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# Articles

## The Status of Amalgams in Pediatric Dentistry: Pros and Cons

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Silver amalgam has been used for restoring teeth for over 150 years and is still used extensively in general practice and in pediatric dentistry. However, the improvement in the physical properties and clinical handling of the tooth color materials, together with the continuing concern over the toxicity of dental amalgam, led to the questioning of the desirability of continuing to use dental amalgam in children. The subject has been so widely investigated[1-6] that the British Society of Paediatric Dentistry produced a document to provide guidance on the use of amalgam in children's dentistry in the United Kingdom.[7]

The present report attempts to summarize the several factors that affect the effectiveness, the advantages and disadvantages of the use of dental amalgam in primary teeth.

**Factors related to the Material**

*Toxicity of Amalgam*

The potential toxicity of mercury, inhaled or ingested, is the main concern regarding the use of dental amalgam. The use of silver/tin alloy capsules and mercury has considerably reduced the risk of inhalation during mixing. However, despite encapsulation, concerns still persist and relate mainly to the effects of inhalation of mercury vapor or amalgam dust, the ingestion of amalgam, allergy to mercury and environmental considerations.

*Inhalation of Mercury Vapor by Dental Personnel*

Eley described a few instances of mercury intoxication in dental staff owing to poor mercury hygiene.[1] A fall in the excreted mercury in the urine of dental personnel has been demonstrated after correct handling of mercury and amalgam.

*Ingestion of Amalgam by Patients*

Inhalation and ingestion of mercury from dental amalgam can occur during placement, polishing or removal of restorations, or chewing. The daily dose of mercury from dental fillings produced by chewing (1 - 2µg/adult) is much lower than the threshold for hazard to health from air/mercury exposure.[1]

A considerable number of studies investigated the fate of inhaled or ingested mercury in the body. The usual routes for excretion (after placement of restorations) are feces or urine. Plasma and urine mercury levels following placement or removal of restorations


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can be considerably reduced when the rubber dam is used.[8,9] Some dental procedures, such as bleaching, can increase the release of mercury from amalgam. It has been shown that 10% carbamide bleaching agents increased the mercury release from amalgam in vitro.[10]

Mercury can also pass from mother to fetus, and may be detected in the milk. However, animal and human studies have not demonstrated any association between amalgam fillings and birth defects.[1]

**Allergy to Mercury**

True allergies to amalgam are rare; about 50 cases have been reported in the past 100 years, although it is uncertain what proportion of these were children.[1] There have been some reports of an association between some oral lichenoid lesions and the presence of amalgam fillings adjacent to the affected area of the oral mucosa. It should be kept in mind that other restorative materials can also cause lichenoid lesions.[11,12]

**Environmental Issues**

Many countries have planned to reduce the industrial use of mercury and its use in dental amalgam for environmental reasons. The use of mercury in dentistry accounts for about 3% of the total amount used on a worldwide basis. Several European countries have encouraged good mercury hygiene in dental practices, including proper handling of waste amalgam to prevent it from reaching the environment.[1,13]

Major reviews on the risk of dental amalgam in both the United States[2,3] and the United Kingdom[1] concluded that "over the years amalgam has been used for dental restorations without evidence of major health problems." Recently, Dodes reported many errors in the antiamalgam literature and concluded that the evidence supporting the safety of amalgam restoration is compelling.[5]

*Composition and Properties of Amalgam*

Dental amalgam consists of an alloy of silver, copper, tin and zinc combined with mercury. Unreacted alloy particles are called the gamma phase and are mainly silver-tin. These particles combine with mercury, forming a matrix consisting of gamma 1 and gamma 2 phases. The gamma 1 phase involves the binding of silver and mercury ($Ag_2Hg_3$) and the gamma 2 phase the binding of tin and mercury ($Sn_7Hg$). The gamma 2 phase is responsible for early fracture and failure of amalgam restorations.

Copper was introduced to avoid the gamma 2 phase, replacing the tin-mercury phase with a copper-tin phase ($Cu_5Sn_5$). The copper-tin matrix decreases the corrosion of tin, preventing secondary weakening with subsequent fracture of the restoration.[14]

*Marginal Integrity*

Amalgam is the only restorative material existing nowadays in which the marginal seal improves with time. This is mainly due to the acid environment and low oxygen concentration in the space between the tooth and the restoration, leading to corrosion. In the low copper amalgam, the gamma 2 phase that was formed slowly filled the mentioned space, creating the marginal seal.

In the high copper amalgams, there is no formation of gamma 2; therefore, it takes double the time (up to 2 years) of the low copper amalgam to produce a similar marginal seal.[15-17]

*Cavity Design*

Although amalgam is still widely used as a restorative material worldwide, its lack of bonding capability makes it generally unsuitable for the restoration of minimal carious lesions. The achievement of adequate resistance and retention for such restorations requires the removal of a considerable amount of healthy tooth structure. Thus, for minimal Class I preparations, a preventive resin restoration may be preferable.[18]

The most common cavity design problem leading to immediate failure concerns retention.[19] In Class II preparations, particularly when the proximal outline flares out buccally and lingually, it could stress the material at these margins. Isthmus width is also

important. If the proximal box is large and the isthmus is narrow, a fracture could eventually occur. Conversely, if the isthmus is too large, a great deal of tooth material is wasted, the cusps are weakened and the pulp horns are endangered. Another common mistake is the presence of occlusal flash. These thin amalgam spurs, if subjected to stress, will fracture, leaving a ledge of rough amalgam at the margin, offering a protective area for plaque accumulation and debris.[19] In primary teeth, many practitioners limit Class II amalgam restorations to relatively small two-surface restorations. Three-surface restorations (MOD) may be done, but studies have shown that stainless-steel crowns are more durable and predictable.[20,21] This issue is discussed further under Clinical Implications and Recommendations.

*Technique Sensitivity*

Amalgam tends to be much less technique sensitive and more operator friendly when compared with other restorative materials, particularly the new composites. Minimal deviations from the manufacturer's recommendations may compromise the final result of the composite restoration, whereas amalgams are less affected.[15] However, moisture contamination should also be controlled in amalgams because excess moisture causes delayed expansion, particularly in zinc-containing alloys. The use of a rubber dam can prevent moisture contamination and isolate the working field effectively.[14]

**Factors Related to the Patient**

*Caries Risk Assessment*

Caries risk assessment has been considered important for the individual patient because most risk factors, when analyzed individually, have low predictive value. It could be anticipated that a patient who has low fluoride availability, high dietary sucrose intake and poor compliance with dietary and oral hygiene advice and who has reduced salivary flow, is an irregular dental attender, has a high mutans streptococci (MS) count and already has active caries would be at high risk of further caries. Reducing the number of risk factors may reduce the risk, but the influence of each factor may vary with each patient.[18]

Thibodeau and O' Sullivan measured annually the salivary mutans streptococci (SMS) counts to identify the long term risk in both primary and mixed dentition.[22] They concluded that despite some limitations of determining caries risk using microbiologic methods, the use of SMS testing in children as young as 3 years old may provide valuable information for identifying and aggressively treating those children at greatest risk of developing dental caries in the primary and permanent teeth.

An expert system for caries assessment has been suggested by Tinanoff and Douglas.[23] This system considers caries risk indicators suggested at the American Academy of Pediatric Dentistry Restorative Dentistry Consensus Conference[3]:

1. Present caries activity
2. Past caries experience
3. Demineralized areas
4. Mother's caries activity
5. Sibling's caries activity
6. Socioeconomic status
7. MS levels
8. Water fluoridation
9. Sugar consumption (including bottle and sippy cup)
10. Dental home
11. Other high-risk factors (appliances in the mouth, children with special needs)

When the above list is considered, the relevant evaluations, with the possible exception of the quantitative assessment of MS, may be readily available to the dentist in the dental office. Based on these points, it should be possible to identify the at-risk patient with reasonable accuracy and, consequently, to make a decision on the need to restore a lesion. The decision not to restore a lesion should be associated with the beginning of preventive therapy, ultimately followed by the assessment of whether a particular lesion is active at the time of the assessment.


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*Salivary Flow*

Although less common in children, certain patients present with unusual amounts of plaque owing to a diminished salivary flow, induced by taking certain drugs. The solution might actually be in restoring the salivary flow by having the patient chew sugarless gum to generate stimulated saliva.

Stimulated saliva offers more buffering protection than nonstimulated saliva, with mastication being the main stimulant. That is why chewing sugarless gum can often help prevent caries.[24]

*Presence of Orthodontic Appliances*

The main source of salivary bacteria is the oral soft tissues, which continually shed oral mucosal cells. Therefore, from a bacterial point of view, the solid and nonshedding surfaces of the teeth are very attractive. However, oral bacteria do not grow on all tooth surfaces with equal preference or intensity. Thus, the presence of orthodontic appliances, or, more specifically, bands and brackets, may favor the accumulation of bacteria with cariogenic potential.[25] If no measures are taken to disturb or remove the cariogenic plaque, the condition becomes a self-perpetuating process that slowly may result in a visible destruction.[25]

*Patient Age and Type of Tooth*

The age of the patient at the time of restoration placement has been reported to be a determinant in restoration longevity in primary molars.[26-29]

Studies evaluating the durability and life span of stainless steel crowns and Class II amalgams revealed that in children 4 years of age and younger, crowns had a success rate of approximately twice of that of amalgams.[26] It was also reported that restorations placed in first primary molars exhibit a shorter survival time than those placed in second primary molars.[28]

**Factors Related to the Operator**

*Operator Skills*

Lavelle studied 6,000 defective restorations in adults and concluded that operator skill was the greatest factor in determining the durability of the restorations and recurrent caries was the main reason for their failure.[30] These views were shared by Dahl and Eriksen.[31]

In the primary dentition, Qvist et al. found that the major reason for replacement of restorations was their fracture or total loss, again factors related to operator error.[32] This point can be reinforced by the low failure rate reported from a specialist practice,[33] suggesting that familiarity with behavior management and restorative techniques increase the success rate in young children.

*Correct Diagnosis and Treatment of Caries*

Restorative dentistry seems to have been based on the belief that dental caries could be treated effectively by restoring and, therefore, that such dental treatment would automatically result in oral health. Elderton claimed that many dentists are quick to replace restorations that they judge to be imperfect in some way; at each replacement the tooth becomes weaker and the restoration more complex and costly – the "repeat restoration cycle."[34]

The cure for caries, according to Elderton, lies in changing lifestyles and treatment with topical agents[34]; restorations per se do not offer these and hence do not provide the cure that they are often believed to effect.

**Longevity of Restorations**

This issue has been the focus of attention during the past decades, and several cross-sectional studies have been carried out assessing the age of the fillings and the reasons for their replacement.[30-32,35-38] Ozer and Thylstrup analyzed 18 of these studies and concluded that about half of all replacements occur because of the diagnosis of secondary caries.[39] Qvist et al. studied the accumulated percentage distribution of replaced amalgam restorations in adults and reported that 50% of them were replaced after 8 years.[40]


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The durability of amalgam restorations in primary molars has been assessed in amalgam studies proper[3,26,28,41] or as controls for resin-modified glass ionomer,[42,43] compomers[44-46] and composites.[47-49]

In one of the early studies of Class II amalgam in primary molars, McRae and coworkers concluded that failure of the amalgam itself was responsible for more marginal defects than enamel breakdown.[41] Most failures were observed in first primary molars,[28,41] and the buccal margins on the occlusal were the most susceptible to this failure. Qvist and coworkers found that the major reasons for replacement of restorations in primary molars were their fracture or total loss, factors related to operator error.[32]

Most reports on the longevity of restorations have been based on treatment by more than one operator,[26,28,30,32,50,51] with relatively few by a single operator.[27,33,52,53] In the first case, factors such as operator skills, patient management techniques and materials used introduce several variables that are difficult to control. To overcome these difficulties, Randall and coworkers evaluated the efficacy of stainless steel crowns versus amalgam restorations in primary molars by means of a literature review and meta-analysis.[21] Ten of 35 articles fulfilled the criteria and were analyzed qualitatively.[52-57] The highest success rate for both restorations and crowns was reported in the study with the largest sample size and longer follow-up time.[33] The low failure rate of 11.6% for amalgam and 1.9% for crowns was attributed to limiting the use of amalgam to small lesions and for the experience in managing children in a specialist practice setting.[33] Conversely, Eriksson et al. reported a failure rate of 76% using amalgam mainly to restore small lesions, leading to the conclusion that operator error again appears to be the main source of failure.[54]

Levering and Messer assessed the durability of amalgams in primary molars using the records of pediatric patients attending a dental school clinic.[26] The authors reported that their selection was biased because only the records of children with amalgam in at least 4 primary molars were included. Possibly, these children had extensive restorative histories and were at increased risk of caries and restoration replacement. These amalgams may not be representative of those in children with lower caries indices and cannot be extrapolated for children with less than 4 restored molars. True failures occurred more frequently among Class II amalgam than among Class I amalgam, regardless of age at placement. However, particularly significant was the large number of true failures (46%) and the relatively few successful restorations (47%) among those younger than 4 years.

**Present Use of Amalgam in Primary Molars**

The daily practice of pediatric dentistry some 50 years ago did not have many choices concerning restorative materials.[58] For primary molars, amalgam and stainless steel crowns were mainly used, but sometimes cemented orthodontic bands were used as restorations.[58] Presently, as are other dental practitioners, the pediatric dentist is confronted with many materials to select for each situation.

The British Society of Paediatric Dentistry, analyzing the use of amalgam in the United Kingdom and other European countries, observed that although there was no policy concerning the use of amalgam, most parents ask for esthetic alternatives.[7] In Sweden, the original ban on amalgam use was for environmental reasons and has now been lifted. However, dentists usually avoid amalgam use in children and pregnant mothers.

In a recent survey of North American dental schools, Guelmann and coworkers observed that amalgam continues to be the material of choice for Class I and II restorations in primary molars, although hybrid composites and compomers are gaining some popularity.[59] The findings of this survey reinforce the need of a consensus and guidelines for restorative materials and techniques in pediatric dentistry.

**Clinical Implications and Recommendations**

Treatment of caries should meet the needs of each particular patient, based on his or her caries risk. Restorative decisions for the primary dentitions are taken based on the different objectives and expectations than those for the permanent dentition. Quoting Seale, The primary teeth are a temporary dentition with known life expectancies of each tooth.[35] By matching the “right” restoration with the expected life span of the tooth, we can succeed in providing a “permanent” restoration that will never have to be replaced.


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Picking the "right" restoration involves understanding the limitations of the primary dentition to hold certain types of restorations over time and the durability of the restorative options available.

Based on these considerations, for small occlusal lesions, a conservative preventive resin restoration, using composite or compomer in conjunction with a sealant, would be more appropriate than the classic Class I amalgam preparation.[2,3]

For proximal lesions, amalgam would be indicated for two-surface Class II preparations that do not extend beyond the line angle. This recommendation might not be appropriate for restoring first primary molars in children 4 years of age and younger. If the carious lesion is extensive and/or in more than two surfaces, a stainless steel crown would be indicated, even for children older than 4 years.[2,3]

Although stainless steel crowns are recommended mainly for restoring pulpotomized primary teeth, Class I amalgam can be an appropriate restoration when the remaining walls are thick enough to withstand the occlusal forces and their natural exfoliation is expected within not more than 2 years.[60] Other factors that would influence the recommendation of stainless steel crowns instead of amalgam are poor parent compliance and the lack of possibility of a long term follow-up.[34]

In an article entitled "Restorative Dentistry for Pediatric Teeth – State of the Art 2001," Christensen discussed the popular trends in pediatric restorative dentistry.[61] In his opinion, the several alternatives to amalgam challenge the continued use of amalgam in children.

Despite the fact that the use of amalgam has diminished significantly during the past few years, more studies with long-term follow-up of compomers or other esthetic materials are necessary before they can be considered a definitive alternative for amalgam in primary teeth.

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