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Original Research Article

Clinical and Radiographic Evaluation of MTA (Mineral Trioxide Aggregate) As Furcal Perforation Repairing Material in Primary Teeth: Uncontrolled Clinical Trial

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Abstract

Purpose: Uncontrolled clinical trial aims to evaluate clinical and radiographic healing after repairing mechanical furcal perforations that occurring during pulpotomy in primary molars by using MTA (Mineral Trioxide Aggregate). ***Materials and Methods:*** 34 primary molars in 32 healthy children aged 5-10 years old were treated after occurring of mechanical furcal perforations during pulpotomy by using MTA. Mediate and immediate treatment had been performed after clinical and/or radiographic diagnosis of the perforation, and then teeth had been followed clinically at 1st week 3rd, 6th, 9th, and 12th month and radiographically at 6th and 12th month after perforation repair. Statistical analyses were done at *p*-value = 0.05 and confidence interval CI 95%. ***Results:*** All teeth were successful at the first week. Overall success rate recorded 79.3%, and CI of success was 65% to 93%, 5 teeth had been extracted because of totally failure. There was no significant statistically difference between totally success rates according to gender, tooth position, tooth type, previous sub-base of ZOE, pre-used of Formocresol (*p*-value > 0.05). ***Conclusions:*** Iatrogenic furcal perforated primary molars can be treated by using MTA successfully. Mediate treatment and pre used of FC may have unfavorable prognosis of repairing perforations.

Keywords: Furcal perforations, MTA, Primary teeth.

INTRODUCTION

Preserving primary molars until successor eruption is a very important object to preserve shape and function of the dental arch [1], because the premature loss of deciduous teeth results in physiological, morphological and functional disorders [2]. Conservative pulp treatment in deciduous teeth aims to preserving pulp vitality, subsequently these teeth until natural exfoliation [3, 4]. Accidental problems may occur with under graduate students because of the limited experience especially with young children, so that furcal perforations can occur during treatment them [3]. Furcal perforation is undesirable accident commonly occurs during access cavity and exploration of canal orifices [5, 6] because of the insufficient knowledge of the anatomy of the pulp chamber, malalignment or failure in estimation of the anatomical differentiations, and calcification of the pulp chamber, and affects the treatment prognosis and maybe results in tooth losing [7].

The AAE_S (American Association of Endodontists) glossary of endodontic terms defined the perforation as "the mechanical or pathologic communication between root canal system and external tooth surface" [8]. The furcation area which encompasses the region around the division of the roots has a special importance in primary molars because of its close anatomical relationship with the follicle of the succedaneous permanent teeth [9]. Perforations were considered the second most common reason for endodontic treatment failure [10]; where Ingle stated that perforations account for 9.6% of all unsuccessful cases [11]. Perforations lead to destruction of the dentin-root wall or the floor with the covered cementum [7]. If these perforations are not treated, they will be followed by a bacterial infection, destruction of the periodontal fibers, inflammation and resorption and/or necrosis of the adjacent bone [10, 12-14], and the result will be a chronic inflammation of the periodontal ligament which can lead to irreversible losing of the attachment, subsequently losing the affected tooth [15]. Repairing perforations in primary teeth has become more important than extraction, to prolong the longevity of them in the mouth, and avoiding premature problems [16]. The prognosis of the perforation depends on the

ability to repair it; which prevents or eliminates the bacterial infection [17, 18]. Several factors affect the ability to control the infection in the perforation site, subsequently the ability of the repairing material to seal the defect. These factors include time from occurrence of the perforation until detection and treatment, repairing material, perforation size, shape, and location [16, 10, 13, 17], doctors' experiences [19], presence of a legion in the perforation area before the treatment, direct connection between the perforation site and oral cavity [20], gender and age of the patient [21, 22], and location of the tooth in the mouth (maxillary/ mandibular) [23]. Perforation repair is indicated as much as possible when tooth is strategically important [7], where this treatment aims to prevention the adjacent healthy tissues from inflammation happening or continuing, or loss of the periodontal attachment [11].

Several materials have been used to management perforations whether in primary or permanent teeth in an attempt to achievement a typically material to repair perforations, which have to establish an appropriate sealing [24] and biocompatibility, and induce bone generation and cementogenesis. It should be nontoxic or carcinogenic, bacteriostatic or bactericidal, nonabsorbable (in permanent teeth, and primary teeth with no succedaneous permanent), radiopaque, dimensionally stable, insensitive to the moisture and blood, and easy to use and relatively inexpensive [15, 25]. A lot of materials have been suggested for repairing perforations in permanent teeth such as Amalgam, calcium hydroxide, tri-calcium phosphate, reinforced zinc oxide- eugenol cement, gutta-percha, Cavit, , PC (Portland cement) and MTA [11, 25], while In primary teeth a few studies have been conducted on repairing furcal perforations which included Portland cement, Atelocollagen, MTA cements (Pro Root MTA®, MTA Plus™, Root MTA®), Biodentine™ and CEM [6, 26-31]. Our study aims to testing the activity of MTA in repairing mechanical furcal perforations in primary teeth that occurs during pulpotomy procedure.

MATERIALS & METHODS

Study Design

An Uncontrolled clinical trial on upper and lower primary molars; with iatrogenic furcal perforations that occurred during pulpotomy procedure. They had been followed clinically and radiographically within 12 months from the treatment date. Sample of the study was calculated and followed within 3 years, It had been approved by the research ethics committee of Tishreen University (No. 3532/ 14. July. 2015).

The study sample included 34 primary molars for 32 healthy children of the patients in pediatric dental clinic of the faculty of dentistry in Tishreen university-Syria; which were perforated during pulpotomy procedures by pre-graduated students. Patients were transferred to the department of pediatric dentistry. We ensured from the medical history which includes systematic problems that conjunct with the treatment. We talked to the parents about the treatment, and the written concent was taken. Sample size was determined by using statistical sampling method to achieve 95% confidence interval and 5% accuracy according to our pilot study of four cases which recorded 75% success rate. Results showed that sample size should be at least 17 subjects to achieve 95% confidence interval, so we treated 34 cases to obtaining the largest retention rate of treated patients in our study and minimize dropout rate.

Study sample included teeth those previously concepted for pulpotomy treatment which furcation was perforated mechanically; for immediate treatment, and teeth which previously filled with sub-base material of ZOE since no more than one week for the mediate treatment. We excluded the following: tooth that cariously perforated, tooth which pulpotomy procedure was not the real indication, uncontrolled bleeding from the canal orifices during pulpotomy, un-restorable teeth, and when there was no rubber dam application or saliva contamination during pulpotomy.

Study Procedure

Clinical Procedure

Perforation Diagnosis

Clinical examination was the main criteria for diagnosis without using radiographic imaging. The visually aggressive bleeding from the furcation area and probing it by a gingival probe were the main ways for diagnosis after conjunction all other causes of bleeding in these area by removing residual roof of the pulp chamber completely, amputating inflamed-coronal pulp, and removing the pulp debris adequately. All those procedures were done with copious irrigating of saline solution. Because of the uncooperative behavior of the children after long chair time, only post treatment diagnostic periapical radiographs were taken instead of the pre-treatment radiographs, which ensured the presence of the perforation and would serve as a comparative baseline for future films.

Perforation Treatment

After perforations had been diagnosed, the treatment had done as following:

Immediate Treatment

We cleaned the work area, ensured that rubber dam in the right place, and irrigated the pulp chamber and perforation site with copious saline solution, then a moist cotton pellet of 2.5% Sodium Hypochlorite (SH) (Al-Fares, Damascus, Syria) was placed in the perforation site to control bleeding and disinfect perforation site with surrounding tissues until mixing white Mineral Trioxide Aggregate cement WMTA (MTA Cem®, NEXOBIO, Chungcheongbuk-do, Korea) –excess moisture obstruct the setting of MTA and affect its properties [37] then material was transferred to the

cavity by an amalgam carrier and condensed slightly to the wanted place in 3mm thickness by a cotton pellet damped with sterile water and squeezed well. Then teeth were restored with Glass Ionomer Cement GIC (Cavitan® Plus, SpofaDental, Markoca, Jicin, Czech), and then periapical radiographs were taken to ensure that MTA and GIC in the right place.

Mediate Treatment

Treatment of perforations was introduced as soon as possible (no more than one week after the initial treatment of pulpotomy). After radiographic imaging and visibility of the perforation with excess sub-base material of ZOE, local anesthesia with lidocaine hydrochloride 2% and epinephrine 1:100,000 was introduced (Huons Lidocaine HCl, Seocho-gu, Seoul, Korea), and then rubber dam was placed in site. Then restoration and sub-base material were removed completely, opening access was completed and residual pulp tissues were removed when we needed that, also we removed little debris of sub-base material (ZOE) and necrotic tissues which were a result of Formocresol FC application during pulpotomy procedure by a sterile dentinal excavator, all that was done under a copious irrigating with saline solution, and then we applied a moistened cotton pellet with 2.5% SH, and work had completed as the immediate ones.

At the next appointment after one week, all teeth were prepared for restoring with appropriate stainless steel crowns (3M ESPE, st. Paul, USA), then they were adhered with GIC (Kavitan® CEM, SpofaDental, Markoca, Jicin, Czech). Debris was removed from the gingival sulcus and interproximal surfaces by using the dental probe and dental floss.

In both treatments, we instructed parents to call us immediately if pain or discomfort occurred following treatment.

MTA Preparation

MTA is usually mixed according to the manufacturer instructions with 3:1 ratio powder/sterile water (solution) to achievement a past capable to transferring to the application site [36]. We can alter the ratio to obtaining an appropriate consistency for the work according to the amount of material we need to apply and type of used MTA. Here, and because of the 1g powder amount of MTA witch is enough for many applications; we depended on the achievement pasty texture as an appropriate consistency for repairing perforations and also as a sub-base material for pulpotomy. Material had been mixed with sterile water on a clean glass plate by using sterile spatula until achievement the required consistency. Mixed was transferred to the pulp chamber by using an amalgam carrier, and debris thrown after the operation.

Clinical & Radiographic Evaluation

All treatments procedures, clinical and radiographic examinations were introduced in the department of pediatric dentistry by one person. The baseline clinical and radiographic evaluation was done at the treatment time. Clinical evaluations were performed at the 1st week after treatment, then at the 3rd, 6th, 9th, and 12thmonth, while radiographic evaluations were only at 6th and 12th month after repairing perforations. Then whole evaluation was done by two independent specialists in pediatric dentistry.

We considered case clinically successful when the examined tooth was functionally active and without pathologic symptoms and/or signs such as the presence of pain, gingival redness, abscess, fistula or pathologic movement, and they considered clinically failed when there was any one of the previous signs or symptoms, according to that affected tooth was extracted immediately. On the other hand, case was considered radiographically successful when there was no pathologic radiographic signs such as furcal and/or periradicular radiolucency, pathologic internal/external resorption, canals obliteration, or extension of the ligament space that does not excess double of the normal space, and considered failed when there was any of the last signs. In overall evaluation we had calculated total success and failure, and considered case totally failure when it was clinically failure at any of the follow-up periods. It was considered totally success when it was clinically successful at all follow-up periods.

Statistical Analysis

The statistical analysis had been performed by using SPSS bundle version 19 (SPSS Inc., Chicago, IL, USA). We used fisher exact test at 95% confidence interval and *p*-value 0.05, to finding the significant statistically differences when the probability values were smaller than or equal to 0.05. All statistical analyses had been done by the researcher.

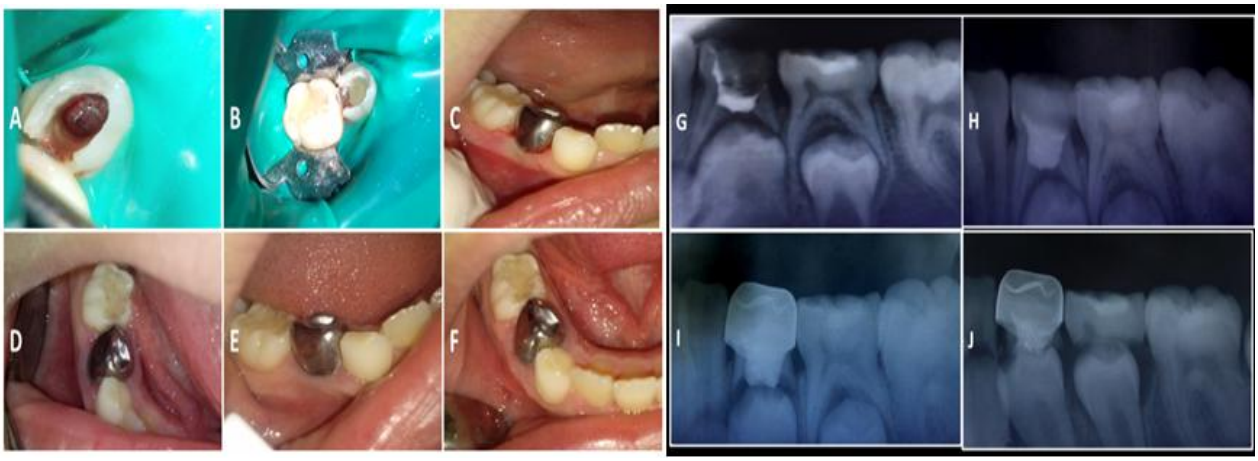
RESULTS

We had treated 34 furcal perforations in first/second- upper/lower primary molars for 32 children (20 male, 12 female) was aged from 5 to 10 years old (Median =7.7 years ±1.5). Cases had been followed clinically and radiographically within 12 months and more than that period for some cases (Figure-1). Success rates differed within follow-up periods, and Table-1 shows clinical/radiographic success and failure rates at 3rd, 6th, 9th, and 12th month, whereas Table-2 shows the overall success rates according to numerous factors which may interfere with the results of treatment. We had evaluated the success and failure according to gender, age, location and type of the tooth, presence of sub-base material (for mediate-treated cases), pre medicaments that were used during pulpotomy.

Table-1: Clinical & radiographic outcomes of furcal perforations repair using MTA within 12 months

Follow-up	Success	Failure		
	N (%)	N (%)	Total number	*P*-value
1st Week (*clinically*)	(100) 34	(0) 0	34	NA
3rd month (*clinically*)	(100) 21	(0) 0	21	NA
6th month(*clinically*)	(95.8) 23	(4.2)1	24*	< 0.001
6th month (*radiographically*)	(76.2) 16	(23.8) 5	21	0.027
9th month (*clinically*)	(100) 12	(0) 0	12**	NA
12th month (*clinically*)	(86.4) 19	(13.6) 3	22	0.001
12th month (*radiographically*)	(73.7) 14	(26.3) 5	19	0.064
Overall evaluation	**(79.3) 23**	**(20.7) 6**	29***	0.002

*extraction of one tooth because of the clinical failure. ** Physiological exfoliation of one tooth. *** drop-out of 5 patients.
NA: not applicable



Clinical and Radiographic success of mediate treatment of a furcal perforated-first primary molar that had been repaired with MTA: A,G: Perforation detection. B: MTA application. C: Restoring with Stainless Steel Crown. D, E, F: Clinically after 3, 6, 12 months respectively. H: Radiographically after MTA application. I, J: Radiographically after 6, 12 months respectively.

We had 6 failure teeth, 5 of them were extracted because of the clinical or clinical and radiographic failure together. The 6th molar was considered failure because of the furcal radiolucency at the end of 6th month with no another follow-ups. We had one case with internal resorption, and we considered it totally successful because there was no involvement of the supporting bone or interfering with physiological resorption and normal exfoliation.

Table-2: Success rates distribution according to gender, tooth position and type, previous sub-base of ZOE, pre-used of FC

Variables		Overall success N (%)	P value
Gender	**Male**	14 (82.4)	0.48
	female	9 (75)	
Tooth position	**upper**	5 (100)	0.28
	lower	18 (75)	
Tooth type	**1st molar**	10 (71.4)	0.29
	2nd molar	13 (86.7)	
Previous sub- base of ZOE	**Yes**	5 (62.5)	0.19
	No	18 (85.7)	
pre used of Formocresol (FC)	**Yes**	12 (70.6)	0.18
	No	11 (91.7)	

Table-3 shows the number of the clinical and/or radiographic failure cases in this study within 12 months follow-ups which distributed as the following:

- Two molars (palpation pain, abscess, gingival redness, radiolucency)

- One molar (pathologic movement and external resorption, radiolucency)
- One molar (palpation pain, gingival redness, radiolucency)
- One molar (palpation pain, radiolucency)
- One molar (radiolucency) at 6th month, patient dose not complete the follow-ups.
- One molar (internal resorption).

Table-3: Clinical and radiographic failure distributions

Clinical failure					
Spontaneous pain	Palpation pain	Gingival redness	abscess	fistula	pathologic movement
0	4	3	2	0	1
Radiographic failure					
Furcal and/or inter-radicular radiolucency	Internal resorption	Pathologic-external resorption	Canals obliteration		
6	1	1	0		

Some cases were followed for more than 12 months, and there was no obstruction of the permanent succedaneous teeth eruption or deflection in the eruption axes, some cases had been followed until the eruption of the succedaneous premolars, especially clinically and radiographically unsuccessful cases, and there were no hypoplastic or hypocalcified areas in the crowns of those teeth. Two second primary molars had been followed until the eruption of the first permanent molars normally behind them.

DISCUSSION

Management of iatrogenic perforations especially furcal perforations may constitute important clinical challenge especially when they occur in primary molars [3], because furcal perforations have the weakest prognosis between perforations [13], in addition to the presence of permanent buds under the primary teeth.

MTA and improved MTAs _in three case reports and number of in-vitro studies_ had demonstrated an excellent sealing ability, obstruction of the microbacterial leakage, and clinical and radiographic healing [3, 6, 16, 26, 27, 29-31]. MTA also demonstrated high success rates in pulpotomy treatment [37]. There was no clinical research included repairing furcal perforations in primary molars and detecting the effected factors on the treatment results until now. In our study we had repaired 34 furcal perforated- 1st/2nd maxillary/mandibular primary molars, and because perforation is a procedural accident; it was impossible to obtaining the same conditions for all cases before the treatment and modeling controlled clinical trials [32], in addition to that extraction was the only choice to management those cases, subsequently leaving some cases without treatment or extraction to form a control group in this study was unethical, likewise leaving ZOE as a sub-base layer over furcal perforation was also unethical, because in these cases ZOE may lead to periodontal inflammation and abscess formation [26,30]. All that because it is unethical to expose patients to a study in which some patients are expected to do worse or less well than others. In addition to that finding two perforations or more than that in same patient was very difficult, so we were not able to compare different repairing materials.

We used 2.5% Sodium Hypochlorite (SH) in our study to control bleeding and disinfect the pulp chamber, where Torabinejad referred to apply a cotton pellet moistened with SH for 2 minutes on the perforation site and surrounding infected dentin to obtaining hemostasis and disinfection, as well in pulpotomy with MTA where hemostasis institutes by applying a pressure on the pulp trunk with a cotton pellet moistened with 1.25-6% SH [33].

We used pre-packed MTA (1g powder via package), and in our study it was sufficient for treating 8-10 cases. We mixed powder with sterile water to obtaining pasty texture without commitment with the common ratio (3:1) because the appropriate amount differentiated from one tooth to another because of the different size of the treated teeth and perforations. We applied a slight pressure when we was condensing material, because excess pressure leads to less voids and micro cannulas, subsequently reducing the available space that required to entering the necessary water for hydrating the cement, in contrast slight pressure leads to distinctive crystalline structure [34].

In our study, treated teeth were filled directly with GIC over MTA to obtaining an appropriate sealing after pulpotomy procedure and perforation repair. Parirokh *et al*., reported that we can apply GIC over MTA without moistened cotton pellet because setting reaction of both materials was not affected [35]. In addition, most investigators did not perform this procedure in pulpotomy treatments in primary molars, Camilleri also recommended for this procedure when using MTA in vital pulp treatment [43], because moisture that supporting setting reaction of MTA usually becomes from the surrounding tissues or the moistened cotton pellet that applied over it [33].

All teeth had been restored with stainless steel crowns, because they have been considered the most active and long-term restorations, and because most of the treated teeth were multi- affected surfaces [37]. Teeth had been restored after one week from repairing perforations in order to investigating any pathological signs and/or symptoms within this period, and all teeth were asymptomatic with 100% success rate (34/34).

Clinical success rates were 95.8% at the end of 6^{th} month and 86.4% at the end of 12^{th} month with significant statistically differences between clinical success and failure rates (p-value <0.05), whereas the radiographic success rates was 76.2% at the end of 6^{th} month and 73.7% at the end of 12^{th} month with significant statistically differences between radiographic success and failure rates (p-value< 0.05), while the overall success rate of MTA as a material for repairing furcal perforations in our study was 79.3% (p-value < 0.05). These results are different from the success rates in permanent teeth that ranged from 73% to 89% in a number of clinical and retrospective studies [19-21, 23]. The differences between success rates of these studies beyond to the differences in the conditions of every study as perforation size, previous lesion, perforation location, age and another factors, but in comparison to our study the differences beyond to that: our study had done on furcal perforations through the treatment of pulpotomy in primary molars, in children aged from 5 to 10 years old, with or without Formocresol application in the furcation area and in the presence of succedaneous teeth, in addition there was no presence of legions in the furcation areas. MTA has been considered as a slightly resorpable material [38], so there was no obstruction to the eruption of the permanent succedaneous teeth or deflection in the eruption axes within the follow-up periods in our study.

Most investigators preferred to treat perforations immediately after happening or as soon as possible, because of the considerable influence of treatment time on the results [11-13, 17]. We found such result in our study where success rate in the immediate treatment were favorable more than mediate treatment but with no significant statistically difference (p-value > 0.05). The differences between success rates may be attributed to the use of ZOE and FC which reducing it because of their negative effects on periodontal tissues [39, 40]. In two case reports of Oliveira and Marques, mediate treated cases were totally successful [26, 30], but in our study 3 cases from 5 mediate- treated teeth were failure, their failure maybe attributed to that those cases were accompanied with large sized- perforations.

The presence of FC in our study had a negative effect on the treatment outcomes, where success rate reduced in cases with previous application of FC, and recorded 70.6% versus 91.7% for cases without it (p-value>0.05). The reduction of success rate may be attributed to the residual necrotic tissues in site and inflammation that associated with it, where FC results in bone and gingival inflammation and subsequent necrosis [40].

CONCLUSION

Within the limitation of this study we can say that**:**

- MTA can be used successfully for repairing furcal perforations in primary molars.
- Some factors may affect the prognosis of treatment, such as previous sub-base material of ZOE and per-used of FC.
- The presence of MTA in the furcation area has no negative effects on the eruption of succedaneous permanent teeth.

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