A COMPARATIVE STUDY ON THE DISLODGING FORCE OF MAGNETIC ATTACHMENT TO THE DENTURE RESIN BY MAGNETIC DESIGN AND FIXING MATERIALS

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INTRODUCTION

Magnetic attachments are widely used for prosthodontic treatment in contemporary dentistry. In comparison to conventional attachments utilizing mechanical friction, their advantages include the lack of visible metal frameworks, simplified tooth preparation, and less traumatic lateral forces.[1]

The magnetic keeper is usually cast-bonded or cemented with a root post, while the magnetic assembly is fixed to the denture base with auto-polymerizing resin. Detachment of magnetic assemblies are frequently reported.[2] And efforts have been made to prevent the detachment of magnetic assembly by using several kinds of fixing material or modification of the design of the magnetic assembly.[1,3,4]

Magnetic assemblies are generally covered with stainless steel.[5] The AUM20 alloy is a magnetic steel used for the yoke and keeper components of a magnetic attachment (Fe 78.4 %, Cr 19.2 %, Mo 1.9 %).[2] In many cases magnetic assemblies are fixed to the denture base using auto-polymerizing acrylic resin. Matsumura *et al.*[6] reported strong bonding of SUS 304 stainless steel using a composite luting agent that contained a phosphate-methacrylate monomer. Recently a variety of adhesive system for the stainless steel have been reported and used for veneered crowns,[7] stainless steel denture bases,[8] core build-ups,[9] steel attachment sleeves,[10] cementation[11] and orthodontic appliances.[12] Although silicoater and silicoater MD techniques have been successfully used for prosthetic appliances,[13] these require a special apparatus and complicated procedures. It is noteworthy that some bonding systems containing 10-methacryloyloxydecyl dihydrogen phosphate (MDP) or 4-methacryloyloxyethyl trimellitate anhydride (4-META) significantly improved the bonding of resin to stainless steel.[2,14-18]

Another method to reduce the detachment of the magnetic assemblies from the denture base was the modification of magnetic assembly design. It has been reported that with or without wing design, the fixation strength respectively appear to be about 4 kgf and 22 kgf.[2]

The purpose of this study was to compare the dislodging force by the fixing materials and the designs of the magnetic assembly, and to compare the effect between the fixing materials and the designs of the magnetic assembly.

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MATERIAL AND METHODS

Two kinds of fixing material were used in this study to attach the magnetic assembly to the denture base resin. And the fixing materials used in this study are presented in Table Ⅰ (Fig. 1, 2).

In addition, two types of magnetic assembly which were classified by the existence of wing were used (Fig. 3, 4). The magnetic assemblies used in this study are presented in Table Ⅱ. MAGNEDISC was used for the design of magnetic assembly which had no wing (NW) and MAGFIT DX for the design of magnetic assembly which had wing (W). The dimension of the magnetic assembly was 4.5 mm in diameter and 1.3 mm in height.

1. Fabrication of the specimen

20.0 (width) × 20.0 (height) × 9.0 (thickness) mm denture base resin blocks were fabricated with Lucitone®199 (Dentsply, York, PA, USA). Then a 5.0 mm diameter and 2.0mm depth chamber with the 2.0 mm diameter accessing canal in the middle of the chamber was prepared at each denture resin block (Fig. 5).

2. Classification of the experimental groups

32 resin blocks were divided into 4 groups by kinds of fixing material and designs of magnetic assembly as presented in Table Ⅲ.

Table I. Fixing materials used in this study

Fixing material	Abbreviation	Manufacturer	Component
Jet denture repair acrylic®	DR	Lang Dental Mfg.Co., Inc., Wheeling, IL ,USA	Monomer: MMA, Dimethyl-p-toluidine Polymer: PMMA, Diethylphthalate
Super-Bond C&B®	SB	Sun Medical Co., Moriyama, Japan	Initiator: Tri-butylborane Monomer: 4-META, MMA Polymer: Pulverized PMMA

MMA: methyl methacrylate; PMMA: poly (methyl methacrylate); 4-META: 4-methacryloyloxyethyl trimellitate anhydride.

Table II. The magnetic assemblies used in this study

Magnetic assembly	Design	Abbreviation	Manufacturer	Surface coverage
MAGNEDISC	No wing	NW	Aichi steel Co., Tokai, Japan	AUM20 (78Fe-19Cr-2Mo-0.1Ti)
MAGFIT DX	Wing	W	Aichi steel Co., Tokai, Japan	AUM20 (78Fe-19Cr-2Mo-0.1Ti)

Table III. Classification of the experimental groups

Group	Wing	Fixing material	Number
1 (NWDR)	×	DR	8
2 (NWSB)	×	SB	8
3 (WDR)	○	DR	8
4 (WSB)	○	SB	8
			Total 32

DR: Jet denture repair acrylic®; SB: Super-Bond C&B®

Fig. 1. Jet denture repair acrylic® (Lang Dental Mfg. Co., Inc., Wheeling, IL, USA).

Fig. 2. Super-Bond C&B® (Sun Medical Co., Moriyama, Japan).

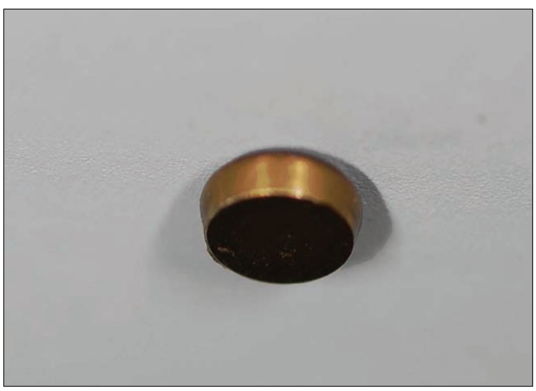

Fig. 3. Magnetic assembly with no-wing design (MAGNEDISC, Aichi steel Co., Tokai, Japan).

Fig. 4. Magnetic assembly with wing design (MAGFIT DX, Aichi steel Co., Tokai, Japan).

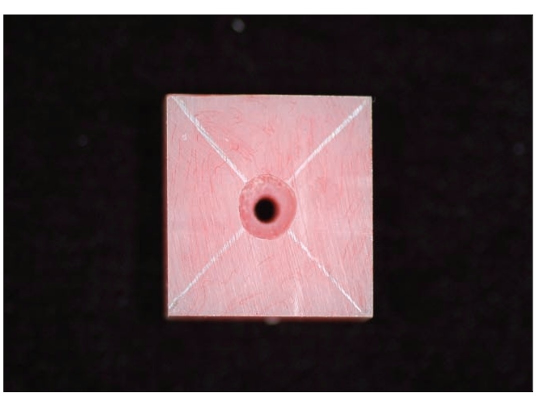

Fig. 5. Denture base resin block fabricated with Lucitone® 199 (Dentsply, York, PA, USA).

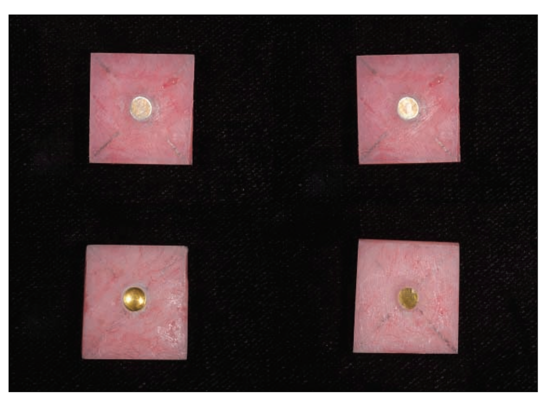

Fig. 6. Resin blocks with the magnetic assemly fixed by each fixing material.

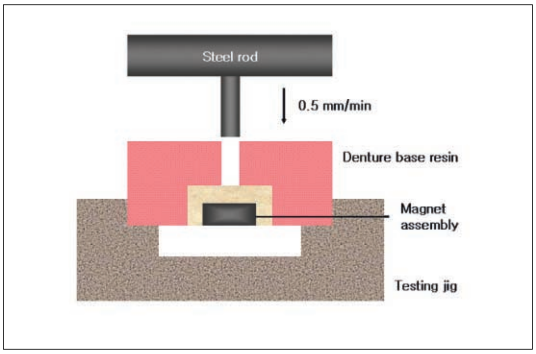

Fig. 7. Experimental setup for the push-out testing.

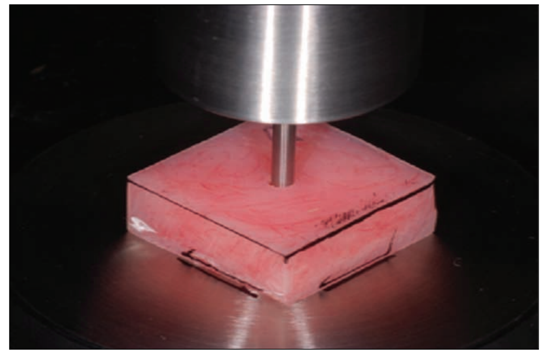

Fig. 8. Push-out test.

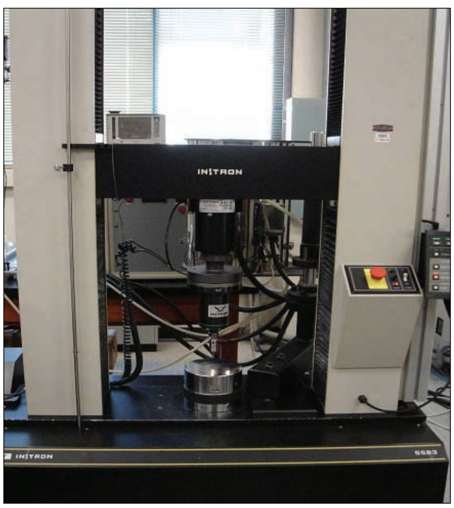

Fig. 9. Universal testing machine (Instron®5583; Instron Co., Canton, MA, USA).

3. Fixation of magnetic assemblies

Each magnetic assembly was fixed to the resin block by the forementioned fixing materials (Fig. 6). According to the manufacturer's instruction each fixing material was added to the chamber of resin block with the brush-on technique, and each magnetic assembly was place to the chamber. Before the setting of the fixing materials the excess were removed. After fixing the magnetic assemblies, all specimens were immersed in the distilled water at room temperature for 24 hours.

4. Treatment of the specimen

The specimens were thermocycled in the water held at 4 ℃ and 60℃ with a dwell time of 1 min each for 2,000 cycles. After the thermocycling each specimen was seated in a testing jig and then a push-out test (Fig. 7, 8) with a universal testing machine (Instron®5583; Instron Co., Canton, MA., USA) (Fig. 9) was performed at a cross-head speed of 0.5 mm/min[16] to measure the maximum dislodging forces. The load applied to the specimen was perpendicular to the magnetic assembly surface, and the load at failure was measured.

5. Statistical analysis

The mean value and the standard deviation of each group were calculated. All data were analyzed with one-way analysis of variance (ANOVA) and multiple range test to check for significant differences between the groups. Pearson's correlation analysis was also used for comparing the effect of the fixing materials and design of the magnetic assembly. SPSS software (Version 12.0, SPSS Inc., Chicago, IL, USA) was used for these statistical analyses.

RESULTS

The mean value and the standard deviation of each group are presented in Table Ⅳ.

Dislodging forces ranged from 120 to 527 N. Group 1 in which the no-wing magnetic assemblies were luted with Jet

Table IV. The results of dislodging force (unit: Newton)

Group	N	Min	Max	Mean	SD
1 (NWDR)	8	120	204	147	28.40
2 (NWSB)	8	187	253	226.87	22.38
3 (WDR)	8	135	237	182.37	33.20
4 (WSB)	8	261	527	403.87	89.46

SD : Standard Deviation

Table V. Results of multiple range test (Scheffe)

Group	1 (147.00N)	2 (226.87N)	3 (182.37N)	4 (403.87N)
1 (NWDR)				
2 (NWSB)				
3 (WDR)	*			
4 (WSB)	*	*	*	

* : Denotes pair of groups significantly different at level of 0.05.

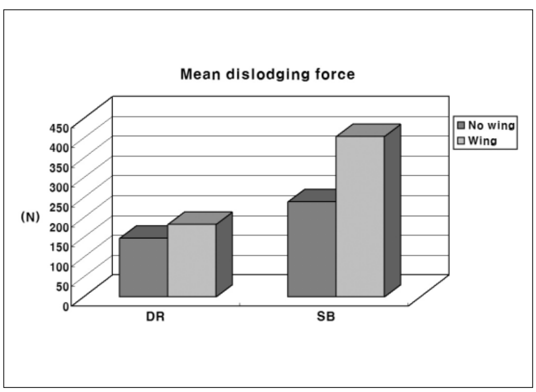

Fig. 10. Comparison of dislodging force between DR and SB groups.

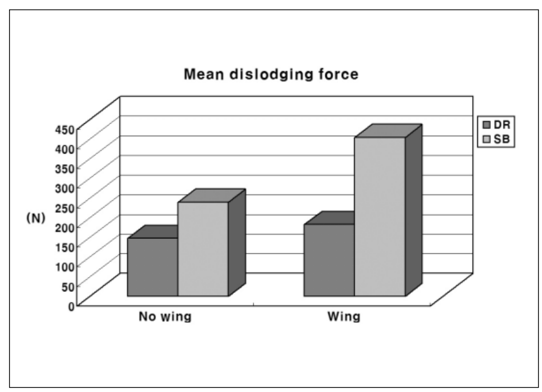

Fig. 11. Comparison of dislodging force between no wing and wing groups.

denture repair acrylic® (DR) showed the lowest mean dislodging force with 147.00 N. Group 2 in which the no-wing magnetic assemblies were luted with Super-Bond C&B® (SB) showed higher mean dislodging force with 226.87 N. In group 3 in which the wing magnetic assemblies were luted with DR, the mean dislodging force was 182.37 N. And group 4 in which the wing magnetic assemblies were luted with SB showed the highest mean dislodging force with 403.87 N.

In Group 2 and 4 which were luted with SB revealed higher dislodging force than Group 1 and 3 which were luted with DR (Fig. 10).

Comparing the effect of the wing design, Group 1 and 2 which have no wing design in the magnetic assembly showed respectively a lower dislodging force than the Group 3 and 4 which have wing design in the magnetic assembly (Fig. 11).

Table Ⅴ represents the pair of groups significantly different at level of 0.05 by the Scheffe's multiple range test. Group 4 shows significantly higher dislodging force than the groups 1, 2 and 3 with mean values of 403.87 N versus 147.00 N, 226.87 N and 182.37 N. And Group 3 shows significantly higher dislodging force than Group 1 with mean values of 182.37 N versus 147.00 N.

By Pearson's correlation analysis, Pearson's correlation coefficient in fixing material was 0.687 (P=0.00), whereas in magnetic design the Pearson's correlation coefficient was 0.484 (P=0.05). This result implicates that the fixing material plays an more important role than the design of the magnetic assembly in dislodging force.

DISCUSSION

Bonding of auto-polymerizing resin to the denture base resin (Lucitone® 199 in this study) is achieved from the penetration and diffusion of monomer in to the denture base resin.[19,20] But the bonding between stainless steel and resin has something to be considered. The magnetic assembly, covered with stainless steel, is embedded into the denture base with auto-polymerizing adhesive resin. It is necessary for the denture that the magnetic assembly and the denture base have to be strongly bonded to avoid detachment of the magnet component from the denture base.

AUM20 is a magnetic stainless steel designed for dental magnetic attachment.[13] The magnetic assembly used in this study was covered with AUM20. Taira *et al.*[21] demonstrated that since the stainless steel is categorized as base metal alloy, it is reasonable to consider that the surface is covered with metallic oxides, characterized by a hydroxyl group and water molecules in the atmospheric environment. The carboxylate group of 4-methacryloyloxyethyl trimellitate anhydride (4-META) interacts with metallic oxide films created on base metal alloy.[3,4,21,22] This fact can explain the stronger dislodging force of SB (Super-Bond C&B®) which have 4-META as a functional monomer compare to DR (Jet denture repair acrylic®) which has no functional monomer in this study.

The second method in this study to prevent the detaching of the magnetic assembly from the denture base was modification of the magnetic assembly design. As expected the wing design in the magnetic assembly, significantly improved the bonding capacity. This result can be explained by the increasing of the bonding area as well as by the mechanical locking of the magnetic assembly into the denture base. Retention of magnetic assembly in prostheses might be improved by physical attachments if the magnetic assembly has undercut like wing design.

Without adhesive bonding, however, the retention force would be reduced by the severe thermal stress due to the difference in the coefficients of thermal expansion between the methacrylic resin and the stainless steel.[1,11,23] There is no doubt in the fact that the combination of magnetic assembly with wing design and Super-Bond C&B® as fixing material can amplify the bonding durability. Although intraoral environment may compromise the bonding between the magnetic assembly and the denture base, a better bonding durability can be achieved by this combination (magnetic assembly with wing design and Super-Bond C&B® as fixing material). But when this combination cannot be satisfied, there should be a consideration about the effect of the fixing materials and design of the magnetic assembly to achieve an adequate dislodging force. In this study by Pearson's correlation analysis, fixing material plays a more important role than the design of magnetic assembly in dislodging force.

There are many reports representing the effect of primer for both of the corrosion resistance and the bonding durability.[21] Moreover, there are many brand-new primers for base metal alloys to enhance the dislodging force between resin and metal alloys. And there has been many reports representing the good combination to increase the dislodging force.[1,3,14,16,21,23] Further efforts should be made to investigate the best combination between the adhesive primer and the fixing materials of magnetic assembly to the denture base.

CONCLUSION

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

1. There were significant differences between Jet denture repair acrylic® and Super-Bond C&B® (P<0.01). Super-Bond C&B® showed a superior dislodging force than Jet denture repair acrylic®.
2. There were significant differences between the designs of magnetic attachment (P<0.05). The wing design in magnetic assembly enhanced the dislodging force.
3. The more influencing factor was the kind of fixing material than the design of magnetic assembly.
4. The combination of Super-Bond C&B® as a fixing material and the magnetic assembly with wing showed the highest dislodging force.

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STATEMENT OF PROBLEM: Detachment of the magnetic assembly from the denture base has been a problem in magnetic overdenture patients. **PURPOSE:** The objectives of this study were to compare the dislodging force by the fixing materials and the designs of the magnetic assembly, and to compare the effect between the fixing materials and the designs of the magnetic assembly. **MATERIAL AND METHODS:** Two fixing materials, Jet denture repair acrylic® and Super-Bond C&B® and two types of magnetic assembly designed with or without wing were used. Each magnetic assembly was fixed in the chamber of the denture base resin block (Lucitone®199) with each fixing material respectively. These specimens were thermocycled 2,000 cycles in the water held at 4℃ and 60℃ with a dwell time of 1 min each time. Each specimen was seated in a testing jig and then a push-out test was performed with a universal testing machine at a cross head speed of 0.5 mm/min to measure the maximum dislodging forces. **RESULTS:** Comparing the fixing materials, Super-Bond C&B® showed superior dislodging force than Jet denture repair acrylic®. Comparing the design of the magnetic assemblies, the wing design magnetic assembly showed better dislodging force. Combination of the Super-Bond C&B® as a fixing material and wing design magnetic assembly revealed a greatest dislodging force. The kind of fixing material was more influential than the type of magnetic assembly. **CONCLUSION:** The dislodging force of Super-Bond C&B® was significantly higher than Jet denture repair acrylic®. And the dislodging force of magnetic assembly which have wing design was significantly higher than magnetic assembly which have no wing design.

KEY WORDS: Magnetic assembly, Denture base, Fixing material, Design of magnetic assembly, Dislodging force

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