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Mineral Trioxide Aggregate and Calcium Hydroxide Pulpotomy Outcomes of Primary Molars-A Systematic Review

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Abstract: ***Objective: To assess the literature regarding the clinical and radiographic outcomes of MTA and Calcium Hydroxide pulpotomy in primary molars. Data Sources: An electronic literature search was performed within PubMed and Google databases from 1st January 2005 till 31st December 2016. Results: Preliemnary screening consisted of 78 articles,37 articles were selected. Only 5 with full text were selected. Conclusion: MTA pulpotomy showed higher success rate when compared with Calcium Hydroxide pulpotomy in primary molars. Despite its tendency to discolor MTA can be used as a suitable material as an alternative to Calcium Hydroxide.***

Keywords: Mineral Trioxide Aggregate, Calcium Hydroxide, Pulpotomy, Vital Pulp Therapy

1. Introduction

According to AAPD (1999) "Pediatric dentistry is an age-defined specialty that provides both primary and comprehensive preventive and therapeutic oral health care for infants and children through adolescence, including those with special health care needs." Pediatric dentistry encompasses a variety of disciplines, techniques, procedures, and skills that share a common basis with other specialties, but are modified and adapted to the special needs of infants, children, adolescents, and those with special health care needs. These skills are applied to the needs of children throughout their ever-changing stages of development and to treating conditions and diseases unique to growing individuals.[1]

Pulpotomy in primary teeth is a standard procedure to amputate the inflamed and infected dental coronal pulp tissue and is usually undertaken when coronal pulp tissues are exposed by caries, during caries removal or trauma[2]. It aims healing of the healthy pulp tissue at the entrance of the root canal, after the removal inflamed coronal pulp tissue containing microorganisms. After a coronal pulp is amputated, pulp stump are treated with several agents, leaving vital and uninfected radicular pulp tissue intact [3].

On the basis of treatment objectives, Don M. Ranly classified pulpotomy procedure as Devitalization (Mummification or Cauterization), Preservation (minimal devitalization or noninductive procedure) and Regeneration (inductive or reparative procedure). In inductive or reparative mechanism of pulpotomy the radicular pulp is allowed to heal and form a dentin bridge / hard tissue barrier. Regeneration, the stimulation of a dentin bridge, has long been associated with calcium hydroxide [4]. Mineral Trioxide Aggregate (MTA) and Calcium Hydroxide are regeneration type of materials used for pulpotomy.

In 1990's MTA was developed and introduced as a root-end filling material at the Loma Linda University, California, USA, and was approved by The US Food and Drug Administration for human teeth treatment in 1998 [5]. Tricalcium oxide, Tricalcium aluminate, Tricalcium silicate, Tetracalciumaluminoferrite and Calcium sulfate dehydrate are principal components of the grey-coloured MTA [6-9]. The more aesthetic white-coloured preparation lacks the tetracalciumaluminoferrite[10,11]. Lately, MTA has been used as a pulpotomy material in primary molars and it was found to be a successful material [12,13]. Stimulating cytokine release from bone cells, inducing hard tissue formation, dentinogenic effect on the pulp, antimicrobial property, and maintenance of pulp integrity after pulp capping and without any cytotoxic effect, are the few ideal features of MTA which make this material to be served as control in researches based on pulpotomy[14-17].

Calcium Hydroxide(CH) was introduced by Herman (1930) for pulp capping. In 1938,Teuscher and Zander introduced calcium hydroxide in the United States. They histologically confirmed complete dentinal bridging with healthy radicular pulp under Calcium hydroxide dressings. CH as is a white, crystalline, highly alkaline, and slightly soluble basic salt, which is able to induce the formation of a hard tissue bridge[18,19]. Internal root resorption as the most frequent side effect is a reason for failure of pulpotomy with CH in primary teeth.

Systematic reviews have gained an important position in the dental literature, aiding in clinical decision making. The value of a good systematic review is that it minimizes bias, provides a comprehensive and contemporary overview, and is objective in its appraisal of quality. It is transparent to allow others to appraise the methods and quality of the review. If such conditions are met, the reader should have greater confidence in the conclusions of the review than other summaries of clinical evidence. [20]. Till date there is no systematic review performed to assess the outcome of

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Calcium hydroxide Pulpotomy over MTA pulpotomy in primary molars hence the aim of this systematic review was to gather and evaluate the clinical and radiographic outcomes in primary molar in a systematic manner to help clinicians to make decision for the use of material.

2. Literature Survey

Methods:

A comprehensive computerized search (since1st January 2005 and 31st December 2016) was conducted in PubMed. In PubMed the Clinical Queries filter, facilitated finding the controlled clinical trials (RCTs) for comparing MTA and Calcium Hydroxide as primary pulpotomy agents. In addition to PubMed, general search engine such as Google was used. The bibliographies of retrieved articles were also searched for references, which were not included in the electronic search. The following keywords were used with different combinations for trial searching like MTA, Calcium Hydroxide, Pulpotomy, Primary molar.

Inclusion Criteria

1) Articles in English or those having detailed summary in English.
2) Studies published between 1st January 2005 and 31st December 2016.
3) Studies that provided information for age groups of 3 to 10yrs old.
4) Randomized controlled trials and Original prospective clinical trials comparing MTA and Calcium Hydroxide Pulpotomy agents.
5) Pulpotomy performed on human vital primary molars with carious pulp exposure.
6) Follow-up periods of at least 2 months or more.
7) Reporting clinical or radiographic success and failure rates.

Exclusion Criteria

1) Review, case reports, abstracts, letters to editors, editorials, retrospective studies and in vitro studies are excluded.
2) Articles published in languages other than English.
3) Studies having follow-up shorter than 3 months.

PICO Format

P	Primary molars
I	MTA
C	Calcium Hydroxide
O	Clinical and radiographic success rate

Sr No	*Author*	*Year*	*Location*	*Sample Size*	*Age Group*	*Intervention*
1	Uddin et al	2013	Bangladesh	40	5-7 years	MTA, Calcium Hydroxide
2	Liu et al	2011	China	40	4-9 years	MTA, Calcium hydroxide
3	Yildiz et al	2014	Turkey	147	5-9 years	MTA, Calcium Hydroxide, Ferric sulphate, Formocresol
4	Sonmez et al	2008	Turkey	80	4-9 years	MTA, Calcium Hydroxide, Ferric sulphate, Formocresol
5	Oliveira et al	2013	Brazil	45	5-9years	MTA ,Calcium hydroxide,Portland cement

Sr No	*Product Considered*	*Radiographic Features*						
		Internal Resorption	*External Resorption*	*Furcation Lesion*	*Apical Radiolucency*	*PDL Widening*	*Pulp Canal Obliteration*	*Bone Destruction*
1	MTA=20	0	0	0	1	0	0	0
	Calcium hydroxide=20	0	0	0	3	0	0	0
2	MTA=20	0	0	0	1	0	0	0
	Calcium hydroxide=20	6	0	0	0	0	0	0
3	MTA=41	2	0	0	0	0	1	0
	Calcium hydroxide=35	5	0	1	1	0	2	0
4	MTA=20	1	4	0	10	0	4	0
	Calcium hydroxide=20	3	4	0	14	0	1	0
5	MTA=15	0	0	0	0	0	1	0
	Calcium Hydroxide=15	6	0	6	0	0	0	6

Sr No	*Product Considered*	*Evaluation Time*	*Clinical Features*					
			PAIN	*P.O.P*	*Mobility*	*Swelling*	*Fistula*	*Crown Discoloration*
1	MTA=20	12 months	1	1	0	0	0	0
	Calcium hydroxide=20		3	3	0	3	0	0
2	MTA=20	56 months	0	0	0	0	0	11
	Calcium hydroxide=20		0	0	0	0	0	0
3	MTA=41	30 months	0	1	0	0	0	0
	Calcium hydroxide=35		1	2	1	0	1	0
4	MTA=20	24 months	0	0	0	0	2	0
	Calcium hydroxide=20		0	1	0	0	0	0
5	MTA=15	24 months	0	0	0	0	0	0
	Calcium Hydroxide=15		0	0	2	2	2	0

Study Selection

The titles and abstracts of the identified studies were reviewed for relevance. No articles were found after hand searching. Overall 78 articles were selected through PubMed and Google. 41 articles were excluded after removal of duplicates. Remaining 37 articles were screened for title and

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abstract. For accuracy of this review, 32 articles were excluded based on either MTA or Calcium Hydroxide as pulpotomy agent. Finally 5 articles with comparative study of MTA and Calcium Hydroxide pulpotomy material were selected for the present systematic review. Articles were screened by one reviewer (PG) and was crossed checked by second reviewer (RD).

Data Collection Process

A standard pilot form in excel sheet was initially used and then all those headings not applicable for review were removed. Data extraction was done for one article and this form was reviewed by an expert and finalized. This was followed by data extraction for all the articles.

3. Discussion

The preliminary goal of pulp therapy in primary dentition is that, the tooth should remain in non-pathological and functional condition in the mouth. Pulpotomy is indicated when caries removal results in pulp exposure of primary tooth with normal or reversible pulpitis or after traumatic pulp exposure. The coronal pulp tissue is amputated and remaining radicular pulp tissue is judged to be vital by clinical and /or radiographic criteria. The objective is that radicular pulp should remain healthy without adverse clinical signs or symptoms such as sensitivity, pain or swelling with no postoperative radiographic evidence of pathologic external or internal root resorption and no harm to succedaneous teeth.

Following are the 5 studies considered for this systematic review with comprehended clinical study design, results, analysis and interpretation aiding readers to understand easily.

LIU etal et al [21], clinically and radiographically assessed the efficacy of Mineral Trioxide Aggregate (MTA) and Calcium Hydroxide as pulpotomy medicaments in primary dentition.A total of healthy 40 sample size of 4 to 9 years old children having at least two similar-sized cavities on bilateral primary molar requiring pulpotomy were selected. Random assignment of the pulpotomy medicaments was done as follows: Group I- MTA; Group II- Calcium Hydroxide under Local Anesthesia, and isolation was maintained by use of rubber dam. All the pulpotomized teeth were evaluated at 10 to 56 months clinically and radiographically, based on the scoring criteria system. Both MTA and Calcium Hydroxide showed 94.1% and 64.70% clinical success rate and 100% and 65% radiographic success rate for MTA and Calcium Hydroxide at 56 months follow up. Presence of minor internal changes observed radiographically within the root canal, such as signs of apical radiolucency and/or internal resorption, were kept under follow- up observation and not designated as failure.. The radiographic success rate considering PCO and non-perforated internal resorption, which were under observation, was 92% and 80% for MTA &Biodentine. Internal resorption was a common sign in Calcium Hydroxide group 35% CH-treated failed because of internal resorption. Though it was categorized as a radiographic failure but they were left for follow up observation. In this study crown discoloration occurred in 11 out of 17 cases in MTA group, which affected tooth aesthetics to some extent. Other than that, the better results of MTA than CH in this study indicate that MTA is superior than calcium hydroxide and can be used routinely.

Uddin et al[22]conducted a study to observe clinical and radiographical findings of pulpotomies done with MTA and Calcium Hydroxide and to evaluate the success rate of MTA in maintaining pulp pulpal health in teeth with carious lesion. 40 primary molars in of age 5-7 years children whose pulpal status warranted pulpotomy were selected and randomly assigned into above two groups allocating 20 mandibular teeth to each group. Follow- up of 3, 6 and 12 months for clinical and radiographic evaluation was maintained. Calcific metamorphosis was a common radiographic finding in both the groups. The results showed that MTA have high success rate than Calcium Hydroxide. However, the comparison between two groups was not statistically significant ($p > 0.05$). Based on this clinical and radiographic evaluation study of 3,6 and 12 months follow up, MTA could be used as a safe material for pulpotomy in cariously and mechanically exposed primary molars seems to be a suitable alternative to Calcium Hydroxide. However, further research is required to clarify this conclusion.

Sonmezet al[23] performed a RCT comparing four pulpotomy medicament formocresol, ferric sulphate, Calcium Hydroxide & MTA. The mean age group was 4-9 years and duration of follow-up was 24months.The sample size was 13 for Calcium Hydroxide & 15 for MTA, the procedure was performed under cotton roll isolation and after completion of treatment teeth were restored by Dental amalgam. At the end of 24 Month clinical success rate for Calcium hydroxide was 46.15% and for MTA it was 66.66%, while the radiographic success rate at the end of 24 month for Calcium Hydroxide was 76.9% and for MTA it was 93%. Clinical failure symptoms of swelling were reported with 1/13 in the calcium hydroxide group and 2/15 showed sinus tract in MTA group. In radiographic evaluation, the most common finding over time in all groups was External resorption. It was 4/13 in the calcium hydroxide group, 4/15 in the MTA group. Internal root resorption was seen in the 1/13 in Calcium hydroxide and 4/15 in MTA group. The overall success rates after 24 months of follow-up for Calcium hydroxide and MTA was 46.1% & 66.66% .

EsmaYildizet al[24] performed a RCT comparing four pulpotomy medicament formocresol, ferric sulphate, Calcium Hydroxide & MTA. The mean age group was 5-9 years and duration of follow-up was 30 months. The sample size was 35 for CH& 41 for MTA. The teeth were restored by composite resin as a final restoration. At the end of 30 Month clinical as well as radiographic success rate for Calcium Hydroxide was 85% and for MTA it was 96.4%. The clinical failure such as pain, tenderness on percussion, mobility and fistula were seen in calcium hydroxide group. Radiographic failures were mentioned such as internal resorption 5/35 in CH group 2/41 in MTA group, also furcation radiolucency was seen in 1 tooth of CH group. PCO were observed in two teeth in CH group (6%), and one teeth in the MTA group (2%). Dentin barriers were observed in eight teeth in CH group (23%) and 11 teeth in MTA(27%).

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Oliveriaetal[25] performed a RCT comparing three pulpotomy medicament Calcium Hydroxide, MTA and Portland cement. The mean age group was 5-9yrs and duration of follow-up was months. The sample size was 15 for CH & 15 for MTA. The teeth were restored by resin modified glass ionomer cement. At the end of 24 month, clinical as well as radiographic success rate for Calcium Hydroxide was 33.33% and for MTA it was 100%. In CH group, after 6 months, 6 teeth (42.9 %) presented radiographic failures including internal resorption, interradicular bone destruction and furcation radiolucency. The clinical failure such as pain, tenderness on percussion, mobility and fistula were seen in calcium hydroxide group. Additionally, the exfoliation of one tooth was detected after 12 months. The author didn't mentioned about overall success rate and conclusion of article states MTA and PC may serve as effective materials for pulpotomies of primary teeth as compared to CH.

Study criteria and case selection plays vital role in deciding the fair prognosis of tooth. In the studies mentioned above, minimum age considered was 4 to 7 years, however, considering physiologic resorption pattern of tooth, age 9 and 10 year might be considered as bias. The regenerative ability of dental pulp varies as the age increases. In all studies, sample size considered was 15, and highest was 41. Case selection criteria seemed to vary study-to-study which were subjective and less objective based. Color of bleeding after pulp exposure was not mentioned. More specificity in regards to inclusion criteria of caries involvement or remaining tooth structure or restorable tooth would have been authenticated if carious involvement of marginal ridge were included. Also, expecting history from children in regards to pain, swelling and fistula in past is not reliable. Teeth selected for study were not same, few study didn't mentioned about quadrant and which molars were used specifically .

Most of the included RCTs failed to follow the guidelines. First, the randomization method (i.e. computer, envelope, random sequence, etc.) will exclude subjective interference in case selection and distribution. Other studies failed to describe their ways of randomization clearly. Secondly, allocation concealing, which means the estimator, the patient himself and outcome reporter were blinded to the treatments allocation, will guarantee an objective and accurate assessment. This was reported only in the study of Yildizet al[40]. Thirdly, a small sample size will lead to a lower power of test and lack of adequate evidence, whereas a large one will cause the difficulties of trial control and obtaining long-term data, waste of labour, money and time. In addition, withdrawal rates that are caused by emigration, death, etc during a long-term follow-up should be < 10% of the total number of the included cases.

Four studies [21,23-28] were carried out under local anesthesia whereas 1 study [22] did not mention about anesthesia technique carried out for pulpotomy. Calcium hydroxide used in all 5 studies was commercially available as (DEEPPLL DENTAL PRODUCTS OF INDIA), (Kalsin; AktuTicaret, Izmir, Turkey), (Sultan Chemists, Englewood, USA) (BiodinaˆmicaQuı´mica e Farmaceˆutica Ltda., Ibiporaˆ, PR, Brazil) and MTA as ProRoot MTA Dentsply, Tulsa, Mallifer, USA; (Angelus, Londrina, PR, Brazil). None of the authors mentioned the specificity of MTA used as white/Grey MTA in all the studies. Manipulation of material varied from study to study in regards to both materials, MTA was mixed using saline as well as sterile water. None of the studies specifies about restoring the tooth with stainless steel crowns.

Evaluation time considered in all studies were different. The highest follow-up period was 56 months follow up [21]. Blinding of the examiner is difficult, as it can be identified by the opacity of material. As to the definition of success and failure, all 5 studies demonstrated that the case was regarded as failure when one or more of the following signs were present: furcation radiolucency, peri-apical bone destruction, pain, swelling, or sinus tract. One study was assessed clinically and radiographically by two unblinded standardized pediatric dentist. Teeth were scored clinically successful if they had no pain symptoms, tenderness to percussion, swelling, fistulation, with sinus tract or pathologic mobility.

The restorations of pulpally treated teeth have been shown to have an impact on the prognosis of the pulp therapies. Stainless steel crowns (SSCs) were highly recommended for treating pulpotomized teeth, based on the assumption that there is less leakage in crowned teeth than those restored with amalgam. Out of 5 studies only none of them used a Stainless steel crown as a restoration after completion of treatment. Many of the studies failed to perform a pulpotomy procedure under rubber dam isolation which is the best way to prevent contamination from saliva.

4. Conclusion

- Based on 5 studies results LIU etal, Yildiz et al, Uddin et al, Sonmez et al, Oliveria et al state that MTA have good results, and Yildiz et al reported no clinical and radiographic difference between Calcium hydroxide and MTA and both materials can be used successfully.
- Overall success rate was higher in MTA when compared to Calcium hydroxide in all studies clinically and radiographically.
- Thus to conclude with this systematic review, MTA was better than Calcium hydroxide, though the success rate was not statistically significant, also all studies mentioned the same.

5. Future Scope

All above studies were carried out under subjective protocol. Objective protocols in relation to case selection, diagnosis, treatment plan, follow up period and assessment outcomes are needed to be set and emphasis should be given to follow.

a) Case selection criteria :

- Age range of the patient should be of narrow range, as regenerative property of pulp decreases as the age increases as well as chances of drop out increases due to physiologic exfoliation of the tooth.
- Teeth selected in study, should have similar sample size for each group and same morphology. Consideration should be taken on account of morphology of tooth.

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- Need for a uniform guidelines for indication of pulpotomy to be used.

b) Methodology :

- Newer modifications of MTA have been introduced, that can be used in future for further future implications.
- Guidelines for manipulation should be same and have uniformity to avoid bias.

c) Outcomes :

- Follow up period for pulpotomy should be standardized along with the assessment of symptoms and scoring scales should be devise to analyze the success or failure of the study.

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