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Research Article

Radiographic changes in root maturation of immature dog premolars after direct pulp capping with Mineral Trioxide Aggregate (MTA): A randomized controlled trial

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Abstract

Background: Direct pulp capping (DPC) is the preferred management for small pulp exposures to maintain pulp vitality, thereby delaying or preventing non-vital pulp therapy in an immature permanent tooth with an open apex. **Objectives and Aim:** This study aimed to evaluate the effect of MTA when used as a DPC material on root maturation. **Materials and Methods:** A randomized controlled trial with a total number 24 premolars of 2 mongrel dogs were involved in the experiment. Each dog received an intramuscular injection of chlorpromazine hydrochloride at a dosage of 1 mg/kg as premedication. followed by the administration of general anesthesia via intravenous injection of a 2.5% thiopental sodium solution. After general anesthesia was established a periapical radiograph was taken for the targeted teeth using paralleling technique. Then direct pulp capping with MTA was done to 12 premolars and the other twelve were used as a passive control. Based on AI dental clinic software (version7; woodpecker, Golin, China), the Radiographic measurements included the following parameters: Root length (RL): a straight line from the CEJ to the apical foramen and the apical foramen width (AFW). **Results:** After 3 months, the difference in apical foramen diameter was greater in the MTA group which indicates the greater increase in root dentin thickness, while there was no statistically significant difference in the increase in root length between the two groups. **Conclusion:** MTA is an effective direct pulp capping material in immature young permanent teeth hence it stimulates root maturation and apical foramen closure.

Keywords: MTA, Radiographic changes, Direct pulp capping, Dog premolars

Introduction

Dental caries is a worldwide health issue, with a higher frequency observed in younger demographics; especially school-aged children[(1)]. Dental caries poses a significant threat to the health of developing teeth. This may lead to irreparable pulpal damage, ultimately resulting in death of the pulp tissues and stunting the tooth root development. And as a result atypical development of the root will affect the long-term survival of the tooth [(2)].

Direct pulp capping (DPC) is the preferred management for small pulp exposures to maintain pulp vitality, thereby delaying or preventing non-vital pulp therapy in an immature permanent tooth with a wide-open apex. This approach facilitates continual root development, enables odontoblasts to form a dentine bridge at the pulp- DPC material interface and sustains pulp function[3].

Direct pulp capping in immature teeth facilitates the normal development of the root complex. This treatment outcome offers long-term treatment outcome advantages compared to apexification treatment. The produced tooth structure is substantial in quantity and has enhanced structural integrity in its composition. The outcome demonstrates that a fully formed tooth exhibits greater resistance to vertical root fracture[4].

Direct pulp capping entails the application of a medicament, above the exposed pulp to maintain its vitality, encourage reparative dentine production, specifically a dentine bridge, and seal the pulp exposure, making it a preferred treatment option [5].

A material used for vital pulp therapy should biologically stimulate odontoblasts and dental pulp cells, promoting the creation of new hard tissue over the exposed pulp and therefore stimulate root maturation[6].

Various materials including calcium-hydroxide, zinc oxide eugenol (ZOE), Dentine bonding agents have been proposed for DPC in the literature.
Calcium hydroxide (Ca(OH)2) was previously the preferred material for pulp capping in young permanent teeth[7].

Calcium Hydroxide has long- been regarded as the "gold standard" for direct pulp capping materials[8].
Calcium hydroxide possesses several ,advantages that have led to its recognition including a high pH and remarkable antibacterial characteristics[9]

Calcium hydroxide has a proven history of being an efficient direct pulp-capping material for durations of up to 10 years [10].
The development of tunnel defects in the dentin bridge, substantial deposition of dentine occluding the pulp space, high oral fluid intolerance and insufficient adhesion and breakdown are some drawbacks associated with calcium hydroxide[11, 12].

Because of these disadvantages possessed by calcium hydroxide as a direct pulp capping material a new material which is Mineral trioxide aggreate(MTA) has been introuduced. MTA has greater antiflam-mtory and antibacterial effects, higher and more sustained PH , greater seal and higher biocompatability [13].

Therefore, this study aimed to evaluate the effect of MTA when used as a DPC material on root maturation through root length and apical foramen diameter measurements.

Materials and Methods

Ethical approval

The research ethics committee of the Faculty of Dentistry at Minia University provided ethical approval for the current study(approval number: 94/708/2023)

Experiment design and location

This study is a randomized controlled trial; hence the teeth to be involved in the experiment were randomly selected and compared to other passive control teeth. The experiment was carried out at the Department of Surgery, Anesthesiology and Radiology, Faculty of Veterinary Medicine, Minia University, El-Minia Governorate, Egypt.

Animal Model

A total number of 24 premolars of 2 mongrel dogs were involved in the experiment. Animals were accommodated in a place with all standards in respect to excellent animal welfare with food and water always available.
They were dewormed 2 weeks before the procedure using Parasiticide of 1mL/50 kg

of Ivermectin (Ivomec supra® 1% injection, Merial, USA) [14].

Clinical procedures

A. Anesthesia

The dogs were maintained under identical management and feeding protocols throughout the experiment. Food and water were withheld for 6 to 8 hours prior to anesthesia. Each dog received an intramuscular injection of chlorpromazine hydrochloride (Misr Co. Pharm. Industries, S.A.A, Cairo, Egypt) at a dosage of 1 mg/kg as premedication. The surgical site was aseptically prepped, followed by the administration of general anesthesia via intravenous injection of a 2.5% thiopental sodium solution (Sandoz GmbH, Kund, Austria) until the main neurological reflexes were neutralized [15].

B. Direct pulp capping (DPC)

After general anesthesia was established a periapical radiograph was taken for the targeted teeth using paralleling technique. For standardization a film holder was used with a custom-made acrylic stent in order to keep the same vertical and horizontal angulation in all images and this was repeated postoperative and for every follow up for 3 months.

The dog jaws were maintained opened using a spring mouth gag and the tongue laterally retracted using a tongue forceps to expose the surgical field. Rubber dam was applied for isolation then the teeth had a Class V cavity prepared on their labial surface, 2 mm coronal to the gingival border. An inverted cone bur size 1 (Dentsply Maillefer, USA) was utilized at high speed (30,000 rpm) with a contra-angle handpiece (serona, Germany) under water coolant until a pink hue was observed at the cavity floor, without exposure. Subsequently, the exposure was attained by a precise probe to standardize the dimensions. Hemorrhage was managed within seconds using a moistened cotton pellet with 2.5% sodium hypochlorite (NaOCl) and sterile cotton pellets applied to the exposure site. The cavity was rinsed with normal saline , after which it was dried and prepared for the application of MTA as a DPC material [15].

Grouping of the samples:

In this study we have two groups, the first group are the premolars which have received MTA as a direct pulp capping material and a passive control group which are completely sound premolars without any intervention in order to compare the difference in root length increase and the difference in apical foramen diameter decrease.

Radiographic Measurements:

Based on AI dental clinic software (version7; woodpecker, Golin, China), the Radiographic measurements included the following parameters: Root length (RL): a straight line from the CEJ to the apical foramen as shown in (Fig. 2.1A) and the apical foramen width (AFW) as shown in (Fig. 2.1B) [16]

Results

After 3 months, the difference in apical foramen diameter was greater in the MTA group (p value = 0.036) as shown in (table 2) and (Fig.3.2) which indicates the greater increase in root dentin thickness, while there was no statistically significant difference in the increase in root length between the two groups (p value = 0.453) as shown in (table 1) and (Fig.3.1). Thus, these results show that direct pulp capping with MTA lead to successful root maturation of immature dog premolars as shown in (Fig.3.3A, B, C).

Table (1): showing mean scores of root length

Foramen diameter	MTA group (n = 12)	Control group (n = 12)	95% CI of mean difference	p value
Basal foramen diameter (mm) • Mean ± SD • Range	 1.83 ± 0.17 1.5 - 2.1	 1.65 ± 0.23 1.2 - 1.9	0.0003 – 0.34	0.05
Final Foramen Diameter (mm): • Mean ± SD • Range	 0.46 ± 0.08 0.3 - 0.6	 0.48 ± 0.08 0.4 - 0.6	-0.08 – 0.56	0.064
Difference in foramen diameter: • Mean ± SD • Range	 1.36 ± 0.19 0.9 – 1.7	 1.17 ± 0.22 0.8 – 1.5	**0.013 – 0.36**	**0.036***

Analyzed by Independent Samples t Test.
****: Significant difference at P value < 0.05***

Table (2): showing mean scores of apical foramen diameters.

Root length	MTA group (n = 12)	Control group (n = 12)	95% CI of mean difference	p value
Basal root length (mm): • Mean ± SD • Range	 5.14 ± 0.1 5 - 5.3	 5.59 ± 1.03 4.2 - 6.9	-1.07 - 0.17	0.161
Final root length (mm): • Mean ± SD • Range	 7.12 ± 0.5 6.6 - 8.3	 7.7 ± 0.99 6.5 - 9.1	-1.2 - 0.09	0.093
Difference in root length: • Mean ± SD • Range	 1.98 ± 0.53 1.4 – 3.3	 2.1 ± 0.15 1.8 – 2.3	-0.46 – 0.21	0.453

Analyzed by Independent Samples t Test.
****: Significant difference at P value < 0.05***

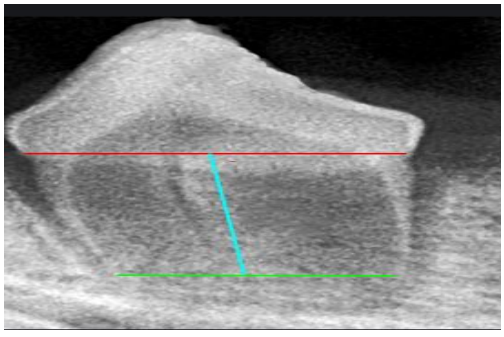

Fig.2.1A showing the method of measuring Root length by a straight line from the cemento-enamel junction to the apical

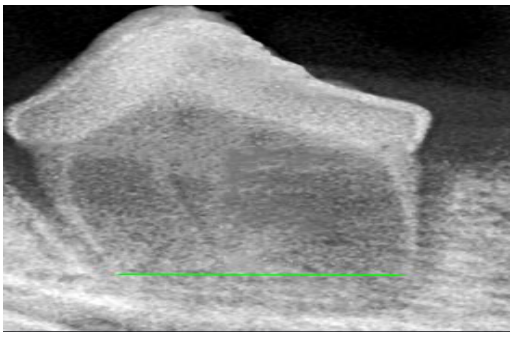

Fig.2.1B showing the method of measuring the apical foramen diameter

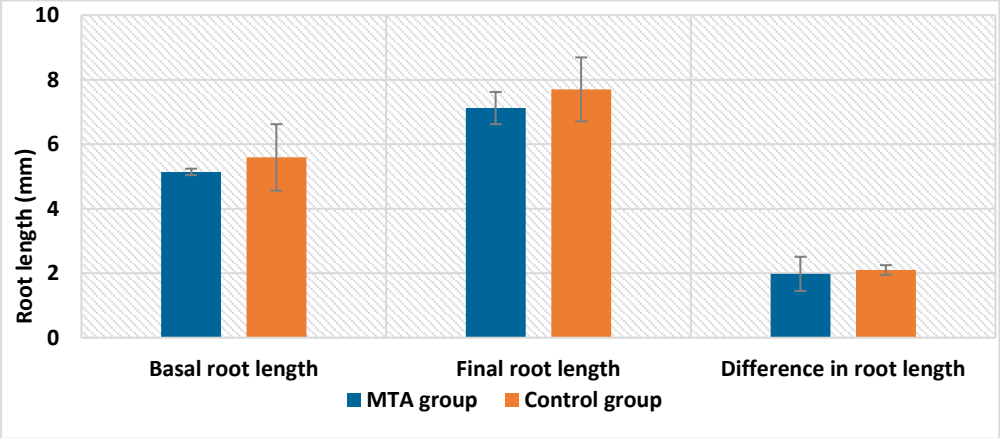

Fig.3.1: showing a Comparison of mean scores of root lengths between MTA group and control group

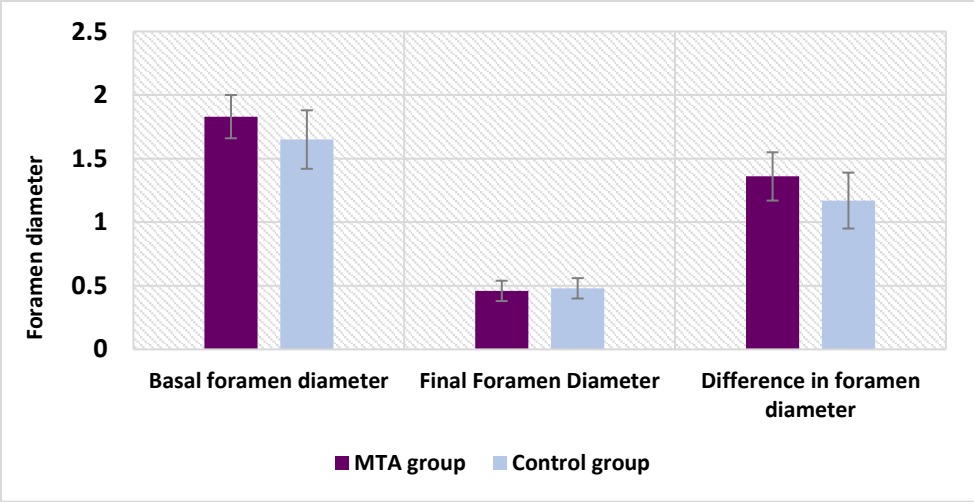

Fig.3.2: showing a Comparison of mean scores of apical foramen diameters between MTA group and control group

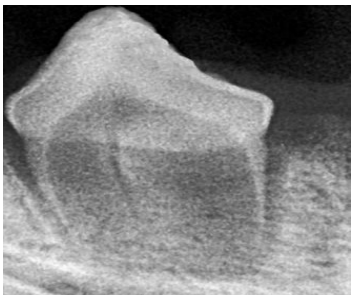

Fig.3.3A showing a preoperative x-ray image of an immature dog premolar.

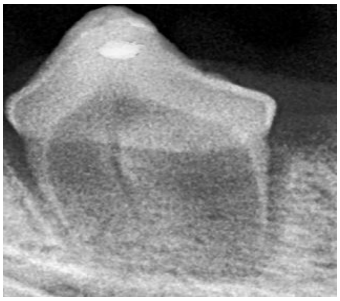

Fig.3.3B Showing an immediate post-operative xray image of an immature dog premolar after direct pulp capping with MTA

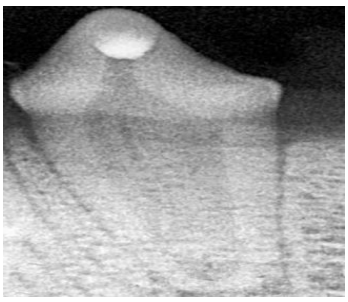

Fig.3.3C Showing a 3 months follow up xray image of a dog premolar after direct pulp capping with MTA with a completely mature root.

Discussion

The results of the current study showed the superiority of the MTA group in terms of the apical foramen diameter closure which indicates the great ability of MTA in inducing dentine formation by odontoblasts it also showed that there was no difference in root length increase between the two groups which also proves the ability of MTA in inducing dentine formation and root length increase thus root maturation.

Another study also indicated that MTA can encourage the formation of hard tissues from odontoblasts and foster a mineralization-friendly environment[17].
Furthermore, it releases Calcium Hydroxide, interacts with phosphate-containing compounds, and precipitates hydroxyapatite[18]. These MTA characteristics align with the current research results.

According to another research, biocompatible materials like MTA can improve pulpal repair after offering an excellent seal following direct pulp capping. The capacity of MTA to enhance reparative dentine production through the typical defensive mechanism of early pulpal lesion healing has demonstrated its efficacy as a pulp capping material thus retaining the pulp's vitality while promoting physiological root development successfully[19]. which also comes in line with the findings of our study.

MTA also show many drawbacks including very long setting time as stated by Torabinejad[20] and Chng HK[21], extremely difficult handling[22], tooth discloration, leaching out of toxic elements and an extremely high cost[23].

Also, another published Literature stated that in traumatized anterior and carious posterior teeth, the success rate of Vital Pulp Therapy with MTA was 82.5% and 96.4%, respectively. However, tooth discoloration remains a major concern, particularly in the anterior region [24].

The main limitation of the present study is that it composes only the radiographic part in the evaluation without clinical and histological evaluations, and also the study was performed in sound dog's teeth with intact pulps with no previous inflammation. So further studies are needed to overcome these limitations.

Conclusion

Within the limitation of the current study, the radiographic assessment showed successful maturation of the dog premolar roots after direct pulp capping with MTA which proves that it is an effective direct pulp capping material in immature young permanent teeth which stimulates root maturation and apical foramen closure.

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