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British Society of Paediatric Dentistry: a policy document on the use of amalgam in paediatric dentistry

This policy document was prepared by A. J. Rugg-Gunn, R. R. Welbury & J Toumba on behalf of the British Society of Paediatric Dentistry (BSPD). Policy documents produced by the BSPD represent a majority view, based on a consideration of currently available evidence. They are produced to provide guidance with the clear intention that the policy be regularly reviewed and updated to take account of changing views and developments.

1. Introduction

Silver amalgam has been used for restoring teeth for over 150 years and is still used extensively in children's dentistry. Over recent years there have been improvements in the clinical handling and physical properties of tooth-coloured plastic filling materials which, together with the continuing concern over the toxicity of dental amalgam and associated environmental issues, requires an evaluation of the desirability of continuing to use dental amalgam in children's dentistry in the UK. This policy document will consider the toxicity of mercury and amalgam, environmental issues, the comparative clinical effectiveness of plastic filling materials in children's dentistry, and make recommendations. The reader is referred to the Society's policy document 'Management of caries in the primary dentition' for a fuller discussion of restoration of primary teeth [1].

2. Toxicity of amalgam

2.1 Introduction

The potential toxicity of amalgam has been recognised since its introduction into dentistry in the early 19th century [2]. Mercury, either inhaled as a vapour, or ingested, is the main concern. Encapsulation of the silver/tin alloy and mercury during mixing, has reduced considerably the risk of inhalation. The alloy also usually contains small percentages of copper and zinc. Despite encapsulation, concern over toxicity persists. These concerns can be grouped into:

- inhalation of mercury vapour and amalgam dust
- ingestion of amalgam
- allergy to mercury
- environmental considerations

2.2 Inhalation of mercury by dental personnel

A few instances of mercury intoxication involving dental staff have been reported, including one fatality [2]. All these resulted from mercury spillage, poor mercury hygiene, or incorrect amalgam preparation technique, and were totally avoidable if correct handling techniques had been carried out. Dental personnel have been found to excrete greater quantities of mercury in their urine than control populations, but these urinary excretion levels have fallen since dental personnel have responded positively to advice on correct handling of mercury and amalgam [2].

2.3 Inhalation of mercury and amalgam dust and ingestion of amalgam by patients

Inhalation and ingestion of mercury in dental amalgam can occur during placement, polishing or removal of the restoration, or during chewing. The daily dose of mercury from dental fillings, produced by chewing, would appear to amount to about 1–2 μg/adult. The threshold for hazard to health from air/mercury exposure in the general population is 5 $\mu g/m^2$ air, while it is 1 $\mu g/m^2$ for children, pregnant women and the sick. All estimates of the daily total amalgam-associated mercury intakes are well below these thresholds [2].

The fate of inhaled or ingested mercury in the body has been investigated in animal and human studies. After placement of amalgam, there is a rise in faecal mercury due to ingested surplus amalgam. In the longer term, urine is the route of excretion, with higher mercury levels occurring in those with amalgam fillings. Tissues with the highest mercury levels are the kidneys and the brain. Mercury can pass from mother to foetus and may be detected in milk. However, any correlation between mercury levels in the mother and new-born child is far more closely related to the amount of fish consumed, than the number of amalgam fillings in the mother. Animal and human investigations have not demonstrated any association between amalgam fillings and birth defects. Likewise, there is no demonstratable relationship between the presence of amalgam fillings and neurological disorders, abnormalities in white cells and immuno-competence, kidney function, or the general health of patients [2].

The UK Department of Health Committee on Toxicology (COT) reviewed the use of dental amalgam in 1998, and stated 'that there is no evidence that the placement or removal of amalgam fillings during pregnancy was harmful'. Despite the lack of evidence, the Committee advised that 'it may be prudent to avoid amalgam placement or removal during pregnancy where clinically reasonable' [3].

Rubber dam use whenever possible has been recommended by paediatric dentists for the restoration of primary teeth with amalgam [4]. Plasma and urinary mercury levels following placement or removal of amalgam restorations have been shown to be reduced when using rubber dam [5]. The small potential risk of mercury toxicity for the patient can be minimised by using rubber dam. It should be borne in mind that some dental procedures can increase the release of mercury from amalgam. The use of 10% carbamide bleaching agents has been shown to increase the mercury release from amalgam restorations *in vitro* [6].

2.4 Allergy to mercury

True allergies to dental amalgam have been reported rarely–about 50 cases in the past 100 years [2], although it is uncertain what proportion of these were children. Hypersensitivity testing revealed that some, but not all, were due to mercury–a small number of cases were due to copper or silver hypersensitivity. Amalgam replacement is an effective cure.

There have also been reports of an association between some oral lichenoid lesions, and the presence of amalgam fillings adjacent to the affected area of oral mucosa. Removal of the amalgam fillings is only recommended if there is clear contact between the restoration and the lesion: it should be noted that other restorative materials can also cause lichenoid lesions [7,8].

2.5 Environmental Issues

Due to the awareness of the toxicity of mercury, many countries have sought planned reductions in the industrial use of mercury and its use in dental amalgam. The reasons are solely environmental, as mercury contamination of rivers and lakes has led to increasing mercury levels in plants and animals living in these environments. The use of mercury in dentistry accounts for about 3% of the total amount used on a world-wide basis. In the 1970s and 1980s, 50% of mercury used in dental practices was discharged into the environment, amounting to over 5 tonnes of mercury discharged into UK sewers per year [2]. The three countries to the fore on this issue are Sweden, Germany and Finland. The governments of these countries, however, do not interfere with the clinical freedom of dental practitioners to use whatever material they think is clinically indicated, but have encouraged good mercury hygiene in dental practices and demanded that effective measures are in place for dealing with waste amalgam to prevent it from reaching the environment [2,9].

2.6 Toxicity of alternatives to amalgam

A number of concerns have been raised about the clinical safety of composite resins, although there has been much less research in this area than with mercury in amalgam. Concerns have centred on composites and specifically on: peroxides and free radicals produced during polymerisation, which are known to be promoters of skin cancers, and bisphenol-A, which may leach out of bisGMA type materials and may mimic the effects of natural oestrogens. The clinical relevance of these claims has yet to be determined but indicates that choosing alternative restorative materials to amalgam is not risk-free [2].

2.7 Major Reviews of the Risk of Dental Amalgam

The United States Public Health Service conducted a comprehensive scientific review of dental amalgam with respect to its benefits and risks: nearly 500 scientific articles were used as a basis for this report [10]. The report concluded that there were no data to compel a change in the use of dental amalgam, but urged that research should continue. Amongst its conclusions were that: (a) it had not been demonstrated that people experienced any clinical effects from the small additional body burden of mercury from dental amalgam; (b) there was no persuasive evidence that the mercury dose produced by amalgam fillings was capable of causing the wide variety of non-specific symptoms that have been attributed to fillings in anecdotal reports, or that cure or health improvement can be achieved after their removal. Furthermore, the report identified many benefits from the use of amalgam restorations.

In 1998, the American Dental Association Council on Scientific Affairs published a document updating safety concerns regarding dental amalgam [11]. The summary and conclusions from the report are as follows: 'Millions of people have amalgam restorations in their mouths, and millions more will receive amalgam for restoring their carious teeth. Over the years amalgam has been used for dental restorations without evidence of major health problems. Newly developed techniques have demonstrated that minute levels of mercury are released from amalgam restorations; but no health consequences from exposure from such low levels of mercury released from amalgam restorations have been demonstrated. Given the available scientific information, and considering the demonstrated benefits of dental amalgams, unless new scientific research dictates otherwise, currently there appears to be no justification for discontinuing the use of dental amalgam. Carefully designed, comprehensive research is encouraged to investigate the potential biological effects resulting from low level mercury exposure from amalgam restorations. The ADA's Council on Scientific Affairs will continue to review and evaluate scientific data on the safety of amalgam, and will make recommendations to the dental profession that are grounded on sound science'.

In the UK, by far the most comprehensive review of dental amalgam is that published by Eley in the British Dental Journal in 1997 [2]. This series of seven articles discussed the chemistry of amalgam, mercury bio-availability and toxicity, hypersensitivity and the benefits and risks of using dental amalgam. The conclusion states: 'The present evidence does not appear to demonstrate that amalgam restorations are hazardous to the health of the general population. Amalgam has been used in clinical dentistry for over 100 years. Approximately 22 million amalgam restorations are placed each year in National Health treatment in England and Wales, and it is used for about 75% of all restorations. The only adverse effect documented is the rare occurrence of hypersensitivity to mercury in a very tiny proportion of the population. However, in continuing to use amalgam, dentists should observe strict mercury and amalgam hygiene procedures in their practices, so that the health of dental workers is not put at risk. It is also essential that all waste amalgam is safely disposed of: this waste must be prevented from reaching the sewage system, so that contamination of the environment is avoided. If environmental contamination from dental practices is not cut down to a very low level, then this is likely to be the main reason for Government action against the use of amalgam in the future'.

2.8 Recommendations on the use of dental amalgams in other countries

The result of an investigation into the use of dental amalgam in the European Community in 2000 is as follows:

- *Finland.* In 1987, the Finnish Medical Board recommended increased use of glass ionomer cements in children and adolescents. Glass ionomer was thought to be biologically more satisfactory than other materials, and the need for removal of sound tooth substance was less than when amalgam was used. It should be noted that, in 1992, the Finnish National Board of Waters and the Environment estimated that mercury in dental amalgam made up around 20% of the total annual mercury consumption in Finland. In 1994, the Ministry of Social Affairs and Health recommended that the use of dental amalgam should be decreased for environmental reasons. Amalgam was only to be used when there was no acceptable alternative: it did not advise routine removal of well-functioning existing amalgam restorations [9].

- *Sweden*. No policy, parents usually insist on other materials. Original ban on amalgam use was for environmental reasons and this has now been lifted. Usually avoid amalgam use in children and pregnant mothers.
- *Belgium*. No policy, amalgam used but more parents asking for alternatives.
- *Denmark*. No policy, amalgam used but more parents asking for alternatives.
- *Netherlands*. No policy, amalgam used but more parents asking for alternatives.
- *Norway*. No policy, use of amalgam in children has declined considerably [12], amalgam is used but more parents asking for alternatives.
- *Germany*. No policy, parents usually insist on other materials.
- *Switzerland*. No policy, parents usually insist on other materials.
- *Israel*. No policy, amalgam still used, some parents object.
- *France*. No official policy but avoidance for children and pregnant mothers.
- *Greece*. No policy, amalgam widely used.
- *Ireland*. No policy, amalgam widely used
- *Italy*. No policy, amalgam widely used.
- *Spain*. No policy, amalgam widely used.
- *Iceland*. No policy.

2.9 Conclusions

Amalgam has been used in dentistry for over 150 years. Presently, around half to three quarters of all restorations placed in the UK are of amalgam. Evidence at present does not appear to indicate that amalgam is hazardous to the general population. Hypersensitivity to mercury can occur, but is rare and is successfully treated by replacement of such restorations. Environmental contamination by mercury is a concern, and is the main reason for restrictions in the use of dental amalgam. Dental surgery staff are at risk of mercury intoxication if materials are handled incorrectly. It is essential that dentists using amalgam pay strict attention to guidelines, both in the surgery and in the disposal of waste [13].

3. Clinical effectiveness of amalgam and its alternatives in children's dentistry

3.1 Summary

The requirements for a restorative material in the primary dentition are different from those in the permanent dentition. Primary teeth usually have a maximum normal life span of 8–9 years and many restorations will only have to last a fraction of this time in the oral environment.

Restorations fail or are replaced (or both) for many reasons and at different times during service. The terms 'failure' and 'replacement' seem to be used synonymously in the dental literature, and in clinical practice there are few specific points of measurable failure. Failures such as fracture, loss of a restoration and missing contact points are generally agreed on by the profession, but discrepancies in anatomical form, marginal deterioration and tissue response to restorations elicit a wide spectrum of responses. The decision to call a discrepancy a failure and to recommend replacement draws on individual clinical judgement that is highly variable and not clearly defined.

3.2 Amalgam

In the primary dentition, the survival rate of amalgam restorations can be low. Survival rates of 50% after 2 years [14], 38–48% after 3 years [15], and 67% after 5 years [16] have been reported. The survival time has been shown to increase with increasing age of the patient at placement of the restoration [15,17], and one prospective clinical trial using a split mouth 'paired cavity' design for class II amalgams, showed a survival rate of nearly 80% at 5 years [18].

3.3 Stainless steel crowns

These should be the restoration of choice for cavities of greater than two surfaces in primary molars. Amalgam in this situation performs poorly with as many as 89% of restorations requiring follow-up treatment at two years [19], compared with only 3% of stainless steel crowns requiring replacement during their lifetime [16].

3.4 Composite resin

In the short term, these are nearly as durable as amalgam in class II cavities, with 16% requiring replacement after 3 years compared with 8% for amalgam [20]. However, after 6 years the failure rate had risen to 62% [21] compared with 20% for amalgam after 5 years [18].

3.5 Glass ionomer cements and cermet cements

Conventional glass ionomer cements have been shown to have a mean survival time of 33 months, compared with 41 months for amalgam when used in class II cavities in primary molars over a 5–year period [18]. Cavity preparation involves removing less sound tooth tissue in comparison with amalgam because of 'adhesive' cavity designs. In other studies they have been shown to have failure rates of 23% at 2 years [22] and 60% at 3 years [20].

The search for improved mechanical properties of glass ionomer cements to add to their ability to bond to both enamel and dentine, led to the incorporation of metal into the glass ionomer cement powder to produce cermet cements. Unfortunately, these cermet cements perform poorly as restorative materials in the primary dentition and failure rates of 23% after 5–14 months [23] and 41% at 2 years have been reported [22].

3.6 Resin modified glass ionomer cements

The continued search for improvements to the mechanical properties of glass ionomer cements led to the incorporation of light-cured resin components to give 'resin modified' glass ionomer cements. These retained a significant acid-base reaction in the overall curing process. However, the physical properties of these cements suggest they should be considered as lining materials rather than definite restorative materials. Nevertheless, this research has led to the development of cements with more light-cured resin components and hence improved physical properties, but which still retained an acid-base reaction. These cements are called 'polyacid modified resin composites' or compomers.

3.7 Compomers

Compomers were marketed in the 1990s to overcome the technique-sensitive mixing and handling properties of resin modified glass ionomer cements. They contain acid-decomposable glass and acidic, polymerisable monomers substituting for the poly alkenoic acid polymers. McLean *et al.* [24] suggested the term polyacid modified resin composites for these materials, but they are commonly termed 'compomers'. Unlike glass ionomer cements and resin modified glass ionomer cements, they will not set in the dark, as there is insufficient water present to encourage any significant acid-base setting. The dominant setting reaction is resinous photopolymerisation. Compomer materials combine the advantages of both glass ionomer cements and resin composites, and their physical properties are similar to those of resin composites [25]. *In vitro* evaluations have shown high bond strengths for compomers to both enamel and dentine [26,27]. Compomer materials release fluoride, but to a lesser extent than the glass ionomer cements [28].

Recent clinical research has shown that compomers have survival rates comparable with amalgam when used as restorative materials in class II cavities in primary molars after 24 months [29–31], 36 months [32,33], and 42 months [34].

4. Recommendations

4.1 No restrictions should be placed upon the use of silver amalgam to restore children's teeth at the present time. Dental surgery staff should observe very closely published guidelines concerning the storage and disposal of mercury, the preparation of dental amalgam and disposal of waste amalgam.
4.2 It is advisable to use rubber dam where practical (whenever possible) when placing or removing amalgam restorations in order to reduce any potential risk of mercury toxicity to a minimum.
4.3 Parents and patients should be made aware of the current status of alternatives to amalgam, including safety aspects.
4.4 Manufacturers should be encouraged to continue the development and clinical testing of non-amalgam plastic restorative materials for use in children's dentistry. Available evidence indicates that 'compomer' restorative materials are as satisfactory as silver amalgam for restoring primary molar teeth, but the data are limited.
4.5 Clinicians should be encouraged to test the efficiency of promising new materials for restoring primary molar teeth, in well-designed randomised clinical trials in hospital and practice settings.
4.6 More research should be conducted on the toxicity of alternatives to amalgam.
4.7 These recommendations should be reviewed at least every three years as progress to improve the

properties of restorative materials is rapid and future reports of clinical trials may show improved non-amalgam plastic restorative materials to be clinically superior to amalgam.

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