日磁歯誌
J J Mag Dent
ISSN 0918-9629

日本磁気歯科学会雑誌 第二十九巻 第二号 J J Mag Dent

2020 Volume 29. Number 2

JSMAD

# 日本磁気歯科学会雑誌

# The Journal of the Japanese Society of Magnetic Applications in Dentistry

Volume 29, Number 2

The Japanese Society of Magnetic Applications in Dentistry

日本磁気歯科学会

日本磁気歯科学会 20

# The Journal of the Japanese Society of Magnetic Applications in Dentistry

Volume 29, Number 2

*Proceedings of the 19th International Conference on Magnetic Applications in Dentistry*

The Japanese Society of Magnetic Applications in Dentistry

# The 19th International Conference on Magnetic Applications in Dentistry

The 19th International Conference on The Japanese Society of Magnetic Applications in Dentistry organized by JSMAD was held on the Internet as follows;

**Meeting Dates:**

Friday, February 28 to Tuesday, March 17, 2020

**Location:**

JSMAD web site

http://jsmad.jp/international/19/

**General Chair:**

Prof. Shin-ichi Masumi, Kyushu Dental University

**Subjects:**

Researches and developments related to dentistry and magnetism such as:

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

## Conference Committee

**The Japanese Society of Magnetic applications in Dentistry**

**President of the Japanese Society of Magnetic applications in Dentistry**

Dr. Chikahiro Ohkubo, Tsurumi University

**Vice-President of the Japanese Society of Magnetic applications in Dentistry**

Dr. Yukyo Takada, Tohoku University

### Conference Secretary

Dr. Yasunori Suzuki. Tsurumi University

### Conference Organizing Committee

Dr. Hideki Aita, Health Science University of Hokkaido
Dr. Tetsuo Ohyama, Nihon University
Dr. Shunsuke Minakuchi, Tokyo Medical and Dental Universit
Dr. Masatake Akutagawa, The University of Tokushima
Dr. Kazuo Nakamura, Sanno Hospital
Dr. Tetsuo Ichikawa, The University of Tokushima
Dr. Kazuhiro Nagata, The Nippon Dental University
Dr. Tohru Kurabayashi, Tokyo Medical and Dental University
Dr. Masayuki Hideshima, Tokyo Medical and Dental University
Dr. Hisashi Koshino, Health Science University of Hokkaido
Dr. Yuji Homada, Homada Shika Daiichi Shinryoujo
Dr. Shuji Ohkawa, Meikai University
Dr. Masato Makita, Keitendo Dental Office
Dr. Jun Takebe, Aichi-Gakuin University
Dr. Eri Makihara, Kyusyu Dental University
Dr. Joji Tanaka, Tanaka Dental Clinic
Dr. Tatsuhiko Masuda, Aichi-Gakuin University
Dr. Naoki Tsukimura, Nihon University
Dr. Shinichi Masumi, Kyusyu Dental University
Dr. Fujio Tsuchida, Mami's Dental Office
Dr. Motonobu Miyao, Asahi University

### Conference Arrangements Committee

Dr. Masatake Akutagawa, The University of Tokushima
Dr. Tetsuo Ohyama, Nihon University
Dr. Hisashi Koshino, Health Science University of Hokkaido
Dr. Yuji Homada, Homada Shika Daiichi Shinryoujo
Dr. Eri Makihara, Kyusyu Dental University
Dr. Juro Wadachi, Tokyo Medical and Dental University

**Proceeding Committee**



Published by the Japanese Society of Magnetic applications in Dentistry

c/o Division of Dental Biomaterials,
Tohoku University Graduate School of Dentistry
4-1, Seiryo-machi, Aoba-ku, Sendai 980-8575 JAPAN



B&W: Kisatu α print Co.,Ltd
3Jyo16-1-45, Hiragishi, Toyohira-ku, Sapporo, Hokkaido 062-0933 JAPAN

# The 20th International Conference on Magnetic Applications in Dentistry General Information

## General Information

The Japanese Society of Magnetic Applications in Dentistry (President: Chikahiro Okubo, Tsurumi University) is a scientific association founded in 1991 and is devoted to furthering the application of magnetism in dentistry. The 20th International Conference on Magnetic Applications in Dentistry organized by JSMAD will take place on the Internet as follows.

**Meeting Dates:**
Friday, February 26 to Tuesday, March 16, 2021

**Location:**
JSMAD web site:
http://jsmad.jp/international/20/

**General Chair:**
Prof. Jun Takebe, Aichi-Gakuin University

**Executive Committee Chair:**
Hirokazu Kumano, Aichi-Gakuin University

**Subjects:**
Researches and developments related to dentistry and magnetism such as:

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

## Registration Information

**Registration:**
Send e-mail titled "registration for 20th international conference" with your Name, University or Institution, Postal address, Phone, Fax and E-mail address to conference secretariat.

**Registration Fees:**
No registration fees. Anyone who is interested in magnetic applications in dentistry can participate in the conference via the Internet.

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

## Guidelines for Presentation

**Deadlines:**
Entry: January 25, 2021
Poster submission: February 12, 2021

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

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

**Discussion:**
Discussions will be done using a bulletin board on JSMAD Web Site via the Internet. The authors should check the board frequently during the meeting dates. If questions or comments on your presentation are posted, please answer them as soon as possible.

**Notice to Contributors:**
Freely-given informed consent from the subjects or patients must be obtained. Waivers must be obtained for photographs showing persons.

**Note:**
Copyright of all posters published on the conference will be property of the Japanese Society of Magnetic Applications in Dentistry. Copies of the posters will be made and transferred to JSMAD web site for continuous presentation after the meeting dates.
For further information,
send e-mail to conference secretariat.

## Conference Secretariat

Hirokazu Kumano, Aichi-Gakuin University
E-mail: jsmad30@dpc.agu.ac.jp
Tel: +81-52-759-2152

Visit JSMAD Home Page for updates!
http://jsmad.jp/

# Contents

# Attractive force of magnets and magnetic fields Strength and range of impact by the attractive force of magnets

H. Yamaguchi[1,2], M. Takahashi[2], G. Togawa[2], and Y. Takada[2]

[1]Division of Advanced Prosthetic Dentistry, Tohoku University Graduate School of Dentistry

[2]Division of Dental Biomaterials, Tohoku University Graduate School of Dentistry

**Abstract**

Most of the dental magnetic attachments used in Japan utilize a closed magnetic circuit. They show very good retentive force for their small size. However, some magnetic attachments used in other countries utilize an open magnetic circuit. In this study, we investigated the attractive force of magnets and the range of impact exhibited by the magnetic fields. Cylindrical neodymium and ferrite magnets were set up in various combinations. The keeper was made of SUS XM27 stainless steel. Attractive force was measured using a measuring device that matched ISO 13017. The pattern of magnetic fields formed was observed using iron powder. In combinations that involved one type of magnet, the attractive force and range of impact by the magnetic fields increased as the number of magnets increases possibly due to a decrease in demagnetizing fields. Combinations that involved different kinds of magnets; the magnet in contact with the keeper had the greatest influence on attractive force. The range of impact by magnetic fields did not change remarkably with the combination of magnets made of different materials. It is possible to control the range of magnetic fields without altering the attractive force by combining different kinds of magnets.

## Introduction

Most dental magnetic attachments used in Japan utilize a closed magnetic circuit[1)]. Such attachments show excellent attractive force because the magnetic flux density is enhanced within the yoke. On the other hand, other countries use some magnetic attachments that utilize an open magnetic circuit, such as that of a basic magnet[2)]. The attractive force generated in open magnetic circuit attachments is weak compared with that of closed magnetic attachments. Open magnetic circuit attachments are still used in some countries and may have some advantages.

## Objective

The aim of this study was to investigate the influence that combining similar and different types of magnets has on attractive force and the extent of magnetic fields.

## Materials and Methods

Cylindrical neodymium magnets (4 mm in diameter and 2 mm in height, Trusco) and ferrite magnets (5 mm in diameter and 3 mm in height, Trusco) were used in this study. Multiple magnets made of two different materials (neodymium and ferrite) were combined and arranged in various fashions, as shown in Fig. 1. Each magnet was fixed using a cyanoacrylate adhesive. The keeper (4 mm in diameter and 12 mm in length), made of SUS XM27 stainless steel, was used in all setups. The attractive force between the magnets and the keeper was measured using a measuring device at a crosshead speed of 2 mm/min. The measuring device used in this study matched ISO 13017 specifications[3,4)] and was connected to a digital force gauge (ZPS, Imada). A typical curve of the attractive force generated is shown in Fig. 2. The attractive force of magnets [C, Fig. 2] is acquired by subtracting the weight of the mobile part of the measuring device and the friction during movement [B, Fig. 2] from the peak of the curve [A], which is the value of the magnetic attachment's attractive force, the weight of the magnet and the movable part of the measuring device, as well as the friction during movement. Point A [Fig. 2] signifies the time scenario when the magnet is in contact with the keeper just before separation begins.

C＝A–B (A: initial separation point value; B: weight of the device and friction; C: attractive force)
The range of influence of magnetic fields that resulted in an attractive force between the keeper and the magnet was derived from the attractive force curve and is represented as $S_0$ [Fig. 2]. Additionally, the patterns formed by iron powder around the magnets were observed.

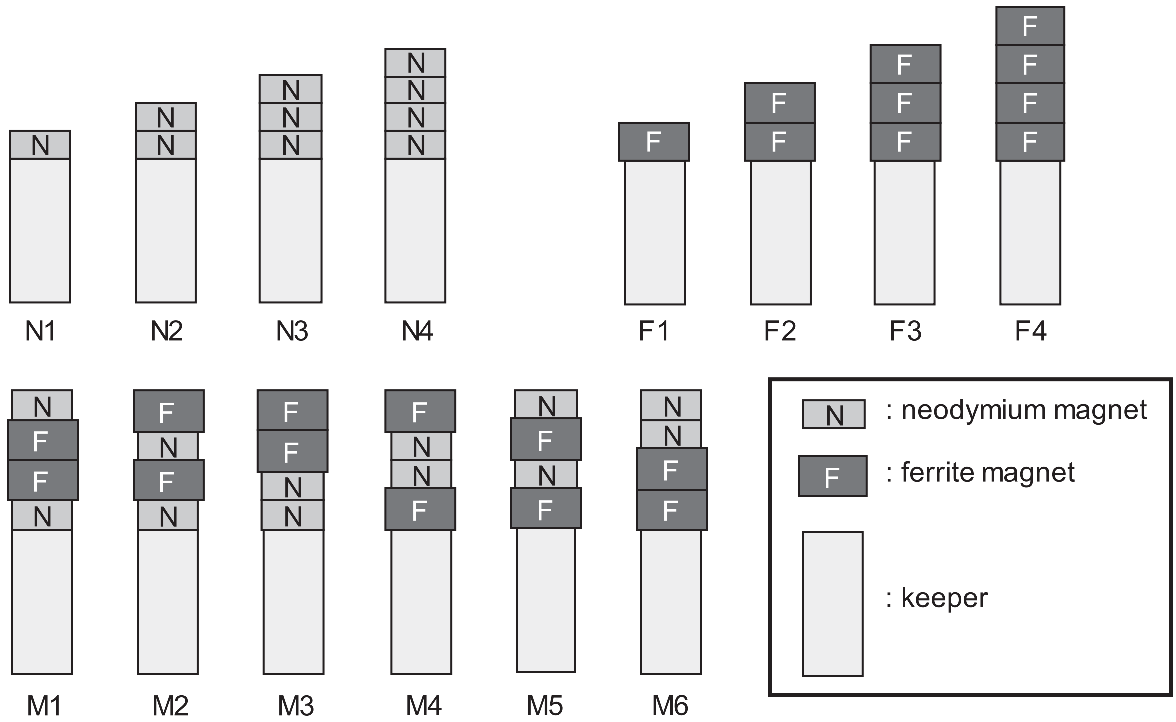



Fig. 1 Combination of magnets

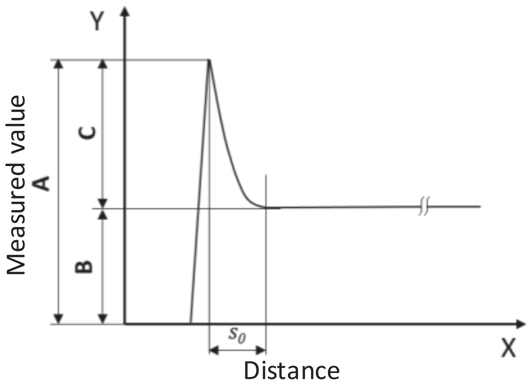



Fig. 2 Attractive force curve

## Results

The measured attractive force generated by multiple neodymium magnets and the range of impact of the attractive force is shown in Fig. 3, whereas that of ferrite magnets is shown in Fig. 4. The attractive force value and range of impact by attractive force increased with an increased number of magnets. The dependency relationship was not linear, and the increase diminished with an increased number of magnets.

The attractive forces of neodymium and ferrite magnets combined in different arrangements and the range of impact by the attractive forces are shown in Figs. 5 and 6. When a neodymium magnet was in direct contact with the keeper (conditions M1–3), the attractive forces ranged between 3.5 and 4.0 N. The order in a descending manner was M3, M2, and M1. The range of impact of the attractive force was approximately 6–10 mm with no significant difference across different setup conditions.

When a ferrite magnet is in contact with the keeper (conditions M4–6), the attractive forces measured were 0.5–0.7 N. The highest was M6, followed by M5 and M4, in descending order. The extent of their magnetic fields was approximately 6–7 mm with no significant difference across various setup conditions.

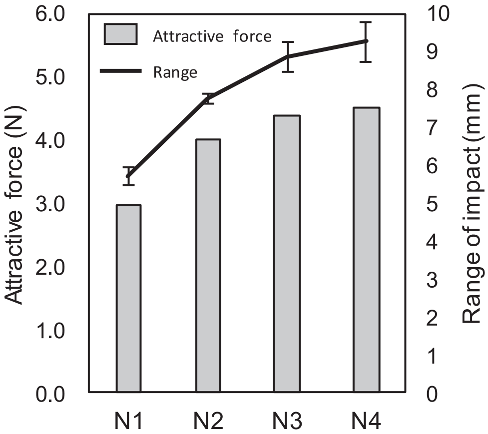



Fig. 3 Attractive force values and range of impact by the magnetic fields of multiple neodymium magnets

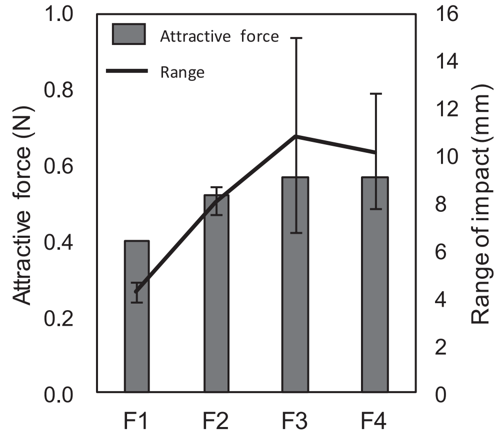



Fig. 4 Attractive force values and range of impact by the magnetic fields of multiple ferrite magnets

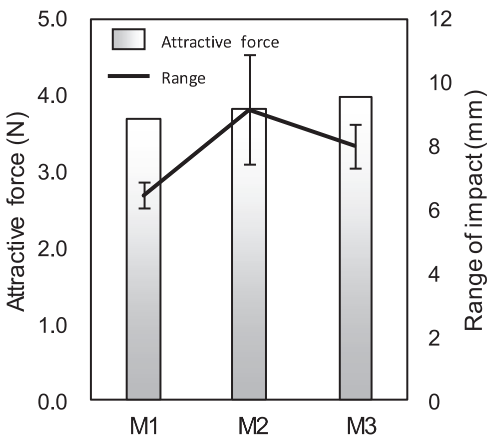



Fig. 5 Attractive force and range of impact of combined neodymium and ferrite magnets (neodymium magnet is in contact with the keeper)

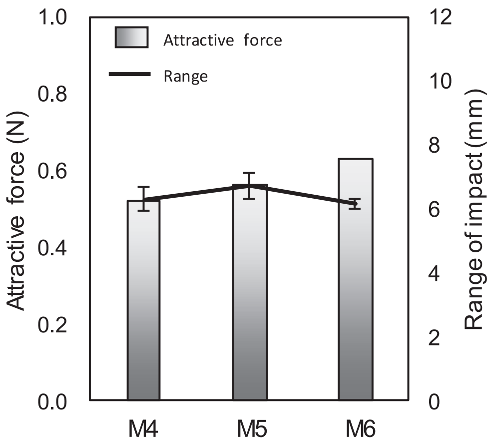



Fig. 6 Attractive force and range of impact of combined neodymium and ferrite magnets (ferrite magnet is in contact with the keeper)

## Discussion

### 1. Multiple magnets of similar types

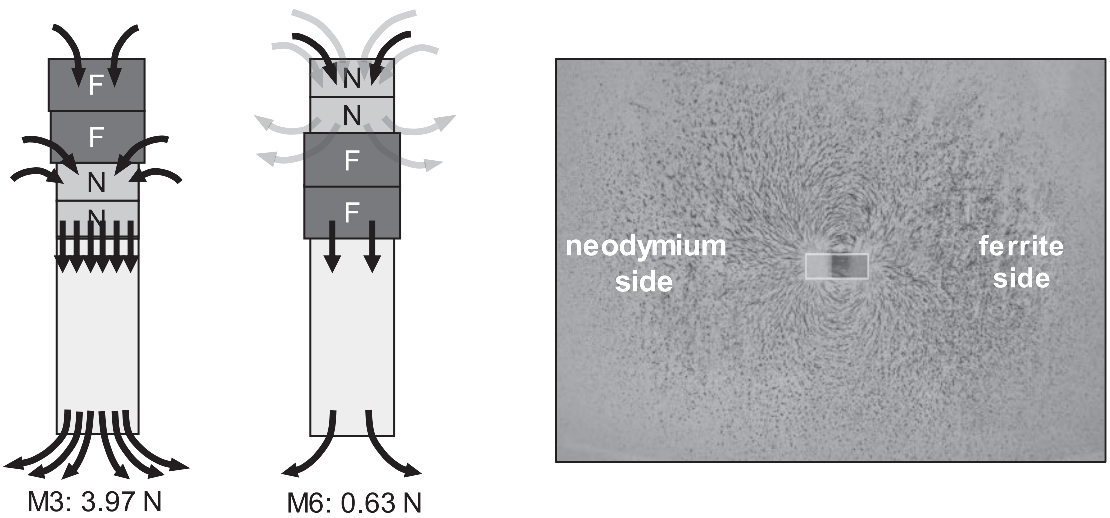
The demagnetizing field is the magnetic field generated by the magnetization in a magnet[1)]. The term *demagnetizing field* reflects its tendency to act on the magnetization so as to reduce the internal magnetic field, otherwise known as the attractive force. The demagnetizing field of a magnet is inversely proportional to the square of the distance between the magnetic poles. The distance between the magnetic poles increases as the number of magnets increases. An increase in the distance between magnetic poles causes a significant change (decrease) in the demagnetizing field. Consequently, the attractive force and the extent or range of the impact of the attractive force increased because the demagnetizing field decreased with an increased number of combined magnets. Since the demagnetizing field becomes negligibly small when the distance between the magnetic poles is very large, the attractive force stagnates at a certain value.

## 2. Combinations of different types of magnets

When different types of magnets were combined and the magnet in contact with the keeper was neodymium, the attractive force increased as the number of ferrite magnets between the neodymium magnets was reduced. The attractive force of a setup involving different types of magnets with a consecutive pair of neodymium magnets in contact with the keeper (M3) was equal to the attractive force of two (similar) neodymium magnets (N2). A setup that involves ferrite magnets sandwiched between a pair of neodymium magnets attenuates the attractive force. The range of impact of the attractive force measured in setups M1–3 also was equal to that of N2.

When the magnet in contact with the keeper was ferrite (M4–6), it was expected that neodymium magnets would enhance the attractive force of ferrite magnets. However, the obtained results differed from the expectation. The amount of magnetic flux that can pass through a ferrite magnet is much less than that of a neodymium magnet. A ferrite magnet placed adjacent to the keeper would, therefore, interfere with the flow of magnetic flux from a neodymium magnet to the keeper. The attractive force of mixed types of magnets whereby two consecutive ferrite magnets were in contact with the keeper (M6) was relatively higher than that of neodymium sandwiched between ferrite or one ferrite magnet adjacent to keeper M4–5. Possibly, a part of the magnetic flux from the neodymium magnet leaked around the sides of the cylindrical keeper. Although the attractive force of M4–6 was equal to or higher than that of F2–4, the range of impact by the attractive force for M4–6 setup was smaller than that of F2–4. It is desirable that magnets for intraoral applications have a small range of magnetic field impact[1]. This study demonstrated that it is possible to control the extent of magnetic fields without changing the attractive force through combinations of different kinds of magnets.

Setups denoted as M3 and M6 consist of two consecutive neodymium and ferrite magnets. Excluding the keeper, M3 is the reverse setup of M6, whereas M2 is the reverse of M5. However, the attractive force when neodymium contacts the keeper (M2 or M3) was higher than that of ferrite in contact with the keeper (M5 or M6). Even if the magnetic composition was the same, the force of the magnet structure changed based on which side is in contact with the keeper. This is because the amount of the magnetic flux that can pass through ferrite and neodymium materials differs, as shown in Fig. 7. From these results, we may be able to develop a magnetic application in which the attractive force differs depending on the contact side.




Influence of the magnetic pole in contact with the keeper on the attractive force value

Pattern of magnetic fields (M3, M6)

Fig. 7 Features of combined magnets of different types

## Conclusion

Similar or different types of magnets combined in various fashions showed unique features with regard to the strength of the attractive force value and the range of impact. This study suggests that the attractive force value and range of impact of magnetic fields can be controlled through the combination of different kinds of magnets.

## Acknowledgments

The authors are pleased to acknowledge the assistance of Dr. Mary Wambui KANYI in proofreading and editing the English version.

## References

1. Y. Tanaka, New dental magnetic attachment, pp 2-90, Ishiyaku Publishers, Inc, Tokyo, 2016.
2. Y. Takada, M. Takahashi, Y. Kikuchi, Y. Nakamura, Y. Tanaka, H. Sato, A. Izumida, and T. Tenkumo: Materials and internal structures of foreign-mad dental magnetic attachments, J J Mag Dent, 22(1), 96–102, 2013.
3. ISO 13017:2012. Dentistry—Magnetic attachments.
4. ISO 13017:2012/Amd.1:2015 Dentistry — Magnetic attachments.

# Influences of magnetic attachment for implants on MRI scans

Maruo R, Imaizumi N, Muto R, Suzuki Y, Ohkubo C
Department of Removable Prosthodontics, Tsurumi University School of Dental Medicine

**Abstract**

【Introduction】

In recent years, due to advances in medical technology, MRI has been frequently used. It has been considered that metal artifacts during MRI scanning affect diagnoses. At this time, the influences of magnetic attachments for implants on MRI are discussed.

【Materials and Methods】

Magnetic attachments for implants (Magfit MIP, Magfit IP), cast keepers, and healing abutments were used as samples. Each sample was placed in an acrylic container (150 mm x 150 mm x 150 mm) and filled with an aqueous solution of nickel nitrate using an acrylic jig. Four types of imaging methods were used: spin echo, F spin echo, STIR, and gradient echo. The images obtained were adjusted with ImageJ (NIH), and the area of the artifact was compared.

【Results, Discussion】

The magnetic attachments for implants showed obvious artifacts with all imaging methods, but the artifacts in the healing abutments were small. The gradient-echo method produced the largest artifact among the different imaging methods. The size of the artifact of Magfit IP was larger than that of Magfit MIP. The diameters of the artifact were about 15 to 20 mm for Magfit IP and approximately 15 mm for Magfit MIP.

## Introduction

In recent years, due to advances in medical technology, MRI has been used frequently. It has been considered that metal artifacts during MRI scanning affect diagnoses. At this time, the influences of magnetic attachments for implants on MRI are discussed.

## Materials and Methods

| Name | Manufacturer | Size | Suction power | Abbreviation |
|---|---|---|---|---|
| Magfit IP (flat) IDF30 | AICHI STEEL | Φ4.7mm × 3.0mm | 750gf | IFD |
| Magfit IP (dome) IDD30 | AICHI STEEL | Φ4.7mm × 3.2mm | 600gf | IDD |
| Magfit MIP (flat) | AICHI STEEL | Φ3.7mm × 3.1mm | 400gf | MIP-F |
| Magfit MIP (dome) | AICHI STEEL | Φ3.7mm × 3.3mm | 350gf | MIP-D |
| Hyper slim (for casting) | NEOMAX | Φ4.8mm × 0.8mm | 980gf | Cast |
| RN healing cap | Straumann | Φ5.5mm × 3.0mm | — | Heal |

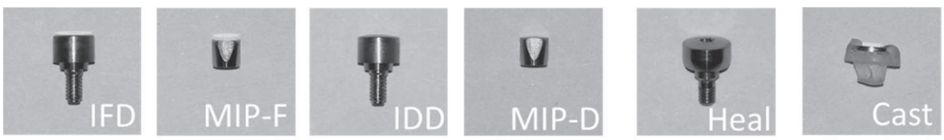
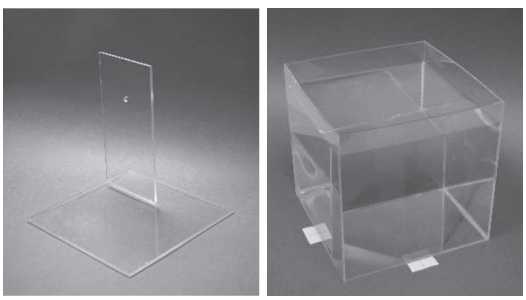



Fig.1 Sample details

Magnetic attachments for implants (Magfit MIP, Magfit IP), keepers for casting, and healing abutments were used as samples (Fig.1).



Each sample was placed in an acrylic container (150 mm x 150 mm x 150 mm) filled with an aqueous solution of nickel nitrate. An acrylic jig was used to position the sample in the center of the container. The direction of the sample was the same as that in an actual clinical situation (Fig.2).

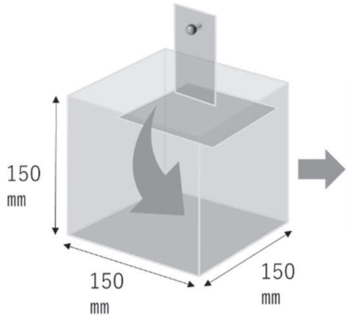



Fig.2 Acrylic container and jig

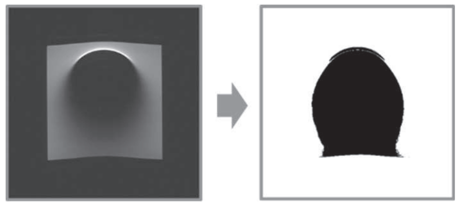


Fig.3 Image processing

The obtained images were compared visually. The images were adjusted with ImageJ (NIH), and the area of the artifact was compared (Fig.3).

Table 1 Details of imaging methods

| | SE | | | GE |
|---|---|---|---|---|
| | T1 | T2 | STIR | |
| FOV | 240 mm | 240 mm | 240 mm | 240 mm |
| Thickness | 5.0 mm | 5.0 mm | 5.0 mm | 5.0 mm |
| TR | 500 msec | 4900 msec | 4000 msec | 400 msec |
| TE | 10.7 msec | 120.0 msec | 20.0 msec | 14.0 msec |
| matrix | 256 × 192 | 256 × 224 | 288 × 256 | 256 × 192 |
| NSA | 2 | 3 | 2 | 3 |

Four types of imaging methods were used: spin echo (SE) (T1-weighted image (T1), T2-weighted image (T2), STIR) and gradient echo (GE) (Table 1).

## Results, Discussion

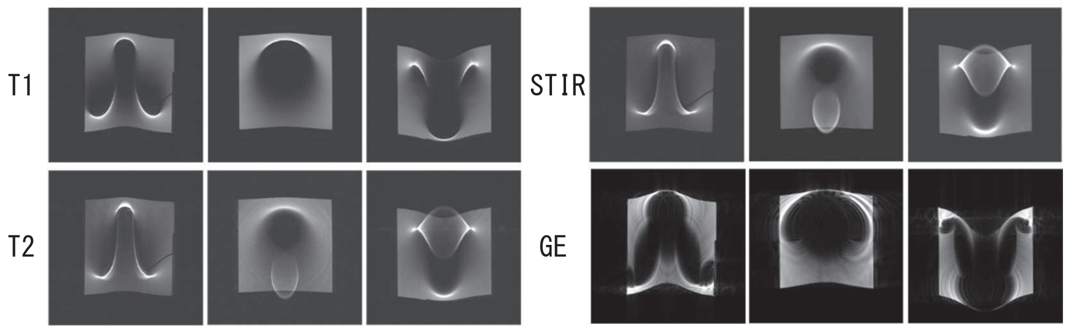



Fig.4 Imaging results (IDD)

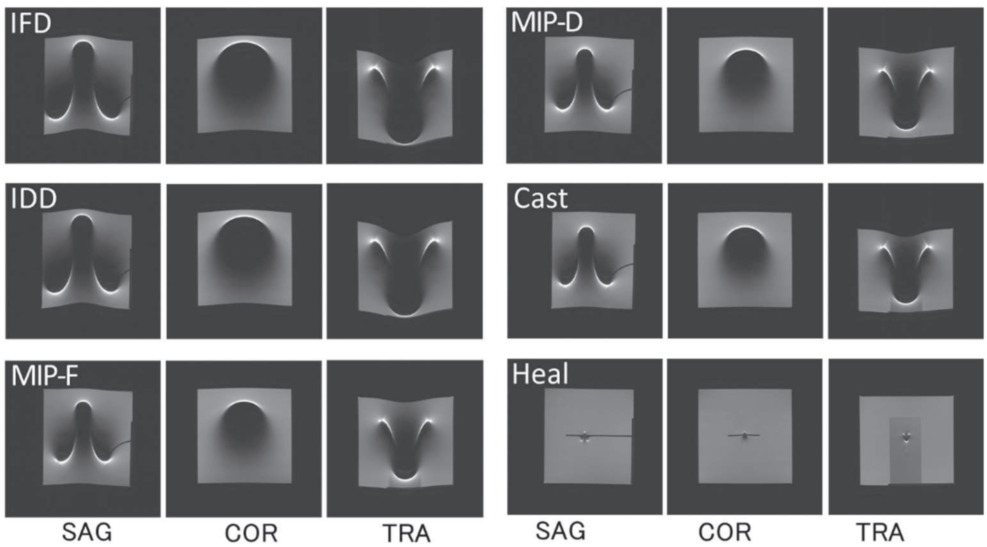



Fig.5 Imaging results of each sample (T1)

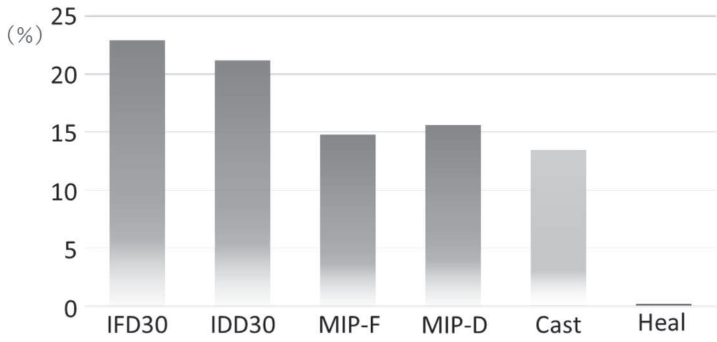



Fig.6 Artifact area (area ratio)

The magnetic attachments for implants showed obvious artifacts with all imaging methods, but the artifacts in the healing abutments were small. The gradient-echo method produced the largest artifact among the different imaging methods. The size of the artifact of Magfit IP was larger than that of Magfit MIP. The diameters of the artifact were about 15 to 20 mm for Magfit IP and approximately 15 mm for Magfit MIP.

In this study, the volume of samples greatly affected the size of the artifact as compared to the diameter of the keeper and the strength of the attachment. Therefore, replacement of the keeper on the implant to the healing abutment during MRI scan would be necessary.

# Effect of the keeper on attractive force after MRI irradiation

S.Masumi,[1] E.Makihara,[1] H.Ikeda,[2] H.Shimizu,[2] M.Oda,[3]
Y.Morimoto,[3] T.Watanabe,[1] S.Tsuda,[1]
M.Yagi,[1] M.Arita,[1] T.Masumi,[1] and A.Kikuchi[4]

1. Division of Occlusion & Maxillofacial Reconstruction, Department of Oral Function, Kyushu Dental University
2. Division of Biomaterials, Department of Oral Functions, Kyushu Dental University
3. Division of Oral and Maxillofacial Radiology, Department of Science of Physical Function, Kyushu Dental University
4. NEOMAX Engineering

---

## Abstract

The purpose of this study was to evaluate the attractive force of the dental magnetic attachment against the keeper before and after MRI irradiation.

The lower non-magnetic table of the ISO tensile test jig was duplicated with an immediate polymerization resin, the magnetic assembly was then attached to the upper non-magnetic table of the jig, and each keeper was attached to the lower duplicated resin table. The attractive force before irradiation was measured with a universal tensile tester. Next, a table made of resin with a keeper was placed in a mold that assumed the upper and lower incisors, premolars, and molars; and the attractive force was measured after MRI irradiation for about 16 minutes.

There was no significant difference in the attractive force before and after irradiation, and no problems were found with the attractive force even if MRI irradiation was performed on the patient with the keeper.

---

## Introduction

There have been some reports that patients with dental magnetic attachments have decreased attractive force after MRI irradiation. In this study, MRI was irradiated to a commercially available magnet keeper, and verification was performed by measuring the attractive force of the dental magnetic attachment to the keeper before and after irradiation.

## Materials and Methods

1. Duplication of the lower non-magnetic table

Prior to the experiment, 6 ISO tensile test jigs of the lower non-magnetic table were duplicated with an immediate polymerization resin (Ortho Crystal, Nissin), the magnetic assembly (Hyper Slim 4813 magnet structure, NEOMAX) was placed on the upper non-magnetic table (Fig.1), and the duplicated lower non-magnetic table was mounted. A keeper (DB keeper 4813, NEOMAX) was adhered to the lower non-magnetic table (Fig.2).

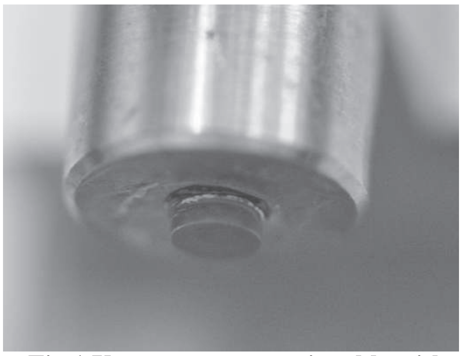


**Fig.1 Upper non-magnetic table with magnetic assembly**


**Fig.2 Duplicated lower non-magnetic tables with keeper**
**UA: upper anterior; UP: upper premolar**
**UM: upper molar; LA: lower anterior**
**LP: lower premolar; LM: lower molar**

2. Tensile test

An ISO tensile test jig was attached to a universal tensile tester (Autograph AGS-H, Shimadzu Corp.), and the attractive force before irradiation was measured at a crosshead speed of 5 mm/min (Fig.3).

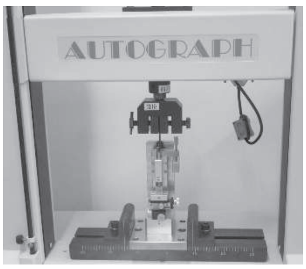



**Fig.3 Universal tensile tester with ISO tensile test jig**

3. Fabrication of a mold for MR imaging

Next, an acrylic mold that assumed six upper and lower anterior teeth, premolars, and molars was fabricated (Fig.4). The positions of the upper and lower central incisors, first premolars, and second molars were determined with reference to the report by Takigami et al.[1] The distance from the occiput to the distal end of the second molar was calculated from MR images stored at the Department of Dental Radiology, Kyushu Dental University Hospital.

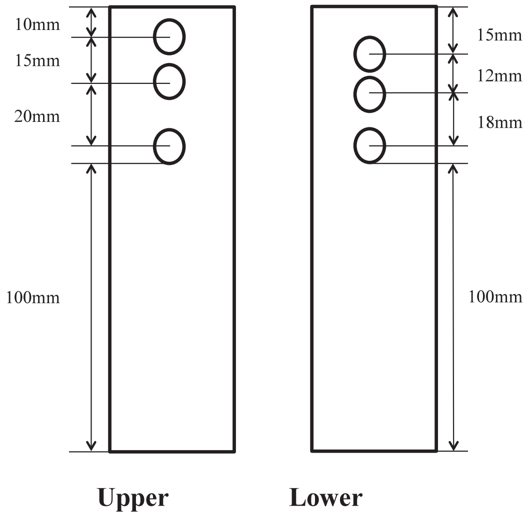



**Fig.4 Fabricated mold for MR imaging**

After fixing the upper and lower molds on the acrylic plate, a socket was provided to fix each lower non-magnetic table using silicone putty. The distance between the upper and lower mold was 40 mm (Figs.5,6).

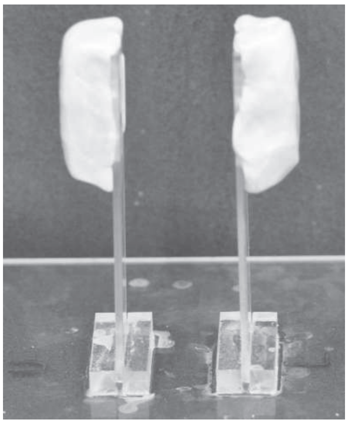


**Fig.5 Upper and lower molds fixed on the acrylic plate**

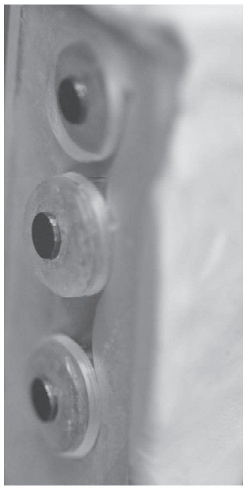


**Fig.6 Lower non-magnetic tables set into the sockets**

4. MR imaging

The mold with a lower non-magnetic table with a keeper was installed in the MRI gantry (1.5-T, full-body, MR system (EXCELART Vantage$^{TM}$ Powered by Atlas; Toshiba, Tokyo, Japan)). It was irradiated for about 16 minutes to display an image of the head and neck tumor. The attractive force of the keeper after irradiation was measured using the same method as before irradiation, and the attractive forces before and after irradiation were compared and examined.

## Results

Table 1 shows the results of evaluating the attractive force of the magnetic attachment before and after MRI irradiation on the keeper.

**Table 1 Results of evaluating the attractive force of the magnetic attachment before and after MR irradiation of the keeper**

| position | before | after | p-value |
|---|---|---|---|
| UA | 6.20±0.08 | 6.47±0.25 | N.S. |
| UP | 8.22±0.56 | 8.78±0.04 | N.S. |
| UM | 8.96±0.20 | 9.54±0.05 | N.S. |
| LA | 4.42±0.42 | 5.75±0.04 | N.S. |
| LP | 4.87±0.12 | 4.97±0.10 | N.S. |
| LM | 8.48±0.58 | 9.49±0.10 | N.S. |

The attractive force of Hyper Slim 4813 is displayed as 9.6 N. The attractive force of the magnetic attachment using the keeper before MRI irradiation varied widely, from 4.42 N to 8.96 N on average, which is considered to be a technical error when bonding the keeper to the lower non-magnetic table. Similarly, the attractive force after irradiation ranged from 4.97 N to 9.54 N on average, and the attractive force tended to increase after MRI irradiation.

The attractive force at each position before and after MRI irradiation was examined, and no significant difference was observed at any position. No problem with the attractive force was found, even when the keeper was irradiated with MRI.

## Discussion

Tsuchibashi et al.[2)] reported that when an MRI examination was performed with a denture with a magnetic attachment, significant artifacts were generated, and the spontaneous magnetization of the magnet portion was reduced due to the magnetic field of the MRI, which reduced the attractive force. It has been reported that the denture must be removed before MRI is performed, which seems to occur at most facilities in Japan.

On the other hand, there have been reports of keeper dropout during MRI examinations,[2)] as well as cases where the attractive force of the magnetic attachment decreases after MRI examination.[3)] In this regard, Yamamoto et al.[4)] reported that in a static MRI magnetic field, torque was generated so that the keeper surface became parallel to the magnetic field, and the keeper was displaced very slightly, and the condition of contact with the magnet assembly changed. In addition, in an object with an anisotropic shape, such as a keeper, the magnetization induced inside the object varied depending on the direction of the object in the magnetic field; this results in torque, in which the direction of the long axis of the object points in the direction of the magnetic field. In other words, the long axis of the object tends to be oriented in the direction of the magnetic field.

In this experiment, there was no significant difference in the attractive force before and after MRI irradiation to the keeper in all six positions. Therefore, there is no problem in the attractive force even if MR imaging is performed while the keeper is worn in the oral cavity. In addition, a tensile test using a keeper after MRI irradiation showed a tendency for the attractive force to increase at any position. It is possible that the keeper itself is slightly magnetized by MRI irradiation, but we will discuss the details in the future.

## Conclusion

In a case report in which a patient with a dental magnetic attachment had reduced attractive force after MR imaging, the authors verified the case by irradiating a commercially available magnetic keeper with MRI and measuring the attractive force of the dental magnetic attachment before and after irradiation. No problem was found with the attractive force, even if MRI irradiation was performed on the patient with a keeper.

## Conflict of interest

Regarding this report, all authors affirm that they have no conflicts of interest.

## References

1. Takigami, Y., Yamaguchi, Y. and Yoshitake, K.: Dentoskeletal changes caused by a plaster model in adults with normal occlusion. J. Jpn. Stomatol. Soc. 2001; 50: 293-298.
2. Tsuchibashi, T., Fujita, I., Maki, T., Kitagawa, M. and Suzuki, T.: Influence of dental magnetic attachment on MR imaging. Jpn. J. Rad. Tech. 1998; 54: 517-520.
3. Yamamoto T. Issues and expectations of metallic materials in MRI. Mateia Japan 2010; 49: 157-160.
4. Yamamoto T., Nagayama Y. and Tamura M.: A blood-oxygenation-dependent increase in blood viscosity due to a static magnetic field. Phys. Med. Biol. 2004; 49: 3267-3277.

# Patient-reported outcome of immediately loaded mandibular 2-implant overdentures retained by magnetic attachments: a 3-year follow-up

Y. Uehara,[1] M. Kanazawa,[1] A. Miyayasu,[1] R. Shimada,[1] M. Negoro,[1] D. Sato,[2] S. Minakuchi[1]

[1]Gerodontology and Oral Rehabilitation, Graduate School of Medical and Dental Science, Tokyo Medical and Dental University
[2]Oral Implantology and Regenerative Dental Medicine, Graduate School of Medical and Dental Science, Tokyo Medical and Dental University

**Abstract**

**Objectives**

There is much evidence about the immediate loading of mandibular implant overdentures. However, the evidence of the long-term prognosis of immediate loading is lacking. This study aimed to evaluate patient-reported outcomes of immediately and conventionally loaded mandibular 2-implant overdentures retained by magnetic attachments.

**Methods**

Nineteen patients with edentulous mandibles were enrolled in this study. Patients were randomly divided into the immediately loading group (IL group) and the conventionally loading group (CL group). The keepers of the magnetic attachments were connected to the implants on the day of implant surgery for the IL group, while for the CL group, keepers were connected in 3 months. Oral health-related quality of life (OHRQoL) was evaluated by the Japanese version of the Oral Health Impact Profile for edentulous subjects (OHIP-EDENT-J), and 100mm VAS was used to measure satisfaction ratings.

**Results**

Patient satisfaction tended to be high in both groups from the early stage of implant placement.

OHIP improvement only showed in the IL group for up to 3 months after implant surgery, and in both groups after 6 months.

Three years after implant placement, patient-reported outcomes were suggested to be maintained at high levels in both groups.

## Introduction

In recent years, several studies have reported that immediately loading 2-IOD with non-splinted attachments is a feasible way of treating mandibular edentulous patients.[1,2] However, the evidence of the long-term prognosis of immediate loading as compared with conventional loading is lacking.

## Objective

This study aimed to evaluate patient-reported outcomes for immediately and conventionally loaded mandibular 2-implant overdentures retained by magnetic attachments.

## Materials and Methods

(1) Nineteen patients were randomly divided into the immediately loading group (IL group) and the conventionally loading group (CL group) (Figure1). Before implant surgery, a new mandibular complete denture was delivered to each patient. Assessments were done after they adapted to the new denture. The results were used as baseline data.

(2) The keepers of the magnetic attachments were connected to the implants on the day of implant surgery for the IL group, while for the CL group, keepers were connected after 3 months (Figure2).

(3) OHRQoL was evaluated by the Japanese version of the Oral Health Impact Profile for edentulous subjects (OHIP-EDENT-J), and 100 mm VAS was used to measure satisfaction ratings.

(4) The differences were analyzed by using the Wilcoxon signed-rank test within each group and the Mann-Whitney U test between groups.

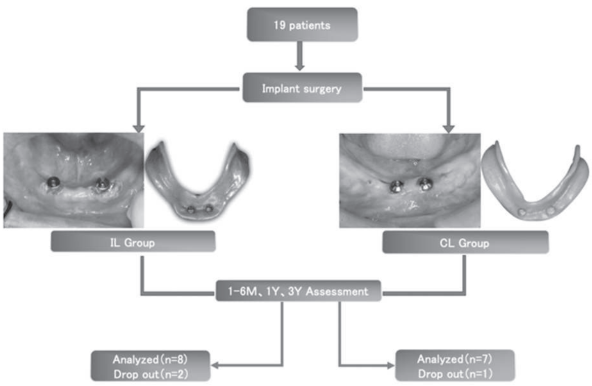



Figure1

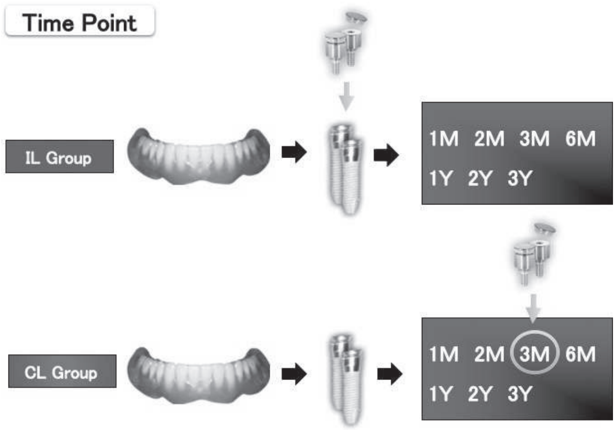



Figure2

## Results

1. OHRQoL

- There were no significant differences as compared to the baseline in 1Y and 3Y assessments within and between the IL and CL groups (Table1,2).

- Through the first 3 months, improvement of OHRQoL was observed only in the IL group. Both groups showed lower OHIP scores in the 6-month follow-up, which means both groups got higher OHRQoL, and the immediately loading improved at a comparatively earlier time after implant placement (Figure3 ).

2. Patient Satisfaction

- There were no significant differences between the IL and CL groups as compared to the baseline up to 1Y and 3Y (Table1).
- Within the IL group, patient satisfaction was significantly increased 1Y and 3Y after implant placement. Both groups had higher satisfaction as compared to the baseline and had maintained a high level from the early stage to 3 years (Table2, Figure4).

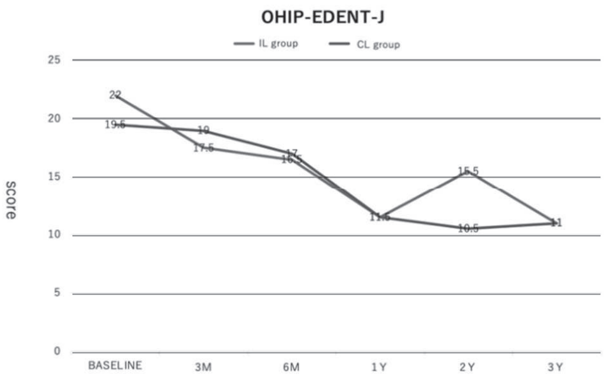



Figure3

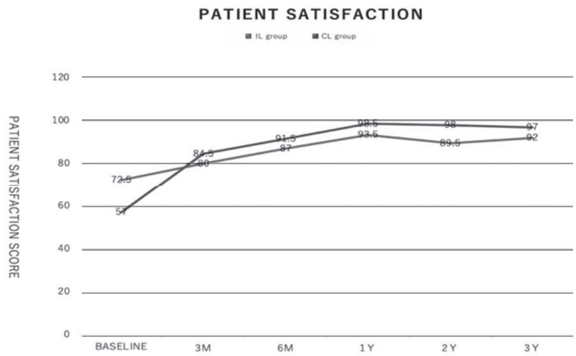



Figure4

Table1

| | **Median(first, third quartile)** | | |
|---|---|---|---|
| | Baseline | 1Y | 3Y |
| **OHIP-EDENT-J** | | | |
| IL group | 25.5 [16.3, 31.0] | 11.5 [8.0, 19.5] | 11.0 [6.8, 20.3] |
| CL group | 25.0 [11.0, 25.0] | 13.0 [8.0, 16.0] | 14.0 [9.0, 15.5] |
| P value | 0.448 | 0.779 | 0.955 |
| **Patient Satisfaction** | | | |
| IL group | 72.5 [36,8.8] | 93.5 [91.0, 96.5] | 92.0 [90.8, 96.8] |
| CL group | 57.0 [55.5, 96.0] | 99.0 [98.0, 99.5] | 97.0 [94.0, 97.5] |
| P value | 0.643 | 0.102 | 0.413 |

The median, first quartile, and third quartile values for OHIP-EDENT-J and Patient Satisfaction between IL group and CL group from baseline to 1Y and 3Y evaluation time-point. P*< 0.05

Table2

| | P value | |
|---|---|---|
| | Baseline-1Y | Baseline-3Y |
| **OHIP-EDENT-J** | | |
| IL group | 0.136 | 0.056 |
| CL group | 0.16 | 0.055 |
| **Patient Satisfaction** | | |
| IL group | 0.034* | 0.024* |
| CL group | 0.086 | 0.182 |

The P value for OHIP-EDENT-J and Patient Satisfaction between baseline to 1Y and baseline to 3Y evaluation time-point. P*<0.05

## Discussion

1. Why was there no significant difference in OHRQoL within and between the IL and CL groups?
   - Baseline OHIP scores were already low.
   - OHIP only captures negative impacts, which is not good at showing positive changes in patients who had few complaints about their dentures.
   - Small sample size is a limitation due to its low statistical power.
2. Why was there no significant difference in patient satisfaction between the IL and CL groups?
   - Patient satisfaction is a complex phenomenon influenced by many factors, not only the oral system.
   - Complaints about upper dentures were heard in this study, which may indirectly affect the satisfaction of the 2-IODs.
   - Small sample size is a limitation due to its low statistical power.

## Conclusion

Immediately loading mandibular 2-implant overdentures with magnetic attachments is a feasible treatment for mandibular edentulous patients. The results indicate that immediate loading may achieve earlier satisfaction improvement as compared to conventional loading protocol.

## References

1. Marzola R, Scotti R, Fazi G, Schincaglia GP. Immediate loading of two implants supporting a ball attachment-retained mandibular overdenture: A prospective clinical study. Clin Implant Dent Relat Res 2007;9(3):136-143.

2. Büttel AE, Gratwohl DA, Sendi P, Marinello CP. Immediate loading of two unsplinted mandibular implants in edentulous patients with an implant-retained overdenture: an observational study over two years. Schweiz Monatsschr Zahnmed 2012;122(5):392-397.

# Comparison of masticatory performance between immediately loaded and conventionally loaded mandibular 2-implant overdentures with magnetic attachments

Watanabe M,[1] Kanazawa M,[1] Miyayasu A,[1] Shimada R,[1] Negoro M,[1] Uehara Y,[1] Sato D,[2] Sato Y,[1] Minakuchi S[1]

[1] Gerodontology and Oral Rehabilitation, Graduate School of Medical and Dental Sciences, Tokyo Medical and Dental University

[2] Oral Implantology and Regenerative Dental Medicine, Graduate School of Medical and Dental Sciences, Tokyo Medical and Dental University

## Abstract

### Objective

The aim of this study is to compare the masticatory performance between immediately loaded and conventionally loaded mandibular 2-implant overdentures with magnetic attachments.

### Materials and Methods

Nineteen participants with edentulous mandibles were randomly assigned to an immediately loaded group or a conventionally loaded group. In the immediately loaded group, a magnetic attachment was applied on the same day as implant surgery, and in the conventionally loaded group, a magnetic attachment was applied 3 months after implant surgery. The masticatory performances of both, measured by a color-changeable chewing gum and a gummy jelly, and maximum occlusal force were assessed at a baseline and at 1, 3, 6, 12, 24, 36, and 48 months after implant insertion.

### Results

At the 6 - month evaluation time point, the immediately loaded group exhibited a significantly higher gummy jelly score than the conventionally loaded group. There were no significant differences in masticatory performance, as measured by the color - changeable chewing gum, between the two groups at any evaluation time point.

### Conclusion

Masticatory performance, measured by a gummy jelly, is improved with 2-IOD immediately loaded at a time point earlier than that of conventionally loaded 2-IODs.

## Introduction

The McGill consensus suggested that the 2-implant overdenture (2-IOD) should become the first choice of treatment for the edentulous mandible.[1)] Furthermore, to recover masticatory performance (MP), 2-implant overdentures (2-IODs) were introduced as a standard treatment option for edentulous individuals.[2)] However, no reports are available regarding the MP of 2-IODs retained by modified magnetic attachments. Moreover, no reports are available comparing MPs of immediately loaded 2-IODs and conventionally loaded 2-IODs.

## Objective

The aim of this study is to compare the masticatory performances of immediately loaded and conventionally loaded mandibular 2-implant overdentures with magnetic attachments.

## Materials and Methods

1. Study design

This study was a randomized unblinded parallel-group trial.

2. Participants

Participants were recruited by telephone from among patients who had previously visited the Dental Hospital of Tokyo Medical and Dental University. All participants were given oral and written information regarding the study and provided written informed consent. The Ethical Review Committee of the Faculty of Dentistry, Tokyo Medical and Dental University, approved the study protocol. The following inclusion criteria were applied:

1. A completely edentulous mandible and any opposing maxillary occlusion status.
2. Adequate bone volume in the anterior mandible for the placement of two implants with minimum dimensions of 4.0 × 10.0 mm.
3. No requirement for bone augmentation.
4. Commitment to undergo at least 4 months of healing after extraction.
5. Good oral hygiene.

The following exclusion criteria were applied:

1. Uncontrolled systemic disease that could compromise implant surgery.
2. History of chemotherapy or radiography in the head and neck region.
3. Heavy smoker status.
4. History of taking bisphosphonates.

**1. Surgical and prosthetic procedure**

Each participant received new appropriate mandibular complete dentures (CDs). When the adjustment was finished, computed tomography (CT) scans were obtained using the denture as a radiographic guide. From the obtained CT image, the implant planting position was simulated using simulation software to produce surgical guides. Two implants (Nobel Speedy Groovy RP 4×10–18 mm, Nobel Biocare, Gothenburg, Sweden) were inserted by the same experienced implantologist in the interforaminal area of each participant according to the manufacturer’s protocol for a flapless surgical procedure. In the immediately loaded group, magnetic attachments (Magfit, Aichi Steel Co., Aichi, Japan) were applied to the implants on the same day as implant surgery, and in the conventionally loaded group, healing abutments were applied. The conventional group was fitted with magnetic attachments three months after implantation. After surgery, participants were instructed to keep wearing their dentures 24h a day for 7 days except for denture cleaning to prevent swelling of the mucous tissue that would make it difficult to wear dentures. The equivalent part of the implant on the denture mucosal surface was sufficiently relieved so as not to apply stress on the implant.

### 2. Outcome

MP was evaluated using a color-changeable gum, a gummy jelly, and an occlusal force meter. Gum was used to evaluate mixing ability, the gummy for evaluating comminuting ability, and the occlusal force meter for evaluating maximum occlusal force. As for each measurement method, the gum (Xylitol Masticatory Performance Evaluating Gum, Lotte, Japan) was freely chewed 60 times, and the amount of color change was calculated. We then evaluated how the color change corresponded to the number of chews. Gum jelly (Test Gummy Jelly for Evaluating Masticatory Performance, UHA Mikakuto, Japan) was chewed 30 times, and the bite fragments were evaluated on a scale of 1–10. The maximum occlusal force was measured when the occlusal force meter (GM10, Nagano Keiki, Japan) was occluded for several seconds. The evaluation periods were preoperative and 1, 2, 3, 6, 12, 24, 36, and 48 months after the operation.

### 3. Statistical analysis

The baseline characteristics of the participants in both groups were compared by using the non-paired t-test and the chi-square test. The Mann-Whitney U test was used to analyze differences in MP and maximum occlusal force between the two groups at a baseline and at each evaluation time point after implant insertion. Steel's test was used to compare MP and maximum occlusal force at a baseline with MP and maximum occlusal force at each evaluation time point after implant insertion within each group. All statistical analyses were performed by using the statistical software JMP ver.13 (SAS Institute, North Carolina). Statistical significance was set at $P < .05$ for all tests.

## Results

The flow of participants in the study is shown in Figure 1. Nineteen participants with edentulous mandibular arches were recruited for the study. There were a total of 6 dropouts. In the conventionally loading group, one patient lost the implant within 3 months of the operation, and the remaining 5 patients were unable to continue the study due to the circumstances of the participants. The final analysis was carried out for a total of 13 people—7 in the immediately loading group and 6 in the normally loading group—4 years after implantation.There were no significant differences in MP as measured by the color-changeable chewing gum between the two groups at any evaluation time point (Table 1). At the 6-month evaluation time point, the immediately loading group exhibited a significantly higher gummy jelly score than did the conventionally loading group (Table 2). There were no significant differences in maximum occlusal force between the two groups at any evaluation time point (Table 3).MP measured by the color-changeable chewing gum was significantly higher than the baseline at the 36-month evaluation time point and the 48-month evaluation time point in the immediately loading group, and there were significantly higher differences at the 48-month time point. From the 3-month evaluation time point to the 36-month evaluation time point, MP as measured by the gummy jelly score was significantly higher than at the baseline in the immediately loading group; however, in the conventionally loading group, the gummy jelly score did not differ significantly from the baseline at any evaluation time point (Table 4). Maximum occlusal force was significantly higher at the 12-month evaluation time point in the immediately loading group as compared with baseline, but there were no other significant differences in either group at any time point (Table 4).

**Figure1** The flow of participants

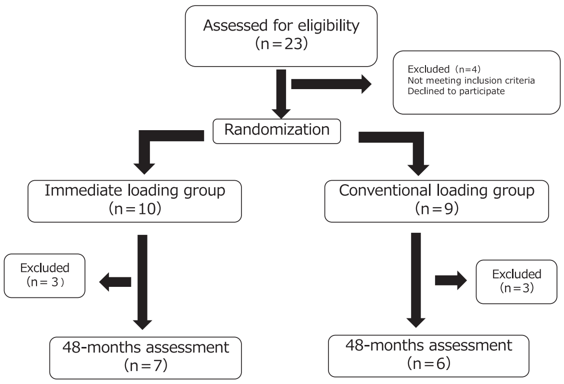



**TABLE1** Masticatory performance scores measured by a color-changeable chewing gum in the two groups from baseline to the 48-month time-point

| | Median | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | BaseLine | 1 month | 3 months | 6 months | 12 months | 24 months | 36 months | 48 months |
| Imediaete | 60.0 | 66.8 | 59.1 | 75.7 | 73.7 | 87.2 | 104 | 129 |
| Convetional | 53.3 | 60.2 | 48.8 | 59.3 | 73.5 | 82.8 | 110 | 134 |
| P value | .689 | .399 | .198 | .307 | .962 | .689 | 1.00 | .721 |

*P value <.05.

**TABLE2** Masticatory performance scores measured by a gummy jelly in the two groups from baseline to the 48-month time-point

| | Median | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | BaseLine | 1 month | 3 months | 6 months | 12 months | 24 months | 36 months | 48 months |
| Immediate | 2 | 3 | 4 | 4.5 | 4 | 4.5 | 5.5 | 5.5 |
| Conventional | 1 | 1.5 | 3.5 | 3 | 3.5 | 5 | 4 | 4 |
| P value | .784 | .433 | .504 | .034* | .617 | .890 | .319 | .428 |

*P value <.05.

**TABLE3** Maximum occlusal force in the two groups from baseline to the 48-month time-point

| | Median | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | BaseLine | 1 month | 3 months | 6 months | 12 months | 24 months | 36 months | 48 months |
| Immediate | 165 | 198 | 185 | 268 | 350 | 303 | 286 | 139 |
| Convetional | 53.3 | 60.2 | 48.8 | 59.3 | 73.5 | 82.8 | 110 | 191 |
| P value | .859 | .12 | .143 | .79 | .414 | .824 | .772 | .830 |

*P value <.05.

**TABLE4** The P values for differences in masticatory performance measured by color-changeable chewing gum and gummy jelly and maximum occlusal force between baseline and each evaluation time-point

| | P value | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 month | 3 months | 6 months | 12 months | 24 months | 36 months | 48 months |
| Color-changeable chewing gum | | | | | | | |
| Immediate | .737 | .993 | .192 | .267 | .098 | .004* | .002* |
| Convetional | .910 | .994 | .963 | .603 | .138 | .083 | .005* |
| Gummy jelly | | | | | | | |
| Immediate | .504 | .042* | .002* | .003* | .003* | .031* | .070 |
| Conventional | .914 | .266 | .331 | .205 | .159 | .407 | .253 |
| Maximum occlusal force | | | | | | | |
| Immediate | .515 | .570 | .098 | .032* | .098 | .087 | .098 |
| Conventional | .999 | 1.00 | .383 | .174 | .065 | .182 | .128 |

*P value <.05.

## Discussion

MP measured by color-changeable gum did not differ significantly between two groups at any evaluation time point. In contrast, MP measured by the gummy jelly increased significantly at the 6-

month evaluation time point. These results suggest that comminuting ability improves quickly after surgery. The reason that there was no significant difference in the mixing ability between the two groups was that the color-changeable gum was soft and easy to chew for CD wearers. In within-group comparisons, there were no significant differences in MP as measured by the color-changeable chewing gum between the immediately loading group and the conventionally loading group before the 36-month time point. This is because the gum texture and increased occlusal contact area are due to artificial tooth wear.

There was a significant difference in the gummy jelly score in the immediately loading group from a 3-month time point to a 36-month time point. This suggests improved comminuting ability as compared with that preoperatively. On the other hand, the gummy jelly scores in the conventionally loading group did not differ significantly from the baseline score at any time point after implant loading. This lack of a significant increase might be related to data variations.

There were no significant differences in maximum occlusal force between the two groups at any time point, and in within-group comparisons of maximum occlusal force as compared to the baseline in both groups, only the score at 12 months in the immediate group was significant, and the maximum occlusal force showed a decreasing trend after one year. This was thought to be due to the aging of the participants.

## Conclusion

Within the limitations of the clinical research, the MP measured by a gummy jelly is improved by immediately loading mandibular 2-IODs with magnet attachments at an earlier time point than that of conventional loading. Therefore, immediately loading 2-IODs retained by magnetic attachments is recommended with regard to MP.

## References

1. Feine JS, Carlsson GE, Awad MA, Chehade A, Duncan WJ, Gizani S, et al. The McGill consensus statement on overdentures. Mandibular two-implant overdentures as first choice standard of care for edentulous patients. Montreal, Quebec, May 24-25, 2002. Int J Oral Maxillofac Implants 2002;17:601-2.
2. Thomason JM, Kelly SA, Bendkowski A, Ellis JS. Two implant retained overdentures-a review of the literature supporting the McGill and York consensus statements. J Dent. 2012;40:22-34.

JJ Mag Dent vol.29 No.2 2020

# A case report of a removable partial denture using a magnetic attachment considering the load-bearing capacity of abutment teeth

M. SONE, D. MATSUMOTO, N. KOYAMA, F. NARUMI, T. MATSUKAWA, S. UCHIDA, S. SOMEKAWA, K. TAKAHASHI, M. SUZUKI, Y. MIYOSHI, T. YOSHIDA, D. SAKAMOTO, K. OKAMOTO, and S. OHKAWA

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

**Abstract**

In this presentation, we report on a case in which two different types of magnetic attachments, depending on the load-bearing capacity of the abutment teeth, were applied to one removable partial denture.

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

The definitive denture had the first molar as a homemade metal tooth and the second molar as a hard resin tooth (SR-Orthosit-PE, Ivoclar-Vivadent AG, Liechtenstein). In addition, GIGAUSS (GC) was used for a magnetic attachment (the coping type was the D400, and the D600 was applied to the extracoronal type).

## Introduction

Prosthetic treatment options for a partially edentulous maxilla have been increasing in recent years. In particular, many patients choose implant treatment rather than a removable partial denture due to the superiority of chewing efficiency and foreign body sensation (Fig. 1).

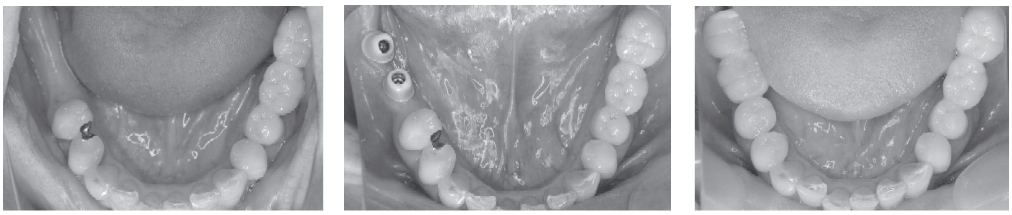


Fig. 1 A case of implant treatment

However, in Japan, patients with systemic diseases are increasing, and as an alternative to implant treatment, conventional treatment using partial dentures that have “Syoku-Riki” (predation, mastication, and swallowing capabilities) is necessary for maintaining patients’ QOL, which leads to the extension of healthy life expectancy.[1)]

A magnetic attachment (Fig. 2) can exert stable maintenance power by using the suction force of the magnet for the desorption of the denture while chewing. In addition, it is possible to apply various support devices to abutment teeth in various conditions, which has various advantages for the elderly, such as easy attachment and removal by the patient. In other words, depending on the application method, a denture support device can maintain and improve "Syoku-Riki." In this presentation, we report on a case in which two different types of magnetic attachments, depending on the load-bearing capacity of the abutment teeth, were applied to one removable partial denture.

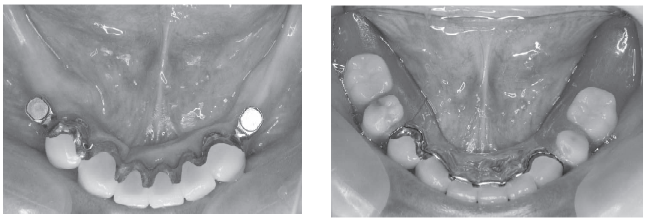


Fig. 2 A case of a denture using a magnetic attachment

## Clinical History

Clinical History: The patient, a 59-year-old male, complained of masticatory dysfunction. He had a partially edentulous maxilla (Kennedy Class Ⅱ) and a history of arrhythmia. He complained that he wanted to seat the denture firmly on his right jaw, but he did not want the implant treatment due to his current systemic history.

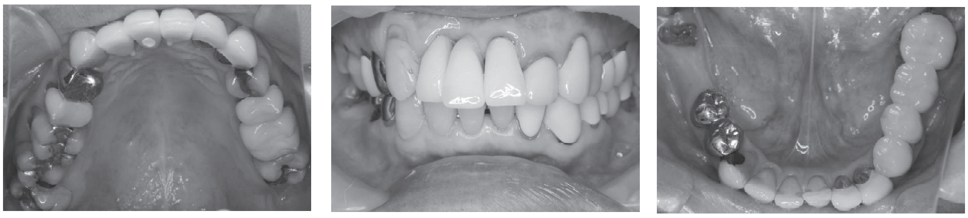


Fig. 3 Intraoral view at first visit

Treatment Procedure: Based on dental X-rays (Fig. 4) and periodontal disease examination (Fig. 5), the distal root of the mandibular right second molar was fitted with a coping type of magnetic attachment (Fig. 6) in consideration of its load-bearing capacity as an abutment tooth, and we decided to fabricate an extracoronal magnetic attachment using an EC Keeper Tray (GC, Japan) for the mandibular right first and second premolars (Figs. 7 and 8).

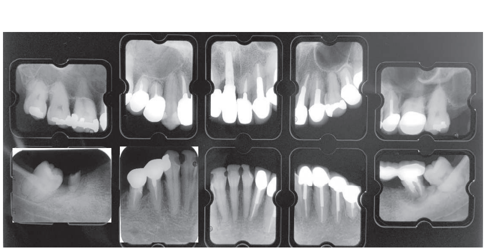


Fig. 4 X-rays at first visit

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

Fig. 5 Periodontal disease examination at first visit

Fig. 6 Coping-type magnetic attachment

Fig. 7 Extracoronal magnetic attachment

Fig. 8 EC keeper tray

After fixing the coping-type magnetic attachment to the oral cavity, a pick-up impression was taken in the oral cavity to make a working model, and a framework of the denture was fabricated on it (Fig. 9). The definitive denture had the first molar as a homemade metal tooth, taking into account the space of the housing portion of the extracoronal magnetic attachment, and the second molar as a hard resin tooth (SR-Orthosit-PE, Ivoclar-Vivadent AG, Liechtenstein) (Fig. 10). In addition, GIGAUSS (GC) was used for a magnetic attachment (the coping type was the D400, and the D600 was applied to the extracoronal attachment).

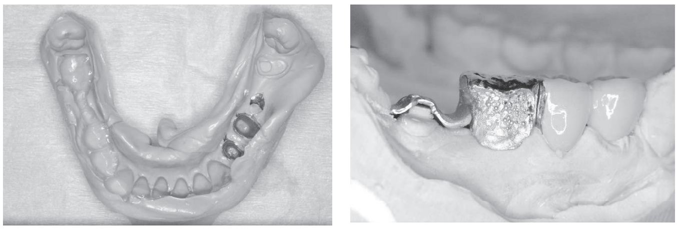


Fig. 9 Pick-up impression and denture framework

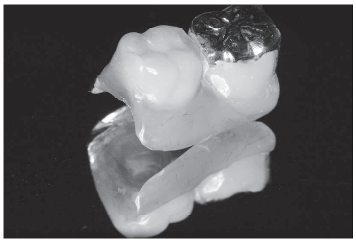


Fig. 10 Definitive denture

## Conclusion

Magnetic attachments can be used as support teeth by reducing the lateral pressure of coping types, even if the remaining teeth have problems with the crown-to-root ratio due to the absorption of alveolar bone. In addition, if the crown-to-root ratio is good, it is possible to produce highly stable dentures by having the abutment teeth carry the retention force and bracing force as an external type of crown.[2] In this case, we applied these advantages and produced a denture. As a result, OHIP-14, which is related to QOL, was 0 points of the minimum value. By analyzing the amount of glucose discharge during gum-jelly chewing, mandibular movements were quantitatively evaluated to be 188 mg/dl. Therefore, we were able to produce a prosthesis device that could maintain and improve “Syoku-Riki” (Fig. 11). We plan to confirm the postoperative course while performing regular maintenance in the future.

Fig. 11 Intraoral view of treatment procedures

## References

1. S. Ohkawa: For contribution to extension of healthy life expectancy, Ann. Jpn. Prosthodont. Soc, 11, 117–178, 2019.
2. Y. Tanaka: SHIN JISEI ATATCHIMENTO (New Dental Magnetic Attachment). ISHIYAKU PUBLISHERS INC, Tokyo, 2016.

# Mandibular IOD using a Riegel telescope with a magnetic attachment

IMAIZUMI N,[1,2] MARUO R,[1,2] MUTO R,[2] SUZUKI Y,[1,2] NAKATA T,[1,2]
SHIMPO H,[1,2] KURIHARA D,[1,2] OHKUBO C[1,2]

1) Department of Removable Prosthodontics, Tsurumi University School of Dental Medicine
2) Center of Maxillofacial Implantology, Tsurumi University Dental Hospital

**Abstract**

**【Objective】**

Retention and stability of a mandibular complete denture for fully edentulous patients can be improved by implant placement. In this case, three implants were placed in the mandibular jaw, and a Riegel telescope denture with magnetic attachments was delivered to obtain good function.

**【Method】**

Three implants (Brånemark MK II RP 10 mm, Nobel Biocare) were placed between the foramen mentale in the edentulous mandibular jaw. The Riegel telescope system was selected as a retainer of mandibular implant overdenture (IOD), and the milling bar and outer crown were fabricated with optimal fitting. Three implants were connected by a milling bar with two holes, in which two rods could be inserted. The keeper and magnetic attachment (Hyper Slim 5213, Neomax) were attached to the rods and outer crown of the denture, respectively. The Riegel telescope, metal backing, and T-shape structured framework were cast with an Au-Pt alloy and then accurately constructed.

**【Results, Discussion】**

Approximately 18 years after delivery, there was little bone resorption around implants, and the patient's satisfaction could be maintained by good denture stability. Magnetic attachment must be useful not only for a direct retainer on the root and implant but also for fixing the rods in the Riegel telescope.

## Introduction

The use of implant support and retention to rehabilitate an edentulous mandibular jaw is a well-established and contemporary clinical method. There is a lot of evidences that a mandibular implant overdenture (IOD) significantly reduces certain problems as compared to conventional complete mandibular denture.

## Outline of the Case

The patient was a 55-year-old partially edentulous woman with 3 remaining teeth (#11, #13, and #14) in the maxillary jaw and a fully edentulous mandibular jaw. Her chief complaint was an unstable existing mandibular denture (Fig.1).

The patient received an explanation of the treatment plan and was informed of the possibilities of using a conventional removable denture, an implant-fixed prosthesis, or an implant-retained overdenture. After informed consent was obtained, for economical and anatomical reasons, the patient selected a conventional overdenture for her maxillary jaw and implant-retained overdenture for her mandibular jaw.

Fig.1 Intraoral view before treatment

## Clinical Procedure

Three implants (Brånemark MK II RP 10 mm, Nobel Biocare) were placed between the foramen mentale in the edentulous mandibular jaw (Fig.2). The Riegel telescope system was selected as a retainer of mandibular implant overdenture (IOD); the milling bar and outer crown were fabricated with optimal fitting. Three implants were connected by a milling bar with two holes, in which two rods can be inserted. The keeper and the magnetic attachment (Hyper Slim 5213, Neomax) were attached to the rods and outer crown of the denture, respectively (Figs.3,4). The Riegel telescope, metal backing, and T-shaped structured framework were cast with an Au-Pt alloy and then accurately constructed.

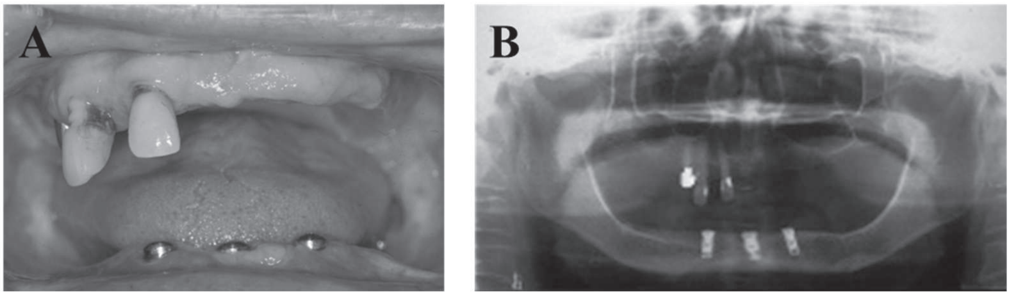



Fig.2 Three implants were placed following the surgical template:
A. Intraoral photography
B. Panoramic X-ray

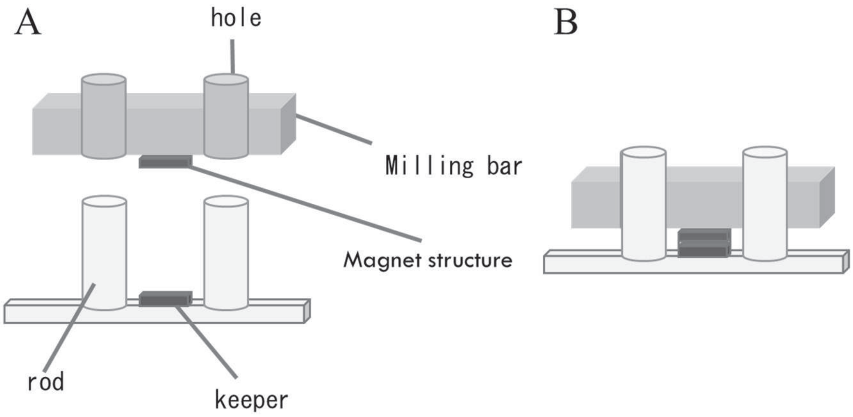



Fig.3 Schematic drawing of the Riegel telescope system: A. without locking, B. with locking

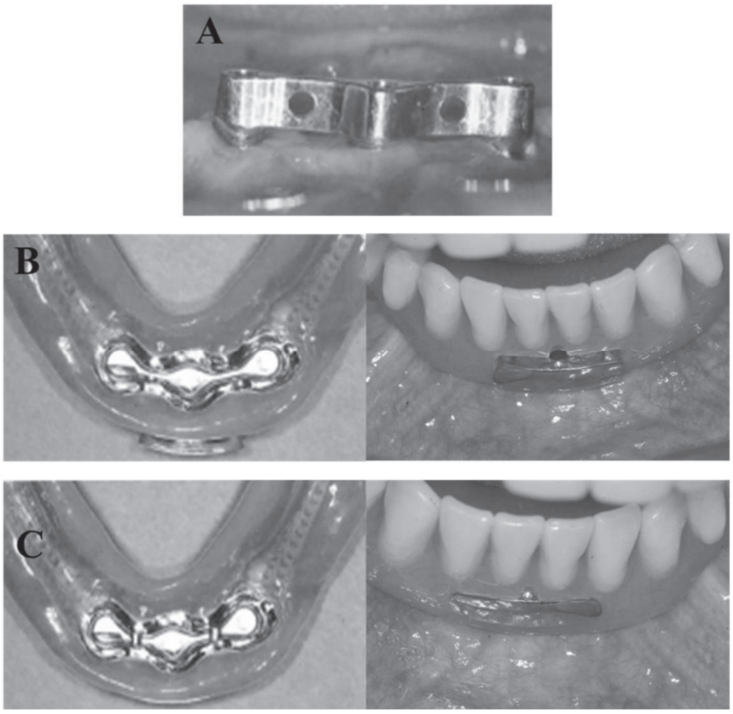


Fig.4 Riegel telescope system
A. Milling bar on the three implants
B. Inner and labial surface of the denture base without locking
C. Inner and labial surface of the denture base with locking

After the auto-polymerizing PMMA resin was polymerized, the implant-stabilized overdenture was delivered. For the maxillary arch, the middle coping was placed on the right canine and second premolar, and a conventional overdenture was fabricated (Fig.5).

## Results

Denture maintenance has been continued once every 6 months. Approximately 18 years have passed since delivery; there has been little bone resorption around the implants, and the patient's satisfaction could be maintained by good denture stability (Fig.6). Although the lateral incisor was extracted due to periodontal disease, the maxillary denture could continue to be used with the direct reline and repairs.

Fig.5 Placement of the dentures: A. maxillary view, B. front view, C. mandibular view

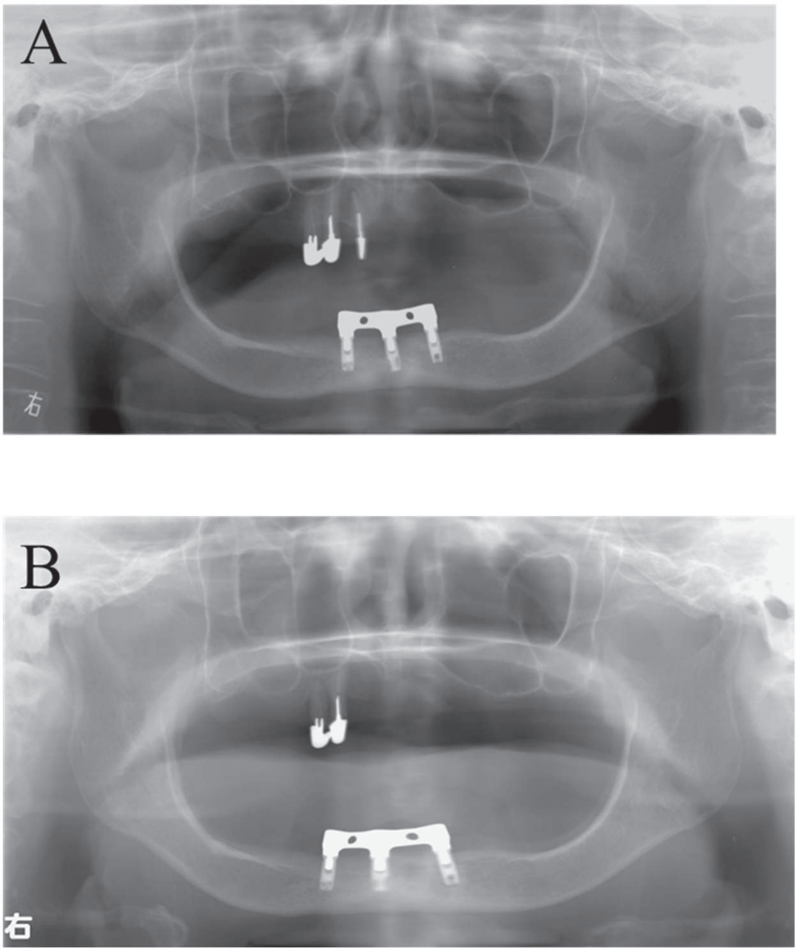



Fig.6 Panoramic X-ray: A. after 10 years of wearing dentures, B. after 17 years of wearing dentures

**Discussion**

Sufficient retention and stability could be provided by the combination of the Riegel telescope system and magnetic attachments, and satisfactory aesthetics and function could be achieved using a mandibular IOD. Magnetic attachment must be a useful device not only for a direct retainer on the root and implant but also for fixing the rods in the Riegel telescope.

# Mechanical analysis of implant support in removable partial denture design applied to a magnetic attachment

R. Kanbara, H. Kumano, R. Aoyama, W. Fujinami, Y. Nakamura, K. Shoji, H. Nagai, and J. Takebe

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

**Abstract**

The purpose of this study was to investigate the effect of implant support on the tissue around the abutment tooth and the behavior of a removable partial denture using a three-dimensional finite element method in the design of a removable partial denture applied to a magnetic attachment.

The analysis model was constructed using a mandibular plaster model and a skull model. The missing teeth were the lower right second premolar, the first and second molars, the lower left second premolar, and the first molar. The basic model used a retainer with an RPI clasp on both the first premolar and the magnetic attachment on the second left molar. The items analyzed included two types of the basic model and the implant support model in which implants were embedded in the missing right free end of the basic model. The analysis conditions were set for these models, and three-dimensional finite element analysis was performed.

This analysis showed that the mechanical effect of the implant support in the design of removable partial denture decreased the displacement of the denture and relaxed the stress of the tissue around the abutment tooth on the implant side.

## Introduction

In the design of removable partial dentures in which tooth support and tissue support with different amounts of tissue displacements are complicated, it is very difficult to set appropriate mechanical distribution, especially for free end missing.

In such a situation, the application of the magnetic attachment to the posterior molar can change the missing form from free end missing to intermediary missing by providing tissue support at the posterior position. In addition, it is clinically very useful to acquire the retentive force of the denture by the attractive force of the magnetic attachment. In recent years, although implant treatment has been established as a method of defect prosthesis from the crown bridge to the removable denture, as another method, as well as applying the magnetic attachment to the posterior molar, there is also a report regarding the use of implant support at the posterior position to stabilize a removable partial denture. However, for the intervention of implant support in the design of removable partial dentures, at present, many questions remain about the mechanical effects.

## Objective

The purpose of this study was to use the three-dimensional finite element method to analyze and examine the mechanical effects of using implant supports in designing removable partial dentures with magnetic attachments.

## Materials and Methods

### 1. Analysis model

The mandibular model used in this study is shown in Fig.1. For model construction, a mandibular plaster model and a skull model (P10 - SB.1) manufactured by Nissin Co., Ltd. were used (Fig.2).

Initially, this mandibular plaster model was scanned using a model and impression scanner (7 series, Dental Wings, Montreal, Canada) to create model shape data in the STL format. Next, a skull model was CT photographed, and the CT data obtained was prepared in the STL format with mandibular bone data and tooth root shape data using three-dimensional soft construction (Mimics version l1.0, Materialise, Leuven, Belgium). We imported these data into computer-aided engineering (CAE) pre／post processing software (Patran 2013 Windows 64-bit, MSC Software, Los Angeles, CA, USA) and constructed a model. The thickness of the residual ridge mucosa and periodontal ligament were set in reference to the literature values, and the morphology of the mandible was a simple form.[1]

Fig.1: The mandibular model used in this study

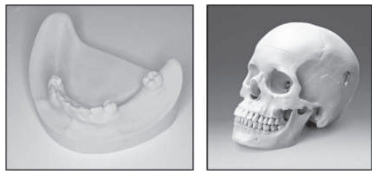


Fig.2: A mandibular plaster model and a skull model

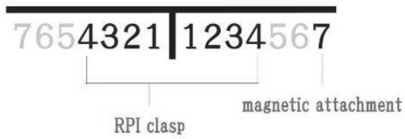



Fig.3: The design of the removable partial denture

The design of the removable partial denture is shown in Fig.3. The magnetic attachment was designed for the mandibular left second molar, and the RPI clasp was applied on both sides of the first premolar as the direct retainer. The magnetic attachment applied in this research was GIGAUSS D1000, and its high diameter and width were accurately reproduced for model construction.

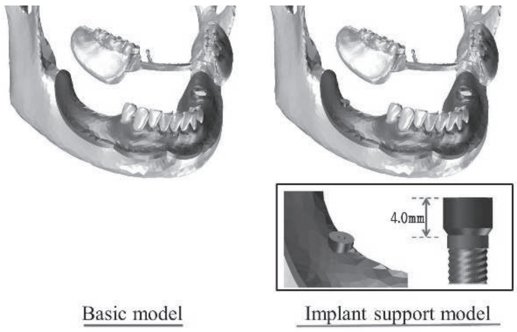



Fig.4: Analysis items

## 2. Analysis Items

Analysis items are shown in Fig.4.

The analysis items were two types of the basic model and the implant support model with the implant (length 10.0 mm φ3.8 mm) embedded in the second molar equivalent of the right side of the mandible of the basic model. The implant of the implant support model was equipped with a healing abutment (height 4.0 mm) and set as a support area under the denture base.

The mechanical property values of the analysis model are shown in Table 1. The nonlinear viscoelastic properties of the periodontal ligament and the residual ridge mucosa were introduced by a material constant conversion program (Table 2).

Table1: Mechanical property values

| | Young Modulus (MPa) | Poisson Ratio |
|---|---|---|
| mandibular bone | 11,760 | 0.250 |
| enamel | 41,400 | 0.350 |
| dentin | 18,600 | 0.350 |
| resin | 2,450 | 0.300 |
| Co-Cr | 200,000 | 0.300 |
| Gold Alloy | 136,000 | 0.350 |
| Titanium | 104,100 | 0.300 |
| Ti-6Al-4V | 113,800 | 0.300 |

Table2: Material constant conversion program

| | Young Modulus (MPa) | | Poisson Ratio |
|---|---|---|---|
| periodontal Ligament | 0.020 | ≦ | 0.200 |
| | 0.085 | ≦ | 0.300 |
| | 1.500 | ≦ | 0.350 |
| | 2.500 | ≦ | 0.400 |
| | 4.000 | ≦ | 0.490 |
| residual ridge mucosa | 0.150 | ≦ | 0.300 |
| | 0.700 | ≦ | 0.350 |
| | 3.000 | ≦ | 0.350 |
| | 3.900 | ≦ | 0.350 |
| | 4.600 | ≦ | 0.450 |
| | 11.000 | ≦ | 0.470 |
| | 16.500 | ≦ | 0.490 |

## 3. Analysis conditions

The load conditions are shown in Fig.5. There were four load sites on the both side of the mandibular denture, the second premolar and the first molar occlusal surface, and the loading direction was perpendicular to the occlusal plane. Based on literature value, the total load amount was 200N.[2]

The inferior border of the mandible was defined as a constraint condition in the x, y, and z directions. In the contact condition, the contacting relationship with the tooth and the mucosa in contact with the denture was added by Coulomb friction, and the coefficient of the defined Coulomb friction was set at μ = 0.090 for this study.[3]

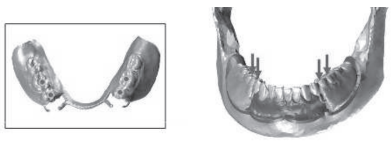


Fig.5: Load conditions

## Analysis Results

The stress in this analysis was evaluated by Von Mises stress.

### 1. Alveolar cavity of the mandibular left second molar

Figure 6 shows the stress distribution of the alveolar cavity of the mandibular left second molar. As compared with the basic model, stress relaxation was confirmed in the implant support model.

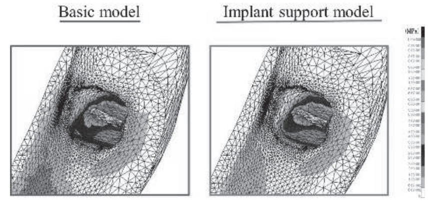


Fig.6: The stress distribution of the alveolar cavity of the mandibular left second molar

### 2. Alveolar cavity of the mandibular left first premolar

Figure 7 shows the stress distribution of the alveolar cavity of the mandibular right first premolar. As compared with the implant support model, stress spread was observed at the distal portion of the alveolar cavity in the basic model, but no significant difference was observed around the alveolar cavity.

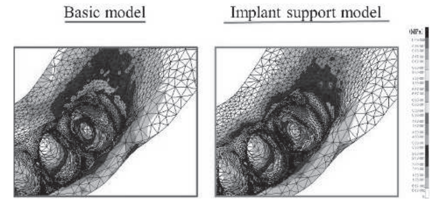


Fig.7: The stress distribution of the alveolar cavity of the mandibular left first premolar

### 3. Alveolar cavity of the mandibular right first premolar

Figure 8 shows the stress distribution of the alveolar cavity of the mandibular right first premolar. At the distal portion of the alveolar cavity and around the alveolar cavity, as compared to the basic model, stress relaxation was confirmed in the implant support model.

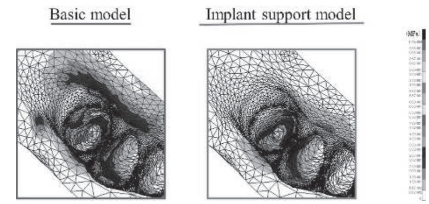


Fig.8: The stress distribution of the alveolar cavity of the mandibular right first premolar

### 4. Displacement of the denture base

Figure 9 shows the amount of denture base displacement. Displacement equivalent to that of the mandibular right second molar, first molar, and second premolar was reduced in the implant support model as compared with the basic model. As for the amount of displacement, in the basic model, it tended to increase with distance from the distal, and it tended to increase in the implant support model with distance from the mesial. There was no significant difference in displacement in the two models equivalent to the mandibular left second molar, the first molar, and the second premolar. As for the amount of displacement, both models tended to increase with distance from the mesial.

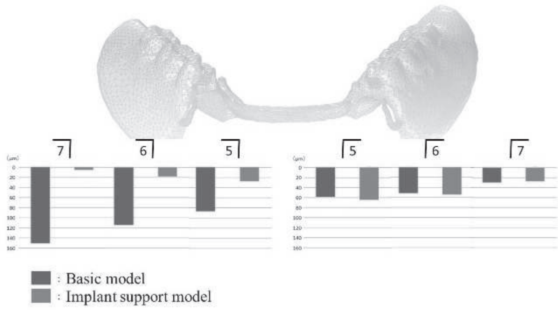


Fig.9: The amount of displacement of the denture base

## Discussion and Conclusion

The results of this study confirm that the mechanical effects of implant support in the design of removable partial denture using magnetic attachments include stress relaxation of the tissue around the abutment tooth using the magnetic attachment and the tissue around the abutment tooth on the implant support side. It was also confirmed that the use of implant support for the free end missing reduced the mucosal burden zone of the denture and suppressed the amount of the denture base displacement. From the information above, in designing removable partial dentures in the free end missing, taking advantage of implant support of the rearmost missing form as an intermediate missing reduction, the possibility of obtaining stability of the partial denture was suggested.

## References

1. M. Kishi : Experimental studies on the relation between area and displacement of loading surfaces in connection with displaceability in the mucosa of edentulous alveolar ridge under pressure, Shikwa Gakuho, 72, 17-45,1972.
2. M. Manda, C. Galanis, V. Georgiopoulos, C. Provatidis, P. Koidis : Effect of severely reduced bone support on the stress field developed within the connectors of three types of cross-arch fixed partial dentures, J Prosthet Dent, 101, 54-65,2009.
3. Y. Sato, Y. Abe, Y. Yuasa, Y. Akagawa : Effect of friction coefficient on Akers clasp retention, J Prosthet Dent,78, 22-7,1997.

25 mm

25 mm 25 mm

# How to Write the proceedings
# TiTle including No. : Times New Roman 14pt Bold

0.5 line

Name (Initial. Family name) : Times New Roman 11 pt, (indent of a 0.5 line above and under this line)
ex. Y. Takada, N. Takahashi[1] and O. Okuno[2]

0.5 line

Affiliation: Times New Roman 11 pt, ex. Division of Dental Biomaterials, Graduate School of dentistry, Tohoku University
[1]Depatrtment of Magnet Science, School of Dentistry, Inaka College
[2]Laboratry of Magnet, Institute of Sendai

0.5pt line (Black)

One line

0.5 line

**Abstract**: Times New Roman bold 11 pt. Type
Abstract should be 10.5 point type (fonts such as Times New Roman (for body text) and Arial(for Headlines) are easy to read)

0.5pt line (Black)

One line

## Manuscript Basics

0.5 line

The proceedings book will be printed directly from the manuscript provided by the author. The conference secretariat staff does not edit or proofread manuscripts, so all material should be concise and error free. The entire paper must be legible.

The components of a paper are (in order of appearance)

Introduction
Objective
Materials and Methods
Results or (Results and discussion)
Discussion
Conclusion
Acknowledgements
References

One line

## Manuscripts Should

0.5 line

- be in a one-column format
- be 10.5 point type (fonts such as Times New Roman (for body text) and Arial(for Headlines) are easy to read)
- be single-spaced
- be justified within the column
- be written by the standard format of MS Word 2003 (number of characters and lines in a page)

Authors should use the page size of A4 format (210 mm × 297 mm). Four spaces (half size English character) should be inserted in the head of first line between paragraphs.

## Main Headings

- bold 12 pt. Type
- 12 pts. (1 line space) before and 6 pts. (0.5 line space) after
- upper- and lower-case
- NO underline (underscore)
- NO italic
- one line of space above and below, except when the heading is at the top of a column
- left justified

### Subheadings

- be bold 10.5 pt. type (font: Arial)

25 mm

- upper and lowercase
- NO underline (underscore)
- NO italic
- indented and on-line with the rest of the paragraph (no extra space above and below)
- *Secondary Subheadings*
- italic 10.5 pt. type (font: Arial)
- upper and lowercase
- NO underline (underscore)
- NO bold
- indented and on-line with the rest of the paragraph (no extra space above and below)

## Margins

- Top 25 mm
- Bottom 25 mm
- Left and right 25 mm

## Figures and Tables

All figures and tables should be imported directly into the document and will be printed along with the text. Figures and tables will NOT be reduced or enlarged by the conference secretariat staff. All figures and tables will be printed in black and white, so do not refer to colors within text to describe graph lines or particular areas of photos.

However, if you will demand the PDF file of your manuscript, you may use colors because the PDF file refer to colors. Note, however, that you should use colors which can be distinguished even when they are printed in black and white.

All figures and tables should be numbered consecutively and placed in numerical order within the manuscript. For each figure, a caption should be placed directly below the figure, and should include the figure number and caption text.

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