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Proceedings of the 9th International Conference on Magnetic Applications in Dentistry

March 1 to 19, 2010

The Japanese Society of Magnetic Applications in Dentistry

日本磁気歯科学会

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http://wwwsoc.nii.ac.jp/jmd/international-e.shtml

The Japanese Society of Magnetic applications in Dentistry

The 9th International Conference on Magnetic Applications in Dentistry

The Japanese Society of Magnetic Applications in The 9th International Conference on Magnetic Applications in Dentistry organized by JSMAD took place on the Internet as follows;

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Researches and developments related to dentistry and magnetism such as:

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

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Department of Oral Functional Reconstruction, Kyushu Dental College
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The 10th International Conference on Magnetic Applications in Dentistry General Information

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- Orthodontic appliances using magnets
- Measurement of jaw movement using magnetic sensors
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- Dental applications of MRI
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Application of a Night Guard Using a Magnetic Attachment on a Patient with Bruxism

S. Kamogawa,[1] N. Tsukimura,[1,2] M. Morokuma,[1] N. Suzuki,[1] Y. Takeuchi,[1] S. Ohno,[1] T. Azuhata,[1] Y. Abe,[1] T. Ishigami[1,2]

[1] Department of Partial Denture Prosthodontics, Nihon University School of Dentistry, Japan
[2] Division of Clinical Research, Dental Research Center, Nihon University School of Dentistry, Japan

Introduction

For handling of a removable denture, most dentists usually instruct patients to remove their dentures overnight. On the other hand patients with bruxism are occasionally advised to wear at night because remain teeth should be protect from the mal-functional pressure under bruxism. However, when dentures are used during sleep, the mal-functional pressure under bruxism may result in their repeated fracture.

One clinical case involved a bruxism patient who used a night guard with a magnetic attachment while sleeping.

Case

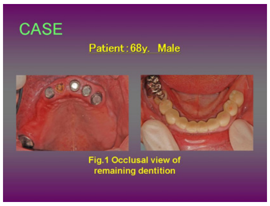


Fig.1 Occlusal view of remaining dentition

Figure 1 shows the oral cavity.

The patient is a 68-year-old male.

The copings with a post-keeper were set at Nos. 12, 17, 21, 22, and 23, all of which were concave due to lack of clearance except for No. 17.

The No. 35-44 dentition (6 anterior and 4 posterior teeth) was fabricated by resin facing cast crown in mandible. Maxillary right incisor (No. 11) that was un-extractive owing to patient systemic condition (hypertension).

.


Fig.2 Intraoral view with existing denture

Figure 2 is a recently fabricated maxillary denture.

This denture was not extended to spaces Nos. 26 and 27 because of missing teeth (No. 36 and 37) in the mandible. A non-palatal metal denture frame was designed for comfort, increased strength, and fracture avoidance.

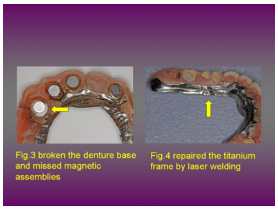


Fig.3 broken the denture base and missed magnetic assemblies
Fig.4 repaired the titanium frame by laser welding

Figure 3 and 4 show the old denture that the patient wore while sleeping.

The denture caused significant problems (abrasion and break of the artificial teeth, loosing of the magnetic assembles and damage of the metal frame) when worn as a night guard while asleep. In addition, some of the covered hard resin on the anterior teeth was repeatedly chipped and damaged. A soft night guard was worn over the mandible dentition. However, the patient did not wear the device due to discomfort and interference with sleep.

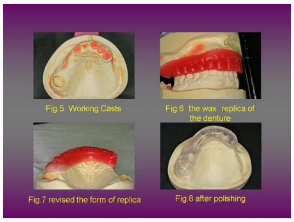


Fig.5 Working Casts
Fig.6 the wax replica of the denture
Fig.7 revised the form of replica
Fig.8 after polishing

After taking an impression for a night guard, a working cast was fabricated (Fig. 5).

The night guard was took a registration of interocclusal relation using the replica of the new denture, so that was obtained similar occlusal vertical dimension (Fig. 6).

After the working cast was mounted on the articulator, the replica was revised to the form of the sprint, and then the core of the splint was taken by putty type of silicone impression material for making same form of the replica (Fig. 7).

The night guard using a magnetic attachment was made with a transparent acrylic denture base resin (Palapress Vario, Heraeus Kulzer). The acrylic resin of the artificial teeth was injected into the core on the working cast and polymerized in the Palamat practice pressure curing unit 55℃ at 2 bars pressure for 30 min using the pressure pot.

The product was polished using the conventional method (Fig. 8).

Fig.9 the night guard with magnetic attachment

Figure 9 shows the night guard with a magnetic attachment.

Five magnetic assemblies were set in the corresponding keeper position in the night guard with a quick self-curing (ORTHOFAST, GC) in the oral cavity.

The finished night guard form was considered to be similar to that of the existing denture as long as it was acceptable for the patient.

Fig.10 wearing the night guard with magnetic attachment

Figure 10 shows the night guard with the magnetic attachment.
All functional cusps in centric occlusion were adjusted to a point contact to avoid occlusal interference.

Considerations

In clinical practice, it is frequently difficult to find a satisfactory treatment solution.
Our results showed that the night guard that we provided in this case remained in good condition for 6 months and offered full satisfaction for the patient. However, follow-up of the progress over a long term will be needed.
In conclusion, the night guard with a magnetic attachment was useful for a patient with bruxism who wore an overdenture using magnetic attachments. Magnetic attachments may have various possibilities for application in complicated cases involving prosthetics.

References

1. Y. Komasa, E. Nagai, K. Sugikami, and Y. Shiina, Dental Technology of Denture: 235-237, Ishiyaku Publishers, Inc., Tokyo, 2007.
2. S. Endo, T. Ishigami, K. Miyata, H. Toyoma, M. Tsuyumu, and T. Azuhata, Hardening time of self-curing resin for installing magnets and removing dentures, JJ Mag Dent, 18 (2): 46-49, 2009, 3.

Development of a Magnetic Rest Clasp
Part 2. An Application of a Magnetic Rest Clasp for Porcelain Fused to Metal Crowns

Toshiaki Hasuike, Toshiyuki Kusano, Fumiko Okutsu, Takaaki Matsukawa, Mineyo Sone, and Shuji Ohkawa

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

Introduction

The increased emphasis on physical appearance in contemporary society has increased the demand for esthetic dental treatment.

The metallic color of the buccal clasps on premolars or canines is one of the common causes of patient rejection. The appearance would be vastly improved if metal buccal clasps were eliminated. However, the retentive function of clasps without buccal arms is extremely poor. We developed a new retainer without a buccal clasp arm and with a magnetic attachment in the occlusal rest of the clasps (Magnetic Rest Clasp). [1,2]

Objective

The purpose of this study is to introduce the fabrication of a new retainer, a “Magnetic Rest Clasp,” for porcelain fused to metal crowns on lower premolars with a plastic jaw model having artificial teeth.

Materials and Methods

Table 1 Materials used

Materials	Product name	Manufacturer
Magnetic attachment	GIGAUSS C400	GC
Housing pattern	Housing pattern (C400)	GC
Keeper tray	KB keeper tray (C400)	GC
Alloy for ceramic bonding (Type □)	Bio Herador N	Heraeus-Kulzer
Alloy for framework (Type □)	Bio Maingold SG	Heraeus-Kulzer
Veneering ceramics	VINTAGE Halo	SHOFU
Cementing material	Super-Bond C&B	SUN MEDICAL
Pattern resin	PATTERN RESIN	GC

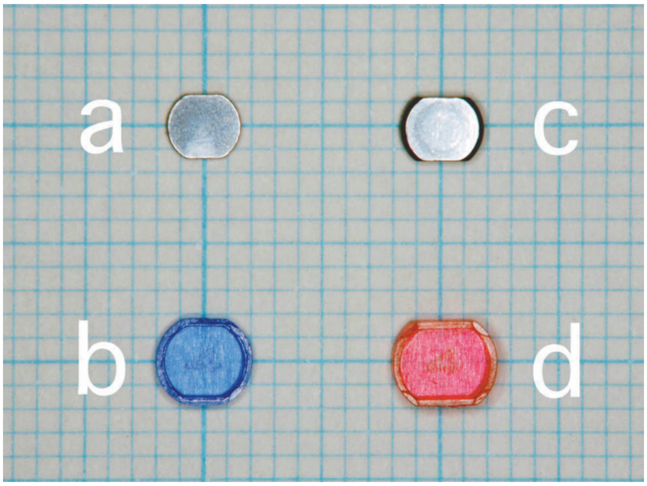


Fig. 1 Magnetic attachment a: keeper; b: keeper tray; c: magnetic assembly; and d: housing pattern GIGAUSS C400 (GC) used in this study.

Figs. 2 and 3 Working model
The working model is made from a plastic jaw model (DENTAL STUDY MODEL E50-526, NISSIN).

Fig.4 Working model (occlusal view of the abutments) Fig.5 Working model (lingual view of the abutments)
The abutments have partially concave forms for the magnetic attachment.

a: 7.0mm b: 3.0mm c: 3.8mm

Figs. 6 and 7 Wax pattern of porcelain fused to a connected metal crown
The wax pattern has a guide plane on the lingual and distal sides.

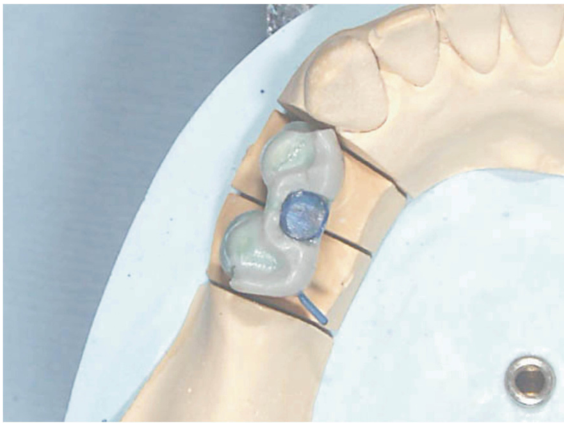


Fig.8 Wax pattern with a keeper tray
A minimum 0.3mm thickness of wax between the keeper and abutment is required for proper casting.

Figs. 9 and 10 Framework of porcelain fused to a connected metal crown without a keeper on the working model (buccal view and lingual view)
The framework is cast with a type □ gold alloy (Bio Herador N, Heraeus-Kulzer).


Figs. 11 and 12 Porcelain fused to a connected metal crown without a keeper on the working model (occlusal view and lingual view)
The abutment crown has guide planes and channels.


Figs. 13 and 14 Lingual view of porcelain fused to a connected metal crown
A hygienic design is used for the gingival surface.

Fig. 15 Porcelain fused to a connected metal crown with a keeper on the working model
The keeper is fixed with a cementing material (Super-Bond C&B, SUN MEDICAL).

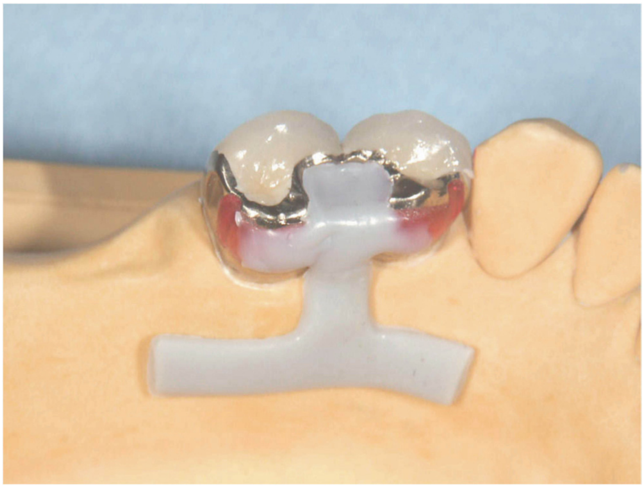
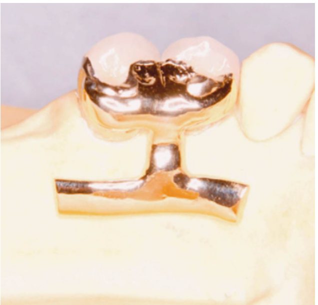


Fig.16 Resin and wax pattern of the Magnetic Rest Clasp and minor connector incorporating the housing pattern of the magnetic assembly (lingual view)
This pattern has no buccal clasp arm.

Fig.17 Inner surface of the finished Magnetic Rest Clasp with a magnetic assembly
The Magnetic Rest Clasp is cast with a type □ gold alloy (Bio Herador SG, Heraeus-Kulzer) and has a channel at the lingual clasp arm tip.



Figs. 18 and 19 Magnetic Rest Clasp seated in the porcelain fused to a connected metal crown on the working model (lingual view and occlusal view)

Figs. 20 and 21 Magnetic Rest Clasp seated in the porcelain fused to a connected metal crown on the working model (buccal view and mesial view)

The advantages of the Magnetic Rest Clasp are esthetic. Among the disadvantages to the use of this clasp are its complex structure of abutment and problems for the patient's intact teeth.

Conclusions

We introduced the fabrication of a new retainer, "Magnetic Rest Clasp," for porcelain fused to connected metal crowns on lower premolars with a plastic jaw model. In the future, we will try to use the Magnetic Rest Clasp in patients.

References

1. Hasuike T, Kusano T, Okutsu F, et al. An Application of a Magnetic Attachment to a Cast Clasp - Development of a Magnetic Rest Clasp -, J J Mag Dent, 18(1) ,64-68, 2009.
2. Hasuike T, Kusano T, Okutsu F, et al. An Application of a Magnetic Attachment to a Cast Clasp - Development of a Magnetic Rest Clasp -, J J Mag Dent, 18(2) ,91-93, 2009

Influence of the Measuring Methods on the Attractive Force of Magnetic Attachments

Y. Nakamura, K. Shoji, R. Kanbara, H. Kumano, A. Ando, T. Iwai, T. Kogiso, Y. Ohno, Y. Takada[1], Y. Tanaka

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

Introduction

There has been an increasing use of magnets in the clinical dental setting. Magnetic attachments are excellent retaining devices with many functional applications and aesthetic benefits. These attachments have also had high satisfaction ratings for the treatment results when used in conjunction with dental implant treatments. A magnetic attachment consists of a magnetic assembly and a keeper. The optimum attractive force relationships between these two components are of prime importance. Therefore, a careful evaluation of the relationship of attractive force and magnetic assembly mechanism is required. Our department has been conducting studies on magnetic attachments such as attractive force measurements to elucidate magnetic attachment properties. Several different methods have been reported on magnetic attachment measurement techniques. A specialized jig orientation measuring device was designed, reported and tested upon at Department of Removable Prosthodontics, School of Dentistry, Aichi Gakuin University. The validity of the attractive force measuring method using this jig was confirmed.

Objective

A simply designed device for the measurement of the attractive force between a magnet and a keeper was proposed by the Australian magnet research institute at the 2009 ISO conference. The comparison to existing measurement techniques was desired. In the present study, we compared the results of the attractive force measurement method proposed by Australian magnetic institute with our measurement method to verify the validity of the newly proposed method.

Materials and Methods

1. Materials

GIGAUSS C (GC) was used as a magnetic assembly testing subject(Fig. 1). Attractive force was measured using a compact tabletop EZ-test tensile tester (Shimazu) (Fig. 2).

Fig 1: GIGAUSU C600 (GC)

Fig 2: EZ test (SIMAZU)

2. Methods

1) Experimental items

(1) Attractive force measurement using a special jig

Attractive force of a magnetic assembly was measured using a special jig shown in Fig. 3. In obtaining measurements of attractive force measurement using a conventional jig, there have been vertical and horizontal restrictions on the attractive surface between a magnetic assembly and a keeper when vertically separating a magnet potentially interfering with vertical measurement accuracy. Repeated accurate repositioning of the magnetic assembly and a keeper to an original position is also very difficult. A special jig device was designed, consisting of a pair of upper and lower holding members. Bilateral bars guide the movement of a jig, preventing unwanted axial and horizontal deviations during the elevating movements on a magnetic assembly. Two horizontal bars in the upper member of the jig can be fit inserted into the guide holes of the lower member jig part. The holes in the bottom are longitudinal bearing structure to avoid the friction resistance during the measurement. A magnetic assembly and a keeper can be returned to the original position by using a mold and a guide bar shown in Fig. 4. The accurate attractive force measurement was achieved by using this special jig design.

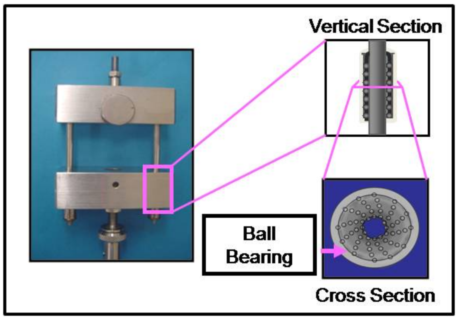


Fig 3: special jig

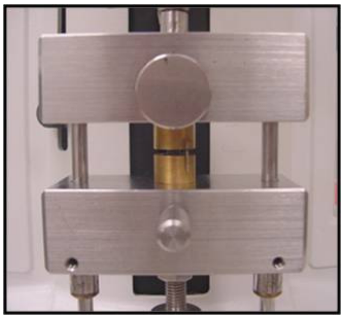


Fig 4: mold and a guide bar

(2) Attractive force measurement proposed by the Australian magnetic institute.

The following is the attractive force measurement design proposed by the Australian magnetic institute in 2009 ISO conference. A simple jig is used instead of a complex previously reported design jig regulating the sideslip on the attractive surface between a magnetic assembly and a keeper. Reliable measurement can be achieved by using cotton string for flexible traction of a magnetic assembly.

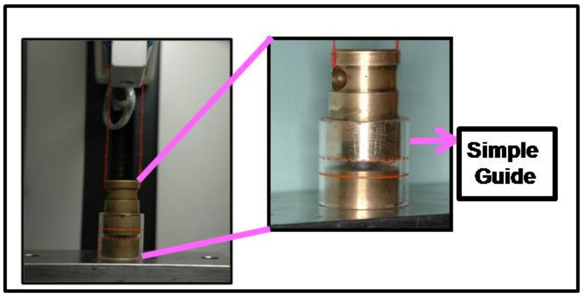


Fig 5: simple jig based on the Australian design proposal

Based on the Australian design proposal, another simple jig to correct sideslip was designed (Fig. 5). It is difficult to control the movement between a magnetic assembly and a keeper due to the small size (GIGAUSS C 600 - major axis 4.1 mm and minor axis 3.3 mm). Therefore, a magnetic assembly and a keeper were attached to a holding mold. A simple guide was fabricated using acrylic cylinder around the mold. Adjustment was made between a guide and a mold to avoid friction resistance. Cotton string was used for flexible traction of a magnetic assembly.

(3) Attractive force measurement without vertical and horizontal restrictions

Attractive force measurement without vertical and horizontal restriction was applied to compare the attractive force measurement methods between the Australian magnetic institute and the specialized jig measuring method (Fig. 6). Horizontal and vertical restrictions were eliminated by removing the holding mold from the magnetic measurement assembly, and the cotton string for traction, respectively.

2) Measurement conditions

Attractive force measurement was repeated 10 times for each of the 5 samples using the EZ test. The cross head speed was 5 mm/minutes.

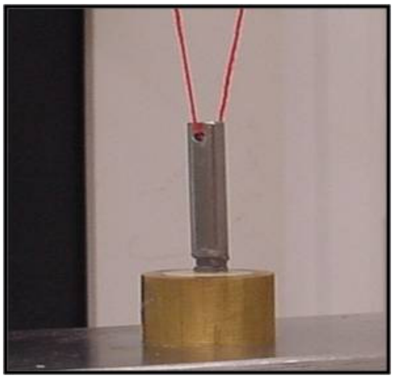


Fig 6: attractive force measurement without vertical and horizontal restrictions

Results

1. Attractive force measurement method using a special jig

Fig 7 shows the results of the attractive force measurement using a special jig. Minor variation was noted in measurements between each sample. The maximum attractive force was 570 gf, and the minimum attractive force was 543 gf. It was confirmed that the standard deviation for measurement precision was subtle in 10 measurements of each sample.

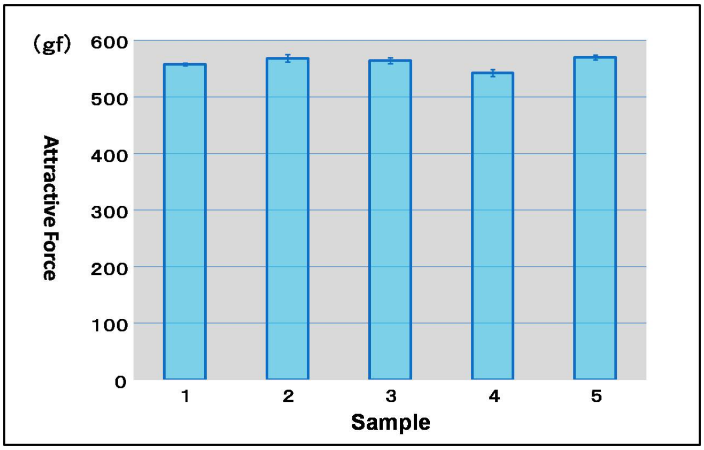


Fig 7: attractive force (special jig)

2. Attractive force measurement proposed by Australian magnetic institute

Fig 8 shows the results of attractive force measurement proposed by the Australian magnetic institute using a simple guide. A significant variation in measurements and standard deviation were observed between each sample. The maximum attractive force was 424 gf, and the minimum attractive force was 337 gf.

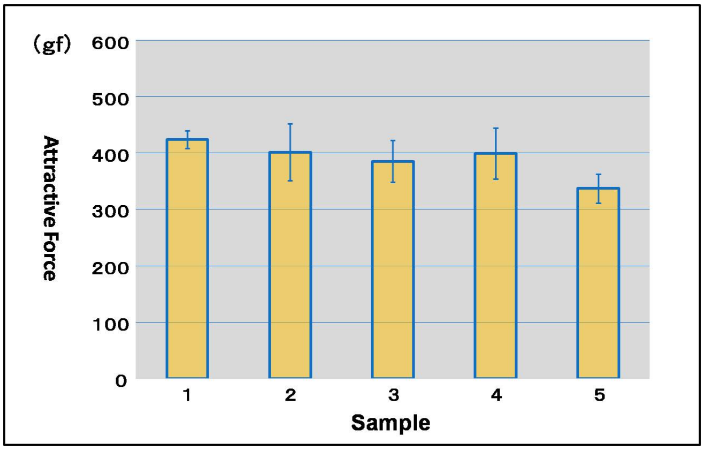


Fig 8: attractive force (simple guide)

3. Attractive force measurement without vertical and horizontal restrictions

Fig 9 shows the results of attractive force measurement without vertical and horizontal restrictions. Restriction-free measurements were achieved by eliminating the magnetic assembly holding mold and using a cotton string traction.

The variation in measurements between each sample was larger than other two measuring methods. The maximum attractive force was 437 gf, and the minimum attractive force was 351 gf. Standard deviation between each sample was larger than the method using a special jig.

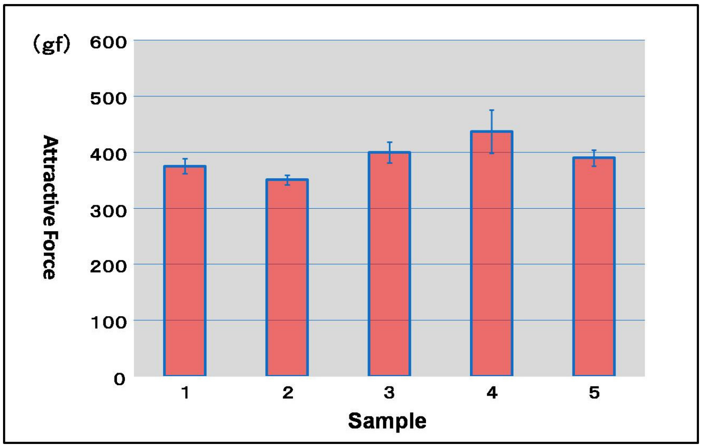


Fig 9: attractive force
(measurement without vertical and horizontal restrictions)

4. The influence of the measuring methods on the attractive force of magnetic attachments

The influence of the measuring methods on the attractive force was investigated by comparing attractive force measurements of 5 samples obtained by 3 measuring methods. Multiple comparison test was performed using one-way analysis of variance and Scheffe's test to determine differences between the measuring method using a special jig and other methods.(Fig 10)

A significant difference was observed in the mean attractive force measurements between three measuring methods. The difference in the measurements was subtle between the measuring method using a simple guide and the measuring method without restriction.

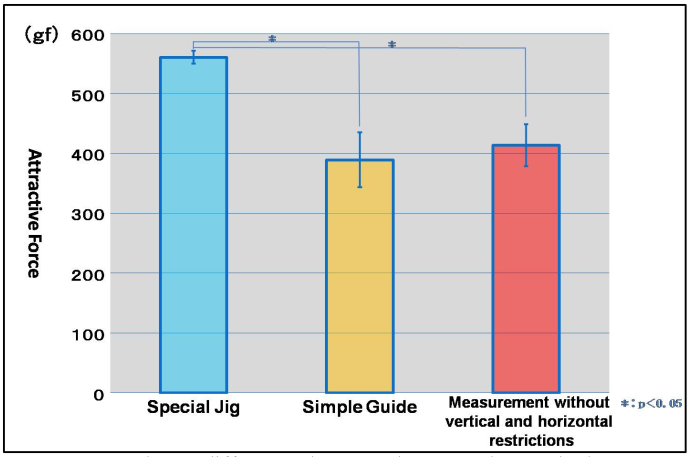


Fig 10: differences between the measuring method
using a special jig and other methods

Discussions

1. The design of the simple guide in the measuring method proposed by the Australian magnetic institute

We fabricated a simple guide based upon a design presented by the Australian magnetic institute. However, exact duplication was unknown since there was no specific information regarding guide design. One application method considered direct application of a keeper and a magnetic assembly attractive surfaces. However, frictional resistance during the traction would likely adversely affect accurate measurement. Correct guide placement was repeatedly difficult as the combination of a keeper and a magnetic assembly were only 2 mm in thickness.

Recommendations and considerations for the optimal measurements of magnetic attachments include indirect guides for placement positioning when using the special jig testing apparatus reported. In the present study, measurements were performed by using a mold in a magnetic assembly and a keeper, and a guide was placed indirectly to the mold. This design seeks to minimize the friction resistance between a mold and a guide. Inter-guide lubricans were considered but were not used. The effect of added lubricants could not be accurately assessed.

2. Measurements

A significant difference was observed in the obtained attractive force methods using a simple guide and another method without vertical and horizontal restrictions compared with the special jig method. The method using a special jig showed the highest attractive force measurement values for the identical magnetic device.

1) Measuring method of the attractive force using a special jig

Greatest measurement accuracy was achieved by using the special jig design testing method. Unlike other measuring methods, there was vertical and horizontal axis control of the magnetic attachments during separation. Friction resistance during traction was not encountered due to the ball bearing structure design and minimal measurement error. Disadvantages of the special jig design remain including high cost and high maintenance requirements. Considered of these issues lead to a simple measuring method. The jig design is of importance for accurate measurement of magnetic assembly attractive forces. The present study demonstrated the role of a special jig in the attractive force measurement, and confirmed the measurement accuracy.

2) Attractive force measurement proposed by Australian magnetic institute (Simple guide)

The results of the attractive force measurement using a simple guide showed lower magnetic force measurements. This finding is thought to be due to the lack of vertical control during the traction of a magnet assembly. The traction using a cotton string produces not only vertical but also horizontal stress between a magnetic assembly and a keeper in the guide, causing a non-axial rotational force. This force creates rotational movement when a magnetic assembly and a keeper detatch, resulting in a decrease in measureable attractive force.

3) Attractive force measurement without vertical and horizontal control

A decrease in the attractive force was observed due to the rotational movement caused by traction with a cotton string. The results of the attractive force measurement without vertical and horizontal control showed similar measurement values as the degree of attractive force in the simple guide method (Fig 10). The results suggested that the rotational force caused by cotton string traction affects the results of the attractive force measurement more than the horizontal restriction design.

Conclusion

The influence of the measuring methods on the attractive force of magnetic attachments was investigated. Our prior report described the attractive force measurement of a magnetic assembly using a special jig, but a more simple method was proposed by Australian magnetic institute. In the present study, the attractive force of magnetic attachments using a simple guide was measured according to the specific designs proposed by the Australian magnetic institute, and the results were compared. The following conclusions were drawn:

1. The measurement error was the smallest in the measuring method using a special jig that controls vertical and horizontal direction during traction, and the highest attractive force was measured.
2. Although attractive force measurement using a simple guide fabricated according to the proposal appears to provide horizontal displacement. The effectiveness of this design component was not shown.

References

1. Tanaka,Y.: Dental Magnetic Attachment,Q&A,Ishiyaku Publishers,Inc.(Tokyo),1995.
2. Gillings,B.R.D.: Magnetic retention for complete and partial overdentures, Part.J.Prosthet.Dent.,45(5):484-491,1981.
3. Jackson,T.R.: The application of rare earth magnetic retention toosseointegrated implant.Inc.J.Oral & Maxill.Imp.,1:81-92,1986.

Influence of Cast Magnetic Alloy Keeper Thickness on the Attractive Force of a Magnetic Attachment

T. Iwai, Y. Nakamura, K. Shoji, T. Masuda, R. Kanbara, K. Yoshihara, M. Hata, Y. Ohno, Y. Takada[1], Y. Tanaka

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

Introduction

Magnetic attachments which have multiple features such as smaller size, a stable retentive force, and an improved operability, have become widely available thanks to the clinically-based research. The conventional magnetic attachment consists of a magnetic assembly and a keeper. Using a conventional magnetic attachment often involves some difficulty in designing a prosthesis due to the restrictive flexibility of the keeper. Attract P (TOKURIKI-HONTEN Co.) is the only commercially available moldable magnetic alloy that attaches to a magnet. The use of Attract P for the fabrication of a keeper may allow the expansion of the magnetic attachment application. However, few studies are available in the literature on the mechanical properties of Attract P. The basic data of Attract P is required to use this alloy for the extensive variety of prosthetic designs.

In the present study, we fabricated keeper prototypes with the same planer morphology as GIGAUSS C 600 and with a thickness between 0.2 mm and 1.8 mm using Attract P. The attractive force of the keeper prototype and magnetic assembly was measured, and compared with that of a GIGAUSS C 600 keeper.

Objective

The purpose of the present study was to evaluate the effect of keeper design using cast magnetic alloy "Attract P", and investigate the relationship between the keeper thickness and attractive force.

Materials

Table 1 shows the mechanical properties of Attract P. Attract P is a Type III gold alloy. The mechanical properties of this alloy include magnetic attraction as well as having high ductility. The entire surface of a keeper fabricated from this alloy has magnetic attraction potential, and, therefore, there is great design flexibility with the "Attract P" alloy use.

Ingredient	: Au;3% Pd;48% Ag;14% Co;32% (*others*: Zn,In)
Tone of colo	: silvery white
Point of fusion	: 1148-1192℃
Castable temperature	: 1300℃
Specific gravity	: 10.5g/㎤
Strength	: 197HV
Offset yield strength	: 300MPa

Table. 1 : 「Attract P」 (TOKURIKI-HONTEN)

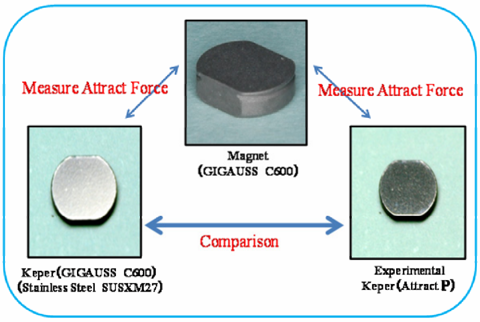


Fig .1 : A flow chart of study

Methods

Cast test sample keepers were prepared with Attract P alloy. They keeper samples had an identical planar shape as a conventional keeper (GIGAUSS C 600) for comparative purposes. The fabricated keeper thickness varied from 1.8 to 0.2 mm. Attractive force measurement between a magnetic assembly and the test keepers were then measured, and compared with the result of the attractive force between the standard magnetic assembly and the conventional GIGAUSS C 600 keeper design. Six samples of each were fabricated under identical conditions to test reproducibility.

1.Fabrication of samples

1) Pattern fabrication

Two GIGAUSS C 600 keeper trays (GC) were prepared for each sample. Inlay wax was poured into the trays. Two tray were combined, and the attractive force side wax surface was polished. Ready casting wax R32 and R40 (GC) was used as a sprue (Figures. 2 and 3).

Fig .2 : Two Keeper trays

Fig .3 : Sprued the Keeper trays

2) Casting

The wax pattern was invested with phosphate bonded investment CERAVEST (GC), and cast in the ceramic crucible at 1300 degrees following the conventional method using a vacuum casting machine CASCOM (KDF) (Fig. 4).

Fig .4 : Casting

Fig .5 : Experimental Keeper of Attract P

3) Recontouring and polishing

The oxide layer was removed by air abrasion with aluminum oxide particles after casting, followed by recontour polishing. The external morphology and surface areas of both the marginal and non-attractive faces were adjusted to match the comparative sample keeper size (GIGAUSS C 600). Samples were polished under running water, and cleaned ultrasonicically (Fig. 5).

2.Attractive force measurement

Attractive force measurements were performed using a compact table-top universal tester machine (SHIMAZU) (Fig. 6). A custom made jig and mold devised in our department were used to stabilize and maintain the samples during measurement. Attractive forces were measured 10 times for each sample at 5 mm/min crosshead speed. Test sample thickness was sequentially reduced by grinding removal of the non-attractive face with a # 100 wet-dry sandpaper.

Surface parallelism was confirmeded and measured using a seven-point method to ensure parallel thickness of the samples tested (Fig. 7). Samples were polished with a grinder “ECOMET 3” to # 1000 until mirror-like surfaces were obtained, followed by the final buff polished finish. Attractive forces of finalized samples were measured. This process was repeated for each of the 6 samples until the minimum thickness of 0.2 mm was achieved and tested (Fig. 8).

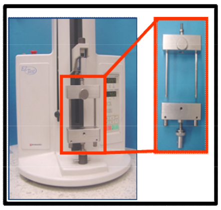


Fig. 6 : EZ test

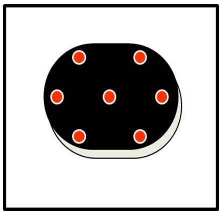


Fig .7 : Measuring Points

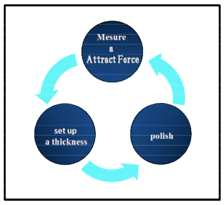


Fig. 8 : Flow chart of study

3.Statistical analysis

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.

Results

Keeper samples of sequentially different thickness were prepared with cast magnetic alloy “Attract P”, and the attractive forces of each sample were measured. Fig.9 shows the relationship between the sample thickness and mean attractive force of 6 samples. No significant difference was observed at a significant level of 5% in samples of 1.8 -0.7 mm thickness. Attractive force started to decrease with a decreasing sample thickness from 0.7 mm, showing statistically significant difference. The attractive force of 330 – 340 gf was maintained in samples of 0.7 mm or more. The attractive force measured was 65% of a comparative GIGAUSS C 600 keeper. The results suggested that this alloy has an inflection point at 0.7 mm thickness.

Fig.10 shows the comparison of the attractive force between Attract P and GIGAUSS C 600. We focused on 0.7 mm thickness Attract P since it is the same thickness as GIGAUSS C 600. The attractive force of Attract P was 60% of GIGAUSS C 600 keeper sample.

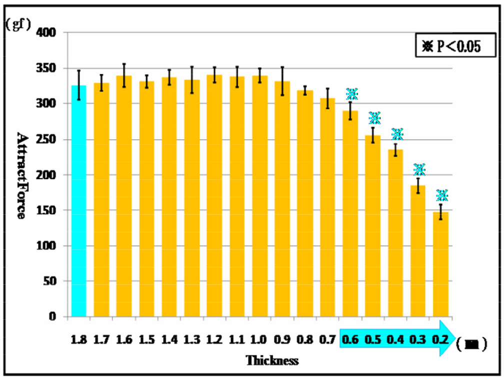


Fig.9 : Relations between Thickness and Attract Force

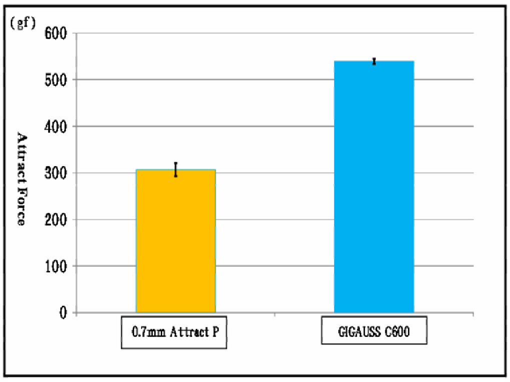


Fig.10 : Attract Force of Experimental Keeper and GIGAUSS C600

Discussion＆Conclusion

Attract P is moldable magnetic alloy that may be used for keeper attachment to a magnet in clinical practice. The result of the present study demonstrated that the attractive force of Attract P alloy was 60% of GIGAUSS C 600 keeper. However, the comparative actual total space clearance requirement of GIGAUSS C 600 is 1.3 mm including extra consideration for a cast holding support for the keeper. The measured Attract P attractive force at a 0.7 mm thickness was found to be 31 gf. The application of this material may be useful for clinical requirements of minimal space clearance such as application on vital teeth.

References

1. Y.kiuchi:Magnetic Devices for Retaining Dental Prostheses,Bioinstrumentation and Biosensors (Ed.D.L.Wise),pp.145－164,1991(Marcel Dekker,Inc)
2. Okuno,O.,Ishikawa,S.,Iimuro,F.T.et al.:Development of sealed cup yoke type dental magnetic attachment,Dental Materials Journal,10(2):172-184,1991.
3. Y.Terao, Y.Nakamura, T.Ishida, A.Ando, H.Nakamura, et : Measuring Methods of the Attravtive Force of Magnetic Attachment 16(2) :14~19, 2007.

Measurement of wax patterns of magnetic keeper coping

S. Okano,[1] E. Nagai,[1,2] K. Ohtani,[1,2] Y. Umekawa,[1,2] Y. Fukase,[3] T. Uchida,[1] M. Kiuchi,[1] N. Tsukimura,[1,2]

T. Ishigami[1,2]

[1] Department of Partial Denture Prosthodontics, Nihon University School of Dentistry
[2] Division of Clinical Research, Dental Research Center, Nihon University School of Dentistry
[3] Division of Biomaterials Science, Nihon University School of Dentistry

Introduction

Recently, magnetic attachments have been used in prosthodontic treatments due to improved masticatory stability. We investigate the kinds of magnetic keeper copings worn in clinical applications. The purpose of this study was to investigate types of teeth with magnetic keeper copings and measure the wax patterns made on working casts with artificial gums to select the keeper size.

Materials and Methods

1. Types of teeth

The investigation period was from 2007 to 2009. Working casts of 100 teeth and artificial gums of keeper copings were prepared, and the types of teeth were investigated.

2. Preparation of samples

Wax working casts with artificial gums were prepared (Fig. 1). Reference surface have connecting mesial and distal gingival margins on waxing up.

CT images of the wax patterns were then obtained with a Microfocus X-ray CT system (Shimadzu Corporation). Based on the image obtained, they were measured using analysis software CT-Solver (Shimadzu Corporation). The resolution of CT images was established as 23 micrometers to the XY plane and the direction of Z. The measurement point is shown in Fig. 2.

3. Selection of keeper tray

The mesiodistal width (reference surface) of the wax pattern and that of the abutment tooth were compared to select the keeper tray (Fig. 3). Dentists frequently find it difficult to choose between the mesiodistal width (reference surface) of the wax pattern or the abutment tooth.

Results and Discussion

Figure 4 shows the type of tooth for which a keeper coping was made. Both Upper jaw and Lower jaw, most used as abutment tooth with magnetic keeper was the canine tooth (32% and 26%). (Note: The above is not at all clear. Please check and change or clarify as appropriate.) For the upper jaw, the next is the first premolar (19%), lateral incisor (18%), central incisor (11%), first molar (6%), and then the second molar (3%). For the lower jaw, the next is the second premolar (24%), first premolar (21%), lateral incisor (13%), and then the second molar and central incisor (8%). The first molar is not used (0%) in this report. Because the root of the canine tooth is long, it often remains in the oral cavity. The root of the canine tooth has high rates of life expectancy.[1) 2)] The length of each tooth post is shown in Fig. 5. In a comparison, the teeth averaged 4 to 6 mm.

Figure 6 shows the mesiodistal width of the wax pattern and the abutment tooth. And horizontals line were keeper tray width between D400 and D1000. The data in this sample indicate that the width of the abutment tooth is narrower than that of the wax pattern. Therefore there is a possibility that size of magnetic keeper was selected reference to cross-section of remaining root.

Conclusion

Based upon the results of this study, the following conclusions were reached:

1. In both the upper (32%) and the lower (26%) jaws, the tooth most often used for abutment was the canine tooth.
2. The post length was 4 to 6 mm.
3. Many dentists choose smaller magnetic keeper trays.

References

1) Y. Tanaka, The Application of the Sandwich-type Dental Magnetic Attachment, "MAGFIT-600" in Various Clinical Cases, J Jpn Prosthodont Soc, 36: 471-480, 1992. (in Japanese)
2) H. Yosikawa, Clinical survey of dentures with magnetic attachments, The Journal of the Osaka Odontological Society 61(2):105-111, 1998. (in Japanese)

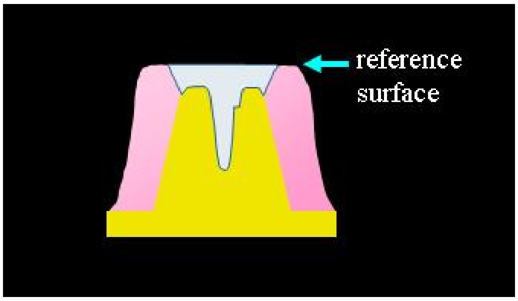


Fig. 1 Schema of the wax pattern

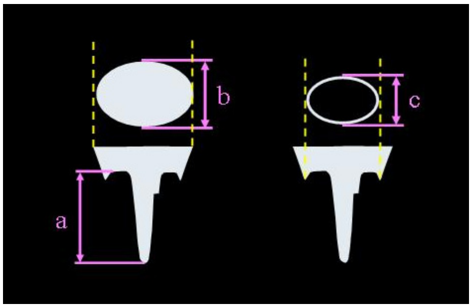


Fig. 2 Measurement point
a. Length of post
b. Mesiodistal width of the wax pattern (reference surface)
c. Mesiodistal width of the abutment tooth

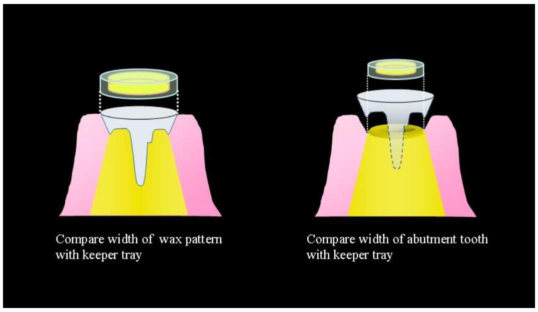


Fig. 3 Compared width of the wax pattern and the abutment tooth with a keeper tray

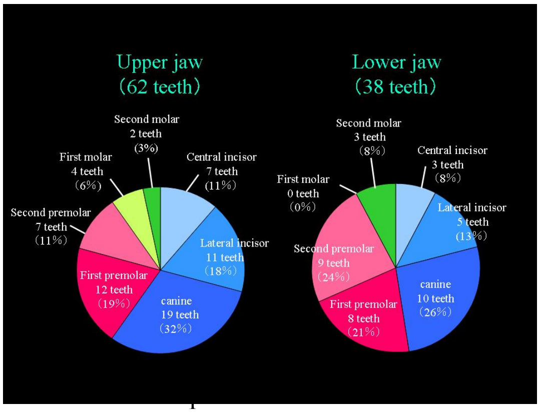


Fig. 4 Type of tooth

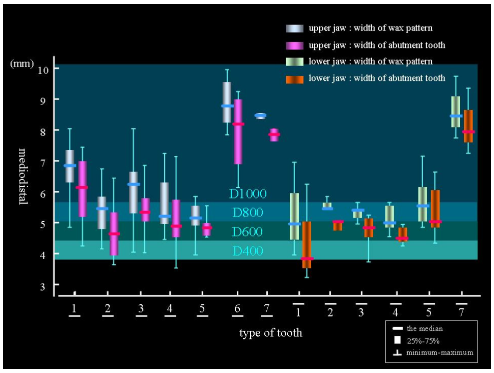


Fig. 5 Length of post

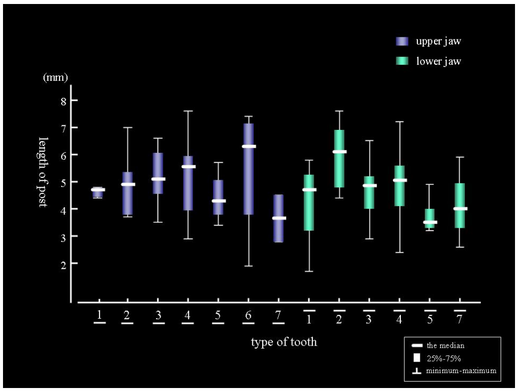


Fig. 6 Compared mediodistal width of the wax pattern and the abutment tooth with a keeper tray

The Influence of Keeper Tray Materials on Casting Precision

T. Kogiso, Y. Nakamura, H. Kumano, Y. Ohno, M. Sakane, T. Tanaka [1], M. Okada [1], M. Hata
Y. Takada[2], Y. Tanaka

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

Introduction

A cast-bonding technique is one of two techniques use to fabricate a keeper coping of a denture with magnetic attachments. A plastic pattern is used in this technique. However, problems including a rough surface and a misrun inside the keeper tray are indicated for a keeper coping fabricated by a direct-bonding technique. Therefore, adjustment of castings is required at the lab bench and chairside (Fig. 1).

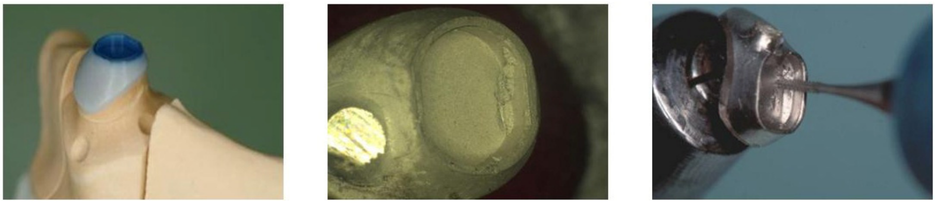


Fig.1

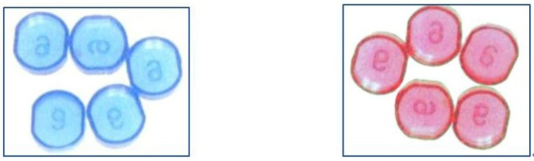
Objective

The purpose of the present study was to compare casting precisions between samples fabricated using a commercial ready-made pattern and a new prototype pattern.

Materials and Methods

1.Materials

GIGAUSS C 600 KB (GC) was selected as a commercial ready-made pattern sample. The casting pattern samples tested were fabricated of two different materials. The chief component of the first tray design was acrylic. The prototype second tray design was made of polyethylene plastic (Fig. 2).



commercial ready-made pattern prototype pattern

Fig.2 Materials

2.Experimental items

Four different sampling categories with five testing specimens each were prepared: 1. Cast of a commercial ready-made pattern (AC), 2. Cast of a prototype pattern (PE), 3. Cast of a combined pattern of commercial pattern and dental wax (AC-WAX), and 4. Cast of a combined pattern of prototype pattern and dental wax (PE-WAX) (Fig. 3).

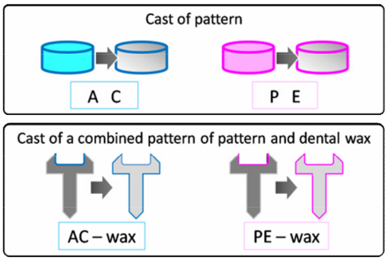


Fig.3 Experimental items

3.Methods

This study was designed to prosthetically simulate an edentulous patient clinical situation. The preparation of an abutment for a keeper coping was performed using a conventional method, followed by abutment impression taking and second model fabrication (Fig. 4).

Medium Inlay Wax (GC) was used for abutment and keeper tray wax pattern fabrication using conventional methods (Fig. 5).

The keeper coping wax pattern was sprued with ready casting wax (R15), and placed on the investing ring pattern holding cone (Fig. 6). The pattern was conventionally invested(CRISTQUICK II GC), and cast with a Au-Ag-Pd alloy (CASTWELL MC GC).

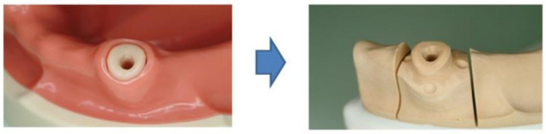


Fig.4 preparation of abutment

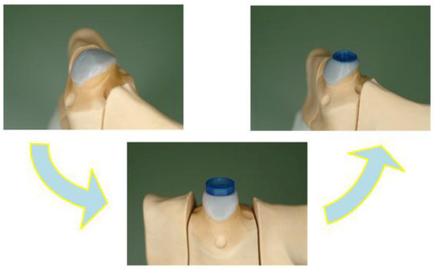


Fig.5 Wax up

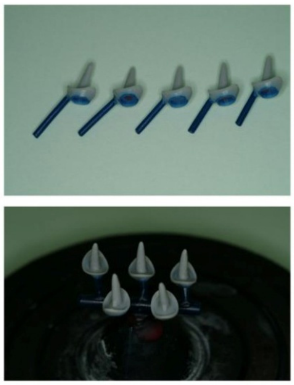


Fig.6 Keeper coping wax pattern

Casting was performed under the following two heating conditions shown in the following figure.

The casting condition 1 shown in Fig. 7 follows the manufactures' instruction for plastic material incineration. 1. Casting with heating at 250°C, and 2. Casting without heating at 250°C.

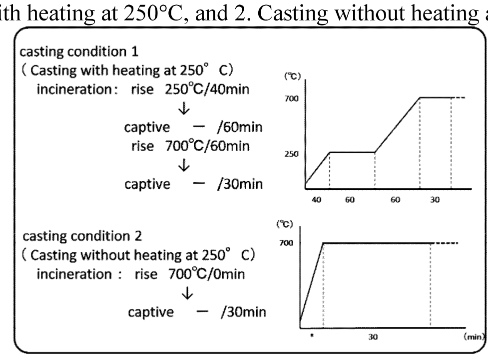


Fig.7 Casting condition

Casting was performed using a vacuum-pressure casting machine (Heracast RC, Heraeus). The casting was steam cleaned, and immersed in a ultrasonic cleaner with Palla-Clearn (GC) for 5 minutes, and testing was then performed (Fig. 8).

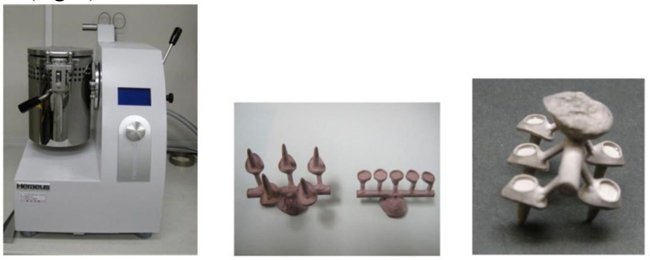


Fig.8 Finished cast

4.Evaluation

1) Cast observation using stereomicroscope
2) Quantitative evaluation of casting surface roughness

Digital Microscope VHX-500 was used for obtaining measurements (Fig. 9). The surface of the keeper tray base was evaluated three-dimensionally to measure the vertical surface interval difference variations. These measurements results were quantitatively compared as findings of surface roughness variation.

Fig.9 Digital Microscope VHX-500 (KEYENCE)

Results

1.casting observations using stereomicroscope

Fig. 10 shows the observational comparisons between conventional AC and prototype PE castings with heating at 250°C. No major casting defect was observed in both samples.

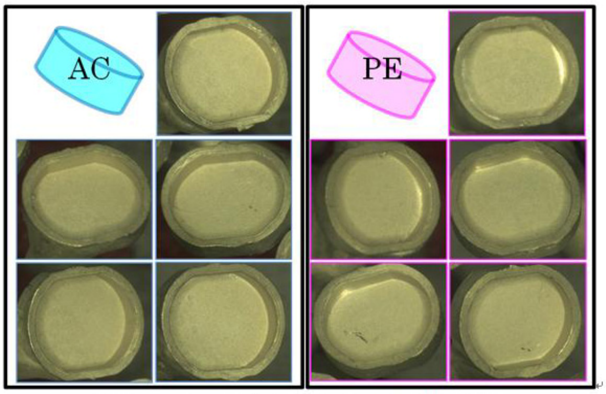


Fig.10 Heating at 250°C (AC,PE)

Fig. 11 shows the observational comparisons between conventional AC and prototype PE castings without heating at 250°C. No major casting defects were observed in both samples.

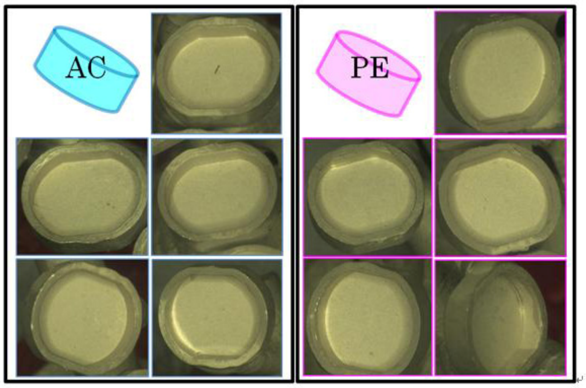


Fig.11 No heating at 250°C (AC,PE)

Fig. 12 shows the observational comparisons between AC-WAX and PE-WAX castings with heating at 250°C. Casting defects were observed on the corner edges of all AC-WAX samples. No major casting defects were observed in PE-WAX samples.

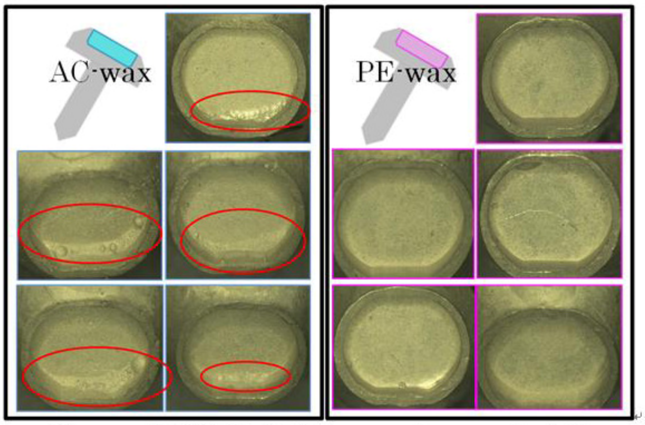


Fig.12 Heating at 250°C (AC-wax,PE-wax)

Fig. 13 shows the observational comparisons between AC-WAX and PE-WAX castings. Significant casting defects such as burrs, blow holes were observed in the corners of AC-WAX casting. No major casting defects were observed in PE-WAX casting.

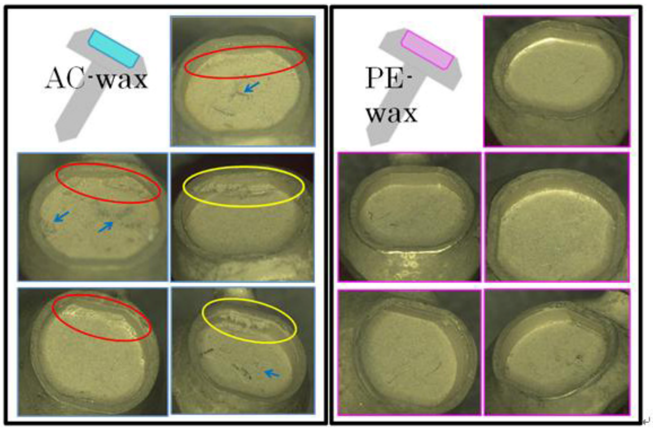


Fig.13 No heating at 250°C (AC-wax,PE-wax)

2.Three-dimensional image and surface evaluation

Fig. 14 shows the AC and PE casting data.
The numbers under the graph shows the mean values of 5 measurements for each sample.
The measurements were 3.9 ± 0.5 µm with heating at 250 °C, 4.6 ± 0.3 mm without heating at 250 °C in AC, 4.3 ± 0.5 µm with heating at 250°C and 4.2 ± 0.3 µm without heating at 250 °C in PE.

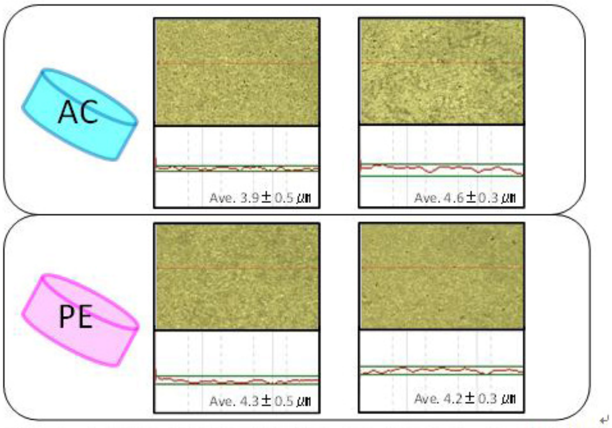


Fig.14 Three-dimensional image and surface evaluation

Fig. 15 shows the AC-WAX and PC-WAX data.
The measurements were 8.3 ± 0.8 µm with heating at 250°C, 16.3 ± 4.2µm without heating at 250°C in AC-WAX, 4.3 ± 0.4 µm with heating at 250°C, and 9.5 ±2.4 µm without heating at 250°C in PE-WAX.

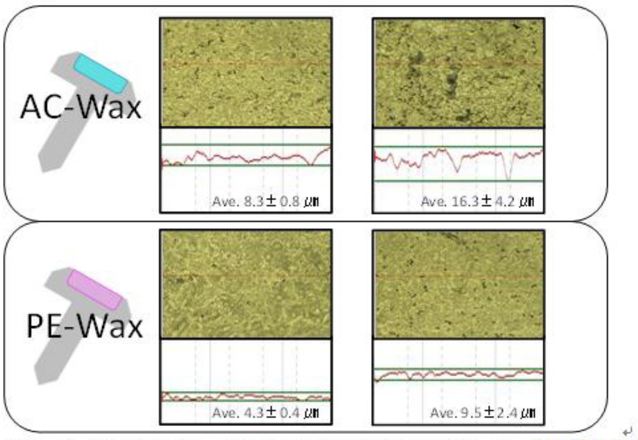


Fig.15 Three-dimensional image and surface evaluation

3.Measurement of the casting surface roughness

No statistically significant differences were observed between AC and AC-WAX, and AC-WAX and PE-WAX with heating at 250°C. There was no statistically significant difference between PE and PE-WAX (Fig. 16).
For samples without heating at 250 °C, statistically significant differences were observed between AC and AC-WAX, but not between PE and PE-WAX castings (Fig. 17).
The comparison of samples depending on different conditions demonstrated a statistically significant difference in AC-WAX and PE-WAX (Fig. 18).

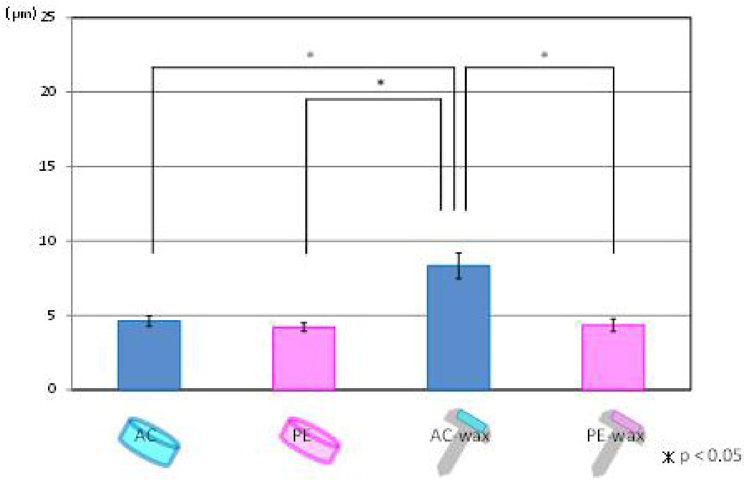


Fig.16 The casting surface roughness (heating at 250 °C)

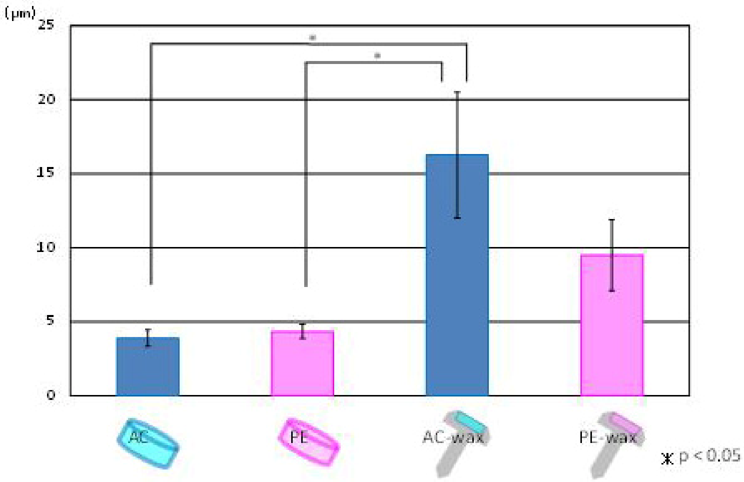


Fig.17 The casting surface roughness (no heating at 250 °C)

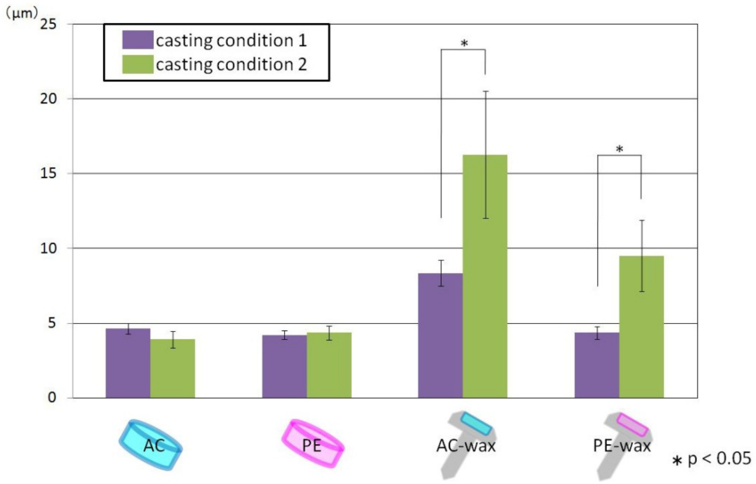


Fig.18 Comparison of samples by different conditions

Discussion

In each tested casting condition, the differences in a surface roughness were confirmed in AC and AC-WAX using conventional keeper trays. No significant differences were observed in prototype keeper trays.

It is speculated that acrylic, a chief component of the conventional pattern and wax adversely interact with each other during the heating step after investment flasking.

Further studies are needed to elucidate the postulated relationships between the keeper tray materials and casting defects, and to determine the causes of casting defects.

Conclusion

Samples were fabricated using a commercial ready-made pattern and new prototype pattern, and then compared for casting precision. The following conclusions were drawn:

1. No major casting defects were observed in the conventional and prototype castings when the patterns were individually cast.
2. The keeper coping patterns prepared by added dental wax demonstrated a significant unwanted casting defects such as blow holes and burrs in the conventional type patterns. No major casting defects were observed using the reported prototype casting pattern.
3. When dental wax was added to the original pattern to make the shaped coping, differences in surface roughness depending on different casting conditions was observed in both the conventional and prototype keeper trays.

These results show that the prototype keeper tray design with the added dental wax technique demonstrated a better casting precision compared to the conventional type.

References

1. Tanaka,Y.: Dental Magnetic Attachment,Q&A,Ishiyaku Publishers,Inc.(Tokyo),1995.
2. Gillings,B.R.D.: Magnetic retention for complete and partial overdentures,Part.J.Prosthet.Dent.,45(5): 484-491,1981.
3. Jackson,T.R.: The application of rare earth magnetic retention toosseointegrated implant.Inc.J.Oral & Maxill.Imp.,1:81-92,1986.

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

M. Hideshima, Y. Igarashi, T. Ichikawa, J. Tanaka, T. Kochi, T. Ishigami, T. Andoh,* A. Nishiyama**

Dental Care Council, the Japanese Society of Magnetic Applications in Dentistry,
Section of Removable Prosthodontics,* Temporomandibular Joint and Occlusion,**
Graduate School of Medical and Dental Sciences, Tokyo Medical and Dental University

Introduction

In the past decades, major methodological developments have occurred with regard to the clinical domains of etiology, diagnosis, prognosis, and therapy. As a result, evidence-based guidelines for clinical practice in dentistry have increased, and scientific journals are demanding increasingly higher standards of research.

The Japanese Society of Magnetic Applications in Dentistry (JSMAD) has also formed a dental care council that has discussed the formulation of clinical practice guidelines (CPG) for magnetic applications in dentistry according to the directions of the Japanese Association for Dental Science.

In addition, the council discussed the social health (dental treatment) insurance should cover the treatment of magnetic attachments or not.

As a result the council developed a questionnaire survey dealing with the subject of magnetic attachments and distributed it to general practitioners of dentistry, including those who were not members of the Japanese Society of Magnetic Applications in Dentistry.

Objective

The objective of this survey was to analyze the kinds of clinical questions that arise among general practitioners with regard to the use of magnetic attachments and to encourage them to develop and to refer them to formulate clinical practice guidelines (CPG).

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. The council members distributed the survey among attendees of the 19th annual meeting of the society of magnetic applications in dentistry at Morioka, Iwate Prefecture.

The survey contained questions regarding clinical experience, the 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 survey also inquired on the issue of whether social health insurance should cover treatment with magnetic attachments (MA) (Table 3).

The completed questionnaires were returned by e-mail or FAX, 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 less 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 2) In case of implant-supported overlay dentures, 3) When applying a magnetic attachment to a remaining abutment teeth	is magnetic attachment is magnetic attachment is flat type keeper	compared to applying clasps compared to other type of retainers compared to dome-shaped keeper	effective? effective? effective for stability of the denture?
①			
②			
③			
④			
⑤			

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

Q6. Please indicate below whether you believe that the application of magnetic attachments should be covered by social health insurance.
・agree ・disagree ・agree with reservations ・both acceptable ・not understandable
(reservation: ______________________)

Table 3: Questionnaire regarding social health insurance (Q6)

Results

A total of 74 participants, including 12 council members and 23 attendees of the 19th annual meeting, completed the questionnaire, and 102 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～	38
5～10y	15
2～5y	20
Resident	1

Table 4: Q1. Participants classified by years of clinical experience (N=74)

Workplace	Number of persons
Dental Office	30
University Hospital	44

Table 5: Q2. Participants classified by workplace (N=74)

	Number of persons
Member	49
Non-member	25

Table 6: Q3. Participants classified as member or non-member of JSMAD (N=74)

Number of cases	Number of persons
10～	37
5～9	9
1～4	15
None	13

Table 7: Q4. Participants classified by number of cases of MA (N=74)

Clinical questions (CQ)

A total of 102 CQs were divided into 5 categories shown below according to their applications.

1) Applying MAs to abutments of dental implants
(Implant): 14CQs
2) Compared to other type of retainers when applying in certain type of defects
(Defects): 40CQs
3) Compared to other type of retainers when applying in certain type of occlusion
(Occlusion): 9CQs
4) Arrangement of MAs in the remaining dentition or configuration of MA
(Arrange / Form): 21CQs
5) Management of MA or others
(Manage/etc): 18CQs

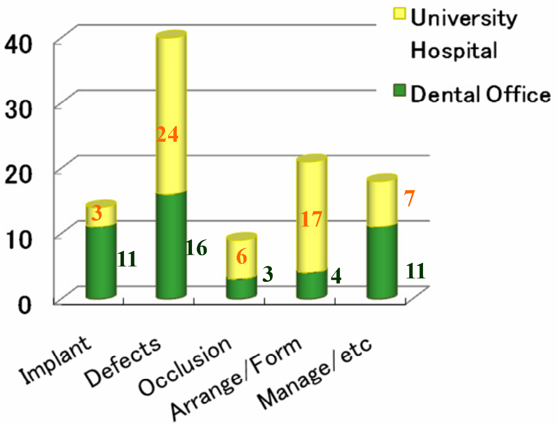


Fig. 1: Distribution of each categorized CQ classified by workplace

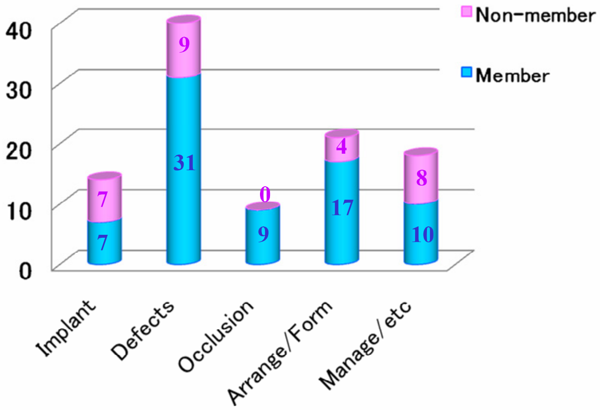


Fig. 2: Distribution of each categorized CQ classified by member/non-member of JSMAD

Social health insurance

The answers with regard to social health insurance are shown in the table below.

	agree	agree with reservation	disagree	both acceptable	don't understand	Total
Member	13	12	17	2	5	49
Non-member	7	4	8	1	5	25
Total	20	16	25	3	10	74

Table 8: Answers with regard to social health insurance classified as member or non-member.

	agree	agree with reservation	disagree	both acceptable	don't understand	Total
Dental Office	4	1	7	1	0	13
Univ. Hospital	9	11	10	1	5	36
Total	13	12	17	2	5	49

Table 9: Numbers of answers in members of JSMAD on social health insurance classified by workplace.

Discussion

The results of this preliminary survey indicate that one half of the participants had more than 10 years of clinical experience and had used MAs at least 10 times. Sixty percent of the participants were university hospital staff members, and 66 percent of them were members of the Japanese Society for Magnetic Applications in Dentistry. Before clinical guidelines are written, it would be valuable to seek a greater consensus among individuals new to the clinical practice of dentistry, dental office workers, and those who are not members of the Society for Magnetic Applications.

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 question and corresponding answers which should be synthetically recommended by evidences from the concerning articles, doctors' skill and patients conditions.

To make it possible to search professional literature files, the PICO question then has to be converted into key words. Articles subsequently located should then be evaluated in terms of their scientific quality and usefulness for answering the question. After this procedure has been followed, an evidence-based answer to the original question can be given.

Approximately 40% of the 102 collected CQs were classified according to the type of defect; e.g.: lower few remaining dentition or free-end saddle cases, and 60% of them were from university hospital practitioners and 80% were from the members. On the other hand, 14% of the CQs dealt with implants, and 80% of those were received from dental office practitioners of whom 50% were members of the society. Affiliation of the participants reflected differences in their clinical interest.

Regarding the application of social health insurance to MA, 25 of 74 participants disagreed, and 36 agreed, although 16 of these agreed with reservations. There were no notable differences in the answers from members and non-members of the society.

Among the members, more than 50% of dental office practitioners disagreed; on the other hand, approximately 30% of university hospital practitioners agreed (9% agreed, 11% agreed with reservations, and 10% disagreed).

The Society for Magnetic Attachments currently lacks sufficient information to make a recommendation regarding health insurance coverage for MAs and should take cautious steps referring to general practitioners opinion when applying MAs to social health insurance.

Conclusion

- A preliminary questionnaire survey for Clinical Questions (CQs) was conducted, and 74 answers and 102 CQs were collected.
- Half of the participants were clinicians with more than 10 years of experience who averaged 10 cases each involving MAs.
- CQs were classified into 5 categories: (applying to) Implant 14, (compared to other retainers when applying certain type of) Defects 40, (ditto; type of)Occlusion 9, Arrange/Form (arrangement in dentition and configuration of MA) 21 and Manage/etc.(management of MA or others) 18.
- With regard to the use of social health insurance to cover for MA, 25 or 74 participants disagreed with the idea of coverage, 20 agreed and 16 agreed with reservations.

Acknowledgement

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.

References

1. Global Program on Evidence for Health Policy World Health Organization: Guidelines for who guidelines. Geneva, Switzerland, 2003.
2. Guyatt G, Gutterman D, Baumann M, Addrizzo-Harris D, Hylek E, Phillips B, Raskob G, Lewis S, Schunemann H. Grading strength of recommendations and quality of evidence in clinical guidelines. Report from an American college of chest physicians task force. Chest. 129(1): 174-181, 2006 Jan.
3. Grant W. An evidence-based journal club for dental residents in a GPR program. J Dent Educ. 69: 681-686, 2005.
4. Loveren C, Aartman I. The PICO question. Nederlands Tijdschrift voor Tandheelkunde 114: 172-178, 2007.

Longitudinal Study of Magnetic Attachments
―Investigation of Probing Depth on Abutment teeth―

R. Ito , K. Hoshiai , Y. Tanaka , T. Ishigami[1],K. Ishibasi[2] , E. Bando[3] , H. Sasaki[4]

Department of Removable Prosthodontics , School of Dentistry, Aichi-Gakuin University
[1]Department of Partial Denture Prosthodontics , Nihon University School of Dentistry ,
[2]Department of Fixed Prosthodontics , School of Dentistry ,Iwate Medical University ,
[3]Department of Fixed Prosthodontics , Institute of Health Biosciences Graduate School The University of Tokushima ,
[4]Sasaki Dental clinic

Introduction

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

Methods

The transition of probing depth (PD) of the 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 were measured by the 6 points method.
After 5 years , the patients were recalled and PD was measured. This time, 5 departments of the JSMAD showed in the title participated in this study.
At the beginning of the study, 44 patients were participate in the study. However, 12 patients were censored so 29 patients were able to participate in the study.

Results

- Start cases　44cases
  Censored cases　12cases
  Extracted teeth　14teeth
- Total Cases： 29cases（62teeth）
  1. Maxillary：16plates（32teeth） Mandiblular：19plates（30teeth）
  2. Incisor:12teeth Cuspid: 24teeth Premolar:17teeth Molar: 9teeth
  3. Resin plate： 21plates Metal plate：14plates

Table. 1
Construction of Abutment teeth

Table. 1 details the cases which were able to participate in the study.The dentures were 6 maxillary plates and 19 mandibular plates .The abutment teeth were 12 incisor teeth, 24 cuspid teeth, 17 premolar teeth and 9 molar teeth.The materials of the dentures were 21 resin plates and 14 metal plates.The results were statistically analyzed using Willcoxon signed rank test. The significance level was set at 0.05 (SPSS Ver. 17.0 ; SPSS Japan Inc.).

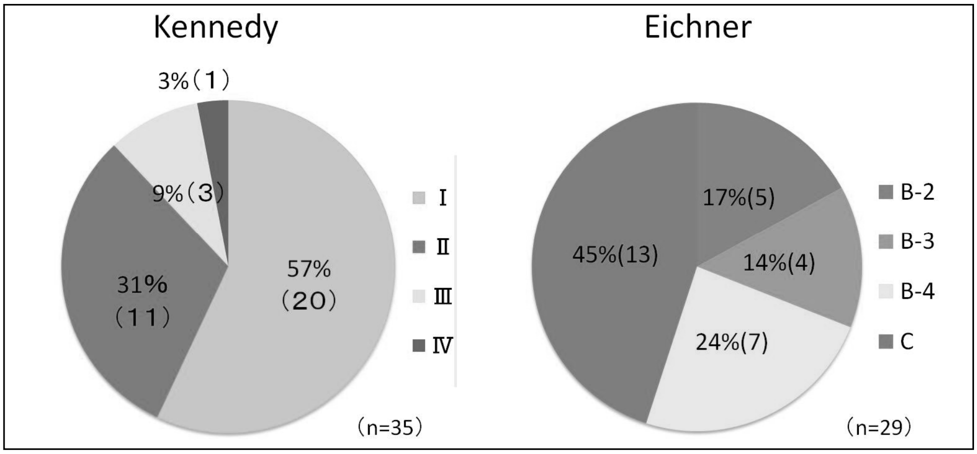


Fig. 1
Comparison of Kennedy and Eichner Clasification

Fig.1 shows the cases by removable partial denture classifications.
The Figure shows that missing distal extension (Kennedy's classifications class1 and 2) were about 90%, and that lost occlusal support cases (Eichner's Classifications class B-4 and C) were about 70%.

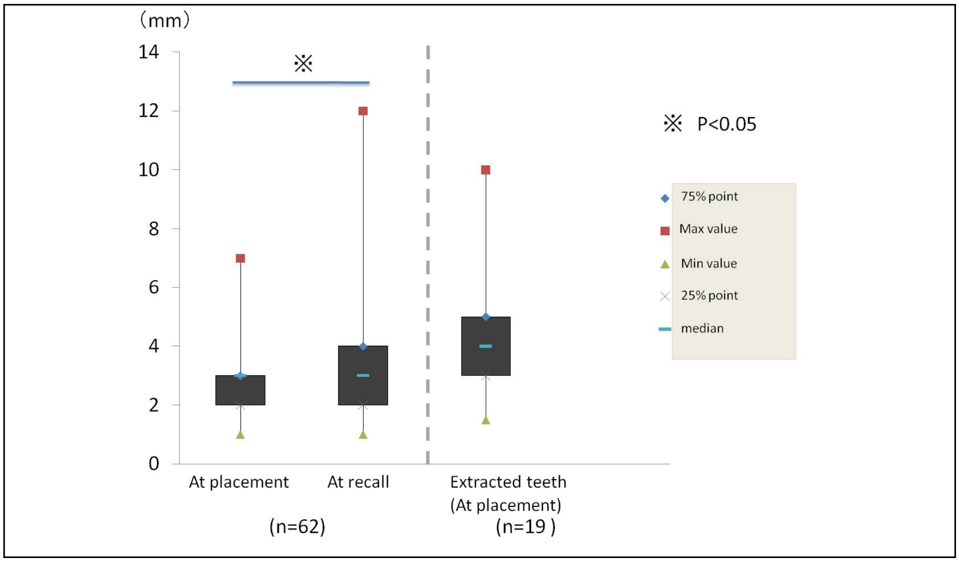


Fig. 2
Transition of Pocket Depth(comparison with extracted teeth)

Fig 2 shows the transition with Median value and quartile deviation of PD of surviving teeth for 5 years.
For this study, only max point of 6 points counted as PD of the abutment teeth.
A significant difference was found between initial PD and PD after 5 years .
The right side of the graph shows PD of the extracted teeth which were measured after cementation.

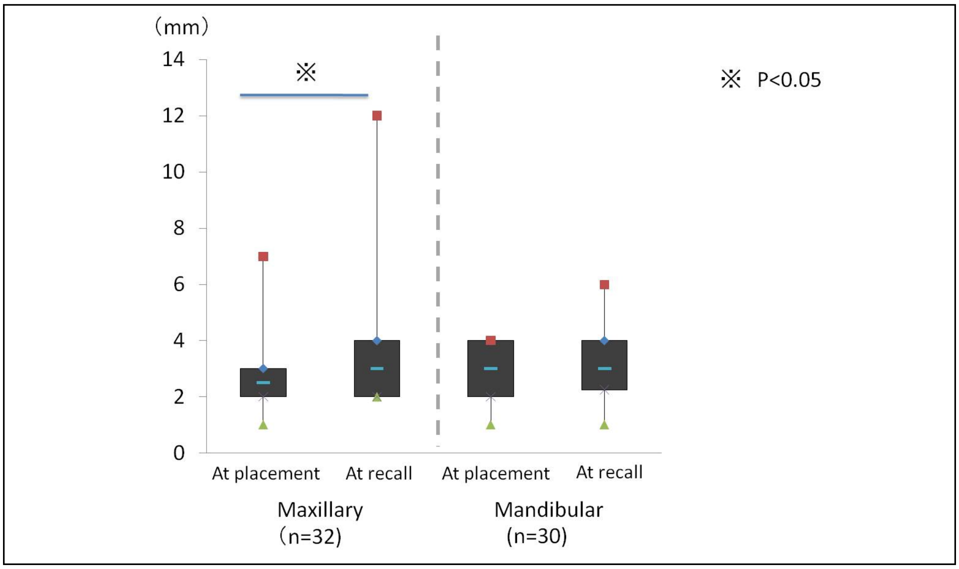


Fig.3
Transition of Pocket Depth(maxillary and mandibular)

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

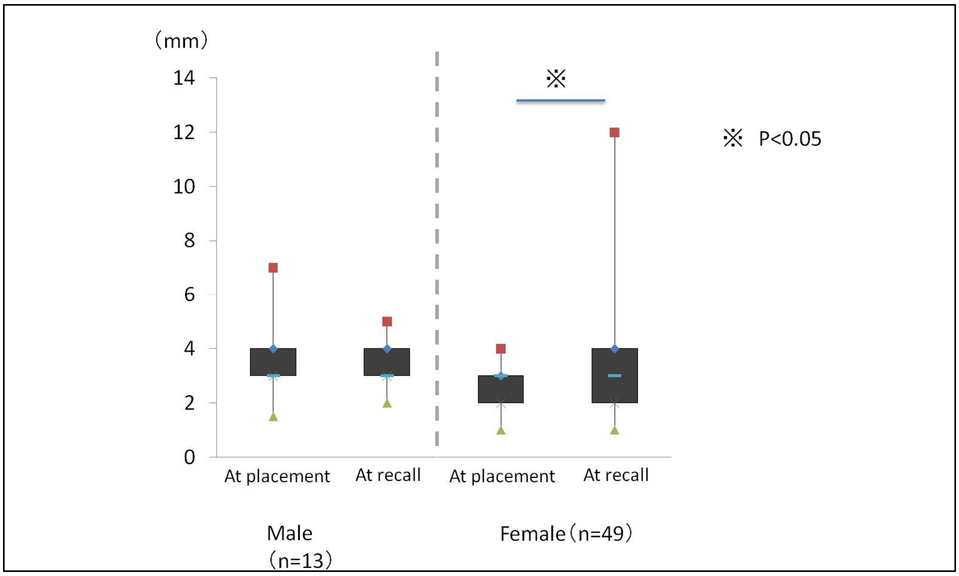


Fig.4
Transition of Pocket Depth (gender)

Fig 4 shows the transition of PD of gender.Significant differences were found for females. The PD of females significantly deteriorated.

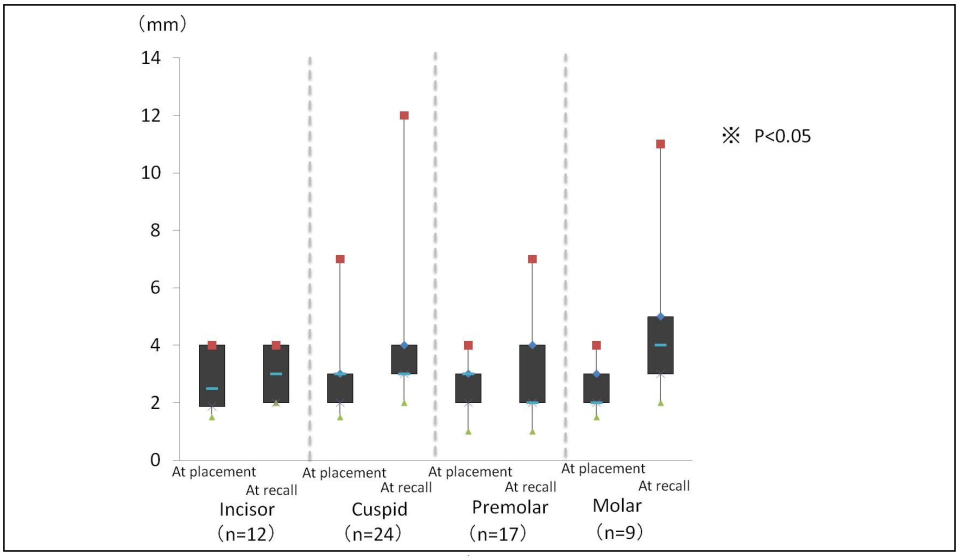


Fig.5
Transition of Pocket Depth(abutment teeth)

Fig 5 shows the transitions of PD by abutment teeth. No significant differences were found .

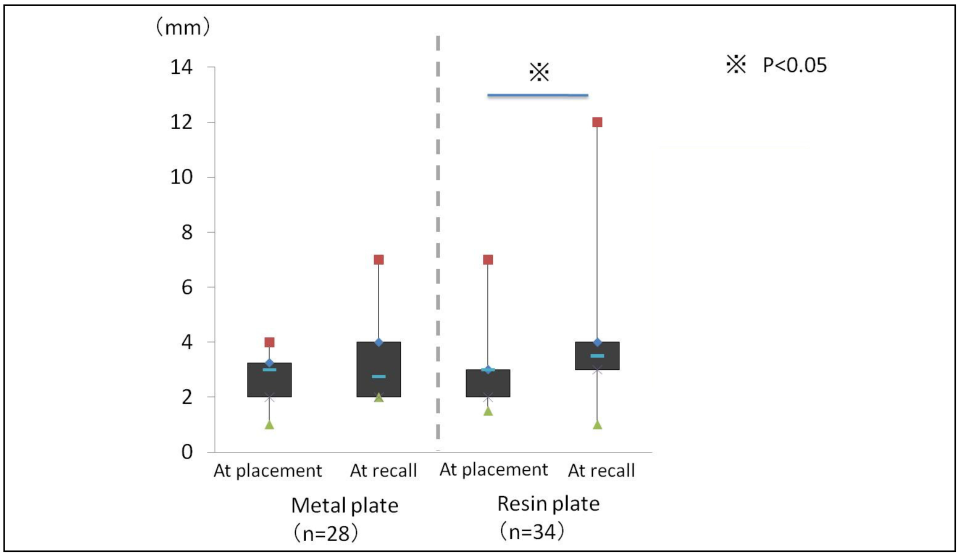


Fig.6
Transition of Pocket Depth(metal and resin plate)

Fig 6 shows the transitions of PD of materials of plates Significant differences were found for resin plates.

Discussion

The null hypothesis that PD (Probing depth) of the abutment teeth would not deteriorate was rejected, as significant difference was found between initial PD and PD after 5 years .
We reported a retrospective cohort study that the survival rate of resin plates was worse than that of metal plates[2).

The result that a significant difference was found in resin plates, corresponds with this study. The major connector of metal plates is solid, so flexure of metal plates are less than that of resin plates. Therefore the abutment teeth of metal plate were not moved. So, 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 observation of magnetic attachments from the point of the transition of PD for 5 years are below.

- PD of the abutment teeth were increased over 5 year period.
- Significant differences were found between initial PD and PD of 5 years later for maxillary plates , resin plates, and for females.

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, 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.

Longitudinal Study of Magnetic Attachments —Characteristic of Long-term Success Cases—

T. Shigemori, K. Hoshiai, K. Watanabe, R. Ito, T. Kawaguchi, T. Yokoyama, M. Miwata, N. Kimura, Y. Tanaka

Department of Removable Prosthodontics , School of Dentistry, Aichi-Gakuin University

Introduction

Magnetic attachments have increasingly been used in the treatment of various cases. However, the usefulness of magnetic attachments has not yet been confirmed. Thus, we carried out a postoperative investigation of magnetic attachments from1993, and report our findings in this study.

Methods

1,400 teeth were used as abutments fitted with magnetic attachments.252 teeth set in 105 metal plates dentures were selected for postoperative investigation. Untracable teeth were 117, the number of extracted teeth were 29, and remaining teeth were 106. The survival probability of all abutment teeth was calculated using a Kaplan Meier analysis. The survival rate of abutment teeth with metal plate was approximately 88% after 10 years and approximately 77% after 15 years. The red line shows resin plates which were used during the same period. A random sampling of resin plates were selected of 111 abutment teeth. The survival rate of abutment teeth with resin plate was 70% after about seven years and 53% after about 10 years (Fig1). The survival rate of metal plates tended to remain fixed after about 10 years, as compared to resin plates which tend to have a fixed survival rate after about seven years. Postoperative investigation was conducted to confirm the condition of abutment teeth in the metal plate at this period where the survival rate tended to remain fixed. Out of 17 cases (51 teeth), 11cases (25 teeth) were investigated.

Results

Case	Age	Gender	Anamnesis	Regio of magfit	Survival time (month)
1	68	F	Nothing	876┘ / └5	157
2	71	F	HT, DM, Breastcanser	7┴7	145
3	82	F	HT, Pharynx canser	3┴3	141
4	76	F	Stenocardia	6┘	167
5	85	F	Hypercardia	53┴35	145
6	73	F	Rheumatism	7┴1256	157
7	65	F	Recta canser	3┬4	159
8	74	F	HT	3┐	168
9	73	F	Cataract	6┬6	146
10	77	M	Hypopiesis	┌5	173
11	72	M	Nothing	┌7	148
Ave	74.2				155
SD	5.7				10.8

M : male , F : Female

Table. 1 Distribution of subject

Table1 shows the outline of cases investigated. The average age was 74.2 years. The subjects were 2 males and 9 femals. These patients were diagnosed with a systemic illness. There was a single case where the magnetic attachment was applied to both the maxilla and mandible magnetic attachment was applied in 5 cases each of maxilla and mandible. The breakdown of attachment is 2 incisor teeth, 6 cuspid teeth, 6 premolar teeth, 11 molar teeth. The average survival time was 155 months or about 13 years.

Case	Age	Gender	Anamnesis	Regio of magfit	Survival time (month)
1	68	F	Nothing	876| / |5	157
2	71	F	HT, DM, Breastcanser	7|7	145
3	82	F	HT, Phar nser	3|3	141
4	76	F	Sten ı	6|	167
5	85	F	Hyp ia	53|35	145
6	73	F	Rhe m	7|1256	157
7	65	F	Recta r	3|4	159
8	74	F		3|	168
9	73	F	Cataract	6|6	146
10	77	M	Hypopiesis	|5	173
11	72	M	Nothing	|7	148
Ave	74.2				155
SD	5.7				10.8

M : male , F : Female

Table. 2 Use of the denture

Table2 shows the general condition of dentures. Only 2 subjects were regularly doing the recall, and 2 cases were burshing their 3 times a day. Half of the cases were using the denture's brush when cleaning their dentures. 2 cases wore the dentures when they sleep. Fig.1 shows the cases by removable partial denture classifications.

Case	Regio	Pocket depth(mm) (最大値)(BOP)	Mobility(M)
1	876| / |5	3 3 3| / |3	000| / |0
2	7|7	3|5	0|0
3	3|3	5|5	3|3
4	6|	3|	0|
5	53|35	3 2|2 2	01|10
6	7|1256	6|2 3 3 3	1|0000
7	3|4	3|4	0|2
8	3|	7|	0|
9	6|6	3|3	2|2
10	|5	|1	|1
11	|7	|2	|0

Table. 3 Catastasis of abutment tooth

Table3 shows the state of the abutment teeth. Adjustments were from tooth 1~ 5. Seven cases, more than half of the total number of cases, involved adjustment of more than one teeth. The majority of he periodontal pocket depth measured by 6 point method were less than 4mm and the maximum value was 7mm. Many abutment teeth showed mobility in the range of M0～M2. Case No.8 abutment tooth that showed the depth of the periodontal pocket 7mm and on other point 1mm and M0. Case3 the depth of the periodontal pocket was 5mm, and tooth mobility of M3 thus was suitable for tooth extracyion.

Case	Masticatory Score (point)	Prescale area(mm^2)	Prescale Force (N)	Prescale Point
1	87.9	8.8	84.4	16.0
2	98.0	8.4	72.0	13.5
3	74.9	2.5	49.2	7.0
4	100.0	5.3	84.7	10.3
5	100.0	6.5	80.5	7.3
6	98.0	4.4	84.0	11.8
7	100.0	4.5	76.5	8.0
8	100.0	5.3	120.0	9.3
9	98.0	3.4	77.6	10.6
10	100.0	6.5	84.4	15.5
11	50.9	7.5	76.9	10.7
Ave	91.4	6.0	84.1	10.9
SD	14.8	1.7	12.7	2.3

Table. 4 Masticatory parameter

Table4 shows the state of masticatory function of each case. It seemed that sufficient mastication was achieved by almost all the cases. As evidenced from the masticatory score. Similar results were obtained by using dental prescale. The contact side product average was 6.0mm^2 , the maximum occlusion power was 84.1N, and the contact point was 10.9 points. Therefore, the artificial dentures were functionallyg acceptable.

Discussion

Magnetic attachments were applied to maxilla so that the arrangement of abutment teeth were aligned on both sides. The Kennedy's classification is from class Ⅰ to class Ⅴ. The Eichner's classification is class B to class C. The number of magnetic attachment to the mandible were fewere as, compared to the maxilla and the periodontal pocket depth remained same except for a single case.

Conclusion

We carried out the postoperative investigation on magnetic attachment that had been in use for 13 years.

1. Cases which had magnetic attachment in to the maxilla, had a large number of abutment teeth per plate.
2. For mandible magnetic attachment, the number per plate were few.
3. Judging from the condition of the dentures and abutment teeth, it seems that dentures continue to function well and last for extend period.

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. 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.

Stress Analysis of an Abutment Tooth with Extracoronal Magnetic Attachment -Introduction of Nonlinear Property into Three-Dimensional Finite Element Method-

R. Kanbara, Y. Nakamura, A. Ando, H. Kumano, T. Masuda, M. Sakane, Y. Ohno, R. Matsukawa, Y. Takada[1], Y. Tanaka

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

Introduction

The importance of understanding and defining the mechanical properties of supporting tissues is of interest in prosthodontic investigation. The finite element method (FEM) has been commonly used for dental application analysis in recent years. However, it has proven difficult to analyze soft tissues such as the oral mucosa and periodontal ligament of abutment teeth using currently available methods. This includes a simple theoretical analysis, a model experiment, and the FEM for elastic displacement due to their viscoelastic properties. It has been reported that the dynamics in denture supporting mucosa during occlusion is complex. The oral mucosa and the periodontal ligament demonstrate a viscoelastic property specific to the soft tissues. During load application, these tissues, unlike other tissues, show a non-linear, phase proportioned complex elastic displacement. The initial displacement is rapid in the low-load condition, but then, slows as the load increases (secondary displacement), thus demonstrating a two-phase characteristic.

Objective

The purpose of the present study was to construct a Finite Element Model demonstrating incorporated nonlinear behavior to simulating physiologic tissue viscoelasticity for evaluation of complex oral tissues including the oral mucosa and abutment tooth periodontal ligament.

Methods

1. Introduction of Nonlinear Property

A mathematically described nonlinear property was introducted into a Finite Element Analysis model to simulate oral mucosa and periodontal ligament using he following methods, and a stress analysis was performed: Analysis model

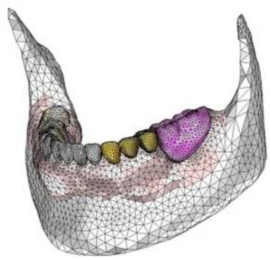


Fig 1 : Analysis Model

Fig. 1 shows the analysis model created by Ando from our department. The three-dimensional FEM model was constructed from patient CT data according to the method developed by Ando for accurate morphologic simulation. A fixed partial denture with attachments was designed on the analysis model, and connective crowns incorporating extracoronal magnetic attachments were placed on the abutment left lower canine, first and second premolars for the loss of left lower first and second molars. The comprising elements type designations were pentahedral element for the periodontal ligament, and tetrahedral for the other tissues. The point total of the analysis model was 27,083, and a total element count was 118,085.

1) Material Properties (Mucosa and Periodontal ligament)

Material constants for oral mucosa and periodontal ligament under load application were determined prior in order to simulate analysis model comlex tissue behavior. Material constants were set to for automatic control by the computer program to account for load weight. This permitted simulation of the human behavior by the model. Prior reports by Kishi (Fig 2) and Ogita (Fig 3) were used as reference for the respective measurement of oral mucosa and periodontal ligament. Fig. 4 shows the sequential process.

The denture was removed from the analysis model shown in Fig. 1, and loads were directly applied on to the oral mucosa and abutments to create the program.
Patran 2007 r1b (MSC) was used as the modeling software, and Marc 2008 r1 was used for analysis solution solving.

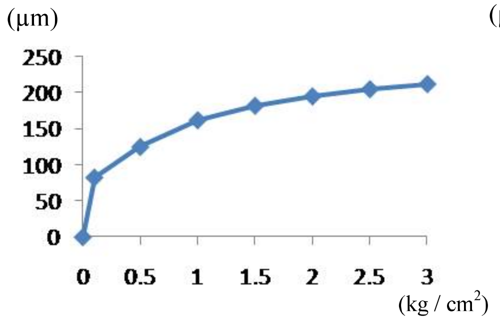


Fig 2: Displacement of Mucosa

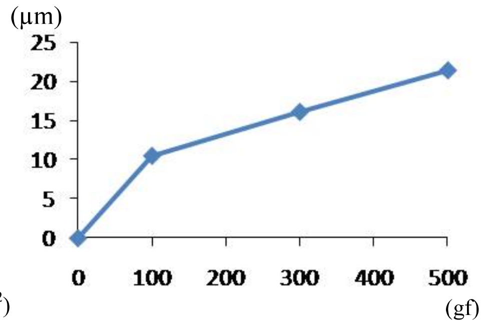


Fig 3: Displacement of left lower canine

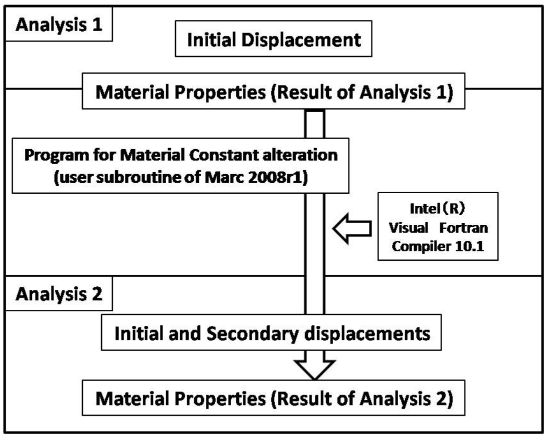


Fig 4: Sequential Process

(1) Analysis 1

The measurement conditions shown in references (Fig 2 and 3) were reproduced as closely as possible to simulate the initial displacement.

① ┌ Mucosa

Fig. 5 shows the load conditions of the oral mucosa.The load applied was 0.1 kg / cm^2, and the loading range was 60 mm^2. The surface load was applied, and maximum vertical displacement of the oral mucosa was measured. Material properties (Young modulus and Poison ratios) of the oral mucosa were determined so that those values were close to the actual measurement value found in human subjects under the same loading condition (82.5 μm). The oral mucosal elements stress value of maximum vertical displacement was measured as well(von Mises equivalent stress). The results are shown in Table 1.

② Periodontal ligament

Fig. 6 shows the load condition of the periodontal ligament. A 100 gf contact load was applied on the crown of abutment left lower canine in the tooth axial direction. The maximum vertical displacement was measured, and the material constant was determined so that the value was close to the actual measurement value in humans (10.0 µm). The maximum stress value in the periodontal ligament element was also measured (von Mises equivalent stress). The results are shown in Table 2.

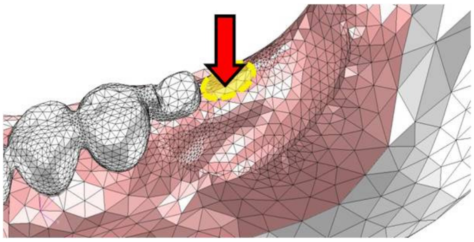


Fig 5 : Load Conditions of Initial displacement (Mucosa)

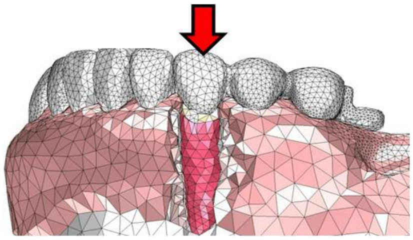


Fig 6 : Load Conditions of Initial displacement (canine)

Table 1: Result of Analysis 1 (mucosa)

Young Modulus (MPa)	Poisson's ratio
0.265	0.300

⇩

83.0 µm Sinkage

Max Stress (MPa)

σ : 3.2905E-004

Table 2: Result of Analysis 1 (Periodontal Ligament)

Young Modulus (MPa)	Poisson's ratio
0.150	0.300

⇩

10.8 µm Sinkage

Max Stress (MPa)

σ : 5.204E-004

(2) Program for Material Constant alteration

A program was specifically created for conversion of the material constant for oral mucosa and periodontal ligament during the analysis. This program was used as a user subroutine of the analysis solver Marc 2008 r1 in order to reflect the program in the analysis. The program was reflected in the analysis through Intel (R) Visual Fortran complier 10.1.

Element numbers of the oral mucosa and the periodontal ligament were assigned to the program so that those material constants can be changed automatically. Stress value at the subject elements was extracted as von Mises stress. The program was set so that the stress values shown in Tables 1 and 2 were used as material constants until the stress reached a conversion point, and then material constants changed when further stress was applied. This program automatically changes the material constant when the further stress was applied. The results suggested that the stress values arising in the oral mucosa and the periodontal ligament automatically change when they exceeded the value in the initial displacement.

(3) Analysis 2

A second analysis was performed using the program described above to reproduce the when higher loading exceeding the first analysis loading was applied. The analysis conditions were identical to the first analysis conditions except for the new higher loading force evaluated.

①Mucosa

The load applied on the oral mucosa was 3.0 kg / cm^2. The maximum vertical displacement of the oral mucosa was measured in the same manner as the first analysis, and material constants of the oral mucosa were determined so that those values were close to the actual measurement value in humans under the same loading condition (210.0 µm). The results are shown in Table 3.

② Periodontal ligament

The load applied on the abutment was 500 gf. The maximum vertical displacement of the abutment was measured, and material constants of the periodontal ligament were determined so that those values were close to the actual measurement value in humans under the same loading condition (20.0 μm). The results are shown in Table 4.

Table 3: Result of Analysis 2 (mucosa)

Young Modulus (MPa)	Poisson's ratio
3.500	0.490
⇩ 212.3 μm Sinkage	

Table 4: Result of Analysis 2 (Periodontal Ligament)

Young Modulus (MPa)	Poisson's ratio
0.750	0.300
⇩ 20.3 μm Sinkage	

The program allows the simulation of the initial displacement when a load of < 0.1 kg / cm^2 and < 100 gf were applied on the oral mucosa and the periodontal ligament, respectively, and the secondary displacement when a heavier load was applied. Stress-strain curve obtained by the computation history of the analysis was used to check if the material property conversion in the second analysis was performed using the stress value obtained in the first analysis.

2. Stress analysis

A load was applied on the analysis shown in Fig. 1 using the material nonlinear program developed in the present study. The detailed conditions for the analysis were as follows:

The analysis type used was elastic stress analysis. General purpose finite element program Marc 2008 r1 was used as an analysis solver.

1) Boundary conditions

Coulomb's friction coefficient μ=0.01 was applied as a contact condition at a contact point between a denture and retainer.

Fig. 7 shows the constraint condition and he loading condition.. A compete constraint was applied to the inferior border of the mandible in the X, Y, and Z directions.Vertical surface pressure loads of 10, 20, and 30 N were applied on the occlusal plane of a denture. The loading range was entire occlusal surface of the denture.

2) Material properties

Table 5 shows components and mechanical property values of the analysis model. The same material constant was used for a crown, attachment, and metal frame.

The material constants of the oral mucosa and periodontal ligament were changed by the program to reflect the analysis, and the initial and secondary displacements were reproduced.

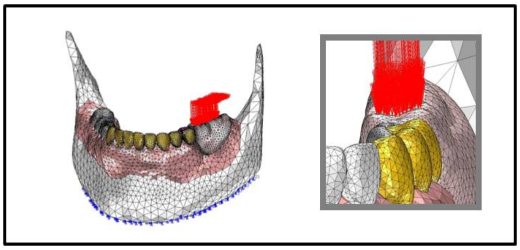


Fig 7: Boundary Condition

Table 5: Material Properties

	Young Modulus (MPa)	Poisson's ratio
Mucosa	0.265 ↓ 3.500	0.300 ↓ 0.490
Periodontal Ligament	0.150 ↓ 0.750	0.300 ↓ 0.300
Compact bone	117,60	0.250
Cancellous bone	14,70	0.300
Dentin	117,60	0.350
Metal	940,80	0.300
Denture	14,70	0.300

Results

1. Introduction of nonlinear property

1) Comparison of analysis result and actual measurement

Nonlinear properties were introduced into the finite element model for the analysis. The comparison was made between actual measurements in humans described in the references (Fig 2 and 3) and analysis results.

① Mucosa

Fig 8 shows the vertical displacement of the oral mucosa.

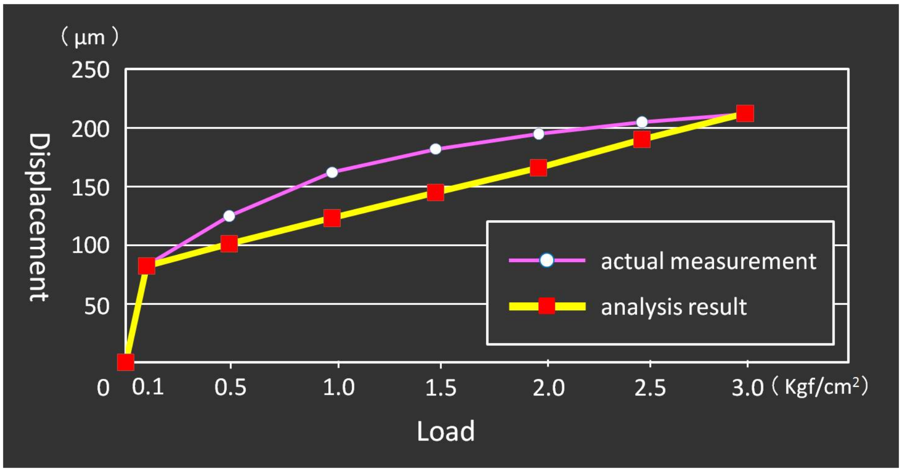


Fig 8: Vertical displacement (mucosa)

② Periodontal ligament

Fig 9 shows the vertical displacement of the abutment.

The initial and secondary displacements of the oral mucosa and the periodontal ligament were simulated to be close.

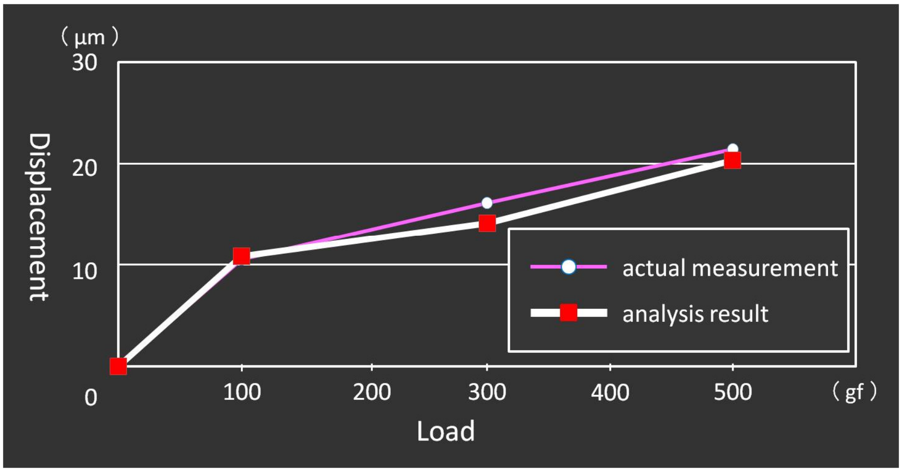


Fig 9: Vertical displacement (canine)

2. Stress analysis results

Load was applied to the analysis model shown in Fig. 1 using the material nonlinear program, followed by the analysis. The analysis results of the displacement amount of a denture and abutment were as follows:

1) Displacement of an abutment

Fig 10 shows the displacement of an abutment under three loading conditions. The displacement amount increased with increasing applied load, but no commensurate increase against the load was observed.

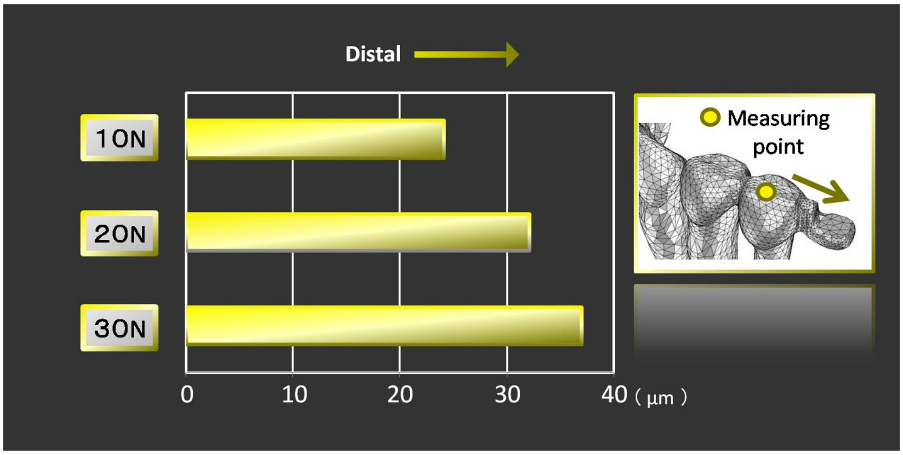


Fig 10: Distal displacement of Abutment

2) Displacement of a denture

Fig 11 shows the vertical displacement of the inferior border of a denture under three loading conditions. The displacement amount increased with increasing applied load, but no commensurate increase against the load was observed.

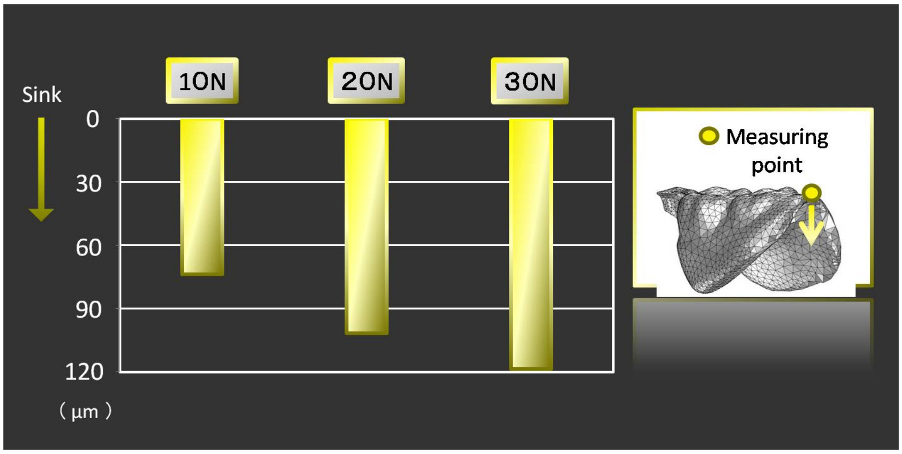


Fig 11: Vertical displacement of Denture

Discussions

1. Finite element method

There have been many reports on the stress analysis in dentistry. Although the analysis subjects vary from hard tissues to implants, few reports are available on the stress analysis of the soft tissues. The dearth of soft tissue analysis studies suggests and inherent difficulty in the evaluation and simulation of viscoelasticity and soft tissues behavior. An elastic element with true elastic properties and alternative elements can be used to simulate the viscoelasticity of the soft tissues. Solid biologic foundational information of oral mucosa and periodontal ligament tissues is required to accurately use these methods. However, few reports are available on physiologic behavior of the oral mucosa and the periodontal ligament. In the present study, the difference in the displacement between the oral mucosa and the periodontal ligament under loading conditions were evaluated. The material constant was changed using adaptational programming with a user subroutine utilizing loading conditions based upon actual body measurements for close simulation of oral mucosa and periodontal ligament behavior. This study will be of great value to future stress analyses investigations of intraoral soft tissues.

2. Introduction of nonlinear property

Two phase behavior of the oral mucosa and the periodontal ligament can be simulated by using the program in which the stress value of the element under load application was set to be a turning point of the material constant. This method allows simulation approaching human physiologic tissue boundaries. This program also allows the simulation of both oral mucosa and the periodontal ligament tissues by different analysis models and using other materials to show complex behaviors. The methods in the present study was based on the previous efforts by Ishida (The First Department of Prosthodontics, School of Dentistry, Aichi-Gakuin University).

1) Mucosa

Initial and secondary displacements of the oral mucosa against load were simulated by finite element method using two material constants. However, due to the complex human behavior as reported by Kishi (Fig 2), no significant change was observed in the displacement with an increase in the load above 1.5 kg/cm^2. The program used in the present study was designed for simulation of two-phase human tissue behavior by change of the material constant value. The results shown in Table 9 suggest a minor difference in the displacement of tissues.

Further studies are required to simulate complex human tissue behavior more accurately by the subdivision of displacements against different loads based upon the program and setting the material constant for each displacement.

2) Periodontal ligament

Initial and secondary displacements of the periodontal ligament against load were simulated by finite element method using two material constants.

The analysis of the periodontal ligament was performed in the program using two material constants to compare the results with Ogita's report shown in Fig 9 . A minor difference was noted in the displacement between 100 gf and 300 gf. Unlike the oral mucosa where the load is directly applied, the load is transmitted to the periodontal ligament through an abutment. In the analyses 1 and 2, the material constants were determined to be close to the actual measurements in humans. In contrast, there are minor variations in stress generated in the periodontal ligament element depending on the morphology of abutment roots under 300 gf load application.

The results suggest the necessity of subdivision of displacements against different loads and the setting of the material constant for each displacement in the periodontal ligament.

3. Stress analysis results

Although the greater displacement was observed at 30 N load application than 10 N, an increase in the displacement was not in proportion to the load as was the case in material linear analysis. This is considered to be due to the fact that stress arose in the oral mucosa and periodontal ligament elements by load appication reached a turning point, resulting in an increase in rigidity of elements and an inhibition of displacement. The rigidity of the oral mucosa and periodontal membrane increased by using this system, allowing the application of heavy loads that could not be used in the conventional material linear analysis. This system provides a more practical stress analysis.

Conclusion

A material nonlinear property was introduced to the finite element method in order to accurately simulate the viscoelastic behavior of oral mucosa and the periodontal ligament. The present study demonstrated the analysis results and the availability of the material constant changing program can be effectively used in material nonlinear analysis. The following conclusions were drawn:

1. Two-phase behavior similar to that found in humans was simulated by introducing a material nonlinear property into the oral mucosa and the periodontal ligament estimations of the finite element model, allowing practical simulation.
2. The analysis of the mechanical properties demonstrated a decrease in the displacement of oral mucosa and periodontal ligament with an increase of Young's modulus and Poisson's ratio.

References

1. Akihiro Ando, Yoshinori Nakamura, Ryo Kambara., et al. Stress Analysis of the Surrounding Tissue of a Extracoronal Attachment using Three Dimensional Finite Element Method, The Journal of the Japanese Society of Magnetic Applications in Dentistry. Vol.18, No.1: 2009
2. Takashi Ishida, Improvement of Finite Element Method through the introducing the Nonlinear Property into the Visco-Elastic Tissues and Sliding Mode into the Contact Factor, The Aichi-Gakuin journal of dental science 39(1): 2001
3. Masataka Kishi. The relationship between the pressure surface of the alveolar mucosa and the artesian displacement, Dental Journal 72. 6: 1972
4. Kunihisa Ogita. Measurement of Three-Dimensional Movement of Anterior teeth. J. Japan Prosthodont. Soc. 27 : 1983

Attractive Force Analysis of Magnetic Attachment using Three Dimensional Finite Element Method -Influence of the Keeper Thickness on Attractive Force-

H. Kumano, T. Masuda, Y. Nakamura, T. Miyata, T. Iwai, T. Kogiso, Y. Ohno, R. Matsukawa, Y. Takada[1], Y. Tanaka

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

Introduction

The clinical efficacies of a magnetic attachment have been widely demonstrated. This includes a small lateral load on an abutment tooth due to its non-mechanical retentive force and aesthetic appearance[1)].

Although the magnetic assembly and retaining keeper are designed to exert a concentrated maximum attractive force within a small particular size and area, the problem of space constrains and attachment positioning related to clinical applications with adjacent or opposing dentition often occurs[2,3)] . It is not recommended to process commercial magnetic attachment since it may diminish attractive force and corrosion resistance. However, partial processing of a keeper is often inevitable to enhance clinical results. In such cases, it is important to understand the influence of processing on the attachment function.

Objective

The stainless steel used for magnetic attachments exhibits non-linear attractive force properties. The accounting of non-linear behavior results in difficulties for accurate force calculations. FEM analysis is necessary to estimate the size and structure of a magnetic attachment. The present study focused on the effect of magnetic keeper thickness, and investigated upon the influence of keeper thickness and attractive force using a three-dimensional finite element method.

Analysis Method

1: Analysis model

A common proprietary magnetic attachment was selected as reference model for creation of an analysis model (GIGAUSS C 600 GC) (Fig. 1). Sample measurements were made prior to modeling procedures. Actual and proprietary measurements 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, and then internally measured to determine internal shape and measurement configurations. An analysis model was constructed using a special software program (MENTAT - MSC Software) and the external and internal attachment measurements. Element breakdown of the analysis area selected was determined to be 10 mm x 10 mm in height and width. A three-dimensional model with ¼ minor axis section in size was constructed considering the axis shape of a GIGAUSS C 600 magnetic attachment. The element type designation was three-dimensional hexahedral element. Element count was 12052, and nodal point was 10395 (Fig. 2).

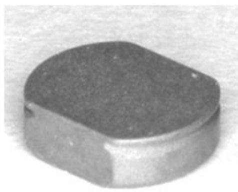


Fig 1: GIGAUSS C600 （GC）

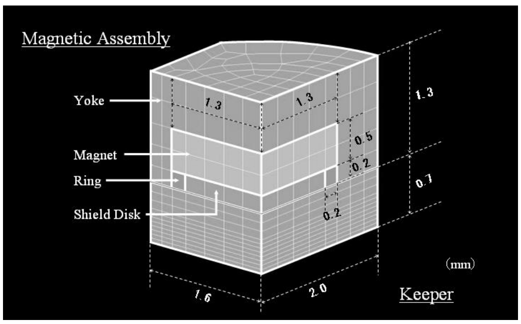


Fig 2: Size of the magnetic attachment

2: Analysis condition

The magnet used in the present study was neodymium iron and boron (Nd-Fe-B). The SUS447J1 stainless steel was used for a yoke and a keeper. The magnetic property value was determined based on the thermal property of GIGAUSS D 600 obtained from a data report [4] and manufacturer's information. Although it was determined that the original stainless steel material of a yoke and keeper was SUSXM27, a different steel substitute value for SUSXM27 required selection. The steel selected for similar and functionally identical magnetic properties was SUS447J1 steel material. The SUS447J1 steel material values were assigned since proprietary information of SUSXM27 was not available. The B-H curve was then approximated and selected from these values, and then, designated as magnetic properties (Table 1). The GiD (CIMNE) was used for the input of the analysis condition, and the MAGNA/FIM (CTC Solution) was used for the analysis. Nastran format was used for the file exchange between MENTAT and GiD.

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

3: Analysis items

Thirteen items were analyzed when the keeper thickness was changed by 0.05 mm between 0.30 and 0.90 mm. The analysis was performed on the magnetic flux density distributions and attractive forces when the keeper thickness was changed.

Results

1: Magnetic flux density distribution

The comparison of the magnetic flux density distribution with the change of keeper thickness (Fig. 3) showed the specified saturation magnetic flux density distribution between a magnetic and a keeper with 0.90, 0.80, 0.70 and 0.60 mm in thickness. However, no significant difference was confirmed in the magnetic flux density distribution of a magnetic assembly and inner keeper. The area of the specified saturation magnetic flux density distribution increased with a decrease of keeper thickness from 0.50mm to 0.40 mm and 0.30 mm. Oversaturated magnetic flux density distribution was confirmed in the saturated magnetic flux density distribution. The area of the oversaturated magnetic flux density distribution increased with a decrease of keeper thickness. The comparison of the magnetic flux density distribution between major and minor axes in the keeper showed a significant difference in the saturated magnetic flux density distribution in the thinner keeper, and increase in the oversaturated magnetic flux distribution in the long axis.

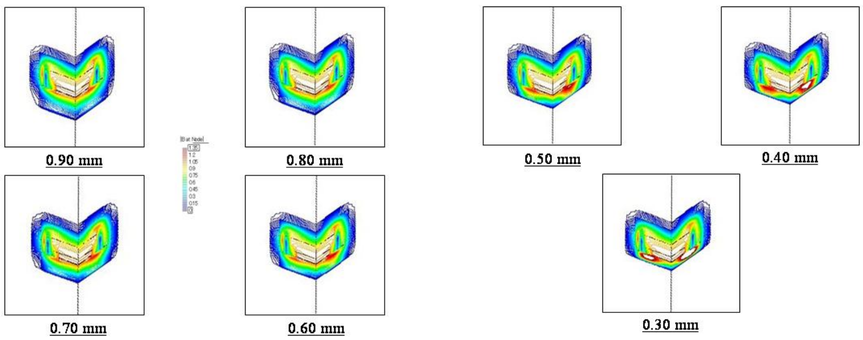


Fig 3: Magnetic flux density distribution

2: Attractive force

Fig. 4 shows the relationship between a keeper thickness and attractive force. Keepers with > 0.7 mm thickness showed attractive force of 520 – 530 gf. A decrease in the attractive force was observed in keepers with < 0.7 mm thickness. The attractive forces were 95% in 0.6 mm, 86% in 0.5 mm, 71% in 0.4 mm, and 38% in 0.3 mm when the 0.7 mm thickness was defined as 100%.

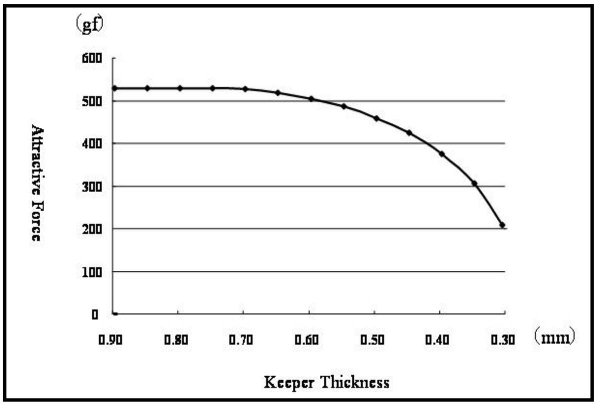


Fig 4: Attractive force

Discussions

The attraction and repulsion force dynamics of a magnet have not been well reported. Although magnetic force and magnetic fields can be measured using specialized measuring devices, it is difficult to design a magnet with maximum magnetic force based solely on the results, and also to verify the optimal properties for minimal field leakage. The FEM technique is the only known method that allows simultaneous visualization of system dynamics under variable conditions. In the present study, we measured the internal structure of a magnetic attachment sample, and constructed the correlated analytical model based on the known measurements. Therefore, the constructed model accurately reproduced the morphology of the original sample. For the analysis condition, a different steel substitute value for SUSXM27 required selection. The steel selected for similar and functionally identical magnetic properties was SUS447J1 steel material. The SUS447J1 steel material values were assigned since proprietary information of SUSXM27 was not available. The B-H curve was approximated, and the magnetic properties were assigned for the magnetic attachment. The further areas of investigation include more accurate measurement and a search for improved magnetic materials. GIGAUSS C 600 was used as a reference in the present study. A significant increase in the saturated magnetic flux density distribution was observed in keepers with <0.7 mm thickness. Attractive force peaked at 530 gf in a 0.7 mm keeper, and gradually decreased with a decrease in the keeper thickness. Ninety percent attractive force was maintained in keepers of >0.55 mm thickness, suggesting that there was no significant decrease in the attractive force. This is considered to be due to the magnetic flux density distribution in the keeper. In a cup-type keeper, magnetic flux density distribution concentrated on the center of minor and major axes of a keeper, and gradually decreased towards the margin. Due to the wide cross-sectional area perpendicular to the magnetic flux, magnetic saturation does not occur with a decrease of the keeper thickness. The influence of saturation magnetic flux density on the attractive force of a cup-type attachment is smaller compared to the sandwich type. Sufficient attractive force for clinical use can be maintained in thin keepers. It is considered that a stainless keeper can be reduced in thickness due to its high saturation magnetic flux density, suggesting further clinical application.

Conclusion

The present study focused on a keeper of a magnetic attachment, and investigated the influence of the keeper thickness on attractive force using FEM. The following results were obtained:
1. The area of the oversaturated magnetic flux density distribution increased with a decrease of keeper thickness. Oversaturated magnetic flux density distribution was observed in the saturated magnetic flux density distribution.
2. Attractive force peaked at 530 gf in a 0.7 mm keeper, and gradually decreased with a decrease in the keeper thickness. Ninety percent attractive force was maintained in keepers of >0.55 mm thickness.

References

1. Tanaka, Y. : Dental Magnetic Attachment, Q&A, Ishiyaku Publishers, Inc (Tokyo), 1995
2. Nakamura, Y. : Stress analysis of overlay denture and a magnetic attachment using finite element method. J Jpn Prosthodont Soc, 42:234-245,1998
3. Nakamura, Y. Tanaka, Y. Ishida, T. and et al : Dynamic Analysis of a Magnetic Attachment using Finite Element Method –Comparison of the two dimensional analysis with the three dimensional one-.J J Mag Dent.8:57-62,1999
4. Miyata, T. Niimi, J. Ando, A. and et al: Influence of heating of a magnetic attachment on the attractive force. J J Mag Dent.17:44-50,2008

Mechanical Analysis of Unilateral Distal Extension Partial Denture Design

Y. Ohno, R. Kanbara, Y. Nakamura, K. Shoji, H. Kumano, K. Yoshihara, A. Ando, T. Iwai, Y. Takada[1], Y. Tanaka

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

Introduction

Numerous variations of partial denture designs exist. Most conventional partial denture framework designs for unilateral partially edentulous distal extension treatments requires use of includes indirect retainers on supporting dentition contralateral to the missing tooth area. However, unilateral design is often employed to meet patients' aesthetic expectations and comfort. The application of magnetic attachments has rapidly expanded by using them for extracoronal applications. In the 18th Conference of the Japanese Society of Magnetic Applications in Dentistry, Ando (The Department of Removable Prosthodontics, School of Dentistry, Aichi-Gakuin University) reported that the effect of abutment tooth connection reaches maximum when three abutments are connected in a unilateral denture with extracoronal magnetic attachments. Kanbara (The Department of Removable Prosthodontics, School of Dentistry, Aichi-Gakuin University) comparatively evaluated and confirmed the effectiveness and use requirements of bracing arms with extracoronal attachments with a rest or lingual bar options.

Objective

The aim of the present study was to evaluate design criteria for different unilateral distal extension partial denture designs and make recommendations for an optimal design. The designs evaluated in this present study include extracoronal retainer attachments and conventional Akers clasps retainer designs. The influence of the denture design on adjacent abutments and supporting tissues was investigated and compared using finite element method (FEM).

Analysis models

1.Denture design

The following designs were proposed for the unilateral distal extension partial dentures replacing the lower left first and second molars (Fig. 1):

1) Denture with extracoronal magnetic attachment
2) Conventional denture with unilateral design
3) Conventional denture with bilateral design.

Bilateral denture design
Akers clasp was applied on the distal side of the lower left second premolar, and double Akers clasp was applied on the lower right second premolar and first molar.

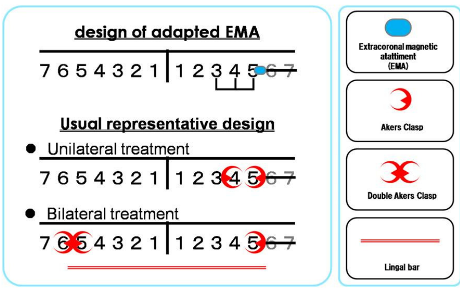


Fig. 1. Denture design

2.Finite element model construction

Each denture design was applied to the FEM model constructed by Ando. The model was fabricated based on the CT data and study model of an actual patient (Fig. 2). The samples for CT scan shown in the fig. 3 were fabricated using scanning resin (Yamahachi dental material) to embed the retainers designed for the present study. Each sample was scanned with Micro CT (Shimazu), and three-dimensional model was constructed using Mimics (Materialize). Morphological data was altered, imported into Patran (MSC), and incorporated into the denture design on the computer (Fig. 3).

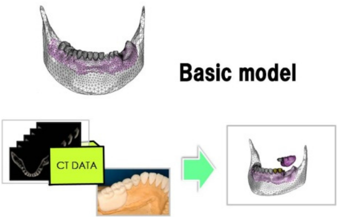


Fig. 2. Basis model

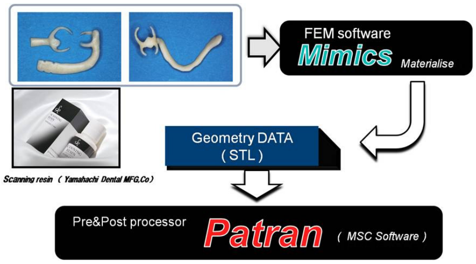


Fig. 3. Import of data

3.Analysis model

Each analysis model, element and contact points are shown in Fig. 4.

Canine, first and second premolars were interconnected in all models to compare the influence of the difference in denture design on the periodontal tissue and denture movement.

1) E-A model

The model with a bracing arm incorporated into an extracoronal attachment on the lingual side of the lower left second premolar (E-A model)

2) A-C model

The unilateral model with Akers clasps on the mesial side of the left lower first premolar and distal side of the second premolar (A-C model)

3) L-B model

Indirect retainer model with a Akers clasp on the distal side of the lower left second premolar and twin clasp on the right lower second premolar and first molar (L-B model)

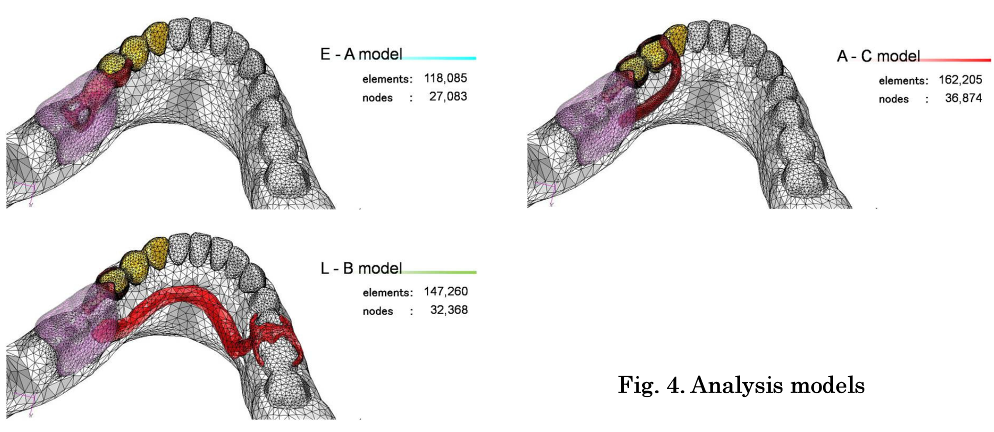


Fig. 4. Analysis models

Analysis

Mechanical property value was input into the constructed FEM model. The boundary conditions were applied, followed by the analysis using a nonlinear structure analysis solver (Marc2005r3, MSC Software).

1.Analysis condition

Contact conditions were applied between a denture and the mucosa, and an abutment and an attachment. The coulomb friction was applied, and friction coefficient was set at $\mu = 0.01$. Analysis type was linear elastic stress analysis, and three-dimensional tetrahedron and pentahedron elements were employed. DELL PRECISION 470 (DELL) was used for the analysis.

Mechanical Properties

	Young's Modulus (MPa)	Poisson's Ratio
periodontal ligament	1.00	0.45
oral mucosa	0.10	0.45
cortical bone	11,760	0.25
cancellous bone	1,470	0.30
tooth	11,760	0.35
casting metal	94,080	0.30
denture	2,450	0.30

Table1. Mechanical Properties

2.Components and mechanical properties

Table 1 shows model components and mechanical properties of each component. Mechanical property values close to precious metal materials for dental metal ceramic restoration (Degdent Universal, Densply Sankin) that are widely used in clinical practice were applied to the metals used for crown, attachment, and metal frame. For the periodontal membrane and mucosa, exploratory analyses were repeated for the vertical displacement, and mechanical property value close to the reported measurement value was employed.

3.Boundary condition

The lower bilateral coronoid processes were under complete restraint (Fig. 5). A total of 10 N loads vertical to the occlusal plane was applied to the occlusal surface of artificial teeth (Fig. 6).

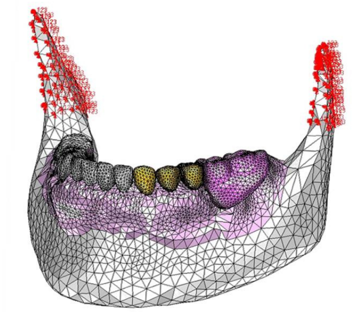


Fig. 5.Fix condition

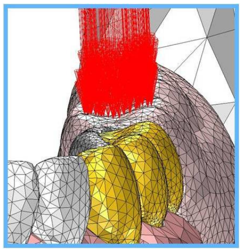


Fig. 6.Load condition

Results

1.Stress distribution

The following are the results of stress distribution. The Von Mises stress test was used for the stress distribution analysis.

1)Abutment

Fig. 7 shows the stress distribution of abutments from the distal-lingual side of the second premolar. The second premolar received the highest stress, followed by the canine and the first premolar. The stress was concentrated on the margin of abutments. Stress concentration was observed around extracoronal attachment and slit in the E-A model with attachments, and just below the rest in the A-C and L-B models with clasps. The stress distribution on the root was measured to assess the stress on the periodontal tissue. The result showed stress concentration on the distal side of the second premolar in all models. The E-A model demonstrated the highest stress concentration, followed by A-C and L-B models.

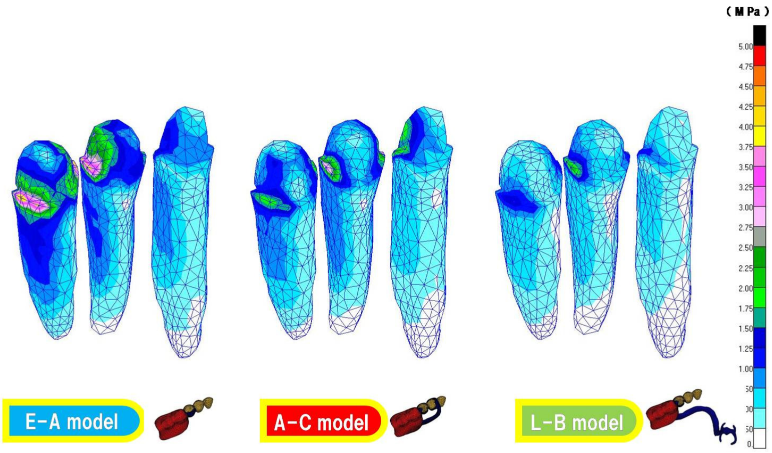


Fig 7.Abutment

2)Alveolar bone

Fig. 8 shows the stress distribution of the alveolar bone from the distal-lingual direction. Stress concentration was found around the margin of the alveolar socket especially in the distal side of the canine and mesial side of the first premolar. The E-A model demonstrated the highest stress concentration, followed by A-C and L-B models, suggesting the same trend as the stress concentration on abutments.

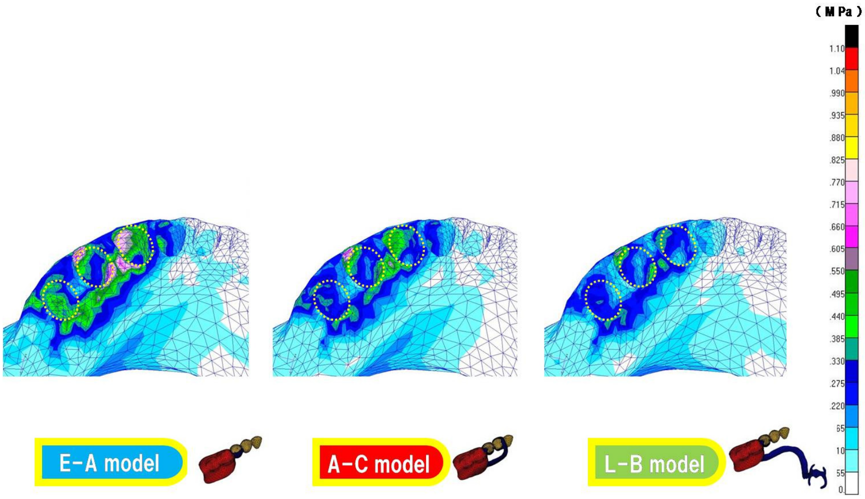


Fig 8. Alveolar bone

2.Displacement

1)Vertical displacement of dentures

Fig. 9 shows the vertical displacement of the posterior margin of the denture. The most posterior abutment was used as a reference. Measuring points were the posterior margin of the denture and the cusp tip of the most posterior abutment. The largest vertical displacement was observed in the A-C model. The E-A model showed a smaller vertical displacement than the bilateral L-B model.

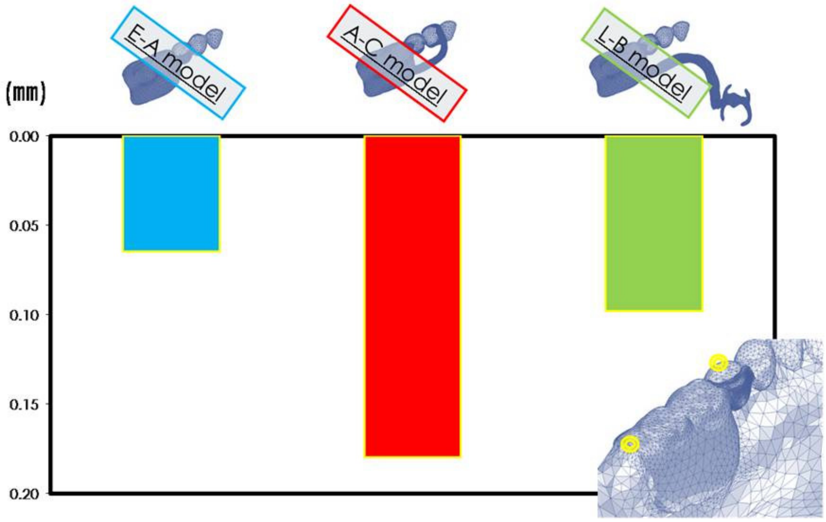


Fig. 9. Vertical displacement of dentures

2)Distal displacement of abutments

Fig. 10 shows the distal displacement of abutments. Measuring point was a cusp tip of the most posterior abutment. The E-A model showed the largest distal displacement of an abutment although the displacement amount was much smaller compared to the vertical displacement. The L-B model showed the smallest distal displacement.

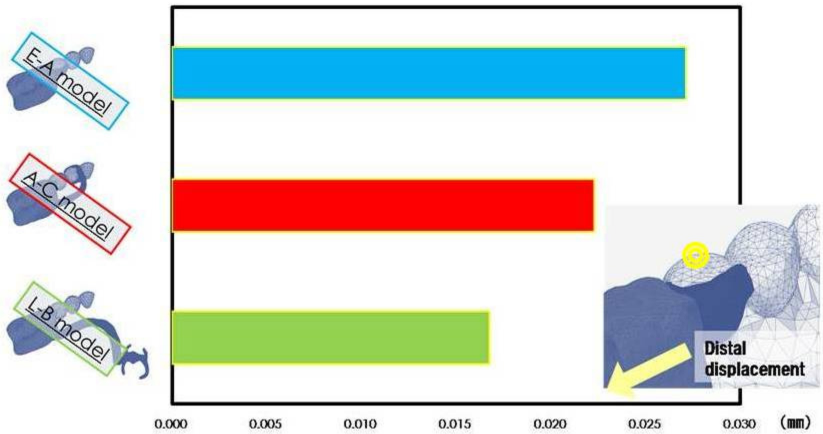


Fig. 10. Distal displacement of abutments

Disucussion

1.Analysis model

Clasps were fabricated with a scanning resin, and incorporated into the ready-made FEM model. This construction method allows simulation of various denture designs.

Three abutments adjacent to the edentulous space were rigidly splinted interconnected in all three models to compare the mechanical properties depending on the denture design. However, rigidly splinting fixed abutments for partial denture supporting abutments is not a common treatment methods. Further research is required to establish clinical evidence.

2.Analysis results

The E-A model showed the larger stress distribution on abutments and the alveolar bone compared to the other two models, but showed the smallest vertical displacement. Rigid designs including slit in the attachment, lingual bracing arm and interlocking attachments reinforce the denture. Although this model has the most pleasing aesthetics, the design resulting in large stresses being placed on the remaining tissues. Careful assessment and diagnosis are required prior to selection of this design.
The unilateral A-C model is thought to mitigate the patients' discomfort of patients compare to bilateral partial denture designs. However, the unilateral A-C model demonstrated the largest vertical displacement, suggesting possibility of a poorer prognosis.
The bilateral L-B model showed a smaller stress distribution on abutments and the alveolar bone compared to the other two models, and an identical vertical displacement as the E-A model. Considering the small stress distribution on abutments and the alveolar bone and vertical displacement, the L-B model is considered to be the design that provides the most ideal results and possible clinical outcome.

Conclusion

Mechanical analysis was performed in three denture designs for the lower left first and second molars loss case, and the following conclusions were drawn.

1. Mechanical properties were different depending on the denture design. It is considered important to design the denture considering patients' request and periodontal tissue condition.
2. The A-C model demonstrated a larger vertical displacement compare to the E-A model.
3. The L-B model demonstrated a smaller stress on the periodontal tissue compare to the E-A model. This model also showed a small vertical displacement and small abutment displacement, suggesting that the L-B model is the most efficient design.
4. The E-A model demonstrated a small vertical displacement, but a larger stress on the periodontal tissue and abutment displacement compare to the other two models, suggesting that this design is the most rigid among 3 designs.

References

1. Ando A., Nakamura Y., Kanbara R. and et al: The Effect of Abutment Tooth Connection with Extracoronal Attachment using the Three Dimensional Finite Element Method- Part 2 The Construction of Finite Element Model from CT Data- . JJ Mag Dent 18:2009
2. Tanaka Y.: Dental Magnetic Attachment, Q&A, Ishiyaku Publishiers, Inc(Tokyo),1995
3. Nakamura K., Hiroshi M., Fukuzawa N. and et al: Influence of Heat Treatments on Attractive Force of Magnetic Attachments.J J Mag Dent.6:63-70,1997.

Theoretical study of MRI artifacts by dental alloys

H. Samejima,[1] Y. Tegawa,[2] Y. Kinouchi,[3] and M. Akutagawa[3]

[1] Graduate School of Advanced Technology and Science, The University of Tokushima,
[2] Institute of Health Sciences, Graduate School, The University of Tokushima,
[3] Institute of Technology and Science, Graduate School, The University of Tokushima

Introduction

The metal artifact of MRI by dental alloys becomes the problem in the clinical site. Therefore, it is important to discuss effects of them.

Objective

Objective of this study is to propose a theoreticaly method to calculate the metal artifact of MRI by dental alloys.

Methods

In this study, a magnetic dipole is uses as an approximate model of dental alloys.
In addition to the simulation of MRI that uses approximate models substitution for the finite element method (FEM).
The FEM is used widely to calculate the magnetic field surrounding magnetic materials. Although the results by the FEM fit the practical conditions, it is necessary to include the amount of time for preparation and calculation.
In contrast, The simulation is simple and easy to understand. Moreover it does not take much time.

Materials

A small amount of magnetic material in the magnetic field, such as a magnetic keeper in the MRI equipment, can be assumed to be a magnetic dipole[1].
This analysis is only on the z-axis for the understanding of the phenomenon.
The keeper's position is the starting point (z=0).
A magnetic field becomes strong by a gradient magnetic field if z is larger than z=0, and it becomes weak if z is smaller than z=0.

Figure 1 shows the parameter of the simulation.

Keeper	Material	Soft magnetic stainless steel
	Saturation magnetic flux density	1.6T
	Height	1mm
	Diameter	4mm
MRI	Static magnetic field strength	1.5T
	Gradient magnetic field strength	30mT/m
	Analytical domain	z(-100mm～100mm)

Fig. 1 Parameter of the simulation

The magnetic flux density on the z axis by MRI is expressed as

$$B(z) = B_0 + \Delta B_z z + B_{dp}(z) \qquad (1)$$

where B_z is the magnetic flux density on the z, B_0 is static magnetic field(T) ,
ΔB_z is gradient magnetic field(T/m) , B_{dp} is magnetic dipole(T)
The distortion of the image is caused by $B_{dp}(z)$.

$B_{dp}(z)$ on z axis is expressed as

$$B_{dp}(z) = \frac{VB_0}{2\pi|z|^3} \qquad (2)$$

where V is keeper's volume(m^3)

The MRI recognizes position information by the magnetic flux density.
Relations of magnetic flux density for position recognition of the MRI and magnetic flux density in a certain position z is expressed as

$$B_0 + \Delta B_z z' = B_0 + \Delta B_z z + B_{dp}(z) \qquad (3)$$

where z' is the z position in the MRI image.

Result

Relations of z that before and after an image reconfiguration as

$$z' = z + \frac{V B_0}{2\pi |z|^3 \Delta B_z} \tag{4}$$

This is solved (3) about z'

Figure 3 is drawn by using (4)

Figure 3(a) shows an example of the geometric distortion.

For example the signals of the MRI from -18mm is done an image reconfiguration of in the location of the 20mm of a image.

Figure 3(b) shows the sample of the intensity distortion.

The signals of the MRI from the volume of dz' is regarded as the signal from the volume of dz on MRI. In other words, Signal strength changes that because volumes are different; therefore ,It can express the signal strength in z' by dz'/dz.

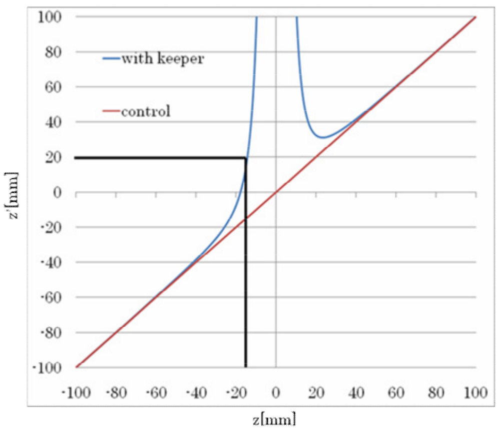


Fig. 3(a) Geometric distortion

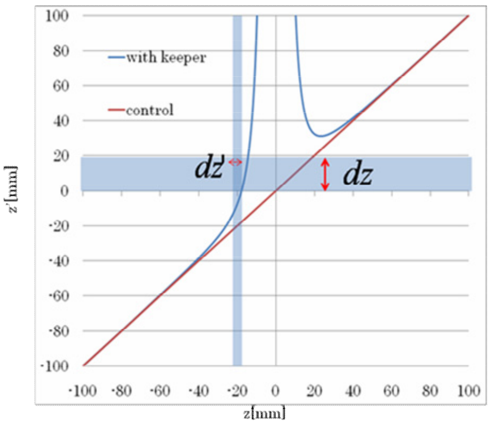


Fig. 3(b) Intensity distortion

Figure 4 shows the NMR signal strength on a z ' axis.

Figure 4 is that differentiated (4) with respect to z .

Since the uniform domain is assumed, the signal strength must be 1 in every position, but it is small around the keeper.

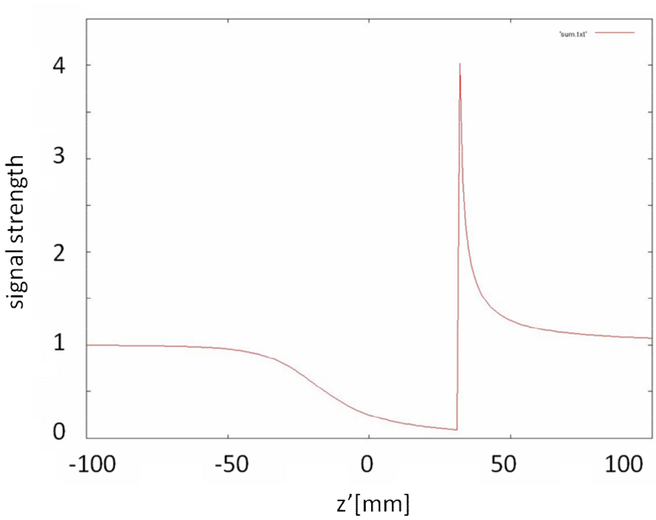


Fig.4 signal strength on a z ' axis.

Conclusion

The MRI artifact by dental alloys contains geometric and intensity distortion.

Intensity distortion causes a decrease and an increase in the signal strength of NMR.

Geometric distortion is an error of the position information of the signal.

The result of this study shows a tendency similar to that in other clinical studies[2] and confirm that this study method is useful.

This study is only for the z-axis , but it is necessary to do research in the three dimensions as a future problem.

References

[1]Takeyama Setsuzan: Electric magnetic phenomenon theory
pp.271-277, pp.301-304

[2]Iimuro T. Florentina:
Magnetic Resonance Imaging Artifacts and the Magnetic Attachment System.
Dental Materials Journal 13(1) pp.76-88, 126 19940625

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Conclusion
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2. Book (example): R. Kunin, On Exchanging Resins, pp 88, Robert E. Kreiger Publishing Company, New York, 1972.