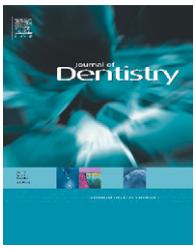
available at www.sciencedirect.com

ScienceDirect

journal homepage: www.intl.elsevierhealth.com/journals/jden



Effect of curing mode on the polymerization characteristics of dual-cured resin cement systems

Cesar A.G. Arrais [a], *Frederick A. Rueggeberg* [b], *Jennifer L. Waller* [c], *Mario F. de Goes* [d], *Marcelo Giannini* [e,*]

[a] *Department of Operative Dentistry, School of Dentistry, University of Guarulhos, Guarulhos, SP, Brazil*
[b] *Department of Dental Materials, School of Dentistry, Medical College of Georgia, Augusta, GA, USA*
[c] *Department of Biostatistics, Medical College of Georgia, Augusta, GA, USA*
[d] *Department of Restorative Dentistry, Dental Materials Section, Piracicaba School of Dentistry, University of Campinas, SP, Brazil*
[e] *Department of Restorative Dentistry, Operative Dentistry Seciton, Piracicaba School of Dentistry, University of Campinas, SP, Brazil*

ARTICLE INFO

Article history:
Received 26 July 2007
Received in revised form
20 February 2008
Accepted 21 February 2008

Keywords:
Degree of conversion
Dual-cured cementing systems
Indirect restorations
Self-cure1

ABSTRACT

Objectives: To evaluate the effects of different curing conditions on the degree of conversion (DC) of dual-cured cementing systems [combination of bonding agent (BA) and resin cement (RC)] using infrared spectroscopy.

Methods: Four fourth generation products [Scotchbond Multipurpose Plus/RelyX (3M ESPE), Optibond/Nexus 2 (Kerr), All Bond2/Duolink (Bisco), and Bond-It!/Lute-It! (Pentron)], and three fifth generation materials [Bond1/Lute-It! (Pentron), Prime&Bond NT Dual-Cure/Calibra (Dentsply), and Optibond Solo Dual Cure/Nexus 2 (Kerr)] were applied to the surface of a horizontal attenuated-total-reflectance unit, and were polymerized using one of four conditions: self-cure (SC), direct light exposure through glass slide (DLE, XL3000/3M ESPE) or through pre-cured resin discs (shades A2;A4/2 mm thick/Z250/3M ESPE). Infrared spectra of the uncured cementing systems were recorded immediately after application to the ATR, after the system was light-cured or left to self-cure, and spectra were obtained 5 and 10 min later. DC was calculated using standard techniques of observing changes in aliphatic-to-aromatic peak ratios pre- and post-curing. Data ($n = 5$) were analyzed by two-way repeated measures ANOVA and Tukey's test ($p = 0.05$).

Results: Changes in aliphatic-to-aromatic peak ratios before and after placing RC onto the BA demonstrated that a combined layer was created. All groups exhibited higher DC after 10 min than after 5 min, except the DLE group of Bond-it!/Lute-it!. No significant differences in DC were observed among light-activated groups regardless of the resin disc shade in three of the four fourth generation cementing systems. The SC groups exhibited lower DC than the DLE groups for both fourth and fifth generation products either after 5 or 10 min.

Conclusion: The chemistry of the bonding interface changed when RCs were applied to uncured BAs. The presence of an indirect restoration can decrease the DC of some cementing systems and the self-curing mode leads to lower DC than the light-activating one.

* *Corresponding author at*: Department of Restorative Dentistry/Operative Dentistry, Piracicaba School of Dentistry, UNICAMP, Av. Limeira, #901, Piracicaba, SP 13414-900, Brazil. Tel.: +55 1934125340; fax: +55 1934125218.
E-mail address: giannini@fop.unicamp.br (M. Giannini).
0300-5712/$ – see front matter
doi:10.1016/j.jdent.2008.02.014

1. Introduction

The clinical success of composite and ceramic indirect restorations is attributed to the reliable bond between adhesive cementing systems (resin cements/bonding agents) and mineralized dental tissues.[1,2] Light intensity reaching the resin cement is strongly attenuated by either the distance from the light source or by the absorbing characteristics of the indirect restorative material. This attenuation results in low degree of conversion (DC) and compromised mechanical properties of the dentin/adhesive interface when only light-cured resin materials are used to bond the restorations.[3,4] In an attempt to overcome this problem, manufacturers developed dual-cured resin materials, which contain self-curing components to initiate the polymerization reaction in the absence of light.[5,6]

Dual-cured cementing systems contain a mixture of monomers and initiators, and are formulated to not depend only on light activation to polymerize. Therefore, light activation of adhesive resins prior to delivering an indirect restoration might not be necessary. Among commercial resin-based indirect cementing systems available, manufacturer instructions differ widely in advocating the pre-curing of the dentin bonding agent. Some products advocate light-curing of the dentin bonding agent prior to cementation, others indicate the clinician can choose to light cure or not, while others state that light curing should not be performed prior to resin cement application. Clinically, however, it would be advantageous not to light-cure the dentin bonding agent separately. If the thickness of polymerized dentin bonding layer is large, its added dimension would result in incomplete seating of the restoration, generating large marginal discrepancies and the necessity to adjust occlusion.[7]

Acidic resin monomers from two-step total etch and self-etching adhesives may impair the polymerization of dual-cured cements and composites that are initiated via a peroxide-amine binary redox system.[8,9] As a consequence, low bond strength values are reported when light activation of the dentin bonding agent is not performed.[10,11] In order to overcome this chemical incompatibility, chemical co-initiators have been introduced in the dentin bonding agent, such as aryl sulfinic acid salts, organoboron compounds, and barbituric acid/cupric chloride.[12] These components react with the acidic resin monomers to produce either phenyl or benzenesulfonyl free radicals that initiate the reaction of dual-cured resin cements when light from the curing unit is not available.[12]

Several studies have demonstrated that ceramic or resin-based composite inlays/onlays reduce the amount of light reaching the bottom of the restoration, and therefore compromise photo-activation of light-activated luting materials.[13,14] Moreover, when evaluating *in vitro* occlusal wear, quantity of remaining double bonds, and cement system hardness, some authors indicate that the chemical curing mechanism alone is less effective than the light-activated reaction when dual-cured resin cements were used.[13,15] However, there is no information regarding the DC of such dual-cured resin cements when they were combined with dual-cured adhesive systems in simulated clinical conditions when light intensity is strongly attenuated or totally absent.

Thus, the purpose of this study was to measure the DC of representative commercial fourth and fifth generation dual-cured cementing systems, when they were applied and light-activated with little attenuation (through a microscope slide) or when light was attenuated by passing through pre-cured resin discs (shades A2/A4), or when light from the curing unit was totally absent (self-cured (SC)). Most manufacturers suggest the interval between 5 and 10 min after seating the indirect restoration as the most appropriate moment for occlusal adjusts, finishing, and polishing procedures, all of which are capable of generating stress. Therefore, the 5- and 10-min DC analysis was performed to provide information about a possible indicator of the physical properties of the adhesive interface during such procedures. The research hypotheses tested for each dual-cured cementing system were: within a given dual-cured cementing system: (1) conversion using direct light exposure (low light attenuation) will be higher than when the systems are allowed to self-cure only; (2) attenuation of curing light delivered to the dual-cured cementing system by passing through pre-cured resin discs will result in lower DC compared to when light passes through only a glass slide (low attenuation); (3) for similar thickness of pre-cured composite, the conversion of a dual-cured cementing system, when light-cured, will be less for the darker-shaded composite; and (4) DC after 10 min will be higher than that measured after 5 min from polymerization initiation for SC and all light-curing modes.

2. Materials and methods

2.1. *Specimen preparation and Fourier transformed infrared analysis*

Four fourth and three fifth generation adhesive systems (Tables 1 and 2) and their recommended dual-cured resin cements (Table 3) were used (adhesive system/resin cement): All Bond2/Duolink (AB2/DUO; Bisco), Bond-It!/Lute-It! (BIT/LUTE; Pentron), Optibond/Nexus 2 (OPT/Nexus; Kerr), Scotchbond Multipurpose Plus/Rely X (SBMP/RelyX; 3M ESPE); Bond1/Lute-It (B1/LUTE; Pentron); Prime & Bond NT Dual-Cure/Calibra (NTD/Cal; Dentsply) and Optibond Solo Dual Cure/Nexus 2 (SOLOD/Nexus, Kerr), respectfully. Light-cured composite resin discs (2 mm thick, 10 mm in diameter – A2/A4 shade – Z250, lot# 5LB; 3M ESPE) were prepared to simulate overlying laboratory-processed composite resin restorations. The adhesive systems and resin cements were applied as described in Tables 1 and 2 to a horizontal diamond ATR element (Golden Gate, Specac, Woodstock, GA, USA) in the optical bench of a Fourier transform infrared spectrometer (FTS-40, Digilab/BioRad, Cambridge, MA, USA). Adhesive tape (3M) was placed around the diamond surface to act as a spacer, ensuring standard thickness for all specimens (100–120 μm). All adhesive systems were placed according to manufacturer instructions, but none were light-cured prior to placement of the resin cement. The deposited material was covered with a Mylar strip and polymerized using one of 4 different curing modes: light activation (sn#202149, XL3000, 3M/ESPE power density: 600 mW/cm^2;) through a glass slide (~2 mm thick) (direct light exposure (DLE)); light activation through A2 or A4-shade pre-cured resin discs (A2/A4) (Fig. 1); or