

Scientific Article

Pulpotomy to Stainless Steel Crown Ratio in Children With Early Childhood Caries: A Cross-sectional Analysis

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Abstract: ***Purpose:** This study's purpose was to determine the pulpotomy-to-crown ratio (PCR) in a high-early childhood caries patient population and factors associated with choice of pulpotomy and crown treatments. **Methods:** This was a retrospective quality assurance chart review. Five calibrated examiners ($\kappa=0.86$) rated radiographic caries from available films. Demographic data, including age, health status, medications, and pain score, were collected along with pulpotomy- and crown-related treatment characteristics of location of tooth, treatment site, and level of operator skill. **Results:** The record review of 521 patients (mean age=5.1±1.9 years old) revealed 1,365 stainless steel crowns (SSCs) performed with 461 pulpotomies in a 6-month period, in both operating rooms (1,043 SSCs) and ambulatory settings (322 SSCs). The mean PCR was 0.34, with PCR decreasing with increasing patient age. Pulpotomy and crown treatments increased with radiographic caries severity with a significant association between pulpotomy and radiographic severity ($P<.001$). More severe pain was associated with greater likelihood of pulpotomy ($P<.001$). Age, operator type, and site of treatment did not affect choice of pulpotomy. **Conclusions:** The mean pulpotomy-to-crown ratio in this high-early childhood caries pediatric population was 0.34. Pain, the American Society of Anesthesiologists classification system, and radiographic caries severity were predictors of pulpotomy, but operator type and location of treatment were not. (Pediatr Dent 2011;33:496-500) Received March 30, 2010 | Last Revision October 7, 2010 | Accepted October 10, 2010*

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Early childhood caries (ECC) is one of the most prevalent public health issues today, found in nearly 30% of all US children¹ with a higher prevalence in those of lower socioeconomic status.^{2,3} Children who experience ECC as infants/toddlers are more likely to have subsequent caries in their primary and permanent dentition.⁴

Deep interproximal caries in primary molars is often an indication for vital pulp therapy and placement of stainless steel crowns (SSCs) to maintain a functional dentition and arch health. Depending on the dentist's educational background and work experience, the recommended restorative procedure for deep proximal caries in primary molars can be different.^{5,6} SSCs are recommended for primary teeth in many situations, including significant ECC.⁷ After a pulpotomy, a tooth may become brittle and prone to fracture⁸, so an SCC is strongly recommended to prevent fracture, provide strength to the devitalized teeth, reduce microorganism invasion, and maintain space.

Little evidence supports pulpotomy as the most appropriate technique for primary teeth,⁹ and often a dentist chooses this technique based on educational background and individual preference. In the United Kingdom, the national clinical guideline in pediatric dentistry recommends a pulpotomy when more than two thirds of the marginal ridge of a primary molar is compromised with caries.¹⁰ Alternatively, Fuks et al., strongly recommend an

indirect pulp capping procedure as the most appropriate treatment for symptom-free primary teeth with deep ECC.⁹ Coll et al., suggest not performing a pulpotomy, but rather a pulpectomy when the pulp is already exposed from caries, due to the chance of radicular pulp infection and the low likelihood of a totally vital tooth.¹¹

The patient's age can also influence decision-making: the earlier a child is affected by ECC, the greater the risk of future caries in the child.¹² In a young high-risk population, more aggressive treatment, such as pulpotomy followed by SSC, may be recommended to arrest deep proximal caries. Depending on the setting where dental care is delivered, at a clinic or private practice, the treatment decision to perform pulpotomy may vary.⁷ Due to co-operation issues and the extent of dental disease, children may be placed under general anesthesia (GA) to receive comprehensive dental care. This is a costly procedure with increased risk.⁷ Considering cost, health risk, and a historically low level of compliance with follow-ups, an aggressive approach to dental rehabilitation under GA may be considered, resulting in a higher number of pulpotomies and crowns.¹ A recent report on ECC among American Indian and Alaskan Native children suggests that this aggressive approach has application in high-carries children.¹³

The pulpotomy-to-crown ratio (PCR) is an informal measure used in a variety of ways to understand how dental interventions are employed in children with high caries risk. This numeric value is simply the number of pulpotomies per tooth treated with SSCs and can be portrayed as a percentage or a fraction:

$$\frac{\text{Teeth crowned with pulpotomies} \times 100}{\text{Total teeth crowned}} = \text{PCR score}$$

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The PCR concept has been used by third parties as a gauge of appropriateness of care and potential "over-treatment" by dental providers.¹⁴ The PCR may also be used as a surrogate measure of ECC severity, reflecting both real caries incidence and professionally perceived risk, as manifested in treatment choices. The PCR is relative, since no reports assign a PCR value according to a level of caries severity. In cases of third-party use, the PCR may be compared to a typical or acceptable profile of a cross-section of dentists providing those services.

A reasonable PCR determination in a high-risk ECC population would provide a guide to clinicians and others for assessment of provider practice when judging appropriateness of care, as opposed to using a profile based on aggregate services from a cross-section of high and low caries-risk populations. The purpose of this study was to determine the pulpotomy-to-crown ratio in a population of low-income children with severe early childhood caries and to relate the PCR to variables employed in treatment decisions.

Methods

This retrospective, cross-sectional quality assurance study involved a chart review of patients treated at the Nationwide Children's Hospital (NCH) Dental Clinic, Columbus, Ohio, over a 6-month period. The publication of the impersonal analyzed data was authorized as exempt by the human subjects committee of NCH.

Sample. Data were collected from 521 patients who received either SSCs alone or SSCs with pulpotomies on at least 1 primary molar or canine. Children who had primary teeth present, restorable, and with a reasonable projected lifespan at the time of treatment, as judged by the respective provider, were included in the study.

Procedures. Data were collected from patient records by trained examiners and included the patient's medical history, medications, face pain scale¹⁵ score (0-10), and location of treatment (NCH ambulatory Dental Clinic or NCH Dental Surgery Center). History of over-the-counter pain medication use and the names of medication were also obtained.

A standardized radiographic template and scoring system were established and piloted, with calibration of examiners and a subsequent inter-rater reliability analysis of examiners conducted. Without magnification and using standard dental viewing illumination, 5 calibrated examiners evaluated the radiographic findings on bitewing and periapical radiographs of the treated primary teeth, and the extent of caries was determined according to the following ordinal scoring scale:

0=clinical decalcification (white spot), no radiographic caries noted;

1=radiographic caries confined to enamel;

2=radiographic caries confined to the outer half of dentin;

3=radiographic caries extended to the inner half of dentin; and

4=radiographic caries contacting the pulp chamber.

The total teeth treated at each visit and tooth type were also recorded. The type of treatment (whether SSCs only or pulpotomies plus SSCs), and any record of repeated visits for the same teeth, were also assessed. All pulpotomies were performed using ferric sulfate as an intrapulpal medicament followed by zinc oxide-eugenol cement in the pulp chamber. SSCs (3M ESPE Corp, Minneapolis, Minn) were used to restore the pulpotomized teeth, and all SSCs were cemented with Ketac, a glass ionomer luting cement (3M ESPE Corp). No teeth received a pulpotomy

without an SSC, as recommended by American Academy of Pediatric Dentistry guidelines.¹⁶ Primary teeth with a history of swelling, visible radiographic resorption, pathologic mobility, and periapical or furcal radiolucency were excluded at the time of treatment.

Statistical analysis. Data were entered into a database (Microsoft Excel, Microsoft Corp, Redmond, Wash) from a hand-written data collection sheet. Data analysis of categorical and ordinal variables was done, respectively, using Fisher's exact test and a 2-tailed *t* test. Finally, multivariate linear regression was used to detect significant associations. Statistical significance was established at $P \leq .05$.

Results

Demographic information. Data from 521 patient charts were collected between July 2008 and December 2008, comprising 1,365 SSCs placed on primary teeth over that period. Most children treated (351; ~66%) were classified as healthy according to the American Society of Anesthesiologists' (ASA) system, with the remaining 170 (~34%) ASA Class II. A total of 1,043 crowns (~77%) were placed by 6 pediatric dentistry faculty members while the child was under GA. The remaining 322 (~24%) were placed by pediatric dental residents, in an ambulatory setting, with faculty supervision. Of all crowns placed, 610 (~45%) were on maxillary teeth and 755 (~55%) on mandibular teeth. A total of 461 pulpotomies were performed on the teeth with SSCs.

Patient ages. Of 521 patients, 43 (~8%) were 0- to 36-months-old, 258 (~50%) were 37- to 72-months-old, and 220 (~42%) were older than 72-months-old, with a mean age of 5.1 ± 1.9 years old. Only 123 (9%) of the teeth treated were performed in 0- to 36-month-old children. Children older than 72 months had 377 (~30%) of the total teeth treated with either SSCs or pulpotomies (Figure 1). There was no significant association between the patient's age and the overall number of teeth treated per child ($P > .13$).

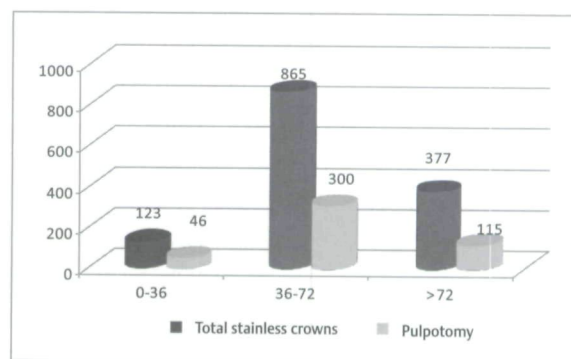


Figure 1. No. of teeth treated as a function of different age groups with stainless steel crowns (SSC) and pulpotomy.

PCR values. The PCR was: 37% for 0- to 36-month-olds; 35% for 37- to 72-month-olds; 31% for children older than 72-months-old; and 34% overall when all 1,365 SSCs were placed. The PCR difference between the 0- to 36-month-olds and 36- to 72-month-olds was not significant.

Radiographic score. Radiographs were present for 1,336 (~98%) of all SSCs placed. A weighted kappa of 0.86 was obtained for the examiners, indicating a good level of inter-rater

Table 1. PROCEDURES AND PULP-TO-CROWN RATIO (PCR) BASED ON RADIOGRAPHIC SCORE

Radiographic score	Stainless steel crowns	Pulpotomy	PCR
0	12	1	0.08
1	51	3	0.06
2	234	9	0.04
3	709	197	0.27
4	337	251	0.78
Total procedures and mean PCR	1,343	461	0.35

reliability. Table 1 shows radiographic and PCR scores. Less than 1% (12) of the teeth was scored as a "0," meaning no radiographic decay was noted by the examiners and no clinical decalcification was noted in the patients' records. A total of 51 teeth (~4%) was scored as having radiographic caries confined to enamel. Radiographic caries into dentin was noted in 943 (~71%) teeth, and this was further subdivided into caries in the outer half of dentin (234/~18%) and inner ½ of dentin (709/~53%). Finally, 337 of the teeth (~25%) had caries, which on radiographs appeared to contact the pulp chamber. There was a significant association between an increase in radiographic score and a pulpotomy being performed ($P<.001$). A graphic representation of the relationship between radiographic score and treatment performed is presented in Figure 2.

PCR ratio. When the subsample of 1,343 SSC teeth with available radiographs was considered, the overall PCR was 34%. The remaining PCR values by radiographic score are presented in Table 1.

Variables associated with pulpotomy. Multivariate linear regression was performed to determine the relationship between pulpotomy and other variables collected (Table 2). Significant associations were found with parental reports on the faces pain scale ($P<.001$). Children reporting a higher pain level were more likely to have a pulpotomy performed. Additionally, if a child's medical status was ASA II, there appeared to be a significant association with pulpotomy therapy ($P=.05$). Fewer pulpotomies per crown were performed on ASA II patients. The breakdown of pulp therapy and ratios based on ASA status is presented in Table 3. Within the ASA II group, the most common diagnosis was asthma (32%) followed by behavior disorders (autism spectrum disorder=~10%; attention deficit disorder/attention deficit hyperactivity disorder=~9%).

Regression analysis determined that teeth with higher radiographic scores were more likely to have pulpotomy therapy ($P<.001$). We also were interested in testing the concept that children with a higher caries rate, as manifested by a higher number of crowns, would be more likely to have a higher PCR because clinicians would treat them more aggressively. In other words, was a child with extensive ECC considered more likely to have pulpal involvement by a clinician vs a child with 1 or 2 isolated carious lesions. Figure 3 shows a strong correlation ($R^2=0.90$) between the number of SSCs and the number of pulpotomies, and the PCR increased from 0.32 for children with 2 SSCs to 0.36 for those who received 8 SSCs.

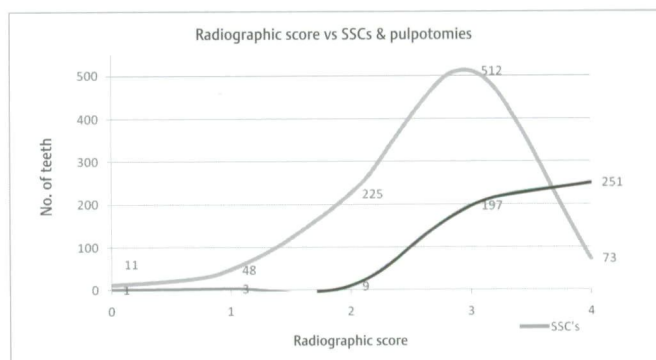


Figure 2. Overall number of teeth with stainless steel crowns (SSCs; gray) and pulpotomies (black) based on radiographic score.

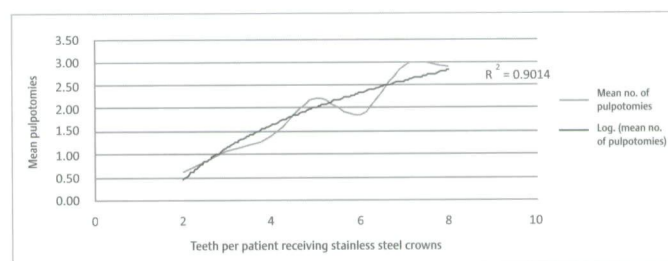


Figure 3. Mean pulpotomies and stainless steel crowns (SSCs) per patient.

Discussion

This quality assurance project was 1 clinical monitor in a larger global program of corporate integrity that involved billing, record keeping, trainee supervision, and other indicators of consistency within a very busy children's hospital clinical enterprise. Recent legal challenges to corporate dentistry and initiatives in the area of Medicaid fraud identification and prosecution nationally suggested that self-profiling would be a good exercise.¹⁶

The PCR is a clinical indicator that may show how certain dental procedures are deployed in various populations. There is some debate as to the utility of this figure, since scant literature exists on the topic. A higher ratio might indicate that more crowned teeth are being treated with pulpotomies, but not necessarily due to disease status of the teeth. In unstable socioeconomic populations, where caries prevalence is high and timely recall visits low, dentists may treat deep carious primary teeth with more aggressive and definitive pulp therapy, resulting in an increase in a higher PCR. The opposite may also be true, with dentists practicing in stable socioeconomic populations and performing fewer pulpotomies because the caries rate and risk is lower and return visits are more predictable. To date, no benchmark value for PCR has been proposed, but some data on PCRs from clinics and pediatric dentistry educational programs are available.¹⁷

The radiographic diagnosis was a significant diagnostic predictor for primary pulp treatment ($P<.001$) in our population. Radiographs were available for approximately 98% of all SSCs placed ($N=1,343$). Expectedly, as the caries involvement became more extensive, the radiographic score increased and pulpotomies and crowns became more common. Also, as expected, "no radiographic evidence" or "just enamel etching" (scores 0 and 1 respectively) were associated with a lower PCR.

Table 2. REGRESSION ANALYSIS OF PREDICTORS FOR PULPOTOMY

Variable	P-value	r ²
Age	>.13	0.02
Faces pain scale score	<.001*	0.05
American Society of Anesthesiologists status	.05*	0.006
Maxillary or mandibular tooth	.28	0.007
Radiographic score	<.001*	0.03
Operator type	>.14	0.578
General anesthesia or ambulatory	>.31	0.578
Repeat visit	.09	0.007
Use of over-the-counter medications	<.24	0.002

* Significant at $P=.05$.

Table 3. PULP-TO-CROWN RATIO (PCR) BASED ON AMERICAN SOCIETY OF ANESTHESIOLOGISTS (ASA) STATUS

ASA status	Stainless steel crowns	Pulpotomy	Pulpotomy-to-crown ratio (%)
I	899	319	35
II	462	142	31
Total and mean PCR	1,361*	461	34

*ASA status not available for all subjects.

It should be noted, however, that some teeth without radiographic evidence of caries did receive crowns. The professional decision to do so in these patients may have been because of clinically detected decay, decalcification or even perceived future risk or likelihood of noncompliance with recalls. These few cases accounted for only 5% of teeth crowned. Our results suggest that crowning may be justified in the absence of radiographic findings in some children, and that, while not common, legitimate treatment may be rendered without corroborating radiographs, providing that the dentist has proper documentation to justify the treatment, such as a caries risk assessment or photograph. Unfortunately auditing bodies, dental consultants, and others often consider a corroborating radiograph as the "gold standard." Consequently, whenever possible and ethical, it is strongly recommended to secure indicated radiographs before treatment.

The faces pain scale score was also a strong predictor of pulpal treatment in primary teeth ($P<.001$), with a patient with an increased pain score more likely to receive a pulpotomy. This corresponds to existing literature, which reports that carious painful permanent molars often receive more endodontic treatment than asymptomatic teeth.¹⁸ The pain scale may also have served as a surrogate or adjunctive measure of pulpal health for the treating dentist, who then became more aggressive in determining pulpal health of teeth treated in that patient. This finding supports the fact that clinicians, particularly those who treat a

high ECC population, use indirect or corroborative factors in treatment planning, based on their experience.

The operator type—resident or faculty—did not seem to affect the decision-making process yielding a pulpotomy ($P>.14$). Residents accounted for approximately 24% of all crowns placed and were trained with similar curricular and clinical guidelines to those used by faculty. Type of dental practitioner and varied experience influence treatment, but a potential weakness of our study is that resident preference might have been based on attitudes and experiences of attending faculty for some cases they supervised.

Based on multivariate regression, the patient's age was not a reliable indicator for pulp therapy in primary teeth ($P>.13$). The data from this study, however, indicated that most primary teeth were treated in 36- to 72-month-olds. A total of 865 crowns were placed within this age group, accounting for 63% of those placed in the sample. This finding corresponds with the current state of literature regarding the treatment of young primary molars. Seale⁷ strongly recommends restoring multisurface caries in primary molars with SSCs when the patient is younger than 6-years-old or when the restoration lifespan is required to be longer than 2 years.⁷ It is the patient's chronological age, as well as size of the carious lesion, that should be considered when determining restoration options for primary teeth.⁷

Additional limitations or weaknesses in this study include: its retrospective nature and use of chart review; operative treatment performed by a number of dentists, including pediatric dental faculty members and pediatric dental residents at NCH with varying skills and knowledge; 5 examiners to review the treatment notes/charts, with some possibility of examiner variance; and use of periapical and nonstandardized bitewing radiographs. Finally, it should be noted that the range of the correlation coefficient (R^2) values associated with the regression analysis was 0.002 to 0.578. This demonstrates that, even while the overall statistic was significant, the amount of variance of the outcome variable explained by the predictor variable(s) was small. No other studies examining the PCR have been conducted on this magnitude, and it is entirely possible that this study was inadequately powered, with inadequacy masked by a sizeable sample.

If this study is repeated, collapsing the radiographic categories 2 and 3, which were most often the cause of question, could simplify the rating scale. This would potentially reduce rater variance, although doing this would reduce the sensitivity of results. The inter-rater kappa was 0.86, which demonstrated good agreement, so variance may not have been an issue.

The mean PCR from the NCH Dental Clinic was approximately 34%. This compares favorably with other reported PCRs from corporate dental clinics and educational programs.¹⁷ Although this PCR may not represent the "absolute" value for the metric, it does provide some evidence of a reasonable value in a high-ECC population. These results also suggest that the PCR in such a population may range widely. Since auditing often relies on profiling and the use of an aggregate pool of providers is heavily weighted with general dentists, these results offer a more realistic vision of pulp therapy. General dentists tend to recommend amalgam restoration more often in proximal decay in primary teeth while pediatric dentists recommend a higher percentage of SSCs.¹⁹ Since most general dentists have little experience with SSCs, they tend to restore proximal lesions more with amalgam,

while pediatric dentists most often use SSCs for the same lesions.¹⁹ Dentists who treated an average of 6 to 16 children per week in their practices are also more likely to recommend restoration with pulp therapy than those who were not currently involved in treating children.²⁰

Conclusions

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

1. There was significant association between the pain scale ($P=.001$) and the radiographic score ($P<.001$) and pulpotomies being performed.
2. The operator type ($P>.14$) and the location of the treatment ($P>.31$) had no significant association with treatment performed.
3. The overall pulpotomy-to-crown ratio was 34% at Nationwide Children's Hospital.

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