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# CLINICAL AND RADIOGRAPHICAL EVALUATION OF NANOHYDROXYAPATITE PASTE ON PULPOTOMIZED PRIMARY MOLARS

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## *ABSTRACT*

**Objective:** To evaluate the effect of Nano-hydroxyapatite on pulpotomized primary molars clinically and radiographically in comparison to Zinc Oxide Eugenol and Mineral Trioxide Aggregate. **Subjects and Method:** Thirty-six children patients (4-8y) had primary molars indicated for pulpotomy. The children's teeth were classified randomly according to the applied capping material into 3 equal groups (Zinc Oxide Eugenol, Nano-hydroxyapatite crystals, and MTA). The teeth were evaluated clinically and radiographically at 1, 3 & 6 months intervals. **Results:** The clinical and radiographic success rates were 88% in the Zinc Oxide Eugenol group. While the clinical and radiographic success rates were 91.77% & 83.33% in the Nano-hydroxyapatite group and 100% and 91.77% in the Mineral Trioxide Aggregate group respectively. However, the comparison between the three groups revealed no significant difference between them. **Conclusion:** Nano-hydroxyapatite can be used efficiently as a pulpotomy agent for primary molars.

**KEYWORDS:** Pulpotomy, primary molars, Nano-hydroxyapatite, MTA, Zinc Oxide Eugenol.

## INTRODUCTION

The dental pulp is a soft connective tissue confined within the hard walls of the dentin which plays an important role in the prognosis of the tooth. Exposure of the pulp due to various reasons like caries, fractures, cracks, or an open restoration margin often results in inflammation of the pulp which can subsequently lead to pulpal death if not treated at the earliest. Preservation of pulpal vitality is of paramount importance as the vital functioning pulp is capable of initiating several important functions like the formation of dentin, providing nutritive support to the tooth, enabling a defensive function, and possessing a unique reparative capacity (1).

Pulpotomy is a vital pulp therapy in which the coronal portion of the pulp is removed surgically and the remaining radicular pulp is preserved intact. Over the remaining radicular pulp tissue, a suitable material is placed which has the potential to protect the pulp from further insult and initiate healing and repair. The rationale behind pulpotomy procedures is based on the ability of the remaining radicular pulp to recover following the removal of the infected coronal pulp tissue and placement of a suitable medicament (2).

Various root canal filling materials for primary teeth have been used from time to time; the most commonly used and readily available materials are zinc oxide eugenol (ZOE) and calcium hydroxide. ZOE has a slow rate of resorption and has a tendency to be retained even after tooth exfoliation; in some cases unresorbed material has been found

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to cause deflection of the successor tooth. ZOE has also been used in combination with different fixative agents, viz, formocresol, paraformaldehyde, and cresol, all of which have inherent cytotoxicity apart from other drawbacks. Calcium hydroxide, despite its antiseptic and osteo-inductive properties, tends to get depleted from the canals earlier than the physiologic resorption of the roots [3].

Mineral Trioxide Aggregate (MTA) is a biocompatible material approved by the US Federal Drug Administration (FDA) with a wide range of applications in restorative dentistry and endodontic regenerative therapy [4,5]. MTA is mainly composed of inorganic oxides such as tricalcium silicate, dicalcium silicate and tricalcium aluminate containing bismuth oxide and plaster[6]. This material is hydraulic modified Portland cement that was originally developed as root-end filling material. In addition to these applications, MTA has been applied to direct pulp capping, vital pulpotomy, root canal fillings and root resorption repair [7]. Therefore, it has attracted attention as a biomaterial for pulp capping instead of calcium hydroxide, which has been used until now.

To overcome the disadvantages of ZOE, calcium hydroxide, and iodoform, and their different formulations, various materials have been advocated for use in pulpotomy procedures based on their important properties such as biocompatibility, sealing ability, and antimicrobial efficacy when placed in contact with the inflamed pulp. The use of Nanohydroxyapatite crystals was assessed for their regenerative potential. Nanohydroxyapatite is biocompatible material for soft tissues and bone. It's effective in alveolar ridge augmentation healing of periodontal bone defects and osseointegration of titanium implants. Hydroxyapatite, which is the main constituent of dental hard tissues, may immediately provide an artificial barrier. Despite the putative abilities of Hydroxyapatite to be osteoconductive, osteogenic and dentinogenic [8], up to our knowledge, there are few studies that investigate Nano-hydroxyapatite as a pulpotomized agent for primary teeth.

## SUBJECTS AND METHODS

The present study was conducted in the Department of Pedodontics and Oral Health Department, Faculty of Dental Medicine, Al-Azhar University (Cairo, Boys). The sample size for the current study was determined based on previous research [9].

Thirty-six primary molars suffering from caries with pulp involvement indicated for pulpotomy aged between 4 and 8 years were treated. The teeth indicated for pulpotomy were assessed and evaluated at one, three and six months follow-up periods.

**Inclusion criteria:**

The Children age from 4 to 8 years old, vital primary molars, inflammation confined in coronal pulp only.

**Exclusion criteria:**

History of spontaneous pain, Mobility (grade I, II and III), external or internal resorption.

**Ethical consideration:**

The study was approved by Ethical Committee of Faculty of Dental Medicine, Boys, Cairo, Al-Azhar University. NO. (560/2943) Every patient's parent signed an informed written consent form.

Nanoydroxyapatite crystals with an average particle size of 15-25 nm were used for the study. The Nanoydroxyapatite crystals were mixed with sterile physiological saline solution to form a paste before its application (Fig. 1).

FIG (1) Nanohydroxyapatite paste mix (15-25 nm)

The primary molars under this group were treated with mineral trioxide aggregate paste (MTA). Then prepared according to the manufacturer's instructions to obtain a putty-like consistency.

**Pulpotomy procedure [10]:**

The procedure was carried out step-by-step in one visit as follows; under local anesthesia, rubber dam was used to isolate the tooth, Figs 2. The establishment of cavity outline form was done and all marginal caries were removed before the pulp was exposed. Exposure of the coronal pulp was carried out with a round bur:

1. The access cavity was enlarged to the limit of the pulp horns to simplify coronal pulp removal.
2. The coronal pulp was removed with a sterile sharp spoon excavator. The pulp was amputated to the entrance of the root canal.
3. The pulp chamber was irrigated with sterile saline to prevent dentinal chips from being forced into the radicular pulp.
4. Following irrigation, sterile cotton pellets were applied to the amputated pulp stumps to aid in hemostasis. The selected molars were randomly divided into three groups consisting of 12 primary molars each:

A. Formocresol Pulpotomy group.

B. Nanohydroxyapatite crystals group.

C. Mineral trioxide aggregate group.

***Group A***

1. All the primary molars under study were treated with a cotton pellet moistened with Formocresol using a sterile cotton pellet for 3–5 minutes.
2. After removal of the cotton pellet, zinc oxide eugenol was then placed over the pulp stump, subsequently the tooth was restored

***Group B (Figs 2 a-d)***

1. All the primary molars under study were treated with a paste of Nanohydroxyapatite crystals (mixed in sterile physiological saline solution) such that a layer of the paste covers the floor of the coronal pulp chamber.

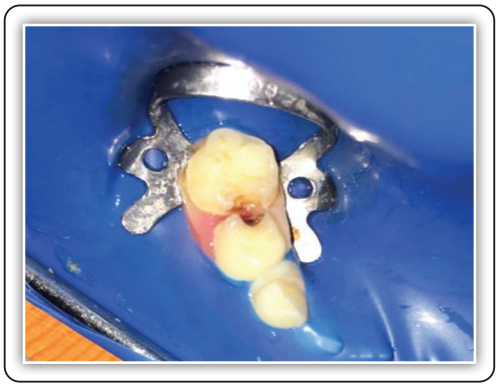

FIG (2-a) Tooth isolated with rubber dam for Nano hydroxyapatite Pulpotomy

FIG (2-b) Showing the same teeth immediately after caries removal, and pulp amputation

FIG (2-c) Showing the same teeth after placing of a paste of Nanohydroxyapatite as pulp capping material

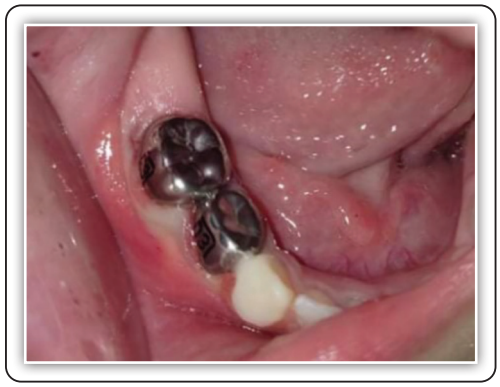

FIG (2-b) Showing the same teeth immediately after caries removal, and pulp amputation

FIG (2) Nano-hydroxyapatite pulpotomy steps in lower deciduous molars of 6y boy.

2. Zinc oxide eugenol base was then placed over the pulp stumps. Subsequently, the tooth was restored.

***Group C***

1. The primary molars under this group were treated with mineral trioxide aggregate paste (MTA). MTA was prepared according to the manufacturer's instructions to obtain a putty-like consistency.
2. The mixture was delivered to the pulp stumps and was condensed lightly with a moistened sterile cotton pellet to ensure a thickness of 2 to 3 mm. followed by the final restoration.

The children under study were recalled for clinical and radiographic examination at follow-up of 1, 3 and 6 months (Figs 3). Clinical assessment at the follow-up examination (Table 1). Radiographic assessment at the follow-up examination (Table 2). The data obtained were tabulated and statistical analysis done. The differences in the clinical and radiographic success among the three groups were statistically analyzed by F-test (one way Anova) test.

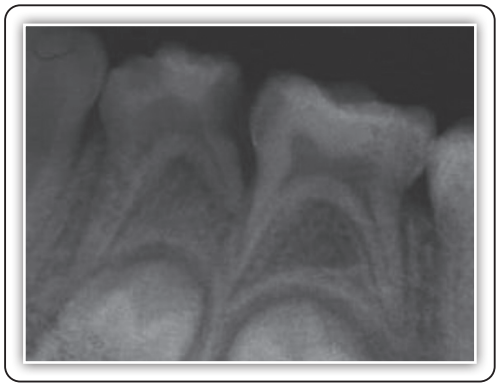

FIG (3-a) Decayed lower right second primary molar (pre-operative).

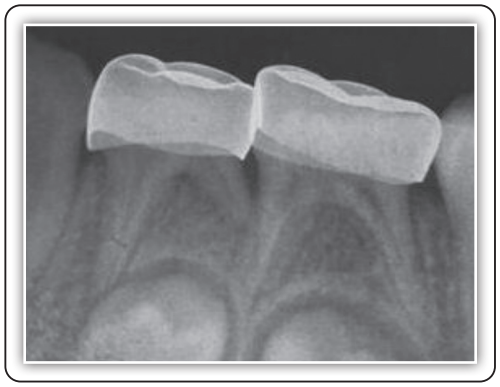

FIG (3-b) After one month follow-up.

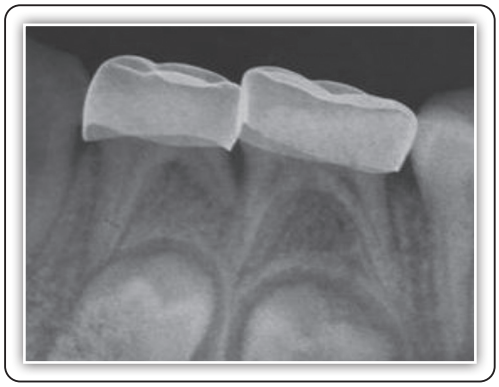

FIG (3-c) After three months follow-up.

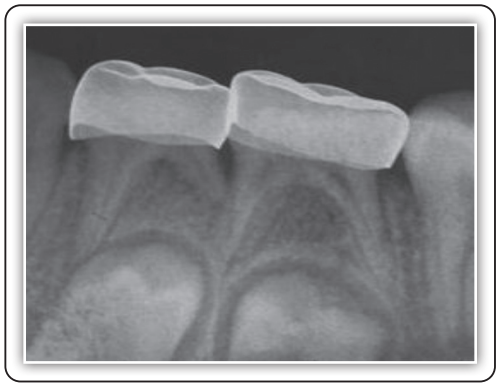

FIG (3-d) After six months follow-up.

FIG (3) (A-D): Nanohydroxyapatite Obturation material (group B) after pulpotomy of primary molar of 6 years aged child

**TABLE (1)** Clinical assessment

| S. No. | Clinical evaluation criteria | Yes | No |
|---|---|---|---|
| 3. | Mobility of the tooth | | |
| 4. | Presence of pain | | |
| 5. | Presence of swelling | | |

**TABLE (2)** Radiographic assessment

| S. No. | Radiographic evaluation criteria | Yes | No |
|---|---|---|---|
| 1. | Internal resorption | | |
| 2. | Radiolucency at the periapical Region | | |

### Statistical analysis

The data were collected, tabulated and statistically analyzed using SPSS program software, version 22.0. Paired t-test and ANOVA test were used to compare between sample means for quantitative data with normal distribution. The statistical significance level was set at 5% ($p \leq 0.05$ is considered statistically significant).

## RESULTS

The age of children in this study were ranged from (4-8y) age. Twelve children with a mean age 4.5 ± 0.45 years for group A; 12 children with a mean age 4.75 ± 0.62 years for group B, and 12 children with a mean age of 4.92 ± 0.79 years for group C. There was a statistically non-significant difference between the three groups regarding the mean of age.

Twenty-one children (58%) were females, their ages were also ranged between 4-8 years. Fifteen out of them (42%) were males their ages were ranged between 4-8y and the mean age was 4.78 y. It was found that there is no significant difference between the ages of the males and females [*P*>0.05]. Table (3)

**TABLE (3):** Comparison between the three studied groups according to demographic data

| | **ZOE (n = 12)** | **NHA (n = 12)** | **MTA (n = 12)** | **Sig.** |
|---|---|---|---|---|
| **Gender** | | | | |
| Male | 5 (41.7%) | 6 (50.0%) | 4 (66.7%) | p1=0.682 |
| Female | 7 (58.3%) | 6 (50.0%) | 8 (66.7%) | p2=0.673<br>p3=0.407 |
| **Age (years)** | | | | p1=0.415 |
| Mean ± SD. | 4.50±0.79 | 4.75±0.62 | 4.92±0.79 | p2=0.178<br>p3=0.586 |

*SD:* **Standard deviation**

*p: P-value for comparing between the studied groups*

**F***:* **F for ANOVA test**,*Pair wise comparison bet. each 2 groups was done using* **Post Hoc Test (Tukey)**

*P1: Difference between ZOE&NHA, P2: difference between ZOE&MTA , P3: difference between NHA& MTA*

### Radiographic evaluation

#### *Resorption*

It was found that at one and three months follow up in group A, all primary molars (100%) responded positively to obturation material after pulpotomy, Meanwhile, at 6 months evaluation only one molar complained of resorption. In group B no resorption was reported at one and three months follow up, at six months there were three molars. In group C at one and three months follow up no resorption was reported, while at six months there was only one molar complained of resorption. There was a statistically non-significant difference in mean resorption measurements between groups, Table (4).

## RADIOLUCENCY

In regarding to the main of radiolucency it was found that in group A none of the treated molars showed radiolucency at one month follow up, at three months there was only one molar and at six months there were two molars. In the group B no

**TABLE (4)** Comparison between the three studied groups according to Radiographic criteria

| Character | Intervals | Criteria presence | ZOE (n = 12) | NHA (n = 12) | MTA (n = 12) | Significance |
|---|---|---|---|---|---|---|
| Absence of Resorption | 1st M | Yes | 12 (100.0%) | 12 (100.0%) | 12 (100.0%) | ——— |
| | | No | 0 (0.0%) | 0 (0.0%) | 0 (0.0%) | |
| | 3rd M | Yes | 12 (100.0%) | 12 (100.0%) | 12 (100.0%) | ——— |
| | | No | 0 (0.0%) | 0 (0.0%) | 0 (0.0%) | |
| | 6th M | Yes | 11 (91.7%) | 9 (75.0%) | 11 (91.7%) | p1=0.273 |
| | | No | 1 (8.3%) | 3 (25.0%) | 1 (8.3%) | p3=0.273 |
| Absence of Radiolucency | 1st M | Yes | 12 (100.0%) | 12 (100.0%) | 12 (100.0%) | ——— |
| | | No | 0 (0.0%) | 0 (0.0%) | 0 (0.0%) | |
| | 3rd M | Yes | 11 (91.7%) | 11 (91.7%) | 12 (100.0%) | p2=0.307 |
| | | No | 1 (8.3%) | 1 (8.3%) | 0 (0.0%) | p3=0.307 |
| | 6th M | Yes | 10 (83.3%) | 9 (75.0%) | 11 (91.7%) | p1=0.615 |
| | | No | 2 (16.7%) | 3 (25.0%) | 1 (8.3%) | p2=0.537 p3=0.273 |

**F*: F for ANOVA test***, *One Way ANOVA test*

** Significant at p≤ 0.05. p: P-value for comparing between the studied groups*

*P1:difference between ZOE&NHA, P2: difference between ZOE&MTA, P3: difference between NHA& MTA*

molars come with radiolucency at one month follow up, at three months there was only one molar and at six months there were three molars. Meanwhile in group C it was found that none of the treated molars complained of radiolucency at one and three months follow up so this group showed the highest success rate but at six months one molar comes with radiolucency. There was a statistically non-significant difference in mean radiolucency measurements between groups, Table (4).

## Clinical evaluation

### *Mobility*

After one month follow up in ZOE group, all the treated molars showed no Mobility and the same after three months follow up. After six months, two molars showed mobility. Meanwhile in NHA group, at one month there are no mobility, but after three to six months follow up period, there are two molars with mobility. There was a statistically non-significant difference in mean mobility measurements between groups, Table (5).

### *Pain*

Regarding pain, it was found that in group A at one and three months follow up none of the molars complained of pain, at six months there was only one molar with pain. In group B no molars come with pain at one month follow up, at three months there was only one molar and at six months there were two molars. In group C, none of the molars complained of pain at the different times intervals of follow up which makes group C higher in success rate than that found in groups A and C, although there a difference between the groups Comparison

**TABLE (5)** Comparison between the three studied groups according to clinical criteria

| Character | Intervals | Criteria presence | ZOE (n = 12) | NHA (n = 12) | MTA (n = 12) | Significance |
|---|---|---|---|---|---|---|
| Absence of swelling | 1st M | Yes | 12 (100.0%) | 12 (100.0%) | 12 (100.0%) | ——— |
| | | No | 0 (0.0%) | 0 (0.0%) | 0 (0.0%) | |
| | 3rd M | Yes | 12 (100.0%) | 11 (91.7%) | 12 (100.0%) | P1=0.307 |
| | | No | 0 (0.0%) | 1 (8.3%) | 0 (0.0%) | P3=0.307 |
| | 6th M | Yes | 11 (91.7%) | 10 (83.3%) | 12 (100.0%) | P1=0.537 |
| | | No | 1 (8.3%) | 2 (16.7%) | 0 (0.0%) | P2=0.350<br>P3=0.139 |
| Absence of Mobility | 1st M | Yes | 12 (100.0%) | 12 (100.0%) | 12 (100.0%) | ——— |
| | | No | 0 (0.0%) | 0 (0.0%) | 0 (0.0%) | |
| | 3rd M | Yes | 12 (100.0%) | 10 (83.3%) | 12 (100.0%) | P1=0.139 |
| | | No | 0 (0.0%) | 2 (16.7%) | 0 (0.0%) | P3=0.139 |
| | 6th M | Yes | 10 (83.3%) | 10 (83.3%) | 11 (91.7%) | P2=0.537 |
| | | No | 2 (16.7%) | 2 (16.7%) | 1 (8.3%) | P3=0.537 |
| Absence of pain | 1st M | Yes | 12 (100.0%) | 12 (100.0%) | 12 (100.0%) | ——— |
| | | No | 0 (0.0%) | 0 (0.0%) | 0 (0.0%) | |
| | 3rd M | Yes | 12 (100.0%) | 11 (91.7%) | 12 (100.0%) | P1=0.307 |
| | | No | 0 (0.0%) | 1 (8.3%) | 0 (0.0%) | P3=0.307 |
| | 6th M | Yes | 11 (91.7%) | 10 (83.3%) | 12 (100.0%) | P1=0.537 |
| | | No | 1 (8.3%) | 2 (16.7%) | 0 (0.0%) | P2=0.350<br>P3=0.139 |

**F*: F for ANOVA test***, *One Way ANOVA test* * *Significant at p≤ 0.05.*

*p: value for comparing between the studied groups*

**P1:difference between ZOE&NHA, P2: difference between ZOE&MTA , P3: difference between NHA& MTA**

between the three studied groups according to mobility. Pain evaluated at 1, 3, and 6 months intervals. There was a statistically non-significant difference in mean pain measurements, Table (5).

***Swelling***

Regarding swelling measurement, it was found that in group A at one and three months follow up none of the molars complained of pain, at six months there was only one molar complained of swelling, In group B no molars comes with swelling at one month follow up, at three months there was only one molar and at six months there were two molars. In group C, none of the molars complained of swelling at the different times intervals of follow up which makes group C higher in success rate than that found in group A and group B. There was a statistically non-significant difference in mean swelling measurements, Table (5).

## DISCUSSION

For many years the use of Formocresol has been proved as the most successful medicament for pulpotomy of primary teeth. However, several studies have raised concerns over the safe use of this material in the pulp. This has led to several investigations looking at the potential alternative for Formocresol including, Glutaraldehyde, and MTA [10].

In the last years MTA was dominant as highly successful capping material due to its biocompatibility, bioactive, hydrophilic, radiopacity, and sealing ability and low solubility. However it showed some drawbacks as discoloration, long sitting time and expensive price. So many investigations were made to reach an ideal alternative capping materials as bioactive glass and Nanohydroxyapatite [11].

The rationale for the use of Nanohydroxyapatite crystals in this study was because the mineral content of bone and teeth is a calcium phosphate salt, hydroxyapatite is biocompatible material for soft tissues and bone which would be a potential medicament for pulpotomy procedure.

Several researchers have tried to customize its properties' bioactivity, mechanical strength, and solubility by controlling its composition, morphology, and nano-particle size. Thus, nanotechnology can play an important role in the development of porous bioceramics with high mechanical strength, as well as enhanced bioactivity and absorbability. Using nanotechnology, calcium and phosphate can be manipulated at the molecular level and assembled to produce materials with unique structural and functional properties [11,12,13].

ZO/E based restorative material is one of the most commonly used restorative materials in dentistry, and it is widely used as a base in pulpotomy because of its antibacterial and analgesic properties. The results of the current study were confirmed by the systematic review and meta-analysis held by Coll et al [14] ,they evaluated the outcomes of different pulp therapy techniques in primary molars. The highest level of success and quality of evidence was related to the use of MTA followed by FC after a 12-months follow up period. These results could be attributed to the favorable pulpal response, the high potential healing capability and the high regenerative power associated with the use of MTA maintaining the primary pulp vital and healthy [15].

The results are in agreement with the results of Olatosi et al. [16] evaluated and compared the clinical and radiographic response of mineral trioxide aggregate (MTA) as pulpotomy materials on primary molars. At the end of the follow-up, the clinical success rates MTA were 100%. While the radiographic success rates MTA were 96%. MTA showed a higher clinical and radiographic success rate as a pulpotomy medicament in vital primary molars.

The promising clinical outcome of vital pulpotomy performed with Nanohydroxyapatite paste may be explained on the bases that has excellent biocompatibility with human teeth and bone, making it very attractive for biomedical applications[17]. Hydroxyapatite and Mineral Trioxide Aggregate (MTA) are capable of releasing calcium ions into an environment with high pH and enabling regeneration of hard tissues. This has prompted dental researchers to evaluate the possibility of its use as an alternative to calcium hydroxide and formocresol in pulp capping procedures.

The observed clinical success rate of NHA is nearly in agreement with the results was previously reported by Adlakha et al.[18] whom evaluated the efficacy of HA crystals and Glutaraldehyde as pulpotomy agents for primary molars and reported that all treated molars in the HA group, after 6 months follow-up period, were clinically successful. However, their radiographic findings showed a success rate of 80.33%. These high success rates were attributed to the high biocompatibility, alkalinity, regenerative power, and excellent sealing ability of Nana-HA and were also explained based on the histologic findings recorded by Haghgoo

et al. [19] stated that NHA may act as chemical cell absorbent that facilitates the invasion of osteoblasts. This may have greater penetration, better contact with pulp tissue and better sealing ability.

## CONCLUSION

Based on the results of the current study Nanohydroxyapatite is a promising pulpotomized material with a high clinical and radiographical success rate and showed competitive properties to ZO/E after FC application.

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