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EFFECTS OF BISPHENOL A RELEASED FROM ORTHODONTIC MATERIALS: A REVIEW

Orthodontics

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ABSTRACT

The purpose of this review is to evaluate the existing data on bisphenol A (BPA) release from various orthodontic materials. Orthodontic materials that are mostly manufactured with the use of BPA are polycarbonate brackets and Bis-GMA based orthodontic adhesives. Traces of the molecule were identified in thermo-formed aligners as well as acrylic retainers. BPA is a toxic compound that acts as an endocrine disruptor that can affect human health. The effects of BPA studied are analysed and few methods to reduce exposure to BPA in an orthodontic setup is discussed.

KEYWORDS

Bisphenol A, orthodontic materials, estrogenic activity

INTRODUCTION

Bisphenol A (BPA) is a chemical compound used in the manufacturing of certain types of plastics, including some orthodontic materials. BPA is used in the process of manufacturing the monomers contained in orthodontic composites, as a precursor of bis-GMA and bis-DMA. The potential of BPA release is restricted to materials that contain BPA as a precursor during the manufacturing process. Orthodontic materials that are mostly manufactured with the use of BPA are polycarbonate brackets and Bis-GMA based orthodontic adhesives. Traces of the molecule were identified in thermo-formed aligners aswell as acrylic retainers Within the oral cavity, the polymer disintegrates due to extreme changes of temperature, mechanical wear, changes in pH and enzymatic, bacterial and salivary aggression resulting in the release of BPA. BPA has been detected in biologic fluids like urine, breast milk, amniotic fluid, fetal and adult blood.

BPA has been reported to produce biological effects at very low concentrations. It has potential negative health effects, particularly hormonal effects. BPA express biologic effects similar to those induced by natural estrogens because of it's similar chemical structure to natural estrogen (17-beta estradiol). This is the reason for this deviation of the hormonal homeostasis from the proper pathway [1]

BPA has been classified as a category 3 toxic substance and a significant risk factor in human fertility. However, concern is not focused exclusively at molecular level. A recently published warning stated that exposure to BPA derivates-based composite resins can affect the psychosocial health of children. Increased levels and a long exposure period (5 years) to composites evidence higher levels of anxiety, depression and social stress in children[2].

Release of BPA from Orthodontic Materials

Suzuki et al. [3] described the release of BPA from polycarbonate orthodontic brackets. Study demonstrated that non-reactive BPA remained inside the material during polycarbonate synthesis and that it was released when the material was immersed in water or in organic solvents. The results of this study also showed that thermal conditions had triggered decomposition of the polymers, thus resulting in the formation of BPA.

Watanabe et al. [4] measured the quantity of BPA released by orthodontic polycarbonate-based brackets in water at 37 °C and 60 °C at different time intervals. Analysis of their water content showed that the BPA content had increased with time to attain 3.8 times more after 12 months at 37 °C and 12.4 times more after 14 weeks at 60 °C compared with the initial values.

Watanabe[5] validated these results by studying the long term degradation of polycarbonates and the formation of in vivo and in vitro BPA Kang et al. [6] examined the level of BPA in saliva and urine samples of 22 volunteers with a fixed lingual retainer. Samples were taken immediately prior to placement of the retainer, at 30 minutes, 1 day, 1 week and 1 month following retention. The authors found that the only significantly high level of BPA was observed in the saliva collected shortly after placement of the retainer but was much lower than the reference daily dose. Nevertheless, in view of the evidence regarding the "low dose effect", the investigators concluded that clinicians should prophylactically limit the non-polymerized level of material using pumice stone

Kloukos et al. [7] calculated the amount of BPA released in vivo by a light-curable orthodontic composite immediately after bracket bonding. In group A (11 patients), 25 ml of water was used as mouth rinse after bonding. In group B (9 patients), a mixture of 20 ml of water with 5 ml of absolute ethanol were used. The mouth-rinsing solutions were collected before, immediately after bonding, and after a second mouth-rinse. An increase in BPA concentration was observed in the two mouth-rinse solutions immediately after the bonding. The level decreased after the 2nd post-bonding mouth-rinse. Water alone evidenced higher levels of BPA than the water/ethanol solution. However, BPA levels were relatively low and far less than the tolerable daily intake limits

Sunitha et al. [8] calculated the BPA level released by a light-cure orthodontic composite depending on the distance of the light-cure lamp. They concluded that BPA levels were higher in the polymerized samples when the distance was greater. The conversion rate decreased with increased light-cure distance. A negative correlation was found between the BPA level released and the degree of conversion.

Eliades et al. [9] evaluated the amount of BPA released by a light-cure orthodontic composite used to bond lingual retainers in an invitro study. Results showed measurable quantities of BPA with the highest amount in the groups' immersion fluid at 1 month (2.9 mg/l) whereas the control group (tooth storage solution) received a 0.16 mg/l dose

Malkiewicz et al. [10] calculated the level of BPA released from orthodontic materials commercially available in Europe. Eluants from 6 commonly used orthodontic composites were obtained after 1 hour, 24 hours, 7 days and 31 days of storage of the samples in water. The highest concentration of BPA was 32.10 mg/ml. It was shown in this study that most of the evaluated orthodontic composites released bisphenol A, thus posing a potential threat to patients' health.

In a study done by Moreira etal [11], composites evaluated in vitro released small amounts of BPA. Among other composites, Enlight composite showed the greatest release, at 1 month. Regarding the in-vivo study, the mean BPA level in saliva increased significantly only at 30 minutes after bonding in comparison with measurements recorded before bonding

Studies by Kotyk and Wiltshire [15] The level of BPA released by orthodontic splints was measured during simulated intraoral exposure. The authors found that the BPA level was as high as 7.63 mg/g.

Raghavan etal [18] did a pioneer study to check the BPA levels from removable retainers using liquid chromatography technique and concluded that BPA levels in saliva were greatest for the vaccum

formed retainers, followed by Hawley retainers processed by chemical cure, and least with Hawley retainers processed by heat cure

Estrogenic effect of BPA

Gioka et al. [12] evaluated the estrogenic action of self-cured and light-cured adhesives. Specimens were prepared by simulating the bonding procedures. Samples of ground composite were immersed in a saline solution at 37 °C for 1 month. Eluants from the immersion solution of the two composites were added to an estrogen responsive cell line derived from human breast carcinoma (MCF-7). Estrogenicity was assessed at 1 day and at 7 days following incubation. Results show that both types of composite exhibited estrogenic action through induction of the proliferation rate of MCF-7 cells (160% and 128%, respectively, compared to control). Therefore, these composites can act as endocrine disruptors.

Another potential risk for endocrine disruption lies at the debonding stage, in which the particulate matter produced by grinding of the resin adhesive might have an estrogenic action [12]. This finding is of particular interest because greater volumes of adhesive are bonded on the teeth for aligner attachments and must be subsequently removed by grinding. [19]

Eliades et al. [13] studied the estrogenic properties of Invisalign appliances. The authors found no sign of proliferation of the MCF-7 cell lines, at the different concentrations, thus indicating the non-estrogenicity of the aligner eluants. However, this study presented a number of confusion biases such as the short duration of the study and the stability of the splints as a material

Eliades et al.[14] measured the estrogenetic action of an orthodontic self-curing composite and of an orthodontic light-curing composite used in bracket bonding. The samples were immersed in a standard saline solution. Samples of the eluants were taken from each group at 1 day, 1 week after incubation. Estrogenicity was tested by measuring their effect on the proliferation of estrogen-sensitive MCF-7 breast cancer cells. No stimulation of cell proliferation was observed and no estrogenic activity of the composites was reported in this study.

CONCLUSION

Unfortunately, despite years of research and dozens of studies, controversy still rages regarding levels of exposure and the potential undesirable effects of BPA released from orthodontic materials.

The review found that there was considerable variability in the methods used to measure BPA release and the reported levels of BPA release across studies. However, the majority of studies found that BPA was released from orthodontic materials, with levels ranging from below the limit of detection to over 200 ng/mL.

A quantitative synthesis of the studies included was not possible due to the heterogeneity of settings under which they were conducted. However, BPA release is a well-documented phenomena in oral health disorders that necessitates specialised clinical care and additional investigation to determine long-term implications.

Clinical Recommendations

- Hold the tip of the light-curing lamp as close as possible to the composite
- Polishing the composite with pumice stone could lessen the potential of BPA release
- Light-curing around the edges of the bracket instead of direct light-curing through the bracket
- Patient should rinse their mouth with copious amount of water in the 1st hour after procedures that use composites.
- For debonding, removal of as much material as possible without using rotary instruments is suggested to prevent aerosol dispersion

Modulating the release of BPA is not just dependent on the choice of materials. Proper adherence to treatment protocols can effectively minimise exposure of patients and staff to this chemical to levels below what is established as standard dietary intake

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