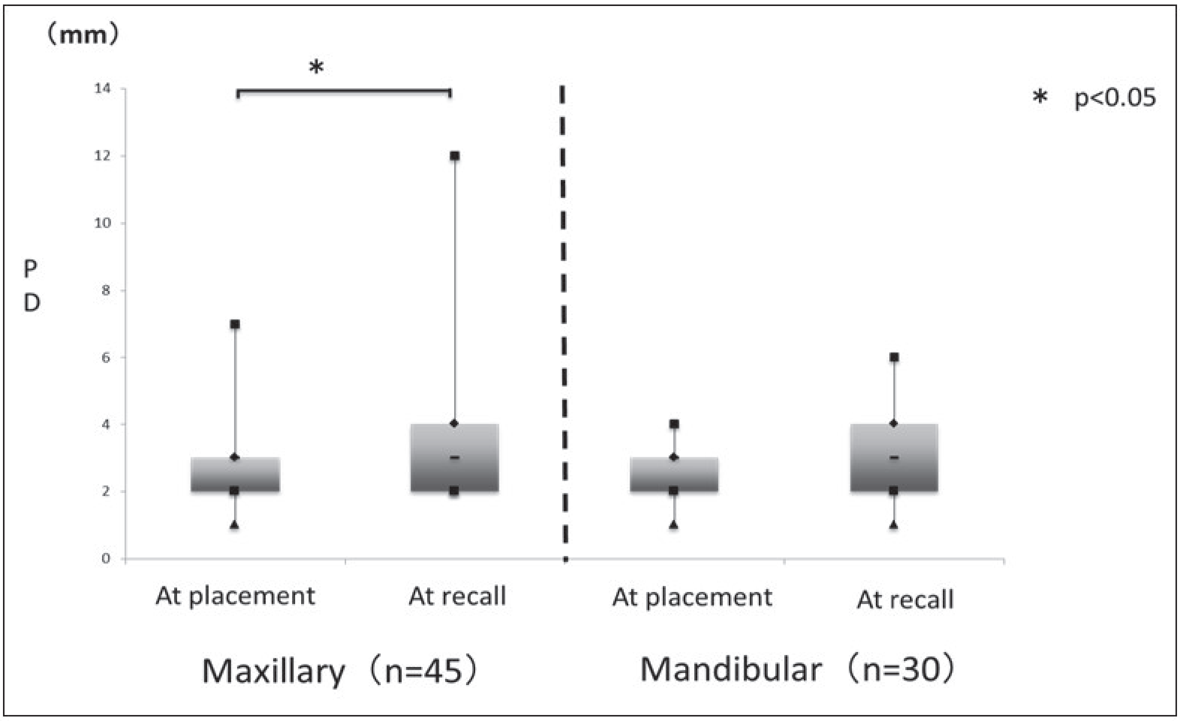

Fig3. .Transition of Pocket Depth (maxillary and mandibular)

Fig 4 shows the transition of PD by gender. Significant differences were found between placement and recall for females. Significant differences were found between males and females at placement. The PD of females significantly deteriorated.

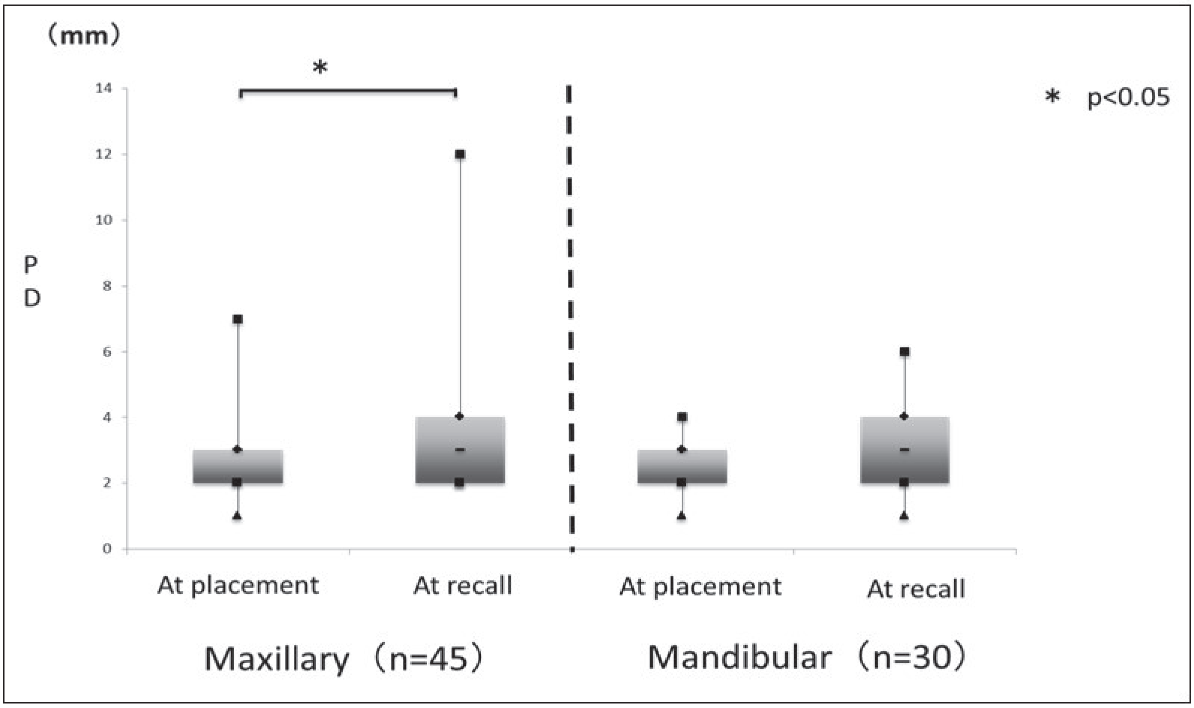

Fig4. .Transition of Pocket Depth (gender)

Fig 5 shows the transitions of PD of materials of plates. No significant differences were found .

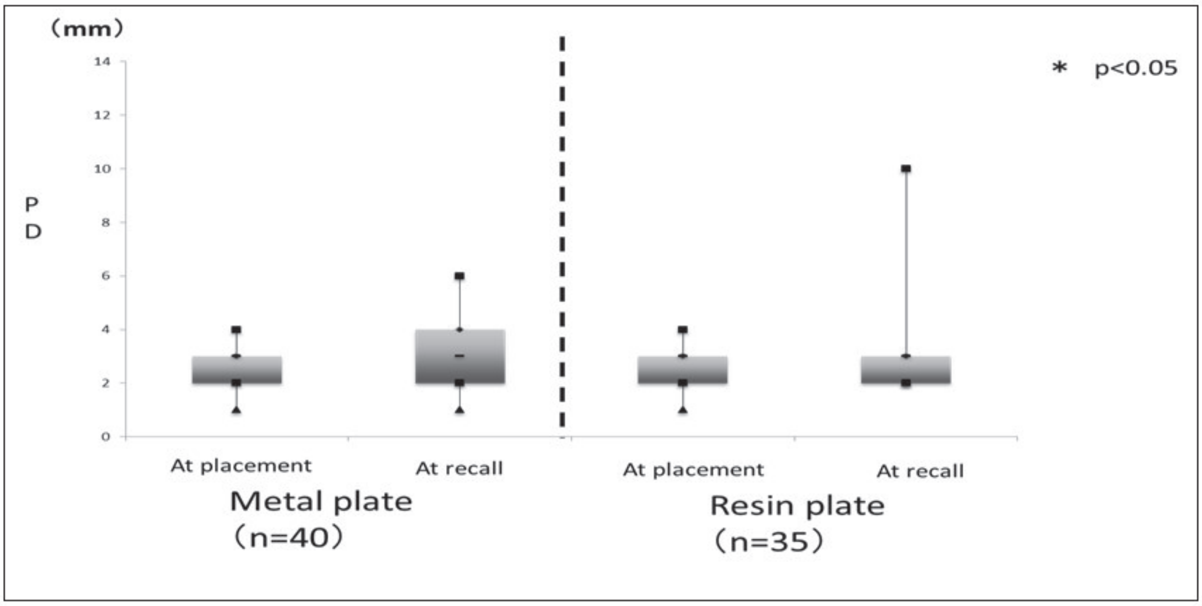

Fig5. .Transition of Pocket Depth (metal and resin plate)

Fig 6 shows the transitions of PD of materials of plates and gender. Significant differences were found in Female/Resin plates. Significant differences were found between Female/Metal plates and Female/Resin plates at recall. Significant differences were found between Male/Metal plates and Female/Metal plates at placement.

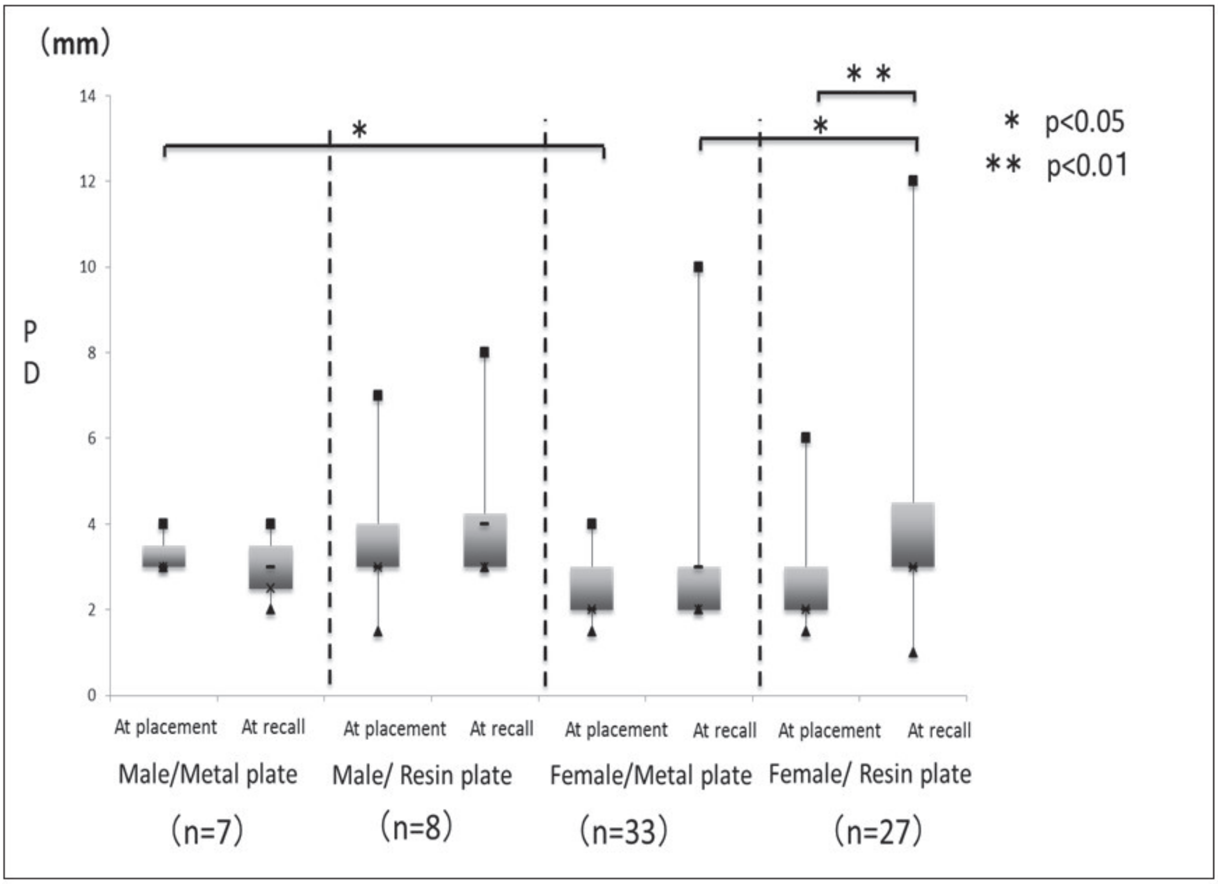

Fig6. .Transition of Pocket Depth (metal and resin plate/gender)

Fig 7 shows the transitions of PD by abutment teeth. Significant differences were found for cuspids.

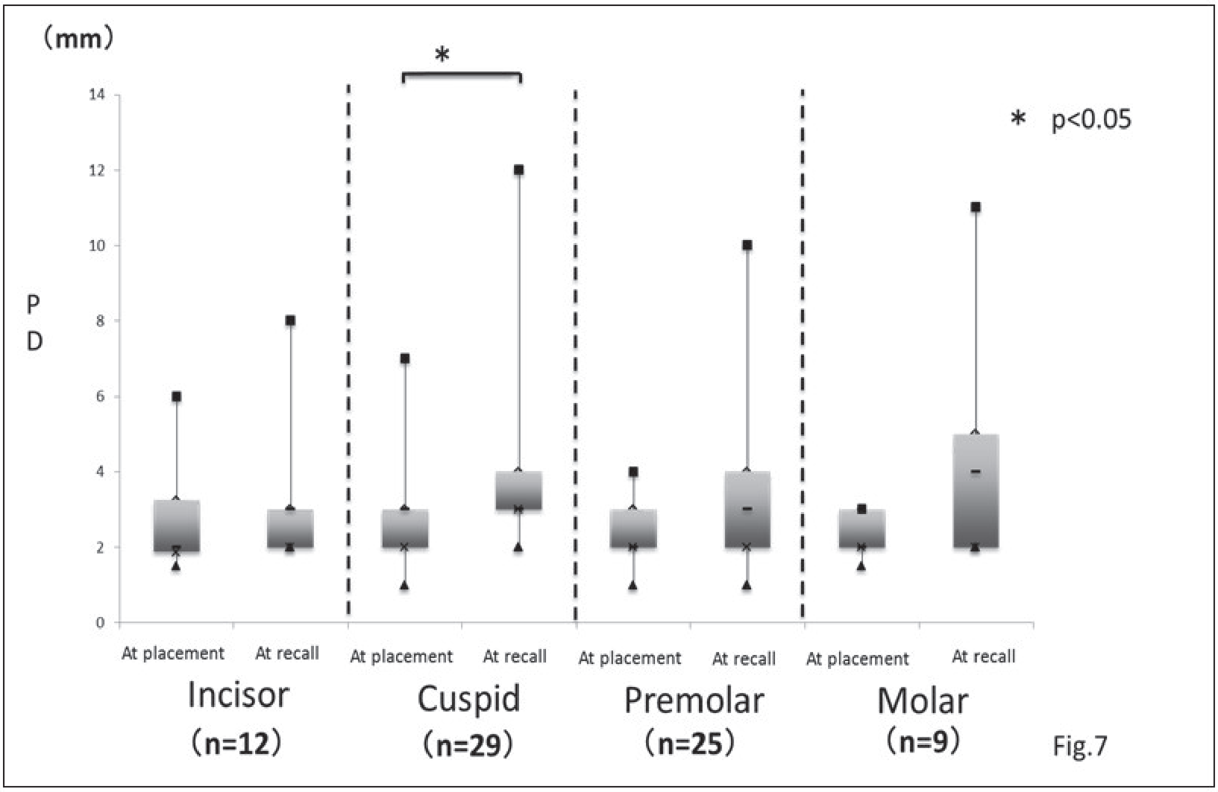

Fig7. Transition of Pocket Depth (abutment teeth)

Discussion

The null hypothesis that PD (Probing depth) of the abutment teeth would not deteriorate was rejected, as a significant difference was found between initial PD and the PD after 5 years. We reported in a retrospective cohort study that the survival rate of resin plates was worse than that of metal plates[2)]. In the present study, the resin plate analysis did not produce the same results, and therefore, cannot be said to correspond to the cohort. However, we can say that when considering the response looking at the data for the female's cohort, the major connector of metal plates is solid; thus, flexure of metal plates is less than that of resin plates. Therefore the abutment teeth of the metal plates were not moved, meaning that the PD of metal plates was less than that of resin plates. With respects to the significant differences found in maxillary plates and for women, further study is required.

Conclusion

The results of prospective observations of magnetic attachments from the point of the transition of PD for 5 years are given below:

- PD of the abutment teeth were increased over a 5-year period.
- Significant differences were found between initial PD and PD 5 years later for maxillary plates, females, Female/Resin plates, and cuspids.
- Significant differences were found between residual teeth and extracted teeth , Male/Metal plate and Female/Metal plate of initial PD.
- Significant differences were found between Female/Metal plate and Female/Resin plate for the PD after 5 years.

References

Literature references should be listed at the end of the paper in the same order that they appear in the text, and in accordance with the following examples.

1. K. Hoshiai, Y. Tanaka, M. Kawakita, W. Fujinami, K. Wakayama, Y. Imaizumi, T. Matumoto and M. Sakane: Longitudinal Study on Metal Plate Denture with Magnetic Attachments-Part 4, J J Mag Dent, 13(2), 26-29, 2004.
2. R. Ito, K. Hoshiai, Y. Tanaka, T. Ishigami, K. Ishibashi, E. Bando and H, Sasaki: Longitudinal Study of Magnetic Attachments -Investigation of Probing Depth on Abutment teeth-, J J Mag Dent, 19(2), 35-39, 2010.

Effect of the Angle of the Axial Surface of a Root Cap upon the Abutment Tooth during Simulated Incisal Clenching –The Boundary Condition in Consideration of Human Mandible Movement–

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Introduction

When a root cap is applied to the abutment tooth for an overdenture, the shape of the root cap may affect the stress distribution of the abutment tooth and the circumferential tissue. In the case of anterior residual teeth, the clenching of residual teeth has an influence on the abutment teeth and the residual ridge. In this study, incisal clenching was simulated with a joint element that permitted rotation and translation and was applied on the mandibular condyle and bite points on complete overdentures. The effects were analyzed regarding the axial surface angle of the root cap for the abutment teeth and the circumferential tissue using three-dimensional finite element analysis.

Materials and Methods

A complete overdenture model with root caps delivered on the mandibular bilateral canine was evaluated. The outline of the abutment teeth and mandible were modeled on the basis of data from a multi-detector CT (Asteion Super4 Edition, Toshiba, Japan). The periodontal ligament, cortical bone, cancellous bone, and alveolar mucosa shapes were modeled with reference to anatomical measurements. The analysis models constructed were tooth, cortical bone, cancellous bone, periodontal ligament, alveolar mucosa, denture base, and root cap. For this study, Rhinoceros (Version 1.0, Robert McNeil & Associates, U.S.A) and ANSYS (Version 11.0, Ansys Inc., U.S.A.) were used. Table 1 shows the Young modulus and Poisson's ratio.

Table 1: Material Properties

Material	Young's modulus (MPa)	Poisson's ratio
Dentin	11721.1	0.30
Cortical bone	10414.7	0.30
Cancellous bone	88.3	0.30
Denture base	1896.3	0.30
Au-Ag-Pd alloy	94080	0.30
Periodontal ligament (First load)	0.049	0.49
Periodontal ligament (Second load)	0.7	0.49
Alveolar mucosa	0.045	0.49

The height of the root cap was 2.5mm from the lingual alveolar crest, and the top surface was set parallel to the occlusal plane. Three inclination angles (0, 15, and 30 degrees) on the axial surface of the root cap were designed (Fig. 1).

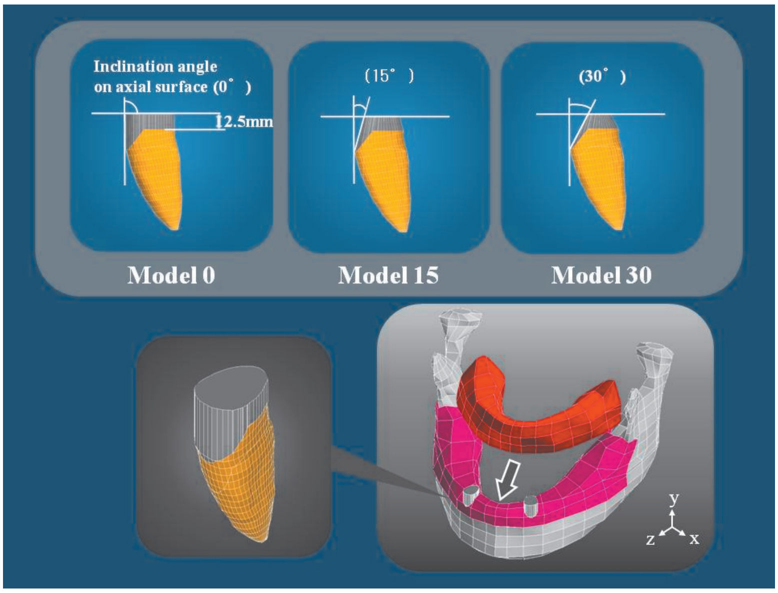

Fig. 1: Design of the Root Cap

The loading conditions determined the vector and force of muscular contraction of the incisal clenching. Table 2 shows the loading conditions. Figure 2 shows the loading directions with arrows.

Table 2: Loading Conditions

	Node number	Load
Superficial Masseter	14	76.2
Deep Masseter	5	21.2
Medial Pterygoid	11	136.3
Anterior Temporalis	9	12.6
Middle Temporalis	12	5.7
Posterior Temporalis	9	3.0
Inferior Lateral Pterygoid	3	47.5
Superior Lateral Pterygoid	3	14.4
Anterior Digastric	1	20.0

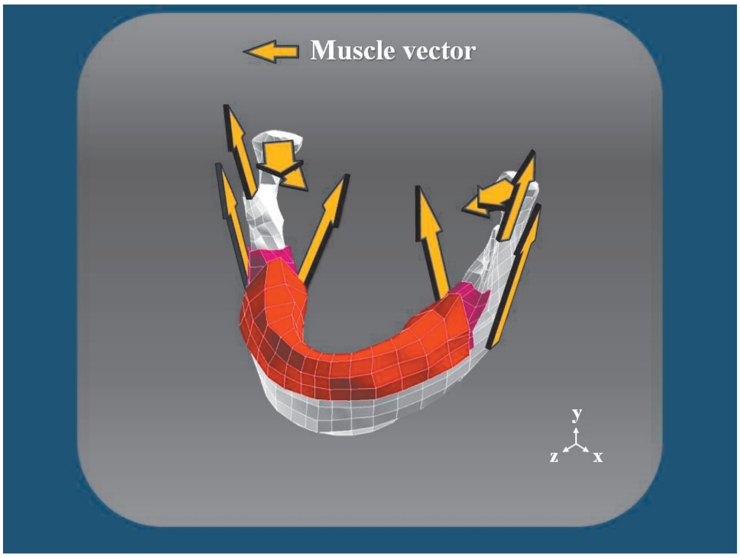

Fig. 2: Loading Directions

The joint element was applied on the upper part of the mandibular condyle and 16 occlusal stops on the complete overdenture. In modeling of the joints between the parts, the joint element permitted simple kinematic constraints, such as identical displacements, between the two parts at the junction or more complicated kinematic constraints that allow for the transmission of motion between two flexible bodies (Fig. 3).

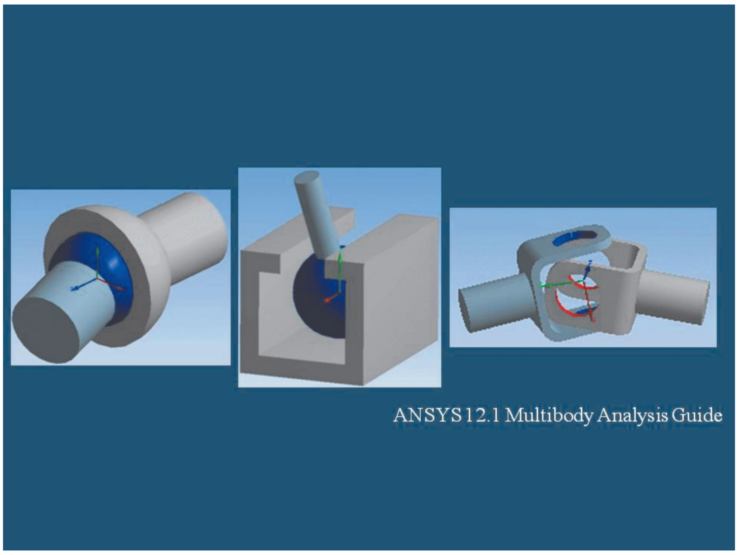

Fig. 3: Types of Joint Elements

The path of each mandibular condyle was constrained. Guidance by the articular eminence was simulated with a planar constraint. It permitted rotation in all dimensions and translation in the specified plane and was analogous to a sphere moving between two parallel, frictionless flat plates.

The constraining plane was angled 30° forward and downward relative to the horizontal dental occlusal plane, and it was canted 5° medially. The inclination angle of the cusp of artificial teeth was set to 25°, and balanced occlusion was simulated by 16 occlusal stops on a complete overdenture (Fig. 4).

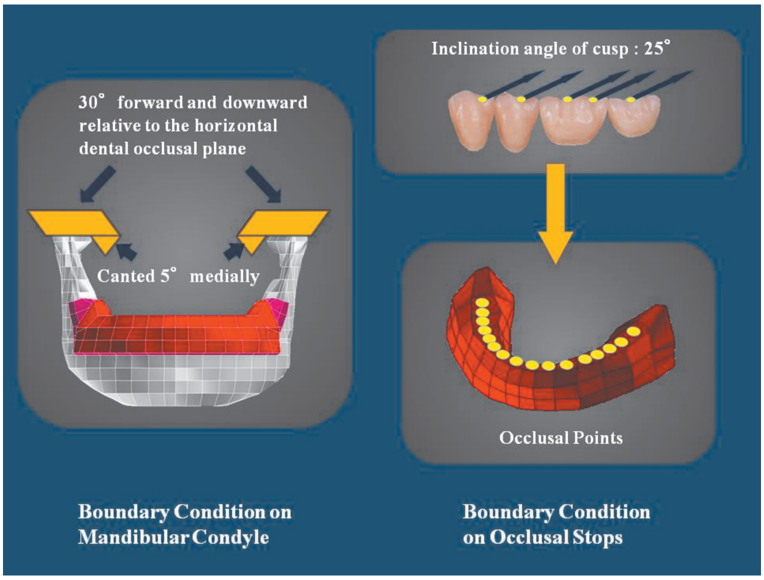

Fig. 4: Boundary Conditions

Stress levels were calculated under the minimum principal stress on the surface of the cortical bone, and the force added to the abutment teeth was calculated on the nodes of the surface of the abutment teeth.

Results

Figure 5 shows the stress distribution of the abutment teeth. Figure 6 shows the stress distribution graph of the top surface of the cortical bone. The stress concentration was detected on the labial and lingual side of the abutment teeth. Stress concentration was detected on the anterior surface in contrast to the posterior surface, where it was on the cortical bone, and, in the model where the inclination angle of the axial surface was 30 degrees, the minimum principal stress had the smallest value.

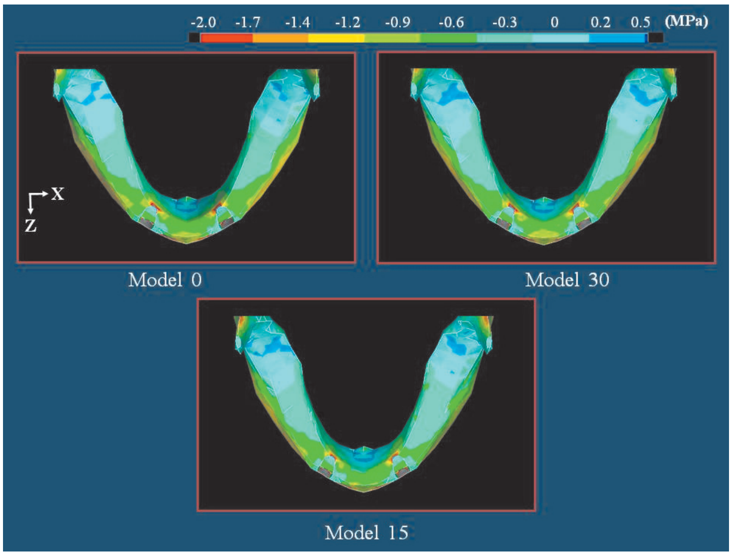

Fig. 5: Stress Distribution (Minimum Principal Stress)

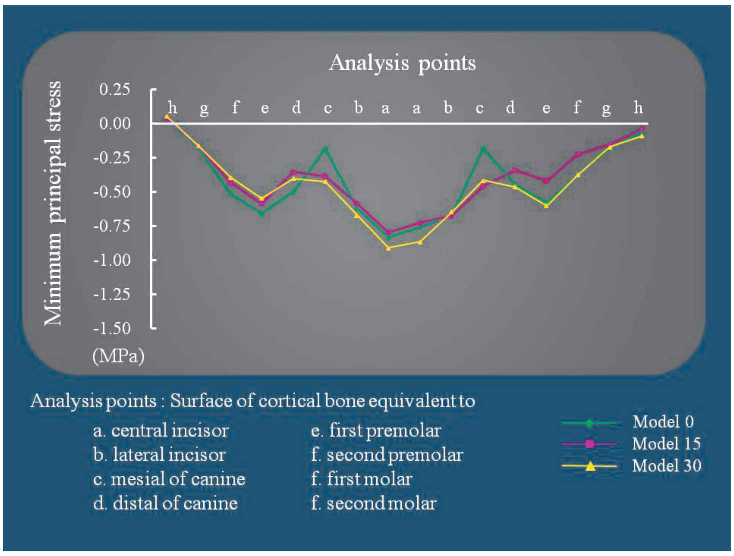

Fig. 6: Stress Distribution Graph of the Top Surface of Cortical Bone

Figure 7 shows the force added to the abutment teeth during simulated incisal clenching. The force added to the abutment teeth decreased when the inclination angle of the axial surface was inclined.

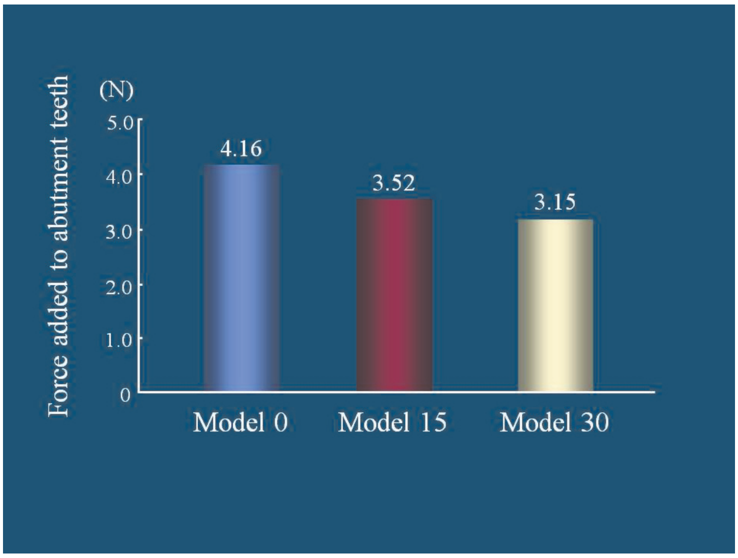

Fig. 7: Force added to Abutment Teeth

Discussion

The biomechanics of the human jaw during incisal clenching is largely unknown, but, in this study, a boundary condition that was similar to the human mandible enabled a biomechanical analysis during incisal clenching by applying the joint element. The movement of the abutment teeth for the complete overdenture was assumed to have increased when the inclination angle of the axial surface was inclined. As a result, the force added to the abutment teeth decreased, and the stress concentration was detected on the anterior surface of the cortical bone.

Conclusions

By the inclination angle of the axial surface was inclined, the stress concentration was detected on the anterior surface rather than on the posterior surface of the cortical bone. However, the force added to the abutment teeth decreased.

References

1. Korioth TW, Hannam AG, Deformation of the Human Mandible During Simulated Tooth Clenching, J Dent Res 73:56-66, 1994.
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Survey of Dental Magnetic Attachments by Quality Function Deployment Method

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Purpose

In order to determine the basic requirements for users of magnetic attachments, we carried out an investigation using the QFD (Quality Function Deployment) method. We determined the postulated conditions for magnetic attachments and selected 19 items. Then, by examining these items, we aimed to determine the clinical applications of effective magnetic attachments.

Methods

In order to determine the requirements for magnetic attachments, we conducted an initial survey of about 40 dentists who had a low degree of interest in magnetic attachments. QFD method was employed for these subjects. Fig.1 shows flow chart of QFD. The flow chart of QFD is as follows.

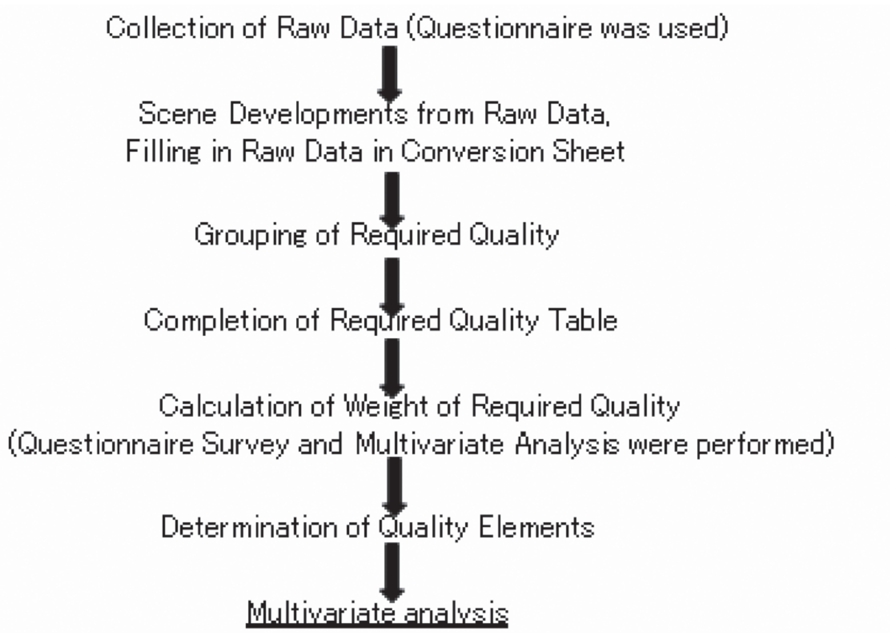

Fig.1 Flow chart of QFD

Table 1. Secondary requirement

① Explain the treatment procedure	⑪ Easy to obtain informed consent
② There are contraindications	⑫ Available treatment device
③ The prognosis is clear	⑬ Create free forms
④ Suitable manual	⑭ Size and share are adequate
⑤ There are indications	⑮ Simple maintenance
⑥ Remove resin easily	⑯ Sufficient magnetic force
⑦ Easy to clean	⑰ Sufficient retentive force
⑧ Easy to remove from wrapping	⑱ Not easily scratched
⑨ Easily find the magnet structure	⑲ Use for a long time
⑩ Suitable for models and samples	

We then created a second survey of 19 items (Table.1), and using this second list, we conducted a second VAS-method questionnaire survey of dentists with a high degree of interest. We also examined the requirements of dental practitioners work at a university with the second questionnaire using multivariate analysis (Table.2).

Table 2. Investigation object

Group I	University work dentist	56
Group II	More clinical experience ten years in group I	15
Group III	Less clinical experience ten years in group I	41
Group IV	Medical practitioner	12
Total	Group I + Medical practitioner	68

Results and Discussion

When magnetic attachments were investigated using the QFD method, practitioners gave high responses concerning the quality with such comments as, " able to use for a long time " and " has sufficient magnetic force ". Two items (" able to use for a long time " and " has sufficient magnetic force ") were chosen from the high-ranking requirements in all groups, including in the practitioner group, as a result of examining the trends among prosthodontists. The requirements were different depending on the workplace of the dentist who investigated. The medical practitioners cited the reliability and secure sense of usage with magnetic attachments, and how there was little trouble with such devices. Also, dentists with considerable clinical experience thought that magnetic devices were safe and trouble free. (Table.4)

Table3.Correlation cocfficienct matrix

	①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩	⑪	⑫	⑬	⑭	⑮	⑯	⑰	⑱	⑲
①	1	0.21	−0.056	0.322**	0.711*	0.408	0.442	0.262	0.048	0.732*	0.212	0.757*	0.24	0.442	0.455	−0.115	0.265	0.308	0.318
②	0.21	1	0.402	0.154	0.364	−0.047	−0.348	−0.333	−0.215	0.354	0.332	0.162	0.028	0.118	0.462	0.522	0.362	0.355	0.365
③	−0.056	0.402	1	−0.178	−0.121	−0.287	−0.205	−0.126	−0.118	0.128	0.53	0.118	0.311	0.465	0.559	0.234	0.108	0.625*	0.338
④	0.322**	0.154	−0.178	1	0.320**	0.334	0.502	0.248	0.128	0.600*	0.162	0.564	−0.118	0.128	0.182	0.212	0.18	0.342	0.225
⑤	0.711*	0.364	−0.121	0.320**	1	0.392	0.658*	0.102	0.411	0.412	0.032	0.56	−0.337	0.022	0.054	0.328	0.31	0.275	0.326
⑥	0.408	−0.047	−0.287	0.334	0.392	1	−0.047	0.730*	0.254	0.595	−0.083	0.23	0.022	0.428	0.192	−0.032	0	0.108	−0.384
⑦	0.442	−0.348	−0.205	0.502	0.658*	−0.047	1	−0.005	0.482	−0.003	−0.186	0.328	−0.362	−0.073	−0.324	−0.083	0	−0.06	0.332
⑧	0.262	−0.333	−0.126	0.248	0.102	0.730*	−0.005	1	0.17	0.262	−0.231	0.03	−0.032	0.528	0.058	−0.231	0.13	−0.071	−0.484
⑨	0.048	−0.215	−0.118	0.128	0.411	0.254	0.482	0.17	1	−0.282	−0.083	0.172	−0.525	−0.272	−0.351	0.022	−0.08	0.128	0.076
⑩	0.732*	0.354	0.128	0.600*	0.412	0.595	−0.003	0.262	−0.282	1	0.528	0.675*	0.552	0.621*	0.725*	0.076	0.03	0.54	0.065
⑪	0.212	0.332	0.53	0.162	0.032	−0.083	−0.186	−0.231	−0.083	0.528	1	0.402	0.332	0.328	0.654*	0.478	−0.384	0.362**	0.03
⑫	0.757*	0.162	0.118	0.564	0.56	0.23	0.328	0.03	0.172	0.675*	0.402	1	0.516	0.333	0.645*	0.033	0.232	0.576	0.242
⑬	0.242	0.028	0.311	−0.118	−0.337	0.022	−0.362	−0.032	−0.525	0.552	0.332	0.516	1	0.528	0.783*	−0.238	−0.047	0.342	−0.025
⑭	0.442	0.118	0.465	0.128	0.022	0.428	−0.073	0.528	−0.272	0.621*	0.328	0.333	0.528	1	0.603*	−0.385	0	0.36	−0.115
⑮	0.455	0.462	0.559	0.182	0.054	0.192	−0.324	0.058	−0.351	0.725*	0.654*	0.645*	0.783*	0.603*	1	0.152	0.292	0.783*	0.148
⑯	−0.115	0.522	0.234	0.212	0.328	−0.032	−0.083	−0.231	0.022	0.076	0.478	0.033	−0.238	−0.385	0.152	1	0.217	0.548	0.114
⑰	0.265	0.362	0.108	0.18	0.31	0	0	0.13	−0.08	0.03	−0.384	0.232	−0.047	0	0.292	0.217	1	−0.084	−0.086
⑱	0.308	0.355	0.625*	0.342	0.275	0.108	−0.06	−0.071	0.128	0.54	0.362**	0.576	0.342	0.36	0.783*	0.548	−0.084	1	0.258
⑲	0.318	0.365	0.338	0.225	0.326	−0.384	0.332	−0.484	0.076	0.065	0.03	0.242	−0.025	−0.115	0.148	0.114	−0.086	0.258	1

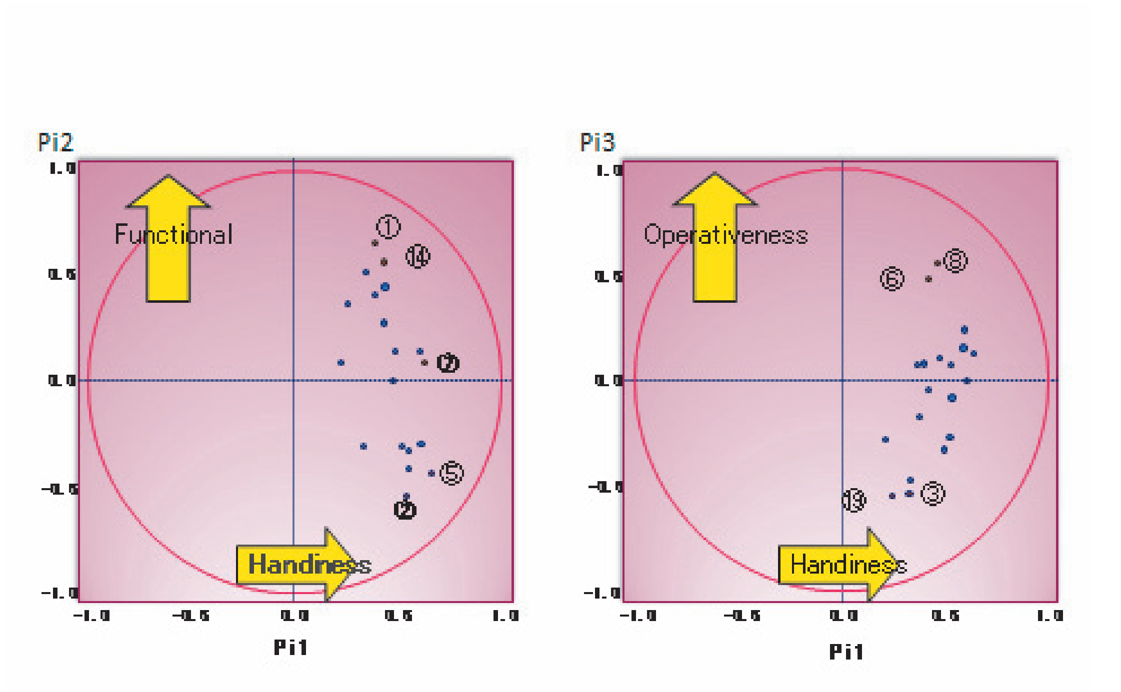

Fig.2 Principal component revealed the factors 1, 2, and 3

Table4.Results of principal component

	Group Ⅰ	Group Ⅱ	Group Ⅲ	Group Ⅳ	Total
Pi 1	Handiness	Safety	Development	Reliability	Handiness
Pi 2	Functionality	Operativeness	Functionality	Handiness	Functionality
Pi 3	Reliability	Functionality	Operativeness	Operativeness	Operativeness

PI : Principal Ingredient

Handiness
- There are indications
- Easy to clean
- Suitable manual

Functionality
- Sufficient magnetic force
- Create free forms
- Simple maintenance

Reliability
- Suitable for models and samples
- Available treatment device
- Sufficient magnetic force

Safety
- The prognosis is clear

Operativeness
- Easily find the magnet structure
- Size and share are adequate
- Simple maintenance

Development
- Easy to obtain informed consent
- Suitable for models and samples
- Suitable manual

Reference

Literature references should be listed at the end of the paper in the same order that they appear in the text, and in accordance with the following examples.

1. R. Ito, K. Hoshiai, N. Hasegawa, N. Muraji, T. Kawaguchi, K. Noda, K. Watanabe and Y. Tanaka: Longitudinal Study on Metal Plate Denture with Magnetic Attachments, J J Mag Dent, 18(2), 8-14, 2009.

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1. Journal article (example): Y. Takada, N. Takahashi and O. Okuno: Electrochemical behavior and released ions of the stainless steels used for dental magnetic attachments, J J Mag Dent, 16(2), 49-52, 2007.
2. Book (example): R. Kunin, On Exchanging Resins, pp 88, Robert E. Kreiger Publishing Company, New York, 1972.