Original Article

A comparative analysis of shear bond strength of two veneer composite resins with Ni-Cr alloy subjected to different surface treatments

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The aim of this study was to evaluate shear bond strength between the Nickel-Chromium (Ni-Cr) alloy and composite veneer resin after different surface treatments using two different materials.

Preparation samples (120) were equally divided into two categories on the basis of resin used:

Category A: Consists of 3M resin

Category B: Consists of solidex resin

Load was applied in kilogams (kg) and recorded at the point of bonding failure. Shear bond strength was evaluated as failure load divided by specified area on the bonding surface of samples in terms of pressure units-MegaPascals (Mpa).

Two way ANOVA (Analysis of variance) and Student's t-test for intergroup comparison were used for statistical analysis.

Results revealed that the mean shear bond strength was higher for all groups of Solidex when compared with 3M.

This study concluded that sandblasting the metal surface with 60 μ alumina followed by acid etching and the application of the primer and adhesive along with the composite veneer resin gives higher shear bond strength at the Ni-Cr alloy and composite resin interface

Key words: Composite veneer resin, Ni-Cr alloy, 4-META.

Creating a natural appearance in a restored tooth has become a challenging field because of widespread demand for esthetic dentistry pertaining to fixed partial dentures (FPD).

Porcelain fracture and metal exposure are common clinical conditions in metal ceramic crowns and FPD.

Laboratory light-cured composite resins have been introduced as an alternative veneering material to porcelain and are based mostly on bisphenol-A-glycidymethacrylate (bisGMA) composite resin.

REVIEW OF LITERATURE

Thompson[1] found that acid-etch treatment increases the surface area which would enhance the mechanical bonding.

Tanaka[2] reported higher shear bond strength due to oxidation of Ni-Cr alloys.

Cincone Stojkovich (1993) stated that the combination of creating a high energy clean metal surface and its subsequent coating with liquid to enhance surface wetting facilitates micromechanical retention.

McLean[3] concluded that sandblasting increases mechanical interlocking and surface area.

Goldstein *let al*.[4] reported that the use of bonding agents can result in a strong and durable bond between the composite veneer and the Ni-Cr alloy.

MATERIALS AND METHODS

1. Phosphate-bonded investment material (Wirovest)
2. Ni-Cr alloy (Sankin CB-80)
3. Circular buttons [Figure 1]
4. Composite veneer resin (3M)
   - Single bond adhesive
   - Opaquer
   - Ceramic primer
5. Composite veneer resin (Solidex)

! • Metal photo primer !
• Opaquer!

6. Debubblizer (Dentafill)!

The study was carried out in the following order

Preparation of standard Ni-Cr metal samples

Circular buttons of 10 mm diameter and 1 mm ! thickness were used to prepare all samples.

Spruing and investing

Patterns were sprued using wax sprue formers ! which were attached to common preformed sprue ! formers. This common sprue former was mounted ! on a crucible former and care was taken to keep the ! patterns 6 mm short of the open end of the casting ! ring [Figure 1].

To enhance the wetting of the sprued patterns, debubblizer ! was sprayed and allowed to dry on them.

The powdered resin and monomer! were hand-! spatulated in a clean dry mixing bowl to form a paste. ! The mix was tapped to remove entrapped bubbles ! and the ring was filled with the investment under ! constant vibration to prevent air entrapment.

Casting

The ring was kept at room temperature for 60 min ! to allow crystallization of the investment.

At this stage, the ring was placed in a cold furnace ! and allowed to dry at a temperature of about 250 / ! 300°C for 30 min. After the initial drying time, the ! temperature was allowed to rise to 500°C and held ! for another 10 min in a "Zeus" burnout furnace.

Once the ring tempertature reached and was ! maintained at 500°C for 10 min, the temperature was ! slowly allowed to rise to the final desired temperature ! of 950-1000°C. At this moment, the ring was transferred ! from the furnace to the induction casting machine and ! then to a preheated ring carrier.

The alloy and carbon crucible were also preheated. The ! alloy was heated to complete melting where it was held ! for approximately four seconds (as recommended by ! the manufacturer). The casting was done by activation ! of the centrifugal arm, affter which, the machine was ! allowed to spin freely until it had nearly stopped. ! The ring was removed and then promptly quenched ! in water [Figure 2].

Individual samples were separated from the feeder ! sprue leaving a part of the sprue attached to the ! sample. This sprue helped in precise positioning later ! in the Instron machine.

All irregularities were removed and the samples ! were !finally finished.

Finishing the metal in only one direction as it leaves ! the metal smooth and debris-free.

The metal surface was absolutely clean after the ! samples were cleaned in distilled water in an ultrasonic ! cleaner (Systronics). !

Thus, the samples obtained were equally divided into ! two categories on the basis of the materials used.

Category A: This category consists of samples to ! which 3M composite resin was applied.

Category B: This category consists of samples to ! which Solidex composite resin was applied.

Each category consisted of three groups of 20 samples ! each.

A-1 (Control group)

Adhesive-applied samples were used as the control ! group. An orthodontic elastic band measuring 5 mm ! in diameter and 2 mm in thickness was used as the ! matrix for placement of the composite resin. !

After primer and adhesive application, the orthodontic ! elastic band was centralized on the metal surface and ! a layer of 3M opaquer was applied to metal samples ! and cured for 20 sec.

Light-cured composite veneer resin was condensed ! in increments inside the band taking care to avoid air ! bubble entrapment during condensation.

Composite resin was light-cured for 60 sec using a ! Solidillite laboratory light-curing unit. !

The above procedure was followed for the Solidex ! control group (B-l) except that the opaquer and body ! composite resin were made of Solidex.

Group A-2

This group consists of metal samples that were ! sandblasted with 60 μ alumina and bonded using 3M ! ceramic primer and 3M single bond.

A layer of ceramic primer was applied to the bonding ! surface of each sample after which the samples were ! air-dried for five seconds.

All subsequent steps were as described for A-1.

The above procedure was carried out for the Solidex ! (B-2) group except that the adhesive did not require ! special curing, being cured after application of opaquer ! for 20 seconds.

Group A-3

This group consists of samples that were initially ! sandblasted with 60 μ alumina and then acid-etched.

The acid mixture consists of[6]

1. !20% nitric acid ! 100 ml!
2. !75% sulfuric acid ! 100 ml!
3. !05% phosphoric acid 100 ml!

The metal samples were immersed in this acid mixture ! for 30 min after sandblasting.

The samples were then thoroughly washed in distilled ! water and dried before composite application.

All subsequent steps were as described for A-1.

The same procedure was followed for the Solidex !

(B-3) group except that the adhesive was not cured separately but along with the opaquer [Figure 3].

Testing for shear bond strength

Samples were then tested on an 'Instron' universal testing machine (No. 4467).

A shearing blade was fitted to the upper jaw of the machine and the samples were mounted onto the lower jaw such that the metal-composite interface lay parallel to the shearing blade.

Now the load was applied at a speed of 0.5 mm/sec till debonding occurred and the readings were recorded on the computer simultaneously [Figure 4].

RESULTS

The mean standard deviation (SD) and standard error (SE) were calculated for all groups. Statistical analysis of test results was performed for all groups with two way ANOVA (Analysis of variance) and student's t-test for intergroup comparison.

The mean shear bond strength was higher for all Solidex (B) groups when compared with 3M (A).

In the different pretreatments that were carried out, groups A-3 and B-3 of 3M and Solidex had the highest mean bond strength.

This was followed by groups in which samples were sandblasted and to which adhesive was applied (A-2 and B-2).

When 3M and Solidex were compared, Solidex showed higher mean shear bond strength.

Our results indicate that both pretreatment with sandblasting and acid-etching increased the mean shear bond strength of the composite veneer skin to the Ni-Cr metal surface in the case of both materials (3M and Solidex).

Figure 1: Sprued samples

Figure 3: Finished samples

Figure 2: Samples after casting

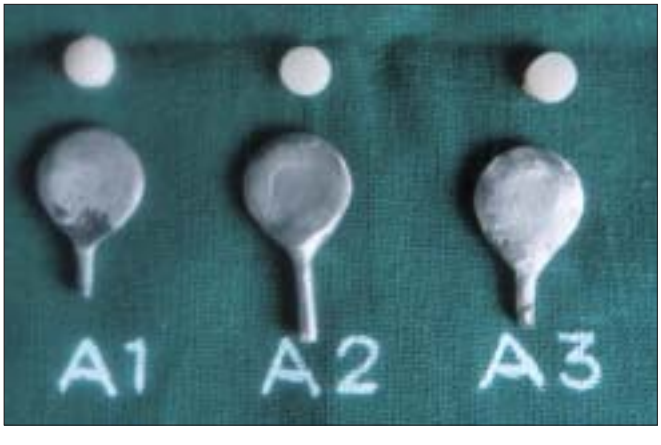

Figure 4: Debonded samples

Table 1: Range of shear bond strength (3M)

Group in test	No. of samples	Shear bond strength range values (Mpa)
A-1	20	5.4-6.3
A-2	20	6.4-9.9
A-3	20	9.3-12.4

Table 2: Range of shear bond strength (Solidex)

Group in test	No. of samples	Shear bond strength range values (Mpa)
B-I	20	6.4-7.1
B-2	20	10.4-12.3
B-3	20	12.08-14.01

DISCUSSION

A plausible explanation for the higher shear bond strength of Solidex over 3M may be the presence of 4-methacryloyloxyethy trimellitate anhydride (4-META) in Solidex which helps in chemical bond formation between the resin and the alloy.

The surface treatment of acid-etching on the Ni-Cr alloy leads to oxidation of the Ni-Cr surface so that the alloy is now covered by the protective film consisting of the oxide. This oxidation confers significant improvement in the durability of the adhesion of the resin to the alloy which suggests that the 4-META resin may have the capacity to adhere to the oxide film more strongly than it does to the metal itself.

This study is in agreement with those conducted by Thompson,[1] Tanaka,[2].

In the case of the 3M acid-etch group (A-3), the functional component of the primer is an organo-functional trioxysilane which has been used extensively as an adhesion promotor to glass and metal surfaces. Due to this affinity for alloy surfaces, methacrylate groups such as those found in adhesives, liquid and composite resins are placed in configurations favoring cross-linking with the resin phase.

Hence, the 3M acid-etched group showed highest strength in the 'A-3' category.

According to Kwok-Hung Chung, the reason for the higher bond strength of the sandblasted group may be due to roughening of the surface area for bonding and increasing the surface area.

It has also been reported that the alumina content of base metal alloys increases up to 37% (by weight) after sandblasting. The presence of alumina particles may have a positive effect on bond strength.

Based on the results, the following conclusions can be drawn

1. Samples with primer and adhesive application directly on the Ni-Cr metal surface without any surface treatment, showed the least shear bond strength between the veneer resin and the metal.
2. Sandblasted surface treatment of the Ni-Cr alloy and the application of 3M primer and adhesive along with 3M composite veneer resin showed significantly higher bond strength than the samples without any surface treatment.
3. Sandblasting surface treatment of the Ni-Cr alloy and the application of Solidex metal photo primer along with the composite veneer resin showed significantly higher bond strength.
4. Acid-etching treatment gave highest mean shear bond strengths for both 3M and Solidex groups.
5. The mean shear bond strength was higher with Solidex than with 3M for all the treatment groups.

This study concludes that sandblasting the metal surface with 60 µ alumina followed by acid-etching and the application of the primer and adhesive along with the composite veneer resin, gives higher shear bond strength at the Ni-Cr and composite interface.

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