

Shear bond strength of nickel-chromium alloys with different surface treatments

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ABSTRACT

The main objectives of this study were to determine the effect of different nickel-chromium alloys with different surface treatment bonded to enamel tooth surface on the shear bond strength. Seventy five wax disc-shaped samples were prepared. These discs were divided into three groups, (25) in each. The first group was casted with CB-Bland 72 alloy, the second with CB-soft alloy, and the third group with Kera-N alloy. For surface treatment procedures each group was divided into five subgroups, five samples in each: the first subgroup was sandblasted with (50) μm Al_2O_3 plus electrolytical etching. The second subgroup only electrolytically etched; the third subgroup sandblasted with with (50) μm Al_2O_3 ; The fourth subgroup sandblasted with (100) μm Al_2O_3 , and the fifth subgroup received no surface treatment. The metal discs were bonded to the labial surface of upper central and lateral incisors using intermediate resin and adhesive luting cement. The samples were thermocycled between (5-60) $^\circ\text{C} \pm (2)^\circ\text{C}$ for (500) cycles at (1) minute dwell time and then stored in distilled water in an incubation at (37) $^\circ\text{C}$ for seven days. After that the shear-bond strength were tested.

The results showed that the mean shear-bond strength of CB - Bland 72 alloy was found to be greater than that of Kera - N and CB - Soft alloys, and surface treatment with (100) μm Al_2O_3 procedure exhibit the highest bond strength.

Key Words: Resin bonded fixed partial denture, adhesive bridges, shear-bond strength

الخلاصة

الهدف الرئيسي لهذه الدراسة هو تحديد تأثير أنواع مختلفة من سبائك النيكل - كروم مع طرق مختلفة لمعاملة السطوح على قوة الربط الانزلاقي. تم تحضير (75) قالب شمعي ومن ثم تقسيمها إلى ثلاث أقسام: القسم الأول تم صبه من سبيكة (CB - Bland 72) والثاني من سبيكة (Kera - N) والثالث من سبيكة (CB - Soft). تمت عملية معاملة السطوح للسبائك بطرق خمسة: الأولى بمعاملتها بأكاسيد الألمنيوم ذات حجم (50) مايكرون ثم تخريشها كهربائياً، الثانية بتخريش السبائك كهربائياً، الثالثة بمعالجتها بأكاسيد الألمنيوم ذات حجم (50) مايكرون، الرابعة بمعاملة السبائك بواسطة أكاسيد الألمنيوم (100) مايكرون، والخامسة استخدام القوالب بدون معاملة.

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تم ربط القوالب المعدنية مع أسنان علوية قاطعة خالية من التسوس باستخدام مادة الراتنج الرابطة واستعمال المادة اللاصقة الراتنجية، ثم بعد ذلك تم إجراء عملية التدوير الحراري لها ثم خزن النماذج في الماء المقطر وتحت درجة حرارة (37) درجة مئوية في حاضنة لمدة سبعة أيام، ثم تم فحص قوة الربط الانزلاقي لهذه النماذج.

تبين من هذه الدراسة أن سبيكة (CB - Bland 72) هي أكثر قوة في الربط من سبيكتي (CB-Soft) و (Kera - N). كذلك تبين أن طريقة المعالجة بأكاسيد الألمنيوم ذات حجم (100) مايكرون تعطي أكبر قوة ربط.

INTRODUCTION

Resin bonded fixed Partial dentures had been used for more than 30 years. The conservation of tooth structure aids in the development of such type of prosthesis, since then many attempts had been made to increase the bond strength between metal and tooth structure, in that Rochette⁽¹⁾ used a perforated framework to splint maxillary anterior teeth, Livaditis and Thompson⁽²⁾ developed the electrolytical etching of the metal which accelerated the acceptance of this innovative treatment. Kohli *et al.*⁽³⁾ suggest the use of sandblasting of the metal by aluminum oxide particles to increase the bond strength between metal and tooth structure.

As a bonding agent between metal and etched enamel, composite resin play an important role. A variety of resin adhesives have specifically been introduced for this purpose, phosphate ester group has been added to the monomer and this allows chemical bonding to both metal alloy and etched tooth structure. The base metal alloys used for the construction of resin bonded fixed partial dentures were mainly Nickel-Chromium alloys. This type of metal is used because it offers many advantages which are low cost, minimal overcontouring of the prosthesis due to high strength of the metal which mean more conservative work, it allowed thin, well polished, durable casting.

The important aspect of resin bonded fixed partial dentures is the mechanism of attachment of a metal to tooth structure. This mechanism consists of tow interfaces, the resin bond to metal framework and the resin bond to enamel. The weakest link in the attachment mechanism is between the metal framework and the resin. Accordingly this study was designed to evaluate the following:

1. The shear bond strength of different Nickel-Chromium alloys bonded to enamel.
2. The effect of different metal surface treatment on shear bond strength.
3. The type of debonding failures.

MATERIALS AND METHODS

Seventy five disc-shaped metal samples (figure 1) were casted from three Nickel-Chromium alloys (CB-Blando 72, Kera-N and CB-soft), (25) discs from each type of the alloy. The disc samples were prepared from casting wax using a mold. The diameter of the disc was (5) mm with a thickness of (1) mm. After casting all samples

cleaned with No.400 grit abrasive paper, for surface treatment procedures each group was divided into five subgroups, five samples in each, the first subgroup was sandblasted with (50) μm aluminum oxide plus electrolytical etching, the second subgroup only electrolytically etched, the third sandblasted with (50) μm aluminum oxide, the fourth subgroup sandblasted with (100) μm aluminum oxide and the fifth subgroup receive no surface treatment and considered as a control group.

Seventy five sound caries free human upper central and lateral incisors were collected and their labial surface was slightly flattened and divided randomly into (15) groups containing (5) teeth in each, and then fixed in a plastic cylindrical ring. The metal discs were bonded to the labial surface of the teeth by using intermediate resin and resin based adhesive luting cement. The samples were thermocycled between (5-60) $^{\circ}\text{C} \pm (2) ^{\circ}\text{C}$ for (500) cycles at (1) minute dwell time and then stored in distilled water in an incubator at (37) $^{\circ}\text{C}$ for seven days before shear testing.

Modified electric unconfined compress apparatus (Soil Test Co., USA) was used to test the shear bond strength between metal and tooth structure.

The sample was placed at the base of the apparatus and fixed by special grasping unit. A chisel – like rod that attached to the fixed part of the apparatus where loading cell was mounted had been used to separate the metal disc from tooth surface at speed of (0.5) mm/minute.

RESULTS

The results showed that the mean shear bond strength of CB-Blando 72 alloy was found to be greater than that of CB-soft and Kera-N alloys Fig.(2). And surface treatment with 100 μm aluminum oxide procedures exhibit the highest bond strength followed by sandblasting with 50 μm aluminum oxide, then sandblasting with 50 μm aluminum oxide particles plus electrolytical etching, following by only electrolytical etching and then control group in descending order for the three types of the alloys. Table (1). Examination the type of debonding failure showed that most of failures were cohesive-adhesive followed by adhesive failure at the interface between resin and tooth followed by adhesive failure between metal and resin. Table (2) shows the types of debonding failure that occurs after shear testing. Examination of samples under reflected light microscope X100 showed three types of debonding failure, cohesive adhesive failure, adhesive failure at the interface between resin and tooth structure and adhesive failure at the interface between resin and metal. The failures were mostly cohesive-adhesive failure. The total number of cohesive-adhesive failure was (51) in three alloys used with five surface treatments, the adhesive failure at the interface between resin and tooth structure was (14), while the adhesive failure between resin and metal was only (8).

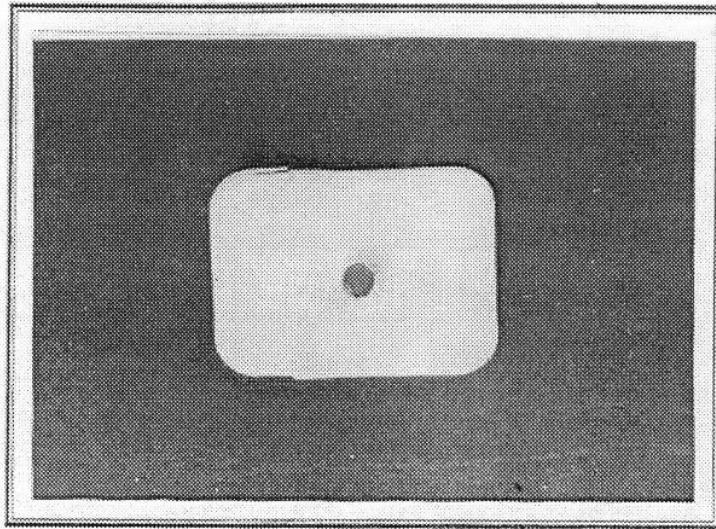


Figure (1): Disc shaped metal sample

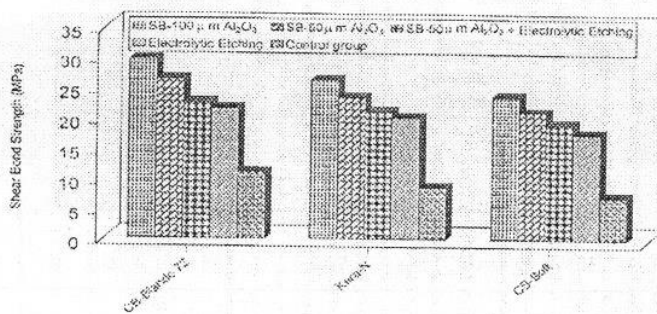


Figure (2): Shear bond strength for the alloys and the surface treatment procedures used in this

Table (1): Mean and Duncan of interaction between alloys and surface treatment procedures.

Alloy Type	SURFACE TREATMENT PROCEDURES				
	SB 100 μm Al_2O_3	SB 50 μm Al_2O_3	SB 50 μm Al_2O_3 + Electrolytic Etching	Electrolytic Etching	Control
CB-Blando 72	29.51 ^A	26.23 ^B	22.46 ^E	21.52 ^F	10.97 ^K
Kera-N	26.23 ^B	23.36 ^D	21.16 ^G	20.17 ^H	8.60 ^L
CB-Soft	23.62 ^C	21.03 ^G	19.16 ^I	17.56 ^J	7.11 ^M

- Means with same letter are not significantly different, else it will differ at level 0.05 according to Duncan multiple range test.
- SB = Sandblasting.
- Al_2O_3 = Aluminum Oxide.

Table (2): Percentage of debonding failures of the Alloys.

Alloys	SB 100 μm Al_2O_3			SB 50 μm Al_2O_3			SB 50 μm Al_2O_3 + Electrolytical Etch			Electrolytical Etch			Control		
	CA %	A(t) %	A(m) %	CA %	A(t) %	A(m) %	CA %	A(t) %	A(m) %	CA %	A(t) %	A(m) %	CA %	A(t) %	A(m) %
CB-Bland 72	16.66	4.16	0	12.5	4.16	0	16.66	4.16	0	16.66	4.16	0	12.5	4.16	4.16
Ker-N	20	0	0	16.0	4.0	0	16.0	4.0	0	12	4	4	8	4	8
CB-Soft	16.66	4.16	0	12.5	8.23	0	12.5	8.33	0	12.5	4.16	0	8.33	0	12.5

SB = Sandblasting.

CA = Cohesive- Adhesive.

A(t) = Adhesive failure at the interface between resin and tooth structure.

A(m) = Adhesive failure at the interface between resin and metal.

DISCUSSION

The results of sandblasting produced the highest bond strength among other surface treatment procedure. This maybe due to the fact that aluminum oxide roughened the metal surface which elevated the reaction to resinous cement beside its effect on creating a micromechanical retention to improve the bond strength, this is in agreement with Rubo *et al.*⁽⁴⁾

The microirregularities produces by sandblasting were large in number which mean providing more retentive feature per unit area than etching and these microirregularities were round-ended that would prevent the concentration of forces which maybe present in sharp ends which are produced by electrolytical etching. That is why sandblasting decrease the chance for fracture of resinous material at round ended irregularities of the metal and increases the surface area for bonding. This is in agreement with other studies^(3,5). The metal surface treated with (50) μm and (100) μm aluminum oxide have the same microstructure pictures, but there are much more irregularities in metal treated with (100) μm aluminum oxide that could cause that the surface treated with (100) μm aluminum oxide produced higher bond strength than those treated with (50) μm aluminum oxide. This is in agreement with Hsing *et al.*⁽⁶⁾

The metal surfaces treated with sandblasting with (50) μm aluminum oxide plus electrolytical etching and electrolytic etching only have almost the same microstructure picture with slight difference that explain the slight higher bond strength of sandblasting plus electrolytic etching than only electrolytically etched metal. The suggested explanation is that the etching may decrease the effect of a part of the microrretentive irregularities produced by sandblasting and produced a sharp-ended irregularities instead, this result in decreasing the bond strength than metal had been treated with sandblasting alone, and produced a higher shear bond strength than electrolytical etching alone. This is in agreement with other studies^(7,8,9).

The difference in bond strength of the three alloys used in this study maybe due to the difference in composition of the three alloys which leads to the difference in physical and mechanical properties of the three alloys. The CB-Blando 72 and Kera-N alloys have lower hardness number than CB-Soft alloy, and as the hardness is the resistance of the metal to indentation or even cutting or scratching so CB-Blando 72 and Kera-N alloys are more susceptible to be scratched i.e. more susceptible to form microirregularities than CB-Soft alloy.

Also concerning the type of failures it was found in this study that the number of cohesive-adhesive failures in the three alloys were higher than the adhesive failures, and most of the adhesive failures that occurred at the interface between metal and resin is noticed in control groups, this maybe due to higher bond strength of the resin to both enamel and surface treated metal. This is in agreement with other studies^(5,10,11).

CONCLUSION

The following results were concluded :-

- 1- The mean shear bond strength of CB-Blando 72 alloy was found to be greater than that of Kera-N and CB-Soft alloys.
- 2- This study indicates that sandblasting with 100 μm aluminum oxide exhibits the highest bond strength followed by sandblasting with 50 μm oxide plus electrolytical etching and electrolytical etching only in descending order.

- 3- CB-Blando 72 alloy produced the strongest shear bond strength when sandblasting with 100 µm aluminum oxide while CB-Soft alloy produced the weakest bond strength when used as a control group.
- 4- Examination of samples under a reflected light microscope X100 after debonding showed that 69.8 % of debond failure was cohesive-adhesive while adhesive failures at the interface between the tooth and resin were 17.3 % and the remaining were adhesive failure at the interface between the metal and resin.

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