



Success rate of formocresol pulpotomy in primary molars restored with stainless steel crown vs amalgam

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Abstract

Purpose: The purpose of this retrospective study was to compare the success rates of formocresol pulpotomy in primary molars restored with stainless steel crowns (SSC) to those restored with amalgam (AM).

Methods: Radiographs of pulpotomized primary molars restored with SSC or AM in the principal author's pediatric dentist practice were evaluated and defined as a "failure" when one or more of the following signs were present: internal (IR) or external (ER) root resorption and periapical (PR) or inter-radicular (IRR) radiolucency. Pulp canal obliteration was not regarded as failure. Three hundred and forty-one molars were available for follow-up evaluations ranging from 6 to 103 months.

Results: Forty-seven (14%) teeth were defined as "failure," with a rate of 13% (36/287) for teeth restored with SSC and 20% (11/54) for AM. This difference was not statistically significant ($P>0.1$). Failure rates of 2 surfaces AM was 23% (7/30), much higher than that of one surface AM (10%, 2/20). Most of the failed teeth presented more than one pathologic finding, with IR being the most frequently observed (36%), followed by ER (31%), IRR (22%) and PR (11%). Pulp canal obliteration was detected in 80% of the teeth, with similar rates in both groups. Failures were observed initially after a mean follow-up of 27 and 29 months in teeth restored with AM and SSC, respectively.

Conclusions: Pulpotomized primary molars can be successfully restored with one surface amalgam if their natural exfoliation is expected within not more than two years. (*Pediatr Dent* 24:212-216, 2002)

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Pulpotomy is indicated in primary molars when the radicular pulp tissue is healthy or is capable of healing after surgical amputation of the affected or infected coronal pulp.¹ Pulpotomy is regarded as failure if one or more of the following clinical or radiographic pathological signs exist: pain, swelling, fistula, periapical or inter-radicular radiolucency and pathologic internal or external root resorption.²⁻⁵ Signs of failure can be seen on radiographs long before they are expressed clinically.⁶⁻⁸ One of the radiographic pathologic signs is pulp canal obliteration (sometimes termed "calcific metamorphosis"), which can be seen in root canals of pulpotomized primary molars. Its presence, however, is not considered as a failure.^{4,9}

Formocresol was, for many years, an acceptable and the most commonly used dressing material for the amputated pulp.¹⁰ Success rates of pulpotomy with formocresol in primary molars ranged between 70% to 97%^{2,11,12} and declined with time.^{2,4,6}

Failure of pulpotomy in primary molars was attributed to several factors: (1) Erroneous diagnosis of a chronically inflamed radicular pulp as non-inflamed and non-infected,⁶ (2) the irritating effect of eugenol as a component of the pulp space filling material,¹³ and (3) attempt to preserve a tooth with a deep proximal carious lesion, a condition leading to leakage due to incomplete coverage.⁶

The role of the final restoration of pulpotomized primary molars as a contributing factor to failure of the endodontic treatment gained only little attention in the dental literature. Croll and Killian¹⁴ recommended stainless steel crowns as the treatment of choice for teeth that have undergone pulpotomy, assuming there is less leakage in crowned teeth compared to those restored with amalgam. This recommendation, however, was not supported by any controlled study.

A search in the dental literature revealed no study that investigated the effect of the type of tooth restoration on the success rate of pulpotomy. The purpose of this retrospective

Table 1. Distribution of Pulpotomized Molars with at Least 6 Months Follow-Up According to Tooth Type, Type of Restoration and Failure Rate

Tooth type	Total n	Type of restoration							
		Stainless steel crown				Amalgam restoration			
		Total n	%	Failure n	%	Total n	%	Failure n	%
Maxillary first molar	66	50	76	5	10	16	24	3	19
Maxillary second molar	63	50	79	5	10	13	21	1	8
Mandibular first molar	107	99	93	20	20	8	7	4	50
Mandibular second molar	105	88	84	6	7	17	16	3	18
Total	341	287	84	36	13	54	16	11	20

*Chi-square test; $P > 0.1$

Table 2. Success/Failure Rate of Pulpotomized Primary Molars Restored with Amalgam According to the Number of Surfaces

Number of surfaces	Tooth type				Total
	1 st molar		2 nd molar		
	Failure	Success	Failure	Success	
1 surface	2	6	0	12	20
2 surfaces	5	10	2	13	30
3 surfaces	0	1	2	1	4
Total	7	17	4	26	54

*Chi-square test; $P > 0.1$

study was to compare the success rates of formocresol pulpotomy in primary molars restored with stainless steel crowns (SSC) to those restored with amalgam in a pediatric dentistry private practice.

Methods

Data collected

Data in this retrospective study were collected from the records of all the patients who had at least one molar pulpotomized by the principal investigator in his private practice between July 1983 and April 1999. The data consisted of the child's gender, his/her age when pulpotomy was performed, the type of tooth treated, the type of restoration and, in the case of amalgam, the number of surfaces restored.

Pulpotomy technique

In all cases, pulpotomy was chosen as the treatment of choice when the following criteria were fulfilled:

1. No clinical or radiographic pathologic signs were present;
2. The pulp was exposed during caries removal or in cases of accidental pulp exposure during cavity preparation;
3. Bleeding was observed from the pulp, as expected from a vital pulp;
4. Bleeding time after amputation of the coronal pulp tissue was within normal limits, indicating unaffected radicular pulp tissue.

All pulpotomies were performed using a conventional technique in which the coronal pulp tissue was completely removed. Bleeding was controlled with dry cotton pellets. A cotton pellet soaked with formocresol was placed on the radicular pulp stumps for 5 minutes, after which the coronal pulp space was filled with IRM.

The crown was restored during the same visit with either a SSC or an AM restoration.

Occasionally, the final restoration was postponed to a later appointment. In some cases, teeth were pulpotomized in patients seeking emergency treatment only, and some patients never returned for the permanent restoration of the crown or follow-up examination. The type of restoration was selected according to both the amount of sound tooth structure remaining after caries removal and the estimation of the time remaining until normal shedding.

Radiographic evaluation

Teeth with less than 6 months follow-up and or with temporary fillings were excluded from the study.

Follow-up radiographs were evaluated by a trained person (NK) whose reliability to detect pathologic findings was confirmed by the two senior authors. The following pathologic findings were evaluated: (1) periapical or inter-radicular radiolucency, (2) internal or external pathologic root resorption and (3) calcific metamorphosis in the radicular pulp canal.

The pulpotomy was defined as a failure when one or more of the aforementioned signs, except for pulp canal obliteration, was detected. Follow-up time for teeth with pulpotomy failure was defined as the time elapsed between treatment and the first visit in which pathologic finding was detected.

Study material

During the evaluation period, a total of 753 primary molars were pulpotomized in 513 patients (287 boys and 226 girls). Seventy-nine percent of the teeth (596 teeth) were restored with a SSC, 15% (112 teeth) had an AM restoration and 6% (45 teeth) had a temporary restorative material.

Teeth analyzed

Four hundred twelve molars were excluded from the study: 404 of these had less than 6 months follow-up, 4 had only a temporary restoration and 4 teeth had unclear radiographs. Thus, a total of 341 molars in 227 patients (129 boys and 98 girls), with radiographs taken at least 6 months postoperatively, were included in the study.

Of the 341 teeth available for statistical analysis 287 (84%) were restored with SSC and 54 (16%) with AM.

Table 3. Children's Age (Months) at Time of Treatment

	Type of restoration		Total
	Stainless steel crown	Amalgam	
Failure			
Mean	69	80	71
Range	39-110	30-112	30-112
SD	19	26	21
Success			
Mean	74	67	73
Range	24-147	29-123	24-147
SD	20	25	21
Total			
Mean	73	69	72
Range	24-147	29-123	24-147
SD	20.07	25.56	21.03

There was no statistically significant difference between the distribution of teeth excluded from the study and those included, regarding age of patients, type of teeth and type of restoration.

The distribution of assessed teeth with more than 6 months follow-up is presented in Table 1.

Age factor

The children's age at time of treatment is summarized in Table 3. The mean age of the children at the time of treatment was 72(\pm 21) months with a range of 24 to 147 months. Pulpotomized teeth were restored with amalgam in children with a mean age of 69(\pm 26) months compared to 73(\pm 20) months for SSC.

The follow-up factor

Follow-up time ranged between 6 and 103 months with a mean of 28(\pm 19) months. The mean follow-up for SSC was 28(\pm 19) months and for AM 26(\pm 19) months (Table 4).

Effect of number of amalgam surfaces

Of the teeth restored with AM, 20(37%) had one surface, 30(56%) had two surfaces and 4(7%) had three surfaces.

The difference between success rates of formocresol pulpotomy in primary molars restored with SSC and those restored with AM was analyzed statistically using the chi-square test. Significance was determined at $P < 0.05$.

Results

Of the 341 pulpotomies assessed, 47(14%) were defined as failure: 36(13%) of the 287 teeth restored with a SSC and 11(20%) of the 54 teeth restored with AM (Table 1). Table 2 shows the success/failure rate of pulpotomized primary molars restored with amalgam according to the number of surfaces. The difference between the success rates of the teeth restored with SSC or amalgam was not statistically significant ($P > 0.1$).

Table 4. Follow-Up Periods (Months) of Pulpotomized Primary Molars Restored with Amalgam or Stainless Steel Crowns

	Type of restoration		Total
	Stainless steel crown	Amalgam	
Failure			
Mean	29	27	28
Range	6-103	9-49	6-103
SD	21	16	20
Success			
Mean	28	26	28
Range	6-94	6-98	6-98
SD	18	20	19
Total			
Mean	28	26	28
Range	6-103	6-98	6-103
SD	19	19	19

Table 5. Interval (Months) between Treatment and Detection of First Pathology in Pulpotomized Primary Molars Restored with Amalgam or Stainless Steel Crowns

	Type of restoration	
	Stainless steel crown (n=36)	Amalgam restoration (n=11)
Range	6-103	9-49
Mean	29	27
SD	19	19

Radiographic pathologic findings

The failed teeth of both groups presented more than one pathologic finding. The most frequent pathologic finding observed was internal resorption (36% of all pathologic defects found), followed by external root resorption (31%) and inter-radicular radiolucency (22%). Periapical radiolucency was the least-detected pathology (11%). The pathologic defects were first detected after a mean follow-up time of 27 and 29 months in teeth restored with AM and SSC crowns, respectively (Table 5).

Pulp canal obliteration was detected in 79%(226/287) of the teeth restored with SSC and 80%(43/54) of the teeth restored with AM.

The mean age of the children when a failure was first observed was 80(\pm 26) months for AM and 69(\pm 19) months for SSC.

Failure of the pulpotomy was found in 10%(2/20) of the teeth restored with a 1-surface AM restoration, 23%(7/30) in 2-surface AM restorations and 50%(2/4) in 3-surface AM restorations. These failures were found mostly in first primary molars (7/11) as compared with to second primary molars (4/11). This difference was not statistically significant (chi-square, $P > 0.1$).

Discussion

The mean success rate (86%) of pulpotomy found in this study is in agreement with previous reports.^{2,11,12} The success rate of pulpotomized molars restored with SSC, although higher than that of AM, was not statistically significant. This difference was even greater in multisurface amalgam, yet still not significant. However, it must be emphasized that, in this retrospective study, there was no random selection of the type of restoration. On the contrary, based on the operator's judgment, only teeth with thick cavity walls that enabled achievement of a proper retention form were restored with AM. One would expect an even lower success rate of AM in a prospective and controlled study, in which the type of restoration is selected randomly. Such a study however, would be unacceptable, for ethical reasons.

Success rates of pulpotomy in human primary molars are not consistent in the final restoration used as reported in the literature. In some studies, the teeth were restored exclusively with stainless steel crowns,^{4,5,9,11,15} others used amalgam^{6,7} and still others used either type of restoration.^{2,16} In animal studies, pulpotomized teeth are usually restored with amalgam^{17,18} or IRM.¹⁹ These studies, however, concentrated on the effect of the dressing material and did not assess the role of the final coronal restoration in the success rate of pulpotomy.

In animal studies, where sound teeth are pulpotomized, the operator controls the size and type of cavity. Conversely, in human studies the extent of crown destruction dictates, in many instances, that the SSC is the treatment of choice. An amalgam restoration becomes an option only when thick cavity walls remain and a retention form can be achieved. Some clinicians advocate SSC for all cases,^{14,20} claiming that complete coverage with a preformed SSC protects against leakage at the pulpal space restoration. Rolling and Thylstrup² suggested the use of a silver amalgam restoration in cases with destruction on the occlusal surface only. In the present study, the mean follow-up time was just over 24 months. Thus, it seems reasonable to suggest that one surface amalgam could be an accepted treatment for pulpotomized primary molars if the expected exfoliation time is within this limit.

Randall et al²¹ summarized the findings of 10 clinical studies that compared success rates of preformed metal crowns vs amalgam restorations. These studies demonstrated superiority of SSC over multisurface amalgam restorations in primary molars. However, only some teeth in these studies were pulpotomized and a failure was defined as the indication for replacement of the restoration. Holland et al²² reported a higher failure rate in first primary molars when compared to that in second primary molars. This can explain the higher failure rate of pulpotomy in first primary molars in our study. However, the number of teeth in each category was too small to have any statistical meaning.

The main reasons for failure reported in the studies evaluated by Randall et al²¹ were fractures, ditching and secondary caries in amalgam restorations and the need to recement crowns. A loose SSC and a gap at the AM tooth interface are conditions allowing bacterial penetration underneath the restoration and toward the pulp. The effect of marginal microleakage on pulpal inflammation gained much attention in the dental literature.²³ In pulpotomized teeth, however, the invading microorganisms originating from a faulty restoration margin have to cross another barrier (ie the cement covering the radicular pulp stumps) before they can affect the pulp.

The most common dressing materials used in primary molars following pulpotomy are zinc-oxide/eugenol (ZOE) cements. IRM, one of these cements, was used in the present study. The sealing ability of these cements was tested in several in vitro studies^{23,24} and found to be inadequate. In vitro studies were claimed to be irrelevant, since they evaluated only the leakage of the materials using dyes, ignoring the antibacterial effect of the cements.²³ The effectiveness of ZOE in protecting the pulp was attributed to its antibacterial properties, which minimize the chance of survival of microorganisms that reach the cavity floor via microleakage.²³

However, one could speculate that bacterial toxins, originating from faulty restoration margins or enamel cracks, could permeate through the IRM layer, affecting the radicular pulp. It is a known fact that the coronal dentin, deprived of its odontoblastic processes, as in cervical pulpotomies, becomes brittle and prone to cracks or fractures. Full coverage prevents these cracks, providing a leakage-free restoration. In a study evaluating primary molars restored with SSC, Roberts and Sherriff²⁵ found failures in a few pulpotomized molars. They considered these as false failures attributing this to occurrence or recurrence of infection, since the crowns properly seal the tooth.

Conclusions

Pulpotomized primary molars can be successfully restored with one surface amalgam if their natural exfoliation is expected after not more than two years.

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