

Shear Bond Strength of Scotchbond XT with MTAD as a Dentine Conditioner

SADJ August 2009, Vol 64 no 7 p306 - p309

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SUMMARY

The purpose of this *in vitro* study was to investigate the effect of 1% NaOCl (15 min) and MTAD on dentine shear bond strength, when using the Scotchbond XT(3M ESPE) adhesive system. Thirty extracted, human, third molar teeth were embedded into metal rings with self-curing acrylic resin. The teeth were ground wet using 600-grit silicone-carbide paper to expose superficial dentine. The samples were randomly divided into 2 groups (n=15). In group 1 (SB) the dentine surfaces were treated according to the manufacturer's instructions (etched with 37% phosphoric acid before application of the bonding resin). In group 2 (MTAD) the dentine surfaces were treated by rinsing it with 1% sodium hypochlorite for 15 minutes followed by the application of a freshly prepared solution of MTAD, left undisturbed for 5 minutes. Thereafter the solution was rinsed off with water, air-dried, leaving the treated surface visibly moist. Following the application of the adhesive resin, composite resin were condensed into an Ultradent mould and then light-cured for 40 seconds. The bonded specimens were stored in 37 °C water for 24 hours. The shear test was performed in a Zwick testing machine. The mean values were analyzed using the Student- t test. The results were as follows: SB= 15.4 ± 3.4 MPa and MTAD=21.8 ± 3.6 MPa. There was a statistically significant difference in dentine bond strength between the two groups (p<0.05). Conditioning of the dentine with MTAD significantly increased the dentine bond strength of Scotchbond XT to dentine.

INTRODUCTION

Many dentine bonding systems consist of a conditioner/etchant, a primer and an adhesive. Acids or conditioners are applied to the dentine surface in order to remove the smear layer (amorphous layer of cutting debris and bacteria that is left on the dentine after cavity preparation) and concurrently decalcify the underlying intertubular dentine¹.

The extent of the dissolution depends on the type and concentration of the acid, as well as the viscosity and the exposure time of the etchant². The dentine may be extensively demineralised and weakened if the concentration of the acid is too high or if the exposure time is too long^{3,4}. The depth of dentine demineralisation has become an important issue in dentine bonding⁵. The incomplete penetration of bonding resin into the demineralised microporous collagen network could result in a delicate zone inside

the hybrid layer and the unaltered dentine that could be susceptible to continuous degradation⁶ and microleakage⁷. Therefore, it is recommended that dentine should not be conditioned/ etched for longer than 15 seconds⁷.

When a dentinal surface is etched with an acid and copiously washed with water, the surface is demineralised for about 3-5 microns, leaving a collagen network behind⁸. When the primer is applied it wets the collagen network, raising it to almost to its original level. The unfilled resin adhesive which is applied last, penetrates the primed dentine, and copolymerises with the primer to form an intermingled layer of collagen and resin. This resin interdiffusion zone appears to be the primary site of dentinal bonding and is called the "hybrid layer"⁹.

The immediate restoration of endodontically treated teeth with bonding materials is an excellent way to prevent coronal leakage¹⁰. If the use of the root canal irrigant could aid in conditioning the dentine surface for bonding, this would be an additional benefit¹¹.

Most clinicians use sodium hypochlorite (NaOCl) to irrigate root canals during endodontic therapy. The major drawbacks of NaOCl includes: (1) It does not alter or remove the dentinal smear layer; (2) It does not have a complete antibacterial effect¹²; (3) It can be toxic to the periapical tissues¹¹. Chappel and co-workers advocated the use of NaOCl for dentine surface treatment in combination with acid conditioning¹³. They theorized that dentine substrate conditioning with NaOCl could significantly enhance the long-term bond strength and durability of resin adhesive systems to dentine.

EDTA solutions are also recommended by some clinicians to remove the smear layer after irrigation with NaOCl¹³. These solutions have also been used to prepare dentine surfaces prior to the application of a dentine bonding system. EDTA solutions have also been used to condition dentine surfaces prior to dentine bonding application. Investigators have found that EDTA in combination with bonding agents results in significantly higher bond strengths to dentine compared to conventional acid etching¹⁴.

MTAD, (a mixture of a tetracycline isomer, citric acid and a detergent) is a recently developed irrigation solution that is capable of effectively removing the dentinal smear layer¹⁵. In addition it does not significantly change the structure of the dentine tubules when it is used as a final root canal irrigant in conjunction with

Table 1: Mean shear bond strengths (MPa) and standard deviations of Scotchbond XT in conjunction with the phosphoric acid and NaOCl/MTAD pretreatment groups.

	Mean (MPa)	Standard Deviation
37% Phosphoric acid	15.43	± 3.4
1% NaOCl / MTAD	21.80	± 3.6

low concentrations of NaOCl¹⁶. The citric acid may produce a similar effect on dentine compared to traditional phosphoric acid etching. Another major benefit of MTAD is that the doxycycline which is present in the irrigation solution has a high affinity for dentine. This can allow for a prolonged antibacterial effect¹¹.

The purpose of this *in vitro* study was to investigate the effect of 1% NaOCl and MTAD on the dentine shear bond strength, when using the Scotchbond XT(3M ESPE) adhesive system.

MATERIALS AND METHODS

Shear Bond Strength Testing

Thirty, freshly, extracted human third molar teeth were cleaned, and embedded into metal rings with self-curing acrylic resin. The occlusal surfaces of the teeth were ground wet using 600-grit silicone carbide paper to expose superficial dentine. The samples were randomly divided into 2 groups (n=15).

- Group 1 (Control)

The dentine surfaces were treated according to the manufacturer's instructions (etched with 37% phosphoric acid (3M ESPE) for 15 seconds, rinsed with water and air-dried, leaving the treated surface visibly moist).

- Group 2

Dentine surfaces were treated with 1% NaOCl for 15 minutes followed by the application of MTAD solution (Dentsply), left undisturbed for 5 minutes. Thereafter the solution was rinsed off with water, air-dried, leaving the treated surface visibly moist.

All dentine surfaces were treated with two consecutive coats of Scotchbond XT (3M ESPE), lightly air-thinned and light-cured for 20 seconds. Resin composite (Filtek Supreme, 3M ESPE) was condensed into an Ultradent mould (diameter = 3.2 mm) and light-cured for 40 seconds onto each treated dentine surface. The bonded specimens were stored in 37 °C water for 24 hours. The shear test was performed in a Zwick testing machine operating at a crosshead speed of 0.5mm/min. Data was collected and the mean values were analyzed using the Student- test ($p < 0.05$).

SEM Examination

Twelve extracted human third molar teeth were cleaned and ground wet using 600-grit silicone carbide paper to expose superficial occlusal dentine. The samples were randomly divided into 3 groups (n=4). In Groups 1 and 2 the exposed dentine surfaces were treated as outlined in the SBS testing. In Group 3 (control) the ground exposed dentine surfaces were left undisturbed.

The samples of each group were prepared for the scanning electron microscope (JEOL JSM-840 SEM). Samples were sputter-coated with gold in a vacuum evaporator. The samples were observed and photographs of the most representative regions were taken.

RESULTS

The means and standard deviations of the shear bond strength testing are presented in Table 1. There was a statistically significant difference in dentine bond strength between the two groups ($p < 0.05$). The results of the SEM examination are illustrated in Figure 1 to 3.

DISCUSSION

Dentine surfaces ground wet on 600 grit silicone carbide paper produced a smear layer on the surface, occluding all the dentinal tubules (Figure. 1). Etching the dentine with 37% phosphoric acid for 15 seconds prior to the application of Scotchbond XT produced a mean shear bond strength of 15.4 MPa.

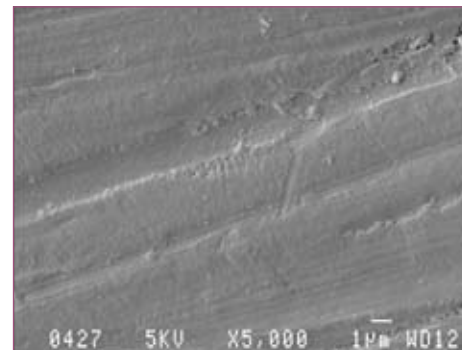


Figure 1. Dentine ground on 600 grit silicone carbide paper. A smear layer is visible on the surface, covering the dentine surface and occluding the dentinal tubules. Final magnification: 5000X.

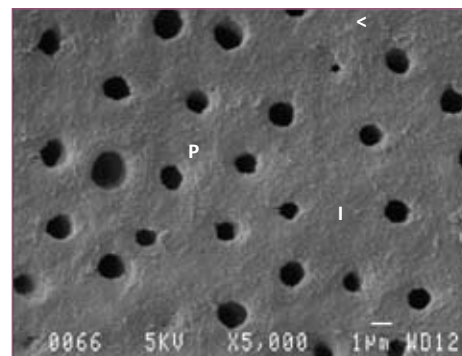


Figure 2. Dentine etched with 37% phosphoric acid for 15 seconds. It is clear that the etchant removed the smear layer, exposing the peritubular (P) and intertubular dentine (I) and the orifices of numerous dentinal tubules. Also visible is the granular appearance of the intertubular dentine probably caused by a deposit of silica (<) that is present in the phosphoric acid etch. Final magnification: 5000X.

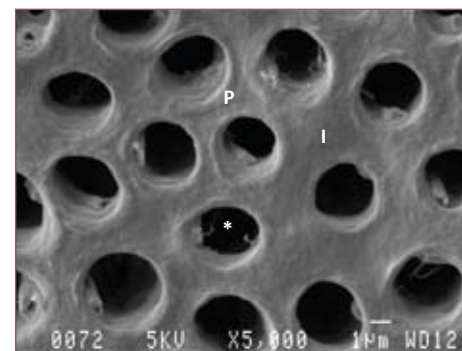


Figure 3. Dentine treated with 1% NaOCl for 15 minutes followed by MTAD for 5 minutes. The smear layer is completely removed, exposing the peritubular (P) and intertubular dentine (I) and also the orifices of numerous dentinal tubules. The dentinal tubules appear larger in diameter compared to those observed when the dentine was treated with 37% phosphoric acid for 15 seconds (Figure 2). It appears as if the NaOCl/ MTAD combination removed some of the peritubular dentine on the inner surfaces of the tubules. Note some fibrous structures inside the tubules (*), which may correspond to remnants of odontoblastic processes. Note also the absence of silica deposits. Final magnification: 5000X.

The SEM results of the dentine etched with 37% phosphoric acid for 15 seconds (Figure 2) revealed the complete removal of the smear layer, exposure of the peritubular (P) and intertubular dentine (I) and the orifices of numerous dentinal tubules. This provides a network for adhesive resin tag formation within the dentinal tubules and the anastomosing of lateral canals to promote the development of a strong resin/dentine bond¹⁴.

MTAD solution contains tetracycline (150mg/5ml Doxycycline), citric acid, and a detergent (Tween 80). The citric acid and tetracycline removes the smear layer and allows the antibiotic molecule to enter into the dentinal tubules. Thereafter, the detergent has the function of reducing the surface tension and increasing the penetrability of the irrigation solution into the dentinal tubules. According to Berutti and Castellucci, BioPure MTAD irrigation solution also has the following properties:

1. It solubilizes the organic components of the pulp residues and inorganic components of the dentine;
2. It is an efficacious antibacterial agent, even against *E. Faecalis*;
3. It does not alter the organic properties of dentine;
4. It can reduce coronal leakage of the teeth obturated with gutta-percha¹⁷.

When the dentine surfaces were treated by rinsing them with 1% NaOCl for 15 minutes followed by the application of a freshly prepared solution of MTAD for 5 minutes prior to the application of Scotchbond XT, it produced a mean shear bond strength of 21.8 MPa. The SEM results of this pretreatment method (Figure 3) revealed the complete removal of the smear layer, exposure of the peritubular (P) and intertubular dentine (I) and also exposure of the orifices of numerous dentinal tubules. It appeared that the dentine treatment with 1% NaOCl treatment for 15 minutes followed by the application of a freshly prepared solution of MTAD for 5 minutes produced a dentine surface that is very similar to standard 15 seconds etching with phosphoric acid. However, the dentinal tubules appear larger in diameter compared to those observed when the dentine was treated with 37% phosphoric acid for 15 seconds (Figure 2).

Machnick and co-workers demonstrated in 2003 a slight decrease in dentine and enamel bond strengths when the pretreatment involved 20 minutes 1.3% NaOCl/ 5 minutes of MTAD compared to conventional acid etching with phosphoric acid prior to the application of Optibond Solo Plus¹¹. In the present study we obtained a higher dentine bond strength (21.8 MPa) compared to the conventional acid etch group (15.8 MPa) when it was used in conjunction with Scotchbond XT. It is important to note that not all the dentine bonding systems have the same mechanism of action; therefore, the results of these studies could vary depending on which materials were used.

Another advantage of the NaOCl/MTAD pretreatment is the antimicrobial properties of the irrigation solution. According to Brännstrom and Nordenvall in 1978 it is very important to eliminate any remaining bacteria on the cavity walls, smear layer and enamel-dentine junction or inside the dentinal tubules prior to any bonding procedure¹⁸. Dentine bonding systems with antibacterial properties can also help to control bacteria (and their toxic by-products) at the bonding interface.

CONCLUSIONS

1. Conditioning of the dentine with 1% NaOCl/MTAD significantly increased the dentine bond strength of Scotchbond XT to dentine.

2. When MTAD is used as an irrigation solution during endodontic treatment the dentine may not need additional dentine conditioning with phosphoric acid before the application of the dental adhesive.

RECOMMENDATIONS

Future research studies should include bond strength testing using other dentine bonding systems. In addition, the long term stability of the resin dentine interface after using MTAD as a dentine conditioner should be established.

Declaration: No conflict of interest was declared

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ERRATUM:

In respect of the article on Surface roughness of Composite Resin (SADJ July 2009, Vol 64 no 6 p260 - p265) the following error occurred. In Table 2 (page 261): Columns 2 and 3 have the same headings - Before Polishing (Mylar). The heading of the second column is incorrect. The heading of the second column should read "After polishing".