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Review Article

Review on Bisphenol-A In Orthodontics

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Context: Bisphenol A is a manmade organic chemical. It is a primary component of polycarbonate plastic used in wide range of products from paints to food and drink packages. Research has demonstrated that BPA can migrate from consumer goods into food items and other sources including dentistry. Various studies show leaching of BPA from orthodontic appliances and products to oral environment. Bisphenol A is reported to have adverse effects on brain, mammary gland and reproductive tract. In this review article we discuss the adverse effects of BPA, release of BPA from orthodontic materials and recommendations to limit BPA exposure.

Keywords: BPA, Endocrine disruptor, Leaching, Tolerable intake, Estrogenic, Release from Orthodontic materials.

INTRODUCTION

BPA, was first synthesized in 1891 by a Russian chemist Aleksander P Dianin. The chemical formula of BPA is $(CH_3)_2 C(C_6H_4OH)_2$ belonging to the group of diphenylmethane derivatives and bisphenols, with two hydroxyphenyl groups. It is a colourless solid substance which is readily soluble in organic solvent and poorly soluble in water. BPA is widely used in polycarbonate plastics and epoxy resins. It has applications ranging from paints, coatings, and adhesives to electrical components, food container liners, and data storage.

About 100 tons of BPA are released into the atmosphere each year during production (Markey, C.M. *et al* 2001b). BPA has been found in aerosols and in dust particles (Berkner, S. *et al* 2004) and in surface and drinking water (Rodrigues-Mozaz, S. *et al* 2005). BPA plastics and resins are used in the manufacture of milk and food containers, baby formula bottles, water carboys (Biles, J.E. *et al* 1997), the interior lining of food cans (Brotons, J.A. *et al* 1994), and dental resins and composites (Olea, N. *et al* 1996).

In clinical dentistry, BPA is found in most of the monomers used in dental sealants, adhesive resins and composite resins. BPA is used as a starting material in most of the products used in orthodontic treatment such as retainers, brackets, adhesives etc. BPA has been shown to leach from these materials due to incomplete polymerization and to degradation of the polymers by exposure to high temperatures, occurring under normal conditions of use (Biles, J.E. *et al* 1997).

The temporary tolerable daily intake level mentioned by the European Food Safety Authority is 4 mg per kilogram per day (Husøy, T. *et al* 2015). However Hass *et al* suggested that the European Food Safety Authority's temporary tolerable daily intake of

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4mg/kg/day is not sufficiently protective of humans in the general population.

ADVERSE EFFECTS OF BPA

Experts believe that BPA could theoretically act like a hormone, disrupting normal hormone levels in the body. There is evidence that BPA mimics 17 beta estradiol and aims at all estrogen target organs in the body. Reports demonstrating BPAs effect on thyroid hormones as well as reduction in testosterone levels in boys have also been published (Kloukos, D., & Eliades, T. 2014) All hormone mimicking effects can have adverse effect in body. It may lead to obesity, widespread fertility problems, feminisation of boys, accelerated maturational changes in girls, and increased diabetes risks and breast cancer incidences (Kaga, M. *et al* 2001; & Fiege, H. *et al* 2000).

Bisphenol A is reported to have adverse effect on Brain, Mammary gland and reproductive tract. It has been hypothesized that these effects may lead to altered fertility and fecundity, altered lactation and earlier onset/higher incidence of breast, testicular and prostate cancer.

The increased emphasis on BPA release can be attributed to the fact that it affects various organs, has teratogenic effects even at a low dose, results in early onset of puberty, causes feminization in males, and also has carcinogenic effects. BPA is metabolized in the liver to form bisphenol A glucuronide and present in body fluids like urine , adult and fetal blood, amniotic fluid, placental tissues, breast milk, and saliva (Nakamura, D. *et al* 2010; & Malkiewicz, K. *et al* 2015).

PRESENCE OF BPA IN ORTHODOTIC MATERIALS

Malkiewicz *et al* conducted an in vitro assessment of the release of biologically harmful bisphenol A and its derivatives from orthodontic adhesives available on the European market, as a potential health risk factor for orthodontic patients and reported that they released biologically harmful bisphenol A or its derivatives, posing a potential threat to the patients' health (Sunitha, C. *et al* 2011).

Sunitha *et al* , in their study to assess the release of BPA from an orthodontic adhesive (Transbond XT; 3M Unitek, Monrovia, Calif) with various light-curing tip distances and to correlate the release to the degree of conversion reported that BPA release was greater in specimens cured with a greater light-curing tip distance. The degree of conversion decreased with increased light-curing tip distances. A negative correlation was found between BPA release and degree of conversion (Purushothaman, D. *et al* 2015).

Purushothaman *et al* , conducted a study to assess and compare 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. The result of their study showed release of BPA in all the samples in varying proportions (Kloukos, D. *et al* 2015).

Kloukos *et al* conducted a study to assess the in vivo amount of BPA released from a visible light-cured orthodontic adhesive, immediately after bracket bonding.The study showed an increase in BPA concentration immediately after the 1st post-bonding rinse was observed, for both rinsing media, which was reduced after the 2nd post-bonding rinse. Water exhibited higher levels of BPA concentration than water/ethanol after 1st and 2nd post-bonding rinses (Gioka, C. *et al* 2009).

Gioka *et al* evaluated the estrogenic action of self-cured and light-cured adhesives. Specimens were prepared by simulating the bonding procedures, covering the bracket base surface with cellulose films in order to detach the full-set material. 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 (Eliades, T. *et al* 2011).

Eliades *et al* evaluated the amount of BPA released by a light-cure orthodontic composite used to bond lingual retainers. Eighteen recently extracted premolars, divided into 3 groups of 6 teeth each, were used in the study. A light-cure composite was used to bond a wire twisted to fit the lingual surface of the teeth. The results showed measurable quantities of BPA in all the groups. The highest amount was found 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. The authors concluded that the exposure of the composite (additional thickness, influence of oral conditions, position of the retainer) could play a key role in BPA release, contrary to other studies in which the composite was used to bond brackets (exposure along the peripheral margins of the orthodontic brackets) ().

Watanabe *et al* 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.[19]

Suzuki *et al* studied about the release of BPA from polycarbonate orthodontic brackets. The result of this study showed that BPA was released by decomposition of polymers triggered by thermal conditions.[20]

Raghavan *et al* conducted a study to evaluate and compare the bisphenol A (BPA) levels in saliva in patients using vacuum-formed retainers or Hawley retainers. Forty-five patients who had completed their fixed orthodontic treatment and were entering the retention phase were randomly allocated into 1 of 3 groups: vacuum-formed retainer, Hawley retainer fabricated by heat cure, and Hawley retainer fabricated by chemical cure. Saliva samples were collected immediately before placement, within 1 hour after placement, 1 week and 1 month after placement.. Statistically significant BPA levels in saliva were found for all groups ($P \leq 0.05$). The highest levels were noted in the vacuum-formed retainer group, followed by Hawley retainers fabricated by chemical cure; the lowest levels were found with Hawley retainers fabricated by heat cure.[21]

Veerasathpurush Allareddy, Romesh Nalliah, Min Kyeong Lee, Sankeerth Rampa,and Veerajalandhar Allareddy (2017) Examined adverse clinical events after the use of the Invisalign system and provided an overview of the actions taken by the manufacturer to address these events. A retrospective analysis of the Manufacturer and User Facility Device Experience database of the United States Food and Drug Administration was used. All medical device reports reported to the United States Food and Drug Administration pertaining to products of Align Technology from November 1, 2006, to November 30, 2016, were Analyzed. Serious or life threatening events could be associated with use of Invisalign systems. Health care providers should be aware of these events and know how to handle them if they arise in their practices.[22]

Clinical Recommendations To Reduce BPA

1. Brackets around the composite overflowing during the bonding process must be cleaned properly.
2. Optimum adhesive should be used while affixing the brackets. Sufficient adhesive hardness is essential because of exposure of the adhesive to masticatory forces.
3. Patients should be asked to rinse their mouth immediately after the bonding process.
4. Minimise the use of polycarbonate plastic brackets.
5. If possible BPA free materials should be requested from the companies.
6. Tip of the light curing lamp should be held as close as possible to the composite.
7. Chances of BPA release can be reduced by polishing the composite with pumice stone to remove the top liquefied layer. Rinsing the surface with water for 30 seconds immediately after application also has been shown to decrease salivary BPA levels to nearly baseline.
8. Effective elimination of BPA exposure, includes bonding with glass-ionomer cements (not resin-modified glass ionomers), and use of metallic or ceramic esthetic brackets .

In most cases, the exposure of patients to BPA is much lower than that of the operator and staff, who participate in many bonding and debonding procedures daily. Therefore care should be taken by them to minimise contact with the chemical. Some of the recommendations to staff and operators are:

1. Select a bracket base mesh-adhesive filler content combination that results in a resin-cohesive/enameladhesive fracture. [45]
2. Remove as much material as possible without using rotary instruments
3. During resin grinding have access to fresh air, use surgical suction and masks for all staff.
4. Pregnant staff and operators must avoid continuous and long-term exposure to the aerosols produced during debonding.
5. Operatories with multiple dental units in the same area (open-bay plan) must allow sufficient space between chairs and avoid scheduling concurrent debonding appointments in multiple chairs

CONCLUSION

As we discussed in this review article, a few studies that show the presence of BPA release by orthodontic materials, the level remain relatively small and much lower than the tolerable daily intake. However as noted above, people are exposed to BPA from various sources in their life and exposure to BPA release from orthodontic appliances and products may lead to a cumulative effect. So orthodontists should take necessary steps to curb BPA exposure.

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