International Journal of Advanced Biotechnology and Research (IJBR)
ISSN 0976-2612, Online ISSN 2278–599X,
Vol-8, Issue-2, 2017, pp1557-1563
http://www.bipublication.com

Research Article

Evaluation of the effect of storage time on mechanical properties of universal adhesives

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ABSTRACT
Aim: The current research was conducted compare the bond strength of two types of universal adhesives in a period of one year and the impact of time on the physical properties of the adhesives. **Methods:** In an empirical lab experiment, 48 cylindrical composite samples of 0.7.1.1 mm were prepared from the middle third of healthy wisdom teeth. The samples were categorized into 4 groups: (1) tooth samples from fresh single bond universal, 24 hours after sampling; (2) Tooth samples from fresh all bond universal, 24 hours after sampling; (3) tooth samples from single bond universal, one year after sampling; and (4) tooth samples from fresh all bond universal, one year after sampling. The samples then underwent cuts from the universal test machine and the results were analyzed using one-way ANOVA and post-hoc Tukey-Kramer test. **Results:** According to the results, the degree of strength of the fresh single bond universal and the fresh all bond universal were determined to be 49.86 and 39.76 MPa, respectively. In addition, no significant reduction observed in the strength of shear bonds where single bond universal and all bond universals showed 36.12 and 28.91 MPa strength, respectively. **Conclusion:** Based on the findings of this study, the passing of time cannot significantly affect the physical properties of universal adhesives and reduce strength of the bonds.
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Keywords: Shelf life, Shear strength, Universal adhesives

INTRODUCTION

The paramount goal of bonding restorations is to achieve an intimate contact between restorative materials and dental hard tissues (Perdigão, 2007). Dental adhesives are solutions of resin monomers that make the resin–dental substrate interaction achievable (Park et al. 2008). Adhesive systems are composed of monomers with both hydrophilic groups and hydrophobic groups. The former enhance wettability to the dental hard tissues, while the latter allow the interaction and co-polymerization with the restorative material (Perdigão, 2010).

The bonding mechanism of adhesive systems basically involves the replacement of minerals removed from the hard dental tissue by resin monomers, in such a way that a polymer becomes micro-mechanically interlocked to the dental substrate (Munoz et al. 2013). Self-etch adhesives were introduced with the goal of eliminating the highly sensitive technique step of acid etching, as their acidic monomers simultaneously etch and infiltrate the dental substrate, thereby minimizing the discrepancies between hybridized and etched zones in the substrate (Yoshida et al. 2012). Application of selective acid etching on enamel before SE application has been recommended, especially when the use of mild-pH SE is intended. However, inadvertent pre-etching of dentine is a clinical risk, which can negatively affect bonding efficacy (Peumans et al. 2010).

New type of bonding agent was recently introduced to help clinicians save chairtime and simplify the conditioning of both the tooth and restoration surface. This new generation of bonding agent has been named "universal", as it can be used as a total-etch, self-etch or selective-etch adhesive. It is also capable of binding to the tooth structure, as well as indirect substrates such as ceramic, resin and metal (Blatz and Sadan, 2003). Of the bonding agents developed, single bond universal adhesive and All-Bond Universal adhesive are most commonly used (Kim et al. 2015). Evaluations of the effect of this universal bonding system on resin cement to indirect restorations have yielded promising results, with the universal adhesive bonding effectively to stainless steel, lithium disilicate and zirconia (Kim et al. 2015). Among the various methods developed for measuring the bond strength of an adhesive system, microshear bond strength (µSBS) testing offers similar benefits as microtensile strength (µTBS) testing. That is, it provides a more evenly distributed stress through a reduced specimen size. Specimen preparation for the µSBS test is also less demanding than that for the µTBS test. Considering the short time elapsed since these new universal adhesives appeared in the market, only little clinical outcomes are available in the literature (Lohbaueret al. 2008). Aiming to eliminate complications and providing a single product for all situations, universal adhesives that might be indistinctly applied either in self-etch or etch-and-rinse mode have been recently introduced (Van Meerbeek et al. 2011). So, the aim of the currents study was to determine the bond strength of two types of universal adhesives in a period of one year and the impact of time on the physical properties of the adhesives.

MATERIAL & METHODS

Specimen preparation

Study was done on molar teeth. The samples controlled for no possible crack and defects and polished using 400, 600 and 800 grade emery. The 48 samples divided into 4 experimental groups (n=12). Tooth samples from fresh single bond universal (3M, USA), 24 hours after sampling; (2) Tooth samples from fresh all bond universal (Bisco, Germany), 24 hours after sampling; (3) tooth samples from single bond universal (3M, USA) one year after sampling; and (4) tooth samples from fresh all bond universal (Bisco, Germany), one year after sampling. Then, microshear bond strength of the samples was determined after 24 h and 12 months.

Microshear bond strength measurements

The surface of the substrate was ached using a microbrush contacting phosphoric acid (Condac 37, FGM, Brazil) for 15 sec. then the bonding was done according to the instruction of the manufacture using the light cure device (Elipar Free3 M/ESPE, St. Paul, MN, USA). The composite sylinders (1×0.7mm) applied on the substrate (TYG-030, Small Parts Inc., Miami Lakes). Each cylinder was cured light cure device (Woodpecker, Midnet Industry, China) at 700 mv/mm2 for 40 sec. then samples allocated into incubator (37 ˚C, 100% humidity) for 24 h. Then the bounding strength was determined using Universal Testing Machine (Bisco, Germany). The maximum strength force and time was determined in the N and then converted to MPa.

RESULTS

The evaluation of the effect of storage time on mechanical properties of universal adhesives at the moment and after 1 year are presented in tables 1-3 and figure 1-5. According to the table 1, a significant difference detected on the strength of adhesives which strength of single and all universal bonds adhesive after 24 h 49.86 ± 12.01 and 39.7 ± 7.01 MPa, respectively. Also, the strength of single and all universal bond adhesive after 12 months were 36.12 ± 2.88 and 28.91 ± 7.26 MPa, respectively.

Table 1. the results of the microshear bond strength of the different adhesives (MPa)

Experimental groups	Mean ± Sd	P value
Single universal bond adhesive, 24hours	49.86 ± 12.01	
All bond universal, 24hours	39.7 ± 7.01	<0.0001
Single universal bond adhesive, 12 month	36.12 ± 2.88	
All bond universal, 12 month	28.91 ± 7.26	

Table 2. the ANOVA results of the microshear bond strength of the different adhesives (MPa)

Strength	Sum of Squares	df	Mean Square	F	Sig.
Between groups	28684.23	8	3585.52	484.64	0.00001
Within groups	998.77	135	7.39		
Total	29683.00	143			

Table 3. the results of the Post Hoc Tukey-Kramer test of microshear bond strength

Experimental groups	Differences	Sig.
Single Universal Bond Vs. 24 h, Single Bond 12 month	13.24	0.027
All Bond Universal 24 h Vs. All Bond 12 month	-10.85	0.090
Single Bond Universal 24 h Vs. All bond Universal 24 h	10.09	0.126
Single Bond Universal 12 month Vs. All Bond Universal 12 month	-7.70	0.321
All Bond 12 month Vs. Single Bond 24 h	20.94	0.0001

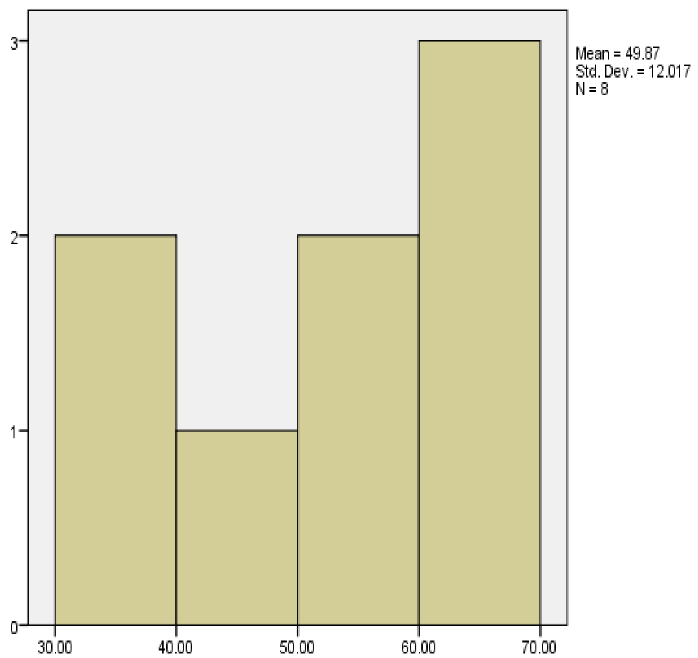

Figure 1. the microshear bond strength results of the single bond universal adhesives after 24 h

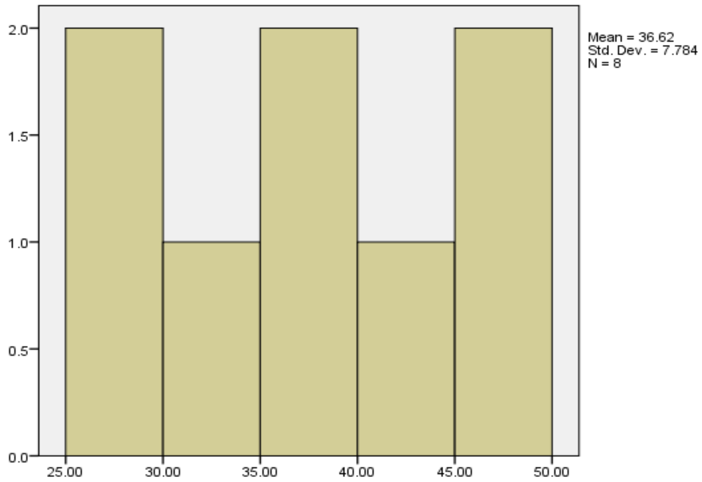

Figure 2. the microshear bond strength results of the single bond universal adhesives after 1 year

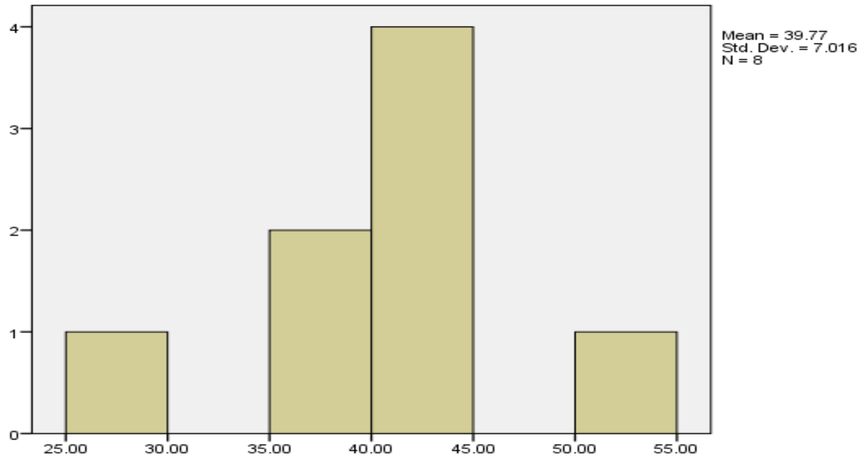

Figure 3. the microshear bond strength results of the all bond universal adhesives after 24 h

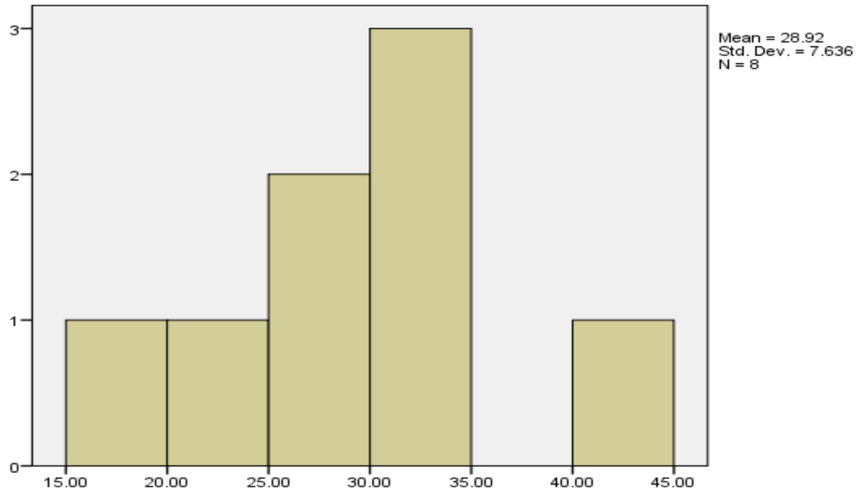

Figure 4. the microshear bond strength results of the all bond universal adhesives after 1 year

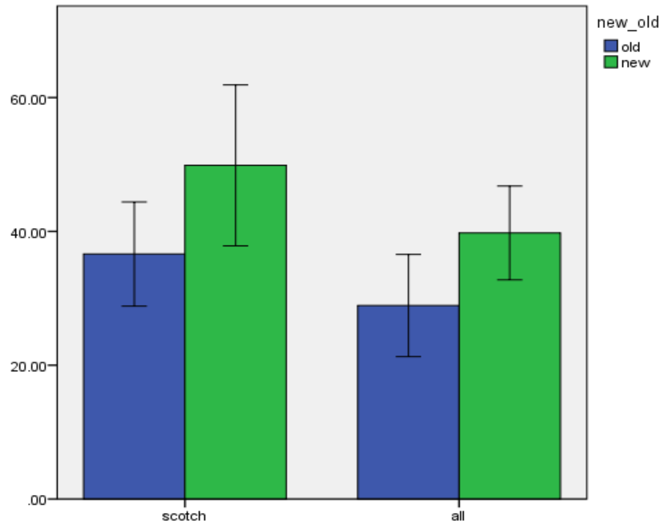

Figure 5. the comparison results of the microshear bond strength of single bond universal and all bond universal adhesives after 24 h (new) and 1 year (old)

As seen in table 2, significant difference detected on strength of different adhesives (single and all universal bonds) after 24 h and 12 months. As seen in table 3, significant difference detected on strength of the single universal bond Vs. 24 h, single bond 12 month (P=0.027). Also, significant difference detected on strength of the all bond universal 24 h Vs. all bond 12 month (p=0.090). A significant difference observed on strength of all bond 12 month Vs. single bond 24 h (p=0.0001). The strength results of the single bond universal adhesives after 24 h is presented in figure 1. As seen, the higher strength in universal adhesives after 24 h was detected in 60-70 MPa. Additionally, the higher strength in universal adhesives after 1 year was detected in 25-30, 35-40 and 45-50MPa, respectively. Furthermore, the higher strength in all bond universal adhesives after 24 h was detected at 40-45 MPa (figure 3). The greater strength in all bond universal adhesives after 1 year was detected at 30-35 MPa (figure 4). The comparison results of the single bond universal and all bond universal adhesives after 24 h and 1 year is presented in figure 5. As seen, no significant difference detected in strength of the single bond universal adhesives after 24 ha and 1 year. Also, no significant difference detected in strength of the all bond universal adhesives after 24 ha and 1 year (P>0.05). The passing of time cannot significantly affect the physical properties of universal adhesives and reduce strength of the bonds.

DISCUSSION

As observed in this study, significant difference detected on the strength of adhesives which strength of single and all universal bonds adhesive after 24 h 49.86 ± 12.01 and 39.7 ± 7.01 MPa, respectively. Also, the strength of single and all universal bond adhesive after 12 months were 36.12 ± 2.88 and 28.91 ± 7.26 MPa, respectively. Significant difference detected on strength of the all bond universal 24 h vs. all bond 12 month. A significant difference observed on strength of all bond 12 month vs. single bond 24 h.Universal adhesives represent the last generation of adhesives in the market. They are designed under the ‘‘all-in-one’’ concept of already existing one-step self-etch adhesives, but incorporating the versatility of adapting them to the clinical situation, by application under different etching modes. In the present study, the use of three of these universal adhesives to dentine following a self-etch or an etch-and-rinse protocol did not affect significantly their mTBS, but showed very different dentine infiltration behavior. They performed better than the two 1-SEAs used here regardless of the application mode (Perdigao et al. 2012). In one study, the use of phosphoric acid prior to self-etch application in dentine created well impregnated hybrid layers, which were associated to significantly improved mTBS values when compared to conventional application of the same 1-SEAs (Hanabusa et al. 2012).The efficacy of the thermocycling test in evaluating bond strength has been questioned and highly conditioned to specific test set-ups. The presence of surrounding dentine and composite could have avoided direct water contact with the specimens, protecting them from accelerated hydrolysis while the low C-factor of the specimens could have diminished the expansion/contraction stress effect (Lohbauer et al. 2008). The similar bonding performance of the universal adhesives after the different application modes in this study indicates their reliability when working under different clinical situations. This is of special usefulness, when strict selective enamel etching turns difficult (e.g. in small approximal cavities) (Munoz et al. 2013). Therefore, considering their similar adhesive performance irrespective of the application mode, inadvertent etching might not significantly compromise the bonding to dentine for these systems (Munoz et al. 2013).

In our study, no significant difference was detected in strength of the single bond universal adhesives after 24 ha and 1 year. Also, no significant difference detected in strength of the all bond universal adhesives after 24 ha and 1 year. The passing of time cannot significantly affect the physical properties of universal adhesives and reduce strength of the bonds. Theoretically, for etch-and-rinse adhesives, the bond strengths obtained for hydrophilic adhesives is a sum of the strengths of the resin tags, hybrid layer and surface adhesion (Loguercio et al. 2007). The chemical interaction is a crucial characteristic of universal adhesives to enhance durability of dentin-resin interfaces. Bond strengths are usually lower than those of two- and three-step etch-and-rinse adhesives, but in line with results reported for self-etch adhesives (Armstrong et al. 2003).

The in vitro performance of universal adhesives has been reported as material-dependent due to the complexity of their chemical composition. As explained elsewhere, all simplified adhesives behave as permeable membranes (either two-step etch-and-rinse or one-step self-etch adhesives). Universal adhesives are one-step self-etch adhesives they behave in the same fashion (Carrilho et al. 2007).

Universal adhesives must also contain water, as it is required for dissociation of the acidic functional monomers, inherent in all these systems, that makes self-etching possible (Ermis et al. 2008). One of many dilemmas faced by chemists developing universal adhesives is that while some water is needed, too much can degrade the chemistry of these systems, contribute to phase separation of monomers, decrease shelf-life, and be difficult to completely evaporate during the air-drying step (Ermis et al. 2008). In fact, phosphate esters form the backbone of virtually all current universal adhesive systems and enable them to do much of what they do. These monomers have many positive attributes, including the potential to bond chemically to metals, zirconia and to tooth tissues through the formation of non-soluble Ca++ salts. In addition, their acidic nature (they are esters of phosphoric acid) gives them the potential to etch and demineralize tooth tissues, which makes them good candidates for use in adhesives that require self-, selective-, and total-etching options (Van Landuyt et al. 2008). The manufacturers of most universal adhesives state they can be used not only for bonding to dentin and enamel, but as adhesive primers on substrates such as zirconia, noble and non-precious metals, composites, and silica-based ceramics (Van Landuyt et al. 2008). In conclusion, these results suggested the passing of time cannot significantly affect the physical properties of universal adhesives and reduce strength of the bonds.

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