

An evaluation of pulpal therapy in primary incisors

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Abstract

In 45 children (18-54 months), 28 pulpotomies, 26 indirect pulp therapies, and 27 pulpectomies were completed in primary incisors with 58 incisors acting as controls. Using clinical and radiographic evaluations, the success rate of pulpotomies, indirect pulp therapies, and pulpectomies did not differ statistically from comparable primary molar rates. Incisor pulpotomy success was 85.7% (mean follow-up 43.8 months), indirect pulp therapy success 92.3% (mean follow-up 42 months), and pulpectomy success 77.7% (mean follow-up 45.5 months). Canal calcifications were common in pulpotomies and indirect pulp therapies. Pulpectomies were affected adversely by preoperative root resorption, but not affected by preoperative trauma nor presence of a preoperative radiolucency. Retained ZOE was found in 73.3% of the exfoliated pulpectomies. The data supported indirect pulp therapy or pulpotomy as the treatment of choice for deep incisor caries unless the dental pulp was necrotic.

Pulp therapy often is indicated for maxillary primary incisors due to extensive caries or trauma. This procedure may involve either partial or complete extirpation of the infected pulpal tissue or indirect pulp therapy. Previous research involving primary teeth evaluating pulpotomies, pulpectomies, and indirect pulp therapy has dealt mainly with primary molars. These studies have mostly evaluated formocresol pulpotomies in primary molars. Success rates have ranged from 70 to 90% depending on the method of evaluation (Law and Lewis 1964; Magnusson 1970; Rolling and Thylstrup 1975). Fewer studies have evaluated pulpectomies. Coll et al. (1985) showed primary molar pulpectomy success rates of more than 80% while Gould's (1972) pulpectomy success was 82%. Nirschl and Avery (1980) found 94.1% success in treating primary molars and young permanent incisors with indirect pulp therapy.

Studies of pulpal treatment in primary incisors usually have dealt with case histories of individual teeth

(Finn 1967; Spedding 1973). However, Flaitz et al. (1987) reported on 57 primary incisor pulpotomies and 87 pulpectomies in teeth that required pulp therapy due to caries or trauma. The incisor pulpotomies were successful in 75.5% of the cases while the pulpectomies were successful in 86.2%. Complete resorption of the paste filler occurred in all the pulpotomies, but in only 55.2% of the pulpectomies.

The purpose of the present study was to: (1) evaluate the success of primary incisor pulpotomies, indirect pulp therapy, and one-appointment pulpectomies; and (2) determine factors that influenced the success of the pulp therapy. Additional assessment was done to evaluate exfoliation of treated teeth, incidence of enamel defects in succedaneous teeth, incidence of canal calcifications in treated teeth, and retention of paste filler material after exfoliation.

Materials and Methods

A total of 45 patients from a private dental practice were included in the the research design. One investigator (JAC) completed 28 pulpotomy procedures, 26 indirect pulp therapy procedures, and 27 pulpectomies in the primary incisors of 30 children. In 15 children, 58 primary incisors were utilized as controls where no pulpal treatment was performed. Children included in this retrospective study were chosen from a patient pool which had adequate preoperative and postoperative radiographs of their incisors, and had been seen for regular recall visits over an 11-year period (July, 1976, to June, 1987).

The criteria for selecting a tooth for a pulpotomy procedure were: (1) absence of a systemic medical contraindication; (2) radiographically deep caries approximating the pulp, but no evidence of pathologic root resorption nor periapical pathology; (3) no sign of mobility nor soft tissue pathology; (4) no history of trauma; (5) presence of a clinical pulp exposure following caries removal; and (6) moderate hemorrhage in the

pulp chamber, but no sign of necrosis extending into the root canal. The criteria for an indirect pulp therapy procedure were the same as the aforementioned 1-4 with no clinical pulp exposure.

Criteria for pulpectomy selection were based on radiographic or clinical signs of pulpal necrosis. In 90% of the cases there was evidence of a draining sinus tract. Other indications for pulpectomy were copious hemorrhage that was uncontrollable or complete lack of hemorrhage upon entrance into the pulp chamber. Radiographically, 22% of the pulpectomy candidates had a periapical radiolucency or incipient pathologic root resorption. A tooth which had been traumatized and discolored was treated with a pulpectomy if a sinus tract was present or if it had the aforementioned radiographic findings. Contraindications for a pulpectomy were signs of extensive internal or external root resorption or lack of adequate bone support as evidenced by excessive mobility.

The formocresol pulpotomy procedure involved isolating the tooth whenever possible with a rubber dam following local anesthesia. If the removal of the soft carious dentin with a slow-speed large round bur revealed a pulp exposure or if, on close inspection, a pinpoint exposure was found, the pulpotomy was started. A #330 high-speed bur was used to open the pulp chamber. A #6 or 8 slow-speed round bur was used to remove the coronal pulp to a depth of 5-7 mm. After the hemorrhaging was controlled by applying pressure with dry cotton pellets, a cotton pellet slightly moistened with Buckley's formocresol (formaldehyde 19%, cresol 35%, glycerin 17.5% — Sultan Chemists Inc, Englewood, NJ) was placed in the pulp chamber for 5 min. A thick mix of ZOE was used to fill the pulp chamber. A final restoration then was completed either at the same visit or at a subsequent one.

The indirect pulp therapy procedure was done following the removal of carious brown leathery dentin. A layer of dentin remained that may have been soft or stained, but its aggressive removal would have revealed a pulp exposure. At this point calcium hydroxide in the form of Dycal® (LD Caulk Co, Milford, DE) was placed over the dentin. The final restoration was placed at the same appointment.

The pulpectomy procedure was similar to the pulpotomy procedure until the pulp chamber was entered. Root canal files starting with size #20-30 up to size #40-50 were used to clean the canal. The files were inserted to a resistance point short of the apex. After each size file was withdrawn, sodium hypochlorite was used to irrigate the canal. After the final irrigation, cotton pellets and paper points were used to dry the canal. One paper point or cotton pellet slightly moistened with Buckley's formocresol was placed in the canal for 5 min. A thick mix

of zinc oxide and eugenol then was condensed into the canal with large root canal lateral condensers. Total treatment time was approximately 20-30 min and all the treatments were done by the same investigator (JAC).

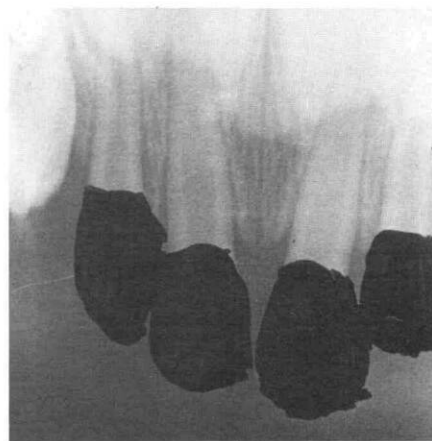
Evaluation of the pulpal therapy's success was done by three investigators. One investigator (JAC) evaluated the clinical success of all the teeth at routine recall appointments. Periapical radiographs usually were exposed every 6-18 months. Success of treatment for the treated teeth was based on a combination of the clinical and radiographic findings. For a tooth to be considered clinically successful, the following criteria were applied: (1) no gingival swelling or residual sinus tract; (2) no sign of purulent exudate expressed from the gingival margin; (3) no abnormal mobility considering the exfoliative state of the tooth; and (4) no history of pain. Radiographic criteria for success were based on the following: (1) no internal resorption of the root canal for pulpotomies or indirect pulp therapy teeth; (2) no external resorption of the root other than that considered normal exfoliation; and (3) a radiolucency resolving as seen in postoperative films. An overall rating of success meant that the treated tooth met all the above clinical and radiographic criteria.

The radiographic assessment method for the pulpotomies, indirect pulp therapies, and untreated controls was based on a double-blind method first tested by Nassof (1981; Fig 1 — next page). In the present study, the individual pre- and postoperative radiographs were mounted beneath clear celluloid plastic sheets. Using typewriter correction Liquid Taperaser® (The Joseph Dixon Crucible Co, Jersey City, NJ), the clinical crown and pulp chamber were obscured. The films were assorted randomly. Two judges (MR, PS) independently rated the pulpal health of the incisors on each film after first standardizing their criteria of assessment on 85 anterior radiographs not included in the study. Then they combined their radiographic assessment with the clinical findings to come up with an overall rating of success or failure for the pulpotomies and indirect therapy-treated teeth, and either normal or abnormal for the controls. In cases of disagreement, the raters reviewed the radiographs and reached agreement or, if necessary, rated the tooth as abnormal.

The radiographic assessment procedure for the pulpectomies differed from that employed for the pulpotomies and the indirect pulp therapy group. In assessing the radiographic success of pulpectomies, one investigator (JAC), viewed all the preoperative and postoperative films sequentially. This finding was combined with the clinical assessment for an overall rating of success or failure.



FIG 1. Radiographs showing the double-blind radiographic assessment method for pulpotomies and indirect pulp therapies. (a, left) Preoperative film, 20 months. (b, right) Same film with type-writer correction fluid applied to obscure pulp chamber contents prior to evaluation. (c, L. left) Patient at 53 months showing failure of maxillary left lateral pulpotomy and success of right lateral which had the common finding of canal calcification. The central incisors were treated with indirect pulp therapies; the left was rated a radiographic failure, the right a success. (d, L. right) Same film as c. with opaque fluid applied that was used to evaluate radiographic pulpal health.



Results

Using the clinical and radiographic criteria for success, the overall success rating for incisor pulpotomies was 85.7% (24/28). The pulpotomies were completed in children with a mean age of 27.5 months (range 18-38 months) and were observed a mean of 43.8 months

(range 20-58 months; Fig 2).

The indirect pulp therapies were rated an overall success in 92.3% (24/26) of the incisors. The mean age at time of treatment was 27.5 months (range 18-38 months) while the mean time followed postoperatively was 42 months (range 20-58 months).

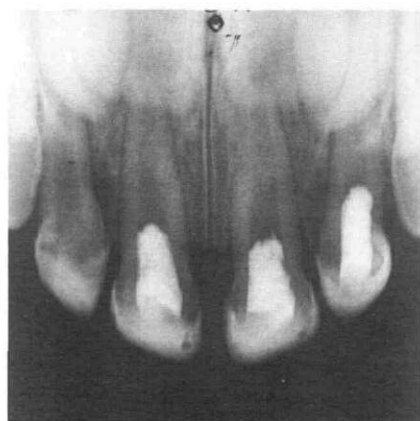


FIG 2. Maxillary incisor radiographs showing 3 pulpotomies and one indirect pulp therapy rated a success. (a, left) Preoperative film at 24 months. (b, center) Patient at age 43 months. (c, right) Patient age 68 months showing normal exfoliation of treated teeth. All 4 permanent incisors erupted without enamel hypoplastic defects.

The incisor pulpectomies were judged successful in 77.7% (21/27) of the teeth (Fig 3). The mean age at the time of treatment for the pulpectomies was 32.7 months (range 22-54 months) and they were followed a mean of 45.5 months (8-77 months).

The success rate of the primary incisor pulpotomies was compared to the rates of primary molar pulp treatments reported by Boeve and Dermout (1982) and Rolling and Thylstrup (1975). There was no statistically significant difference between the success rates for molar pulp treatments and incisor pulp treatments. The indirect pulp therapy-treated incisors had a success rate of 92.3% (24/26) which was not significantly different from the 94.1% rate of success for molars found by Nirschl and Avery (1980) when tested with a Chi-square analysis.

Chi-square analyses were run on incisor pulpotomy success vs. the length of time post-treatment, whether a central or lateral incisor was treated, and age of patient at time of treatment. No significant differences were found among the different primary incisor success rates vs. the above variables. When indirect pulp therapy

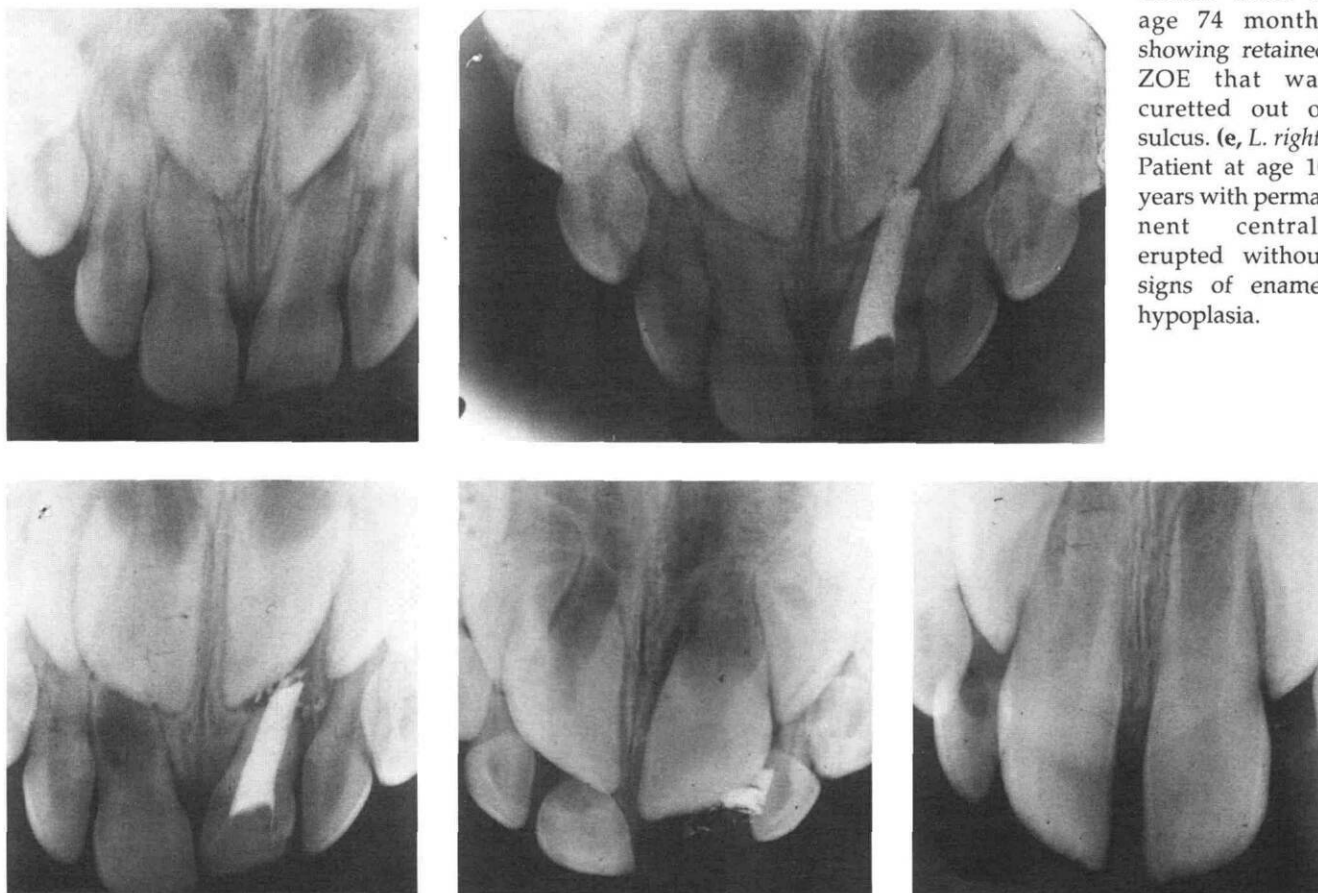
success rates were compared to the same variables, no statistically significant differences were found.

In the 4 of 28 incisor pulp treatments rated as failures, none exhibited pain as a symptom. All 4 teeth showed signs of internal resorption of the root canal and an apical radiolucency. Clinically, none of the 4 incisors had any signs of excess mobility or soft tissue pathology. In the 2 of 26 indirect pulp therapy-treated teeth rated as failures, both showed signs of periapical pathology on postoperative radiographs and one had symptoms of pain.

Canal calcifications were noted in 39.3% (11/28) of the pulp treatments and 15.4% (4/26) of the indirect pulp therapies, while 12.1% (7/58) of the control incisors had calcifications. Chi-square analysis showed that pulpotomy canal calcifications were increased significantly compared to the control teeth (Chi-square 8.45 with 1 df at a .05 level of confidence). There were no statistically significant differences found comparing control teeth calcifications to the indirect pulp therapy group or the pulpotomy calcifications to the indirect pulp therapies.

Fig 3. Series of radiographs showing a pulpectomy in a maxillary right primary incisor that was rated a success. (a, U. far left) Patient age 28 months presented for treatment for a necrotic incisor that had a draining sinus tract following trauma. (b, U. left) Age 48 months postoperative film. (c, L. left) Age 67 months showing initial resorption of root canal. (d, L. center) Exfoliation of

treated tooth at age 74 months showing retained ZOE that was curetted out of sulcus. (e, L. right) Patient at age 10 years with permanent centrals erupted without signs of enamel hypoplasia.



The success rating of the pulpectomies was compared to the presence or absence of preoperative apical resorption (Table 1). There was a statistically significant difference in the rates of success of incisor pulpectomies compared to the presence or absence of preoperative root resorption. Pulpectomy success rates were compared to the presence or absence of a preoperative radiolucency (Table 2). There was no statistically significant difference between the presence of a preoperative radiolucency and the success rates of the pulpectomies. The incidence of trauma vs. success of pulpectomies was studied. The statistical analysis showed no significant difference in success rates of pulpectomies in teeth suffering preoperative trauma and those without a history of preoperative trauma (Table 3).

Chi-square analyses were performed on incisor pulpectomy success rates vs. whether a central or lateral incisor was treated, length of time post-treatment, and age of patient at time of treatment. None of the above variables were statistically significant in affecting pulpectomy success rates. The success rates of incisor

TABLE 1. Effect of Root Resorption on Pulpectomy Success

	Pulpectomy	
	Success	Failure
Pre-op resorption	2	4
No resorption	19	2

Chi Square = 5.85.

Significant at .05 with 1 df using Yates correction.

TABLE 2. Effect of Preoperative Radiolucency on Pulpectomy Success

	Pulpectomy	
	Success	Failure
Radiolucency	4	2
No radiolucency	17	4

Chi Square = .034.

N.S. at 1 df using Yates correction.

TABLE 3. Effect of Preoperative Trauma on Pulpectomy Success

	Pulpectomy	
	Success	Failure
Trauma	6	2
No Trauma	15	4

Chi Square = .079.

N.S. at 1 df using Yates correction.

pulpectomies were compared to the reported molar pulpectomy success rates of Coll (1985) and Gould (1972). No statistically significant difference was found.

In the 6 of 27 pulpectomy teeth rated as failures, two were evaluated as having pathologic root resorption on postoperative films. One pulpectomy rated as a failure had an unresolved draining sinus tract and three others had pathologic root resorption combined with an unresolved apical radiolucency (Fig 4).

The treated teeth were followed an average of 6 postoperative recall visits to evaluate exfoliation, retention of the paste filler, and incidence of hypoplastic defects in succedaneous teeth. There were 53.6% (15/28) of the pulpotomies that exfoliated and none had ZOE paste filler retained in the gingiva. One of these 15 succedaneous incisors had a hypoplastic defect. It should be noted that the child with this hypoplastic defect had severe trauma to the upper incisor area after the pulpotomy had been completed. Of the 15 pulpotomies that exfoliated, 20.0% (3/15) were considered to have been over-retained (treated tooth present for more than 6 months after its antimere exfoliated). The indirect pulp therapy group had 69.2% (18/26) of the incisors exfoliate, and none of the permanent successors erupted with hypoplastic defects, while 5.5% (1/18) were over-retained. In the pulpectomy group, 55.5% (15/27) of the teeth exfoliated and 73.3% (11/15) had the ZOE filler paste retained in the gingival sulcus. In the 14 succedaneous incisors that erupted following a pulpectomy, 14.2% (2/14) had hypoplastic defects in the enamel. These two children had a history of severe trauma prior to the pulpectomy procedure. Of the 15 exfoliated pulpectomized incisors, 73.3% (11/15) were considered to have exfoliated normally. This determination was based on comparing the time of exfoliation of the treated tooth to a contralateral untreated tooth or to the time of eruption of the mandibular incisors. There were 2/15 exfoliated pulpectomized incisors that exfoliated too early (6 months before antimere), and 2/15 that were over-retained.

Discussion

The success rates for incisor pulpotomies (85.7%) and indirect pulp therapy (92.3%) were high. Both types of treatment were done in teeth with clinically and radiographically deep caries, but no sign of periapical pathology nor history of preoperative trauma. Primary incisor pulpotomies appear to be indicated for deep caries where there is a pulp exposure, while indirect pulp therapies seem indicated for a near exposure. Primary incisors that have suffered trauma may or may not have the above rate of success if treated with a pulpotomy because that was not evaluated in this study.

Incisor pulpotomies reported by Flaitz et al. (1987)



FIG 4. (a, left) Patient age 35 months with maxillary right central treated with a root canal after avulsing the right lateral 1 year previously. Note preoperative root resorption at apex of right central. (b, right) Patient 6 months later showing failure of root canal treatment. Both central incisors were extracted. The right permanent central incisor erupted with a small hypoplastic defect, while the left had no defect.



had a success rate of 75.5% and were followed 37.2 months. The present study's 85.7% incisor pulpotomy success rate over a 43.8-month period is consistent with Flaitz's findings, and not significantly different from primary molar success rates reported by Boeve and Dermaut (1982) and Rolling and Thylstrup (1975). An important difference between teeth considered candidates for pulpotomies in the Flaitz study was that 22.8% of the primary incisors had preoperative radiolucencies while none of the present study's pulpotomies had preoperative radiolucencies. Since primary molars are not considered for a pulpotomy if a periapical radiolucency is present, it seemed logical not to attempt incisor pulpotomies if a radiolucency was present. This may explain the lower success rate found in the Flaitz study.

The incisor pulpectomy success rate of 77.7% was not statistically different from molar pulpectomy rates reported by Coll et al. (1985) and Gould (1972). Preoperative root resorption was found to be the significant factor that adversely affected the success rate in incisor pulpectomies. Incisor pulpectomies with the presence of preoperative apical radiolucencies or history of preoperative trauma did not show a statistically different rate of success compared to those incisors without such symptoms. These findings support the belief that a primary incisor pulpectomy is a viable alternative to extraction if the tooth had no root resorption. The presence of root resorption likely made it difficult to obturate the apex and prevent continued pathologic root resorption and resolution of any apical infection.

Flaitz et al. (1987) found that 22.9% of the incisor pulpectomies followed 37.2 months had pathologic root resorption, but the success rate was determined to be 86.2%. In the present study, the pulpectomy success rate was 77.7%. If any pulpectomy had pathologic root resorption, it was classified as a failure because one of the main criteria for pulpectomy failure was pathologic root resorption. Using this criteria, Flaitz's rate of success for incisor pulpectomies would be 77.1% and almost the same as this study's.

A disturbing finding was that 73.3% (11/15) of the exfoliated incisor pulpectomies showed part of the ZOE paste filler retained in the gingiva. This high percentage may have resulted from the parents being told to bring their child in for an examination within 2 weeks of exfoliation of the pulpectomized incisor. A radiograph was exposed and any retained ZOE was curetted out of the gingiva. This procedure was followed because prior research had revealed that in half of the exfoliated molar pulpectomies, retained filler paste was found (Coll et al. 1985). However, Flaitz et al. (1987) found incomplete resorption of the filler paste in 45% of the incisor pulpectomies. It has been shown that ZOE irritates the periapical tissues (Erasquin and Muruzabal 1967). Further research is needed to find a more resorbable and less irritating root canal filler than ZOE, such as an iodoform paste as studied by Garcia-Godoy (1987).

From the data collected on hypoplastic defects in succedaneous incisors, only 1 of 15 pulpotomized incisors and 2 of 14 pulpectomized incisors had succedaneous teeth erupt with hypoplastic defects. In all three cases, there was severe trauma either before pulp treatment, or in the case of the pulpotomy, after treatment. In none of the 10 of 14 exfoliated pulpectomies that were performed due to caries and had no history of trauma, was there any sign of hypoplasia in succedaneous teeth. The history of trauma to the primary dentition appears to be an important factor in causing hypoplastic defects in permanent incisors rather than the performance of pulpal treatment in primary teeth as was proposed by Pruhs et al. (1977).

The finding that canal calcifications were increased in pulpotomized incisors is not surprising. This observation has been reported by Fuks (1983) in rhesus monkey pulpotomized primary incisors and by Willard (1976) in children's pulpotomized primary molars. The incisor canal calcifications were a narrowing of the canal, but it was not always as dramatic as is seen in pulpotomized molars. Possibly this was due to the shorter time the pulpotomized incisor is in place as

compared to a molar. In addition, since 12% of the 58 control teeth exhibited similar narrowing of the canals, incisor canal calcification may not be considered pathologic.

The timing of exfoliation of primary incisors treated with various pulp therapies does not seem to be a problem. Only 3 teeth with pulpotomies, 2 with pulpectomies, and 1 with indirect pulp therapy were over-retained. In addition, only 2 teeth with pulpectomies exfoliated early.

Some dentists, when treating primary incisors with deep caries resulting in a near or frank pulp exposure, believe a pulpectomy should be the treatment of choice in the belief that the tooth will not "flare up" again. The present study has shown that the success rates for a pulpotomy and indirect pulp therapy are higher than a pulpectomy, although not statistically significant. Since pulpectomies showed that more than 73% had retained ZOE paste filler in the gingiva, this leads one to advocate indirect pulp therapy and pulpotomy treatment unless the pulp of the tooth is necrotic.

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