

Peer-reviewed paper; submitted May 2016; accepted March 2017

# A feasibility study of stainless steel crowns placed with the Hall Technique for primary molar carious lesion management in New Zealand primary oral health care

Boyd DH, Foster Page LA, Thomson WM, Innes NP, Marshall D

## Abstract

**Background and Objectives:** The Hall Technique for placing stainless steel crowns (HTSSC) is an approach to primary molar carious lesion management, in which the lesion is sealed in rather than surgically excised. Studies overseas where dentists placed HTSSC showed better success rates than conventional restorations. This study investigated the feasibility of primary-care-based research, dental therapists' attitudes to, case selection for and placement of HTSSC, outcomes of treatment at 6 months, and child acceptance of the treatment.

**Methods:** Ten dental therapists in Hawkes Bay each recruited up to ten 5-8-year-old children fulfilling inclusion criteria. They selected one carious primary molar per child as the study tooth. Questionnaires were completed assessing the dental therapists' perceptions of training and use of the Hall Technique. Case selection was assessed using baseline clinical and radiographic criteria. Follow-up data at 6 months were used to assess crown placement, gingival health, occlusion, clinical and radiographic outcomes. Children completed self-report questionnaires to measure their acceptance of HTSSC.

**Results:** Dental therapists had confidence in their ability to case select for HTSSC. HTSSCs had been well placed in the majority of cases (94%), with case selection criteria fulfilled in 93%. There were no problems with occlusion, TMJ function or gingival health at 6 months, and a successful outcome was recorded for 94%. Most children said that they found the procedure comfortable and enjoyed the dental visit.

**Conclusions:** Dental therapists placed HTSSCs well. Further training in radiography and the pulp-dentine complex may improve case selection. Most children found the procedure acceptable.

## Introduction

Dental caries is the most common chronic condition afflicting New Zealanders, and remains the most common chronic childhood disease (Public Health Advisory Committee, 2003). Dental caries accounts for a large number of hospital admissions, with almost 5,000 children treated under general anaesthesia (GA) in NZ every year (Davidson et al., 2002; Public Health Advisory Committee,

2003; Lingard et al., 2008; Whyman et al., 2014) at a substantial financial and social cost. Approximately 50% of NZ 5-year-olds have dental caries, with significant disparities by ethnicity, region and access to water fluoridation (Ministry of Health, 2009). Poor oral health affects children's development, school performance, and behaviour, as well as their whānau/families and the community (Anderson et al., 2004; Malden et al., 2008; Ministry of Health, 2010; Gaynor and Thomson, 2012). State-funded dental care for children in New Zealand has been largely provided in community-based dental clinics by dental therapists, with support from general and specialist dentists. This service has recently been renamed the Community Oral Health Service (previously the School Dental Service, or SDS). Despite a high level of child enrolment in the service (95%), and most carious lesions receiving restorative treatment (Ministry of Health, 2010), little is known about the outcomes of treatment. Local Otago 2008 SDS audit data showed a high rate of restoration replacement, with about 25% of the children treated receiving replacement restorations, and some children experiencing multiple repeat restorations. This is not surprising, given the international evidence on survival of restorative materials in children (National Health System Centre for Reviews and Dissemination Report 19, 2001; Chadwick and Evans 2007), with poorer outcomes found in primary care than in specialist practice (Innes et al., 2013). It is plausible that repeated restoration failure and replacement could contribute to poor outcomes for children and their families, including pulp morbidity (pulp exposure, pain and infection) due to bacterial invasion and/or iatrogenic damage (Elderton, 1993; Medeiros et al., 2000), early loss of teeth (Qvist et al., 2004), and repeat dental visits. A further concern with extensive retreatment rates is the potential for inefficient use of limited oral health services resources. Conventional restorative dental treatment is invasive, and approximal carious lesion restoration in particular involves the destruction of considerable amounts of sound tooth to gain access to the carious lesion (Vila Verde et al., 2009), with the potential to cause iatrogenic damage to both the treated tooth and those adjacent to it (Elderton, 1993; Medeiros et al., 2000; Ricketts et al., 2013).

Preformed stainless steel crowns (SSCs) are the recommended treatment of choice for deciduous molar teeth with extensive carious lesions (AAPD,

2004; Kindelan et al., 2008), yet they have been rarely used in primary care. A significant advantage of SSCs over other restorative materials is the lower failure rate and associated reduced need for repeat interventions (Attari and Roberts 2006; Seale and Randall 2015). This increases their cost-effectiveness. The conventional use of SSCs involves removing sound and infected enamel and dentine with high and slow-speed drills, usually under local anaesthetic. The Hall Technique (HT) is a relatively new and simpler method of restoring carious primary molar teeth using SSCs. HTSSCs are cemented with no tooth preparation, no caries removal and no local anaesthetic. A practice-based randomised control trial with Scottish general dentists found that SSCs placed with the HT yielded better outcomes. They found much lower repeat treatment rates than the conventional restorative techniques used (mostly glass ionomer restorations), with any propping of the occlusion caused by the crowns resolved during follow-up (Innes et al., 2007; Innes et al., 2011). The concept of sealing carious lesions—where infected dentine is either not removed at all, or only partly removed—has gained momentum in recent years (Innes et al., 2007; Thompson et al., 2008; Innes et al., 2011; Ricketts et al., 2013; Innes and Evans 2013; Schwendicke et al., 2013; Santamaria et al., 2014). The HT combines this concept with the stainless steel crown, the most durable primary molar restoration (Seale and Randall, 2015; Innes et al., 2015).

There has been little research on the outcomes of dental care provided in New Zealand primary oral healthcare. Moreover, any novel material and/or technique that is to be incorporated in the primary care setting should be evaluated there in order to provide the best evidence for its use, because it is naive to expect that findings from other settings (such as secondary or tertiary care, or a different primary care model) would apply in New Zealand. This research set out to evaluate the feasibility of the Hall Technique being used by Dental Therapists for placing SSCs. This was investigated using a prospective convenience cohort of children treated with HTSSCs after therapist training where the following were assessed: (1) dental therapists' attitudes to HTSSC using a questionnaire; (2) their case selection for, and

placement of, HTSSC, assessed through clinical and radiographic measures at baseline, and at 6 months after treatment to verify the appropriateness of case selection and crown placement, and to give a preliminary indication of success; and (3) child acceptance of treatment using child-reported measures to determine the children's acceptance of the treatment.

## Methods

Ethical approval was granted by the Central Regional Ethics Committee (CEN/11/09/055). Māori consultation took place with the Hawkes Bay District Health Board Māori Health Unit.

## Participants

Ten experienced dental therapists in the Hawkes Bay COHS took part. Each held the SSC scope of practice. Each dental therapist was asked to recruit 10 children meeting the study inclusion criteria (Table 1), and to select one carious primary molar needing treatment but which was free from signs and symptoms of pulp involvement. The study tooth was treated with a HTSSC according to protocol. Baseline recording included information on family sociodemographic characteristics, sex and age of the child. Primary ethnicity was recorded as "Māori" or "non-Māori". Deprivation was categorised using the NZDeprivation06 Index (Atkinson et al., 2014), which uses variables from the 2006 Census to assign a deprivation score to geographical units called meshblocks, which contain from 60-110 people. Scores are arranged into deciles from 1 (least deprived) to 10 (most deprived). At the analysis stage, we further grouped the decile scores into high (8-10), medium (4-7) or low (1-3) deprivation.

Children and dental therapists were given a unique identifying code for anonymity, with children coded numerically and dental therapists coded alphabetically.

## Training

Dental therapists took part in a 2-day training programme on the study protocol and procedures. This involved didactic and practical sessions providing background on the HT, case selection criteria (see Table 1), placement of elastomeric separators, crown size selection, adjustment

**Table 1.** Inclusion criteria

Child	Study tooth
Child aged between 5 years and 8 years	Interproximal carious lesion or carious lesion affecting more than one other surface
No complicating medical history *	Crown restorable
Child able to co-operate	Pulp healthy*
Parent/Caregiver and Child have consented/assented	More than half root remaining
One or more primary molar tooth/teeth with carious lesion needing restoration	*No clinical signs or symptoms suggesting irreversible pulpitis, and radiographically deepest portion of carious lesion does not encroach on pulp, and inter-radicular supporting structures appear normal)
PBW radiographs undertaken	
* No allergies to dental materials, no medical condition that puts child at risk of infective endocarditis, joint infection and child not immuno-compromised	

with pliers, and the cementation and removal of excess cement using the technique. Each was provided with the Users Manual and a DVD about the Hall Technique, developed by Innes and Evans<sup>1</sup>.

### *Clinical and radiographic measures*

At baseline, the dental therapists completed history and examination documentation for each child. This included assessing and recording TMJ health, absence/presence of open bite, the study tooth, the site(s) and depth of the carious lesion, the presence/absence of marginal ridge breakdown, and gingival health. At 6 months, they assessed the children and recorded data on TMJ health, the absence/presence of open bite, gingival health, whether any further treatment had been required for the study tooth, and the condition of study tooth, including signs and symptoms of pulp pathology. Posterior bitewing (PBW) radiographs were taken at baseline and follow-up. One paediatric specialist dentist (DB), experienced in assessing bitewing radiographs of children, examined all baseline and 6-month follow-up radiographs, with intra-examiner reliability assessed by re-examining every tenth set of bitewing radiographs. Baseline radiographs were assessed for quality and positioning, and whether the study tooth had fulfilled the inclusion criteria. At 6-month follow-up, the radiographs were assessed for quality and positioning, and the study tooth was assessed for how well the crown had been placed, and signs of pulp health/disease (by pathological inter-radiolar radiolucency/root resorption). Clinical and radiographic outcomes measures were combined to give composite outcomes of "success", "minor failure" or "major failure", as defined by Innes et al., 2007 (Table 2). At the time of treatment, clinicians recorded any problems encountered with the procedure.

### *Self-report measures*

A seven-item questionnaire was developed to measure the dental therapists' evaluation of training, their ability to carry out case selection, their placement of HTSSC, their own attitudes to this treatment, and their assessment of the children's and parents' attitudes. The seven items used a Likert scale with specific statements and freeform comments were also sought. The questionnaire was administered on three occasions: immediately after training (DT0), after placement of the first HTSSC in the study (DT1), and after the tenth HTSSC in the study had been placed (DT2).

Children were asked whether they found the treatment painful, whether they enjoyed their visit, and, if they needed to have another tooth treated, would they like it to be done that way. When necessary, questions were read to the child by the dental therapist or accompanying parent.

## **Results**

All ten dental therapists recruited ten children for the

study; however, two children did not consent to take part, leaving 98 children in the study. Two children did not have a HTSSC placed as it was not possible to find a suitably sized crown, leaving 96 children with a HTSSC placed. Two children who had a HTSSC placed were lost to follow-up. Characteristics of the children, and the study teeth at baseline and at 6-month follow-up are recorded in Table 3. The group had a high carious lesion experience with a mean dmft of 6.0 (SD 2.1). All children met inclusion criteria; however, retrospective analysis of case selection found that 7 (7%) teeth failed to meet the inclusion criteria: excess carious lesion depth in 3 cases (Figure 1); pathological inter-radiolar radiolucency in 2 cases; both inter-radiolar radiolucency and excess carious lesion depth in 1 case; and the study tooth being adjacent to an ectopic upper right first permanent molar in 1 case. Some 8% of the baseline radiographs were poorly positioned, resulting in six teeth (6%) that could not have the inter-radiolar area assessed radiographically, and 6 teeth that could not have the depth of the carious lesion assessed (Figure 2).

### *Dental Therapists' attitude and self-reported outcomes*

All dental therapists strongly agreed or agreed that training had equipped them with enough background information about the HT; to carry out case selection of patients and teeth suitable for HTSSC; and to place elastomeric separators interproximally. Three were undecided about their ability to actually place a HTSSC, whereas the remaining seven were confident about this. Responses to the questionnaires after placing the first HTSSC in the study, and the last SSC in the study are shown in Table 4. Most dental therapists were positive about their acceptance, the child's acceptance, and parental acceptance of the technique, and this increased over the study. Two dental therapists (one after the first crown was placed and one after the tenth crown was placed) noted that it was not always easy to place a HTSSC.

### *Case selection and clinical outcomes*

Of the ninety-eight children recruited, 83 (86%) had elastomeric separators placed prior to HTSSC placement. Complications at treatment were reported for 19 cases (19%), as follows: tooth shape/size caused difficulty finding suitable crown to fit in 10 cases (10%), with no crown being placed in 2 of these; children became upset and treatment had to stop in 3 cases (3%); cement set before placing crown in 1 case, and cement set when the crown was partially seated in 2 cases (meaning that it had to be sectioned with a bur to remove and then replaced with a new crown); it took more than one attempt to seat the crown properly in a further 3 cases. Eighty-eight crowns were judged by radiographic assessment by one author (DB) to be well-seated (92%), 6 teeth (6%) did not have the crowns fully seated, with an example of the latter shown in Figure 3, and 2 teeth (2%) did not have crowns placed.

All radiographs were analysed by one individual with a high rate of intra-examiner reliability (Kappa = 0.8). At 6-month follow-up, the outcome was assessed clinically in 96 cases (98%), and both clinically and radiographically in 78 cases (82%). If the radiograph did not show the

1 Accessed at [https://dentistry.dundee.ac.uk/sites/dentistry.dundee.ac.uk/files/3M\\_93C%20HallTechGuide2191110.pdf](https://dentistry.dundee.ac.uk/sites/dentistry.dundee.ac.uk/files/3M_93C%20HallTechGuide2191110.pdf)

**Table 2.** Outcome criteria (after Innes et al., 2007).

Success
Restoration appears satisfactory, no intervention required
No clinical signs or symptoms of pulpal pathology
No pathology visible on radiographs
Major failure
Irreversible pulpitis/abscess requiring pulp treatment or extraction
Inter-radicular radiolucency
Restoration lost, pulpally involved and tooth unrestorable
Minor Failure
Restoration lost but restorable
Secondary or new carious lesion
Restoration worn and needing intervention
Ectopic 6s adjacent to crowned tooth

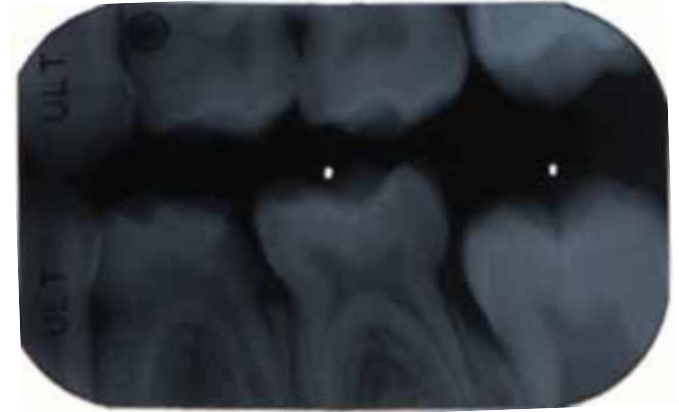
inter-radicular area, clinical information alone was used to assign the tooth to a success category. Overall, success was recorded in 90 cases (94%), with 4 major failures (4%) and 2 minor failures (2%). One major failure was detected clinically and not radiographically (inter-radicular area not radiographically visible), and 3 were detected radiographically and not clinically. One of the minor failures was due to an ectopic first permanent molar (the first permanent molar was seen to be ectopic at baseline) and 1 was due to loss of the SSC. At follow-up, 89 teeth had fulfilled inclusion criteria at baseline, and of these 88 (99%) had a successful outcome recorded, with 1 minor failure (1%). Whereas 7 cases had not fulfilled inclusion criteria, and of these 2 had a successful outcome (29%), with 4 major failures (57%) and 1 minor failure (14%).

#### *Children's responses to treatment with HTSCC*

Responses to the questions "Did you find the treatment painful", "Did you enjoy your visit today", and "If you needed more treatment would you like it to be done this way" were recorded for 93, 95 and 94 children respectively. Sixty-five children (70%) said they did not find the procedure painful, whereas 22 (24%) said they did find the procedure painful, with the remainder (6%) undecided. Almost all children said they enjoyed their visit (90%). Seventy children (75%) said they would like another tooth treated the same way, 14 (15%) said they would not, and the remainder (10%) were undecided.

#### Discussion

This study showed that it is feasible to carry out research in New Zealand primary oral healthcare, and that carrying out case selection and placement of SSCs with HT could be learned and implemented, by dental therapists. There was an excellent follow-up rate of 98% at 6 months.



**Figure 1.** Radiograph of lower left first primary molar that failed to meet inclusion criteria as excessive depth of carious lesion involving the pulp radiographically



**Figure 2.** Radiograph showing that the lower left first primary molar cannot be fully assessed radiographically because of poor radiograph positioning preventing the inter-radicular area from being seen



**Figure 3.** Radiograph showing an incompletely seated SSC on the upper right first primary molar

However, there are several weaknesses in the study. The clinical examinations, and the questionnaires, were administered by ten dental therapists, and individual variations among them may be expected. Children were not randomly selected, as the primary purpose of the study was to evaluate the use of the technique in the



**Table 3.** Study population characteristics at baseline and 6 month follow-up

	Baseline N (%)	Follow-up N (%)
Total	98 (100)	96 (98)
Sex		
Male	49 (50)	48 (50)
Age		
7-8 years	24 (24)	22 (23)
5-6 years	74 (76)	74 (77)
Ethnicity		
Māori	55 (56)	55 (57)
Deprivation *		
High	42 (43)	40 (42)
Medium	40 (41)	40 (42)
Low	14 (14)	14 (15)
Teeth		
First primary molar	54 (56)	53 (55)
Second primary molar	44 (44)	43 (45)
Depth of carious lesion into dentine by distance between amelodentinal junction and pulp		
<=halfway	79 (81)	78 (81)
> halfway	13 (13)	12 (12)
unable to see	6 (6)	6 (6)

\*Deprivation data could not be coded for 2 children.

At 6 month follow-up 2 children, who both had HTSSC placed, were lost to follow-up (one child failed to attend appointments, and one child had left the area) leaving 96 (98%) followed up.

hands of New Zealand dental therapists. The dental therapists selected which tooth would be the study tooth, which limits the generalisability of the findings. Furthermore, since only a single tooth was included as the study tooth, this project did not test the practicalities of the use of HTSSC in New Zealand primary oral health care, where limitations of the technique might foreseeably impact on dental therapists' working environment. For example, it is not possible to place HTSSC on opposing teeth within a short period of time, because around one month is usually allowed for occlusal adjustment and to avoid unacceptable opening of the occlusion, albeit temporarily. Similarly, adjacent teeth usually cannot be treated with HTSSC in the same appointment because there is not enough space available. It is usual practice in New Zealand rural areas for dental therapists to visit an area to examine and treat children over a short period of time, and then move on to a different area. This may mean that opposing and adjacent teeth cannot be treated using HTSSC in the same course of treatment. Accordingly, the translation of the HTSSC to the holistic care of the child rather than at a tooth level in New Zealand primary oral healthcare has yet to be assessed.

Dental therapists were positive about the technique, and capable of carrying it out to a high standard,

as demonstrated by the very low proportion (6%) of inadequately seated crowns. This compares favourably with data from Scottish dentists who carried out HTSSC, where 15% of crowns had been incompletely seated (Innes et al., 2007). Dental therapists were positive and accepting of the technique, although they did acknowledge that it was sometimes difficult to place a crown, with practical problems encountered in almost one-fifth of cases, and failure to place a crown in 2 of those cases. Not surprisingly, therapists' reporting of problems diminished as they became more experienced in the technique.

There were no TMJ or occlusal problems reported at 6 months. This is similar to the findings from other studies, where any opening of the occlusion caused by the HTSSC had resolved at follow-up (Innes et al., 2007; Santamaria et al., 2014). This is reassuring, as the use of HT to place SSC results in opening of the occlusion, which may in theory cause TMJ discomfort and/or occlusal problems, and yet no such problems have been found. Gingival inflammation was recorded in only one case where there was a major failure.

That there had been six failures by 6 months (4 major failures and 2 minor failures) was disappointing with

such a short follow-up period, although it is perhaps to be expected given that, retrospective assessment of the baseline radiographs by the dental specialist showed that three teeth already fell into the “major failure” category, and one tooth was classed as a “minor failure”. Furthermore, radiographic assessment of the inter-radicular area at follow-up was not possible in 18% of cases, and this may have caused an under-estimation of the “major failure” rate. This is important, as the number of radiographs where the inter-radicular area could not be seen at follow-up was three times that at baseline. This finding may be due to the process of occlusal adjustment that takes place following placement of a HTSSC, in which a degree of intrusion of the treated tooth, and/or extrusion of the adjacent teeth occurs. This may make the inter-radicular area of the tooth relatively more apically located, and therefore more easily missed on bitewing

radiographs. This theory is reinforced by the split-mouth study findings of Innes et al. (2007), in which the inter-radicular area could not be seen radiographically at follow-up in 37% of HTSSC treated teeth but only 15% of conventionally restored teeth. One way of avoiding this problem is to use larger films, or to position the films vertically when taking bitewing radiographs, however positioning and tolerance of these can be difficult.

Four of the six failures in this feasibility study could have been avoided by improved case selection, since four teeth should not have had crowns placed (3 showed signs of pathological inter-radicular radiolucency, and 1 was associated with an ectopic first permanent molar at baseline). In fact, major failure rates at 6 months in this study (4%) approximated the numbers of major failures by 48-month follow-up in a practice-based study (3%) (Innes et al., 2011). This, combined with the data on

**Table 4.** Dental Therapists (labeled ‘K’ to ‘T’ for anonymity) Responses to the Questionnaires (T1 after 1 HTSSC, T10 after final HTSSC)

1. I had enough background information about the Hall Technique					
	Strongly agree	Agree	Undecided	Disagree	Strongly disagree
T1	KLR	MNOPQST			
T2	KLOR	MPQSTN			
2. I was able to choose which patients to manage with the Hall technique					
T1	KPR	LMNOQST			
T2	ORN	KLMPQST			
3. I was able to place separating rings (elastomeric separators)					
T1	KLPR	MNOQST			
T2	QR	KLMOPSTN			
4. I was able to place a Hall technique SSC easily					
T1	KP	LMOQRST			N
T2	N	KMOPQRST		L	
5. The technique was acceptable to me					
T1	KNPRS	OQT	LM		
T2	SN	KMOPQRT	L		
6. The technique was acceptable to the patient					
T1	KLR	OPQST	M		N
T2	MS	KLOQRTN	P		
7. The technique was acceptable to the parents					
T1	KNQR	LOST	MP		
T2	MPQST	KLORN			



seating of the crowns, indicates that experienced New Zealand dental therapists were technically more skilled at crown placement than their Scottish dentist counterparts, but that their diagnosis and case selection was poorer. Although inappropriate case selection was low at 7% of cases chosen, it indicates that there should be further teaching on case selection during training, including teaching on the pulp-dentine complex and identification of inter-radicular pathology on radiographs. This may increase the rate of successful outcomes, as we found that when the cases that did not meet inclusion criteria were excluded, the success rate rose to 99%.

The majority of children said they found the procedure to be comfortable (70%), enjoyed their visit (90%), and would like further treatment performed the same way (70%). However, almost one in four (24%) said that they found the treatment painful. This is a little higher than in a European study of HT in secondary care in which, using a different rating scale, 20% of children reported pain to be moderate (10%), intense (6%) or very intense (4%) (Santamaria et al., 2014). Despite describing the procedure as painful, many children still reported enjoying their visit, indicating that prompted pain reports alone are not a good predictor of children's acceptance of treatment. We propose several possible explanations for this: (1) as the clinicians in studies of HTSSC have indicated that they like using the technique (Innes et al., 2007; Santamaria et al., 2015), it is plausible that they are more relaxed and better able to facilitate children's enjoyment of the dental visit; (2) it may be that, as the treatment time is relatively short for HTSSC, children are better able to enjoy their visit despite any discomfort; (3) children may have reported enjoying their visit because they received a "shiny crown" which they prized above any discomfort; or (4) children may have been too polite or constrained by the care-giver/receiver relationship and adult/child relationship power imbalance to say that they did not enjoy their visit, or, perhaps because they did not want to offend the dental therapist. This warrants further research to discover what children find acceptable, can cope with, and find enjoyable in the dental environment. Intriguingly, although a quarter of the children stated that they found the procedure to be painful, the dental

therapist reported that the child became upset during treatment in only 3 cases (3%). This suggests there may be a mismatch between what the child perceived and what the dental therapist interpreted from the child's behaviour; one explanation for this could be that dental therapists under-estimate pain because they do not notice it. Alternatively, it may be that children do not always express pain even though they have felt it. In the study by Innes et al. (2007), there were 2 cases (1.5%) in which the dentists stated that they thought the child experienced unacceptable discomfort during treatment with HTSSC, although the children themselves were not asked in that study.

This study supports the findings of Innes et al. (2007) that HTSSC can be carried out successfully in primary oral healthcare, although in this instance by dental therapists and not dentists. There was good acceptance and, although the follow-up period was short, the high success rate is similar to the other studies, which is not unexpected since SSCs offer a very effective seal and high durability. In the future, a randomised control trial in the same setting is needed to compare HTSSC and conventional restorations, with a longer follow-up period to assess clinical and radiographic outcomes, cost-effectiveness, and practicalities of using HTSSC in the New Zealand primary care setting. Additionally there is a need to monitor whether offering enhanced training in understanding the pulp-dentine complex, diagnosis of pulp pathology, and radiography improves case selection. Further research is needed to attempt to understand the comfort/discomfort and acceptance of this novel treatment for children.

## Conclusions

Dental therapists were adept at placing HTSSC and accepted the technique, however radiography and diagnosis were areas for further development in future training to improve case selection. Most children found the procedure comfortable and acceptable.

---

## Authors:

**Dorothy Boyd** BDS, MDS, FDSRCS

**Lyndie Foster Page** BSc, BDS, DipClinDent, MComDent, PhD

**W Murray Thomson** BSc, BDS, MA, MComDent, PhD

**Nicola Innes** PhD, BDS(Hons), BMSc(Hons), BSc, MFDS, MFGDP

**David Marshall** BDS, DipClinDent, DGD(RCS), DipCommDent

Correspondence to:

**Dorothy Boyd**

Department of Oral Sciences

University of Otago Faculty of Dentistry

PO Box 56, 310 Great King Street, Dunedin, 9054, New Zealand

Email dorothy.boyd@otago.ac.nz

## Acknowledgments

This study was funded by the New Zealand Health Research Council (HRC) and supported by 3M. We are grateful to the Hawkes Bay DHB, and Hawkes Bay Māori Health Unit for supporting the study, to the research research assistants Wendy Aitken and Lernele Wright, and to the dental therapists, children and their families who took part.

## References

- AAPD (2004). Clinical guideline on pediatric restorative dentistry. *Pediatric Dentistry* 26(7):106-114.
- Anderson HK, Drummond BK, Thomson WM (2004). Changes in aspects of children's oral-health-related quality of life following dental treatment under general anaesthesia. *International Journal of Paediatric Dentistry* 14: 317-325.
- Attari N, Roberts J (2006). Restoration of primary teeth with crowns: a systematic review of the literature. *European Archives of Paediatric Dentistry* 7: 12-15.
- Atkinson J, Salmond C. and Crampton P. 2014. NZDep2013 Index of Deprivation. Dunedin: University of Otago. Retrieved from <http://www.health.govt.nz/publication/nzdep2006-index-deprivation>
- Chadwick BL and Evans DJP (2007). Restoration of class II cavities in primary molar teeth with conventional and resin modified glass ionomer cements: a systematic review of the literature. *European Archives of Paediatric Dentistry* 8: 13-20.
- Davidson LE, BK Drummond, SM Williams, DH Boyd, AM Meldrum (2002). Comprehensive dental care under general anaesthesia from 1997-1999 for children under the age 6 years. *New Zealand Dental Journal* 98: 75-78.
- Elderton R (1993). Overtreatment with restorative dentistry: when to intervene? *International Dental Journal* 43: 17-24.
- Gaynor WN, Thomson WM (2012). Changes in young children's OHRQoL after dental treatment under general anaesthesia. *International Journal of Paediatric Dentistry* 22: 258-264.
- Innes NP, Evans DJP and Stirrups DR (2007). The Hall Technique; a randomized controlled clinical trial of a novel method of managing carious primary molars in general dental practice: acceptability of the technique and outcomes at 23 months. *BMC Oral Health* 7: 18-39.
- Innes NPT, Evans DJP, Stirrups DR (2011). Sealing caries in primary molars: Randomized Control Trial, 5-year results. *Journal of Dental Research* 90: 1405-1410.
- Innes NPT, Evans DJP (2013). Modern approaches to caries management of the primary dentition. *BDJ*; 214: 559-566.
- Innes NPT, Clarkson JE, Speed C, Douglas GVA, Maguire A (2013). The FICTION dental trial protocol – filling children's teeth: indicated or not? *BMC Oral Health*; 13: 25
- Innes NPT, Ricketts D, Chong LY, Keightley AJ, Lamont T, Santamaria RM. (2015). Preformed crowns for decayed primary molar teeth. *Cochrane Database of Systematic Reviews* 2015, Issue 12. Art. No.: CD005512. DOI: 10.1002/14651858.CD005512.pub3.
- Kindelan, SA, Day, P., Nichol, R., Willmott, N., Fayle, S.A., 2008. UK National Clinical Guidelines in Paediatric Dentistry: Stainless steel preformed crowns for primary molars. *International Journal of Paediatric Dentistry* 18(SUPPL. 1): 20-28.
- Lingard GL, Drummond BK, Esson IA, Marshall DW, Durward CS, Wright FAC. The provision of dental treatment for children under general anaesthesia. *NZ Dental Journal* 105: 9-13.
- Malden PE, Thomson WM, Jokovic A, Locker D (2008). Changes in parent-assessed oral health-related quality of life among young children following dental treatment under general anaesthetic. *Community Dentistry and Oral Epidemiology* 36:108-17.
- Medeiros VA and Seddon RP (2000). Iatrogenic damage to approximal surfaces in contact with Class II restorations. *Journal of Dental Research* 28: 103-110.
- Ministry of Health (2009). Age 5 and Year 8 oral health data from the School Dental Services. June 2010, from <http://www.moh.govt.nz/moh.nsf/indexmh/oralhealth-resources#statistics>.
- Ministry of Health (2010). Our Oral Health: Key findings of the 2009 NZ Oral Health Survey. Wellington: Ministry of Health.
- National Health System Centre for Reviews and Dissemination Report 19. The Longevity of Dental Restorations. A Systematic Review. York: University of York, 2001. *Evidence Based Dent* 3(4): 96 - 99.
- Public Health Advisory Committee (2003). Improving child oral health and reducing child oral health inequalities. Report to the Minister of Health from the Public Health Advisory Committee. Wellington: Ministry of Health.
- Qvist V, Laurberg L, Poulsen A, Teglers PT (2004). Eight-year study on conventional glass ionomer and amalgam restorations in primary teeth. *Acta Odontologica Scandinavica* 62:37-45.
- Ricketts D, Lamont T, Innes NPT, Kidd E, Clarkson JE (2013). Operative caries management in adults and children. *Cochrane Database of Systematic Reviews* Art No.:CD003808.DOI: 10.1002/14651858.CD003808.pub3.
- Santamaria RM, Innes NP, Machiulskiene V, Evans DJ, Splieth CH. (2014). Caries management strategies for primary molars: 1-yr randomized control trial results. *J Dent Res*; 93:1062-1069.
- Santamaria RM, Innes NP, Machiulskiene V, Evans DJ, Alkilzy M, Splieth CH (2015). Acceptability of different caries management methods for primary molars in a RCT. *International Journal of Paediatric Dentistry*; 25: 9-17.
- Schwendicke F, Dörfer CE, Paris S (2013). Incomplete caries removal: a systematic review and meta-analysis. *J Dent Res*; 92: 306-314.
- Seale NS, Randall R (2015). The use of stainless steel crowns: A systematic literature review. *Pediatric Dentistry* 37:148-162.
- Thompson V, Craig R, Curro F, Green W and Ship J (2008). Treatment of deep carious lesions by complete excavation or partial removal. A critical review. *JADA*; 139: 705-712.
- Vila Verde A, Ramos MMD, Stoneham AM (2009). Benefits in cost and reduced discomfort of new techniques of minimally invasive cavity treatment. *Journal of Dental Research* 88: 297-9.
- Whyman RA, Mahoney EK, Morrison D, Stanley J (2014). Potentially preventable admissions to New Zealand public hospitals for dental care: a 20-year review. *Community Dentistry and Oral Epidemiology* 42 (3): 234-44