EGYPTIAN
DENTAL JOURNAL

VOL. 65, 1949:1954, APRIL, 2019

I.S.S.N 0070-9484

FIXED PROSTHODONTICS, DENTAL MATERIALS, CONSERVATIVE DENTISTRY AND ENDODONTICS

www.eda-egypt.org • Codex : 227/1904

BONDING PERFORMANCE OF A SELF-ADHERING FLOWABLE COMPOSITE RESIN TO DIFFERENT DECIDUOUS SURFACES

Fatma Abdelgawad*, Rasha Abdelraouf** *and* Manar Mohammed***

ABSTRACT

Objective: Evaluation of the shear bond strength of self-adhering flowable composite-resin to different surfaces of deciduous molars.

Methods: Eighteen-freshly extracted sound human deciduous molars were used. The teeth were embedded in acrylic blocks, such that their buccal surfaces were shown and aligned with the acrylic surfaces. The teeth were randomly divided into three groups. Group I: enamel surfaces without any intervention (Uncut Enamel), Group II: enamel surfaces with minimal grinding (Cut Enamel) and Group III: dentin surfaces. For all groups, self-adhering flowable composite-resin (Dyad™-flow, Kerr, USA); was applied. Specially designed holed-split Teflon mould was used for constructing composite - resin cylinders (3×3mm) over the buccal surfaces of the mounted teeth. The Dyad™-flow was applied in a central hole of the mould upon tooth surface, and then light cured for 20 seconds. The teeth were stored in distilled water at 37^{O}C for 24 hours. The strength was recorded blindly by a different assessor using universal testing machine and statistically analyzed. Modes of failure were studied using digital microscope.

Results: Mean values of shear bond strength for groups I, II, III were 9.6, 5 and 3.6 MPa respectively, with statistically insignificant difference P=0.09 (P value≥0.05). Some specimens showed spontaneous de-bonding after water storage [group I (33.3%) and III (83.33%)]. Failure mode was 100% adhesive failure in all groups.

Conclusions: Bonding of Dyad™-flow was highest in uncut enamel however further material improvement may be required.

KEYWORDS: Shear bond strength, Self-adhering resin composite, Deciduous teeth, Dyad flow.

* Lecturer, Department of Pediatric Dentistry and Dental Public Health, Faculty of Dentistry, Cairo University, Giza, Egypt
** Associate Professor, Department of Biomaterial, Faculty of Dentistry, Cairo University, Giza, Egypt
*** Lecturer, Department of Pediatric and Community Dentistry, Faculty of Oral and Dental Medicine, October 6 University, Giza, Egypt

INTRODUCTION

Dentists and patients demands for tooth - colored restorations have been increasing in last years(1). Flowable composites is one of the materials which can subside these demands(1). Dentistry of adhesion is in a constant state of evolution. Adhesive evolution began with Buonocore in 1955 by introducing flowable composites to restore class V lesions. Flowable composites have excellent handling properties, superior injectability and low viscosity(1). The working time for clinicians and chairside time of patients can be reduced by desired and easy handling of flowable composites(2). A new self- adhering flowable composites (Dyad™-flow, Kerr, USA) following the same characteristics was recently introduced in the market(1). Incorporation of an acidic adhesive - free composites due to chemical and micromechanical interaction between material and tooth structures or other substrates(3). Demineralization and infiltration of the tooth surface to the same depth by self - adhesive composites ensuring chemical interaction between functional monomers and residual hydroxyapatite and complete penetration of the adhesive(4). Self- adhering flowable composites allow more simple, less technique sensitive clinical procedure and less time consuming(5). Due to novelty of self- adhering flowable composites Dyad™-flow further investigation of bonding strength is required(1). The aim of this study was to evaluate the shear bond strength of self- adhering flowable composite - resin to different surfaces of deciduous molars.

MATERIAL AND METHODS

Specimens Preparation and grouping:

Eighteen-freshly extracted sound human deciduous molars were used. The teeth were embedded in acrylic blocks (19mmX16mm), such that their buccal surfaces were shown and aligned with the acrylic surfaces (Cold cure acrylic resin, Acrostone, Egypt). The teeth were randomly divided into three groups: Group I: Enamel surfaces without any intervention (Uncut Enamel), Group II: Enamel surfaces with minimal grinding (Cut Enamel) and Group III: Dentin surfaces, as shown in figure 1. In groups II and III, the buccal surfaces of the teeth were grinded using a grinding machine (Red wing, Handler, USA) under water coolant.

Bonding Procedure:

For all groups, self-adhering flowable composite-resin (Dyad™-flow, Kerr, USA); was applied. Specially designed holed-split Teflon mould was used for constructing composite - resin cylinders

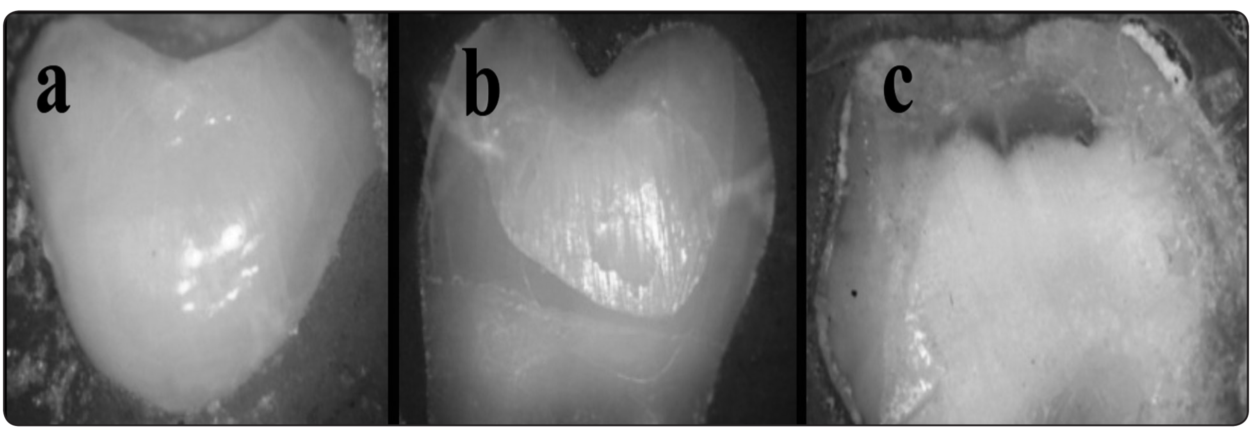

Fig. (1) A photograph showing the different surfaces of deciduous teeth: a) Group I (Uncut Enamel), b) Group II (Cut Enamel), c) Group III (Dentin)

(3×3mm) over the buccal surfaces of the mounted teeth. The Dyad™-flow was applied in a central hole of the mould upon tooth surface as shown in figure 2, and then light cured for 20 seconds using a light emitting diode (L.E.D.) light curing unit (Satelec, Acteon, France). The teeth with the bonded resin cylinders were stored in distilled water at 37^{O}C for 24 hours.

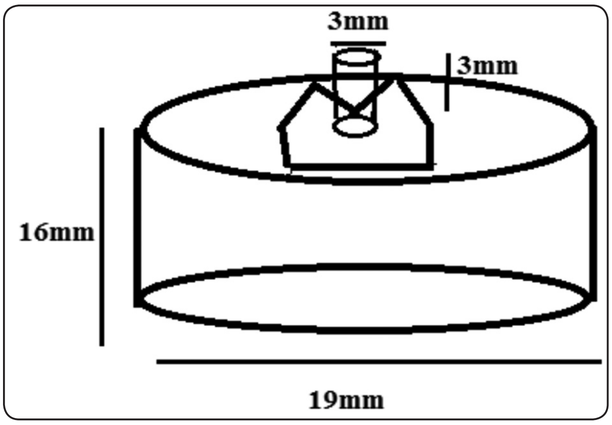

Fig. (2) A diagram showing a bonded resin cylinder to a buccal surface of deciduous tooth embedded in an acrylic block.

Shear bond strength test:

Each acrylic block was secured with tightening screws to the lower fixed compartment of a universal testing machine (Model LRX-plus; Lloyd Instruments Ltd., Fareham, UK) as shown in figure 3, with a load cell of 5 kN and data were recorded using computer software (Nexygen-MT Lloyd Instruments). A shearing load with compressive mode of force by mono-bevel-chisel was applied via materials testing machine at a crosshead speed of 0.5 mm/min. The relatively slow crosshead speed was selected in order to produce a shearing force that resulted in de-bonding of the microcylinder along the substrate-adhesive interface. The load required to de-bonding was recorded in Newton.

Shear bond strength was calculated as the load at failure divided by bonding area to express the bond strength in MPa: $\boldsymbol{\tau = P/ \pi r^2}$

Where; $\boldsymbol{\tau}$ =bond strength (in MPa), **P** =load at failure (in N), $\boldsymbol{\pi}$ =3.14, **r** =radius of cylinder (in mm)

The strength was recorded blindly by a different assessor and the data were statistically analyzed. Modes of failure were studied using digital microscope (Scope Capture Digital Microscope, Guangdong, China), and recorded as cohesive, adhesive or mixed failure by a different assessor blindly.

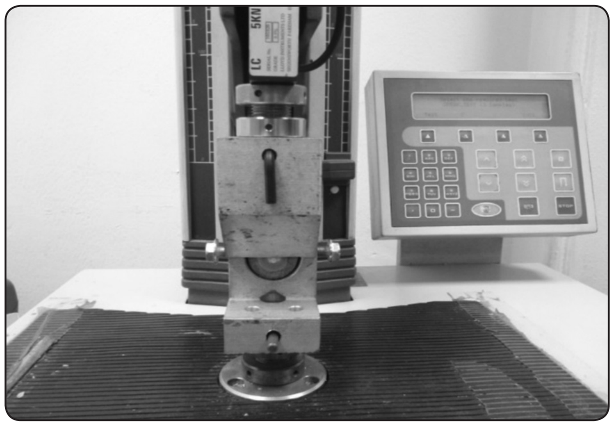

Fig. (3) A photograph showing the universal testing machine used for shear bond strength (Model LRX-plus; Lloyd Instruments Ltd., Fareham, UK).

Statistical Analysis:

Statistical analysis was performed for all data using the statistical package for social science IBM®, SPSS® statistics for windows computer software version 20 {IBM® (IBM corporation, NY, USA) and SPSS® (SPSS Inc., an IBM company, USA)}. Analysis of variance (ANOVA) was used for determining the statistical significance for the mean shear bond strength between groups. All graphs were made using Excel Microsoft windows 2010. The *p*-values were considered statistically significant if less than or equal 0.05 and highly statistically significant if less than or equal 0.01, while not statistically significant if greater than 0.05.

RESULTS

Mean values of shear bond strength for groups I, II, III were 9.6 ± 3.4, 5 ± 1.9 and 3.6 MPa respectively as shown in figure 4, with statistically insignificant difference P=0.09 (P value≥0.05). Some specimens showed spontaneous de-bonding after water storage [group I (33.3%) and III (83.33%)] as shown in figure 5. Failure mode was 100% adhesive failure in all groups.

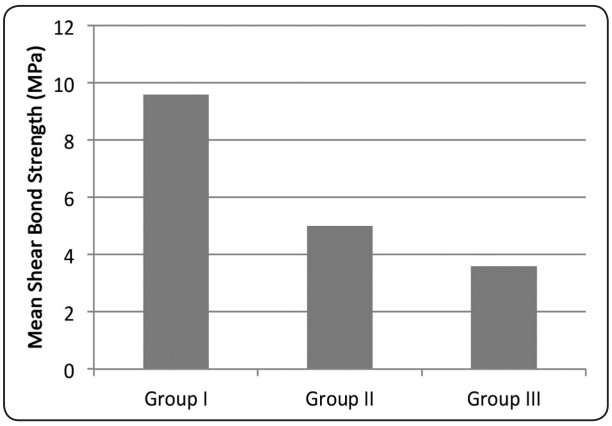

Fig. (4) A bar chart showing the mean shear bond strength (MPa) for all three groups.

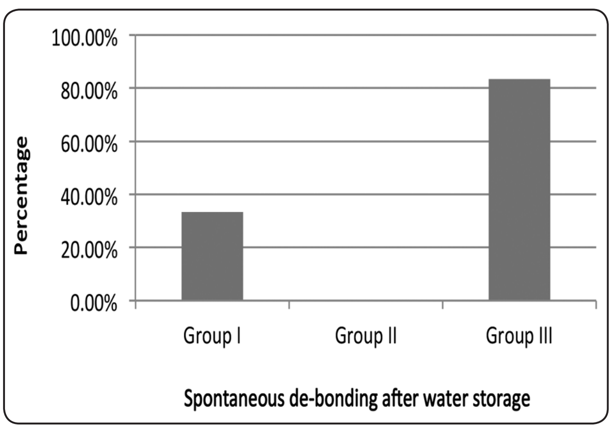

Fig. (5) A bar chart showing the percentage of spontaneous de-bonding after water storage in all three groups.

DISCUSSION

Although the most reliable evidences can be obtained by clinical trials and translation of in vitro findings. However, oral conditions have some limitations, and laboratory tests are still useful at promptly yielding first- hand information[1]. Quantitative assessment of materials' adhesion can be done by bond strength tests[1], based on the concept that the stronger the bond, the better it will resist contraction and functional stresses[5]. Infiltration of resin monomers into etched enamel is the corner stone of adhesion to the enamel surface[1]. Using etch-and-rinse technique provides an optimum etching pattern and higher bonding compared to the self-etching systems[6]. However, multiple steps are required, its use in uncooperative children is sometimes challenging. Thus, self-etching adhesive systems could be considered as a suitable replacement for etch-and-rinse systems[7].

For this study, self-adhering flowable composite resin (Dyad™-flow) was applied to uncut, cut and dentin surface of deciduous molars. There was no statistical difference to all groups. However, Dyad™-flow recorded the lowest shear bond strength value to dentin in comparison to uncut and cut enamel. This might be attributed to the higher organic content of the dentin, its heterogeneous composition and the poor wettability of its self-etched collagen fibrils by the adhesive material [3, 8, 9, 10, 11, 12]. Thus, bonding to dentin is still representing an obstacle with this material. This was represented by the spontaneous de-bonding of five out of the six specimens (83.33%) after one day water storage at 37˚C. Due to the survival of one bonded specimen and pre-test failure of the rest, the result of this group had no standard deviation.

The Dyad™-flow contains an adhesive monomer called glycerol phosphate dimethacrylate "GPDM" having two functional groups; the first is an acidic phosphate for both tooth etching and chemical bonding with its calcium content, while the other is a methacrylate group for polymerization[1]. It showed that GPDM "etches" instead of "bonds" to hydroxyapatite[4]. Since, the Dyad™-flow contains a phosphate functional group which bonds chemically with the calcium ions of the tooth, higher bond strength results were obtained in the enamel rather than dentin.

For better understanding of the bond strength results of enamel, a thorough knowledge is mandatory about the morphology and the mineral content of sound deciduous enamel. It was reported that the enamel of sound deciduous teeth could be either "almost smooth with some grooves" or on the other hand could contain "abundant micro-porosities"[13]. Similarly, the mineral content of the deciduous enamel showed differences due to individual variations and external conditions, where the Calcium/Phosphorous ratio ranging from 1.37 to 1.03 [13]. These differences in the microstructure and elemental analysis might explain why some specimens showed highest bond strength values, while other specimens showed spontaneous de-bonding after the water storage. The surface in the first case with high bond strength values might be with abundant micro-porosities and/or increased mineral content, thus offering better adhesion and contrary in the de-bonded specimens being smooth and/or lower mineral content.

The mean shear bond strength value for the uncut enamel was higher in the bonded specimens (9.6±3.4MPa) when compared to the cut enamel (5±2.9 MPa). This might be attributed to a topographic reason; the uncut enamel surface may contain the end of enamel prisms with a minute micro-size diameter, resulting in a large total surface area favoring the bonding procedure, where the mean prism diameter measurement in deciduous teeth was 2.602 μm[14]. On the other hand, the cut enamel may have scanty larger scratches after grinding with lower total surface area. In addition, the surface of the enamel might contain higher mineral content due to remineralization. Thus, it might be beneficial to use Dyad™-flow as a simple one step pit and fissure sealant for the deciduous teeth surface without any previous bur cutting, etching or bonding. This could be a valuable mean in caries prevention in deciduous teeth in high caries risk uncooperative children.

What this material adds:

- Bonding of Dyad™-flow was highest in uncut enamel.
- The shear bond strength of Dyad™-flow is less concerning dentin surface.
- Further researches are needed for Dyad™-flow improvement concerning dentin surface.

Why this paper is important for paediatric dentists:

- Decrease chairside time.
- Represent a simple technique for children due to elimination of multiple steps.

ACKNOWLEDGEMENT

Words cannot express our feelings to our late eminent dear Prof. Mervat Rashed (Professor of Pediatric Dentistry and Dental Public Health, Pediatric Dentistry and Dental Public Health Department, Faculty of Dentistry, Cairo University, Egypt) for her sincere contribution from the beginning of the research but destiny prevented her from seeing it coming to light. We dedicate this work to her beautiful soul.

REFERENCES

1. Garcia RN, Silva CS, Silva GG, Mocellin G, Ozelame J, Fracasso L, Ozelame MB, Nascimento RFD GA. Bonding Performance of a self-adhering flowable composite to indirect restorative materials. RSBO [Internet]. 2014 [cited 2015 May 30];11(1):6–12. Available from: file-:///C:/Users/hb/Downloads/v11n1a01.pdf

2. Bayne SC, Thompson JY, Swift EJ, Stamatiades P, Wilkerson M. A characterization of first-generation flowable composites. J Am Dent Assoc [Internet]. 1998 May [cited 2015 May 30]; 129(5):567–77. Available from: http://www.ncbi.nlm.nih.gov/pubmed/9601169

3. Fu J, Kakuda S, Pan F, Hoshika S, Ting S, Fukuoka A, et al. Bonding performance of a newly developed step-less all-in-one system on dentin. Dent Mater J [Internet]. 2013 Jan [cited 2015 May 30];32(2):203–11. Available from: http://www.ncbi.nlm.nih.gov/pubmed/23538754

4. Yoshida Y, Nagakane K, Fukuda R, Nakayama Y, Okazaki M, Shintani H, et al. Comparative study on adhesive performance of functional monomers. J Dent Res [Internet]. 2004 Jun [cited 2015 May 30];83(6):454–8. Available from: http://www.ncbi.nlm.nih.gov/pubmed/15153451

5. Van Meerbeek B, De Munck J, Yoshida Y, Inoue S, Vargas M VP et al. Adhesion to enamel and dentin: current status and future challenges. Oper Dent Res [Internet]. 2003 [cited 2015 May 30];28:215–35. Available from: http://www.eapgoias.com.br/arquivos/downloads/Van_Meerbeek_et_al_12197.pdf

6. Erickson RL, Barkmeier WW, Kimmes NS. Bond strength of self-etch adhesives to pre-etched enamel. Dent Mater [Internet]. Elsevier; 2009 Oct 10 [cited 2015 May 31];25(10):1187–94. Available from: http://www.dema-journal.com/article/S0109564109001791/fulltext

7. Obeidi A, McCracken MS, Liu P-R, Litaker MS, Beck P, Rahemtulla F. Enhancement of bonding to enamel and dentin prepared by Er,Cr:YSGG laser. Lasers Surg Med [Internet]. 2009 Aug [cited 2015 May 31];41(6):454–62. Available from: http://www.ncbi.nlm.nih.gov/pubmed/19588530

8. Susin AH, Vasconcellos WA, Saad JRC, Oliveira Junior OB de. Tensile bond strength of self-etching versus total-etching adhesive systems under different dentinal substrate conditions. Braz Oral Res [Internet]. Jan [cited 2015 Jun 1];21(1):81–6. Available from: http://www.ncbi.nlm.nih.gov/pubmed/17384860

9. Rodrigues LV, Vasconcelos AC, Campos PA, Brant JMC. Apoptosis in pulp elimination during physiological root resorption in human primary teeth. Braz Dent J [Internet]. 2009 Jan [cited 2015 Jun 1];20(3):179–85. Available from: http://www.ncbi.nlm.nih.gov/pubmed/19784460

10. Nalla RK, Porter AE, Daraio C, Minor AM, Radmilovic V, Stach EA, et al. Ultrastructural examination of dentin using focused ion-beam cross-sectioning and transmission electron microscopy. Micron [Internet]. 2005 Jan [cited 2015 Jun 1];36(7-8):672–80. Available from: http://www.ncbi.nlm.nih.gov/pubmed/16182542

11. Nakabayashi N, Ashizawa M, Nakamura M. Identification of a resin-dentin hybrid layer in vital human dentin created in vivo: durable bonding to vital dentin. Quintessence Int [Internet]. 1992 Feb [cited 2015 Jun 1];23(2):135–41. Available from: http://www.ncbi.nlm.nih.gov/pubmed/1322546

12. Rocha PI, Borges AB, Rodrigues JR, Arrais CAG, Giannini M. Effect of dentinal surface preparation on bond strength of self-etching adhesive systems. Braz Oral Res [Internet]. Jan [cited 2015 Jun 1];20(1):52–8. Available from: http://www.ncbi.nlm.nih.gov/pubmed/16729175

13. Zamudio-Ortega CM, Contreras-Bulnes R, Scougall-Vilchis RJ, Morales-Luckie RA, Olea-Mejía OF, Rodríguez-Vilchis LE. Morphological, chemical and structural characterisation of deciduous enamel: SEM, EDS, XRD, FTIR and XPS analysis. Eur J Paediatr Dent [Internet]. 2014 Sep [cited 2015 Jun 1];15(3):275–80. Available from: http://www.ncbi.nlm.nih.gov/pubmed/25306144

14. Gentile E, Di Stasio D, Santoro R, Contaldo M, Salerno C, Serpico R, et al. In vivo microstructural analysis of enamel in permanent and deciduous teeth. Ultrastruct Pathol [Internet]. 2015 Apr [cited 2015 Jun 1];39(2):131–4. Available from: http://www.ncbi.nlm.nih.gov/pubmed/25268300