Release of bisphenol-A from a light-cured adhesive bonded to lingual fixed retainers

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Introduction: Our aim was to quantitatively determine the bisphenol-A (BPA) released from a light-cured orthodontic adhesive used to bond lingual fixed retainers. Methods: Eighteen recently extracted premolars, divided into 3 groups of 6 teeth each, were embedded in plaster in an arch shape. A light-cured adhesive (Transbond XT, 3M Unitek, Monrovia, Calif) was bonded to a .0195-in, 3-strand heat-treated twist flex wire (Wildcat, GAC International, Bohemia, NY) adjusted to the lingual surface of the teeth, and the arches were immersed in doubled-distilled water for 10, 20, and 30 days. The concentration of BPA in the 3 eluents was investigated with gas chromatography-mass spectroscopy; all assays were performed in triplicate, and the results were averaged. Results: Measurable amounts of BPA were identified for all groups, with the highest found in the immersion media of the 1-month groups (2.9 mg/L), whereas the control (tooth storage solution) had 0.16 mg/L. Conclusions: The BPA released from a light-cured adhesive used to bond lingual fixed retainers might be assigned to the application mode of the material that differs from conventional use. Further testing including estrogenicity assays will assess the potential estrogenic action of this application. Composite restorative resins should replace orthodontic adhesives that were not intended to function with their surfaces in the oral cavity; alternatively, canine-bonded fixed retainers might reduce the amount of adhesive used. (Am J Orthod Dentofacial Orthop 2011;139:192-5)
to bond lingual fixed retainers and examine the variations of release with time.

MATERIAL AND METHODS

Eighteen freshly extracted premolars were collected and used within 2 months of extraction. The teeth were divided into 3 groups of 6 teeth each, embedded in plaster, and arranged in an arch form with their lingual surfaces pointing inward toward the arch, mimicking the shape of the 6 mandibular anterior teeth. A .0195-in, triple-strand heat-treated twist wire (Wildcat, GAC International, Bohemia, NY) was bent to be passively adjusted to the lingual surfaces of the teeth. The lingual surfaces were acid-etched for 20 seconds with an etching solution (3M Unitek, Monrovia, Calif), rinsed with water, and dried with an air syringe. The wire was placed on the lingual surfaces of the teeth, and, while held in place with stainless steel ligature wires through the interproximal spaces, primer and light-cured adhesive resin (Transbond XT, 3M Unitek) were applied in the middle of the lingual tooth surface covering the wire. Care was taken to avoid excessive paste because excessive thickness can adversely affect the polymerization efficiency of the material. Each tooth with light-cured adhesive paste was irradiated for 20 seconds with a light-curing unit (Elipar Visio II, ESPE, Seefeld, Germany) emitting 650 mW per square centimeter of light intensity at 468 nm, measured with a radiometer (model 100, Demetron, Danbury, Conn). All procedures were performed by the first author (T.E.).

After that process, the 3 specimens were rinsed with copious amounts of water to eliminate the polymerized layer of the material and immersed in 3 glass canisters filled with doubled-distilled water. Samples of the immersion media were collected at 10, 20, and 30 days after immersion, whereas the storage water medium where the teeth had been immersed before bonding was used as a control.

All samples were spiked with internal standard BPA-d16, and solid-phase extraction with Oasis HLB cartridges (Waters Corp., Milford, Mass) was used to isolate the BPA. After standard treatment of samples (percolation, drying, and elution with acetone), the extracts were reduced to 0.5 mL with a gentle stream of nitrogen and submitted directly to the derivatization procedure. The working standards and the final sample extracts were transferred to autosampler vials and evaporated to dryness with a gentle stream of nitrogen. Water from the immersion media from which the teeth originated was used as a control.

The BPA concentration of media was determined by using gas chromatography-mass spectroscopy analysis performed with a gas chromatograph (Trace GC ultra, Thermo Finnigan Electron, Waltham, Mass) coupled with an ion trap mass spectrometer (Polaris Q, Thermo Finnigan), and an Rx-5MS Crossbond 5% diphenyl-95% dimethyl polysiloxane capillary column (Thames, Restek, Buckes, United Kingdom) was used. The mass spectroscopy conditions were as follows: electron ionization mode at ionization energy of 70 eV, emission current of 250 μA, and ion source and transfer line temperatures at 200°C and at 300°C, respectively. The silylated derivatives of BPA were identified by means of matching their retention times with those of calibration standards and by the ratio of target ions, which were 357.2, 358.2, and 372.1. BPA was quantified by calculating the relative response factors based on the area of the internal standard BPA-d16. All gas chromatography-mass spectroscopy assays were performed in triplicate, and the results were averaged.

One-way analysis of variance (ANOVA) with time serving as a predictor and the Tukey test were used to analyze data at the .05 level of significance.

RESULTS AND DISCUSSION

The results of the BPA content of the immersion media are shown in the Table. BPA was released at measurable amounts, whereas the highest concentration was observed for the 1-month group (2.9 μg/L). In contrast, analysis of the storage media of teeth before bonding, which was used as a control, did not exceed 0.16 μg/L.

The actual contribution of this amount of BPA to adolescents and adults remains vague, and it is not likely that it would have a direct effect, considering the age of the average orthodontic patient in retention, which may be well above 14 years of age. At such later developmental stages, the action of BPA might not have the pronounced effects reported for utero or early stages of life.

A recent statement of the US National Toxicology Program concluded that, along with high doses, BPA may show a variety of effects at much lower levels. The highest estimated daily intakes of BPA in the general population occur in infants and children, where it also can have more pronounced effects. Infants and children have higher intakes of many widely detected environmental chemicals because they eat, drink, and breathe more than adults on a pound-for-pound basis.

In contrast to the National Toxicology Program’s position on the safety windows of BPA, a group of experts published a consensus statement emphasizing that extensive evidence indicates 2 routes of plausibility for low-dose in-vivo effects of BPA, which can be as low as 0.23 μg/L (ppb). This value is more than 10 times lower than the figure observed in laboratory conditions.
investigations might be misinterpreted as a lack of excessively high concentrations of effectors in relevant receptors become bound. Thus, the lack of response to hormones such as 17ß-estradiol induce effects at concentrations far below the levels at which all hormone receptors become bound. The lack of response to excessively high concentrations of effectors in relevant investigations might be misinterpreted as a lack of effect.14

Although the majority of the evidence on this subject derives from laboratory studies with animal models, recent investigations with human tissues and epidemiologic assays have confirmed the effects described in in-vitro or animal studies in humans.15-18

The use of human teeth in this research was chosen over plastic models to avoid the potential release of BPA from plastic models of teeth and the increased reactivity of the adhesive at the tooth-adhesive interface arising from the lack of bonding of the resin to the substrate. This would enhance BPA release because of disturbed setting at the free tooth-surface–adhesive interface. Further, the essentially identical compositions of orthodontic light-cured adhesives, with Bis-GMA monomer in the vast majority of these materials, suggest that the results can be generalized for the entire spectrum of orthodontic light-cured adhesives.

The results of this study, which certainly underestimates the full potential of BPA release in actual conditions and for extended periods of time. These researchers proposed the presence of nonmonotonic dose-response curves, which are characterized by a response to minute doses and absence of such at high doses.14 The origin of this pattern of action derives from the fact that natural hormones such as 17ß-estradiol induce effects at concentrations far below the levels at which all hormone receptors become bound. Thus, the lack of response to excessively high concentrations of effectors in relevant investigations might be misinterpreted as a lack of effect.14

Alcohol was found to be released from a light-cured orthodontic adhesive bonded to a lingual fixed retainer. This might derive from the application of this material with its surface exposed to the oral cavity, as opposed to the exposure of the marginal edges of adhesive when used as orthodontic adhesive.

A temporal variation in the elution of BPA in the aging medium was noted with the highest concentration found for the 1-month immersed samples.

CONCLUSIONS

BPA was found to be released from a light-cured orthodontic adhesive bonded to a lingual fixed retainer. This might derive from the application of this material with its surface exposed to the oral cavity, as opposed to the exposure of the marginal edges of adhesive when used as orthodontic adhesive.

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Previous research has shown lack of release and no estrogenic effect when the adhesive was used in conventional applications—ie, for bonding brackets.5 Exposure of the adhesive to the oral environment involves only the bracket’s peripheral margins, where the functional stimuli are minimal, and the subsequent effect of aging might not be potent. This situation, however, changes drastically when the adhesive is used to bond a fixed retainer. In this case, the polymer is exposed to the severe conditions of the oral environment, and the increased thickness of the material might predispose for less cure and, concomitantly, greater leaching. Moreover, the location of the retainer promotes plaque accumulation and maximizes the effect of salivary enzymatic activity—eg, esterases, which can promote degradation of the resin.19 Thus, in the clinical situation, with the substantially longer expected service life of the retainer, masticatory loads arising from the contact of the retainer with the bolus during mastication and chemical aging factors, BPA release might be higher than that reported in this study.

The results of this study show a potential effect of light-cured adhesives in fixed retainers and indicate that alternative materials such as composite resins must be used to eliminate potential concerns arising from the use of bonding materials in applications that which were not prescribed. Dental resins contain a higher ratio of filler to matrix ratio, and thus they have greater strength to mastication forces, whereas, at the same time, the lower organic content reduces the potential for BPA release. Alternatively, canine-bonded fixed retainers might greatly eliminate the amount of adhesive used.

REFERENCES