Scientific Article

A Retrospective Study of a Modified 1-minute Formocresol Pulpotomy Technique Part 2: Effect on Exfoliation Times and Successors

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Abstract: ***Purpose:*** *The purposes of this study were to evaluate the: effect of a 1-minute application of full-strength Buckley's formocresol with concurrent hemostasis using the medicated cotton pledget in human primary teeth on their successors; and exfoliation times compared to the contralateral nonpulpotomized tooth.* ***Methods:*** *Using a retrospective chart review, clinical and radiographic data were available for 557 primary molars in 320 patients.* ***Results:*** *There was no difference between treated and control teeth in the number of enamel defects of succedaneous teeth (P<.45). Approximately 66% exfoliated at the same time as their contralateral counterpart and approximately 29% exfoliated earlier (P<.001).* ***Conclusions:*** *This 1-minute technique showed a tendency toward early exfoliation, but no effect on clinical management, and no increase in incidence of defects on succedaneous teeth was observed. The 1-minute full-strength formocresol technique may be considered an acceptable alternative to the 5-minute formocresol pulpotomy.*
(Pediatr Dent 2011;33:139-43) Received November 14, 2009 / Last Revision April 4, 2010 / Accepted October 4, 2010

KEYWORDS: PRIMARY TEETH, PULPOTOMY, FORMOCRESOL, EXFOLIATION

Carious involvement or traumatic exposure of pulps that remain vital in primary teeth can be treated by a technique called vital pulpotomy. The treatment involves removal of the coronal pulp, application of medicaments, and restoring the tooth to maintain function and arch length until its exfoliation and the eruption of its successor.

Despite the high success rates reported with the use of a 5-minute application of formocresol, it has been postulated that it may be applied for a shorter amount of time and still achieve equivalent results. It is also of interest that few studies have addressed the effects of the medicament on permanent successors and exfoliation times.

There is conflicting evidence concerning the effect of pulpotomies on the age at which primary molars exfoliate. Van Amerongen et al., concluded that there was no significant difference in lifespans between primary teeth with or without pulpotomies.[1] In another study of 27 primary molar pulpotomies, 3 teeth erupted earlier than, 15 teeth later than, and 9 teeth at the same time as the succedaneous teeth.[2] Hobson[3] and Morawa et al.,[4] both reported that pulpotomized molars exfoliated 6 to 12 months earlier than usual. Fuks and Bimstein[5] using a one-fifth dilution and Fuks et al.[6] using full strength and the one-fifth dilution determined that the pulpotomy led to enhanced resorption of the primary tooth. Roberts carried out a 1-visit prospective study of 142 primary molars using full-strength formocresol for 5 minutes and evaluated exfoliation times.[7] Roberts concluded that there were no significant differences in the ages at which the pulpotomized and nonpulpotomized teeth exfoliated.[7] In their investigation, Thompson et al., used the same cotton pellet technique to apply medication and obtain hemostasis.[8] They found that 6 of the 194 treated molars exfoliated earlier than contralateral teeth that had not been treated.[8] There was no clinical significance because the eruption of the succedaneous teeth followed, and space maintenance was not required.[8]

Pruhs et al., evaluated 25 premolars for enamel defects. Their antecedents had been successfully treated with 1-visit, 5-minute formocresol pulpotomies.[9] The premolars on the treated side were clinically and radiographically compared to their antimeres for enamel defects. The investigators reported that 24 of the 25 premolars on the treated side showed enamel defects, and concluded a "definite" relationship existed between formocresol pulpotomies in primary teeth and enamel defects on their successor.[9]

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Rølling and Poulsen concluded that the application of formocresol on pulpal tissue in primary teeth had no effect on the mineralization of the succedaneous permanent tooth germs.[10] Messer et al., also examined 20 premolars for evidence of enamel defects and eruption abnormalities following unsuccessful pulpotomies. The investigators reported on the positional changes affecting 40 percent of premolars that succeeded primary molars treated with either a successful or unsuccessful pulpotomy.[11] Mulder et al., evaluated 139 pairs of premolars for evidence of opacity or enamel hypoplasia.[12] The investigators reported that there were no demonstrable differences between a formocresol pulpotomy in a primary tooth and formation of the permanent successor in terms of hypoplasia and opacities. Thompson et al., found no hypoplastic or hypocalcified areas in the premolars that succeeded the treated primary molars when hemostasis and medication were applied with the same cotton pellet.[8] Furthermore, the effects of shorter application times on success rates have not been adequately reported.

The purposes of this study were to evaluate the: effect of a 1-minute application of full-strength Buckley's formocresol with concurrent hemostasis using the medicated cotton pledget in human primary teeth on their successors; and exfoliation times compared to the contralateral nonpulpotomized tooth.

Methods

Ethics approval was obtained from the Health Sciences Research Ethics Board, University of Toronto, Ontario, Canada. The selection of the subjects, clinical and radiographic indications, radiographic assessments, and modified technique are described in 'Methods' section of Part One of this investigation.[23] The sample size required to achieve 90% power and a 0.05 alpha level using Fisher's exact test was 124 teeth.

Each patient was designated a numerical code for purposes of maintaining anonymity. Data collected for each numerical entry included: date of birth (age); gender; tooth treated; treatment date; follow-up time in months; clinical notes regarding the treated tooth at follow-up or recall intervals; and condition of the contralateral tooth.

The condition of the contralateral tooth served as a control for the treated tooth in evaluating exfoliation times. The contralateral tooth was designated as: absent; untouched; restored with amalgam or stainless steel crown; pulpotomy with stainless steel crown; or root canal treatment. In the event that the condition of the tooth changed, the final condition of the tooth was recorded.

To determine the effect on permanent successors, any abnormality in the surface morphology or color between the treated side and the contralateral untreated side was noted (coronal and radicular morphology, caries, restorations, coronal position, fluorosis) by evaluating chart entries and radiographs. In addition, any areas of hypoplasia (pitting, furrowing) or hypomineralization (round or oval lesions differentiated from normal enamel as creamy yellow or brown in color on normally contoured enamel surfaces) were noted by evaluating chart entries.

The presence and the condition or orientation of the succedaneous teeth on both the treated side and the contralateral side were noted; clinical and radiographic observations were recorded as: intact; hypoplastic or pitted; hypomineralized; positionally altered; and demonstrating abnormal root morphology and or caries.

At recall dates of at least 6 months, clinical and radiographic observations were noted, per the criteria outlined for success and failure (see Part One). These observations were noted until the treated and contralateral teeth exfoliated or were extracted. When the precise date of the 2 events (extraction or exfoliation) were unavailable, the first recall date that indicated absence of the teeth was noted as the endpoint of the treated and contralateral teeth. Clinical and radiographic observations of succedaneous teeth were followed to the last available recall date. The teeth were polished and dried prior to clinical examination.

All data were entered into an Excel spreadsheet (Microsoft Inc, Redmond, Wash) and SAS (SAS Institute Inc, Cary, NC) for statistical analysis. Data for continuous variables, such as patient age and recall interval, were presented as means and standard deviations. Categorical data such as clinical and radiographic observations were summarized as percentages. The principal investigator was standardized against 2 pediatric dentists to determine inter-rater reliability by independently reading radiographs of 30 patients. Inter-rater agreement was measured using the Kappa statistic. The observations of the principal investigator were further evaluated to determine the degree of intra-rater reliability. All radiographs were read using a standard view box illuminator. Measures of inter-rater and intra-rater reliability were categorized as: poor; slight; fair; moderate; substantial; and almost perfect.[13]

The lifespan of formocresol-pulpotomized teeth was determined by recording the time of exfoliation or extraction. In the event that a tooth under question exfoliated between recall dates, the first recall date that indicated the absence of the tooth was noted as the terminal survival date.

Results

Inter-rater reliability was 0.62 (Kappa statistic, considered substantial) with 70% agreement, and intra-rater reliability was 0.70 (substantial) with 86% agreement. The mean age at which the teeth were lost was 128.9 months old (10.7 years old). Among 557 treated teeth, 308 exfoliated, 39 were extracted, and 210 remained in the mouth at the time of data analysis. Of 308 exfoliated teeth, 191 (with contralateral nonpulpotomized teeth) were analyzed to determine treatment effect compared to their contralateral nonpulpotomized tooth.

The mean length of time between the date of treatment and time at which a tooth was extracted was 32.5±13.7 months old, with a range of 7.8 to 60.5 months (0.7-5 years) after treatment. Of the 308 teeth that exfoliated, 191 were compared to contralateral teeth that were nonpulpotomized. Fifty-five (~29%) exfoliated earlier than the contralateral teeth, 125 (~65 %) exfoliated within the same time period as the contralateral teeth, and 11 (~6%) treated teeth exfoliated later than the nonpulpotomized contralateral teeth (Figure 1). When early exfoliation in treated teeth occurred, it did so at a mean of 7.4±4.7 months ($P<.001$) prior to exfoliation of

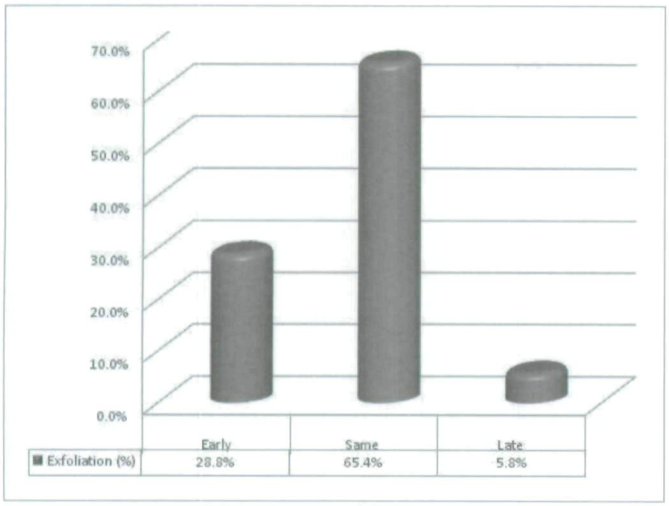

Figure 1. Exfoliation of 191 pulpotomized teeth versus untreated controls.

the contralateral tooth. Considering all the exfoliated treated teeth, the average exfoliation occurred 2.69±8.13 months earlier than the contralateral nonpulpotomized tooth. This result was also statistically significant ($P<.001$).

The condition of the 191 succedaneous teeth that erupted was evaluated based on the previously cited criteria. Five premolars (~3%) that succeeded pulpotomized primary molars presented with surface enamel defects (N=5) and 1 positional alteration (N=1). None of these teeth (N=0) showed abnormal root morphology. There was no statistically significant difference ($P<.45$) in the incidence of defects on the treated vs the control side (Table 1).

Discussion

It was predetermined that a sample size of 124 teeth was required to achieve 90% power and a 0.05 alpha level. The sample size in the present investigation exceeded the predetermined sample size and included 557 teeth from 323 healthy patients requiring at least 1 pulpotomy with a minimum of a 6-month follow-up period.

In assessing the effect of the modified technique on succedaneous teeth, the present investigation compared the treated tooth to the contralateral nonpulpotomized tooth. Using a paired-tooth design eliminated possible confounders regarding the types of teeth involved (that is, maxillary vs mandibular, first molar vs second molar) and interpatient confounders.

A survey of the literature indicated that there are no previous studies which evaluated the effect of a decreased formocresol application time on succedaneous teeth and exfoliation times. Previous investigations have assessed the effects of a 5-minute formocresol application time.[1,7,8,14] The present investigation has the largest sample size compared with other published reports that evaluate the effects of formocresol pulpotomy.[1,5,7,14,15]

Even though exfoliation accounted for most teeth treated (308/557), only those teeth with nonpulpotomized counterparts were selected to evaluate the effects on succedaneous teeth (191/308). In doing so, the treated teeth are compared to nonpulpotomized contralateral teeth in the same patient. Most teeth in the current investigation exfoliated in the same time period as the contralateral nonpulpotomized teeth (controls).

There was, however, a group of treated teeth that exfoliated earlier (~29%), and this effect was found to be statistically significant ($P<.001$). The pulpotomized teeth that exfoliated earlier than the contralateral teeth did so at a mean of 2.68 months earlier than the exfoliated control teeth. This result was comparable to that of Hicks et al., where exfoliation of pulpotomized molars was found to occur approximately 6 months prior to exfoliation of their antimeres.[15] Hicks et al., however, also found that a higher proportion exfoliated earlier than their contralateral counterparts; this is different from the findings of the present investigation. Despite being statistically significant, the clinical relevance of the finding in the current investigation remains uncertain, as the teeth exfoliated within the normal range of physiologic exfoliation defined by Lunt and Law.[16]

Although the early exfoliation time was statistically significant as compared to the contralateral tooth, the premolar erupted soon after the exfoliation of the pulpotomized tooth. Hicks et al., used a nonmedicated cotton pellet followed by a paste of zinc oxide and equal parts of eugenol and formocresol.[15] The authors postulated that the high rate of earlier exfoliation was due to the leaching out of formocresol from the zinc oxide eugenol paste into the surrounding periodontal tissue, resulting in an accelerated root resorption due to the presence of a chronic inflammatory reaction. These findings are higher than those reported by Vargas et al., where 10% of teeth treated with formocresol exfoliated prematurely.[14] The pulpotomy technique employed in the present investigation, however, eliminated the incorporation of formocresol from the zinc oxide eugenol paste, and the application time of formocresol was shorter. The early exfoliation seen in the present investigation may be a result of progressive inflammation that had extended to the radicular pulp. In contrast, other investigations[1,7,8] using full-strength formocresol for 5 minutes reported no significant difference in lifespans.

A small portion (~6%) of the teeth in the present investigation exfoliated later than the contralateral nonpulpotomized teeth. This portion was lower than reported by Hicks et al.,[15] The relationship between treated primary molars and presence of defects on succedaneous teeth in the present investigation was explored using the same sample used to evaluate the effect on exfoliation times (N=191 pairs). A minority (~3%) of the succedaneous teeth in the experimental group showed defects. The control group, consisting of succedaneous teeth from nonpulpotomized primary molars, also

Table 1. NO. OF TEETH WITH DEFECTS IN TEST VS CONTROL GROUP*

	Test	Control
No defects	186	189
Defects	5	2

* $P<.45$.

demonstrated defects (1%). This observation was not found to be statistically significant ($P<.45$). The present study showed that there was no relationship between opacities and hypoplasia of the enamel on permanent teeth and formocresol pulpotomy of its primary predecessor. This is consistent with the findings of other investigations.[10,12] Similar to the findings in the present investigation, Messer et al., found that there were no alterations in the coronal or radicular morphology of succedaneous teeth, although 40% of the bicuspids that succeeded treated primary molars had positional alterations.[11] These authors proposed that the developing tooth bud alters its position to avoid the pathologic processes associated with the primary tooth. Messer et al.,[11] did not collect data regarding the extent and distribution of crowding in the dentition, which could have been a potentially significant confounding variable with regards to positional alterations reported in the succedaneous teeth.

The present study's findings are in contrast with those of Pruhs et al., who concluded that there was a definite relationship between formocresol pulpotomies in primary teeth and enamel defects on their permanent successors.[9] Pruhs et al., however, did not describe how many of the primary molars were diagnosed as vital or nonvital when treated. This becomes relevant since it has been shown that nonvital teeth are more susceptible to causing disturbances in the formation of succedaneous teeth.[17] Alternatively, this could be due to differences in the examination procedure. Pruh et al.,'s findings were based on 25 pairs of teeth.[9] Their procedure involved teeth being dried for a minimum of 1.5 minutes prior to clinical examination. This method of drying the tooth results in the dessication of enamel surface, which may produce an opaque discoloration that could thus have been noted as an abnormality. In the present investigation, a larger sample size is assessed; prior to clinical examination, the teeth were prophied and dried for only a brief period. This method of examining the teeth may be less prone to create these pseudodefects. Messer et al., air-dried and examined each bicuspid using a mirror and explorer.[11] These authors did not mention how long the teeth were dried prior to clinical examination.

The present study also demonstrated that the 1-minute application of formocresol has no effect on the surface or root morphology of the succedaneous teeth. This agrees with the histologic evaluation of pulp tissue, where formocresol was applied for less than 5 minutes and produced the least inflammatory and tissue response.[18,19] The root canal's apical portion was noted to be free of inflammation and comprises vital tissue in investigations that utilize the 5-minute formocresol application[20,21]; therefore, it is not likely to cause disturbances in the surface or the root's morphology. Kahl et al.,[22] demonstrated that formocresol does not get distributed in the peripheral circulation; therefore, it is unlikely to have an effect on succedaneous teeth.

The present study was limited in the fact that the estimation of exfoliation times was based on the absence of the tooth at a specific recall date. The exfoliation date could have been more accurate if the patient was asked to note the exact date when each tooth exfoliated. In addition, the comparison of the treated tooth to the contralateral side could have included assessment of radiographic root resorption rates at recall appointments. The methodology employed in this investigation, however, is similar to the method employed by Roberts[7] and Thompson et al.,[8] in that the exfoliation date was that of the next recall visit when the loss of the tooth was recorded. This method of estimating exfoliation times produces a bias toward late exfoliation times. In doing so, this would also produce a similar bias toward the exfoliation times of controls.

Therefore, this still represents a valid method of evaluating the effect of the treatment on exfoliation times relative to the contralateral controls. By contrast, van Amerongen et al.,[1] assessed the effect on exfoliation by asking patients to report the time of exfoliation, but this method can be subject to recall bias, particularly if more than 1 tooth is involved.

Conclusions

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

1. The modified 1-minute formocresol pulpotomy technique showed a tendency toward earlier exfoliation time; however, this was not found to be clinically significant.
2. This pulpotomy technique showed no increased detrimental effect on succedaneous teeth.
3. One could consider using this pulpotomy technique as an alternative to the 5-minute formocresol pulpotomy based on exfoliation patterns and limited number of succedaneous tooth defects.

Acknowledgment

The authors wish to thank Dr. G. Kulkarni, Department of Pediatric and Preventive Dentistry, Faculty of Dentistry, Toronto, Ontario, Canada, for his input as a committee member over the course of this investigation.

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Abstract of the Scientific Literature

Birth timing: An influence on the prevalence of cerebral palsy

*The goal of this study was to evaluate the influence of gestational age on the birth of infants at risk for cerebral palsy (**CP**). Gestational age was determined by the last menstrual period (LMP) and ultrasound in 1998 and beyond. The study used data from the national health and insurance registries in Norway, where each citizen has a specifically unique identification number and all births are recorded in the Medical Birth Registry of Norway. The Norwegian Data Inspectorate, the Norwegian Directorate of Health, the Office of the National Registrar, and the Norwegian Labor and Welfare Organization approved the study. All births with a gestational age of no less than 16 weeks have been recorded in the registry since 1967. In this study data from all the live single births having a gestational age of 37- 44 weeks from 1967-2001 were evaluated. For this time period of 35 years a total of 2,024,215 live births were recorded. Excluded from the study were infant cases which had missing data, preterm births, gestational age >44 weeks, birth weights not comparable with gestational age, multiple births, infants with malformations, and children dying prior to age 4 years. This left a total of 1,682,441 births with a gestational age of 37- 44 weeks as the cohort for analysis. For statistical analysis each week of gestation from week 37- week 44 was evaluated. Relative risks (RR) was estimated by the ratio of prevalence using 40 weeks as the reference and log-binomial regression was used with adjustments for birth year, sex, mother's age, single mother status, mother and father's educational levels and immigrant status of mother and father. Statistical analysis was performed by SPSS version 17.0. The lowest birth risk for CP was found at 40 weeks of delivery with the highest risk at 37 and 42 weeks. Several factors are indicated as associated with the cause for cerebral palsy, but it has not been determined if congenital problems with the fetus are more of a cause than problems with the delivery process itself. The timing of delivery as too early or too late appears to increase the risk of cerebral palsy.*

Comment:** Patients with a diagnosis of cerebral palsy are routinely treated by pediatric dentists. For CP and all special needs patients, included in the medical history should be a review of the pregnancy and birth histories. This information is important in aiding confirmation of dental anomalies resulting from developmental insults during gestation. **JGJ

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