Dental caries prevention: a review on the use of dental sealants

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KEYWORDS

Caries prevalence; Caries prevention; Pit and fissure sealants; Dental sealants; High-risk caries; Primary oral health care; Resin-based sealant.

ABSTRACT

Aim: *Tooth decay is still one of the most common chronic childhood diseases in the world, even though preventive measures have been developed, tested and applied during the last five decades. Moreover, a rising prevalence of early childhood caries has been reported it has turned from a wealth-related disease into a disease of poverty. Within the prevention methods, dental sealants are still underused even though their efficacy is well documented. The aim of this review is to highlight practice guidelines for the correct use of sealants.*
Results: *The clinician should know which patients need dental sealants and when, in particular high risk subjects and pre-school children. Dentists should also be able to determine the best choice between the different sealant materials of the two main categories, resin-based and glass ionomer sealants, with regard to their different properties, such as caries' preventive effect, fluoride release and retention rate. Several dental resin-based materials, including resin-based dental sealants, contain the monomer bisphenol A diglycidylether methacrylate (Bis-GMA), of which Bisphenol A (BPA) is a component. The controversy about the possible toxicity of this synthetic chemical resin used to produce plastic products is long debated and, even if the amount of BPA released by dental sealants is well below the limit proposed by the U.S. Environmental Protection Agency and the European Food Safety Authority, the risk of exposure, particularly for children, can be further reduces by following precautionary measures.*
Conclusion: *Dental sealants play an important role in preventing the onset and the development of dental cavities Even if the "fluoride-releasing resin sealants" are better than "glass ionomer", with regards to retention of the material, the literature shows that their effectiveness in preventing fissure caries in permanent molars does not differ significantly over 24 months.*

Introduction

Dental caries is the most prevalent condition recorded in permanent teeth by the GBD 2010 Study (global prevalence of 35%) (Marcenes et al., 2013), especially in children: notwithstanding its decrease over the last decades, it is still the 10th most prevalent health condition in children worldwide. In 2010, 2.4 billion people in the world had untreated cavitated dentine carious lesions in permanent teeth, and untreated cavitated dentine carious lesions in deciduous teeth affected 621 million children worldwide (Frencken, 2017). Actually, in the young subjects a higher caries burden is reported (Splieth et el., 2016), particularly in the first 5-6 years of the primary dentition more than in the first 6 years of the permanent one [Bolin, 1997]. This is confirmed by the lower decline of decay recorded for the primary dentition (35%) than for the young permanent dentition (70%) [Deutsche Arbeitsgemeinschaft für Jugendzahnpflege, 2010], whereas in adult subjects caries reduction ranges from 18 to 66% [Menghini et al., 2001; Marthaler, 2004].

In a review by Do [2012], who analyzed the caries experience of 12-year-olds in 43 countries from pre-1980 to 2010, the decrease did not include children of lower socioeconomic status or from lower developed countries, thus highlighting that caries has turned from a wealth-related disease into a disease of poverty. The prevalence data provided by the World Health Organization confirm this hypothesis, showing a lower dmft/DMFT in the high-income group, compared to the middle-income group (Frencken, 2017).

Dental caries is related to individual hygiene and dietary factors, which in turn are connected to the socio-economic status of the subject (education level, employment, etc.).

This is confirmed by the rising prevalence of early childhood caries [Jin et al., 2003; Postma et al., 2008; Treuner and Splieth, 2013], which in developed countries is in fact linked to low socio-economic status [Psoter et al., 2006].

For USA parents children's dental health has a lower priority than school safety, nutrition and the upcoming cold and flu season, though more than 51 million school hours are missed each year due to dental-related illness [The Ad Council's survey, September 2014]; moreover, 1.75% of parents report that their children sometimes or frequently forget to brush their teeth.

In Europe, tooth decay in 5-6-year-old children rages from 20% to 90%, depending on socio-economic determinants (WHO, 2016), oral health problems and access to primary oral healthcare.

That is why the "Europe/WHO 2020 goal" of reaching a caries-free value of 80% in both 4- and 12-year-olds is a long way off.

Preventive dentistry

Education and prevention programs for children and parents at all socio-economic levels are the only means to avoid dental cavities (Colombo and Paglia, 2018). Dentists and oral healthcare providers are therefore called to give priority to prevention and oral health promotion, particularly in early childhood, and implement risk management strategies.

Primary prevention consists of advice and intervention to prevent caries onset, such as encouraging less consumption of sugar, whereas secondary prevention focuses on the detection and management of early caries and cavitation (Colombo and Paglia, 2018).

Fluoride varnishes are the first recommended tool for caries prevention in subjects at risk of developing tooth decay: 2.26 percent fluoride varnish (for children younger than 6 years) or 1.23 percent fluoride (acidulated phosphate fluoride) gel, 2.26 percent fluoride varnish; Home oral care should include 0.05 percent fluoride gel or paste or 0.09 percent fluoride mouthrinse for patients 6 years or older (Weyant, 2013).

Dental sealants are crucial in preventing the onset and the development of dental cavities. They act as a primary prevention barrier against plaque and acids, by forming a shield on the occlusal surface of teeth. Pits and fissures of the occlusal surfaces of posterior teeth are in fact are eight times more susceptible to caries than smooth surfaces (they account for 80% to 90% of the total caries in permanent teeth and about 44% in primary teeth) [Athira et al., 2017]. Sealants are also effective in secondary preventive approach inhibiting caries progression on early non-cavitated carious lesions [Holmgren, 2014].

Wright [2016] reported that the risk of developing new carious lesions in primary or permanent molars decreased by 76% in children or adolescents who received sealants in sound occlusal surfaces or non-cavitated pit and fissure carious lesions, compared with an unsealed control group after two years of follow up. Even after 7 or more years of follow-up, the caries incidence was about 29% in the experimental group, compared to a caries incidence of 74% in the control group.

However, sealants are still underused even if clinical practice guidelines are widely available [AAPD, 2016; Ferrazzano et al., 2016].

Who should receive sealant treatment and when

Newly erupted teeth have a high caries susceptibility as enamel is not completely formed and therefore the eruption of the first primary molar and of the first and second permanent molars represent the right time to apply sealants.

As for primary teeth, evidence supporting the use of sealants is not strong, as there is a lower presence of pit-and-fissure caries in primary than in permanent teeth (44% vs. 90%) [Dye et al., 2007]. The Cochrane Systematic Review underscores that the effectiveness of sealants is clear for children with high caries risk, and less for those with lower risk [Ahovuo-Saloranta et al., 2013].

The American Academy of Pediatric Dentistry suggest to target prevention strategies based on patient's risk and recommends the inclusion of sealants in a comprehensive caries prevention program for children over 3 years of age.

Guidelines of the Italian Society of Paediatric Dentistry (SIOI) recommend applying sealants (and fluoride varnishes, gel and mouthwash) only to high-risk patients over 7 years of age [SIOI, 2013].

The Guideline of the Italian Ministry of Health for oral health promotion in children provides clinical protocols for caries risk assessment [2013], through the experience of caries, eating habits, oral hygiene, fluoride prophylaxis, general health status of the subject and socio-economic background of the family (Strength of recommendations A; Quality of evidence I).

It should not be neglected that patients wearing an intraoral appliance are considered moderately at risk of developing caries [AAPD, 2013] and therefore dental sealants are suggested.

In the case of teeth affected by molar-incisor hypomineralization (MIH), fissure sealants may be useful before breakdown occurs, especially when teeth are fully erupted and when moisture control is adequate. Regular checkups are paramount.

Sealants can be used on non-cavitated carious lesions to inhibit their progression by decreasing the number of viable bacteria [Wright et al., 2016]. Hence, the Bodecker's concept "when in doubt seal" rather than "when in doubt fill".

In other words, sealants do not replace the other preventive interventions, namely daily brushing and healthy diet, but they are part of a comprehensive prevention program and their use should be encouraged, especially in patients at high-risk of developing caries.

Sealants offer 100% caries prevention on the surface as long as they are retained: retention rate is initially about 85%-100%, dropping to about 50% after five years; therefore it is recommended to replace sealants after 5 years.

Efficiency and effectiveness of dental sealants

Before choosing the material some crucial points should be analyzed.

1. Will the sealant have the appropriate preventive effect on caries?
2. How easy is it to use/apply?
3. How long will it last?
4. Is it safe?

According to the "Evidence-based clinical practice guideline for the use of pit-and-fissure sealants" [2016], materials fall into two broad categories: resin-based and glass ionomer sealants, which can be further split into four subclasses:

1. resin-based sealants;
2. glass ionomer sealants;
3. resin-modified GI sealants;
4. polyacid-modified resin sealants.

1. Resin-based sealants can be classified according to their method of polymerization, viscosity (Reddy et al., 2015) and translucency [Simonsen et al., 2002].

Placement procedure starts with pits and fissures cleaning, acid etching and maintaining a dry field until the sealant is placed and cured [Beauchamp et al., 2008]; the literature suggests supplemental techniques, such as the use of bonding agents, rather than mechanical enamel preparation [Ferrazzano et al., 2017].

Eventually, retention should be checked with a probe after polymerization to assess effective sealing.

2. Conventional glass ionomer sealants are generally easier to place than resin-based ones, as they do not need tooth processing before application (enamel and dentin are bond through a chemical reaction) [AAPD, 2016] and are not susceptible to moisture. Moreover, they continuously release fluoride (until the material remains on the tooth), although the clinical effect is not well established. The main liability of this material is retention: glass ionomer sealants have lower retention rates compared to resin-based ones [Forss 1998; Karlzén-Reuterving, 1995; Kervanto-Seppälä, 2008; Poulsen, 2001]: at 36–48-month follow-up, the average retention rate for the resin-based sealants was 76%, while, for the glass ionomers it was only 8% (based on five studies with these follow-up times). For these reasons, glass ionomer sealants may be used as a temporary preventive agent when concerns about moisture control may compromise the placement of Resin-based sealants, as in the case of partially erupted permanent teeth [Dean et al., 2016].

3. In resin-modified glass ionomer sealants resin is incorporated with glass ionomer, in order to improve physical characteristics of the material [Pinkham et al., 20059, which shows less sensitivity to water and a longer working time than conventional glass ionomer [AAPD, 2016]. They set by means of an acid base reaction and partly via a photo-chemical polymerisation reaction.

4. Polyacid-modified resin sealants, also referred to as compomers, combine resin-based material in traditional resin-based sealants with the fluoride-release and adhesive properties of glass ionomer sealants; i.e., they do not contain water, are hydrophobic and can be polymerized after positioning the bonding agents, and release fluoride, though in much smaller amounts.

Several studies [Amin et al., 2008; Antonson et al., 2012; Guler et al., 2013] have found no statistically significant difference in the preventive effect of resin-based and glass ionomer sealants at 24, 36, and 48 months. For this reason, glass ionomer sealant can be also a valid alternative where and when resin sealant placement is not possible.

Bisphenol A: a real threat?

Bisphenol A (BPA) is a synthetic chemical resin used to produce plastic food-storage containers; at very low levels, it has been detected in human blood and tissues. BPA is also a component of the bisphenol A diglycidylether methacrylate (Bis-GMA), which is a monomer used for production of dental resin-based materials, including sealants through its derivatives Bis-GMA and Bis-DMA.

BPA can act as an endocrine disruptor by binding to estrogen receptors as well as blocking the estrogenic response by competing with endogenous E2 [Bailin et al., 2008; Viñas et al., 2012]. Furthermore, it can bind to thyroid receptors and influence thyroid functions thanks to its agonistic and antagonistic effects. It can also interact with the immune system and the developing central nervous system [Wetherill et al., 2007] and may elicit a non monotonic dose response and the response may be greater at low doses [Vandenberg et al., 2012]. The hypothesis that the BPA could have a non monotonic dose-response curve has raised concerns and, in 2012, it was decided to lower the tolerable daily intake (TDI) from 50 ug/kg bw/day, established in 2006 by the EFSA, to 5 ug/kg bw/day [Bakker et al., 2014]. Several studies report that perinatal and early life exposure to BPA can have harmful multisystemic effects [Hong et al., 2017; Rebuli et al., 2014]. The most vulnerable subjects are infants and children for whom the lowest observed-adverse-effect level dose is lower than 5 ug/kg bw/day. The ADA Science Institute tested the BPA release from 12 dental sealants, which resulted to be very low (about 0.09 nanograms/day) and well below the limit proposed for a 6-year-old child (considering an average weigh of about 20 kg/44 pounds) by the US Environmental Protection Agency (1 million nanograms per day) and the European Food Safety Authority (80,000 nanograms per day).

Trace molecules can be found due to degradation, incomplete polymerization or impurity deriving from the manufacturing process. Moreover, BPA can also be released by resin-based materials because of the enzymatic salivary hydrolysis of BPA derivatives, such as the bis-GMA or the bis-DMA [Rathee et al., 2012]. In a study by McKinney et al. [2014], despite the fact that children who had dental sealants had a BPA concentration 20% to 25% higher than children with no dental sealants, there was no statistically significant association between the number of resin-based sealants and urinary BPA concentrations.

There is a number of reports on BPA exposure and adverse perinatal development. Molar Incisor Hypomineralization is a recently reported condition which affects the first molars and the permanent incisors. Randomly scattered white opacities are present on the enamel and a variable prevalence of 2.4% to 40% is reported in children aged 6 to 8 years. Although there are different possible causes for this condition, an association with postnatal BPA exposure has been made and is possibly related to the fact that ameloblasts are susceptible to it.

Factors affecting the elution of BPA are summed up in table 1.

Ultimately, BPA exposure from dental materials seems transient and can be controlled and reduced, particularly for children, by following precautionary measures during the application of resin-based sealants, since the higher risk for potential exposure occurs immediately after application (Colombo et al., 2018).

Removal of residual monomer by rubbing the monomer layer with pumice on a cotton roll.

Having the patient gargling for 30 seconds and spitting immediately after application

rinsing with an air-water syringe when proper rinsing and spitting can be challenging.

Correct use of a rubber dam to protect the operative field.

Conclusion

If on the one hand there is strong evidence that resin-based dental sealants improve children's oral health, on the other hand the possible toxicity of BPA has raised many concerns; however, most studies

Table 1 Factors affecting the elution of BPA

Factor	Outcome
Temperature	Temperature increase and acid-base alterations increase the elution of BPA. A possible explanation may be the oxygen inhibition layer presence on the surface of resin-based sealants [Braun et al., 2011]
Degree of conversion	Adequate light energy density is required for free radical polymerization
Polymerization time	Time is more important than irradiation for a better degree of conversion. The ideal polymerization time is about 20 seconds
Distance from curing light	Elution of BPA increases when the tip-to-RBS surface distance increases
Type of light curing unit	The best polymerisation lamps are LED-type;
Storage medium	According to the American Dental Association, acetonitrile and methanol are strong solvents of organic compounds and are preferred over ethanol for maximizing the number of eluted monomers

report that in vitro and in vivo BPA levels related to dental sealants are well below the limit proposed by the U.S. Environmental Protection Agency and the European Food Safety Authority. Also the debate if the "fluoride-releasing resin sealants" are better than "glass ionomer", with regards to retention of the material, has been settled by the literature showing that their effectiveness in preventing fissure caries in permanent molars does not differ significantly over 24 months.

It should never be forgotten that dental sealants play an important role in preventing the onset and the development of dental cavities and dental practitioners should be knowledgeable on their correct and timely application, and reduce the risk of exposing their patients to potentially hazardous chemicals, particularly children. Clinicians are also called to respond in a reliable and documented way to parents' concerns.

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