

Shear Bond Strength Between Nickel-chromium and Human Dentine Using a Dual-cure, Self-adhesive Universal Resin Luting Agent

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Abstract - The adhesive property of a dual-cure, self-adhesive universal resin luting agent (Rely X Unicem, 3M ESPE) between nickel-chromium (Ni-Cr) and human dentine was compared with three conventional resin luting agents (Calibra, Dentsply; Panavia-F, Kuraray; All-bond 2 C & B cement, Bisco). Ten Ni-Cr rods were bonded to human dentine with each of the four luting agents, and were subjected to shear bond test. Results showed that there was no significant difference in shear bond strengths among the luting agents. A dual-cure, self-adhesive universal resin luting agent was shown to have comparable adhesive property between Ni-Cr and human dentine as three other conventional resin luting agents. Given the simplicity of use of the dual-cure, self-adhesive universal resin luting agent, it appears to be promising in clinical applications.

KEY WORDS: Shear bond strength, dentine, Nickel-Chromium, resin luting agent

INTRODUCTION

Dental luting agents must be able to withstand stresses in the oral environment and be relatively insoluble in order to maintain the integrity of tooth / restoration interface in order to provide retention and reduce microbial leakage. Traditional luting agents include zinc phosphate, zinc carboxylate, glass ionomer, hybrid and resin-based luting agents, but each of them has its limitations. Resin-based luting agents possess high bond strength to the tooth structure and enjoy wide clinical usage. However, such luting agents usually require multiple clinical steps in their application including dentine conditioning and surface treatment of the restoration. A "dual-cure, self-adhesive universal resin" (RelyX Unicem) has been introduced as a luting agent, which eliminates clinical steps such as dentine conditioning and surface treatment of the restoration. The luting agent was intended for all-ceramic, metal or indirect composite resin restorations, including fibre posts. It is composed of the newly developed multi-functional phosphoric acid (meth)acrylates as organic matrix and also inorganic filling bodies (72% by weight). Phosphoric acid (meth)acrylate contains at least two phosphoric acid groups and a minimum of two C=C double bond units which provide high reactivity and high degree of matrix cross-linking. By reaction of the acidic functionalities with the filler molecules, the desired pH level and fluoride ion release have been achieved¹. A radical polymerization reaction in the special monomers mentioned provides curing of the material, which can be initiated either by

light-curing or via a redox system. As a result, high degree of cross-linking and high molecular weight of polymers are generated and low solubility, low swelling and high biocompatibility are achieved.

It was also claimed that mechanical properties of the dual-cure, self-adhesive universal resin are far superior to those of zinc phosphate and glass ionomer cements². The tensile bond strength of metallic rods to dentine using the universal resin was comparable with one but less than other resin luting agents in a recent study³. Yet in other studies, the bond strength of the universal resin luting agent to dentine was comparable with other resin luting agents^{4,5}. The purpose of this investigation was to evaluate the shear bond strengths between nickel-chromium rod and human dentine with a dual-cure, self-adhesive universal resin and three conventional resin luting agents. The hypothesis was that the shear bond strength of a dual-cure, self-adhesive universal resin luting agent is not significantly different from the other conventional resin luting agents.

MATERIALS AND METHODS

The four luting agents studied are listed in Table 1. ISO/TS 11405:2003(E), Dental materials – Testing of adhesion to tooth surface, was adopted for the shear bond strength test⁶. Forty human permanent molars extracted not more than six months prior to experimentation were collected for this study. The teeth were either caries-free, or only had superficial restorations which did not involve the bonding surface. Calculus and adherent soft tissue on tooth surfaces were removed. The storing medium was replaced periodically. Ten teeth were tested for each luting agent.

Tooth blocks were formed by embedding the teeth partially in a slow-setting auto-polymerizing acrylic resin (ProBase Cold) with a powder/liquid mixing ratio of 10g:10ml.

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Table 1. *Constituents of bonding agents used*

<i>Product (Manufacturer)</i>	<i>Constituents</i>
RelyX Unicem (3M ESPE)	Methacrylated phosphoric acid esters Triethylene Glycol Dimethacrylate Substituted Dimethacrylate
Calibra (Densply)	Bis-GMA resin Polymerizable dimethacrylate resin
Panavia F (Kuraray)	Hydrophobic dimethacrylate 10-Methacryloyloxydecyl dihydrogen phosphate N,N'-Diethanol-p-toluidine Sodium aromatic sulfinate
All-bond 2, C&B cement (Bisco)	Na-N-tolyglycine glycidylmethacrylate Bisphenol-A Diaglycidylmethacrylate Triethylene Glycol Dimethacrylate

Table 2. *Shear bond strength and distribution of specimen failure mode*

	<i>Mean (SD) (MPa)</i>	<i>Failure Mode</i>		
		<i>resin-dentine (n)</i>	<i>resin-metal (n)</i>	<i>Mixed (n)</i>
RelyX Unicem	2.4 (1.4)	10	0	0
Calibra	3.4 (3.1)	6	0	4
Panavia F	6.2 (4.1)	10	0	0
All-bond 2, C&B cement	6.9 (5.9)	4	0	6

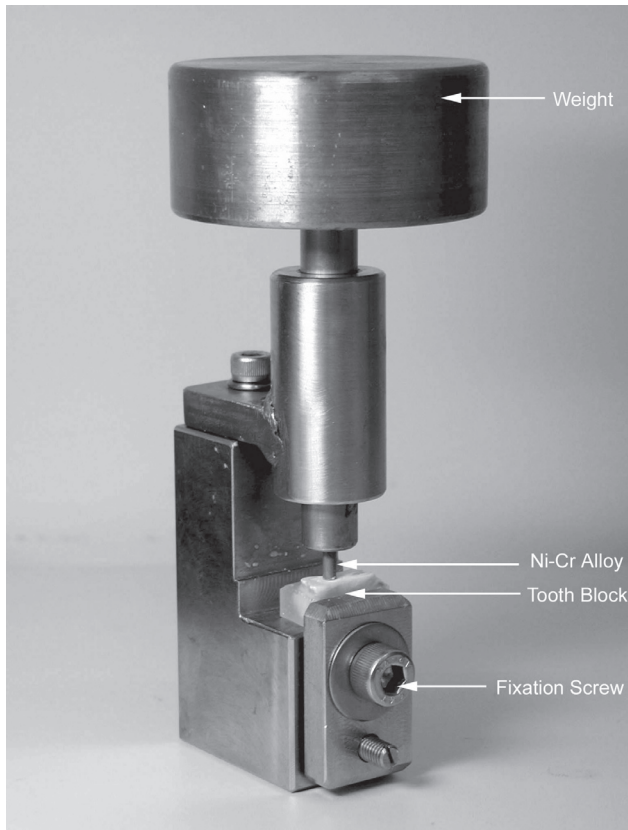


Figure 1. *Cementation jig*

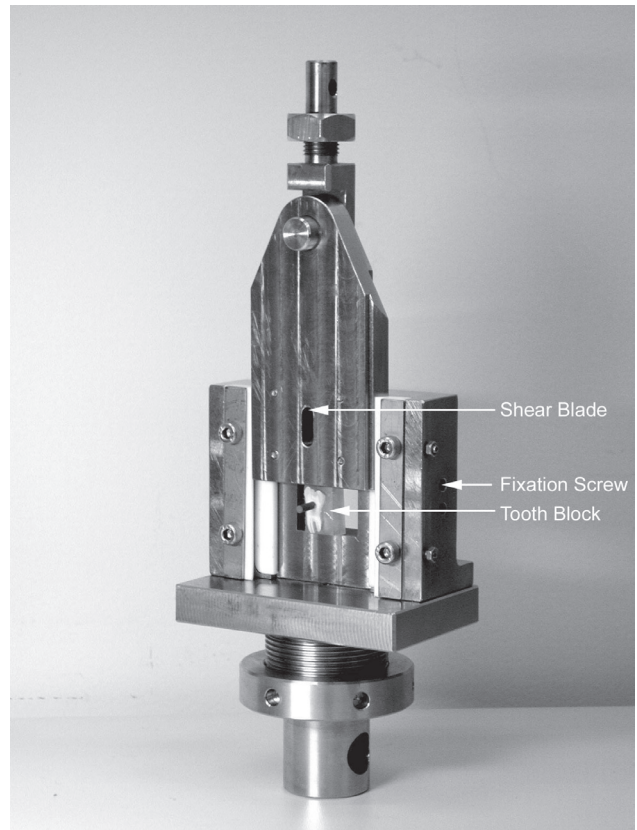


Figure 2. *Shear test jig*

The blocks were immersed in water to dissipate the heat generated during polymerization. The blocks were milled to allow their secure mounting on the cementation and shear test jigs. The dentine surfaces for bonding were exposed with tungsten carbide cutting blade (Micro 100) without perforation into the pulp chamber. The bonding surfaces were finished by hand lapping with 600 grit size silicon carbide abrasive paper under running water. The finished dentine surfaces were examined under a x 2.5 magnification to ensure that uniform surfaces were achieved. Care was taken not to contaminate the dentine surface with acrylic resin residues during milling and polishing. The teeth were stored in water in a refrigerator between preparation procedures.

Forty Ni-Cr alloy rods (Cr: 20%, Mo: 8%, Ni: 72%), 3 mm in diameter and 10 mm in length, were cast from plastic cylindrical patterns. The bonding surface at one end of each alloy rod was ground to a flat surface on a diamond wheel (Noritake, Japan) of a surface grinder (Okamoto, Japan), and was air-abraded with 45-55µm Al₂O₃ under 3 bars for 10 seconds. The area of each bonding surface was calculated from its diameter, which was measured with a micrometer (Digimatic Caliper, Model CD-6" CSX; Mitutoyo, Japan) to the nearest 0.01 mm.

The Ni-Cr rods were cemented onto the dentine bonding surfaces under a 10 N load with a cementation jig (Fig. 1). The luting agents were applied according to the manufacturer's instructions. All bonded specimens were immersed in 37 °C water for 24 hours before being tested for shear strength. Each specimen was fixed onto the shear test jig (Fig. 2), and the load required to break the bond at a cross-head speed of 1 mm/min was measured on a universal testing machine (Instron, Model 1185; Bucks, United Kingdom) equipped with a 1000 N loading cell. The shear bond strength of each specimen was calculated by dividing the load at failure by the area of bonding surface. The results were analysed with one-way ANOVA and Newman Keuls post-hoc test at $P = 0.05$.

The mode of failure of each specimen was observed under x 30 stereomicroscope (Model SMZ-1B; Nikon, Japan) and classified according to the location of failure: 1) at the luting agent-metal interface, 2) at the luting agent-dentine interface and 3) at both the luting agent-metal interface and the luting agent-dentine interface (mixed mode of failure).

RESULTS

One-way ANOVA revealed that there was no significant difference in shear bond strength among the universal resin and 3 conventional resin luting agents. All universal resin and Panavia F specimens failed at the resin-dentine junction. The failure modes of specimens of the two other resin luting agents are either at the resin-dentine junction or are mixed between resin-dentine and resin-metal junctions (Table 2).

DISCUSSION

The present study is in general agreement with previous studies that the bond strength of a dual-cure, self-adhesive universal resin to dentine was comparable with those of conventional resin luting agents^{4,5}. However, another study revealed that the self-adhesive resin had a comparatively lower bond strength⁷. The self-adhesive property of this phosphoric acid (meth)acrylate-based resin is attributed to its chemical structure, which contains two phosphoric acid groups and at least two C=C double bond units per molecule. These monomers supposedly demineralized the dentine smear layer in the presence of water and infiltrated the porous dentinal surfaces.⁸ The comparatively lower bond strength of the self-adhesive luting agent as demonstrated in one study was explained by its high viscosity with the agent failing to penetrate the demineralized dentine⁷.

Stereomicroscopic examination revealed that all 10 specimens of RelyX Unicem and Panavia F failed at the resin-dentine interface. None of the specimens from the resin groups failed at the resin-metal interface. A comparison of the failure mode with shear bond strength did not reveal any trend of a particular mode that favored the shear bond strength.

Given the simplicity of use of the self-adhesive universal resin together with its favourable adhesive property, the material appears to be promising. Further studies are necessary to evaluate the resin's long-term performance under moisture and thermocycling. Similarly, a better understanding of the adhesive property of the resin to substrates other than metal is needed.

CONCLUSIONS

The shear bond strength achieved between dentine and Ni-Cr alloy with a dual-cure, self-adhesive universal resin was found to be not significantly different from three conventional resin luting agents.

MANUFACTURERS' DETAILS

- All-bond 2, C&B cement - Bisco Inc., 1100 West Irving Park Road, Schaumburg, IL 60193, USA.
- Calibra - Dentsply/Caulk, 38 West Clarke Avenue, PO Box 359, Milford DE 19963-0359, USA
- Ni-Cr alloy - Matech Inc. California, USA.
- Panavia F - Kuraray Co. Ltd., 1-12-39, Umeda, Kita-ku, Osaka 530, Japan.
- ProBase Cold - Ivoclar Vivadent, AG. Bendererstrasse 2. 9494 Schaan. Principality of Liechtenstein.
- RelyX Unicem - 3M ESPE, Building 275-25E-03, St. Paul, MN 55144-1000, USA.

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REFERENCES

1. Gerth HUV, Dammaschke T, Züchner H, Schäfer E. Chemical analysis and bonding reaction of Rely X Unicem and Bifix composites – A comparative study. *Dent. Mater.* 2006; **22**: 934-941.
2. Piwowarczyk A, Lauer H-C. Mechanical properties of luting cements after water storage. *Oper. Dent.* 2003; **28**: 535-542.
3. Al-Assaf K, Chakmakchi M, Palaghias G, Karanika-Kouma A, Eliades G. Interfacial characteristics of adhesive luting resins and composites with dentine. *Dent. Mater.* doi:10.1016/j.dental.2006.06.023. (Epub ahead of print)
4. De Munck K, Vargas M, Van Landuyt K, Hikita K, Lambrechts P, Van Meerbeek B. Bonding of an auto-adhesive luting material to enamel and dentin. *Dent. Mater.* 2004; **20**: 963-971.
5. Abo-Hamar SE, Hiller K, Jung H, Federlin M, Friedl K, Schmalz G. Bond strength of a new universal self-adhesive resin luting cement to dentin and enamel. *Clin. Oral. Invest.* 2005; **9**: 161-167.
6. International Organization for Standardization (ISO). Dental materials – Testing of adhesion to tooth structure. ISO/TS 11405:2003(E), *ISO - Geneva. 2nd edition*, 2003.
7. Yang B, Ludwig K, Adelung R, Kern Matthias. Micro-tensile bond strength of three luting resins to human regional dentin. *Dent. Mater.* 2006; **22**: 45-56.
8. Ohno H, Kimura M, Fuchigami, Oguri M. Dental Composition. United States patent No. 5,739,177, April 14, 1998.