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Original Article

Evaluation of Dental Adhesive Agent Film Thickness After Light Curing Under a Stream of Nitrogen

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Abstract

Purpose: The purpose of the study is to evaluate the efficiency of polymerizing unfilled resin based dental adhesives when cured under a continuous stream of nitrogen compared to air thinning and curing in ambient air environment. Materials and Methods: 2 groups of 5 teeth were sectioned parallel the occlusal surface, to expose dentin. Unfilled universal adhesive (All-bond Universal, BISCO) was applied to the 2 groups; Control group, solvent was evaporated using air syringe and cured in ambient air, while for the intervention group nitrogen was used to evaporate the solvent and the adhesive was cured under a stream of nitrogen. After post curing and wiping the surface with alcohol, the teeth were sectioned parallel to the occlusal surface into slides of 1mm thickness to evaluate the film thickness of the cured adhesive under electron microscope (BS-SEM). Images of BS-SEM images were analyzed using (ImageJ2 software). Results: Statistically significant difference between the two groups was found in favor of the intervention group ($P<0.05$). The mean adhesive film thickness of the intervention group and the control group were 7.02µm and 3.33µm respectively. Conclusions: Curing the dental adhesive under a stream of nitrogen from a nitrogen tank connected to a 3-way syringe, can be a clinically achievable alternative to efficiently cure resin. Further studies are required to test the bond strength and durability of the adhesive, when cured under a stream of nitrogen.

Keywords: IDS, Immediate Dentin Sealing, Bonding, Nitrogen, Oxygen Inhibited layer, Indirect Restorations

I. INTRODUCTION

Bonding to the tooth structure is often found to be a challenging and technique sensitive task. The surface of the bonding preparation could be composed of either enamel only or enamel and dentin. Dentin is a heterogeneous and inherently moist structure, thus when combined with the moisture sensitivity characteristic of dental adhesives; presents an added obstacle to the bonding procedure (Liu et al., 2011).

One of the techniques that has been espoused in literature as an optimal technique for bonding whenever dentin is exposed is The Immediate Dentin Sealing “IDS”. In essence,

immediately after the preparation, dentin is etched with phosphoric acid for 5–15 seconds, the primer is then applied and carefully dried, the freshly cut dentin is sealed with a layer of filled adhesive (Optibond FL®, Kerr), and cured for 20 seconds, and finally it is cured for an extra 10 seconds through a layer of glycerin gel (air block/post-curing) to minimize the thickness of the Oxygen Inhibited Layer (Magne, 2005).

Accordingly, there is no doubt that the latest advances in restorative dentistry are mostly, if not completely, centered on bonding, aiming to perfect the bonding process and the adhesive joint (Liu et al., 2011) The newest adhesives have successfully helped minimize the steps needed to achieve a strong adhesive bond. Nonetheless, despite these advances, one flaw persists, which was the inability of the adhesive agents to polymerize in the presence of oxygen. This flaw could lead to unfavorable results, since it would form an oxygen-inhibited layer on the surface, reaching up to 40μm in thickness (Rueggeberg & Margeson, 1990). Thus, in the case of thorough air thinning, the adhesive apparatus may reach a degree of thinness sufficiently low to prevent the polymerization of the entire adhesive resin layer. Magne suggested the application of a thick layer of adhesive ranging from 60-300 microns; to obtain a sufficient thickness of polymerized resin, protecting the hybrid layer after removal of the un-polymerized surface layer (Magne, 2005).

The Un-polymerized surface layer is eliminated in other industries, such as wood coating, by using Nitrogen (Cvetković et al., 2012; Husár et al., 2014; Parker Balston, 2012). However, these industries use a Vacuum-Sealed nitrogen Chamber to cure the full thickness of the resin (Dall'Oca et al., 2007), which is not applicable in the clinical setting (Oyama et al., 2012; Shade et al., 2014). Hence, Park et al. (Park et al., 2004) suggested testing a more clinically achievable scenario, curing under a continuous stream of nitrogen.

Therefore, this study was conducted to test the efficiency of polymerizing unfilled resin based dental adhesives when cured under a continuous stream of nitrogen blown from a 3-way syringe attached to a compressed nitrogen tank.

II. MATERIALS AND METHODS

This in-vitro study was conducted in the laboratory of conservative dentistry department, Faculty of Dentistry, Cairo University, Egypt according to the recommendations and approval of the ethics committee on in-vitro research of Faculty of Dentistry, Cairo University. According to the pre-clinical in-vitro modified CONSORT guidelines, the intervention, outcome, and sample size were recorded.

Ten sound freshly extracted molars were collected, cleaned with dry gauze, then soft tissue and hard deposits on the roots were mechanically removed using an ultrasonic scaler. Teeth were then kept in a clean sealed glass container filled with 0.1% thymol solution and stored in room temperature (Boruziniat et al., 2017).

Using (IsoMet® 4000, Buehler), the occlusal enamel was sectioned parallel to the occlusal plane to expose dentin. Each tooth was then checked under magnifying loupes with 4.3X magnification power (Promag, Carl Zeiss, Germany) to ensure there is no remaining enamel, and any was present, it was removed with additional trimming.

Each molar was given a number, and 2 random sequences were generated in 2 equal columns using the website (http://www.random.org), with the lower limit being 1 and the upper limit being 10. Each sequence was placed in an opaque sealed envelope labelled A and B. Each envelope was randomly assigned to one of the 2 test groups.

For the control group, (All-bond Universal, BISCO) was applied in 2 coats following manufacturer instructions, followed by solvent evaporations using dental unit triple-way syringe, followed by curing for 20

seconds at a 3-mm tip-to-specimen distance and 1200mW/cm2, using calibrated LED curing light (Elipar™ S10, 3M ESPE) mounted on a holder.

For the Intervention group, (All-Bond Universal®, BISCO) was applied in 2 coats as well following the manufacturer instructions, then it was followed by solvent evaporation using a dental air syringe attached to a pure nitrogen tank, followed by curing for 20 seconds at a 3-mm tip-to-specimen distance and 1200mW/cm2, using calibrated LED curing light (Elipar™ S10, 3M ESPE) mounted on a holder, under a continuous stream of nitrogen. Both groups went under 20 seconds of post curing through glycerin gel, then thoroughly rinsed and surface is then wiped with an alcohol swab to remove any remaining un-polymerized resin.

- *Slide preparation*

All samples were sectioned in slices of 1mm thickness using the (IsoMet® 4000, Buehler) saw, perpendicular to the occlusal plane. Three slices were randomly selected from each sample to be imaged under environmental scanning electron microscope at the National Research Center in Giza.

The selected cuts were etched for 30 seconds using 37% orthophosphoric acid in order to cleanly expose the surface of the dentin-resin interface from the smear layer by partially demineralizing the dentin (Magne et al., 2005), this was then followed by thorough rinsing with distilled water, then immersed in a 1% NaOCl solution for 10 minutes to dissolve the unprotected collagen fibrils following the infiltration of adhesive resin. Samples were again thoroughly rinsed with distilled water before placing them for an additional 10

minutes in 100% ethyl alcohol, to eliminate moisture from the samples. Each slide was screened at 800x to avoid areas of bond pooling or slide errors due to sectioning. Then at the 5-7 points were measured at 1500x for each slide. ImageJ2 software was used for image analysis of BS-SEM images, to measure the bonding agent layer thickness. Data was analyzed using IBM SPSS advanced statistics (Statistical Package for Social Sciences), version 20 (SPSS Inc., Chicago, IL).

III. RESULTS

Table 1 lists the thickness values, measured at different areas in each sample, the average film thickness of each sample, the average film thickness per tooth and the average film thickness of each group. The intervention group showed a statistically significant (P=0.011) increase in the bonding agent film thickness with the average of 7.02μm while the control group demonstrated less than half of the film thickness 3.33μm.

Table (1): Comparison of Adhesive Thickness Values in all samples

	Control								Intervention											
	T1	Av	T3	Av	T5	Av	T8	Av	T1	Av	T2	Av	T4	Av	T6	Av	T7	Av	T9	Av
A	0	0	4.013	3.1	5	5.6	0	0	8.807	6.8	10.409	10	4.272	4.6	8.664	7.3	5.307	5.7	7.747	8.5
	0		3.366		5.909		0		7.899		9.825		5.728		7.939		4.984		8.769	
	0		3.236		5.364		0		6.356		10.117		4.369		6.818		6.019		8.643	
	0		2.848		6.091		0		6.083		10.019		4.66		7.295		5.825		8.64	
	0		2.718		5.545		0		5.811		10.603		3.301		5.981		5.761		8.512	
	0		2.718		5.545		0		5.629				4.466				6.472			
	0						0						5.243							
B	0	0	2.783	2.5	7.748	7.9	4.019	3.6	8.253	6.8	5.464	4.5	5.825	4.8	4.951	4.8	6.51	5.6	14.729	15
	0		4.013		7.385		4.473		7.995		4.386		4.531		5.243		5.718		15.116	
	0		1.942		8.354		2.853		7.093		4.258		4.272		4.951		5.73		14.729	
	0		1.618		7.627		2.975		6.705		4.136		3.236		5.243		5.738		15.698	
	0		2.136		8.232		3.436		5.545		4.136		6.472		4.369		5.054		14.729	
	0		2.395				3.89		5.287				4.66		3.981		4.555			
	0																			
C	7.092	5.8	0	0	0	0	2.035	3	4.255	5	8.751	9.6	6.117	3.6	6.117	6.2	6.214	6	10.401	8.9
	6.963		0		0		3.391		3.965		10.15		6.117		6.117		6.084		10.493	
	5.545		0		0		3.004		5.416		10.236		6.505		6.505		5.825		10.219	
	4.771		0		0		4.167		4.255		10.088		6.408		6.408		7.12		8.485	
	4.384		0		0		2.231		5.61		8.837		5.922		5.922		4.79		5.018	
			0		0				5.609											
			0		0				5.706											
		1.9		1.9		4.5		2.2		6.2		8.1		4.3		6.1		5.8		11
Av				3.33										7.02						

IV. DISCUSSION

The result of the present study corresponds with previous studies, suggesting the presence of an unpolymerized layer at the surface, or what is referred to as the oxygen-inhibited layer. From the results, we see the presence of areas of zero film thickness of the adhesive in the control group. This is in accordance with Rueggeberg & Margeson proposing that the oxygen inhibited layer is thicker than the adhesive thickness: preventing it from polymerization (Rueggeberg & Margeson, 1990).

Further, this concurs with Reis et al, stating that air thinning can result in incorporating air bubbles inside the adhesive layer, hindering the polymerization even more and resulting in an uneven layer (Reis et al, 2013).

Moreover, this is in agreement with Magne's rationale behind using a thick layer of adhesive (Magne, 2005) to account for this oxygen inhibited layer, and providing enough adhesive thickness to protect the hybrid layer. However, in his technique, polymerization is undergone conventionally in ambient air. On the other hand, the results of using nitrogen in this study showed promising results, and that curing under a stream of nitrogen could be a close, clinically achievable, alternative to curing in the vacuum-sealed nitrogen Chamber. Using this technique, the oxygen inhibited layer was minimized. Nearly the full thickness of the adhesive was cured. These numbers suggest a less costly and complex alternative technique for the use of IDS. Thanks to the ability of efficiently curing a thin film thickness of unfilled resin-based adhesive, the dentin could sealed following the impression, eliminating interactions with any residual uncured resin (Magne and Nielsen, 2009). This technique could therefore be a new alternative to IDS, provided similar bond strength values are attained and demonstrated

in further studies. Further studies are needed to test these findings in the normal clinical settings.

V. CONCLUSION

Giving to the limitations of the study, curing dental adhesive resin under a stream of nitrogen can efficiently eliminate the oxygen-inhibited layer, and completely cure the full thickness of the adhesive, which enables us to use thin film thickness of adhesive to seal the dentin.

VI. CONFLICT OF INTEREST

The authors declare no conflict of interest.

VII. FUNDING

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

VIII. ETHICS

This study protocol was approved by the ethical committee of the faculty of dentistry- Cairo university on: 28/07/2019, approval number 19-7-36.

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