กำลังแรงยึดแบบเฉือนระหว่างแบร็กเกตจัดฟันโลหะและผิวโลหะหล่อผสมพื้นฐานทางทันตกรรมที่เตรียมด้วยวิธีทางเคมี: การศึกษานอกกาย

Shear Bond Strength Between Metal Orthodontic Brackets and Chemically-Prepared Dental Base Alloy Surfaces: An *In vitro* Study

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บทคัดย่อ

วัตถุประสงค์: การศึกษานี้ออกแบบเพื่อวัดและเปรียบเทียบค่าความแข็งแรงของการยึดติดแบบเฉือนของแบร็กเกตจัดฟันโลหะกับผิวโลหะหล่อผสมพื้นฐานทางทันตกรรมเมื่อใช้เมทัลไพรเมอร์และวัสดุยึดติดต่างชนิดกัน โดยไม่ใช้วิธีการเตรียมพื้นผิวโลหะทางเชิงกลร่วมด้วย

วัสดุและวิธีการ: เตรียมชิ้นงานโลหะหล่อผสมทางทันตกรรมพื้นฐานจำนวน 72 ชิ้น สุ่มแบ่งออกเป็น 3 กลุ่ม ๆ ละ 24 ชิ้นตามชนิดของเมทัลไพรเมอร์ ได้แก่ 1) ไม่ใช้ไพรเมอร์ 2) อัลลอยไพรเมอร์ และ 3) รีไลแอนซ์ไพรเมอร์ ยึดแบร็กเกตกับชิ้นงานในแต่ละกลุ่มย่อยตามระบบของวัสดุยึดติดที่

Abstract

Objectives: This study was designed to measure and compare the shear strength of the bond between metal orthodontic brackets and dental base alloys when different metal primers and different adhesive bonding systems were applied without any mechanical preparation on the alloy surfaces.

Materials & Methods: Seventy-two dental base alloy discs were cast and randomly categorized into three groups (24 each) according to the

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ใช้คือชนิดบ่มตัวด้วยแสง 12 ชิ้นและชนิดบ่มเอง 12 ชิ้น บ่มชิ้นงานในน้ำกลั่นที่อุณหภูมิ 37 องศาเซลเซียสนาน 24 ชั่วโมง ผ่านขบวนการเทอร์โมไซคลิง ทดสอบความแข็งแรงของการยึดติดแบบเฉือนด้วยเครื่องทดสอบอเนกประสงค์ นำข้อมูลมาวิเคราะห์ทางสถิติเชิงพรรณนาและเชิงเปรียบเทียบ และบันทึกค่าดัชนีของวัสดุยึดติดที่เหลือหลังการทดสอบ

ผลการศึกษา: ชนิดของวัสดุยึดติดและชนิดของเมทัล-ไพรเมอร์มีผลต่อความแข็งแรงของการยึดติดแบบเฉือนที่ระดับนัยสำคัญทางสถิติน้อยกว่า 0.05 วัสดุชนิดบ่มตัวด้วยแสงอย่างเดียวโดยไม่ใช้ไพรเมอร์ไม่ยึดติดกับผิวโลหะในการทดลอง ในขณะที่วัสดุชนิดบ่มเองให้ค่าการยึดติดแบบเฉือนสูง การใช้วัสดุชนิดบ่มตัวด้วยแสงร่วมกับอัลลอยไพรเมอร์ให้ค่าความแข็งแรงของการยึดติดแบบเฉือนสูงกว่าเมื่อใช้ร่วมกับรีไลแอนซ์ไพรเมอร์อย่างมีนัยสำคัญทางสถิติ การใช้อัลลอยไพรเมอร์หรือรีไลแอนซ์ไพรเมอร์ร่วมกับวัสดุชนิดบ่มเองให้ค่าความแข็งแรงของการยึดติดแบบเฉือนไม่ต่างกัน กลุ่มที่ใช้เมทัลไพร-เมอร์ร่วมกับวัสดุยึดติดชนิดบ่มเองให้ค่าการยึดติดสูงกว่ากลุ่มที่ใช้วัสดุยึดติดชนิดบ่มเองอย่างเดียวอย่างมีนัยสำคัญทางสถิติ พบการหลงเหลือของวัสดุยึดติดชนิดบ่มเองบนผิวโลหะแตกต่างกันตามชนิดของเมทัลไพรเมอร์ที่ใช้ ไม่พบวัสดุยึดติดบนผิวโลหะเลยเมื่อใช้วัสดุยึดติดชนิดบ่มตัวด้วยแสง

สรุป: เมทัลไพรเมอร์เพิ่มความแข็งแรงของการยึดติดแบบเฉือนระหว่างวัสดุยึดติดกับผิวโลหะหล่อผสมพื้นฐาน การศึกษาในห้องทดลองนี้แนะนำการใช้เมทัลไพรเมอร์ร่วมกับวัสดุยึดติดชนิดบ่มเอง

คำสำคัญ: กำลังแรงยึดแบบเฉือน โลหะหล่อผสมพื้นฐานทางทันตกรรม ไพรเมอร์โลหะ เรซินแอดฮีซีฟ แบร็กเกตจัดฟันโลหะ

different type of metal primer to be used: 1) No primer, 2) Alloy Primer, and 3) Reliance Metal Primer. Brackets were bonded to the discs of each subgroup according to the bonding system used: 12 discs of light-cured adhesive and 12 discs of self-cured adhesive. After the discs were stored in 37°C distilled water for 24 hours, thermal cycling was performed on them. Shear bond strength was tested using a universal testing machine. Descriptive and comparative statistical analyses of the bond strength were carried out. The failure mode was also investigated.

Results: The type of dental adhesive and the type of metal primer affected the shear strength of the bond ($p < 0.05$). Light-cured bonding adhesive without primer could not bond to the alloy surfaces while self-cured adhesive showed high bond strength. For light-cured bonding adhesives, Alloy Primer produced significantly greater bond strength than did Reliance Primer. For self-cured adhesive, Alloy Primer showed comparable bond strength to Reliance Primer. Metal primers with self-cured adhesive revealed significantly greater bond strength than self-cured adhesive alone. The failure mode after bracket debonding differed with the primer used with self-cured adhesive. No adhesive remains on alloy surface when bonded with light-cured adhesive.

Conclusions: Metal primer can significantly improve the shear strength of the bond between orthodontic adhesives and dental base alloy surfaces. In this *in vitro* study, combination of metal primer and self-cured adhesive is recommended.

Keywords: shear bond strength, dental base alloy, metal primer, adhesive resin, metal orthodontic bracket

Introduction

Full coverage crown restorations in posterior teeth are commonly found in orthodontic patients. Most published studies relating to bonding procedures focus on noble or precious dental alloys. The lack of published studies relating to non-precious metal alloys prompted the author to find a method to prepare such alloy surfaces for bonding orthodontic attachments.

Classification of dental alloys is based on noble metal content of an alloy: high noble alloy, noble alloy and predominantly base alloy.(1) Dental cast alloys for crown restorations can be categorized into gold-based alloys, silver-palladium alloys and base metal or non-precious alloys.(2,3) Base metal alloys contains no gold, no platinum and no palladium. There are three types of base alloys: nickel-chromium alloy, cobalt-chromium alloy and titanium alloy.(4) Nickel can cause more allergic contact dermatitis than can other elements.(5) Alloys without nickel have been marketed increasingly.

Some previous studies have reported on the procedures for bonding orthodontic brackets to noble alloy surfaces.(6-8) Those procedures, such as grinding with stone burs, sandblasting or tin-plating, are somewhat uncomfortable in clinical practice. The application of gallium and tin solutions can improve the strength of the bond between the adhesive and alloy surface.(9) One common approach is the use of an adhesive resin, such as SuperBond C&B (Sun Medical Co., Ltd., Shiga, Japan), that can bond to the alloy.(7) This adhesive is composed of 4-methacryloxyethyl trimellitate anhydride (4-META) and tri-n-butylborane (TBB) monomer and polymethyl methacrylate (PMMA) polymer powder. 4-META can bond chemically to alloy. However, the strength of the bond between this adhesive and dental alloy is still lower than that between the adhesive and enamel.(9,10) There are few studies on the strength of the bond between orthodontic brackets and base alloy surfaces.(11,12)

There are three major approaches in the preparation of alloy surfaces before bonding orthodontic attachments: mechanical preparation, chemical preparation and a combination of both.(13) A combination of the two approaches is often recommended to achieve optimal bond strength.

Mechanical preparation aims to create roughness on the alloy surface and to increase the surface area for micromechanical retention. The roughness can be created with various techniques, such as acid etching, sandblasting or roughening with abrasive burs, such as diamond or stone burs.

Chemical preparation with metal primers, developed in the late 1980s, can improve the bonding between adhesive resin and metal alloy.(14) Metal primers modify the alloy surfaces for bonding with resin. There are two components in a metal adhesive primer: resin monomer and solvent. There are three parts in the resin monomer; functional part, polymerizable part and connecting part.(15-17) The functional part is further categorized into four groups: 1) carboxylic acid derivatives; 2) phosphoric acid derivatives, both of which bond chemically to base metal alloys; 3) thiol or thione derivatives, which are composed of mercaptan, and bond chemically with the atoms of noble metal alloys; and 4) thio-phosphate derivatives, which consist of two functional groups, and bond both with noble alloys and the metal oxide layer of base alloys. The other two component parts of this resin monomer are a polymerizable part, which binds to the C=C bond in the adhesive resin and prevents deionization of polymers, and a connecting part, which connects the functional group and the polymerizable part, and induces hardening. Solvents in metal adhesive primer are acetone or alcohol.

Several studies have compared the shear bond strength between metal alloys and adhesive resins, using many types of metal primers.(18-24)

Metal primers significantly improve the strength of the bond between adhesive resin cement and high noble alloys(18,19), noble alloys(20-22), base metal alloys(20,23) and titanium alloys.(16)

The purpose of this *in vitro* study was to measure and compare the shear bond strength between metal orthodontic brackets and non-nickel, non-precious dental base alloys when different metal primers and different adhesive bonding systems were applied without any mechanical surface preparation on the alloy surface. This study also recorded the adhesive remnant index after de-bonding the brackets.

Materials and Methods

Seventy-two non-nickel, non-precious dental base alloy discs (Argeloy N.P. Special; The Argen Corporation, CA, USA) were cast with a diameter of 9 mm and with a 2-mm thickness. The alloy disc was placed on the flat surface, and then the stainless ring was positioned until the disc was at the center of the ring. Each ring was filled with self-cured acrylic resin (Jet™ Tray Resin, Lang Dental, Wheeling, IL, USA). The outside and inside diameters of the rings were 20 mm and 16 mm, respectively; the ring height was 10 mm. After resin polymerization, the specimens were examined, cleaned and checked for parallelism of the resin surface and the rings' edges. The specimens were cleaned for fifteen minutes in an ultrasonic bath filled with 37°C deionized water and dried at the room temperature. The specimens were randomly categorized into three groups (24 each) according to the type of metal primer to be used: 1) No primer, 2) Alloy Primer (Kuraray Noritake Dental Inc, Okayama, Japan), and 3) Reliance Metal Primer (Reliance Orthodontic Products, Inc, IL, USA). Each primer was applied on the alloy surface with a brush in a uniform coating and allowed to dry, strictly according to manufacturer's instructions. Each group was separated into two subgroups of 12 specimens according to the adhesive bonding system to be applied: 1) light-cured adhesive (Transbond™ XT, 3M Unitek, Monrovia, CA, USA) or 2) self-cured adhesive (SuperBond C&B, Sun Medical Co, ltd. Shiga, Japan). Metal maxillary central incisor brackets (GEMINI MBT 0.022 Twin; 3M Unitek, Monrovia, CA, USA) were used in this study. The composition of the dental alloy, the metal primers and the adhesives used in this study, along with their manufacturers and lot numbers, are listed in Table 1.

Each bracket loaded with an adhesive was positioned and subjected to a 200-gram compressive force with a force gauge (CORREX D-7530, Dentaurum, Ispringen, Germany) for ten seconds. At the same time the excess bonding resin was removed with a small scaler. In the groups bonded with Transbond XT bonding system, the force was removed and the adhesive was polymerized with a Mini LED™ (Satelec® Acteon Group, Merignac, France) curing light, providing light intensity of 1,250 mW/cm^2 for twenty seconds on each side (mesial, distal, incisal, and cervical edge) at a controlled distance of 5 mm. After bonding, all specimens were stored in 37°C distilled water for twenty-four hours for complete polymerization of the adhesive systems. Thermal cycling was performed between 5°C and 55°C for 2,000 cycles with a dwell time of ten seconds in each bath, modified from ISO 10477.(25)

The brackets were de-boned with a shear force using a universal testing machine (Instron 5566, Instron Calibration Laboratory, Canton, MA, USA). The applied force was located at the interface and was parallel to the alloy surface. The crosshead speed was set at 1 mm/min and a 1-kN load cell was used. The calculated shear bond strength was determined by dividing the recorded force at which the bond failure occurred (newtons) by the bonding area (mm^2). The bracket base surface average values were 10.9667 mm^2. The de-bonded metal surfaces were examined under 10x magnifications. Remaining adhesive was

ตารางที่ 1 *ส่วนประกอบของโลหะผสมทางทันตกรรม เมทัลไพรเมอร์ และ วัสดุยึดติดที่ใช้ในการศึกษานี้*

Table 1 *The dental alloy, metal primers and adhesives used in this study*

	Contents	**Lot**
Dental alloy		
Argeloy N.P. Special (The Argen Corporation)	Cobalt 59.5%, Chromium 31.5%, Molybdenum 5.0%, Silicon 2.0%, Manganese < 1%, Iron < 1%, Carbon < 1%	-
Metal primers		
Alloy Primer (Kuraray Noritake Dental Inc.)	Acetone > 90% 6-(4-vinylbenzyl-N-propyl) amino-1,3,5-triazine-2,4- dithione (VBATDT) 10-Methacryloyloxydecyl dihydrogen phosphate (MDP)	00444C
Reliance Metal Primer (Reliance Orthodontic Products, Inc.)	Methyl methacrylate 60-99%	134889
Adhesives		
Transbond™ XT primer (3M Unitek)	Bisphenol A diglycidyl ether dimethacrylate (BISGMA) 45-55% Triethylene glycol dimethacrylate 45-55% Triphenyl antimony < 1% 4-(dimethylamino)-benzeneethanol < 0.5% DL-camphorquinone < 0.3% Hydroquinone < 0.03%	N474911
Transbond™ XT Light Cure adhesive (3M Unitek)	-Silane treated quarts 70-80% -BISGMA 10-20% -Bisphenol A Bis(2-hydroxyethyl ether) dimethacrylate 5-10% -Sliane treated silica < 2% -Diphenyliodonium hexafluorophosphate < 0.2%	N467354
SuperBond C&B (Sun Medical Co, Ltd.)	**Catalyst V** -Partially oxidized Tri-n-butylborane (TBB-O) 80% -Hydrocarbon balance **Monomer** -Methyl methacrylate (MMA) balance -4-methacryloxyethyl trimellitic acid anhydride (4-META) ~ 5% **Polymer** (L-type Clear) -Poly(methyl methacrylate) or PMMA balance -Metal oxides 0-50%	GK12 GK1 GE12

ตารางที่ 2 *ค่าเฉลี่ยและส่วนเบี่ยงเบนมาตรฐานของค่ากำลังแรงยึดติดแบบเฉือน (เมกะปาสคาล) ในแต่ละกลุ่มการศึกษาตามชนิดของเมทัล-ไพรเมอร์และชนิดของวัสดุยึดติดที่ต่างกัน*

Table 2 *Means and standard deviations of the shear bond strength (MPa) in the study groups*

Bonding / **Primer**	**Transbond™ XT adhesive (TBXT)**	**SuperBond C&B adhesive (SBCB)**
No primer (NoP)	0 ± 0	11.05 ± 5.61
Alloy Primer (AlloyP)	7.41 ± 1.55	19.77 ± 4.70
Reliance Primer (RelianceP)	4.02 ± 2.49	18.60 ± 3.54

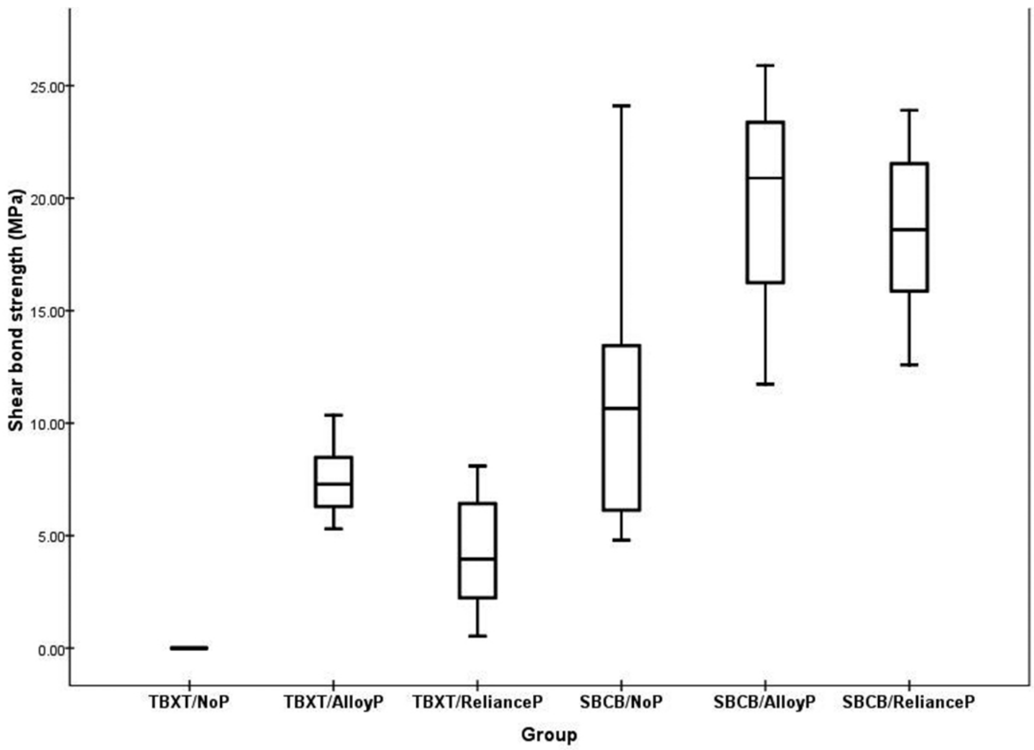
assessed and recorded as modified Adhesive Remnant Index (ARI) scores.[26] The adhesive remnant scores ranged from "0" to "3" to define the sites of bond failure. Score "0" indicated that there was no adhesive left on the alloy surface. Score "1" indicated that there was less than 50% of the adhesive left on the alloy surface. Score "2" indicated that there was more than 50% of the adhesive left on the alloy surface. The maximum score "3" indicated that the entire adhesive was left on the alloy surface.

Descriptive and comparative statistical analyses were carried out using SPSS for Windows (SPSS, Chicago, IL, USA). The mean shear/peel bond strength, the standard deviations were calculated. The analysis of variance and multiple comparison tests were performed. The level of significance was set at $p < 0.05$. The percentage of the bond failure mode was calculated for each group.

Results

Means and standard deviations of the shear bond strength are presented in Table 2 and Figure 1.

Without metal primer, all brackets bonded with light-cured adhesive dislodged after the thermocycling process. The Shapiro-Wilk test demonstrated a normal distribution in all groups with $p>0.05$. Two-way analysis of variances showed that there was no statistically interaction between these two independent variables (the type of adhesive and the type of metal primer). This finding revealed that the type of dental adhesive and the type of metal primer did statistically affect the shear strength of the bond



รูปที่ 1 *กราฟแสดงค่าเฉลี่ยกำลังแรงยึดแบบเฉือน (เมกะปาสคาล) ในแต่ละกลุ่มตามชนิดของเมทัลไพรเมอร์และชนิดของวัสดุยึดติดที่ต่างกัน TBXT: ทรานส์บอนด์เอกซ์ที; SBCB: ซูเปอร์บอนด์ซีแอนด์บี; NoP: ไม่ใช้ไพรเมอร์; AlloyP: อัลลอยไพรเมอร์; RelianceP: รีไลแอนซ์ไพรเมอร์*

Figure 1 *Box plot of mean shear bond strength (MPa) for the different metal primers and different adhesive resins TBXT: TransBond™XT; SBCB: SuperBond C&B; NoP: No primer; AlloyP: Alloy Primer; RelianceP: Reliance Primer* between the adhesive and the alloy surface ($p < 0.05$). Post-hoc comparison using the Tamhane test showed statistically significant differences in the shear bond strength among the groups, as shown in Table 3.

Light-cured bonding adhesive (Transbond™ XT) alone could not hold the bracket on the base alloy surface throughout the experiment. On the other hand, the self-cured adhesive (SuperBond C&B) without metal primer group provided high shear bond strength (11.05±5.61 MPa).

With the use of metal primer, the shear bond strength among the brackets, adhesive and the dental base alloys was improved in all groups. With light-cured bonding adhesives, Alloy Primer produced significantly higher shear bond strength (7.41±1.55 MPa) than did Reliance Primer (4.02±2.49 MPa) ($p<0.05$). With self-cured bonding adhesives, Alloy Primer provided insignificant higher shear bond strength (19.77±4.70 MPa) than Reliance Primer (18.60±3.54 MPa). However, both metal primers provided highly greater significant shear bond strength than that of the group with self-cured adhesive alone (11.05±5.61 MPa).

Shear bond strength in the groups with self-cured bonding adhesives were significantly greater than that with light-cured adhesives, except between the self-cured adhesive alone and the combination of light-cured adhesive and Alloy Primer. The combination of self-cured bonding resin (SuperBond C&B) and either Alloy Primer or Reliance Primer provided significantly greater shear bond strength than did the combination of light-cured bonding adhesive and both metal primers ($p<0.05$). Comparable shear bond strength was achieved in the light-cured adhesive with Alloy Primer group (7.41±1.55 MPa) and the self-cured adhesive without metal primer group (11.05±5.61MPa).

ตารางที่ 3 *การเปรียบเทียบทางสถิติโพสฮอกในแต่ละกลุ่มที่ระดับค่าพี น้อยกว่า 0.05*

Table 3 *Post hoc comparison test between each group at p<0.05*

Tamhane Test	1) TBXT/ NoP	2) TBXT/ AlloyP	3) TBXT/ RelianceP	4) SBCB/ NoP	5) SBCB/ AlloyP	6) SBCB/ RelianceP
SBS:MPa mean(SD)	0(0)	7.41(1.55)	4.02(2.49)	11.05(5.61)	19.77(4.70)	18.60 (3.54)
1) TBXT/ NoP		-	-	-	-	-
2) TBXT/ AlloyP	-		**	NS	**	**
3) TBXT/ RelianceP	-	**		**	**	**
4) SBCB/ NoP	-	NS	**		**	**
5) SBCB/ AlloyP	-	**	**	**		NS
6) SBCB/ RelianceP	-	**	**	**	NS	

***: ต่างอย่างมีนัยสำคัญที่ค่าพีน้อยกว่า 0.05 NS: ไม่มีความแตกต่างทางสถิติค่าพีมากกว่า 0.05*

SBS: ค่ากำลังแรงยึดติดแบบเฉือน; MPa: เมกะปาสคาล; TBXT: ทรานส์บอนด์เอกซ์ที; SBCB: ซูเปอร์บอนด์ซีแอนด์บี; NoP: ไม่ใช้ไพรเมอร์; AlloyP: อัลลอยไพรเมอร์; RelianceP: รีไลแอนซ์ไพรเมอร์

***: Significant difference with p<0.05; NS: Non-significant difference with p>0.05; SBS: Shear bond strength; MPa: MegaPascal; TBXT: TransBond™XT; SBCB: SuperBond C&B; NoP: No primer; AlloyP: Alloy Primer; RelianceP: Reliance Primer*

ตารางที่ 4 *ความถี่และร้อยละของค่าการหลงเหลือของวัสดุยึดติดที่ดัดแปลงในแต่ละกลุ่ม*

Table 4 *Frequencies and percentages of modified ARI scores for each study group*

Group	SBS:MPa Mean(SD)	Modified ARI Score			
		0	1	2	3
1) TBXT/NoP	0(0)	12 (100%)	0	0	0
2) TBXT/AlloyP	7.41(1.55)	12 (100%)	0	0	0
3) TBXT/RelianceP	4.02(2.49)	12 (100%)	0	0	0
4) SBCB/NoP	11.05(5.61)	11 (91.7%)	1 (8.3%)	0	0
5) SBCB/AlloyP	19.77(4.70)	0	0	7 (58.3%)	5 (41.7%)
6) SBCB/RelianceP	18.60(3.54)	4 (33.3%)	6 (50%)	2 (16.7%)	0
Total	72 (100%)	51 (70.8%)	7 (9.7%)	9 (12.5%)	5 (7.0%)

SBS: ค่ากำลังแรงยึดติดแบบเฉือน; MPa: เมกะปาสคาล; TBXT: ทรานส์บอนด์เอกซ์ที; SBCB: ซูเปอร์บอนด์ซีแอนด์บี; NoP: ไม่ใช้ไพรเมอร์; AlloyP: อัลลอยไพรเมอร์; RelianceP: รีไลแอนซ์ไพรเมอร์

SBS: Shear bond strength; MPa: MegaPascal; TBXT: TransBond™XT; SBCB: SuperBond C&B; NoP: No primer; AlloyP: Alloy Primer; RelianceP: Reliance Primer

The modified ARI scores identifying the bond failure mode after bracket de-bonding were calculated in frequencies and percentages. The results are shown in Table 4.

The ARI scores in all groups with light-cured bonding adhesive (100%) revealed no adhesive remaining on the alloy surfaces with ARI scores of 0. The ARI scores in groups with self-cured bonding adhesive showed different percentages, depending on the metal primer used. Firstly, without metal primer there were 8.3% of ARI scores of 1, 91.7% of ARI scores of 0. Secondly, with Alloy primer, only ARI scores of 2 and 3 were recorded (58.3% and 41.7% respectively). Lastly, with Reliance primer the scores of 0, 1 and 2 were detected (33.3%, 9.7% and 16.7% respectively).

Discussion

Chemical preparation with metal adhesive primer improved the bonding of bracket and the adhesive on the alloy surface. The dental alloy in this study (Argeloy N.P. Special) was composed of chromium (59.5%), cobalt (31.5%), molybdenum (5%), silicon (2%) and some trace (<1%) of manganese, iron and carbon. It is the base alloy without any nickel in the composition.

Without the application of metal adhesive primer, light-cured bonding adhesive (Transbond™ XT) alone could not hold the bracket on the alloy surface throughout the study. There is no functional group capable of bonding to dental alloy in this adhesive. It is mainly composed of bisphenol A diglycidyl ether dimethacrylate (BisGMA) and some compositions which cannot create a chemical bond to alloy surface. Self-cured adhesive tested in this study, SuperBond C&B adhesive resin, contains the functional groups which are 4-META in a monomer part and high amount of PMMA in a polymer part. 4-META and PMMA work as carboxylic derivative functional groups which possibly provide high bond strength to base alloy without any addition of metal primer (11.05±5.61 MPa) which was 1-1.5 times the optimal value recommended by Reynolds (6-8 MPa).[27] In other words, this self-cured adhesive resin bonds chemically to the base alloy surface by itself.

Chemical bonding of the resin monomer components in the metal primer to the base alloy occurs on the oxide layer covering the alloy surface.[28,29] The bond strength value depends on the type and the amount of the functional groups in the metal primer.

The functional groups in metal primer modify the alloy surface. Carboxylic acid derivatives and phosphoric acid derivatives in the primers bond chemically to base metal alloy. Alloy Primer is composed of two functional groups; 1) VBATDT which is a thione functional group that bond to noble metal alloy and 2) MDP which is a phosphoric derivative functional group that bond to base alloy. The functional group in Reliance Primer is methyl methacrylate (MMA) which is a carboxylic derivative. In the groups bonded with light-cured adhesive, shear bond strength provided by the combination with the Alloy Primer (7.41±1.55 MPa) was optimal according to Reynolds while with Reliance Primer (4.02±2.49 MPa) was lower than the recommended value (6-8 MPa).[27] The phosphoric derivative functional groups (MDP) in Alloy Primer provided significantly greater shear bond strength than did the carboxylic derivative functional groups (MMA) in Reliance Primer. It could be implied that phosphoric derivative functional groups created more stable and stronger bond than carboxylic derivative functional groups when bonded to dental base alloy. This finding was similar with the use of self-cured bonding resin, however, there was no significant difference in the shear bond strength between Alloy Primer group (19.77±4.70 MPa) and Reliance Primer group (18.60±3.54 MPa). Both metal primers provided highly greater significant shear bond strength for 1) two times than that of the group with self-cured adhesive alone (11.05±5.61 MPa) and 2) 2-4 times greater than the recommended value.[27]

Shear bond strength achieved with SuperBond C&B resin adhesive alone (11.05±5.61 MPa) was greater 2.5 times than with the combination of light-cured adhesive and Reliance Primer (4.02±2.49 MPa). It could be explained that, even though they are all in the carboxylic acid derivative groups, there were more source of the functional groups from both in monomer and polymer of self-cured adhesive (4-META and PMMA) than only one source of functional group from Reliance Primer (MMA). All groups except group 1(TBXT/NoP) and group 3 (TBXT/RelianceP) provided the acceptable bond strength suggested by Reynolds.[27]

All groups with the use of light-cured adhesive showed the bond failure at the alloy-adhesive interface with the ARI scores of 0 which implied the stronger bond between the adhesive and the bracket base than the bond between the adhesive and the alloy surface. With the use of self-cured adhesive with or without the metal primer, there was an increased incidence of the bond failure at the adhesive-bracket interface which implied an improved bond between the alloy and the adhesive. The ARI scores of 2 and 3; with more remnants of the adhesive on the alloy surface, were noticed in the groups of self-cured adhesive and metal primer as shown in Table 4. The higher the shear strength of the bond attained, the more the adhesive remaining on the alloy surface. As a result, increased chair time in cleaning and restoring the dental alloy surface after debonding is unavoidable.

As we know that the de-bonding forces measured *in vitro* were greater than those measured in clinical situation. Shear force from the testing machine is continuously increasing and providing the unilateral load at the bracket–adhesive interface, which may not represent the clinical force applications.[30] In addition, the laboratory study cannot reproduce all condition in oral environment such as complex stresses, masticatory force, humidity, acidity, plaque, saliva or blood contamination, and patient abuse, which may lead to the decrease of bond strength values.[31] Despite that even most of the metal restorations fabricated were curved for the posterior teeth, this study tested the shear strength of the bond on the flat alloy surface in order to control the thickness of the adhesive film. The results should be carefully interpreted and should be used only to indicate which materials seem proper to be include in any further clinical investigation.[6]

For clinical implication from the findings in this study, the choice in bonding the orthodontic attachments on the dental base alloy could be the self-cured adhesive better than light-cured adhesive. Bonding strength could be improved with the combination of metal primer and either Alloy Primer of Reliance Primer.

Conclusions

From this *in vitro* study, the metal adhesive primers significantly improve the shear strength of the bond among metal orthodontic brackets, orthodontic bonding adhesives and the base alloy surfaces. Light-cured adhesive with or without metal primer are not recommended. Self-cured adhesive is a preferred material and would provide increased bond strength when it is combined with the metal primers. There was more percentage of adhesive remnants on the alloy surface with the use of self-cured adhesive and Alloy Primer than with Reliance Primer after bracket de-bonding which indicated a prolong treatment time in debonding.

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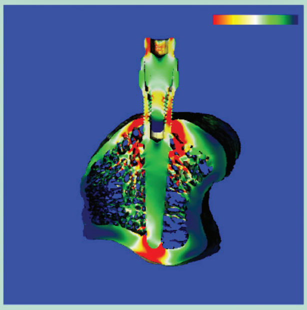

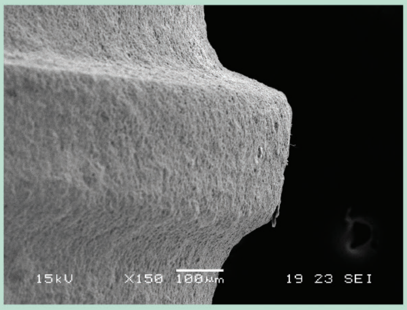

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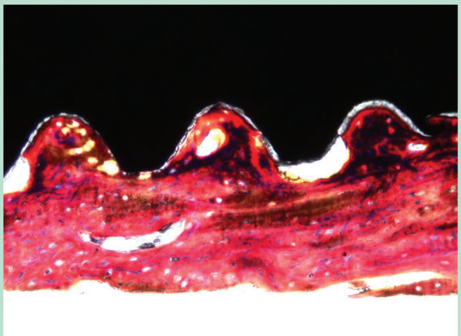

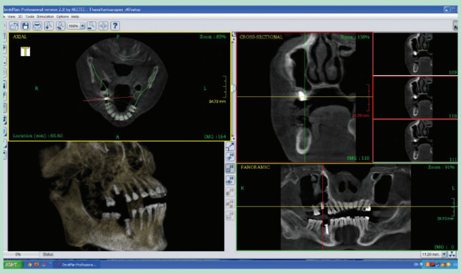

The Creating of Emergence Profile and Interdental Papilla of Two Central Incisors Dental Implant with Modified of Temporary Crown Technique

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Introduction

Although tooth replacement with dental treatment protocol in aesthetic area has been well established. The most difficult clinical situation in aesthetic area is the replacement of both central incisors with dental implants. The factors involved with the dental implant treatment in this situation are the gingival biotype, position of implants, bone quantity and quality, teeth shape, and the distance of the alveolar crest to contact area of the teeth.

Case report

A 43-year-old healthy female with missing of two upper central incisor is present at the clinic with chief complaint of esthetic and confident problem (Fig. 2). The patient has used acrylic partial denture for many years. After prosthodontic and surgical treatment plan and esthetic analysis (Fig. 4), two surgical implant placements were performed (Fig.3). In this case, the implants were 3.75x12 mm. from PW plus (Fig. 1). After osseointegration, the patient returned for clinical evaluation (Fig. 5-6), frequency resonance analysis and radiographs. Closed-tray technique impression was taken. Provisional crowns were fabricated and gradually added with flowable resin acrylic to establish emergence profile (Fig. 7-8, 11). After soft tissue surrounding conformed to the provisional crowns (Fig 9-10), the provisional crowns were removed. The final all ceramic restoration was taken (Fig. 13). After one year, the emergence profile and marginal bone around the dental implants have maintained (Fig. 12, 14-15).

Discussion and conclusion

The outcome of treatment is excellent but it is time consuming. However, the procedure is non-invasive and not complicate to perform.

Fig. 1, Fig. 2, Fig. 3, Fig. 4, Fig. 5, Fig. 6, Fig. 7, Fig. 8, Fig. 9, Fig. 10, Fig. 11, Fig. 12, Fig. 13, Fig. 14, Fig. 15

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