Revista Portuguesa de Estomatologia, Medicina Dentária e Cirurgia Maxilofacial

www.elsevier.pt/spemd

Original research

Effect of time on shear bond strength of four orthodontic adhesive systems

Alexandra R. Vinagre, Ana L. Messias, Marcolino A. Gomes, Ana L. Costa, João C. Ramos*

Área da Medicina Dentária, Faculdade de Medicina da Universidade de Coimbra, Coimbra, Portugal

ARTICLE INFO

Article history:
Received 21 April 2014
Accepted 13 August 2014
Available online 18 October 2014

Keywords:
Orthodontic bracket
Shear strength
Adhesive cement
Self-etch primer
Scanning electron microscopy

ABSTRACT

Objectives: To evaluate the shear bond strength (SBS) of orthodontic brackets bonded to enamel with four adhesive systems tested at three time periods.

Methods: A 180 cross sections of human premolars were randomly assigned into four groups according to the adhesive system used: Concise™ (G1), Transbond™ XT (G2), Transbond™ Plus Self-Etching Primer (TBS) (G3) and Heliosit® Orthodontic (G4). SBS was tested by producing bracket debonding after 15 min of bonding, after 24 h and after 24 h plus 500 cycles of thermocycling (TC). Bond failure was determined with the modified adhesive remnant index (ARI) and composite resin cements, conditioned enamel surfaces and adhesive interfaces were observed by scanning electron microscopy (SEM).

Results: Two-way ANOVA determined no interaction between time or time and TC on the behavior of the adhesive systems ($F = 0.372$, $p = 0.896$). Post-bonding time induced a statistically significant increase in SBS ($F = 37.447$, $p < 0.01$), whereas thermocycling did not influence SBS ($t = 0.608$, $p = 0.544$). Adhesive systems were only different at 15 min ($F = 4.75$, $p = 0.005$). ARI scores revealed differences between groups when the test was performed after 24 h and after 24 h + TC. Groups 1, 3 and 4 showed differences along testing periods. SEM observations revealed that TBS produced a more irregular, shallow structure with less defined indentations of enamel prisms than phosphoric acid.

Conclusions: Regardless of the adhesive system, SBS were significantly higher at 24 h after bracket bonding procedure than after 15 min. The self-etching primer tested can successfully be used for bracket bonding. The thermocycling protocol did not affect shear bond strengths.

Efeito do tempo nas forças de adesão de quatros sistemas adesivos ortodônticos

Palavras-chave:
Bracket ortodôntico

RESUMO

Objetivos: Comparar as forças de adesão (FA) de quatro sistemas adesivos ortodônticos em três períodos de tempo.

* *Corresponding author.*
E-mail address: avinagre@fmed.uc.pt (A.R. Vinagre).

http://dx.doi.org/10.1016/j.rpemd.2014.08.003

Força de cizalhamento
Cimento adesivo
Primer autocondicionante
Microscopia eletrónica
de varrimento

Métodos: Cento e oitenta faces de pré-molares humanos foram distribuídas aleatoriamente em quatro grupos de acordo com os sistemas adesivos testados: Concise™ (G1), Transbond™ XT (G2), Transbond™ Plus Self-Etching Primer (TBS) (G3) and Heliosit®Orthodontic (G4). As FA foram determinadas em três períodos de tempo 15 min; 24 horas e 24 horas seguida de termociclagem (TC). O tipo de fratura foi determinado com o índice de adesivo remanescente (IAR). As resinas compostas, os padrões de condicionamento e as interfaces adesivas foram observadas sob microscopia electrónica de varrimento (MEV).

Resultados: A ANOVA a 2 fatores não determinou interação entre o tempo ou o tempo e TC no comportamento dos sistemas adesivos ($F = 0.372$, $p = 0.896$). O tempo induziu um aumento estatisticamente significativo nas FA ($F = 37.447$, $p < 0.01$), enquanto que a termociclagem não influenciou as FA ($t = 0.608$, $p = 0.544$). Os sistemas adesivos apresentaram diferenças apenas no período de 15 min ($F = 4{,}75$; $p = 0{,}005$). O IAR revelou diferenças significativas entre os grupos nos períodos de 24 h e 24h+TC. Os grupos 1, 3 e 4 mostraram diferenças ao longo dos períodos de teste. As observações em MEV revelaram que o TBS produziu um padrão de condicionamento mais irregular e superficial relativamente ao ácido fosfórico.

Conclusões: Independentemente do sistema adesivo, as FA foram significativamente superiores 24 horas após a colagem dos brackets relativamente aos 15 min. O adesivo autocondicionante pode ser utilizado na colagem de brackets. A termociclagem não afetou as forças de adesão.

Introduction

The introduction of the acid etch bonding technique by Buonocore in 1955[1] was particularly important for bracket bonding in bandless orthodontic treatments as it improved the micromechanical retention of the enamel surface needed to bond resins. Bracket bonding failure during orthodontic treatment is a relatively common problem. This feature may be related to various factors, including operator technique and skills, patient behavior, enamel morphology, and adhesive material properties.

Bond strength to enamel should withstand occlusion forces and stresses exerted by the archwires for tooth movement control in all three planes of space and, simultaneously, make possible the final bracket debonding without damaging the enamel surface.[2,3] For orthodontic treatments, clinical bonding was considered to be successful when shear bond strengths vary between 5.9 and 7.8 MPa.[4] However, the maximum bond strength should be inferior to the tensile strength of enamel, which ranges between 11 and 25 MPa, depending on the prismatic orientation.[5] *In vivo* bond strengths have been shown to be significantly lower than the *in vitro* ones, suggesting that the possibility of enamel damage might be lower under clinical conditions.[2,6,7]

Phosphoric acid solution remains the most widely used enamel conditioner among orthodontists as it promotes the most retentive etching pattern to enamel. Nevertheless, this routine etching technique has been described as a sensitive procedure due to the need of proper moisture control[8] and to the potential mechanical damage to the enamel surface in the course of the debonding procedures.[9–11] To simplify orthodontic bonding, self-etching primer adhesives (SEPs) were introduced, combining the etching and priming steps into one and eliminating the rinsing phase. Furthermore, it has been reported that, as SEPs produce more conservative etching patterns and reduce adhesive penetration, they potentially minimize the amount of enamel loss.[11]

Numerous *in vitro* studies were published revealing contradictory results concerning the effectiveness of the SEPs.[3,12–21] In most cases, shear bond strengths are assessed exclusively at 24 h after the bonding procedure, which does not reflect the most frequent daily clinical practice. On the one hand, the initial bond strength is of the utmost importance as archwires are inserted into the brackets slot 10–15 min after the bonding procedure; on the other hand, routine exposure of the adhesive interfaces of brackets to chemical, mechanical and thermal changes occurring in the oral cavity induces stress capable of affecting the bond effectiveness.[16,19,20,22]

The aim of the present study was to evaluate shear bond strength of four orthodontic adhesive systems at three time point periods and examine the bracket/tooth failure interface. Following this, the null hypotheses formulated were:

(1) There is no difference in the behavior of the adhesive systems across the three testing setups.
(2) Within each setup there are no differences in shear bond strength between the four adhesive systems.

Materials and methods

Ninety intact and caries free extracted human pre-molars were collected and stored in a solution of 0.5% chloramine T for up to 6 weeks after extraction. The crowns were split into two halves by cross-sectioning the tooth along the mesio-distal axis, using a Model 660 precision saw (South Bay Technology, Inc.; San Clemente, CA, USA), so that both lingual and buccal