Journal of Advanced Medical and Dental Sciences Research

@Society of Scientific Research and Studies

Journal home page: www.jamdsr.com doi: 10.21276/jamdsr Index Copernicus value = 85.10

(e) ISSN Online: 2321-95 (p) ISSN Print: 2348-6805

Original Research

Effectiveness of MTA when used as an indirect pulp therapy (IPT) material

[1]Dr. Divyashree R, [2]Dr. Kirthi Raj

[1]BDS, MDS, Department of Pedodontics, Working as Pedodontic consultant in Kirti Eye and dental Hospital, Bangalore, India;
[2]MBBS, MS, FVR, Department of Ophthalmology, Assistant professor in Dr.B R Ambedkar medical Hospital, Bangalore, India

ABSTRACT:
Aim of the study: The present study assessed and compared the success of an IPT procedure radiographically when MTA and Silver Diamine Fluoride (SDF) were used as an IPT material on primary molars. **Methodology:** Children aged 5- 9 years were screened and those who fulfilled the inclusion criteria were selected. Accordingly 50 children were divided into 2 groups with 25 patient in each group. Cavity preparation was done and the two test materials (MTA and SDF) were placed at the base in their respective groups and restored with RMGIC. Post-operative radiograph was taken for baseline data. Patients were assessed at Subsequent at 1, 3 and 6 months radiographically. **Results:** SDF had formed a good biological seal, arrested further caries progression and did not cause any adverse pulpal reaction. However the amount of reparative dentin formed was highest in the MTA group followed by SDF group.

Received: 10 April, 2021 Accepted: 18 May, 2021

Corresponding author: Dr. Divyashree R, BDS, MDS, Department of Pedodontics, Working as Pedodontic consultant in Kirti Eye and dental Hospital, Bangalore, India

This article may be cited as: R Divyashree, Raj K. "Effectiveness of MTA when used as an indirect pulp therapy (IPT) material. J Adv Med Dent Scie Res 2021;9(6):169-174.

INTRODUCTION

Indirect pulp capping has been described as a conservative alternative treatment of the dentin-pulp complex, for primary and permanent teeth, since 1859 by John Tomes. The ADA defines this procedure as a "Procedure in which the nearly exposed pulp is covered with a protective dressing to protect the pulp from additional injury and to promote healing and repair via formation of tertiary dentin." It is a procedure in which the non-remineralizable tissue is removed and a thin layer of caries is left in the deepest sites of the cavity thereby avoiding the possibility of a pulp exposure.(1)

Various materials have been used for Indirect Pulp therapy procedure like Calcium hydroxide,Corticosteroids, Bonding agents, Cyanoacrylates, MTA, Lasers etc.

Dr. Mahmoud Torabinejad in 1990's at the Loma Linda university developed Mineral Trioxide Aggregate (MTA) cement as a root end filling material. The major constituents of this material is dicalcium silicate, tricalcium silicate, and tricalcium aluminate & tetra calcium aluminoferrite & bismuth oxide. MTA exhibits calcified tissue–conductive activity and facilitate the differentiation of human Orofacial mesenchymal stem cells. It has the potential to facilitate mineralization process in human dental pulp which makes it successful to be used as an effective pulp capping agent.(2)

With the advent of technology and quest for newer material has prompted the clinicians to explore the remineralizing abilities of various other materials like Stem cells, Propolis, Bio dentine and Emdogain so on so forth.

Interest in the use of Silver Diamine Fluoride (SDF) has been growing. SDF has been used as an alternative treatment for caries prevention and arrest.(3). In vitro studies have demonstrated that SDF increases the pH of biofilm, reduces dentin demineralization, and has antimicrobial action against cariogenic bacteria.(4) Ex vivo and in vivo studies on cavitated extracted teeth from children

receiving semi-annual applications of SDF have shown effectiveness in arresting lesions as well as higher fluoride uptake compared to fluoride varnish and acidulated phosphate fluoride gel.(5)
Clinical studies have demonstrated the effectiveness of SDF in childhood caries prevention and arrest. Semi-annual applications of SDF at 38% concentration have been recommended.(6) SDF has been suggested for difficult-to-treat lesions and patients with high caries risk, including those with medical or behavioural complications, those who require multiple treatment visits, or those without access to dental care.(7)
A study by Korwae et al reports that SDF when used as IPT material showed no pulpal inflammatory response and detected tertiary dentin formation under a histopathological study.(8)
However, there is a paucity in literature of studies explain the long term success of SDF being used as an Indirect Pulp Capping material and also comparing the effects of MTA and SDF when used as IPT materials for primary teeth. Hence, this study is being undertaken to evaluate the radiographic success and thereby evaluating these materials when used as an IPT material.

AIM
To evaluate the success of MTA (Silver Diamine Fluoride) when used as Indirect Pulp Capping (IPT) materials for primary teeth.

OBJECTIVES
1) To assess the reparative dentine formation of MTA and SDF when used as IPT material radiographically.

MATERIALS AND METHODLOGY
ARMAMENTARIUM
1. Disposable Surgeon's cap (Dispodent)
2. Mouth mask (Suraksha)
3. Sterile gloves (Dispodent)
4. Mouth mirror and Explorer.
5. Pair of tweezers
6. Cotton rolls
7. Single use syringe-2 ml (Uniolok)
8. Local Anesthesia – (Lignox 2 % - Lignocaine hydrochloride 2% with 1:80,000 adrenaline)
9. Rubber Dam (Hygienic-Dental Dam kit)
10. Saliva ejection tips
11. Spoon Excavator
12. Contra angle aerotor handpiece (NSK)
13. Round Diamond Dental Burs (Mani-No 2 & 4)
14. Ball ended condenser tip
15. MTA (Angelus)
16. Amalgam carrier
17. Silver Diamine Fluoride(SDF) (Advantage Arrest)
18. Resin Modified Glass Ionomer Cement (RMGIC)
19. Agate spatula
20. Articulating paper
21. PSP sensor plate
22. PSP scanner (Digora)
23. Position Indicating Device (XCP Holder)

STUDY DESIGN
The present study was a randomized controlled in vivo study between MTA and Silver Diamine Fluoride (SDF) as indirect pulp capping agents in primary molars.

SOURCE OF DATA
The present in vivo study was conducted on 50 children in the age group of 6-9 years of both sexes, who visited the Department of Pedodontics and Preventive Dentistry

SAMPLE SELECTION
The sample size included 50 primary molars indicated for indirect pulp capping procedure. The study subjects were randomly divided into two groups of carrying 25 teeth each according to the indirect pulp capping agents used.
Group 1 - MTA (25 teeth)
Group 2 - Silver Diamine Fluoride (SDF) (25 teeth)

METHOD OF COLLECTION OF DATA
The samples to each group were selected using random sampling technique.

CLINICAL
INCLUSION CRITERIA
1. History of tolerable dull intermittent pain, mild discomfort associated with eating, negative history of spontaneous extreme pain.
2. On clinical examination, large carious lesions involving either the occlusal or proximal surfaces, with normal appearances of gingiva.
3. Radiographic examination showing carious lesion involving more than 2/3 $^{rd.}$ thickness of dentin approximating the pulp, normal lamina dura, normal periodontal ligament space, more than 2/3 $^{rd.}$ of root present, no periapical changes, no pathologic external or internal resorption.

EXCLUSION CRITERIA
1. History of sharp, penetrating pulpalgia indicating acute pulpal inflammation and necrosis, prolonged spontaneous pain at night.
2. Clinical examination showing presence of mobility of tooth, discoloration of tooth, negative reaction to electric pulp testing, sinus opening, or abscessed tooth.
3. Radiographic examination showing carious lesion with definite pulp exposure, interrupted or broken lamina dura, widened periodontal ligament space, periapical radiolucency, internal or external resorption.

METHODOLOGY AND CLINICAL PROCEDURE

Patients were screened initially to determine whether they met the study inclusion criteria and thus the qualified patients were enrolled in the study.

Informed parental and patient consent and ethical clearance was taken from the Institutional Ethical Committee.

A total of 50 subjects were divided into two group based on random sampling method:

GROUPS

Group I - 25 subjects (MTA group)

Group II - 25 subjects (Silver Diamine Fluoride group)

After screening profound administration of local anaesthesia using LIGNOX 2% (Lignocaine hydrochloride 2% with 1:80,000 adrenaline) was done and the tooth was isolated with rubber dam (Hygenic). The caries was removed either by a spoon excavator or round diamond dental bur (no 2) using a hand piece running at a slow speed & copious water irrigation leaving behind the affected dentin.

GROUP 1: MTA GROUP

Following caries removal, MTA powder was mixed with sterile water for 30 seconds so as to get a sandy consistency according to the manufacturer's instructions and was placed on the floor of the cavity using an amalgam carrier. It was adapted using light pressure with moist cotton pellets.

GROUP 2: SILVER DIAMINE FLUORIDE GROUP

Following caries removal, Silver Diamine Fluoride was applied with a micro tip applicator for 15 sec to the floor of the cavity.

Following the placement of the test materials the tooth was subsequently restored with RMGIC to ensure a proper seal in each case.

In both the two groups, after the completion of indirect pulp capping with respective agents, a baseline radiograph was made. Subsequently, at one, three and six months, the tooth was evaluated clinically and radiographically evaluated by taking x rays. Measurements of the digitized radiographs were performed at baseline, and was done at first, third and sixth months. The increase in dentin thickness was measured using Corel Draw software (Version 17) keeping cement-enamel junction and the highest point on the floor of pulp chamber as reference points and the measurements were made till the base of the restoration. The amount of dentin deposited at each time interval was calculated by the difference in the values obtained from the baseline and follow up radiographs.

As the reparative dentine is formed the linear distance between Point A- Point B reduces which inversely reports that there is increase in the reparative dentine which is being formed.

Point A- Point B Reparative dentine formed

STATISTICAL ANALYSIS

The Statistical Analysis were done using SPSS v.22 software IBM., Corp. A descriptive analysis of the data is presented as frequency, mean, and standard deviation (SD).

One-way ANOVA test followed by Tukey's Post hoc Analysis is used to compare the mean thickness of the reparative dentin between the study groups at each time period.

Repeated measures of ANOVA will be used to compare the mean difference between different time intervals [1st Month, 3rd Month & 6th Month] within the same study group. The level of significance will be set at $P<0.05$.

RESULTS

The results of the present study were tabulated and analyzed under the following headings

Table 1

The mean distance from point A- point B (in mm) between 02 study groups at different time intervals using One-way ANOVA Test

Time	Groups	N	Mean	SD	Min	Max	F	P-Value
Baseline	Group 1	25	0.4995	0.1406	0.315	0.795	2.278	0.11
	Group 2	25	0.4494	0.1101	0.289	0.656		
1 month	Group 1	25	0.4471	0.1000	0.301	0.672	12.742	<0.001*
	Group 2	25	0.4481	0.1786	0.222	0.645		
3 months	Group 1	25	0.3946	0.1295	0.212	0.660	8.565	<0.001*
	Group 2	25	0.4452	0.1779	0.220	0.637		
6 months	Group 1	25	0.3829	0.1369	0.170	0.655	9.254	<0.001*
	Group 2	25	0.4418	0.1759	0.200	0.612		

Table 3

Comparison of mean from point A- point B(in mm) between different time intervals in Group 1 using Repeated measures of ANOVA test					
				Greenhouse Geisser	
Time	N	Mean	SD	F	P-Value
Baseline	25	0.4995	0.1406	17.948	<0.001*
1 month	25	0.4471	0.1369		
3 months	25	0.3946	0.1295		
6 months	25	0.3829	0.1000		

Anova test was done for intragroup comparison at different time intervals in Group 1 The table shows that Group 1 showed there is a highly statistically significant difference (P- Value <0.001*) at different time interval, that is at the end of one, three and six months.

Table 4

Comparison of mean from point A- point B(in mm) between different time intervals in Group 2 using Repeated measures of ANOVA test					
				Greenhouse Geisser	
Time	N	Mean	SD	F	P-Value
Baseline	25	0.4494	0.1101	0.047	0.83
1 month	25	0.4481	0.1786		
3 months	25	0.4452	0.1779		
6 months	25	0.4418	0.1759		

Anova test was done for intragroup comparison at different time intervals in Group 2. The table shows that Group 2 showed there is a no statistically significant difference (P- Value 0.83) at different time interval, that is at the end of one, three and six months.

Table 5

The mean Reparative dentin thickness (in mm) between 03 study groups at different time intervals using One-way ANOVA Test								
Time	Groups	N	Mean	SD	Min	Max	F	P-Value
Baseline	Group 1	25	0.0524	0.1268	-0.090	0.400	6.152	0.003*
	Group 2	25	0.0013	0.1887	-0.490	0.200		
1 month	Group 1	25	0.1048	0.0419	0.010	0.280	8.265	0.001*
	Group 2	25	0.0042	0.1884	-0.490	0.210		
3 months	Group 1	25	0.1166	0.0481	0.000	0.280	9.085	<0.001*
6 months	Group 2	25	0.0076	0.1840	-0.490	0.210		<0.001*

One way ANOVA test was used to compare the mean reparative dentin thickness (in mm) among the experimental groups at different time intervals. There was highly statistically significant difference among both the experimental groups at the end of 1st month (P-Value 0.003*). There was highly statistically significant difference among both the experimental groups at the end of 3rd month (P-Value 0.001*). There was highly statistically significant difference among all the two experimental groups at the end of 6th month (P-Value <0.001*)

DISCUSSION

The rationale for IPT is based on the observation that post mitotic odontoblasts can be induced to up-regulate their synthetic and secretory activities in response to reduced infectious challenge. This results in deposition of tertiary dentine formation which increases the distance between caries and pulp cells by deposition of peritubular dentin which decreases the dentin permeability.(9) The rate of reparative dentine formation is 1.4um/day after cavity preparation. The rate of reparative dentin formation is highest in the 1st month and then diminished with time, it continues upto a period of 9-12 months but at a slower rate.(10)

While calcium hydroxide and MTA has been extensively used in the past for IPT procedure, high fluoride releasing materials like Silver Diamine Fluoride (SDF) is proposed newer IPT material which stimulates the formation of reparative dentin. Silver Diamine Fluoride (SDF) was initially used as a cariostatic agent. Various clinical studies [4] have reported its utility in the treatment and prevention of caries. SDF helps in the deposition of silver phosphate to restore mineral content, resulting in

rehardening of tooth structure. It also releases fluoride(11). A 38% SDF product has been accepted as a therapeutic agent by the Central Pharmaceutical Council of the Ministry of Health and Welfare of Japan for dental treatment for half a century.(12)

In the present study, the selection of the cases were done based on the clinical and radiographic criteria for IPT. Ricucci et al correlated clinical and radiographic evaluation of pulp status with histologic classification of pulp conditions and revealed a good agreement especially for cases with no pulpal diseases or irreversible disease.(13)

As the reparative dentine is formed the linear distance between Point A- Point B reduces which inversely reports that there is increase the reparative dentine which is being formed.

Point A- Point B Reparative dentine formed

The mean distance between point A- point B at the baseline in MTA group was 0.4995mm. On intra-group comparison of MTA the mean distance at the end of 1st month it was recorded as 0.4471 mm and by the end of 3 months it is 0.3946 mm. By the end of 6 months the distance has reduced to 0.3829 mm therefore the amount of reparative dentine formed at the end of 6 months is around 0.116mm.

Leye Benoist et al (14) showed 0.121 mm of increase in dentin thickness over 6 months when MTA was used an IPT material for 30 primary molars for a period of 6 months. The values of dentinogensis quoted by various authors in the above mentioned studies are in par with the present study.

The intragroup comparison of SDF group in this study, revealed an average distance from point A-point B of 0.4494mm by the end of 1st month it was recorded as 0.4481 mm and by the end of 3 months it was 0.4452 mm. By the end of 6 months the distance had reduced to 0.4418 mm therefore the reparative dentine formed at the end of 6 months was around 0.0076 mm this gives a statistically insignificant P-Value of 0.83. However there was no further progression of caries both clinically and radiographically.

Nakade *et al.* stated that fluoride at micromolar concentrations can stimulate the proliferation and alkaline phosphatase activity of human dental pulp cells.(15) Fluoride at this level stimulated thymidine incorporation into DNA in dental pulp cells, with optimal effects around 50 μMol. It significantly increased the alkaline phosphatase activity in dental pulp cells by 177 ± 12%. Extracellular-matrix synthesis (Type I collagen) was also shown to increase by 150 ± 8.7%. This suggests that fluoride at low concentrations can be a useful therapeutic agent, where increased Tertiary dentin is desired, such as in IPT procedure. It can be hypothesized that SDF can stimulate the Tertiary dentin when used as an IPT material.

However in our study SDF did not show reparative dentin formation to an extent that was statistically significant. According to Flaster et al and Maltz et al the indirect pulp capping is not considered a material-dependent technique. The role of the lining material is not essential, but a good marginal seal, preventing, (i) bacterial substrate infiltrating the dentin, (ii) the control of the carious activity. These criteria guarantees a high success of IPT.(16) (17)

Yamaga and his co-workers suggest that both fluoride ions and silver ions contribute to its mechanism of action.(12) They propose that fluoride ions act mainly on tooth structure while silver ions act mainly on cariogenic bacteria.

Mei and her co-workers found that SDF provides an alkaline environment to render CaF2 less soluble and, therefore, serves as a fluoride reservoir for acid challenges by cariogenic bacteria.(18) *In vitro* studies show that SDF can inhibit demineralisation of hydroxyl apatite and preserve collagen from degradation in demineralised dentine tissue.(18) In addition, collagen breakdown of dentine was significantly reduced (19), and dentine hardness was significantly increased after SDF application. SDF also has antibacterial properties. Silver ions can bind with negatively charged peptidoglycans in bacterial cell walls and disrupt membrane transport function, which in turn leads to cellular distortions and loss of viability (20). Binding to sulphydryl groups (thio group of cystine), which is essential for enzyme activities, can inhibit bacterial enzyme activities, disrupt metabolic processes, and eventually cause death of the microbe (21).

In our study SDF placed as IPT material and followed up for 6 months did not show any adverse pulp reactions. In a study by Korwar et al (8) SDF was tested for an IPT material in-vivo. The study reports that out of 9 specimens which received SDF as IPT material for a period of 6 weeks 5 specimens showed reparative dentin formation while 4 did not show any odontoblastic formation in histopathological section. However none of them showed any adverse pulpal reactions which is in accordance with our findings.

HOWEVER THE LIMITATIONS OF THE STUDY INCLUDED

1. Sufficient (setting) time was not given between the placement of MTA and the access fill material which could have affected the reparative dentine formation with MTA.
2. SEM and Histopathological investigations would have provided a better insight towards the exact mechanism of SDF.

WITHIN THE LIMITATION OF THE STUDY, THE FOLLOWING CONCLUSIONS WERE DRAWN

1. The two experimental materials MTA, SDF showed reparative dentin formation at the end of 1, 3 and 6 months.
2. Although SDF did not show significant amount of reparative dentin formation compared Dycal and MTA. It still seems to be a good IPT material as it fulfils the other criteria for IPT procedure such as good biological seal and maintenance of the pulp vitality.
3. Thus SDF can be used as an alternative IPT material in severe ECC cases and in un co-operative children.

BIBLOGRAPHY

1. American Academy on Pediatric Dentistry Clinical Affairs Committee-Pulp Therapy subcommittee, American Academy on Pediatric Dentistry Council on Clinical Affairs. Guideline on pulp therapy for primary and young permanent teeth. Pediatr Dent. 2008 2009;30(7 Suppl):170–4.
2. Camilleri J, Pitt Ford TR. Mineral trioxide aggregate: a review of the constituents and biological properties of the material. Int Endod J. 2006 Oct 1;39(10):747–54.
3. Peng JJ-Y, Botelho MG, Matinlinna JP. Silver compounds used in dentistry for caries management: a review. J Dent. 2012 Jul;40(7):531–41.
4. Chu CH, Mei L, Seneviratne CJ, Lo ECM. Effects of silver diamine fluoride on dentine carious lesions induced by Streptococcus mutans and Actinomyces naeslundii biofilms. Int J Paediatr Dent. 2012 Jan;22(1):2–10.
5. Mei ML, Ito L, Cao Y, Lo ECM, Li QL, Chu CH. An ex vivo study of arrested primary teeth caries with silver diamine fluoride therapy. J Dent. 2014 Apr;42(4):395–402.
6. Sharma G, Puranik MP, K R S. Approaches to Arresting Dental Caries: An Update. J Clin Diagn Res JCDR. 2015 May;9(5):ZE08-11.
7. Contreras V, Toro MJ, Elías-Boneta AR, Encarnación-Burgos A. Effectiveness of silver diamine fluoride in caries prevention and arrest: a systematic literature review. Gen Dent. 2017;65(3):22–9.
8. Korwar A, Sharma S, Logani A, Shah N. Pulp response to high fluoride releasing glass ionomer, silver diamine fluoride, and calcium hydroxide used for indirect pulp treatment: An in-vivo comparative study. Contemp Clin Dent. 2015;6(3):288–92.
9. Bjørndal L, Larsen T, Thylstrup A. A clinical and microbiological study of deep carious lesions during stepwise excavation using long treatment intervals. Caries Res. 1997;31(6):411–7.
10. Singhal M, Chaudhary CP, Anand R, Singh N, Sahni T. RECENT ADVANCEMENTS OF INDIRECT PULP CAPPING IN PRIMARY TEETH: A REVIEW. J Adv Med Dent Sci Res. 2015;3(5):5.
11. Gupta A, Sinha N, Logani A, Shah N. An ex vivo study to evaluate the remineralizing and antimicrobial efficacy of silver diamine fluoride and glass ionomer cement type VII for their proposed use as indirect pulp capping materials - Part I. J Conserv Dent JCD. 2011 Apr;14(2):113–6.
12. Yamaga R, Nishino M, Yoshida S, Yokomizo I. Diammine silver fluoride and its clinical application. J Osaka Univ Dent Sch. 1972 Sep;12:1–20.
13. Naseri M, Khayat A, Zamaheni S, Shojaeian S. Correlation between Histological Status of the Pulp and Its Response to Sensibility Tests. Iran Endod J. 2017;12(1):20–4.
14. Leye Benoist F, Gaye Ndiaye F, Kane AW, Benoist HM, Farge P. Evaluation of mineral trioxide aggregate (MTA) versus calcium hydroxide cement (Dycal(®)) in the formation of a dentine bridge: a randomised controlled trial. Int Dent J. 2012 Feb;62(1):33–9.
15. Nakade O, Koyama H, Arai J, Ariji H, Takada J, Kaku T. Stimulation by low concentrations of fluoride of the proliferation and alkaline phosphatase activity of human dental pulp cells in vitro. Arch Oral Biol. 1999 Jan;44(1):89–92.
16. Falster CA, Araujo FB, Straffon LH, Nör JE. Indirect pulp treatment: in vivo outcomes of an adhesive resin system vs calcium hydroxide for protection of the dentin-pulp complex. Pediatr Dent. 2002 Jun;24(3):241–8.
17. Cannon M, Gerodias N, Viera A, Percinoto C, Jurado R. Primate pulpal healing after exposure and TheraCal application. J Clin Pediatr Dent. 2014;38(4):333–7.
18. Mei ML, Chu CH, Lo ECM, Samaranayake LP. Fluoride and silver concentrations of silver diammine fluoride solutions for dental use. Int J Paediatr Dent. 2013 Jul;23(4):279–85.
19. Mei ML, Li QL, Chu CH, Yiu CKY, Lo ECM. The inhibitory effects of silver diamine fluoride at different concentrations on matrix metalloproteinases. Dent Mater Off Publ Acad Dent Mater. 2012 Aug;28(8):903–8.
20. Coward JE, Carr HS, Rosenkranz HS. Silver sulfadiazine: effect on the ultrastructure of Pseudomonas aeruginosa. Antimicrob Agents Chemother. 1973 May;3(5):621–4.
21. Russell AD, Hugo WB. Antimicrobial activity and action of silver. Prog Med Chem. 1994;31:351–70.