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UK National Clinical Guidelines in Paediatric Dentistry: stainless steel preformed crowns for primary molars

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This revised Clinical Guideline in Paediatric Dentistry replaces the previously published sixth guideline (Fayle SA. *Int J Paediatr Dent* 1999; **9**: 311–314). The process of guideline production began in 1994, resulting in first publication in 1997. Each guideline has been circulated widely for consultation to all UK consultants in paediatric dentistry, council members of the British Society of Paediatric Dentistry (BSPD), and to people of related specialities recognized to have expertise in the subject. The final version of this guideline is produced from a combination of this input and thorough review of the published literature. The intention is to encourage improvement in clinical practice and to stimulate research and clinical audit in areas where scientific evidence is inadequate. Evidence underlying recommendations is scored according to the SIGN classification and guidelines should be read in this context. Further details regarding the process of paediatric dentistry guideline production in the UK is described in the *Int J Paediatr Dent* 1997; **7**: 267–268.

Background to updated guideline

Since this sixth National Clinical Guideline was originally published in the *Int J Paediatr Dent* 1999 there have been one meta-analysis[1], four literature reviews[2–5] and one prospective clinical trial[6] published in relation to the use of stainless steel crowns (SSCs) or preformed metal crowns (PMCs) for the restoration of primary molars. All papers have concluded that the failure rate for SSCs used in primary molar teeth is very low compared with plastic restorations. At the time of update of this guideline a randomized control trial (RCT) investigating the effectiveness of SSCs in managing carious primary molars using the Hall Technique is underway, with results published[7].

A Cochrane review pertaining to the use of preformed metal crowns for the restoration of carious primary molar teeth was published in January 2007[8]. The aim of the review was to compare clinical outcomes for primary molar teeth restored with SSCs compared to those restored with alternative filling materials or remaining untreated. Using very stringent criteria, looking for evidence from well designed RCTs, of which none could be found, the authors concluded that whilst there was a subjective impression amongst paediatric dentists that SSCs provide a more durable restoration than plastic restorative materials there is little evidence from good quality clinical trials to support this. The Cochrane report does however stress that a paucity of stringent clinical studies should not be interpreted as evidence for a lack of efficiency of the technique. Indeed whilst studies and reports published may not meet Cochrane standards it is important to emphasize that there is a large amount of useful literature advocating the use of SSCs. Butani and colleagues[9] have described the quantity of published literature available which relate to the use of SSCs. In 2005 they found a total of 122 papers with 52 of these being outcome-related, evidence-based literature and the others reviews/expert opinion, case reports, technique and practice guidelines.

It is essential for the clinician to use the best available evidence to support clinical

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practice. This paper provides the dental practitioner with an update of the current published literature and the available evidence for the use of SSCs in the treatment of the primary molar. British Society of Paediatric Dentistry guidelines for the recommended use of SSCs in primary molar teeth are reiterated. For this updated guideline a search of the dental literature was made electronically from MEDLINE OVID using the key words: preformed crown(s), stainless steel crown(s), (a)esthetic primary (deciduous) molar crown(s). A total of 236 abstracts were identified from 1966 to the current time. Publications pertaining to the use of stainless steel crowns in primary molar teeth were retrieved. All articles previously cited in the 1999 guideline were reviewed in addition to all papers subsequently published.

Introduction

Stainless steel (preformed) crowns are prefabricated crown forms which can be adapted to individual primary molars and cemented in place to provide a definitive restoration. The following guideline is intended to assist in the planning and provision of stainless steel crown restorations for primary molars.

1. Indications

Stainless steel crowns are the *restoration of choice* in the following situations:

1.1**(B)**
Restoration of carious primary molars where more than two surfaces are affected, or where one or two surface carious lesions are extensive;

1.2**(B)**
Following pulpotomy or pulpectomy procedures.

Stainless steel crowns may also be *indicated* in the following situations:

1.3**(C)**
Restoration of primary molars affected by localized or generalized developmental problems, e.g. enamel hypoplasia, amelogenesis imperfecta, dentinogenesis imperfecta.

1.4**(C)**
Restoration of fractured primary molars.

1.5**(C)**
Restoration and protection of teeth exhibiting extensive tooth surface loss due to attrition, abrasion or erosion.

1.6**(B)**
In patients with a high caries susceptibility.

1.7
As an abutment for certain appliances, such as space maintainers.

1.8**(C)**
In patients where routine oral hygiene measures are impaired e.g. patients with special needs, and breakdown of intra-coronal restorations is likely.

1.9**(C)**
In patients undergoing restorative care under general anaesthesia if two or more surfaces are involved.

2.0**(C)**
In patients with infra-occluded primary molars to maintain mesiodistal space.

Stainless steel crowns are *contra-indicated*: (i) if the primary molar is close to exfoliation with more than half the roots resorbed; (ii) in a patient with a known nickel allergy or sensitivity (Note: The ESPE SSC consists of a chromium-nickel steel of surgical quality. Although nickel should not be released in significant amounts under normal clinical conditions ESPE, Service Centre, Germany, recommend that they are not used in patients with nickel allergies except after consultation with an allergologist or dermatologist).

2. Clinical procedure

2.1
Appropriate local analgesia should be obtained and the tooth should be isolated, preferably with rubber dam.

2.2
Caries removal and appropriate pulp treatment (i.e. indirect pulp capping, pulpotomy or pulpectomy) should be completed if necessary. Some clinicians advocate preparation

of the tooth for the crown prior to finalizing caries removal and/or pulp treatment.

2.3**(C)**
Appropriate tooth preparation should be carried out, which should include sufficient occlusal reduction to avoid significant occlusal prematurity, and approximal reduction to allow the crown to be seated beyond the maximum bulbosity of the crown. Occlusal reduction should follow the contours of the tooth. The preparation should finish with a smooth feather edge cervically with no step or shoulder. The preparation should be rounded off with no sharp line angles. Where a primary molar has no adjacent tooth either mesially or distally it is still important to carry out approximal reduction to avoid producing an excessive marginal overhang. This is particularly important on the distal surface of second primary molars where such overhangs can impede the eruption of the first permanent molar. Buccal and lingual preparation is not always necessary and may be detrimental to retention.

2.4
A crown should be selected that is a tight snap fit. Choosing the correct size is assisted by measuring the mesio-distal dimension of the tooth, or contralateral tooth, with dividers or a graduated periodontal probe.

2.5**(B)**
Stainless steel crowns produced by several different manufacturers are available in the United Kingdom. The degree of adjustment necessary to achieve a satisfactory fit is dependant upon the make of crown used. SSCs crowns from 3M^{TM} ESPE^{TM}are anatomically trimmed and contoured cervically and in many instances require little or no modification. Other types of SSC have little or no cervical contouring and hence routinely require modification.

2.51
If the crown is excessively long, the crown margin may impede complete seating, in which case crown length may be adjusted by trimming with crown shears and re-smoothing and polishing the edges with an abrasive stone. Although it has been customary to recommend trimming of crowns where gingival blanching occurs, there is no evidence that this practice reduces post cementation complications. Manufacturers recommend the SSC finishes about 1mm below the gingival margin.

2.52
Over trimming of the crown margin should be avoided, as this may affect retention if it results in reduced adaptation of the crown margin into undercut areas. It is essential that the margins of the crown are well adapted into undercut areas, which is usually achieved by crimping of the crown edges.

2.53
Special attention should be given to adaptation of the distal margin on second primary molars where the permanent molar is unerupted. An uncorrected distal overhang may result in impaction of the first permanent molar. Care should be taken not to cause iatrogenic damage to adjacent teeth or unerupted teeth.

2.6**(C)**
Frequently, reduction in the mesio-distal dimension of the crown will be necessary, especially where mesial drift (often due to caries) has resulted in loss of arch length. Moderate reduction in mesio-distal dimension can be achieved by flattening of the mesial and distal contact areas of the crown with Adam's pattern pliers. Where mesial drift has occurred in the lower arch it may be possible to use a SSC form for the contralateral upper tooth (e.g. ULE crown form for LRE) as these SSC forms have a shorter mesiodistal dimension. Other forms of modification, including vertically slicing one aspect of the crown and spot-welding additional segments of stainless steel band to increase the perimeter or extend the length have been described, but their efficacy remains largely untested.

2.7**(C)**
Excessive occlusal interference should be avoided (greater than 1.0–1.5 mm), but a slightly premature or high occlusal contact up to about 1.0 mm is normally well tolerated in children, who appear to have consid-

erable capacity for dentoalveolar compensation, with the occlusion adapting to any prematurity within a few weeks.

2.8**(C)**
The crown should be cemented with a luting cement. Glass ionomer, zinc polycarboxylate and zinc phosphate cements are all suggested by manufacturers, although fluoride-leaching cements may have added benefits. There is, however, some evidence suggesting that the specific choice of cement does not significantly affect retention, the most important retentive components being derived from correct contouring and crimping of the crown.

2.9**(B)**
Careful attention should be paid to removal of excess cement. This can usually be effectively achieved by running a pointed instrument around the margins of the cemented crown and by passing knotted dental floss bucco-lingually through the contact areas prior to the cement setting. Excess cement has been shown to be detrimental to gingival health.

3. Other considerations

3.1
Stainless steel crowns may be aesthetically improved by placement of composite resin in a window cut into the labial face of the crown post-fitting. Alternatively aesthetic crowns with prefabricated tooth coloured buccal and occlusal facings are available from specialist suppliers.

3.2**(B)**
When cementing orthodontic bands to stainless steel crowns roughening of the internal surface of the band and external surface of the crown prior to cementation has been shown to improve retention.

Explanatory notes

1.0
Stainless steel crowns are widely recognized as the most effective and durable restoration for primary molars. There have been several retrospective studies examining the longevity of stainless steel crowns in comparison with amalgam restorations[10–13]. All have shown stainless steel crowns to have markedly superior longevity when compared with multi-surface amalgam restorations. Retrospective data suggests that stainless steel crowns similarly out-perform glass ionomer cements and composite restorations[14–16]. Two retrospective studies have involved data collected from patients who had undergone comprehensive care of the primary dentition under general anaesthesia[15,16]. These authors strongly recommend the use of SSCs for the restoration of carious primary molars under general anaesthesia.

Eriksson[17] reported a non-randomized clinical trial comparing SSCs to contralateral teeth which were either restored or sound, however, it is unclear whether this trial was retrospective or prospective. When Randall[1] used this study in her meta-analysis but excluded the sound contralateral control teeth SSCs had a significantly higher success rate (78.8%) than amalgams (21.4%) over the 7-year period of the study. Roberts and Sherriff[18] provided a prospective report on the survival of amalgam and SSC molar restorations placed in specialist paediatric dental practice over 10 years. The true failure rate for primary molar restorations was 4.1% for class I amalgams and 11.6% for class II amalgams, while only 1.9% of SSCs failed. The authors gave a 5-year estimated survival rate of 92% for SSCs and 67% for minimal class II cavities restored with amalgam. A more recent prospective study carried out by Roberts and colleagues[6] over a 7-year period gave a 97% success rate for SSCs under the conditions of a specialist paediatric practice. Resin modified glass ionomers were equally as successful as SSCs when used in small class I and minimal class II cavities. Although this study was prospective it was not a randomized control trial as the treatment provided was dictated by the clinical status of the tooth, such that extensive caries was restored with a SSC whilst minimal cavities were restored with resin modified glass ionomer cement. One retro-

spective study has investigated the longevity of restorations placed in primary molars within an NHS practice[19]. Wong and Day screened 361 records of three dentists working in NHS practice, randomly analysing one restoration per patient. They found evidence that SSCs performed better than alternative restorations within the conditions of NHS practice.retention.

In a systematic review and meta-analysis of clinical studies comparing SSCs with amalgam restorations Randall[1] demonstrated the clinical effectiveness of SSCs over amalgam restorations for the treatment of large carious lesions in primary molars. Several of the studies cited allocated SSC treatments to restore large, multisurface carious lesions, whilst amalgam was reserved for the smaller lesions. Thus it can be seen that SSCs outperformed amalgam restorations even when placed in more demanding circumstances, adding a negative bias to the outcome of the crowned teeth and strengthening the evidence for the clinical performance of SSCs.

Despite this favourable outcome, SSCs are seldom used in general dental practice[20]. Many dentists avoid the use of SSCs due to lack of clinical experience and the belief that provision of a SSC is a complex procedure, whilst in reality it is often simpler and more cost-effective treatment modality than a class II restoration. Given the longevity of SSCs[18], a primary molar treated in this way is unlikely to need any further treatment until it exfoliates naturally. It has been suggested that postgraduate training packages, and in particular hands-on training courses, may be the most effective way to encourage dental practitioners to re-evaluate the restorative techniques they undertake and may increase the use of SSCs for the restoration of primary molar teeth[21].

Currently a randomized control clinical trial (RCT) is being carried out in Scotland to investigate the success of cementing SSCs over unprepared carious primary molars (Hall Technique) as a therapeutic option for the pre-co-operative child[7,22]. This has followed a retrospective audit of this technique which found a success rate of 67.6% after 5 years[23]. Outcomes of SSCs placed by the Hall Technique compared to placement of conventional plastic restorations, with a follow-up period of 23 months, are now available[7]. Whilst this technique has not been directly compared to outcomes of SSCs placed following removal of caries, sealing in of dentine caries by placement of SSCs without the use of local anaesthetic (Hall Technique) has been shown to be acceptable to patients and, at 23 months shows more favourable outcomes for pulpal health and restoration longevity than conventional plastic restorations placed by general dental practitioners.

1.2

Retrospective studies have shown the success rate of formocresol pulpotomies to be greater for teeth restored with SSCs compared to those restored with amalgam[24], composite[25,26] or IRM[27]. In addition, indirect pulp therapy in primary molars has been shown to be more successful where the definitive restoration was a SSC[28].

2.3

A study by Rector and co-workers[29] failed to demonstrate that the type of tooth preparation affected retention. In an earlier study[30], however, preparations maintaining the greatest surface area of buccal and lingual tooth structure were shown to be most retentive. This suggests that buccal and lingual reduction does not have any advantage with regard to retention and may even be detrimental.

Studies have failed to show any increase in supra-gingival plaque accumulation associated with SSCs[31–33] except in instances where crowns with defective margins have been placed, or where excess cement has been retained[34,35]. Several studies have investigated gingival health in association with stainless steel crown restorations. Two have suggested higher levels of gingivitis around teeth restored with stainless steel crowns[35,36]. In both these studies, however, no direct comparison was made with unrestored matched control teeth. In two studies where matched control teeth were used no difference in the level of gingivitis around stainless steel crowns was demonstrated[32,33].

The relationship between gingivitis and marginal defects, such as poor marginal adaptation and incomplete removal of excess cement, has been clearly demonstrated by several workers[31–35]. Careful adaptation of crown margins before fitting is thus essential and the incidence of post-fitting gingivitis may be reduced by careful polishing of the crown margin[37]. The presence of a well-adapted SSC on a second primary molar does not affect the periodontal health of the neighbouring first permanent molar[38]. These clinical findings are confirmed by a more recent retrospective study evaluating clinically and radiographically the effect on gingival and bone structures of cemented SSCs in a sample of 177 children followed up from 1 to 38 months[39]. No deleterious effect on gingivae or bone occurred in the presence of good oral hygiene.

2.52
It has been demonstrated that close adaptation of the metal margins of the crown in the undercut areas significantly enhances retention[29].

The impaction of first permanent molars beneath over-hanging distal margins on poorly adapted stainless steel crowns has been reported[40]. Careful attention should thus be paid to adaptation of the distal margin on second primary molars where the permanent molar is unerupted.

2.7
Slightly premature or high occlusal contact seems to be well tolerated in the primary and early mixed dentition and clinically appears to be compensated for within a few weeks. It is probable that there is an adaptation of the dento-alveolar complex to this occlusal interference in the growing child.

2.8
An *in vitro* study comparing stainless steel crown retention with polycarboxylate and glass ionomer cement failed to demonstrate any difference[41], and in an extensive study which demonstrated a 92% 5-year survival[18] the majority of crowns were cemented using a reinforced zinc oxide cement. Choice of cement would therefore appear to be non-critical. Since these guidelines were published a further *in vivo* study has failed to show a significant difference in retention of SSCs cemented with glass ionomer, zinc phosphate and zinc polycarboxylate, although there was only an 8 month follow-up[42].

2.9
Where excess cement has been retained, stainless steel crowns have been shown to be associated with an increased degree of plaque accumulation[34,35]. The relationship between gingivitis and marginal defects, such as poor marginal adaptation and incomplete removal of excess cement, has been clearly demonstrated by several workers[31–35].

3.1
Some parents or patients may complain about the appearance of SSCs. Aesthetic improvement of the appearance of stainless steel crowns by placement of composite resin in a window cut into the labial face of the crown after cementing, has been reported in a case report of a modified SSC followed to exfoliation 23 months later, without evidence of deterioration[40].

Alternatives to this technique are prefabricated tooth coloured crowns supplied by various manufacturers [e.g NuSmile® (Houston, TX, USA) primary crowns]. These require significantly increased space and consequently more preparation due to their greater bulk. With these tooth coloured crowns, manufacturers' instructions advise avoiding crimping of the crown which may make the facing susceptible to fracture. Consequently the tooth is prepared to fit the most appropriate crown. Prefabricated crowns with aesthetic facings have been shown to be prone to fracture *in vitro*[43,44]. A pilot study comparing 11 aesthetic crowns with 11 conventional SSC found the aesthetic crowns were bulkier, more expensive, resulted in poorer gingival health and lacked a natural appearance[45]. After a 4 year follow-up all the aesthetic crowns showed chipping of the facing[46].

More recently Yilmaz[47] compared the clinical success of SSCs made aesthetic by open facing with those which had aesthetic veneers. Eighteen open-faced and 15 veneered crowns were placed and followed up for 18 months. When loss of more than a third of the facing was recorded as a failure, open-faced crowns showed a 95% success, while the veneered crowns showed a success of 80%. The literature supporting the use of the aesthetic modified or prefabricated crown for the primary molar remains modest, with small numbers of patients included in studies. Cost and increased chairside time are unlikely to lead to widespread use of these restorations. It is however useful for the clinician to be aware of this option and include it in the armamentarium of treatment options for occasional use. The patient should be warned about some gradual deterioration in appearance over time.

3.2
Orthodontic band retention on stainless steel crowns has been shown to be poorer than on unrestored teeth. Roughening of the internal surface of the band and external surface of the crown prior to cementation has been shown to improve retention strength to a level comparable with those obtained on unrestored permanent molar and premolar teeth[48].

Summary

The literature discussing SSCs from their introduction to the present day comes largely from retrospective clinical data, involving differing populations of patients, different makes of SSC, varying clinical conditions, luting cements and a multitude of operators. Although the quality of some of the literature may not meet modern day expectations, it still provides valuable data which lend support to the longevity and cost-effectiveness of a restorative technique that has been available since the 1940s.

The recently published Cochrane review[8] did not identify a single randomized control trial which compared removal of dental caries followed by placement of a SSC with restoration using a plastic material or indeed no treatment. However, a conclusion was reached that there is some evidence from clinical studies of poor to medium quality that SSCs may last longer than fillings for carious primary teeth. All reported study results concur that SSCs outperform plastic restorations when used to restore multisurface carious lesions in primary molar teeth. The Cochrane review called for well-controlled clinical trials to properly test the efficacy of the SSC. It may, however, be difficult to attain ethical approval to test a restorative technique that has shown extremely favourable success rates in all studies cited. It would be very difficult to justify restoring a primary molar requiring a large multisurface restoration with an alternative material, or leaving it untreated to compare longevity to primary molars restored with SSCs. All available evidence suggests that SSCs should continue to be used to restore primary molar teeth.

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