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Bisphenol A release from orthodontic adhesives and its correlation with the degree of conversion

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Introduction: Our objective was to quantitatively assess and compare the bisphenol A (BPA) released from an orthodontic adhesive using a light-emitting diode device (LED) or a halogen light-curing unit (HLC) at 3 tip-to-bracket distances (0, 5, and 10 mm) and varying curing times using high-performance liquid chromatography. BPA release with self-etching and moisture-insensitive primers with light-cured and chemically cured composites was also evaluated. BPA release was correlated to the corresponding degree of conversion. **Methods:** Our sample consisted of 598 stainless steel first premolar brackets. Of these, 520 were used for assessing BPA release and divided into 13 groups of 40 each. In groups I, II, and III, the composite was cured with the LED for 20 seconds at distances of 0, 5, and 10 mm, respectively. Groups IV, V, and VI were cured with the HLC for 40 seconds at the same 3 distances. Groups VII and VIII were cured for 5 and 10 seconds with the LED, and groups IX and X were cured for 10 and 20 seconds with the HLC at 0-mm distance. Groups XI, XII, and XIII consisted of brackets bonded with a self-etching primer and Transbond (3M Unitek, Monrovia, Calif), with a moisture-insensitive primer and Transbond, and with a chemically cured composite. The remaining 78 brackets were also divided into 13 groups and used for assessing the degree of conversion. **Results:** The LED devices demonstrated significantly less BPA release and greater degrees of conversion ($P < 0.05$). For both units, BPA release increased and the degree of conversion decreased as the tip distance increased and curing time decreased. The chemically cured group showed significantly less BPA release ($P < 0.05$). Among the light-cured composites, those cured according to the manufacturers' recommendations (40 seconds and 0-mm distance for the HLC unit) released less BPA than did the self-etching primer and the moisture-insensitive primer. The degree of conversion was greatest for the chemically cured composite, whereas it was similar for the conventional, self-etching primer, and moisture-insensitive primer groups. However, correlations ranged from strongly negative to weakly positive between BPA release and degree of conversion. **Conclusions:** Clinicians should consider using LEDs in clinical practice and should keep the light-cure tip as close to the bracket as clinically possible. Curing time should be according to the manufacturer's recommendations. These steps will ensure less BPA release and a greater degree of conversion. Since chemically cured composites had less BPA release and a greater degree of conversion, they can be considered superior to light-cured composites in this aspect. (Am J Orthod Dentofacial Orthop 2015;147:29-36)

One of the most dramatic changes in the orthodontic specialty in the 1970s was the use of composite resin as a bonding material.[1] Both light-cured and chemically cured composites have been shown to be clinically acceptable and effective.[2] However, curing lights are required for light-cured resins. To obtain the correct irradiance using a halogen lamp, the initial power must be considerably high, producing heat that can cause pulpal damage.[3] As an alternative to halogen light curing units (HLC), light emitting diode (LED) technology has been proposed for curing dental composites. The curing time recommended is between 5 and 20 seconds.

Bisphenol A (BPA) is used as a raw material for the formulation of Bisphenol A diglycidyl dimethacrylate (Bis-GMA). Although bond strength has been evaluated, BPA release has not been extensively studied especially in self-etching primers (SEP) and moisture-insensitive primers (MIP); Eliades et al[4] reported no traces, whereas Gioka et al[5] found that the leachable components involved exclusively the TEGDMA monomer.

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In general, the degree of conversion of adhesives modulates the physical and mechanical properties of the material, particularly solubility and degradation.[6] Decreased conversion results in monomer leaching and the release of substances such as plasticizers and polymerization initiators and inhibitors. These can inflict detrimental biologic effects in cell cultures.[7]

The light-curing unit tip should ideally be in direct contact with the resin composite; however, this is not always clinically possible.[8] Inability to place a light tip near the bonding material might reduce intensity and provide a lower degree of polymerization.[8,9] Hence, the aim of this study was to quantitatively assess and compare the BPA released from an orthodontic adhesive (Transbond XT; 3M Unitek, Monrovia, Calif) when using LEDs and HLCs at 3 tip distances (0, 5, and 10 mm) and varying curing times with high-performance liquid chromatography. BPA release from chemically cured composites was also assessed. The degree of conversion was assessed using Fourier transform infrared spectroscopy. The BPA release was also correlated to the corresponding degree of conversion. The hypothesis was that BPA release and degree of conversion depend on the light-cure tip-to-bracket distance, curing time, and curing mechanism.

MATERIAL AND METHODS

We obtained 598 first premolar stainless steel brackets (3M Unitek); 520 of these were used to assess BPA release with high-performance liquid chromatography and 78 for estimating the degree of conversion with the Fourier transform infrared spectrometer (Perkin-Elmer, Norwalk, Conn). For the BPA release, the 520 brackets were divided into 13 groups of 40 each, with groups I, II, and III bonded with Transbond XT (3M Unitek) and cured with an LED (Elipar Free Light 2; 3M ESPE, Seefeld, Germany), with intensity of 1100 to 1200 mW per square centimeter for 20 seconds at light-cure tip-to-bracket distances of 0, 5, and 10 mm, respectively. Groups IV, V, and VI were bonded with Transbond XT and cured with an HLC (Elipar 2500; 3M ESPE) with intensity of 450 to 510 mW per square centimeter for 40 seconds also at light-cure tip-to-bracket distances of 0, 5, and 10 mm, respectively. The varying distances were standardized by following the procedure suggested by Sunitha et al.[10] Groups VII and VIII were cured for 5 and 10 seconds with the LED, and groups IX and X were cured for 10 and 20 seconds at a distance of 0 mm with the HLC. Groups XI, XII, and XIII consisted of brackets bonded with SEP (3M Unitek) and Transbond, MIP (3M Unitek) and Transbond, and a chemically cured composite (3M Unitek). The procedure used for assessing BPA release was similar to that described by Eliades et al[4] and subsequently followed by Sunitha et al. Briefly, the bonded brackets were stored in an incubator for 5 minutes at 37°C and 50% relative humidity and immersed in sterile glass tubes containing 15 mL of absolute alcohol (99% v/v) to induce accelerated aging. During the immersion period, the solution was agitated for 10 seconds twice a day. The processed 50 μL of alcohol solution from each group was removed at days 1, 7, 21, and 35 and filtered through 0.2-μm nylon filter paper injected in the instrument and analyzed with high-performance liquid chromatography (model LC2010A-HT; Shimadzu, Kyoto, Japan). The column was calibrated with known concentrations (standards, 0.1-3 ppm) of BPA (Merck, Darmstadt, Germany) in ethanol. The remaining 78 brackets were divided into 13 similar groups of 6 brackets each and used for assessing the degree of conversion. Sample preparation and degree of conversion assessment were similar to those described by Gioka et al.[5] Briefly, after polymerization at room temperature, the bracket-bonded adhesive, which in clinical conditions corresponds to the material in contact with enamel, was measured, and 5 mg of resin discs was placed between 0.01-mm potassium bromide discs. The discs were then transferred to the Fourier transform infrared spectrometer. The degree of conversion was estimated on a relative percentage basis with the 2-frequency method and tangent baseline technique.

Statistical analysis

Statistical analysis for the BPA release was performed using 2-way analysis of variance (ANOVA), post hoc multiple comparisons Tukey HSD tests, and the paired *t* test. The samples obtained from the degree of conversion were analyzed separately with 1-way ANOVA. The Pearson correlation was used to assess the relationship between BPA release and degree of conversion on day 1.

RESULTS

The BPA release increased from day 1 to day 21, after which the levels mostly decreased (Table I). The least BPA release was observed with chemically cured group (group XIII) and then with the LED and HLC groups when used according to the manufacturers' recommendations (groups I and IV). Greater releases of BPA were observed for the 10-mm LED and HLC tip distances (groups III and VI); the LED group showed less BPA release than did the HLC group for corresponding tip distances (Table I). There was a significant reduction ($P < 0.05$) in BPA for the LED group when compared with corresponding curing times and tip distances