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A Comparison of Shear Bond Strength of Two Resin Cements to Different Metal Alloys

İki Rezin Simanın Farklı Metal Alaşımlara Makaslama Bağlanma Dayanımlarının Karşılaştırılması

ABSTRACT

The aim of this study was to investigate the shear bond strength (SBS) of resin cement to different metals manufactured by computer aided design and computer aided manufacturing (CAD/CAM) and laser sintering. One hundred and sixty specimens were prepared and divided into four groups of metal alloy discs: Cr-Co (hard metal, HM; soft metal, SM; laser sintering, LS), and titanium metal (TM). Specimens were sandblasted with 50 μm aluminum oxide and divided into two subgroups, each of which received one of the following luting cements: Adhesive resin cement, Self-etch/self-adhesive resin cement. 50% of the specimens were thermal cycled (10000 cycles, 5–55°C) before being tested for shear bond strength. At thermocycle 0, the highest SBS value (18.3 ± 3 MPa) was found with the self-etch/self-adhesive cement of the HM group (P < 0.05). At thermocycle 10000, there was a significant difference between the cements in the SM and LS groups (p<0.05). Whereas there was no significant difference between the GL groups in terms of thermal cycling, there was a significant difference in the ME groups. The adhesive resin cement was found to be more resistant to thermal cycling than self-etch/self-adhesive cement.

Key Words: Shear bond strength, cobalt-chromium, titanium.

ÖZET

Bu çalışmanın amacı rezin içerikli simanların bilgisayar destekli tasarım/bilgisayar destekli üretim (CAD/CAM) ve lazer sinterleme ile üretilen metal alaşımlara makaslama bağlanma dayanımlarını (SBS) incelemekti. 160 adet metal alaşım disk şeklinde hazırlanan numuneler 4 gruba ayrıldı: Cr-Co (sert metal, HM; yumuşak metal, SM; lazer sinterleme, LS), and titanyum metal (TM). Numunelere 50 μm alüminyum oksit ile kumlama yapılmış ve adeziv rezin siman ile self-etch/self adeziv rezin siman kullanılmak üzere iki alt gruba ayrılmıştır. Makaslama bağlanma dayanımı ölçülmeden önce numunelerin yarısına termal döngü (10000 döngü, 5-55°C) uygulanmıştır. Termal döngü 0 olan grupların içinde en yüksek SBS değeri (18.3 ± 3 MPa) self etch/self adeziv rezin siman ile HM arasında görülmüştür (P < 0.05). Termal döngü 10000'de ise simanların SM ve LS gruplarında anlamlı derecede farklılık vardır (p<0.05). GL grubunda termal döngü açısından anlamlı bir fark olmamasına karşın ME grubunda fark anlamlıdır. Adeziv rezin siman termal döngüye karşı self etch/self adeziv rezin simandan daha dirençli bulunmuştur.

Anahtar Sözcükler: Makaslama bağlanma dayanımı, kobalt-krom, titanyum

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INTRODUCTION

In 1929 cobalt-chromium (Co-Cr) alloys were introduced for use in dentistry. The physical properties of Co-Cr alloys are strength, hardness, low density and a high elastic modulus (1) which allows base metal frameworks to be thinner, lighter, and inflexible (2). Titanium is extensively used for dental restorations with its good biocompatibility, low allergenic potential, high strength, and corrosion resistance (3-5). In addition, titanium prostheses are lighter than those made from Co-Cr or gold (6). The disadvantages of this material are failures in connection with titanium-porcelain (4).

One of the most frequently used prosthetic approaches in contemporary dentistry is metal-ceramic restorations (7). As an alternative to the lost wax technique in the production of metal substructures two main methods are currently available: a subtractive manufacturing technique, such as soft metal milling (SM), hard metal milling (HM), or titanium milling (TM); and an additive manufacturing technique such as laser sintering (LS) (1, 8-12).

HM and TM are subtractive manufacturing techniques which mill CAD/CAM blocks using diamond rotary instruments. This method effectively provides the desired restorations with independent material selection. The disadvantage is that the material is removed from the block while the restoration infrastructure is being produced. SM is also a subtractive manufacturing technique (13). The advantages of this method are a reduction of stress on milling machines and the short manufacturing time. On the other hand, frameworks require a sintering process after milling (14). Additive manufacturing involves three-dimensional printing or sintering techniques (15). LS is based on a rapid prototyping technique and uses a high-temperature laser. Metal particles melt and produce three-dimensional metallic frameworks in layers (11).

Different types of cements are available to clinicians. The adhesion of resin cements to metal alloys is important for the longevity of metal-based restorations and is accomplished through micromechanical, macro mechanical, and chemical methods (16). Resin cements have many clinical stages. Self-adhesive resin cements may adhere to dental tissues without etching or priming, or use separate adhesive agents (17). Although there are studies in the literature that show the bonding strength of titanium alloys are considerably less than cobalt-chromium alloys (2, 16, 17). The null hypothesis was that there would be no differences among the SBS of different metals and cements.

MATERIALS AND METHODS

1.1.Study Specimens

The materials used are listed in Table 1. In the present in vitro study, 12 x 2 mm sized metal disc specimens were prepared. These specimens were divided into sixteen groups (four main groups of metal alloys and two subgroups of resin cements and thermal cycles) of 10 specimens each. The specimens for the four main groups of metal alloys involved are: 40 specimens from Cr-Co, hard metal (HM; Kera-disc, Eisenbacher, Wörth am Main, Germany), 20 specimens from Cr-Co, soft metal (SM; Ceramill Sintron, Amanngirrbach, Pforzheim, Germany), 20 discs from Cr-Co, laser sintering (LS; Remanium star CL, Dentaurum, Germany) and 20 specimens from titanium metal (TM; Kera Ti-5 disc, Wörth am Main, Eisenbacher, Germany). CAD/CAM milling (Ceramill, Amanngirrbach, Pforzheim, Germany), sinter furnace (Ceramill Argotherm, Amanngirrbach, Pforzheim, Germany), and laser sintering (Concept Laser, 4C Medical, Istanbul, Turkey) were used in the preparation of samples. Specimens were embedded in acrylic resin (Palapress Vario, Heraeus Kulzer, Hanau, Germany) then smoothed with silicon carbide papers (600, 800, and 1000 grits) and sandblasted with 50 µm aluminum oxide at a 10 mm distance and 6 psi pressure emission for 20 seconds. Two luting agents consisting of dual-cure adhesive resin cement (G-CEM LinkForce; GC, Tokyo, Japan) and self-adhesive/self-etching resin cement (Maxcem Elite; Kerr, California, USA) were used for specimens. Custom-made Teflon molds with an internal diameter of 3 mm and thickness of 3 mm put on the surface of the specimens. Resin cements were applied to Teflon molds after they were prepared according to the manufacturer's recommendation and a LED (Woodpecker Med. Instrument, Guilin, China) was used for light polymerization for 20 seconds. Teflon molds were removed and samples were kept at 37 ° C for 24 hours before applying the shear bond strength test.

Table I. Specification materials used in this study

Materials	**Component**	**Manufacturer**
Hard metal	Co 61,5 %, Cr 27,75 %, W 8,45 %, Si 1,61%, Mn 0,25%, Fe 0,2%, Others< 0,1 %	Kera-disc; Eisenbacher, Wörth am Main, Germany
Soft metal	Co 66 %, Cr 28 %, W 0 %, Mo 5 % Si, Mn, and Fe <1 %,	Ceramill Sintron; Amanngirrbach, Pforzheim, Germany
Laser sintering	Co 60.5%, Cr 28%, W 9%, Nb < 1%, Si 1.5%, Fe < 1%, Mn < 1%	Remanium star CL; Dentaurum, Ispringen, Germany
Titanium	Ti 89 %, Al6,4 %, V4,1%, others < 0,1%	Kera Ti-5 disc; Eisenbacher, Wörth am Main, Germany
Adhesive resin cement	Dimethacrylate, silica filler, initiators, stabilizers, pigments (63.0 wt%, 38.0 vol%)	G-CEM LinkForce; GC, Tokyo, Japan
Self-adhesive / self-etching resin cement	Glyceroldimethacrylate dihydrogen phosphate, hydroxyethylmethacrylate, 4-methoxyphenol, titanium dioxide cumene hydroperoxide, methacrylate ester monomers, pigments	Maxcem Elite; Kerr, California, USA

2.2 Shear Bond Strength Test

Shear bond strength (SBS) tests were performed using a custom-made and designed device. Test specimens were placed inside the testing device, which was fixed in a universal testing machine (MTS Criterion® Series 42, MN, USA) (Fig. I). Shear loading was applied at the interface of the cement and the metal surface at 0.5 mm/min crosshead speed. The maximum debonding force for each specimen was recorded.

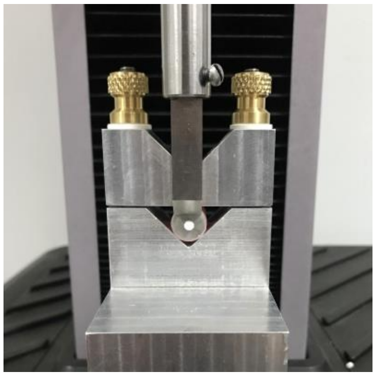

Figure I: Shear bond strength testing

2.3 Statistics

Analyses were performed with statistical software (IBM SPSS Statistics v23.0, IBM Corp, Chicago, USA). The normality of the data distribution was evaluated by the Shapiro-Wilk test. Parameters with a normal distribution were analyzed using one-way ANOVA, the Tukey HDS test was used if the variances of groups were homogenous, and followed by the independent t-test at a significance level 0.05. To compare groups without normal distribution the Kruskal-Wallis H test and Bonferroni corrected Mann Whitney U was used, followed by the Mann-Whitney U test.

RESULTS

The results, as shown in Table II, indicate there was a significant difference between metals in the ME group at thermocycle 0 ($P < 0.05$). In addition there was a significant difference between the cements in the HM group ($P < 0.05$). The highest SBS value (18.3 ± 3 MPa) was found with the ME cement of the HM group ($P < 0.05$). At thermocycle 10000, there was a significant difference between metals in the GL group and between the cements in the SM and LS groups ($P< 0.05$). For the GL group, the SM of SBS (12.8 MPa) was significantly higher than the LS groups (10 MPa; $P < 0.05$). For the SM group, the GL of SBS (12.8 MPa) was significantly higher than the ME groups (7.3 ± 2.3 MPa; $P < 0.05$). For the LS group, the GL of SBS (10 MPa) was significantly higher than the ME groups (4.9 ± 1.9 MPa; $P < 0.05$). While there was no significant difference between the GL groups in terms of thermal cycling, there was a significant difference in the ME groups ($P < 0.05$).

Table II. Values shear bond strength (standard deviations) of the test groups.

	Thermocycle 0			**Thermocycle 10000**		
	GL	**ME**	***P******	**GL**	**ME**	***P*******
Hard metal milling	9.1 ± 3.7	18.3 ± 3^{b}	0.001	10.6 (4.7-12.1)^{ab}	7.4 ± 2.9	0.151
Soft metal milling	12.8 ± 3.1	15.1 ± 3.5^{ab}	0.153	12.8 (9.9-15.3)^{a}	7.3 ± 2.3	**0.001**
Laser sintering	12 ± 4.8	12.6 ± 2.7^{a}	0.734	10 (4.8-10.8)^{b}	4.9 ± 1.9	**0.001**
Titanium milling	11.1 ± 2.7	13.5 ± 2.5^{a}	0.062	11.3 (6.4-14.1)^{ab}	6.8 ± 2.9	0.054
p	0.164*	**0.001***		**0.025*** *	0.153*	

GL; G-CEM LinkForce, ME; Maxcem Elite. Mean values followed by different lowercase letters in the same column Show statistical differences (P<.05). *One-way

ANOVA test and Tukey HSD** Kruskall Wallis test and Bonferroni corrected Mann Whitney U , ***Independent sample t test, **** Mann Whitney u test.

DISCUSSION

The bonding of resin cements to prosthetic materials is an important factor in the final prosthesis.

The current study investigated the SBS of two adhesive resin based cements to four metals manufactured by CAD/CAM and laser sintering. The study result showed that depending on the selected metal, cement, and exposure to thermal cycling, the SBS values may differ. Therefore, the null hypothesis that there would be no significant differences among the SBS of different metals and cements was rejected.

There are many studies on different cements and materials in the literature (2, 16, 17), but the development of technology requires continued study of new materials. Limited articles have been available on the SBS of conventional and self-adhesive resin cements to metal. In the literature, studies of G-CEM LinkForce are limited; there is also no study regarding bonding with the metals investigated with the two types of cement.

In the present study at thermal cycling 0, self-adhesive resin cements showed significantly higher SBS values than thermal cycling 10000, but there was no significant difference between the SBS values of thermal cycles 0 and 10000 for conventional resin cements, perhaps because the bond performance of the cement lies in its additional process. G-CEM LinkForce has a G-Multi Primer which uses three chemical bonding agents such as silane (adhesion to glass ceramics, hybrid ceramics, and composites), MDP (adhesion to zirconia, alumina, and non-precious metal), and MDTP (adhesion to precious metals).

Fujimori et al. (18) investigated the bonding properties of G-CEM LinkForce to lithium-silicate glass ceramics. Similar to this study, there was no significant difference in bond strength before and after thermal cycling.

Zorzin et al. (19) investigated the adhesive performances of self-adhesive resin cements and found a significant decrease in the bond strength of ME cement after thermal cycling, as in the present study. However, unlike the present study, zirconium and lithium disilicate materials were used. Sabatini et al. (20) evaluated the bond strength of ME cement to base metal and found similar results to the current study, but the thermal cycling has not been applied.

This study had some limitations and one of them was the number and type of resin cements. Another limitation was the use of metals produced by different methods. In the following studies, zirconia and CAD/CAM ceramics can be also added.

CONCLUSION

The results covered by this study are as follows:

1. In the ME group, SBS values significantly differed statistically among metals before thermocycling.

2. Thermal cycling did not significantly affect the SBS of G-CEM LinkForce.

3. The adhesive resin cement was found to be more resistant to thermal cycling than selfetch/self-adhesive cement.

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