

## Radiographic Success of Ferric Sulfate and Formocresol Pulpotomies in Relation to Early Exfoliation

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### Abstract

**Purpose:** The purpose of this retrospective study was to evaluate the radiographic findings with formocresol and ferric sulfate pulpotomies in relation to early tooth loss.

**Methods:** Vital pulpotomies with either ferric sulfate or formocresol, performed by faculty members between 1992 and 2002 at The University of Iowa, were evaluated retrospectively. Radiographic criteria were established to assess success or failure of the treated tooth. This was then correlated with time of tooth loss and space management.

**Results:** Eighty-five molars, followed between 6 to 61 months, met the inclusion criteria. Of these, 15 (43%) teeth treated with ferric sulfate, 23 (56%) treated with formocresol, and 5 (55%) treated with a combination of ferric sulfate and formocresol remained free of any radiographic pathology. Overall, 13% of the pulpotomized teeth were prematurely lost due to abscess formation and in need of space management. Regardless of the treatment type, internal root resorption was the most common cause of premature exfoliation.

**Conclusions:** Both ferric sulfate and formocresol pulpotomies can lead to premature exfoliation of primary teeth, with the subsequent need for orthodontic space maintenance. Therefore, radiographic criteria should be taken into consideration when evaluating pulpotomized teeth at recall visits. (*Pediatr Dent* 2005;27:233-237)

**KEYWORDS:** PULPOTOMY, FERRIC SULFATE, FORMOCRESOL, RADIOGRAPHIC FAILURE, EARLY EXFOLIATION, PRIMARY TOOTH

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Over the past 20 years, the use of formocresol as a pulpotomy agent has been challenged due to its systemic distribution, pulpal inflammatory response, cytotoxicity, and carcinogenic potential.<sup>1-3</sup> In 1991, Fei published results on the use of ferric sulfate as an alternative medicament to formocresol.<sup>4</sup> Since then, several other studies on ferric sulfate's use as a pulpotomy agent have been found in the literature.<sup>5-7</sup>

Even though high clinical success rates have been found using both techniques, histologic studies have shown that both ferric sulfate and formocresol produce severe inflammatory responses.<sup>2,8,9</sup> Fuks found that 40% of pulps treated with either formocresol or ferric sulfate had severe inflammation.<sup>8</sup> Similarly, Salako et al found complete pulpal destruction with ferric sulfate and pulpal necrosis with formocresol pulpotomies performed on rat molars. This

contrasted with MTA, which showed dentin bridge formation.<sup>9</sup> The potential for these chronic inflammatory responses to affect tooth exfoliation and succedaneous tooth formation must not be discounted.

Over a period of 8 months, Lin et al evaluated 21 children with premature loss of primary mandibular first molars and found distal movement of the primary lateral incisor into the extraction space.<sup>10</sup> Similarly, Cuoghi et al not only found distal tipping but migration of the permanent incisors to the side of the prematurely lost molar.<sup>11</sup> Finally, Northway evaluated the effects of premature loss of maxillary primary first molars and found space loss caused by the mesialization of the permanent premolar as a result of mesial tipping of the second primary molar.<sup>12</sup> The results from these studies support the need for space maintenance when primary teeth are lost prematurely due to decay, failed treatment, or premature root resorption.

In light of this, the purpose of this retrospective study was to evaluate the radiographic findings with formocresol and ferric sulfate pulpotomies in relation to early tooth loss.

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## Methods

Following Institutional Review Board (IRB) approval, radiographic data were obtained from the records of patients treated at The University of Iowa College of Dentistry and The Center for Disabilities and Development, both in Iowa City, Iowa, by 4 board certified pediatric dentists. All were faculty members at The University of Iowa College of Dentistry.

To obtain the data, a search was conducted on the Windent Scheduler System (v. 3.1.44, HealthSoft, Inc, Dallas, Texas) between the years 1992 and 2002 using the ADA code for pulpotomy. This was done to ensure that both formocresol and ferric sulfate pulpotomized teeth could be found. After a preliminary list of patient names was obtained, patient records were reviewed and included in the study if the following criteria were met:

1. The tooth/teeth receiving the pulpotomy did not show any clinical symptoms or evidence of pulpal degeneration (swelling, sinus tract, mobility, spontaneous pain) and had a pulp that bled upon entering the chamber.
2. The tooth was restored with a permanent restoration at the time of pulpotomy completion.
3. The patient returned for at least one recall visit (6 months after pulpotomy procedure).
4. A diagnostic periapical or bitewing radiograph showing root structure at least 4 mm past the furcation was available for initial and follow-up periods.

In the Department of Pediatric Dentistry at The University of Iowa, all pulpotomies are performed in the following manner. First, after local anesthesia is administered, the tooth is isolated with a rubber dam and caries is removed with a No. 330 carbide bur with water spray in a high-speed handpiece. After chamber access, coronal pulp tissue is removed using a slow-speed handpiece with a No. 6 round bur. If a formocresol pulpotomy is performed, a cotton pellet soaked in 1:5 dilution of Buckley's formocresol (the solution was made by a compounding pharmacist at The College of Dentistry) is placed in the chamber for 5 minutes. The pellet is removed, ensuring that hemostasis is achieved. If this is not the case, a new pellet is placed for an additional 5 minutes.

The pulp chamber is then filled with a zinc-oxide eugenol paste and restored with either a stainless steel crown or an amalgam. If the tooth receives a ferric sulfate pulpotomy, the chamber is scrubbed for 15 seconds with an astringent (Ultradent Products, Inc, Salt Lake City, Utah) in a syringe with a brush tip. The solution is rinsed, making sure that no clot is left. The tooth is then finished in the same manner as the formocresol pulpotomy.

Radiographic criteria used for this study were based on the criteria used by Strange et al.<sup>13</sup> Teeth were scored as: (1) unremarkable; (2) external root resorption; (3) internal root resorption; (4) inter-radicular bone destruction; (5) calcific metamorphosis; and (6) premature exfoliation. All radiographs were read using the same standard view box. Clinical categories were not developed for this study.

The principal and co-investigator were standardized to determine inter-rater reliability. Following standardization, the principal investigator scored all radiographs and the co-investigator randomly selected 40% of the radiographs to score independently. If a discrepancy occurred between examiners, a consensus was reached. All radiographs were read by both investigators using a standard view box illuminator.

## Statistical analysis

The kappa statistic showed highly significant reproducibility between the 2 examiners ( $\kappa=0.73$ ;  $P<.001$ ). Data collected for each patient during the chart review included: (1) age; (2) gender; (3) tooth treated; (4) treatment date; (5) follow-up time in months; and (6) age at time of tooth loss. Chi-square was used for comparison between treatment modalities as well as ANOVA.

## Results

After initial selection using a computerized record handling program (Windent v. 3.1.44, HealthSoft, Inc, Dallas, Texas) 450 patient records were reviewed. The final study sample consisted of 71 children (38 females, 33 males) with a mean age at time of pulpotomy of 5.5 years (range=3-9 years).

A total of 85 primary molars met the inclusion criteria for study. Of these, 35 (42%) received ferric sulfate pulpotomies, 41 (48%) received formocresol (1:5 dilution), and 9 (10%) were treated with a combination of ferric sulfate followed by formocresol. Follow-up times ranged from 6 to 61 months, with a median of 22 months. At the time of the pulpotomy, 74 teeth (87%) were restored with a stainless steel crown and 11 (13%) were restored with an amalgam restoration.

## Radiographic findings

Using the radiographic criteria outlined in the Methods section, 15 of the 35 teeth (43%) treated with ferric sulfate, 23 of the 41 teeth (56%) treated with formocresol, and 5 of the 9 teeth (55%) treated with the combination remained free of any radiographic pathology.

Regardless of treatment type, internal resorption was the most common radiographic finding. More specifically, the authors found that 24% of teeth treated with formocresol and 40% of the teeth treated with ferric sulfate had internal resorption. Unlike other radiographic findings, the authors also found that internal resorption was observed significantly more frequently within the first year after pulp therapy ( $P<.001$ ) regardless of the treatment modality. Furcation involvement was found in 22% of teeth with formocresol pulpotomies, and 20% of teeth treated with ferric sulfate had calcific metamorphosis (Table 1).

Examples of the 3 most common findings (internal resorption, external resorption, and calcific metamorphosis) are given in Figures 1 to 3. The authors have used an example from each type of pulpotomy reviewed in this study.

Table 1. Radiographic Findings of Pulpotomized Teeth at 6 to 12, 13 to 24, 25 to 36, and Greater Than 36 Months Follow-up\*

Radiographic finding	6-12 mos			13-24 mos			25-36 mos			>36 mos		
	FS	FMC	FS+FMC	FS	FMC	FS+FMC	FS	FMC	FS+FMC	FS	FMC	FS+FMC
Internal resorption	10	5	2	3	4	1	1	1	0	0		
External resorption	4	2		0	2		1	1	0	0		
Inter-radicular bone loss	5	4		1	5	1	2	0	0	0		
Calcific metamorphosis	3	3	1	2	0		2	2	0	0		
Early exfoliation									4	4	3	

\*FS=ferric sulfate; FMC=formocresol.

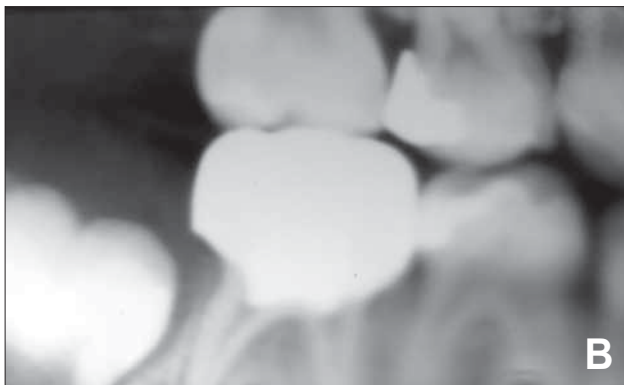
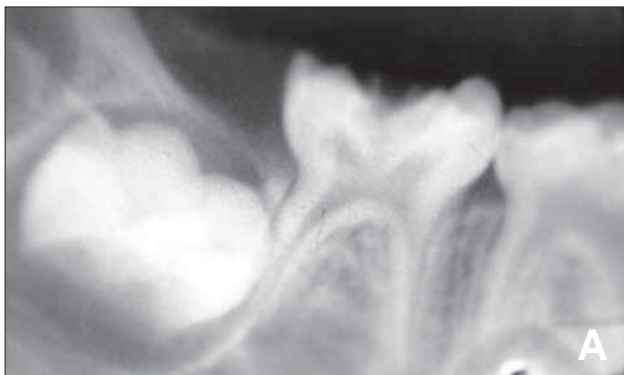


Figure 1. Combination of ferric sulfate and formocresol pulpotomy. (A) Tooth T prior to pulpotomy treatment with normal radiographic findings. (B) Pulpotomy treatment on tooth T at 24 months with internal resorption of mesial and distal root and possible furcation involvement. (C) Tooth T 36 months after treatment with continuing resorption and furcation involvement.

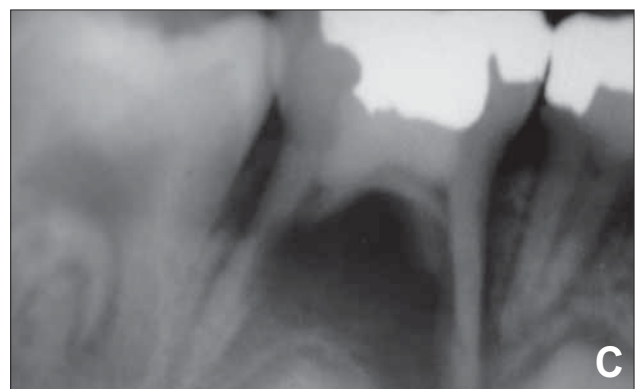
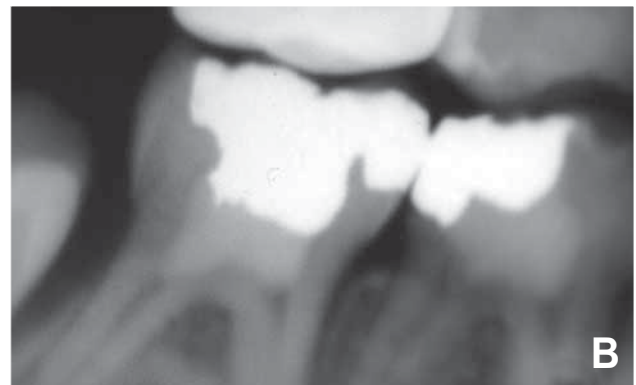


Figure 2. Formocresol pulpotomy of tooth T. (A) Initial radiograph of tooth T with normal radiographic appearance. (B) Tooth T with furcation involvement at 3 months following pulp treatment. (C) Tooth T with furcation involvement and external root resorption 11 months after formocresol pulp treatment.

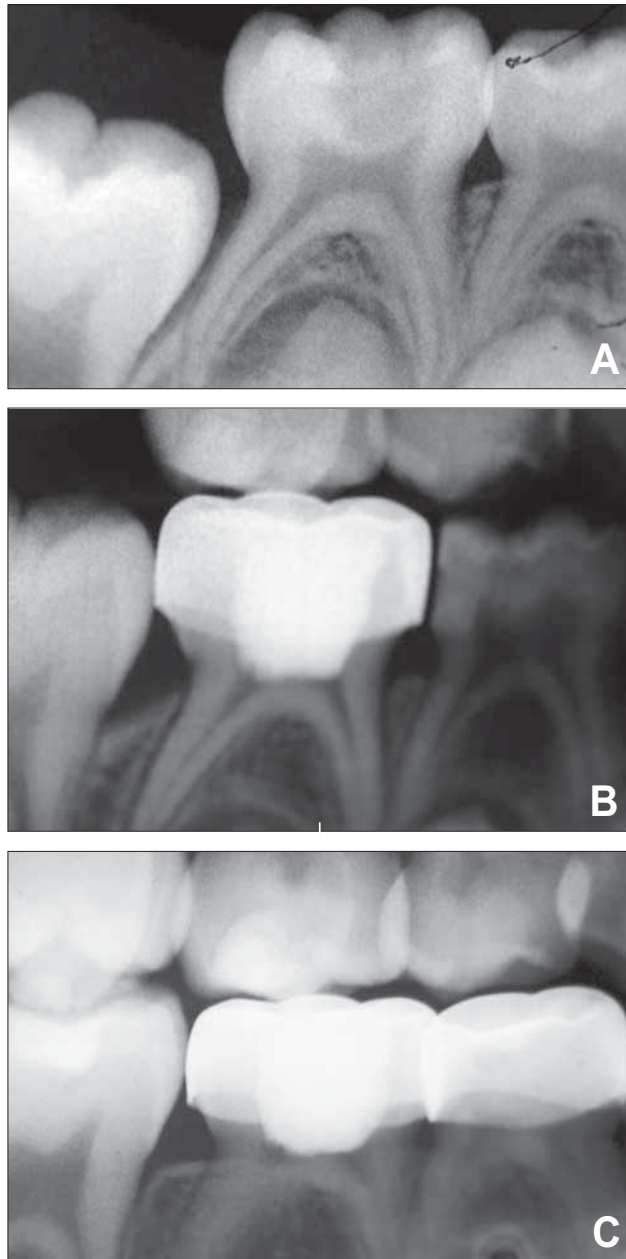


Figure 3. Ferric sulfate pulpotomy of tooth T. (A) Initial radiograph of T with normal radiographic findings. (B) Tooth T 10 months after treatment, with mild calcification of both mesial and distal canals. (C) Tooth T 30 months following treatment. Note significant calcific metamorphosis of both canals.

### Premature exfoliation

Of the 85 teeth that met the inclusion criteria, 11 were lost prematurely: 4 in the ferric sulfate group (11%); 4 in the formocresol group (10%); and 3 in the combined ferric sulfate/formocresol group (33%). Nine (82%) of these teeth were restored with a stainless steel crown, and 2 (18%) were restored with an amalgam restoration. Eight (72%) were first primary molars, and 3 (28%) were second primary molars. All of the teeth in this group were extracted due to abscess formation and were replaced with a space maintainer. Other teeth, however, may have been lost for other reasons.

Due to this study's retrospective nature, this could not be determined. Only 2 teeth presented with internal resorption, and 1 with external resorption, as the sole radiographic finding. The remaining 8 teeth presented with a combination of furcation involvement, enlarged PDL, and internal resorption.

### Discussion

In conducting this retrospective study, it was the authors' intention to focus on radiographic findings over time and relate them to premature loss of the deciduous teeth. Since the sample was taken from records in a university setting, the authors were aiming to minimize variability in practitioner experience by only including those pulpotomies that were performed by full-time faculty members in the Department of Pediatric Dentistry at The University of Iowa College of Dentistry. Unfortunately, this also limited the number of pulpotomized teeth that could enter into the study. Similarly, the authors further restricted the study numbers by requiring that the radiographs show at least 4 mm of root past the furcation.

The authors found that the radiographic success was 43% for ferric sulfate pulpotomies, 56% for formocresol pulpotomies, and 55% for the combined ferric sulfate/formocresol technique. Although this is lower than other published studies, the authors took into consideration all abnormal radiographic findings (calcific metamorphosis, internal resorption, furcation, and external resorption). These results are similar to those reported by Burnett and Walker, who found a 50% failure rate for ferric sulfate and a 70% failure rate for the combined ferric sulfate/formocresol pulpotomy.<sup>6</sup> Conversely, Fei found only a 4% radiographic failure at 12 months using ferric sulfate (out of 28 teeth) and a 22% formocresol failure at 12 months.<sup>4</sup>

Similarly, in 2000 and 2003 Ibricevic and Al-Jame published results on their success rates of ferric sulfate and formocresol pulpotomies over a 4-year period. At 20 months, a 3% radiographic failure rate was observed for both formocresol (Buckley's original formulation) and ferric sulfate. At 42 months, this same group found a radiographic failure rate of 8% for ferric sulfate and 6% for formocresol.<sup>14,15</sup> The high radiographic success rates in this long-term study may be attributed to the use of orthopantomograms for diagnosis of internal resorption, external resorption, and furcation involvement.

Since it has been suggested that radiographic failure may not have much clinical relevance,<sup>13</sup> the authors evaluated the clinical criteria of early tooth loss and need for space maintenance. The authors found that 13% of all teeth in this study were lost prematurely due to abscess formation. More specifically, 11% were lost in the ferric sulfate group, 10% were lost in the formocresol group, and 33% were lost in the combined ferric sulfate/formocresol group. All of these teeth were replaced with a space maintainer.

The authors also found that, of the teeth lost prematurely, 72% were primary first molars and 28% primary



second molars. Similar results were found by Vij et al.<sup>16</sup> In a retrospective evaluation of indirect pulp treatment compared with traditional formocresol pulpotomies, their study showed that 36% of teeth treated with formocresol pulpotomies exfoliated early and only 61% of primary first molars were successful.

In this study, the fact that all teeth lost early to exfoliation had to be replaced by a space maintainer may be due to the mean age of 5.5 in the study sample. This is different from other reported studies, where mean ages have been 7.6 years,<sup>7</sup> 7.5 years,<sup>5</sup> and 6.7 years.<sup>4</sup> The older the child is at the time of pulpotomy, the less probable is the need for space maintenance should the pulpotomy fail.

Space maintenance should be taken into consideration, however, when electing a pulp therapy technique. If the objective is to maintain a primary tooth in place until the succedaneous tooth erupts, then one has to reconsider the qualification of studies stating that radiographic findings such as internal resorption are clinically irrelevant. Instead, one should be vigilant about taking follow-up radiographs at recall visits so as not to miss the signs of radiographic failure. This study showed that, of the 11 teeth lost prematurely, 10 presented with internal resorption and 8 presented with multiple radiographic findings. Restoration type did not seem to influence the probability of tooth loss, as almost all of these teeth were restored with stainless steel crowns.

Internal resorption was found in almost all of the prematurely exfoliated teeth, however, and was found within the first year at a significantly higher rate than other radiographic findings. Because of this, internal resorption should not be taken lightly when noted on follow-up radiographs obtained on this study's patients that have had deciduous tooth pulp therapy with any medicament.

Ideally, conclusions should be drawn on studies that have been conducted in a prospective and blinded fashion. Unfortunately, few of these studies exist in the pediatric dental literature, and conclusions must be drawn based on less-than-ideal data sets. Nevertheless, this study's findings indicate that, regardless of the pulpotomy treatment chosen, the possibility exists that the tooth may fail and have to be replaced with a space maintainer to avoid space loss and subsequent orthodontic issues. In light of this, radiographic findings such as internal resorption should not be dismissed as insignificant.

## Conclusions

Based on this study's results, the following conclusions can be made:

1. Internal resorption may be a predictor for early tooth exfoliation.
2. Teeth with more than 1 radiographic finding were more likely to be lost prematurely.
3. At follow-up recall visits, pulpotomized teeth should be assessed radiographically to monitor any changes.

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