

Original Article

Clinical and Radiographic Assessment of Partial Pulpotomy versus Complete Pulpotomy in Vital Primary Molars Using MTA: A Randomized Controlled Clinical Trial

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Abstract

Aim: The aim is to assess the clinical and radiographic effect of partial pulpotomy versus complete pulpotomy using MTA in asymptomatic vital primary molars with deep caries. **Methodology:** A randomized controlled clinical split-mouth trial was designed, 50 mandibular molars in 25 children aged 4 to 6 years were assigned into two groups (n=25). Each patient had two deep carious non-symptomatic primary molars. Partial pulpotomy (group A) and complete pulpotomy (group B) were done for each child. After coronal pulp amputation and achieving hemostasis, MTA was placed over pulp stumps and teeth covered with stainless steel crown. All treated patients were followed-up at 1 week, and 3,6,9 months post-operatively. **Results:** The partial pulpotomy (group A) showed failure in two cases (8%). The first case reported clinical failure (pain and swelling) and radiographic failure (bone resorption and root resorption) at 6 months follow-up. Complete pulpotomy (group B) showed a success rate of 100% clinically and radiographically. **Conclusions:** The overall success rate of maintaining pulp vitality of 92.0% suggests that partial pulpotomy is a viable operative approach to treat primary teeth with deep carious lesions.

Keywords: Pulpotomy, Partial, Complete, MTA, Radiographic.

I. INTRODUCTION

Children's health, growth, and psychology are the main concern of all parents. Pediatric dentists always aim to get a happy, pain-free, and quick dental visit for their young patients. Using every

effort to apply fast and effective therapy to kids is the target of pediatric dentistry (Ebrahimi *et al.*, 2022). Asymptomatic deeply carious vital primary molars are mainly treated using the pulpotomy technique (Ansari *et al.*, 2018; Dhar *et al.*, 2017).

Special attention while treating deeply carious primary teeth is directed to pulp status. The best dental practice must be followed in diagnosing pulp health or disease and providing evidence concerning the efficiency of different therapeutic interventions (Barnkggei *et al.*, 2013). In children with extensive caries in the primary dentition, pulp treatment is mandatory, especially in molars, which are of major importance for occlusal development. Under such circumstances, a partial pulpotomy may simplify pulpal treatment compared to traditional pulpotomy (Cohenca *et al.*, 2013).

Pulpotomy is the commonly used technique for treating primary molars. Its goals are to retain the tooth, maintain arch length and integrity until the eruption of permanent successors into the oral cavity, prevent discomfort and inflammation, and preserve the radicular pulp (Grewal *et al.*, 2016). Recovery of the non-inflamed radicular pulp can occur along one of three therapeutic approaches following amputation of the inflamed coronal pulp; Devitalization: radicular pulp becomes non vital and nonfunctional, Preservation: radicular pulp demonstrates minimal changes and Regeneration: radicular pulp is not only vital and functional, but is also stimulated to form dentin bridge (Godhi, 2016; Neamatollahi and Tajik, 2006).

The partial pulpotomy technique was introduced mainly for the treatment of young permanent teeth. In 1987, Schröder (Schröder *et al.*, 1987) used partial pulpotomy for treating deeply carious primary teeth with chronic coronal pulpitis, it showed a success rate of 83%. In partial pulpotomy, the coronal pulp next to the site of pulp exposure is only partially removed. The type of pulp treatment has been established by Cvek (Cvek, 1978). The pulp condition at the time of treatment is critical to the result. It is required to choose teeth where the coronal pulp and the region nearest to the exposure site are the only places with chronic inflammation (Kher *et al.*, 2019).

Dental materials have been developed greatly throughout the years. Mineral trioxide aggregate (MTA) is a bioactive material, which was introduced in 1990. It is a fine hydrophilic powder, consisting of tricalcium silicate, tricalcium aluminate, silicate oxide, and bismuth oxide. MTA is proven to be a highly biocompatible material. MTA is currently being used in pulp therapy and has provided an enhanced seal over vital pulp and is non-resorbable. It showed a success rate of 100% when used as a dressing material for pulpotomy in primary teeth (Camilleri and Pitt Ford, 2006; Neamatollahi and Tajik, 2006).

Complete pulpotomy was the most commonly used therapy in treatment of deeply carious primary molars. It has some limitations in being time consuming. So this study is designed to assess the clinical and radiographic effectiveness of partial and complete pulpotomy in primary molars using MTA. This clinical trial has potential benefits to patients because its more conservative to the pulp tissue.

The aim of this study is to assess clinically partial pulpotomy versus complete pulpotomy in treatment of vital carious primary molars using MTA after one week, 3 months, 6 months, and 9 months. Radiographic assessment of either techniques was done at baseline, and after 6 months follow-up period.

II. SUBJECTS AND METHODS

PICO Questions: Is there a clinical or radiographic differences in partial pulpotomy versus complete pulpotomy in vital primary molars using MTA?

The Research Ethics Committee, Faculty of Dentistry, Cairo University approved this research concerning the scientific content and compliance with applicable research and human subjects regulations. This study was registered on clinical trial.gov with the identifier NCT04650113.

Interviews were held with the parents/ caregivers of the participating children to explain the study, and discuss the treatment plan, all the possible outcomes, and the anticipated prognosis. The parents were then asked to sign an informed consent agreeing to the procedure and the use of the patients' data for scientific studies, as well as, agreeing for making radiographs.

A. Study design

This study was a randomized controlled split-mouth trial (RCT) with 1:1 allocation ratio. The children were selected from the outpatient clinic of the Pediatric Dentistry and Dental Public Health Department, Faculty of Dentistry, Cairo University.

Fifty lower primary molars fulfilling the following eligibility criteria were included in the study. Inclusion traits involved: age range from 4-6 years, cooperative, medically free child who was able to attend all the follow-up visits, had asymptomatic lower vital primary molars with a deep carious lesion, had no clinical signs of pulpal degeneration (spontaneous pain, fistula, mobility) prior to treatment, absence of tenderness to percussion, absence of pre-operative pain or only short-term pain, and absence of pathologic internal or external root resorption, or any evidence of inter-radicular bone destruction on preliminary radiographs. Exclusion criteria comprised the parents who refuse to participate in the study.

B. Sample size determination

The Medical Biostatistics Unit reviewed and approved the sample size in 20\7\2019. A power analysis was designed to have adequate power to apply a 2-sided statistical test of the research question regarding the clinical and radiographic assessment of partial pulpotomy versus complete pulpotomy in vital primary molars using MTA: A Randomized Clinical Trial.

According to the result of Isaac et al. (Isaac and Michael, 1995), a success rate of complete pulpotomy of 100 % was shown, by document confidence level (95%) with a margin of error of

(5%) if the success of partial pulpotomy showed (70%). The predictive sample size (n) and the total of 42 primary molars i.e. (21) for each group, included the predicted dropout through the follow-up period. This number was increased for missing data to 50 primary molars i.e. (25) for each group. Size calculation was performed using G* power version 3.1.9.2.

Fifty lower molars in 25 patients were recruited for this clinical trial and were randomly and equally allocated into two groups. Group A; the intervention group using partial pulpotomy and Group B; the control group using complete pulpotomy.

C. Informed consent

Parent guardians written approval were taken by signing the informed consent after discussing the treatment plan and all the possible outcomes.

D. Diagnosis

A specially designed diagnostic chart was utilized for each patient, which comprised five sections, personal history, medical history, dental history, clinical examination, and radiographic examination.

E. Clinical procedure

Routine non-pharmacological behavior management techniques were used to manage the children in both groups. The partial and complete pulpotomy procedure was performed on all the selected molars in a single appointment by the same operator (Main investigator) according to UK National Clinical Guidelines in Paediatric Dentistry, 2006.

Group A (Partial pulpotomy):

The injection site for all lower molars was anesthetized using topical anesthetic gel (Lidocaine Hydrochloride (Lidocaine gel, USA). All lower molars were anesthetized with inferior alveolar

nerve block by 3% articaine, epinephrine (artpharma Co. for pharmaceuticals). All lower molars were isolated using Rubber dam (Sanctuary Health, Malaysia).

Removal of all the enamel and dentin caries by high-speed handpiece with water coolant was done using a sterile round diamond bur (Diamond round bur size 012) with gentle hand pressure. The very superficially inflamed layer of the pulp was gently removed to a depth of 2-3 mm when a pinpoint pulp exposure occurred at the end of caries removal. (AAPD.,2020) Hemorrhage control was obtained within 2-3 minutes using sterile cotton pellets placed with light pressure over the pulpal stumps. The pellet was removed, and the layer of Mineral trioxide aggregate (Angelus cement,white.korea) was placed over the pulp stump that was prepared according to the manufacturer's instructions, and the tooth was filled with Glass Ionomer Cement (GIC). The tooth was prepared and restored with Stainless Steel Crown (SSC) cemented with GIC.

Group B (Complete pulpotomy):

The injection site for all lower molars was anesthetized using topical anesthetic gel. All lower molars were anesthetized with inferior alveolar nerve block by 3% articaine. All lower molars were isolated using rubber dam. Removal of caries in enamel and dentin was done. Coronal pulp was amputated using a no.330 bur, any remains of coronal pulp tissue were removed with a sharp sterile excavator or large bur in the low-speed hand piece under coolant water.

Hemorrhage control was obtained within 2-3 minutes using sterile cotton pellets placed with light pressure over the pulpal stumps. The layer of MTA was placed over the pulp stump, and the tooth was filled with GIC. The tooth was prepared and restored with SSC cemented with GIC.

F. Randomization

We planned for a split-mouth technique and all patients were treated using two different techniques; both partial and complete pulpotomy; for the right and left sides. All participants were randomly assigned the right or left side was allocated randomly in both the control and the intervention group.

Sequence generation eligible consented participants were randomly assigned. To know which side control or intervention group was done according to a sequence generated on a Microsoft Excel sheet where the intervention (I) and the control (C) were simply randomized. The table of sequence generation was kept with the co-supervisor.

G. Post-operative instructions and care

The children were instructed to: avoid lip or cheek biting, avoid eating on the working side for at least 20 minutes, brush their teeth at least 2 times per day using a soft pediatric toothbrush and horizontal scrub technique which is the recommended technique in primary and early mixed dentition (Muller-Bolla and Courson, 2013).

H. Follow-up protocol

All treated patients were followed -up for clinical assessment of pulpotomized molars after 1 week, 3, 6, and 9 months post-operatively. At each visit the patient was asked about: the presence of pain: the patient was asked about its presence, the presence of swelling: by inspection and palpation, and the presence of mobility: by applying pressure with 2 mirror handles from the buccal and lingual sides.

I. Statistical analysis

Categorical data was represented as frequency (n) and percentage (%) and was analyzed using chi-square test for intergroup comparisons and Cochran's Q test for intragroup comparisons. Numerical data was explored for normality by checking the data distribution, calculating the mean

and median values, and using Kolmogorov-Smirnov and Shapiro-Wilk tests. The significance level was set at $P = 0.05$ for all tests. Statistical analysis was performed with IBM SPSS Statistics Version 26 for Windows.

III. RESULTS

1. Clinical assessment (pain, swelling, and mobility):

After one week and both groups A (partial pulpotomy) and B (complete pulpotomy) showed no pain, no swelling, and no mobility. There was no statistically significant difference between both groups. The same findings were recorded after 3 months, as illustrated in Figure(2). While after 6 months, group A revealed pain and swelling for one molar while it showed no mobility in all teeth.

Clinical examination for that molar showed the presence of pain on percussion and swelling related to the buccal mucosa Figure (3)b, while radiographic examination showed pathological internal root resorption of that molar surrounded with bone radiolucency as shown in Figure (4)a; that molar was re-treated using the pulpectomy technique as clarified in Figure(4)b. That molar was considered as a dropout tooth throughout the next follow-up at nine months. On contrary, group B showed no pain, no swelling, and no mobility, and no statistically significant difference was observed between both groups.

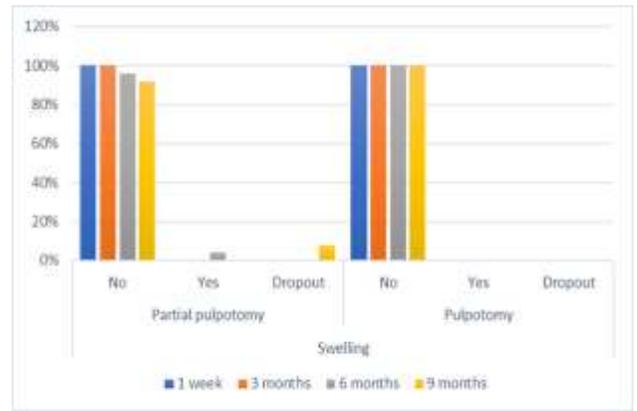


Figure (2): Bar chart showing swelling status in the two groups at different follow-up intervals

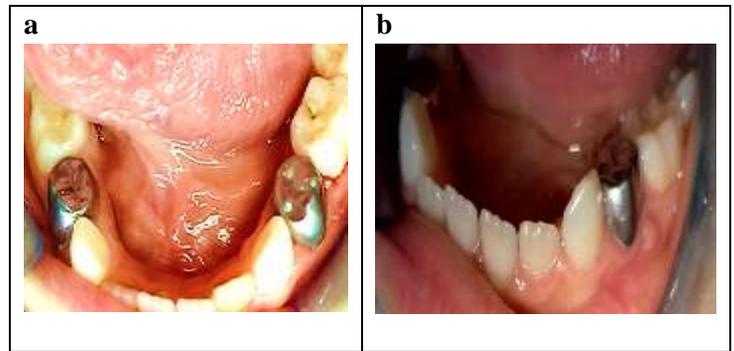


Figure (3): a: post-operative clinical photo at baseline, b: post-operative clinical photo showing swelling in the buccal mucosa related to primary first molar treated with partial pulpotomy after 6 months

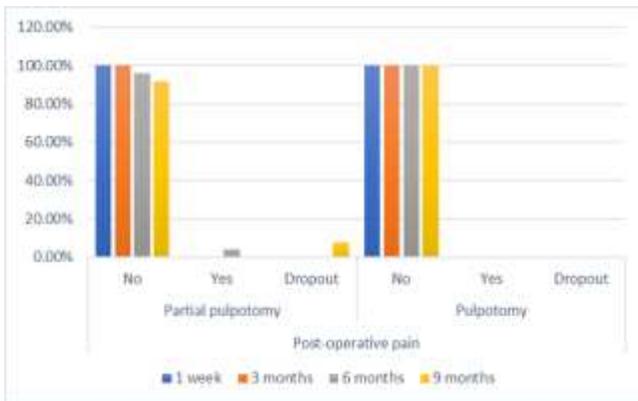


Figure (1): Bar chart showing post-operative pain status in the two groups at different follow-up intervals

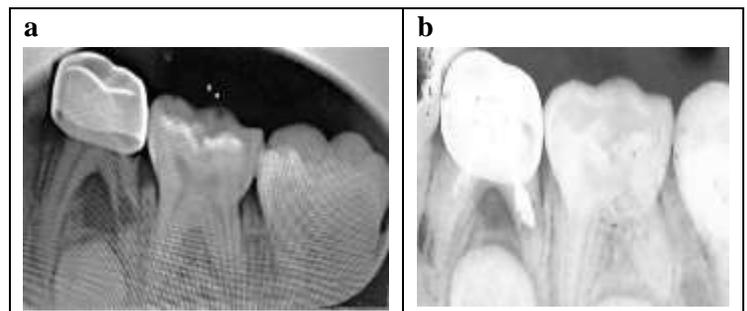


Figure (4): a: post-operative radiograph of primary first molar with partial pulpotomy after 6 months showing bone and root resorption, b: re-treatment for the tooth using pulpectomy technique.

After 9 months, two teeth from the 25 teeth group A were considered as failure. The first failure tooth was the molar that showed pain and swelling at six months follow up periods. The second failure molar was another molar that showed only pathological bone and root resorption at 6 months follow-up periods, as described in Figure (5) although that molar didn't show any clinical signs and symptoms, as demonstrated in Figure (6), thus it was extracted at six months follow-up due to presence of severely resorbed roots, so it was considered as a dropout at the nine month follow-up periods. On the other hand, group B showed no pain, no swelling, and no mobility. There was no statistically significant difference between both groups.



Figure (5): Post-operative radiograph after 6 months follow-up showing bone resorption and root resorption of first primary molar



Fig (6): Post-operative clinical photo at 6 months for partial pulpotomy at right first molar and pulpotomy at left first molar (split mouth)

2. Radiographic assessment

2.1 Root resorption

According to Table (1), group A showed root resorption for 2 molars after 6 months, while group B showed no root resorption. There was no statistically significant difference between both groups.

Table (1): Frequency (n) and percentage (%) values for root resorption status in the two groups at different intervals in intergroup comparison.

Interval	Root resorption		Group		Odds ratio (95%CI)	p-value
			G A	G B		
			Partial pulpotomy	Pulpotomy		
Baseline	No	n	25	25	1 (0.02:52.37)	NA
		%	100%	100%		
	Yes	n	0	0		
		%	0%	0%		
6 months	No	n	23	25	5.43 (0.25:118.96)	0.157ns
		%	92.0%	100.0%		
	Yes	n	2	0		
		%	8.0%	0.0%		

2.2 Bone resorption

After 6 months, group A showed bone resorption for 2 molars, as illustrated in Table (2) and Figures (4 a, 5). While group B showed no bone resorption. There was no statistically significant difference between both groups (p=1).

Table (2): Frequency (n) and percentage (%) values for bone resorption status in the two groups at different intervals in intergroup comparison.

Interval	Bone resorption		Group		Odds ratio (95%CI)	p-value
			G A	G B		
			Partial pulpotomy	Pulpotomy		
Baseline	No	n	25	25	1 (0.02:52.37)	NA
		%	100%	100%		
	Yes	n	0	0		
		%	0%	0%		
6 months	No	n	23	25	5.43 (0.25:118.96)	0.157ns
		%	92.0%	100.0%		
	Yes	n	2	0		
		%	8.0%	0.0%		

3. Overall outcomes:

Group A showed success in 23 molars (92%) and failures in 2 molars (8.0%). While group B showed success in 25 molars (100%). There was no statistically significant difference between both groups ($p=0.157$).

Table (3): Frequency (n) and percentage (%) values for overall success and failure in the two groups

Overall outcome		Group		Odds ratio (95%CI)	p-value
		G A	G B		
		Partial pulpotomy	Pulpotomy		
Failure	n	2	0	5.43 (0.25:118.96)	0.157ns
	%	8.0%	0.0%		
Success	n	23	25		
	%	92.0%	100%		

IV. DISCUSSION

Deeply carious primary teeth are usually treated with pulpotomy, pulp therapy is the most common procedure done for them (Kher *et al.*, 2019). Partial pulpotomy has potential benefits for patients because it's simple, conservative to the pulp tissue, and less time-consuming procedure (Trairatvorakul and Koothiratrakarn, 2012). Also, it preserves cell-rich coronal pulp tissue and enhances physiologic dentin deposition in the cervical area than complete pulpotomy (Godhi, 2016; Nagi *et al.*, 2018). Complete pulpotomy was commonly used therapy in the treatment of deeply carious primary molars. It has some limitations in being a more invasive pulp therapy than partial pulpotomy. So, this study was designed to assess and compare the clinical and radiographic effectiveness of partial and complete pulpotomy in primary molars using MTA.

This current study was designed as a split-mouth randomized controlled trial because each patient has his or her means of control and the results were more accurate and individual differences had the least impact on the study's outcome. This is similar to the findings of Shafie, (Shafie *et al.*, 2017). The procedure of both techniques (partial pulpotomy and complete pulpotomy) and SSC were done in one visit, due to the guardian's financial situation as a result of time off from work and lower transportation costs, particularly in rural areas, and the impact on the behavior of the child compared to two visits.

Only lower molars were included in the study, as identifying the radiographic pathology, and healing in lower molars is relatively easier and more observable compared to upper molars due to the overlapping of permanent teeth buds over primary roots (Ebrahimi *et al.*, 2022; Schröder *et al.*, 1987; Trairatvorakul and Koothiratrakarn, 2012). The molars included in the study are either the first or second primary molar and this is different from the study by Ebrahimi *et al.* (Ebrahimi *et al.*, 2022), who

chose only the second molar to enhance the accuracy of radiographic examination.

In this study, all the teeth included were primary teeth and this is comparable to researches by (Ebrahimi *et al.*, 2022; Schröder *et al.*, 1987; Trairatvorakul and Koothiratrakarn, 2012). While on the (Asgary *et al.*, 2018), (Eghbal *et al.*, 2020) and (Eggmann *et al.*, 2022) used partial pulpotomy in permanent teeth. The included teeth had no history of pain or only short-term pain to make sure that the pulp is healthy unlike the study by Schröder *et al.* (Schröder *et al.*, 1987), who chose the pulp with chronic pulpitis.

MTA was used in this study; because MTA is a biocompatible material, when in contact with the periradicular tissues or tooth pulp; inhibits microleakage and encourages the regeneration of the original tissues (Hilton, 2009). Many studies indicated great clinical success rates when MTA was utilized for critical pulp therapy of cariously exposed permanent and primary teeth and showed success rates ranging from 95% to 100% (Chailertvanitkul *et al.*, 2014; Godhi, 2016; Neamatollahi and Tajik, 2006; Qudeimat *et al.*, 2017).

In this study, all of the treated teeth had SSC as their final treatment because the appropriateness of the ultimate restoration has a significant impact on the long-term success of pulp treatment to prevent restoration fracture and microleakage This is in agreement with Kher *et al.*, (Kher *et al.*, 2019) and Ebrahimi *et al.* (Ebrahimi *et al.*, 2022) however, this is different from the study by Schröder *et al.* (Schröder *et al.*, 1987), who used amalgam as the final restoration.

Regarding signs and symptoms, the included teeth in group A (partial pulpotomy) showed failure in two cases. The first case reported clinical failure (pain and swelling) and radiographic failure (bone resorption and root resorption) at 6 months follow-up, which may be due to undetected pulpitis of the tooth which led to misdiagnosis. These findings are

in agreement with Ebrahimi *et al.* (Ebrahimi *et al.*, 2022), who reported pain in two cases; first case noted sensitivity to percussion, fistula, and the other felt spontaneous pain and mentioned that clinically unsuccessful instances underwent retreatment.

Concerning the mobility of molars in the present study, both partial and complete pulpotomy groups did not show any mobility during all the follow-up periods. This is in disagreement with Ebrahimi *et al.* (Ebrahimi *et al.*, 2022), who reported one case with mobility in partial pulpotomy in primary teeth.

In regard to the pathologic root resorption, at baseline, Group A and group B had no root resorption in the teeth. After 6 months, Group A showed two molars with pathologic root resorption; the first failed tooth was the molar which showed in addition pain and swelling at six months follow-up periods while the second failed molar was another molar that showed only pathological bone and root resorption at 6 months follow-up periods; this negative response to treatment may be due to different condition of pulp tissue. While Group B showed no pathological root resorption. The outcome is consistent with Trairatvorakul and Koothiratrakarn (Trairatvorakul and Koothiratrakarn, 2012), who use Ca(OH)₂ in the partial pulpotomy group in primary molars teeth and observed one tooth has internal root resorption, may be because Ca(OH)₂ has increased microleakage, tunnel defects, and lead to internal root resorption.

Considering bone resorption, there was no statistically significant difference existed between the two groups. At baseline, groups A and B showed no bone resorption. While After 6 months, Group A showed bone resorption for two molars; the first failed tooth was the molar which showed pain and swelling at six months follow-up periods. The second failed molar was another molar that showed only pathological bone and root resorption at 6 months follow-up periods, it was extracted due to the presence of severely resorbed roots, so it was

considered as a dropout at the nine-month follow-up periods.

These findings were in line with Ebrahimi *et al.* (Ebrahimi *et al.*, 2022), as they found also 2 teeth with radiographic failure without any clinical failure, as long as the tooth is devoid of clinical symptoms, radiographic signs of failure are not a reason for retreatment. While group B showed no bone resorption, this came in accordance with Naik and Hegde (Naik and Hegde, 2005), who found in their study on pulpotomized primary molars, and follow-up after 1,3, and 6 months no clinical or radiographic pathological findings.

While group B (complete pulpotomy) showed 100% success clinically and radiographically. As all the included teeth showed no clinical signs and symptoms; pain, swelling, and mobility. Also, their radiographic examination showed no periapical radiolucency and without pathological root resorption throughout the follow-up periods, which was nearly similar to the finding of Cuadros-Fernández *et al.* (Cuadros-Fernández *et al.*, 2016), who found a success rate of 97% with group MTA pulpotomy primary molar. Also the same results were achieved by Najmi *et al.* (Najmi *et al.*, 2022), who reported 92.8% success clinically and 100% success radiographically at 9 months follow-up periods.

The study results disagreed with Shafie *et al.*, (Shafie *et al.*, 2017) who compared the postoperative pain after using MTA and calcium enriched mixture (CEM) as pulpotomy agents in primary carious molars. It was reported pain after pulpotomy and stated that placing of SSC might be the major etiologic factor for the post-operative pain due to irritation of soft tissue around the tooth.

The success rate of the partial pulpotomy group was 92%. This finding suggests that an effective treatment for deciduous molars is partial pulpotomy, this success rate greater than those indicated by earlier researchers (Ebrahimi *et al.*,

2022; Neamatollahi and Tajik, 2006; Schröder *et al.*, 1987; Trairatvorakul and Koothiratrakarn, 2012). Result by Schröder *et al.* (Schröder *et al.*, 1987) reported a success rate of 83% for partial pulpotomy of more than a year, and Trairatvorakul and Koothiratrakarn (Trairatvorakul and Koothiratrakarn, 2012), stated rate of success of 12 months for partial pulpotomy is 92.5%, and this could be attributed to using Ca(OH)₂ rather than MTA as a pulp capping agent, and using SSC rather than an amalgam filling for the final restoration (Neamatollahi and Tajik, 2006; Schröder *et al.*, 1987).

The present study was close enough to that done by Ebrahimi *et al.* (Ebrahimi *et al.*, 2022), as they found that clinical success was 100% and radiographic success 90% over 18 months follow-up periods and that using MTA either itself or coupled with high and low power diode laser did not differ as they reported when using a low or high power diode laser, the success rate of MTA partial pulpotomy did not significantly differ.

The study's success rate estimates were marginally higher than those previously published by the authors. This might be explained by the pulp capping agent, MTA, being used in place of Ca(OH)₂ (Schröder *et al.*, 1987; Trairatvorakul and Koothiratrakarn, 2012); and to replacing an amalgam filling with SSC as the ultimate treatment (Neamatollahi and Tajik, 2006; Schröder *et al.*, 1987) and to the immediate restoration instead of implementing it at the next visit (Neamatollahi and Tajik, 2006).

In addition, Trairatvorakul and Koothiratrakarn (Trairatvorakul and Koothiratrakarn, 2012) compared success rates of Ca(OH)₂ partial pulpotomy versus pulpotomy with formocresol of lower primary molars that have exposed pulp, although he mentioned that MTA is the best choice dressing material but he didn't use it due to high cost which restricts its use in pediatric dentistry, particularly in the setting of a public

hospital. And showed a 92.5% success rate in the partial pulpotomy group.

The excellent success rate we observed in our study may be largely attributable to MTA high-quality seal and the final SSC restoration as demonstrated by Ettinger et al. (Ettinger *et al.*, 1998) and Qudeimat et al. (Qudeimat *et al.*, 2017) and also to the precisely followed inclusion criteria in case selection.

V. CONCLUSION

Based on results of this study;

-MTA-partial pulpotomy was effective therapy for vital primary molars.

-After a nine-month follow-up, cases of complete pulpotomy revealed a complete success versus partial pulpotomy however, the difference is not significant.

-The use of MTA and SSC in a permanent coronal seal for paediatric pulp treatment was successful.

Limitations and recommendations

The limitations of this study were the relatively small sample size, follow up periods.

From the result of the study, the recommendation are:

-Using MTA for pulp therapy in children is recommended according to the success rate achieved through this study.

-Partial pulpotomy can be implemented in cases of minimal pulp inflammation to apply the minimal invasive dentistry.

-Selection of cases should be precise to reduce the incidence of failure regarding partial or complete pulpotomy.

-More follow-up periods is needed to indicate the actual success rate of partial pulpotomy based on the failure has been seen at 6 and 9 months.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Acknowledgements

Not applicable

Ethics

This study protocol was approved by the ethical committee of the faculty of dentistry-Cairo university on 26/1/2021.

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