INTRODUCTION

When dentine was cut, the dentinal tubules were exposed to the oral environment resulting in hypersensitivity. To decrease the postoperative sensitivity, various methods have been used including application of dentine bonding agents, varnishes, laser and cavity desensitisers. With the application of dentine bonding agents, an impervious layer was formed to occlude open dentinal tubules which in turn reduced hypersensitivity. Microleakage was also observed to be reduced in dentine with this layer. This layer might also influence the shear bond strength of the restoration luted with resin luting cement in the subsequent visit.

Thus, resin coating technique was introduced. Resin coating technique involved the application of a low viscosity resin to dentine before taking impression for indirect type of restorations. The restoration was then cemented using a resin luting cement. This low viscosity resin was a dentine-bonding agent. Dentine bonding agents are known to form an effective seal on the exposed dentine which can reduce postoperative sensitivity and microleakage. It may also improve retention and even confer some caries resistance. So the purpose of this study was to evaluate the effect of using resin coating technique on the shear bond strength of Co-Cr discs luted to dentine with resin luting cements.

The aim of this study was to compare shear bond strengths of metal castings cemented to dentine with or without using resin-coating technique.

METHODOLOGY

Forty eight sound extracted premolar teeth were used in this study. The teeth were divided into four groups of twelve teeth each.
Calculus and soft tissue deposits were removed from the selected teeth using ultrasonic scaler. The teeth were then stored in 0.5% chloramine at room temperature. The solution was changed periodically after every fifteen days.

The teeth were mounted using clear cold curing epoxy resin (Mirapox 950-230 A) in plastic holders (Buehler® Sampl-Kup®). The teeth were mounted in such a way that the occlusal surfaces were flushed with the top surface of the mounting resin as shown in Figure 1. The mounted specimens were then stored in tap water until used.4

Measurement of the diameter of dentine of the sample teeth was taken and on average it was found to be 4.0 mm, thus it was decided to prepare metal discs of 3.8 mm to be bonded to the dentine.

The metal used was a chrome cobalt alloy for model casting, Metaplus® VP Hard 1000-50 (AZ & Partner AG, CH- Reiden). Circular castings of 3.8 mm diameter were made. The castings were ground flat on one surface on a water-cooled abrasive wheel (Struers, Rotopol-1). This flat surface would be used for bonding to the tooth samples. The flat metal surfaces were sandblasted with 50 μm aluminium oxide particles5 using Topstar® (Bego, W Germany). The discs were then steam cleaned using Triton® (Bego, Germany).

The occlusal enamel was removed to expose a flat dentine surface perpendicular to the long axis of the tooth initially on a 180 grit-silicone carbide paper. When dentine exposed, it was finally polished on a 500 grit-silicone carbide paper under water coolant (Struers, Rotopol-1). The silicone carbide paper was standardized i.e. 500 grit to obtain a uniform smear layer surface.6 The occlusal surface was ground until the enamel from the pits and fissures disappeared. In order to minimize deviations resulting from differing dentinal depths, all tooth surfaces were ground only to a depth sufficient to create a flat surface area of dentine adequate to accommodate the 3.8 mm diameter metal discs.4

The freshly exposed dentine surfaces of the first and third groups were left uncoated. The freshly exposed dentine surfaces of the second group and fourth group of teeth were coated with Clearfil SE Bond and Syntac® Sprint following the manufacturer’s instructions respectively as shown in Table 1.

The samples were then stored in an incubator at 37°C in 100% relative humidity for one week to mimic the clinical situation for indirect type of restorations.

The metal castings were cemented with Panavia F to the first and second group of teeth and with Variolink II to the third and fourth group of teeth following the manufacturer’s instructions. The luting procedures are given in Table 2.

Two points were marked on the acrylic around the metal disc circumference opposing each other for curing. The tip of light curing unit was placed close to the cement line at about 30°angle to the flat tooth surface. The material was light cured each from the two marked sides.

During cementation, a constant force of 10 Newton was applied for ten minutes to each sample7 as shown in the assembly in Figure 2. This was done to ensure a controlled film thickness of the luting cements to all the specimens.

The specimens were then stored at 37°C in 100% relative humidity for 24 hours prior to testing.

Shear bond strength testing was carried out on the Instron Universal Testing Machine (Instron 4302, Instron Corporation) at a cross-head speed of 1 mm per minute (Figure 3).

The peak load i.e. the force to debond the bonded metal disc-dentine assembly was recorded from the Instron Universal Testing Machine for each specimen. The area (11.35 sq mm) was constant for all the specimens.

Shear bond strength (MPa) = Force (Newtons)/Area (mm.²).
The shear bond strengths of metal discs luted to dentine with a resin cement with or without a prior dentine bonding agent application was analysed using “t-test: Two Sample Assuming Equal Variances”.

RESULTS

The mean shear bond strength of Group I (Control) i.e. using Panavia F without dentine bonding agent coating was found to be 25.93 ± 4.95 MPa. Mean shear bond strength of Group II (Test) i.e. using Panavia F with a coating of Clearfil SE Bond was calculated to be 29.96 ± 4.88 MPa. Groups I and II were analysed using “t-test: Two Sample Assuming Equal Variances”. It was found that there was a statistically significant difference between the shear bond strengths of the two groups (p < 0.05). The teeth coated with Clearfil SE Bond prior to cementing the metal discs with Panavia F showed a significantly higher shear bond strength than those which were directly bonded with Panavia F.

The mean shear bond strength of Group III (Control) i.e. using Variolink II without dentine bonding agent coating was found to be 3.90 ± 1.76 MPa and Group IV (Test) i.e. discs cemented with Variolink II with a coating of Syntac Sprint was 8.72 ± 1.45 MPa. Similarly, groups III and IV were analysed using the t-test. Analysis showed that there was a highly significant difference between the shear bond strengths of these groups (p < 0.05). The shear bond strengths of the discs luted to dentine with Variolink II coated with Syntac Sprint was significantly higher than the uncoated group.

| TABLE 1: BONDING PROCEDURES FOR THE DENTINE BONDING AGENTS |
|---------------------------------|-----------------|-----------------|---------------------------------|-----------------|
| Material                        | Conditioning    | Priming         | Adhesive Dentine Bonding        | Dentine bonding agent |
| Clearfil™ SE Bond               | None            | Clearfil SE Bond Primer 20 seconds Gentle air dry | Clearfil SE Bond Bond Gentle air dry Light cure 10 seconds | Light curing bonding system |
| Syntac® Sprint™                | Total Etch 15 seconds Wash & dry | (One bottle adhesive) Syntac Sprint Apply 10 seconds Leave 15 seconds Gentle air dry Light cure 40 seconds | | Light curing adhesive system |

| TABLE 2: LUTING PROCEDURES FOR THE RESIN LUTING CEMENTS |
|---------------------------------|-----------------|-----------------|-----------------|-----------------|
| Material                        | Conditioning    | Priming         | Bonding         | Cementation     | Polymerisation |
| Panavia™ F                      | None            | Ed Primer 60 seconds Gentle air dry | None            | 2-paste         | Dual curing resin based cement |
| Variolink® II                   | Total Etch 15 seconds Wash & dry | None            | None            | 2-paste         | Dual curing resin based cement |

| TABLE 3: MEAN SHEAR BOND STRENGTHS OF METAL DISCS LUTED TO DENTINE WITH/WITHOUT THE APPLICATION OF DENTINE BONDING AGENTS |
|---------------------------------|-----------------|-----------------|-----------------|
| Material                        | Mean            | S.D.            | Coefficient of Variance |
| Panavia F (Group I: Control)    | 25.93           | 4.95            | 19.10            |
| Panavia F/Clearfil SE Bond (Group II: Test) | 29.96           | 4.88            | 16.29            |
| Variolink II (Group III: Control) | 3.90            | 1.76            | 45.26            |
| Variolink II/Syntac Sprint (Group IV: Test) | 8.72            | 1.45            | 16.67            |
The mean shear bond strengths, standard deviations and the coefficient of variance of the four groups are given in Table 3.

**DISCUSSION**

Polymerised adhesives may serve as a temporary sealant on prepared dentine surfaces and may be used as a precursor to the final bonding of a restoration. Botha et al. observed no significant difference between immediate and delayed bonding on the shear bond strength of a composite resin luted with a luting resin to abraded dentine. Studies have shown that dentine bonding agents are virtually insoluble in the oral environment. In clinical practice the indirect type permanent restorations i.e. inlays, onlays, crowns and

**Fig 2:** Assembly for constant load application

**Fig 3:** Instron Universal Testing Machine

**Fig 4:** Mean shear bond strengths of Panavia F and Variolink II with/without dentine bonding agent coating
bridges were usually placed one week after tooth preparation. The other clinical advantage besides increased bond strength would be reduced post-operative sensitivity in indirect type of restorations. The results of this study showed that the coating of dentine bonding agent increased the shear bond strength.

The in vitro methods used so far for evaluation of adhesive property of cements vary from study to study. It was therefore, often impossible to directly compare results presented by various researchers or manufacturers. Numerous bond strength tests had been used. A survey of published bond strength values indicated large inter and intra study variations. Different methods or small modifications of the same method could give large variation in bond strength values for the same product.

The film thickness could be lowered by increased magnitude and duration of seating force and elevated by higher viscosity of the luting cement. The magnitude and duration of force was kept constant in this study but the viscosity could be another variable. The optimal seating force would probably be cement specific. However, within the groups the thickness would have been relatively constant.

Komatsu and Finger showed that the strength of a bond ten minutes after bonding was very dependent upon the choice and combination of materials. In their study, they advised to view the adhesive and the composite from the same manufacturer as two parts of one system. Following the instructions for use strictly for both materials was the first prerequisite for that system to work. In this study, the dentine bonding agents used were also the ones that were advised by the manufacturers to be used together with the composite resin cements.

In this study, the mean shear bond strength of metal discs luted to dentine with Panavia F was found to be 25.93 ± 4.95 MPa. The mean shear bond strengths to dentine with this adhesive cement was shown to be 22.5 MPa. When Clearfil SE Bond was applied before cementation with Panavia F in Group II, the mean bond strength increased to 29.96 ± 4.88 MPa. Clearfil SE Bond also contains the adhesive monomer MDP. It has a self etching primer and is a light curing bonding system. The statistical analysis showed that there was a significant difference in the mean shear bond strengths of these two groups at 95% confidence interval; thus showing that the use of resin coating technique improved the shear bond strength significantly.

With the use of Clearfil SE Bond, the shear bond strength increased. This increase might be due to better wetting of the dentine with the use of the dentine bonding agent. Many of the current approaches to dentine bonding rely on acid treatment of the dentine surface. The treatment induced removal or alteration of smear layer and establishment of a microporous surface. This microporous surface might be penetrated by bonding agents to create a hybrid structure composed of partially demineralised dentine in intimate association with the bonding polymer. Clearfil SE Bond was less viscous than the Panavia F paste. So there would have been more penetration of the resin into the dentinal substance.

Variolink II recorded a mean shear bond strength of 3.90 ± 1.76 MPa when used alone. However, with the application of Syntac Sprint, the mean shear bond strength increased to 8.72 ± 1.45 MPa. The statistical analysis showed that there was a highly significant difference between the two groups. Hence, showing that the prior coating of dentine bonding agent increased the shear bond strength. Syntac Sprint is a one bottle adhesive system with liquid consistency. Whereas, Variolink II is a dual curing adhesive luting composite. It is a two paste system. Syntac Sprint has lower viscosity, thus it might be able to penetrate into the dentinal tubules forming resin tags and into the collagen of the dentine forming the hybrid layer. The placement of Variolink II on Syntac Sprint would form a chemical bond and polymerise with the bonding agent thus forming a stronger bond. The superficial oxygen inhibition layer formed during curing of a dentine bonding resin in the presence of oxygen ensure that superficial free methacrylate groups could react with monomers of the luting composites. Hence, resulting in a stronger bond when dentine bonding agent was used prior to luting.

The presence of HEMA in Syntac Sprint could absorb water during water storage. This would lead to expansion of the resin which in turn could create stresses in the set material and hence reducing the strength. Clearfil SE Bond also contained HEMA, but the presence of high filler content and the coupling agent (which improved the filler matrix bond) might reduce this effect and hence, improved strength.

Prati et al. showed that Syntac had the least shear bond strength to dentine among the seven adhesive systems they tested. The strength was found to be 11.7 ± 1.6 MPa. Holtan et al. found that Syntac had mean shear bond strength of 13.5 MPa ± 8.6 to the...
dentine of human permanent molars. Öilo and Austrheim\textsuperscript{22} reported the shear bond strength of Syntac to the buccal surfaces of third molars to be in the range of 5.1 - 27.6 MPa with a mean of 14 MPa. They observed no significant difference for tensile and shear bond values after 24 hours of water immersion. In their study, the coefficient of variation exceeded 50%. They argued that it was impossible to standardize the dentine substrate. They also observed that there was no significant difference between the values obtained with the tensile or the shear test methods for any of the materials they tested. This indicated that the two methods were equally good for an in vitro test to evaluate the quality of a bond.\textsuperscript{23,24}

The bond strength of resin-composite materials to dentine improved significantly with the use of dentine bonding systems.\textsuperscript{23,24,25,26} Hadavi et al\textsuperscript{27} reported a significant increase in the bond strength of composite and amalgam using an adhesive system. Similarly this study showed that the bond strength of metal discs luted to dentine with resin cements increased using the dentine bonding agents.

CONCLUSION

Within limitations of this study, it can be concluded that the shear bond strengths of Panavia F and Variolink II were significantly higher (p<0.05) when used to cement non-precious alloy to dentine with a coating of Clearfil SE Bond and Syntac Sprint respectively. The resin coating technique increased the shear bond strengths of Panavia F and Variolink II.

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