

Investigation of the Effect of a Proprietary Dental Waterline Disinfectant on Shear Bond Strengths of Panavia 21 to Enamel and Dentine

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Abstract - This study investigated the effect of 'Alpron mint', a dental unit waterline disinfectant, on shear bond strengths between 'Panavia 21' resin based cement and tooth tissue. Eighty-eight human premolar tooth specimens were prepared in either enamel (N=44) or dentine (N=44). Half the specimens within each group were irrigated with an Alpron mint solution and the other half with distilled water (control) prior to application of Panavia 21 resin luting cement. There was no significant difference in shear bond strengths for both enamel and dentine with Alpron mint irrigation compared with distilled water ($P=0.245$).

KEY WORDS: Waterline disinfectant, Alpron, bond strength, resin cement, tooth tissue

INTRODUCTION

Microbial contamination of water emanating from dental unit waterlines (DUWLs) is a well established finding which has been reported for nearly fifty years^{1, 2}. A plethora of micro-organisms, including potential pathogens, have been identified and their source appears to be derived from biofilms: microcolonies of proliferating species in a protective extracellular matrix. Inevitable exposure of both the patient and dental staff occurs and may potentially result in deleterious consequences, especially for immunocompromised individuals^{3, 4}. The American Dental Association (ADA) has addressed this issue by producing the ADA Statement on Dental Unit Waterlines⁵. This calls for a standard of less than 200 cfu (colony forming units) per millilitre of unfiltered DUWL water. Numerous chemicals and a variety of regimes have been advocated for disinfection of DUWLs. It has been reported that some of these disinfectant media may adversely affect the bond strengths of various dental materials to enamel and dentine⁶.

The popularity of adhesive restorative techniques is growing in accordance with the rising demand for aesthetic restorations which do not further compromise the integrity of tooth structure⁷. Many of the applications of adhesive dentistry remain technique sensitive and contamination of one or other of the substrates may produce compromised performance in terms of bond strengths and durability. This kind of contamination could be endogenous, such as saliva or blood, or exogenous such as oil from handpieces or disinfectants used in dental unit waterlines^{8, 9, 10}. Certain

indirect restorations are completely reliant upon adhesive luting cements for their retention and thus are likely to be most affected by any reduction in bond strengths by chemical disinfectants. Such detrimental effects could ultimately result in microleakage with increased tooth susceptibility to staining, sensitivity and secondary caries, or even the early loss of the restoration.

Currently there have been limited and varying reports of the effect of DUWL treatments on bond strength of dental restorative materials to tooth tissue. One such study has tested the bond strength of composite resin to enamel and dentine, following rinsing of the tooth surface with diluted cetylpyridinium chloride disinfectant and found no significant difference in bond strengths to enamel and dentine, compared with use of distilled water¹¹. *ICX*, another proprietary DUWL disinfectant containing active components such as sodium percarbonate, silver nitrate and cationic surfactants, was also not found to significantly affect bond strengths of composite resin to dentine¹². A similar study by Roberts *et al.* (2000) tested the effect of a variety of DUWL disinfectants on bond strengths to dentine. They reported all disinfectants tested lowered dentine bond strength to composite by varying degrees. However, only citric acid and *Listerine* mouthwash significantly lowered bond strengths¹⁰. The exact mechanism by which DUWL disinfectants may negatively affect bond strengths is not known. Opinions vary from suggestion of an oxidation reaction occurring at the interface between tooth tissue and composite to the deposition of some type of impermeable or hydrophobic layer on the surface of the substrate.

One disinfectant, marketed as Alpron mint, is currently used in dental unit waterlines in Europe and the UK. There have been conflicting results in the literature regarding the effect of this and various other waterline disinfectants on bond strengths^{6, 10, 11, 12, 13}. All such studies have focused upon dentine bonding agents for composite resin, rather than functionally active resin luting cements such as Panavia 21.

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The aim of this *in-vitro* study is to investigate whether Alpron mint, a proprietary DUWL disinfectant containing sodium-p-toluolsulfonechloramide, affects bond strengths between a commonly used proprietary resin luting cement, Panavia 21, and tooth enamel and dentine. The null hypothesis stated that Alpron mint would have no significant effect on these bond strengths.

MATERIALS AND METHODS

Approval was successfully granted by the UCLH and UCL Ethics Committee prior to commencing this study.

Preparation of nickel chromium cylinders

Cylindrical plastic burnout rods of 4mm diameter were sectioned into lengths of five millimetres. One cross sectional surface of each rod was polished, using a standardised protocol, with 1000 grit silicon carbide paper on a Knuth Rotor.

The plastic rods were invested using a phosphate-bonded investment and subsequently cast into nickel-chrome (Figure 1). The nickel-chrome cylinders were sectioned from the sprues using a carborundum disc. The adherend surfaces of these specimens were examined under a light microscope at x25 magnification for any casting defects and then placed in a polishing jig to be finished on the Knuth Rotor, using a standardised protocol with 1000 grit silicon carbide paper. The dimensions of each specimen were measured using callipers and any unsatisfactory cast-



Figure 1. Nickel chrome cylinders prior to sectioning from the sprues

Table 1. Test groups and sample size (N)

Group	Tooth tissue (adherend)	Irrigant	Sample size (N)
1	Enamel	Distilled water	22
2	Enamel	Alpron	22
3	Dentine	Distilled water	22
4	Dentine	Alpron	22

ings rejected. One cross sectional surface of each cylinder was sandblasted with 50µm aluminium oxide particles at a distance of 1cm for five seconds, following which they were steam cleaned.

Preparation of tooth specimens

Eighty-eight intact human premolar teeth were collected and randomly divided into the test groups (Table 1). The sample size for each group (N=22) was determined by undertaking a formal sample size calculation (80% power). These teeth had recently been extracted for orthodontic purposes and subsequently stored in 0.1% thymol solution at 4°C prior to use. The teeth were embedded in acrylic resin to a dimension of 15mm (width) x 25mm (height) x 10mm (depth) in order to fit the testing jig, the adherend surface was left uncovered. The adherend surface was ground flat using 1000 grit silicon carbide paper in a Knuth Rotor to a dimension of at least 5mm by 5mm and stored in de-ionised distilled water at 37°C for 24 hours prior to testing, in accordance with the International Standardisation Organisation (ISO) specification ISO/TR 110405¹⁴.

Cementation of test specimens

Each tooth specimen surface was cleaned with a pumice and water slurry using a rotating bristle brush. Following this, they were either rinsed with distilled water or Alpron mint treated water in accordance to the test group allocation. The Alpron mint was diluted to a concentration of 1% prior to use, in accordance with the manufacturer's instructions. The teeth were washed at a flow rate of 100ml/min for thirty seconds to ensure the removal of all traces of pumice. This flow rate was obtained by measuring water output from a 3 in 1 syringe attached to a dental unit.

Enamel surfaces were then etched for thirty seconds using 40% phosphoric acid. The etchant was washed off using either distilled water or Alpron mint treated water, at the previous rate, for thirty seconds. Following the manufacturer's instructions ED primer was applied to adherend surfaces of the tooth specimen. A similar protocol was followed for the dentine samples, omitting the phosphoric acid application as per the manufacturer's instructions.

Resin cement (Panavia 21, opaque) was applied to the adherend surface of the nickel-chrome cylinder. The cylinder was positioned on the prepared tooth surface and placed without delay under a static load of 5kg for ten minutes, to ensure set of the cement. Immediately after placement under the static loading jig, excess resin cement was removed before it had set and Oxyguard gel applied around the cement junction to prevent oxygen inhibition of the cement.

Testing of shear bond strength

Twenty-four hours after storage, each specimen was secured in the testing jig and shear bond strength testing performed using the Instron Universal Testing Machine. The testing jig was of a guillotine type design (Figure 2), aimed at the junction between tooth surface and nickel chrome cylinder. The specimens were loaded until failure at a crosshead speed of 1mm per minute. Maximum load at failure, measured in kilonewtons (kN), was subsequently noted.

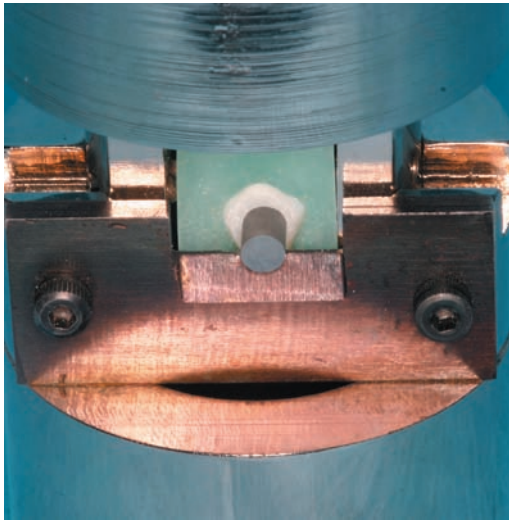


Figure 2. Test specimen located in the testing jig

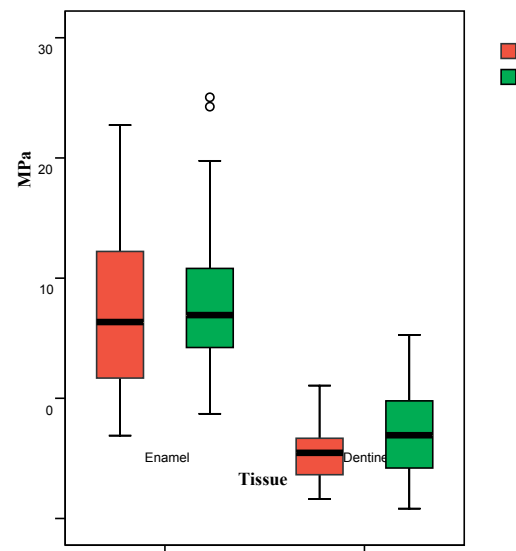


Figure 3. Box and whisker plot to show median shear bond strength for each of the experimental groups. The coloured 'boxes' represent upper and lower quartiles and the 'whiskers' correspond to the limits within which 95% of the values lie. Five outliers are identified.

Table 2. Mean and standard deviation for shear bond strengths recorded for enamel and dentine, following treatment with different irrigants (MPa).

Tooth tissue	Irrigant	N	Mean	Std. Deviation
Enamel	Distilled water	22	17.50	8.00
	Alpron	22	18.77	7.20
	Total	44	18.13	7.55
Dentine	Distilled Water	22	5.23	2.16
	Alpron	22	6.86	3.72
	Total	44	6.05	3.12

Table 3. Results of a two way analysis of variance (ANOVA); Dependent Variable: MPa

	Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3259.297	3	1086.432	32.335	<0.001
Intercept	12866.221	1	12866.221	382.935	<0.001
Between tissue groups	3212.419	1	3212.419	95.611	<0.001
Between irrigant groups	46.150	1	46.150	1.374	0.245
Tissue * irrigant interaction	0.728	1	0.728	0.022	0.883
Error	2822.316	84	33.599		
Total	18947.834	88			
Corrected Total	6081.613	87			

RESULTS

The highest mean value for bond strength was established to be in the enamel/Alpron group (18.77 MPa) and the lowest value in the dentine/distilled water group (5.23MPa). The largest standard deviations were both found to be in the enamel groups, showing greater variation in the values recorded for these groups (Table 2).

A two-way analysis of variance (ANOVA) was used to determine any significant differences in shear bond strengths between the four groups. In all cases, a p-value of less than 0.05 was considered to be statistically significant.

It can be observed from the results of ANOVA (Table 3) that there was no significant difference in shear bond strengths (P=0.245) between the test groups subjected to irrigation with Alpron mint and those irrigated with distilled water. This test also indicates that there is no evidence of an interaction between the irrigant medium and tooth tissue type (P=0.883). Thus the two factors act independently of each other. However when considering tooth tissue type, the shear bond strengths of Panavia 21 to enamel were significantly greater than those to dentine (P<0.001).

DISCUSSION

No significant difference was detected between pre-cementation irrigation of tooth tissue using Alpron mint disinfectant solution compared with distilled water, on shear bond strengths between a resin cement and enamel and dentine. The null hypothesis that Alpron mint would have no significant effect on the bond strength of Panavia 21 to enamel and dentine was therefore not rejected.

Intact premolar teeth were used in this study due to ease of collection as these teeth are often extracted for orthodontic reasons and hence are usually unrestored and caries free. It should be noted that these teeth exhibit a large variation in morphology, which can result in subsequent discrepancies regarding bond tests¹⁵. Enamel with prisms orientated perpendicular to the surface (especially the outer third of labial enamel) show greatest surface area when etched and are thought have more favourable bond strengths, compared with inner depths¹⁶. In this study, labial enamel surfaces for all enamel specimens were ground flat using silicon carbide paper to a level giving a flat surface area, just large enough in diameter to allow for bonding of the nickel chrome cylinder. In this way attempts were made to keep the enamel depth to a similar superficial level for all samples and avoid over-preparation, with consequential extension into dentine.

Dentine composition can vary far more than that of enamel. This is true for different individuals, different teeth within the same individual and also within the same tooth according to depth. A review by Lopes *et al.* reported that variation in depth of the dentine adherend did appear to affect adhesive bond strengths, which decreased with deeper dentine¹⁷. This was thought to be due to reduced availability of peritubular and intertubular dentine, along with increased moisture content from the exposed larger diameter (and more numerous) dentine tubules that are found nearer the pulp chamber. In this study, dentine surfaces were prepared by grinding on the Knuth Rotor use fine grit silicon-carbide paper to avoid excessive removal of peripheral dentine.

The extracted teeth were stored in 0.1% thymol prior to their use. Previous studies have shown that this medium does not affect bond strengths of resin based materials to tooth tissue^{18,19}. Specimens were prepared at room temperature and stored at 37°C for 24 hours prior to testing. The international standards organisation (ISO) implies that this regime suffices to determine any effects a wet environment may have on a material¹⁴. The loading rig ensured correct alignment of cylinder to tooth. Although the static load cannot replicate the clinical scenario of finger pressure, it allows for standardisation that would not otherwise be achieved. The static loading jig also allowed some degree of control over cement film thickness between specimens. Increased film thickness has been shown to result in lower tensile bond strengths to nickel chrome alloy²⁰.

It was decided to use Panavia 21, a functionally active cement, as the test adhesive. This material, contains the functionally active monomer 10-methacryloyloxydecyl dihydrogen phosphate (10-MDP) and is a popular choice when cementing resin retained bridges. Although newer versions of this material are now on the market, Panavia 21 has longer data regarding its clinical performance and has also been used in a plethora of *in-vitro* studies.

The mean bond strength between Panavia 21 and nickel chrome alloy (sandblasted) is 47MPa, higher than for other adherends including enamel and dentine²¹. This study aimed to measure shear bond strengths between tooth structure and the resin cement; thus by employing nickel chrome to be bonded to tooth structure via Panavia 21, the adhesive failure was considered more likely to occur at the weaker tooth-cement interface. Shear bond strength measurement was adopted over tensile bond strength for this investigation as it appears to have less variation in direction of the applied force and is subsequently more likely to be reproducible between specimens²².

The results exhibited a tendency for the shear bond strengths to be higher for both enamel and dentine, where Alpron was used as the irrigant. However, there was no evidence to suggest that this disparity was the result of a genuine difference between the groups ($P=0.245$). This was further confirmed by the post hoc independent sample *t*-tests, which were undertaken as a means of quantifying any differences within the tissue groups.

Alpron mint is a dental unit waterline disinfectant that is marketed in the UK and Europe. Limited data exists on its potential effects regarding bond strengths of dental materials to tooth enamel and dentine. Betke *et al.* (2005) investigated the effect of Alpron mint, amongst other waterline disinfectants, on the bond strengths of dentine to different dentine bonding systems⁶. They found that for three out of four of the dentine adhesive systems tested, Alpron mint did not cause a significant difference in shear bond strengths to dentine. They postulated that waterline disinfectants may influence bond strengths, depending upon the adhesive system used. A similar study by Gray *et al.* indicated that Alpron had a tendency to increase bond strengths to tooth tissue, the magnitude of which appeared to be related to the specific bonding agent used¹².

Alpron mint contains 5% sodium ethylenediamine tetra acetic acid (EDTA) along with sodium-p-toluolsulfonechloramide as the active ingredients. EDTA is considered to be a chelating agent capable of removing the smear layer and demineralising the superficial layers of dentine²³. This may have had an influence in bond strengths to tooth tissue in this study, but this is likely to have been mild as no statistical difference was detected.

A statistically significant difference ($P<0.001$) was found between mean shear bond strengths of Panavia to enamel compared with those to dentine (18.1MPa compared with 6.0MPa respectively). This difference in bond strengths between enamel and dentine has also been proved in numerous other studies and appears consistent with other resin based materials. The difference is attributed to the heterogenous and hydrophilic nature of dentine, which renders it a less receptive surface for bonding compared with enamel. Nevertheless, a number of current products, especially of the self-etch (dissolving the smear layer) rather than total-etch (removing the smear layer) variety, claim to have similar bond strengths to enamel; though it is too early to ascertain their performance *in-vivo* and their durability over time.

CONCLUSIONS

Within the limitations of this *in-vitro* study, the following conclusions may be drawn:

1. There was no statistically significant difference in shear bond strengths (load at fracture) between Panavia 21 and enamel/dentine, with the pre cementation irrigation of tooth tissue using Alpron mint compared with distilled water.
2. Bond strengths of Panavia 21 to enamel (mean=18.13MPa) were significantly higher ($P<0.001$) than those to dentine (mean=6.05MPa). This confirms current understanding that enamel should be the substrate of choice wherever possible.

MANUFACTURERS' DETAILS

1. Cylindrical perspex rods of 4mm diameter
Metrodent Limited, Lowergate Works, Lowergate, Pad-dock, Huddersfield, UK.
2. Rotary Diamond Saw, Model 660 Testbourne Ltd., Bas-ingstoke, Hampshire, UK.
3. Knuth Rotor Struers Ltd., Erskin Ferry Road, Old Kil-patrick, Glasgow, UK.
4. Polishing Jig Constructed by: Graham Palmer, Depart-ment of Biomaterials, Eastman Dental Institute, 256 Gray's Inn Road, London, UK.
5. Sprue wax of 3.5mm and 5mm diameter (Wax Profile) Renfert GmbH, Shulzy Dental, Germany.
6. AuroFilm (surface wetting agent) Bego, D-28359 Bremen, Germany.
7. Ceramic Fibre (asbestos free) Casting Ring Liners Bra-con Ltd, Etchingam, East Sussex, UK.
8. Cera-Fina (Fine grain, phosphate bonded investment) Whip Mix Corporation, Kentucky, USA.
9. Jelenko Accu-Therm 150 Heat-Soaking Furnace Jelenko Dental Health Products, Armonk, New York, USA.
10. Nicor; Nickel-Chrome (Base Metal) Alloy Shutz Dental Group, Dieselstraße 5/6, 61191 Rosbach, Germany.
11. Galloni Fusus 72 High Frequency Induction Casting Machine Castellini UK Ltd., Castle House, Finch Close, Lenton Industrial Estate, Nottingham.
12. Carborundum discs (thin) Chaperlain and Jacobs Ltd., Sutton, Surrey, UK.
13. Wild Microscope M5A Heerbrugg, Switzerland.
14. Silicon carbide paper (1000 grit) Struers Ltd., Erskin Ferry Road, Old Kilpatrick, Glasgow, UK.
15. Callipers Renfert GmbH, Shulzy Dental, Germany.
16. Sandstorm sandblaster (60psi, 4kg/cm²) Vaniman Manufac-turing Company, PO Box 74, Fallbrook CA 90288, USA.
17. Aluminium oxide (50µm particles) Chaperlin and Jacobs Ltd., Sutton, Surrey, UK.
18. Aquaclean 3 (Steam cleaner). Degussa, Degussa AG, D-63403 Hanau, Germany.

19. Lab Putty Coltene/Whaledent Inc 235 Ascot Parkway, Cuyuhoga Falls, Ohio, USA.
20. Special Tray Acrylic Resin (autopolymerising) Dentsply Ltd, Weybridge, Surrey, UK.
21. Pumice (anti-bacterial) Skillbond Direct Ltd, Dudley House, High Wycombe, UK.
22. Distilled water (water for irrigation BP) Parkfields Pharmaceutical Ltd., Pond Lane, Wolverhampton, UK.
23. Alpron mint waterline disinfectant (Lot: 504308) Alpro Dental Produkte GmbH, St. Georgen, Germany.
24. Panavia 21 Opaque (OP) Resin Cement (Batch number: 41170) Kuraray Company Ltd., Japan.
25. Static Loading Jig, Department of Biomaterials, Eastman Dental institute, 256 Gray's Inn Road, London, UK.
26. Lab Thermal Equipment – 37° incubator, Greenfield Nr. Oldham, UK.
27. Instron Universal Testing Machine (Model 4505) Instron Ltd., Coronation Road, High Wycombe, Buckingham-shire, UK.
28. Testing Jig ('Guillotine'). Department of Biomaterials, East-man Dental institute, 256 Gray's Inn Road, London, UK.

ADDRESS FOR CORRESPONDENCE

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