Plasma Treatment of Dentin Surface for Enhanced Wettability

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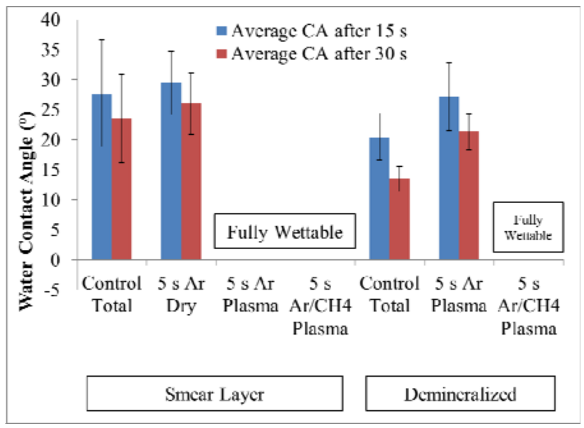
Statement of Purpose: Dentin/adhesive bonding requires an adequate hybrid layer and micromechanical interlocking of adhesive with collagen fibrils and dentin tubules.[1] One major difficulty in evenly dispersing the adhesive through the collagen fibrils in dentin is the variability of collagen in different types of dentin. Occlusal dentin tends to give lower bond strengths than proximal or buccal dentin due to greater regional variability in dentin wetting.[2] The purpose of this study is to investigate various plasma treatment effects on dentin surfaces to improve dental adhesive wettability of demineralized dentin and smear layer. In this study an atmospheric argon plasma brush was applied to demineralized dentin and smear layer and characterized by contact angle measurements. Methane reactive gas was introduced during some trials.

Methods: An atmospheric cold plasma brush, a non-thermal gas plasma source, was utilized to treat and prepare dentin surfaces for dental adhesive and dental composite application. Extracted unerupted human third molars were used for this investigation. The occlusal one-third of the crown was sectioned by means of a water-cooled low speed diamond saw (Buehler, Lake Bluff, IL). The exposed dentin surfaces were polished with 600 grit SiC sand papers under water. Some smear layers were then etched using 36% phosphoric acid gel. The dentin surface was dried for 30 s by oil free air spray from a dental syringe. Immediately after drying the dentin surfaces were treated by Ar plasma with reaction gas addition for 0, 5, 15, and 30 s. The sessile droplet method determined the surface contact angle (VCA 2500XE; Advanced Surface Technologies, Inc., Billerica, MA) to measure the static contact angle, 1.0 μL of distilled water and model adhesive was placed on the dentin surface, and computer software supplied with the equipment was used to obtain a photograph of the image 15 and 30 s after placement on the dentin. The model adhesive, similar to Single Bond (3M ESPE, St Paul, MN, USA) contained 24%wt HEMA, 36%wt BisGMA, and 40%wt ethanol.

Results: Figure 1 shows the water contact angle of plasma modified smear layer became zero after only 5 s of plasma treatment with and without methane reactive gas. Ar gas treatment provides similar water contact angles compared to the control. This implies the collagen treatment effect is from the plasma and not the Ar gas itself. Ar plasma surface treatment of demineralized dentin increased the water contact angle slightly; however addition of methane reactive gas decreased the water contact angle from 20.50° +/- 3.87° to zero. Adhesive contact angle trends were similar to water contact angles, but the adhesive contact angles were larger than the water. The wetting of adhesives was typically better after plasma treatments. This could also result in enhanced collagen adhesive interactions. These results imply that atmospheric plasma is a promising primer for dental adhesives.

Figure 1. Water contact angle dentin over time with various treatments



Conclusions: Ar plasma treatment has effectively lowered the water contact angle of the smear layer. Ar plasma with methane reactive gas will also lower the water contact angle of demineralized dentin. Modifying the collagen in dentin could help to enhance the wetting and thus the bonding of dental adhesives.

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