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Success of MTA pulpotomy in Primary Teeth: A Systematic Review

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Abstract

Aims and Objectives: The aim of this study was to evaluate the success rate of MTA in pulpotomy in deciduous teeth.

Materials and methods: Search strategy includes randomized control trials and clinical trials from the databases of PubMed, DOAJ, and Google scholar from 01/01/2000 until 30/11/2021.A total of 4 studies that met all inclusion criteria were included in this systematic review. The clinical signs and radiographic results were checked for the success or failure of the treatment.

Results: The results of this systematic review demonstrated that MTA has higher success rate in pulpotomy procedure.

Conclusion: Based on the available information, the results of this systematic review demonstrated that MTA has higher success rate in pulpotomy procedure. However, in future, larger blind randomized controlled trials are needed to be conducted evaluating the success rate as well as cost effectiveness of MTA comparing with other routinely used pulpotomy materials.

Keywords: Pulpotomy, MTA, primary teeth, success

Introduction

The most commonly practiced endodontic treatment in deciduous teeth is pulpotomy. It is indicated when there is presence of coronal inflammation of pulp in deciduous teeth with no signs of inflammation in radicular pulp. Most commonly used pulpotomy medicaments are Formocresol and calcium hydroxide which have provided with long term survival rate.1-3

Many young individuals irrespective of their races are in need for pulp treatment because of extensive dental pain caused because of caries. Formocresol even though a gold standard medicament for pulpotomy in deciduous dentition had been found to raise concerns about its

toxicity and mutagenicity and carcinogenicity in humans.4

In the year 1995, Torabinejad first introduced Mineral Trioxide Aggregate (MTA) and it was approved by US Food and Drug Administration authority as a safe therapeutic endodontic material in the year 1998. It contains tricalcium silicate, tricalcium aluminate, tricalcium oxide and silicate oxide. The radiopacity of the material is described by the presence of iron, magnesium and bismuth oxide. The features of MTA include high sealing ability, biocompatibility, dentin bridge formation, cementum formation and periodontal ligament regeneration. It also stimulates cytokine release from bone cells resulting in promotion of had tissue formation.4These characteristics make MTA a suitable material for pulpotomy.5

Several studies evaluated the success rate of MTA in pulpotomy. It has been extensively studied clinically and radiographically. Most of the studies suggest no statistically significant difference in the success of MTA and formocresol.5,6 MTA produces a suitable media for healing. It reacts with tissue fluids after hardening which further leads to the production of calcium hydroxide leading to formation of calcite crystals that gather fibronectin. This fibronectin is responsible for cell connection and differentiation.7

In literature, there is no strong evidence that support the success rate of MTA. However, there is no statistically significant or borderline significant difference between MTA and other materials used for pulpotomy.8 Therefore a systematic review was undertaken to evaluate the survival rate of MTA in pulpotomy in deciduous teeth.

Methods

A systematic review of literature and meta-analysis was performed. This study followed the (PRISMA) Preferred Reporting Items for Systematic Review and Meta-Analyses statement guidelines, the Cochrane Handbook for systematic reviews of interventions, version 5.1.0. AND 4th Edition of the JBI Reviewer's Manual.

Eligibility Criteria

Inclusion criteria

1. Based on study characteristics:
   a. Type of participants:
      i. Studies reporting information about participant characteristics as children with primary dentition belonging to both the genders.
   b. Exposure
      i. Studies reporting information about participants treated with complete or partial pulpotomy using Mineral Trioxide Aggregate (MTA) material.
   c. Outcomes
      i. Studies reporting clinical success in terms of signs and symptoms like pain, abscess, fistula formation, etc. and radiologic success in terms of tertiary dentin deposition.
   d. Study type
      i. Studies reporting information about follow-ups done i.e prospective or longitudinal observational studies.
      ii. Studies reporting ethical approval were included.
2. Inclusion criteria based on publication characteristics:
   a. Studies published between the periods of 1st January 2000 to 30th November 2021. Written in English.
   b. Studies in English language or other language where English translation is possible.

c. Studies published in commercial scientific databases like PubMed, DOAJ (Directory of open access journal) and Google Scholar and available as full text.

Exclusion Criteria

1. Studies in any other language where English translation was not possible.
2. Studies that had only abstracts were excluded.
3. Studies with comparison groups, clinical trials, case reports, reviews and expert opinion were excluded.
4. Studies reporting about a comparison group were excluded.
5. Studies done in adults were excluded.
6. Studies in unpublished format were excluded.

Search Strategy

- The preferred reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) for conducting a meta-analysis were followed.
- The electronic data resources consulted for elaborate search were **PubMed, DOAJ, and Google scholar** with controlled vocabulary and free text terms.
- Articles published from 01/01/2000 until 30/11/2021 were searched, without any restriction concerning the publication's language.
- Following keywords and MeSH terms were used in combination with Boolean operators in the advanced search option:

Table 1: The above mentioned terms were imported in the search strategy in the following databases

Population	Exposure	Outcome	Study Design
Child Adolescent Children Primary teeth Deciduous teeth Primary dentition Deciduous dentition	Pulpotomy Mineral Trioxide Aggregate MTA	Clinical performance Tertiary dentin Radiographic success Dentin bridge	Prospective study Longitudinal study Observational study

Focused Research Question

What is the success rate of Mineral trioxide aggregate (MTA) pulpotomy in Primary teeth?

Following search strategy was used:

1. Population: (Adolescent [MeSH] OR Teenagers [Text Word] OR Teens [Text Word] OR Kids [Text Word] OR School children [Text Word] OR children [Text Word] OR Youngsters [Text Word] OR Youth [Text Word] OR Primary dentition [Text Word] OR deciduous teeth [Text Word] OR Primary teeth [Text Word] OR deciduous teeth [Text Word]
2. Exposure: (Mineral Trioxide Aggregate [Text Word] OR MTA [Text Word] AND Pulpotomy [Text Word]
3. Outcome: (IOPA [Text Word] OR Clinical [Text Word] OR Survival [Text Word]
4. Study design: (Longitudinal studies [Text Word] OR prospective studies [Text Word] OR observational study [Text Word]))

Search Combination

(Adolescent [MeSH] OR Teenagers [Text Word] OR Teens [Text Word] OR Kids [Text Word] OR School children [Text Word] OR children [Text Word] OR Youngsters [Text Word] OR Youth [Text Word] OR

Primary dentition [Text Word] OR deciduous teeth [Text Word] OR Primary teeth [Text Word] OR deciduous teeth [Text Word] AND (Mineral Trioxide Aggregate [Text Word] OR MTA [Text Word] AND Pulpotomy [Text Word] AND (IOPA [Text Word] OR Clinical [Text Word] OR Survival [Text Word] AND (Longitudinal studies [Text Word] OR prospective studies [Text Word] OR observational study [Text Word]))

Selection of Studies

The title and the abstract of each study were reviewed and critically assessed by two independent reviewers. The methods used to apply the selection criteria were the following:

a) Integration of the searched outcomes to delete duplicate entries
b) Examination of titles and abstracts to delete clearly irrelevant articles
c) Recovery of the full text of potentially relevant articles
d) Binding and gathering of multiple articles of the very same study
e) Examination of the articles' full text to verify the degree of compliance that the studies had with the eligibility criteria.
f) Establishing connection with researchers, if necessary, to clarify the study's eligibility.
g) Deciding about the study's inclusion and proceeding with data gathering.

Data Extraction

Two reviewers independently extracted data from the included studies. Disagreements were again resolved through discussion. Data gathered was carried out using a verification list of items that were considered for data extraction. The main items of this list were as follows:

- Study Definition,
- Risk of Bias Assessment,
- Total Length of the Study,
- Unit of Randomization,
- Unit of Analysis,
- Participants' Characteristics,
- Exposure,
- Outcomes,
- Results and Other Items.

Details regarding the publication and the study, the participants, settings, the interventions, the comparators, the outcome measures, study design, statistical analysis and results, and all other relevant data (funding; conflict of interest etc.) were carefully and accurately extracted from all included studies. Data extraction was done and accurately recorded in the excel sheets for all the primary outcomes separately.

Quality Assessment of Included Studies

Quality assessment of the selected studies was executed by using the ROBINS-E tool for risk of bias in exposure studies. It contained domains like confounding bias, selection bias, and misclassification bias, bias due to missing data, bias in measurement of outcomes and overall bias. Studies were qualified in terms of high risk, low risk and unclear risk.

Results

Literature Search: The initial electronic database search on PubMed/MEDLINE and Cochrane library resulted in 750 titles. After screening the abstracts and removal of duplicates, 500 relevant titles were selected by two independent reviewers and 150 were excluded for not being related to the topic. Following examination and discussion by the reviewers, 7 articles were selected for full-text evaluation. No additional papers were obtained on hand searching. After pre-screening, application of the inclusion and exclusion criteria and handling of the PICO questions, four studies remained

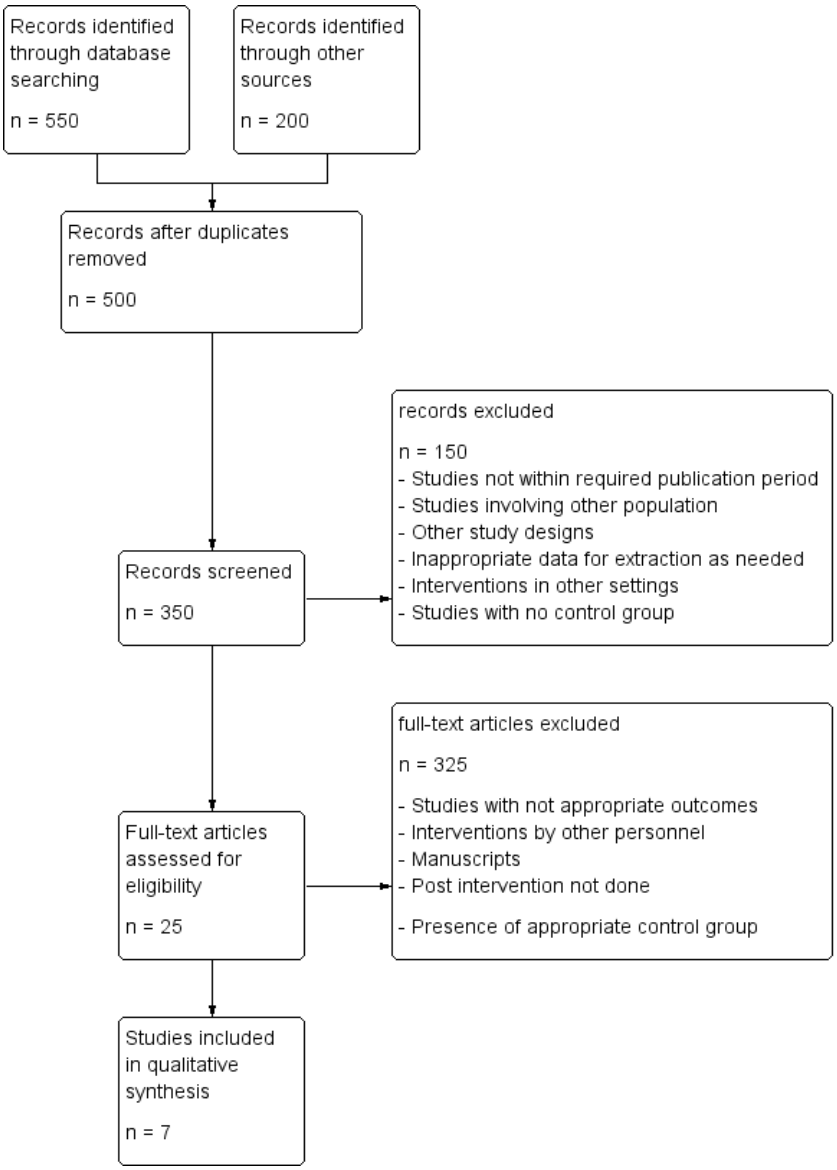
which were included in the qualitative synthesis. These studies were subjected for data extraction.

There are 07 studies included in this review, the general characteristics of which are presented in Table 2.

The study design of all seven included studies is prospective, longitudinal study. The age of the participants ranged from 3 to 9 years old throughout the interventions' conducting period. A total of 312 primary teeth were part of the studies' analyses.

Figure 1 illustrates a flowchart of the search results.

Figure 1: Prisma Flow Chart



Quality assessment of the studies:

Quality assessment showed a huge variety across the included studies. Quality assessment of the selected studies was executed by using the ROBINS-E tool for risk of bias in exposure studies. (Table 2). Three studies showed a moderate potential risk of bias and four studies a high potential risk of bias (Figure 2, 3).

Table 2: Characteristics of included studies

Sn.	Study ID	Place of study	Study design	Sample size	Age group	Follow-up	Exposure	Author's conclusion
1.	Maroto (2005)	Spain	Prospective study	22	-	3 months, 6 months	MTA pulpotomy	Satisfactory results were obtained using MTA pulpotomy and this material could be considered as a reasonable alternative to use of formocresol. However, long term results are needed to confirm the data obtained.
2.	Mahmood (2006)	Kuwait	Longitudinal study	31	-	12 months	MTA pulpotomy	Authors concluded that under the conditions of this prospective clinical study and over a 2 year period, MTA was a suitable material for partial pulpotomy in caries exposed young permanent teeth.
3.	Maroto(2007)	Spain	Longitudinal study	69	-	3 months, 6 months, 12 months, 24 months, 42 months	MTA pulpotomy	Authors concluded that the gray MTA could be considered a rational substitute to the use of formocresol in pulpotomy treatments in primary molars, although more long-term clinical studies are needed to confirm these results.
4.	Mortazavi (2009)	Iran	Prospective study	55	6-7 years	1 month, 3 months, 6 months, 12 months, 24 months	MTA pulpotomy	Authors concluded that MTA could be used as an alternative to the current Formocresol medication with high clinical and radiographic success in pulpotomy of primary teeth.
5.	Haghgoo (2010)	Iran	Follow-up study	70	3-7 years	30 months	MTA pulpotomy	ProRoot MTA and Root MTA can be considered suitable materials for pulpotomy of primary molars.
6.	Tyagi (2019)	India	Observational study	25	5-8 years	3 months, 6 months, 12 months, 24 months, 36 months	MTA pulpotomy	Based on the results, authors concluded that Mineral trioxide aggregate has a biological potential for healing and repair. So it can be recommended as a replacement for pulpotomy procedures.
7.	Kabel (2021)	USA	Prospective cohort study	40	4-7 years	3 months, 6 months, 12 months, 18 months	MTA pulpotomy	Authors concluded that MTA pulpotomy showed 100% success rate both clinically and radiologically.

Table 3: Risk of bias assessment of individual studies

Sn.	Study ID	Confounding bias	Selection bias	Misclassification bias	Bias due to missing data	Bias in measurement of outcomes	Overall bias	Risk of bias
1.	Maroto (2005)	No	Yes	Yes	Yes	No	Unclear	Moderate risk
2.	Mahmood (2006)	Unclear	Unclear	Yes	Yes	No	Unclear	High risk
3.	Maroto(2007)	Unclear	Unclear	Yes	Yes	Yes	Yes	Moderate risk
4.	Mortazavi (2009)	No	Unclear	No	Yes	Yes	Yes	High risk
5.	Haghgoo (2010)	Unclear	No	Yes	Yes	No	Unclear	High risk
6.	Tyagi (2019)	No	No	No	Unclear	No	Yes	High risk
7.	Kabel (2021)	Yes	Unclear	Yes	Yes	Unclear	No	Moderate risk

Figure 2: Risk of bias graph: review authors' judgements about each risk of bias item presented as percentages across all included studies

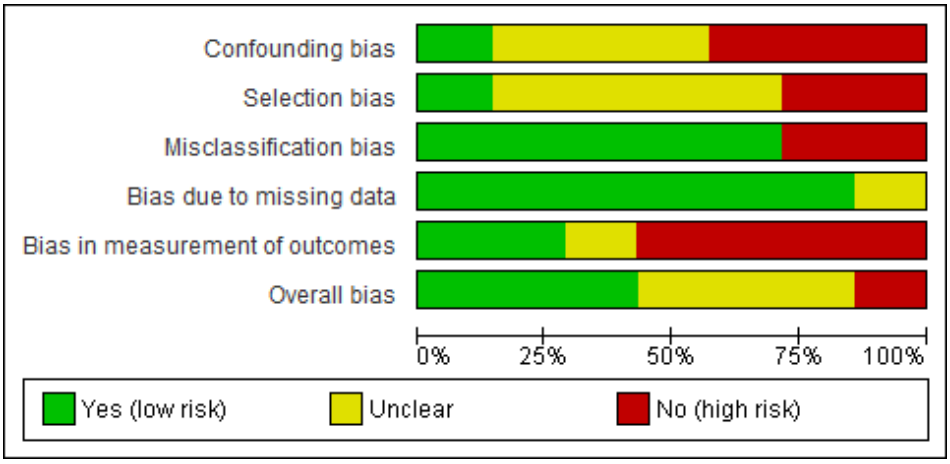


Figure 3: Risk of bias summary: review authors' judgements about each risk of bias item for each included study

Discussion

Dental pulp which is an un-mineralized oral tissue contains a number of important functions such as dentin induction and formation, nutrition, defence and sensation.8,9 Therefore it is important to ensure dental pulp vitality in order to maintain the normal functioning of the tooth. In accidental pulp exposure as well as in exposure occurred due to caries may bring irreversible damage to dental pulp if left untreated or in cases when no adequate treatment is done.8

Due to improved understanding of dental caries and advances in the available materials, the older idea of "extension for prevention" has been substituted by a more conservative approach toward management of dental caries.10 Deep carious lesions with pulpal exposure without any signs or symptoms of extensive pulpal degeneration are managed using pulpotomy procedure. Pulpotomy which is defined as an endodontic procedure wherein the coronal pulp is amputated and the radicular healthy pulp is maintained within the root canals followed by placement of a suitable medicament and obtaining a good coronal seal until the primary tooth is naturally exfoliated. Though the clinical success of various pulpotomy agents have been proved from time to time, questions are raised regarding their effectiveness .With the arrival of newer biocompatible materials such as mineral trioxide aggregate (MTA), with proven success than the older agents, the future of this technique appears promising.11 Formocresol is the common medicament in pulpotomy; it has some distinct disadvantages such as cytotoxicity and potential of mutagenicity and carcinogenicity.12,13 According to Koh et al. (1997)14 MTA stimulates the release of cytokine that in turn, promotes hard tissue genesis which can result in bridge formation across the pulp tissue. It may be assumed that this effect accompanied by favourable pulpal responses and presence of some chronic inflammatory cells indicate a bacterial tight seal preventing microleakage.15

Pulpotomy has been showed to be an effective way for maintaining pulpal vitality and health. Different materials that have been used as pulp-capping agents, include bonding agents, cements, resin, calciumhydroxide, and many others .8, 16 Currently calcium hydroxide and MTA are the most promising agents in pulp therapy. These materials have got the capacity to induce bridging of the pulp surface with reparative dentin.8

MTA which is a new and biocompatible biomaterial used for dental practice, has been proved to be the best material for repairing of root perforations, apexification, root-end filling, in repair of root resorption and pulp capping. Considering pulp capping, various in vivo studies reported in literature have showed that MTA can form a thicker dentin bridge when compared with traditional gold standard pulp capping material calcium hydroxide in histological studies.8,17,18 However, long time observation showed that there was no statistically significant difference was found in the dentine thickness between MTA and calcium hydroxide in human.8,19,20Additionally, there is no clear evidence to prove that the dentin thickness is related with clinical success of maintaining dental pulp vitality. Whereas, many clinical studies have showed that MTA is superior to calcium hydroxide as a direct pulp material. However, most of these studies were not randomized controlled trials (RCTs). Different factors such as pulp exposure type, site, tooth location etc, can confound the results and influence the treatment outcome, so the results were not very substantial. Moreover, some studies reported that calcium hydroxide performed similar to MTA.8,19,21

Systematic review is an optional way to provide reliable and promising suggestion in dental practice. We conducted this systematic review to evaluate the success rate of MTA in pulpotomy. The included studies were longitudinal clinical trials which evaluated the success rate of MTA in pulpotomy. This review included 7 studies where in success of MTA pulpotomy was assessed for minimum of six months and maximum up to 30 months.

All the studies specified a concrete procedure. The clinical signs and radiographic results were checked for the success or failure of the treatment. Mortazavi et al stated that MTA can be an alternative to formocresol in pulpotomy treatment.4 A study conducted by Godhi B et al in India stated that MTA is a biocompatible agent and provides promising results in pulpotomy treatment.6 There was a 100% success rate observed in MTA pulpotomy in a USA study.7Reparative dentin deposition in the pulp canals was detected in most of the cases. This was shown by dentin bridge formation. Dentin formation showed the presence of odontoblastic activity which demonstrated the root canal pulp vitality and the absence of pathology of the treated molars.1-7

A moderate risk of bias was observed in the review. A study done by Godhi B et al showed comparatively high risk of bias.6 Confounding and selection bias were present in all the studies except Kabel et al which reported only about confounding bias and Maroto et al which reported only about selection bias.3,7 Amongst all the studies, study conducted Maroto et al showed potentially low risk of bias.3 The study suggested that MTA is an effective alternative to formocresol in pulpotomy.3

In the present review the teeth include were primary molars. MTA as a pulpotomy agent has shown results in favour of primary molars. However, there is limited literature available regarding its use in primary incisors. Future studies should aim at focusing the success of MTA pulpotomy in anterior teeth.

Conclusion

Based on the available information, the results of this systematic review demonstrated that MTA has higher success rate in pulpotomy procedure. However, in future larger, blind randomized controlled trials are needed to be conducted evaluating the success rate as well as cost effectiveness of MTA comparing with other routinely used pulpotomy materials.

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