Effects of Low Grade Iodine in Dental Unit Waterlines
On
Shear Bond Strength of a Dentin Bonding Agent

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Introduction

Dental unit water systems that are directly rigged to municipal water or that have a self-contained water reservoir system are normally contaminated with high levels of microorganisms that may be pathogenic or non-pathogenic. The source of the microbes being introduced into the line may be from the patients' oral cavity or from source water of poor quality. Over a short period, the water system develops biofilms that coat the inner surfaces of the system and amplifies the contamination in the dental treatment water, commonly exceeding one million colony-forming units per milliliter (CFU/mL). While this problem was known for the past four decades, the American Dental Association set up a goal to control this contamination within the past 4 years. In simple terms the goal indicated that the dental treatment water to be used in a patient's oral cavity during non-surgical care should be <200 CFU/mL. As of today, there are many dental water treatment and biofilm control methods available in the market. Basically there are physical and chemical methods. The physical methods are point-of-use membrane filters (with or without endotoxin control) on individual water lines. The chemical methods are use of constantly present chemicals in the lines or periodic cleaning lines with an antimicrobial/cleaner and use of microbe free water as an irrigant. As filtration of water does not alter the treatment water's chemistry one need not worry about material compatibility of the water to bonding agents or to the shear bond strength of composites. Materials that are used as periodic cleaning agents may or may not leave residue based on the indicated amount of rinse water to displace the agent. The main concern regarding possible alteration of the dentin shear bond strength of composites is when a constantly present antimicrobial/cleaning agent is used in the water system as an irrigant. We would like to compare effects of bonding when 2-3ppm of iodine in tap water and Dallas Municipal Water (about 150-200 ppm of particulate matter that creates hardness) are used as irrigants in the dental unit water system.

Purpose

The purpose of this evaluation was to study the effects of 2-3 ppm of iodine when used as an irrigant on shear bond strength of a dentin bonding restorative agent.

Materials & Methods

This was an in-vitro evaluation and did not involve human subjects. Intact caries free and developmental defect free human molars from patients of age 18-22 years that were extracted were used in this evaluation. All the extracted teeth were handled aseptically and cleaned free of soft tissue.

<u>Teeth Sample/preparation:</u> The treatment group and the control groups comprised of 15 teeth each. These cleaned teeth were preserved in 0.05% aqueous thymol solution. The teeth were vertically invested in dental die stone (Die-Keen) and set in a humidor for 40 minutes at 100%

humidity. The choice of die stone avoids contamination of dentin as opposed to possibility of resin contaminating the dentin surface during sectioning and polishing. The occlusal enamel was removed after mounting using a 600 grit sectioning diamond saw (Buehler) exposing the desired dentin. The exposed dentin was examined at 8X magnification using a stereomicroscope (Zeiss Stemi SR, Carl Zeiss Inc., Thornwood NY) to ensure that all enamel is removed. The teeth were stored at room temperature ($23 \pm 2^{o}C$) in distilled water. At this time 14 teeth were allocated randomly to the treatment and 14 to the control group.

Bonding: The bonding procedure was performed one tooth at a time and one group at a time. Irrigant derived from the Dentapure™ cartridge (2-3ppm of iodine in tap water) was placed on the dentin surface for a period of 2 minutes. After being dried for 10 seconds with oil free, compressed air, a 35% phosphoric acid etchant (Ultra-Etch) was applied for 15 seconds to the dentin surface of each tooth. A thorough rinse was done with the 2-3ppm iodine for a period of 5 seconds to remove the etchant. The same was repeated for the control group using tap water. Excess irrigant or tap water (as the case may be) was dabbed with a 4 X 4 cotton gauze square twice quickly leaving the surface still moist and glistening but with no visible water present to allow collagen fibers to be intact or erect without collapsing (for better bonding). Optibond Solo Plus (Kerr Corporation) bonding agent was per manufacturer's instruction on the dentin surface. Curing was achieved using an Optilux 500, Demetron Research Corporation, Danbury CT) for 20 seconds with an mW/cm^2 of 540-570 (calibrated between each use). A stainless steel washer about 1mm thick and with a known internal diameter (ranging from 3.85-3.90mm measured using a digital caliper [Mitutoyo Corporation, Japan]) was placed on the dentin surface and aligned. Two composite resins per group (Prodigy A1 and Prodigy A2, Kerr Corporation, CA) were inserted into the inner diameter of the washer and activated by exposure for 40 seconds to the light unit.

Thermalcycling of specimens: The cured composite, the washer, the tooth in the die stone samples was thermalcycled for 500 cycles. The two baths had temperatures of 20 and $57^{o}C$ and the samples rested in each bath for one minute per cycle.

Shear Bond Strength Determination: An Instron instrument was used to test the shear bond strength. The metal sleeve containing the tooth invested within the die stone along with the steel washer containing the cured and aged (thermalcycled) composite was mounted on to the machine and fixed without mobility. A steel blade placed vertically on the rim of the washer next to the tooth surface pushed down on the washer exerting a uniform force on the button with a semi-circular contact parallel to the bonded surface. Tipping forces were avoided and the samples that tipped were not used in the analysis. The radius (mm in this example) squared time pi gave the surface area over which the force was applied and the load at breaking time (failure) the acceleration of gravity divided by the area gave the strength of the bond. Fracture of dentin was considered a catastrophic failure. Even the catastrophic failure was included in the equation and not treated as an outlier. Qualitatively, each of the specimens was examined under a stereomicroscope at 8X and fracture area categorized to determine the mode of failure/breakage. The breakage could be within the composite indicating *cohesive resin*, at the bond-area indicating *adhesive,* within the dentin indicating *cohesive tooth*, or that may partially be within the dentin and the composite indicating *mixed*. Mean bond strengths were determined and an

Independent sample T-Test at an alpha of 0.05 was used to compare the differences in bond strengths between the treatment and control groups.

Results & Discussion

Table 1. Results of the Dentin Bonding Study Municipal Water as Irrigant (Control)

Sample	Bonding area diameter	Failure Load with Dentapure	Failure Load with Tap Water
1	3.88	26.53	52.86
2	3.88	5.14	25.82
3	3.88	72.06	-No data-
4	3.88	6.56	49.26
5	3.88	37.44	-No data-
6	3.88	21.36	-No data-
7	3.88	1.63	25.82
8	3.88	40.18	20.29
9	3.88	49.47	28.15
10	3.88	57.20	51.34
11	3.88	-No data-	23.59
12	3.88	-No-data-	7.83
13	3.88	23.69	20.19
14	3.88	26.05	83.51
Mean	3.88	36.13	38.70
SD	-	28.46	19.933

One Way Analysis of Variance showed no difference between the force required to shear the bond between the iodine and tap water groups ($p>0.05$).

Table 1 describes the data values of the "Failure load with 2-3ppm iodine and Dallas Municipal Water was used as a simulated irrigant. The loads described are pounds of force required to dislodge the bonded washer (using the Instron Device). Missing values are denoted by '-no data-' in the table. These missing values were recorded on samples that could not be used in the study due to either failure of the gypsum cast before the bond broke, dislodgment of the tooth with bond intact, or there was spoiling of the samples after thermal cycling. In this preliminary assessment of the samples, a total of 12 samples out of 14 in the iodine group and 11 in the tap water group were found to be viable and remaining not viable. All samples were coded and controlled for fail mode (adhesive, cohesive and mixed), pulp breaching, cracked stone investment, bonding/de-bonding, resin chip, dentin chip, dentin crack and also with qualitative outcomes of operators notes per each sample.

Based on this test, although there was a difference in the mean bond strength between the two groups due to high intra-group variance in bond strength. Previous studies have shown that a various formulations of irrigants may have had some differences in bond strength but had a large variance within groups. The previous comparisons by other researchers were made using distilled water as a control and on bovine teeth as opposed to our using tap water and human teeth matched by age of person. Most dental clinics do not use particulate free distilled water as an irrigant but use municipal water of varying particulate content. As we scrutinize the variance in bond strengths while standardized bonding and measurement techniques were used, we found that the variance in both the treatment and control groups was large. One may infer that the dentin content may vary from person to person and from areas within the tooth. In previous studies by the investigator, iodine at 2-3ppm obtained from Dentapure™ has shown significant control of planktonic organisms in dental treatment water rendering the water/irrigant safe for dental use.

Conclusions

Based on the findings of this study, 2-3 ppm of iodine from Dentapure™ in municipal water can be used as a waterline irrigant with no statistically significant deleterious effect on dentin bond strength.