

Evaluation of Modified Portland Cement versus Mineral Trioxide Aggregate as a pulpotomy agent in Primary Molars: Histological Study

Research Article

Meslmani W^{1*}, Othman R², Kouchaji C¹, Salem Rekab M³, Abo Fakher MA⁴¹ MSc Department of Pediatric Dentistry, faculty of dentistry, Damascus University, Al-MazzeH St. Damascus, Syria.² PhD Department of Histopathology Dentistry, faculty of dentistry, Damascus University, Al-MazzeH St. Damascus, Syria.³ PhD Department of Endodontic, faculty of dentistry, Damascus University, Al-MazzeH St. Damascus, Syria.⁴ MSc Department of Oral Medicine, faculty of dentistry, Damascus University, Al-MazzeH St. Damascus, Syria.

Abstract

Background: The aim of this study was to evaluate the histological response of dental pulp tissue in primary molars to Modified Portland Cement (MPC) mixed with Zirconium Oxide and Calcium Chloride in comparison with Mineral Trioxide Aggregate (MTA).

Methods: The study was conducted on children between 7.5-9 years of age, pulpotomy was performed on 60 Primary Molars (to be extracted as a part of Orthodontic treatment). The molars were divided randomly into two groups, each of them contains 30 teeth. After pulpotomy was conducted, the root Pulp was covered with MTA or MPC and a layer of Glass Ionomer Cement (GIC) and the tooth were filled with amalgam eventually. The teeth were extracted after one week, one month, and two months respectively and histological samples were collected and evaluated Based on the Inflammation response, soft tissue organization, and Dentinal bridge formation.

Results: Modified Portland Cement has showed no significant differences in terms of inflammation response, soft tissue organization, and Dentinal bridge formation in comparison with MTA in the observation period.

Conclusion: MPC can be a replacement material of MTA in terms of primary molars pulpotomy.

Keywords: Pulpotomy; Soft Tissue Organizing; Dentinal Bridge; Inflammation; Histology.

Introduction

Many Researches in the field of Dental Sciences were motivated by conserving of Dental Pulp vitality in Primary and Permanent teeth [1]. The Vital Pulp treatment contains Direct Pulp capping, Indirect pulp capping, and partial and complete Pulpotomy [2].

Pulpotomy was considered as the most common treatment method of Vital pulp in Primary Molars; and has gained high rate of clinical and radiological success [3].

The Pulpotomy is defined as the complete excavation of infected coronal pulp tissues and covering the root pulp tissues with dressing that proceeds pulp tissue healing or remaining pulp fixation. All of that aims to keep the teeth Physiological function [4].

Mineral Trioxide Aggregate (MTA) had gained excellent success rates in many fields of the dentistry in the last two decades, However, Due to the high cost of MTA, many researches have been conducted to find replacements with same results and lower cost [5]. One of the materials that has been studied recently is Portland Cement which is considered as the essential material that exist in MTA. Therefore, its chemical specifications are much similar to MTA [6].

In 2003, Funteas et al., have conducted a comparison study between MTA and Portland Cement, in terms of components. The comparison analysis revealed great similarity between the two materials (14 elements included in both of them), although MTA differs with the amount of Bismuth [7].

*Corresponding Author:

Walid Meslmani MSc,
Department of Pediatric Dentistry, faculty of dentistry, Damascus University, Al-MazzeH St. Damascus, PO Box 30621, Syria.
Tel: 00963949089253
E-mail: dr.walid86@gmail.com

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Despite the specifications and advantages of Portland Cement, it has some undesirable properties like long setting time and radio-translucency. Therefore, the researchers have focused on improving those specifications.

Portland Cement setting time ranges between (70-170) minutes [8], some accelerators have been added to reduce setting time like: Calcium Chloride, Calcium Nitrate, Calcium Formate [9].

In 2002, Abdullah et al., [8] examined the biocompatibility of two kinds of Accelerated Portland Cement in vitro, and they used GIC, MTA, and unmodified Portland Cement as control group. The results had showed that both kinds of Accelerated Portland Cement white were not toxic, and they induced the bone healing. That results were similar to MTA and unmodified Portland Cement results.

In 2006, Bortoluzzi et al., [10] had revealed that adding Calcium Chloride by 10% increases the level of PH, the sealing ability, and reduces the marginal leakage and solubility.

One of the differences between MTA and Portland Cement is the Radiopaque material called Bismuth Oxide, there are other Radiopaque materials like Barium Sulfate, Titanium Oxide, Zirconium Oxide, gold, Silver Amalgam and many more other materials [11].

Thus, the aim of this Histological Study was to examine the Dental pulp response in Primary molars to Modified Portland Cement (MPC) with Zirconium Oxide and Calcium Chloride in comparison with MTA.

Materials and Methods

Materials

The materials that had been used in the research were as following:

Modified Portland Cement: Grey Portland Cement (produced locally in The Syrian corporation for Cement production – Tartus - Syria) has been used in this research. This Portland Cement contains the same components of MTA [6]. However, the lime has been added to the Portland Cement during manufacturing procedure for delaying setting time. for using this material in this research, the lime had been excluded without modifying the Cement's specifications [12]. And the Accelerator, Calcium Chloride, had been added by 10% of the mix and the Radiopaque Zirconium Oxide had been added by 30% of the mix [11]. This material has been sterilized by Gamma rays by cooperation with Nuclear power Agency.

MTA: produced by Dentsply under the commercial name (Procanal Repair Material MTA). The container composed of five envelopes, each envelop contains 1 gram of this material as a powder, in addition there are distilled water capsules, each capsule's capacity is 0.35 gram, for mixing the material.

Study Design

This study was designed as prospective longitudinal study to examine the Histological response of MPC in comparison with

MTA by using them in Pulpotomy in Primary molars. Ethical approval was obtained from the Institutional Review Board, and informed consent was also obtained from parents or guardians of the participating children.

Sample Size

The study sample was consisted of 60 first primary molars that were included in an Orthodontic extraction (Serial extraction) in children aged between 7.5-9 years.

Inclusion Criteria

The patients were selected depending on previous studies and on the Criteria described by Dean in 2016 [13] as follows:

- a- Cooperative and healthy children whom don't suffer from any systematic disease that prevents treatment procedures (Pulpotomy and extraction).
- b- First primary molars that were included in serial extraction for orthodontic treatment with an indication of pulpotomy, such as having two surfaces permeable caries, physiological root resorption less than third of the root and absence of symptoms, clinical and radiographical signs of pulp necrosis.

Allocation

The molars were divided randomly to two groups:

The first group: 30 primary mandibular molars had received the treatment with applying Modified Portland Cement.

The second group: 30 primary mandibular molars had received the treatment with applying MTA.

Then, the teeth had been extracted after the treatment by one week, one and two months. 20 teeth were randomly extracted at each period (10 teeth for each group).

Research Method

Pulpotomy had been applied to the primary molars of children in the Pediatric Dentistry Clinics in Dental college – Damascus University. The same method had been applied to all the sample molars as follows:

- 1- Local anesthesia for mandibular molars.
- 2- The isolation had been applied by the rubber dam.
- 3- The external borders had been prepared by the diamond burs on high speed Dental handpiece with constant water spray.
- 4- The Dental caries had been excavated completely by low speed hand piece.
- 5- The pulp exposure had been resulted after the complete excavation of Dental caries.
- 6- After pulp exposure, the pulp chamber roof was fully removed by a bur with unworking head in high speed with continuous water spray. Then the pulp chamber had been excavated by Sharp Dentin excavators. The bleeding had been controlled by sterilized cotton balls and moisten by serum.
- 7- In MTA Group, the powder had been mixed by the percentage 1:3, and had been transferred to the pulp chamber.
- 8- In Modified Portland Cement, the material had been applied in

the pulp chamber floor in the convenient mix. The Cement had been mixed by adding the distilled water.

9- After that, the Modified Portland Cement had been condensed by moisten cotton ball and condenser on the exposed pulp, then the pulp chamber had been filled by GIC. After that, the teeth had been restored with Amalgam.

Follow-up: The teeth had been divided by the follow up period and the used material into two groups, each group contains 30 teeth. 20 teeth had been extracted (10 teeth from each group) after a week, a month, and two months respectively. The Histological sections had been derived from extracted teeth. The flow of this study is elaborated in figure 1.

Histological sections preparation

- 1) The extracted teeth had been reserved in Formaldehyde 10% directly until the complete fixation.
- 2) The teeth had been put in nitric acid 15% with formaldehyde 10% with observation by Probe. The teeth softness was the indicator for Minerals dissolution.
- 3) Proximal Distal section had been prepared through the pulp center.
- 4) The Sample had been washed by Tap water to get rid of Acid remains.
- 5) The Sample had been dried through soaking in ascending concentrations of Ethanol for half an hour for each, until the absolute Alcohol.
- 6) The Alcohol had been extracted through ascending concentrations of Xylol.
- 7) After that, the process of combination and preserving In Paraffin.
- 8) The Paraffin blocks had been sectioned by Manual Microtome in 6-micron thickness for each.
- 9) The sections had been dried and Paraffin had been extracted.
- 10) The sections had been transferred to glass slides, then colored by Hematoxylin-Eosin.
- 11) By coloration process, the Plasma stained with color, and the nucleus were stained by Purple. The Steps were as follows:

- The sections had been put in specified contained and soaked in Hematoxylin for 2 minutes.
- After that, they had been washed with water, and soaked in Eosin for 1 minute.
- The sections were washed by water, dried by ascending concentrations of alcohol, and finally soaked in ascending concentrations of Xylol to extract Alcohol.
- The sample had been covered and prepared for being assessed under the Microscope.

4 histological Non-consecutive sections had been chosen for every Sample unit to investigate the Dentinal Bridge. Each section was carefully selected to contain the Root canal entrance.

Histological examination

The Histological sections had been examined by an experienced investigator under microscope assisted with specified Camera.

The inflammation grades evaluated by investigating the Inflammatory cells. The grades were classified as following [14]:

- 1st stage: there were no inflammatory Cells in the exposure point or nearby.
- 2nd grade: low grade: low quantity of inflammatory cells:
 - Acute inflammation cells (Macrophages, and Neutrophils)
 - Or Chronic inflammation Cells (Monocytes).
- 3rd stage: plenty of inflammatory cells:
 - Plenty of Neutrophils as an abscess.
 - Or massive inflation of Monocytes exceeds the coronal pulp.

In addition, the Soft tissue organization had been investigated and classified as following [14]:

1. Normal tissue organization in pulp tissue in the place of pulpotomy or under the dentinal bridge, and there are no tissue damages or tears or dead cells.
2. Lack or slight disruption in the normal tissue organization situated in the surface layer of the wound or under the dentinal bridge with Central Normal remaining pulp tissue.
3. Moderate disruption in the general tissue organization of the Pulp tissue deeper than the surface layer.
4. Large loss or severe disruption and degeneration defused in the whole pulp tissue.
5. Pulp necrosis.

The investigations also contained the stage of Dentinal Bridge histological formation, and it was classified as follows [15]:

1. There is no evidence on Dentinal bridge formation.
2. The beginning of Dentinal bridge formation.
3. The Dentinal bridge had been formed, but it is not completed.
4. Complete Dentinal bridge formation.

Statistical Study

Data were transferred into Excel sheets and then analyzed using Social Package for Social Science (SPSS) v 25.00. Kolmogorov test was used to analyze the normality of the data. Mann-Whitney was used for inter-group comparison. Kruskal-Wallis was used for intra-group comparison. And Bonferroni correction was conducted for dual comparisons between the investigation periods. P-value less than 0.05 was considered statistically significant.

Results and Discussion

Results

The sample contained 60 first primary molars prepared for serial extraction for orthodontically reasons. The Pulpotomy had been conducted by Modified Portland Cement (MPC) and MTA.

The teeth had been extracted after (one week, one month, and two months) and the Histological responses had been investigated by measuring the inflammation grade, soft tissue organization, and Dentinal bridge formation in the Sample's teeth.

Descriptive Comparison between MTA and MPC for Inflammation grade, Soft tissue organization and Dentinal bridge formation is shown in Table 1. Regarding soft tissue organization, after two

months, there were slight disruption in soft tissue organization by 50% and moderate disruption by 50% of all the cases. However, in MTA group, after two months, there were slight disruption in soft tissue organization by 30% and moderate disruption by 70% of all the cases. In the group of MPC, after two months, there were no inflammation by 90% and low-grade inflammation by 10% of all the cases. However, in MTA group, after two months, there were no inflammation by 80% and low-grade inflammation by 20% of all the cases. In the group of MPC, after two months, there were incomplete formation in 30%, the beginning of formation in 40%, and there was no evidence on formation in 30% of all the cases. However, in MTA group, after two months, there were incomplete formation in 60%, the beginning of formation in 20%, and there was no evidence on formation in 20% of all the cases.

Mann-Whitney U test had been conducted to study the differences in soft tissue organization, inflammation grade and dentinal bridge formation stages between the two study groups in one week, one month, and two months after the extraction date. The test had showed no significant statistically difference between two study groups ($P > 0.05$). (Table 2)

Kruskal - Wallis test had been used to study the differences in the soft tissue organization, inflammation grade and dentinal bridge formation the teeth after the extraction in one week, and two months after extraction in each study group. The test hadn't shown any statistically significant difference in soft tissue organization grades in each group ($P > 0.05$). On the other hand, the test had showed statistically significant differences in inflammation grades in each group between the investigation periods ($P < 0.05$). (Table 2)

In the MPC group, the dentinal bridge formation had been in-

creased in all cases. Therefore, the increasement was statistically significant ($p = 0.004$). in MTA group, there were 9 cases where the dentinal bridge formation had increased in comparison with one case of equivalence. Therefore, the increasement was statistically significant ($p = 0.006$). (Table 2)

The dual comparisons between the periods of extraction regarding the inflammation grade had been conducted by using Kruskal-Wallis test with Bonferroni correction as shown in Table 3. It was noted that there was significant difference between (after one week) and (after one month/after two month) in both groups ($P < 0.05$).

Discussion

This study had concentrated on an important Object that's related to everyday treatment methods in Periodontology clinics which is primary teeth Pulpotomy.

There are many studies that indicate the similarity between MTA and PC in their Physical, Biological, and microscopic specifications [16, 17]. The researcher Wucherpfennig et al., had assured the Physical similarity between the two materials after conducting an X-ray deviation analysis, and biological response similarity after the application of the two materials in Direct pulp capping on rats teeth in terms of Restorative Dentin formation (Tertiary Dentin) [18], the researcher Esterla et al., also assured the similarity in Ph degree and Antibacterial effect for the two materials [19].

Many studies in Medical literature confirmed the similarity between the MTA and PC in Physical and Chemical Specifications by testing the chemical composition and Compressive strength for PC in comparison to MTA [16, 19].

Table 1. Descriptive Comparison between MTA and MPC for Inflammation grade, Soft tissue organization and Dentinal bridge formation.

Date of extraction	Inflammation grade	Number of teeth		Soft tissue organization (Disruption)	Number of teeth		Dentinal bridge formation	Number of teeth	
		MPC	MTA		MPC	MTA		MPC	MTA
After one week	None	0	0	Slight	2	2	No evidence on formation	6	4
	Low	5	6	Moderate	6	5	Beginning of formation	4	6
	Acute	5	4	Sever	2	3	Incomplete formation	0	0
After one month	None	6	7	Slight	3	2	No evidence on formation	5	4
	Low	4	2	Moderate	7	7	Beginning of formation	4	5
	Acute	0	1	Sever	0	1	Incomplete formation	1	1
After two months	None	9	8	Slight	5	3	No evidence on formation	3	2
	Low	1	2	Moderate	5	7	Beginning of formation	4	2
	Acute	0	0	Sever	0	0	Incomplete formation	3	6

Table 2. Intra- and intergroup Comparison between MTA and MPC for Inflammation grade, Soft tissue organization and Dentinal bridge formation.

Date of extraction	Histological Variable	Mean Rank		P-value *	Histological variable	Mean rank		P-value *	Histological variable	Mean rank		P - value *
		MPC	MTA			MPC	MTA			MPC	MTA	
After one week	Inflammation grade	11	10	0.739	Soft tissue organization (Disruption)	10.1	10.99	0.796	Dentinal bridge formation	9.5	11.5	0.481
After one month	Inflammation grade	10.8	10.2	0.853	Soft tissue organization (Disruption)	9.65	11.35	0.529	Dentinal bridge formation	10.05	10.95	0.739
After two months	Inflammation grade	10	11	0.739	Soft tissue organization (Disruption)	9.5	11.5	0.481	Dentinal bridge formation	9.1	11.9	0.315
P-value **		0.000	0.001			0.189	0.37			0.004	0.006	

*: Mann-Whitney U test to study the differences between the two study groups

** : Kruskal- Wallis test to study the differences in soft after the extraction in one week, one month, and two months in the same group.

Table 3. Differences in inflammation grades after the extraction in one week, one month, and two months.

The group	The investigation periods	The test value	P value*
MPC	After one week - after one month	-3.128	.005
	After one week - after two months	-4.171	.000
	After one month - after two months	-1.043	.891
MTA	After one week - after one month	-3.128	.005
	After one week - after two months	-4.171	.000
	After one month - after two months	-1.043	.891

*: Kruskal - Wallis test with Bonferroni correction.

The Radiological Opacity of MTA due to the existence of Bismuth Oxide, the studies had clarified that this method caused spaces in the material mass by 15-31%, and after adding Bismuth Oxide to Portland Cement the Compressive strength had reduced from 82 to 40 megapascal. Therefore, the researchers had directed to examine other radiological opaque materials [20].

In this study, Zirconium Oxide had been added to Portland Cement by 30% as a radiological Opaque material, the researcher Camilleri et al., in 2011 had proofed that Zirconium Oxide is an inert material if added to Portland Cement, and it doesn't affect on Portland Cement's Biological responses [21].

This study evaluated the Histological responses of Modified Portland Cement in comparison with MTA in primary teeth Pulpotomy after (one week, one month, and two months).

According to this study's results, there were no significant differences between the two groups in investigation periods in terms of Soft tissue organization, Inflammatory responses, and Dentinal Bridge formation stages. However, there were significant differences in Modified Portland Cement group and MTA group between (one week, and one month) and (one week, and two months) investigation periods in the context of Inflammatory responses. In one week, there were Moderate to severe Biological

reaction in the pulp tissue due to the high Alkalinity of both materials which caused fast Biological reaction and acute histological disruption in the early beginning, which afterwards declined rapidly. After time passed, the biological reactions had reduced and the pulp tissue get recovered.

There was also statistically significant difference in both MTA and MPC groups in terms of Dentinal Bridge formation between (one week, and two months) investigation periods, this difference was because of the high sealing ability, High Alkalinity, and Biological compatibility of both materials. The dentinal Bridge formation procedure had been affected by existence of Calcium Oxide, which reacts with Carbon Dioxide from Pulp tissue to form Calcite Crystals which provokes Fibronectin formation. The Fibronectin formation is considered as the starting point of Dentinal Bridge formation.

In terms of Modified Portland cement, due to the lack of studies about this material in the same composition that were used in this study, the comparison will be conducted with studies that used Portland Cement or Modified Portland Cement with materials similar to those added in this study.

This study results agree with the study of Bhagat et al., in 2016 which examined the Histological responses against the Portland

Cement in comparison with MTA in Primary teeth Pulpotomy with 6 months follow up period. Bhagat study founded that the two materials were biocompatible and had Similar responses in terms of Soft Tissue Organization, Inflammatory responses, and Dentinal Bridge formation without any Statistically Significant differences [22]. This study results also agree with Oliveira et al study in 2013, which was Histological, Radiological Clinical study about a comparison between Portland Cement, MTA, and Calcium Hydroxide in follow up periods (6, 12, 24) months respectively. Oliveira study indicated that both Portland Cement and MTA are Biocompatible materials and had similar results in terms of Histological responses such as Soft Tissue Organization, Inflammatory responses, and Dentinal Bridge formation, and their results were better than Calcium Hydroxide which showed Root Pulp Tissue necrosis [23].

This study results were similar also with Barbosaa study in 2018, which had been included Comparing Histological study between MTA and Portland Cement in Direct Pulp Capping on 40 Third molars that were planned to be extracted in (1, 7, 14, 21) days of follow up, Barbosaa found that both materials were biocompatible with a little excellence of MTA in terms of Dentinal Bridge Formation, but without any Statistically significant Differences between the two materials [24].

Conclusions

- The histological responses results in terms of Soft tissue Organization, Inflammation reaction, and the Dentinal Bridge formation were correspondent between Modified Portland Cement and MTA without any Statistically significant Differences between the two groups.
- There were declination in Inflammation grade in Modified Portland Cement and MTA groups between (one week, and one month) and (one week, and two months) investigation periods with statistically significant difference in both Groups.
- There was an increase in Dentinal Bridge Formation in both (one week, and two months) investigation periods in both Modified Portland Cement and MTA groups with Statistically significant difference in both groups.

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