

A long-term followup on the retention rate of zinc oxide eugenol filler after primary tooth pulpectomy

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Abstract

A retrospective study of all the patients' records (> 6000) in a pediatric dental practice was done to assess ZOE retention after a pulpectomized primary tooth was lost and the succedaneous tooth erupted. There were 65 children with 81 ZOE pulpectomies done in 30 incisors and 51 molars. Pulpectomies were done at a mean chronologic age of 52.2 months and followed for a mean time of 90.8 months from time of placement. The initial radiograph after the pulpectomized tooth was lost, showed retained ZOE filler particles in 49.4% of the cases while 27.3% had retained ZOE a mean time of 40.2 months after pulpectomy tooth loss. Short-filled pulpectomies retained significantly less ZOE than long fills ($P = 0.04$). With time, retained ZOE particles either resorbed completely or showed reduction of filler size in 80% of the cases. No pathology was associated with the retained ZOE particles. Retention of ZOE was not related to pulpectomy success ($P = 0.11$), preoperative root resorption ($P = 0.76$), age of the patient ($P = 0.24$ incisors; $P = 0.87$ molars), extraction/exfoliation of the pulpectomy ($P = 0.75$), or timing of the pulpectomy's loss ($P = 0.72$). (Pediatr Dent 15:249-52, 1993)

Introduction and literature review

Zinc oxide and eugenol (ZOE) is one of the most widely used preparations for primary tooth pulpectomies. Erausquin and Muruzabal¹ used ZOE as a root canal filling in 141 rats followed from 1 to 90 days. They noted the ZOE irritated the periapical tissues and caused necrosis of bone and cementum. In addition, they noted that extruded ZOE developed a fibrous capsule that prevented resorption. Gould² first reported a one-visit ZOE pulpectomy study in 1972 in which 39 molars were filled with ZOE. He concluded 35 of the 39 molars followed for a mean time of 16 months were treated successfully. No mention was made whether the ZOE was extruded and retained in the tissue. In 1982, Jerrell and Ronk³ presented a case report of an overfilled ZOE pulpectomy in which the succedaneous premolar was malformed. They noted that special caution should be taken to prevent overfilling with ZOE in teeth with large apical foramina.

Coll et al.⁴ in 1985, reported a more than 80% success rate in one-visit ZOE primary molar pulpectomies followed a mean time of 70 months. They found ZOE retained in the tissue after 8 of 17 molars exfoliated. Spedding⁵ reported two cases of incomplete ZOE resorption after pulpectomies followed over five years. Coll et al.⁶ reported on 27 primary incisor ZOE pulpectomies followed a mean time of 45.5 months. They reported a 77.7% (21/27) success rate, but 11 of 15 pulpectomies had ZOE retained in the tissue after exfoliation.

Flaitz et al.⁷ in 1989 reported findings for 87 primary incisor ZOE pulpectomies in which 84% were rated a success after a mean time of 37 months. The same group, in 1991, reported a 82.3% success rate for 62 ZOE molar pulpectomies followed a mean time of 40.2 months. The

authors wrote subsequent to these two reports that they never observed ZOE on a radiograph after the loss of a pulpectomized molar.⁹ They stated that ZOE can be observed after exfoliation of incisors but will be resorbed.

The purpose of this retrospective study was to examine radiographically the rate of ZOE retention after pulpectomized teeth were lost and the factors that influenced that rate.

Methods and materials

All active and inactive patient records (> 6000) of a pediatric dental practice begun in 1975 were reviewed in 1991 to identify those patients who had a ZOE pulpectomy. To be included in this retrospective study, the patient had to have had a pulpectomy in which the tooth showed preoperative radiographic and/or clinical signs of irreversible pulpitis (i.e., bifurcation radiolucency or fistula). The tooth had to meet the following requirements: 1) have a preoperative and two or more postoperative radiographs to evaluate the pulpectomy; 2) have lost the pulpectomized tooth (exfoliated or extracted) and have erupted the succedaneous tooth; and 3) have a radiograph of the succedaneous tooth. Consent to take the needed radiographs of patients was obtained after risks and benefits were discussed. All pulpectomies were done as described by Coll et al.⁴ and filled with a thick mix of ZOE that contained no formocresol.

The two authors standardized their pulpectomy rating technique by first evaluating five pulpectomies not included in the study. The pulpectomies included in the study were rated independently by each author by reviewing the chart's notations and radiographs. They then

Table 1. Criteria for pulpectomy success

<i>Clinical Criteria</i>	<i>Radiographic Criteria</i>
1. No gingival swelling or sinus tract 6 months or more postoperatively	1. No pathologic signs of external root resorption
2. No purulent exudate expressed from the gingival margin	2. A bifurcation radiolucency resolved 6–12 months postoperatively
3. No abnormal mobility other than mobility from normal exfoliation	3. No periapical radiolucency formation postoperatively
4. No pain on postoperative checkup	

compared their ratings and found more than 90% agreement. The authors discussed the cases they rated differently and reached mutual agreement on the evaluation or ranked the tooth in the lower of the two ratings.

Each root canal was rated a success or failure based on the clinical entries in the chart made at every post-treatment recall and radiographic review. Both authors independently rated pulpectomy success. A successful pulpectomy satisfied all the criteria listed in Table 1.

The radiographs were evaluated for preoperative external root resorption and adequacy of endodontic fill.

Preoperative radiographs were ranked for degree of preoperative root resorption as: 1) *no external root resorption*; 2) *minimal resorption* of any root (1 mm or less of resorption); and 3) *excess resorption* of any root (greater than 1 mm of apical resorption). Adequacy of endodontic fill was recorded from the immediate postfill radiograph. For incisors, a short fill was defined as ZOE 1 mm or more short of the apex, a complete fill had ZOE ending at the apex, and a long fill if any ZOE extruded outside the root. For molars, if any canal showed ZOE outside the root, the fill was termed long. If all the canals were filled 1 mm or more short of the apex, the fill was termed short. The fill was termed complete if one or more of the fills ended at the radiographic apex. A Boley gauge was used when necessary to categorize the teeth.

Each root canal was evaluated for signs of retained ZOE in the first radiograph after the pulpectomized tooth



Fig 1a. Necrotic mandibular right second primary molar with mesial root and bifurcation radiolucency rated as having no preoperative root resorption on 3/2/77, patient age 5 years.



Fig 1b. Pulpectomy almost eight months postfill (10/19/77) rated a success with ZOE fill evaluated as ending at the apex.



Fig 1c. Pulpectomy four years seven months post treatment (10-81) nearing exfoliation.

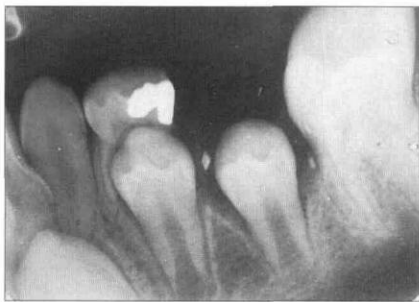


Fig 1d. Pulpectomy two days after exfoliation (6/30/82) rated as early loss (note the first primary molar had not exfoliated) with retained ZOE particles that were unable to be curetted out of the tissue.



Fig 1e. Second premolar had erupted into normal position (1/27/83) seven months after pulpectomy exfoliation with retained ZOE particles visible.



Fig 1f. Second premolar area seven and one-half years after pulpectomy exfoliation (11/22/89) showing total resorption of the ZOE particles.

was lost. Any radiographic evidence of radiopaque material in the region of an exfoliated/extracted pulpectomy was categorized as the ZOE being retained. The ZOE was rated as completely resorbed if no evidence of radiopaque material was noted by both examiners (Figures 1a–f). In those cases in which ZOE was retained and two or more postexfoliation or extraction radiographs were available, the size of the ZOE particle(s) was measured sequentially with a Boley gauge.

The time of pulpectomy tooth loss was categorized as being early, normal, or late. This assessment used radiographs and the chart entries close to the time of the tooth's loss. Comparisons were made to the contralateral tooth if untreated, and the eruption timing of the other adjacent and opposing teeth. More than six months difference in loss or retention of a tooth was considered abnormally early or late as compared to these other untreated teeth (Figure 1d).

Chi-square analysis and paired Student's *t*-tests with significance levels of $P = 0.05$ or less were employed.

Results

There were 65 children who had 81 pulpectomies with adequate radiographs available for this study. This sample had 33 males and 32 females with ZOE pulpectomies in 30 incisors (26 centrals and 4 laterals), and 51 molars (16 mandibular first, 16 mandibular second, 14 maxillary first, and 5 maxillary second molars). One of the authors (JAC) did 77 of the pulpectomies, and another pediatric dentist did the other four. Patients ranged in age from 19–111 months at time of treatment with a mean age of 52.2 months.

The ZOE was retained at a rate of 49.4% (38/77) based on the first radiograph after the pulpectomized tooth exfoliated or was extracted. Based on the final radiograph available, 27.3% (21/77) of cases still had retained ZOE. The mean length of postoperative followup from the date of the pulpectomy until final radiograph was more than seven years (90.8 months), with a range of 20–177 months. The mean length of time from pulpectomy tooth loss until the final radiograph of the succedaneous tooth was 40.2 months (range 0–140 months). Molars had 52.1% (25/48) retained ZOE and incisors, 44.8% (13/29), which was not statistically different ($P = 0.70$, Table 2).

The retention of ZOE was significantly different ($P = 0.04$) in root canals filled short of the radiographic apex, compared to those with ZOE extruded outside the root. Pulpectomies filled 1 mm or more short of the apex showed 35.3% (12/34) ZOE retention, versus 65.4% (17/26) retained ZOE for canals filled long (Table 2). There were 17 pulpectomies with complete fills to the apex, showing 52.9% (9/17) ZOE retention. Pulpectomies filled short were compared to the group with complete fills together with long fills. There was a statistical difference ($P = 0.05$) with respect to retention of ZOE (Table 2).

Factors that may have affected the rate of ZOE retention were tested (Table 2). Success or failure of the pulpec-

Table 2. Pulpectomy ZOE resorption data

Variable	% With Retained ZOE	<i>P</i> Value
Molars	52.1% (25/48)	0.70
Incisors	44.8 (13/29)	
Short fill	35.3 (12/34)	0.04
Long fill	65.4 (17/26)	
Short fill	35.3 (12/34)	0.05
Complete & long fill	60.5 (26/43)	
Success	55.0 (33/60)	0.11
Failure	29.4 (5/17)	
Pre-operative root resorption		
None	45.7 (16/35)	
Minimal	52.2 (12/23)	0.76
Excessive	56.3 (9/16)	
Exfoliated	53.1 (26/49)	0.75
Extracted	46.4 (13/28)	
Normal loss	47.4 (18/38)	0.72
Early & late loss	54.5 (18/33)	
Age of patient at time of incisor pulpectomy		
36 months or less	35.0 (7/20)	0.24
37 months or more	66.6 (6/9)	
Age of patient at time of molar pulpectomy		
48 months or less	51.4 (19/37)	0.87
49 months or more	52.1% (25/48)	

tomy was not significantly related to the retention rate of ZOE. Successful pulpectomies had 55% (33/60) retained ZOE while failed pulpectomies had 29.4% (5/17). A chi-square test of significance showed no significant difference ($P = 0.11$) between these rates. The amount of preoperative root resorption showed no statistical difference in the retention rate of ZOE when tested with chi-square analysis ($P = 0.76$). Teeth with no preoperative root resorption had 45.7% (16/35) retained ZOE, those with minimal resorption 52.2% (12/23), and those with excess resorption 56.3% (9/16). The pulpectomies that exfoliated and retained ZOE did so at a rate of 53.1% (26/49) compared to those that were extracted and retained ZOE at a rate of 46.4% (13/28). There was no significant difference ($P = 0.75$) between these rates when tested by chi-square analysis. ZOE retention was not related to the timing of the primary tooth's loss. Those pulpectomies lost at the normal time showed 47.4% (18/38) rate of ZOE retention, versus 54.5% (18/33) retention in the early and late group. These rates were not statistically different ($P = 0.72$) with chi-square analysis. The age of the patient at time of treatment was not significantly related to whether ZOE was retained or not. Neither incisors nor molars showed a statistical relationship with chi-square analysis between

the rate of ZOE retention and the age of the patient at the time of treatment ($P = 0.24$ incisors; $P = 0.87$ molars).

Pulpectomies exhibiting retained ZOE following tooth loss that also totally resorbed, did so after a mean time of 50.1 months. This was compared to the comparable mean time of the pulpectomies with ZOE retained but still present, which was 24.2 months. There was a statistically significant difference between these means (Table 3). Ten patients with postexfoliation/extraction radiographs were available to measure sequentially the size of the retained ZOE particle(s) over time. In 80% (8/10) of these patients, the size of the retained ZOE particle(s) decreased by .5 mm or more in a mean time of 2.87 years (range 10–89 months). In the other two patients, no decrease in size was noted after one year in one patient or after 4.5 years for the other. Of the 21 pulpectomies that still had ZOE retained on the final radiograph, no pathology was noted around any of these ZOE particles, and no signs of gingival swelling or pain had been noted from the treating dentist's chart notes.

Table 3. Mean time since pulpectomized tooth was lost

	Mean Time (Months)	SD
ZOE retained and still present	24.2	± 26.3
ZOE retained and later resorbed	50.1	± 28.0

t value = 2.191, Critical value = 2.054, $P = 0.05$ significant.

Discussion

The retention rate of ZOE following loss of pulpectomies for all teeth was 49.4% with no significant difference between molars and incisors. The reason for this relatively high rate of ZOE retention was possibly related to the way one of the authors (JAC) treated 42 of the 81 cases. Radiographs were exposed within one month after tooth loss. If the dentist had waited a year or more after tooth loss to take a radiograph, the retention rate may have been lower. The 49.4% (38/77) retained ZOE compares to 59.4% (19/32) retained ZOE in the molars (8/17) and incisors (11/15) reported by Coll et al.^{4,6} in 1985 and 1988. There were nine molars from the 1985 study and 12 incisors from the 1988 study that comprised part of the 81 teeth reported here. These differences likely reflected sampling differences.

Barr et al.⁹ in 1991 stated that after primary teeth with ZOE pulpectomies are lost, they did not find retained filler. They never observed retained ZOE in pulpectomized primary molars. They reported incisor pulpectomies may have retained ZOE initially after exfoliation, but ZOE will not be seen on subsequent radiographs. The 49.4% rate of initial ZOE retention with 27.3% (21/77) of the cases still retaining ZOE over a mean time of 40.2 months postpulpectomy tooth loss conflicts with their contention. From this study, we learned it is possible to remove retained ZOE by curettage immediately after exfoliation or extraction. If retained, observation showed the ZOE could take years to resorb, and in one case no resorption was

seen 4.5 years later. It's disturbing that a few cases showed no ZOE resorption, however, the retained ZOE caused no apparent pathology in the follow-up radiographs or exams. This suggests further research is indicated to confirm that retained ZOE particles cause no harm even if never resorbed.

The time data findings indicated retained ZOE tended to resorb with time. The findings in this study may reflect osteoclastic activity to reduce or eliminate retained ZOE particles. The pulpectomies took a mean time of 50.1 months for ZOE to resorb. In the cases in which ZOE was retained, 80% showed significant reduction of the retained filler's size over time. These later cases showed reductions of the retained filler by .5 mm or more over time. Measurement error is possible since nonstandard sequential radiographs were used, but this seems unlikely since the ZOE particles would break into much smaller particles and have less radiodensity. The volume of the retained ZOE particle may be a factor in some of the cases showing no resorption. The resorbability of the ZOE did not agree with Erausquin and Muruzabal¹ whose 1967 study concluded ZOE was insoluble in rat body fluids over a 90-day postoperative period. They noted that a fibrous capsule formed around extruded ZOE, which reduced resorption. This may be true for the few cases in this study when retained ZOE filler particles did not reduce in size over time. The differences between Erausquin and Muruzabal's findings in rats and this study may reflect differences between the species' abilities to resorb ZOE or the longer followup of this study.

A significantly higher rate of ZOE retention was noted in those pulpectomies where the filling extended outside the root (65.4%) and those filled completely to the apex (52.9%), as compared to those filled 1 mm or more short of the apex (35.3%). The angle of the x-ray beam of the immediate postfill radiograph may have caused some long fills to appear to end at the apex. A slight lingual or buccal root resorption at the apex may have caused an overfill to appear as a fill ending at the apex. Either possibility would result in the group of root canals classified as filled to the apex to contain some long fills. It seems advisable to fill canals short of the apex rather than to the apex or beyond, to avoid retained ZOE.

Yacobi et al.¹⁰ stated that complete pulpectomy obturation with ZOE was preferred to underfilling, based on pulpectomy success. They further stated underfilling was better than overfilling due to the possibility of extruding the ZOE beyond the root and initiating irritation. Their study involved doing pulpectomies rather than vital pulp treatments in an effort to avoid using formocresol. They were not placing pulpectomies in necrotic teeth, so their length of fill data may not apply to necrotic teeth. Their report was a 12-month post-treatment followup, so the issue of retained ZOE and their long-term findings are yet unknown.

Other reports^{11–15} have advocated the use of iodoform pastes as a root canal filler. These types of pastes are

resorbable in the periradicular area in cases where it is expressed inadvertently, and retention of the iodoform paste after pulpectomy loss has not been reported by Garcia-Godoy¹³ or Rifkin.^{11,12} Its cytotoxic effects have not been established though the filler contains combinations of p-chlorophenol, camphor, iodoform, and other materials. Personal use by one of the authors (JAC) has indicated some iodoform pulpectomies resorb inside the root canal to give the appearance of a "long pulpotomy" 6–12 months post-treatment. Further research is warranted to determine if iodoform pastes are better than ZOE for primary teeth.

The present study showed ZOE retention was not related to the following: success or failure of the pulpectomy; amount of preoperative root resorption; whether the pulpectomy was extracted or exfoliated; the timing of the pulpectomized tooth; or the age of the patient at time of treatment. The fact that failed pulpectomies and those with excessive root resorption retained ZOE at the same rate as successful ones and those with minimal or no preoperative root resorption seemed surprising. A possible explanation could be the presence of a mild chronic inflammation at the apex of successful pulpectomies and a chronic infection under failed ones that equally affect the ZOE resorption. A slightly lower rate of ZOE retention for extracted pulpectomies was not statistically different than for exfoliated ones. The extraction process may have removed some of the ZOE that otherwise would have been retained. Whether the pulpectomized tooth was lost early, normally, or late was not related to ZOE retention. This rating system may not have been sensitive enough to test for the effect of time on ZOE retention. The fact that age of the patient at the time of treatment was not related to ZOE retention likely reflected the pulpectomy technique was not different in young versus old.

Conclusions

1. Retained ZOE appeared on the initial radiograph after loss of the pulpectomized tooth in 49.4% of the cases after a mean followup of 90.8 months from the date of the pulpectomy with no significant difference in retention rates between molars and incisors ($P = 0.70$).
2. ZOE was retained in 27.3% of cases after a mean time of 40.2 months after the loss of the pulpectomized tooth. None of the retained filler particles caused any observable pathology.
3. Short-filled pulpectomies (1 mm or more short of the apex) retained ZOE less often (35.3%) than fills beyond the root (65.4%) or those filled completely to the apex (52.9%).

4. The size of most retained ZOE filler particles decreased over time. Retained ZOE that totally resorbed did so after a mean time of 50.1 months following pulpectomy tooth loss but tended to be present after a mean time of 24.2 months. If ZOE was retained initially, 80% totally or partially resorbed with time, while 20% showed no resorption.
5. Retained ZOE was not related to: pulpectomy success or failure ($P = 0.11$), pulpectomy preoperative root resorption ($P = 0.76$), age of the patient at time of treatment ($P = 0.24$ incisors; $P = 0.87$ molars), whether the pulpectomized tooth was extracted or exfoliated ($P = 0.75$), or the timing of the pulpectomy's loss ($P = 0.72$).

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