

# CLINICAL OUTCOME OF DIRECT PULP CAPPING WITH MTA, BIODENTINE AND CALCIUM HYDROXIDE: A SYSTEMATIC REVIEW AND META-ANALYSIS

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## Abstract

**Background:** Direct pulp capping (DPC) is a procedure in which the exposed pulp is covered with a biocompatible material which has been followed from centuries. Many materials have been tried as pulp capping agents and today it has evolved to the extent that many biomimetic materials are available which give successful outcomes. Although dental literature is replete with studies, systematic reviews and meta-analysis on different materials used for DPC, systematic review and meta-analysis has not been conducted on newer materials such as MTA and Biodentine. This systematic review and meta-analysis was done to evaluate the clinical outcome of Mineral Trioxide Aggregate, Biodentine and calcium hydroxide as direct pulp capping agents.

**Materials & Method:** The study list was attained by searching PubMed, ebscohost, sciencedirect, Springer Link, researchgate.net, endo experience and various other websites and journal database. Study was conducted according to PRISMA guidelines. Inclusion and exclusion criteria were made. The outcome was evaluated by clinical symptoms and radiographic changes. Randomization, Blinding, Withdrawals and dropouts were analyzed. Only those papers that met the inclusion criteria were analyzed. The outcome measure was based on dichotomous data success/failure, dentin bridge formation/absence of dentin bridge formation and Statistical analysis was done.

**Results:** Clinical assessments suggest that MTA and Biodentine were superior to Dycal in direct pulp capping ensuing lower failure rate (risk difference 0.1 [95% CI]).

**Conclusion:** MTA and Biodentine have higher clinical success rate for direct pulp capping comparing to calcium hydroxide and might be a suitable replacement for Dycal.

**Keywords:** MTA, Dycal, Biodentine, Direct pulp capping.

## Introduction

American Association of Endodontics glossary of endodontic terms defines pulp capping as treatment of an exposed vital pulp by sealing the pulpal wound with a dental material to facilitate the formation of reparative dentin and maintenance of vital pulp.

Vital pulp contributes to the production of secondary dentine, and reparative dentine in response to biologic and pathologic stimuli.<sup>1</sup> Dentin remains moist because of the supply provided by pulpal tissue, which thus guarantees that the dentin keeps up its strength and hardness. Since a non-vital tooth requires 2.5 times to a greater extent of force than a fundamental vital tooth to enlist a proprioception.<sup>2</sup> The common insurance against an over-load is lessened and the likelihood of fracture increases. Compressive strength of enamel supported by vital dentin is 36-42000 psi but a non-vital tooth loses 40-50% of its strength. Preservation of vitality eliminates the need of post and hence preserves its strength as posts do not increase the strength of tooth but may weaken them.<sup>3,4</sup>

Calcium hydroxide was considered as Gold standard which was introduced by Hermann in the 1920. Brita Willershausen in 2010 done a retrospective study to check the success of calcium hydroxide as a direct pulp capping agent and found that the success of direct pulp capping with Calcium hydroxide is 80.1% after one year, 68% after five years and 58% after nine years. In any case, calcium hydroxide has a few disadvantages as bonding with dentin is not exhibited, material resorption with time and tunnel defect through dentinal bridge under it and mechanical instability are among them.<sup>5</sup>

Thus newer products have been tried to overcome its disadvantages.

MTA was initially developed for use as a dental root repair material or retrograde filling material and for apical plug formation by Dr. Mahmoud Torabinejad in early 1900s but now it is also tried as a direct pulp capping materials demonstrating remarkable success compared with calcium hydroxide. Many histological studies showed that MTA formed thicker dentinal bridge formation as compared with calcium hydroxide in animals or human.<sup>4-6</sup>

A new Bioactive cement, Biodentine (Septodont, St. Maur des Fosses, France) was newly introduced in dental market as a dentine substitute, also known as dentin in a capsule and its properties are almost similar to dentine. Its uses and mechanism of action is similar to Calcium hydroxide, but does not have its disadvantages.

In 2013, TJ Hilton et al clinically compared MTA and Dycal with 2 years follow up and found that the failure rates in MTA is 19.7% and in Dycal it was 31.5%.<sup>3</sup> Similarly, N Alicja et al in 2013 have done a clinical study on humans to evaluate the response of Pulp Capped with Biodentine and MTA and found no significant difference between Biodentine and MTA.<sup>6</sup> Anujalkha et al reported 100% success clinically as well as histologically for 3 weeks.<sup>7</sup>

Aguilar et al showed no statistically significant difference in success rate of direct comparison of calcium hydroxide and MTA as DPC agents whereas MTA was appeared to be superior to Calcium hydroxide when compared indirectly. Conflicting results has been report by various

comparative studies of MTA/Dycal/Biodentine. Some studies have done clinical and histological comparison and analyze that MTA appears to be more effective than calcium hydroxide for maintaining pulp vitality after DPC.<sup>4-9</sup> In addition, some clinical trial demonstrated only borderline significance, which may not be clinically significant.<sup>10</sup> Similarly, conflicting results were found with MTA and Biodentine.<sup>11</sup>

S. Hegde et al in 2017, clinically evaluated MTA and Biodentine as DPC agents in carious teeth and concluded that MTA with or without consolidated standard, Biodentine may be used as DPC agents when the pulpal diagnosis is not more than reversible pulpitis.<sup>12</sup>

Zhu C et al in 2015 have done a systematic review and meta-analysis Clinical outcome of direct pulp capping with MTA or calcium hydroxide that demonstrated that MTA is superior to calcium hydroxide as a direct pulp-capping agent.<sup>13</sup>

As the results of various studies are inconsistent, a systematic review and meta-analysis based on available evidence was planned; comparing all three materials that allow us to best judge the outcome of such studies. Systematic reviews are types of literature reviews that collect and critically analyze multiple research studies or papers and meta-analysis include the statistical procedures for combining data from multiple studies which lies on top of evidence based dentistry (Figure 1).

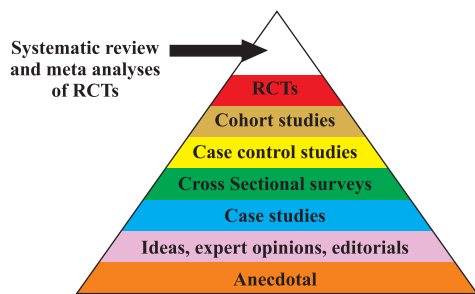


Figure 1: Pyramid of evidence based dentistry

## Materials and method

### Literature research

The systematic review was performed according to PRISMA guidelines. Research was initiated on Direct pulp capping of different pulp capping agents such as ZOE, CaOH, propolis, polycarboxylate, GIC, bonding agents, growth factors, platelets rich plasma, Theracal LC, Biodentine and MTA etc. Study list was acquired by searching PubMed, Sciencedirect, springerlink, cochrane review and other sources published till march 2017 and studies with Dycal, Biodentine and MTA were selected (Table 1).

Inclusion criteria included articles published in English, Studies with statistical analysis, studies done on Human teeth, Pulp exposure with caries/trauma/iatrogenic, Comparative studies included at least two out of Dycal, MTA or Biodentine and follow up of at least 3 months. Exclusion criteria included studies without statistical analysis, studies done on animal, studies involving only one material, studies containing only histological

No.	Search history	No. of publication
1	Direct pulp capping (Pubmed) (Cochrane)	509 991
2	Direct pulp capping with MTA	116
3	Direct pulp capping with Dycal	65
4	Direct pulp capping with Biodentine	4

Table 1: Pubmed search strategy and no. of publication retrieved

evaluation, studies with no follow up and teeth with open apex were excluded. (Figure 2)

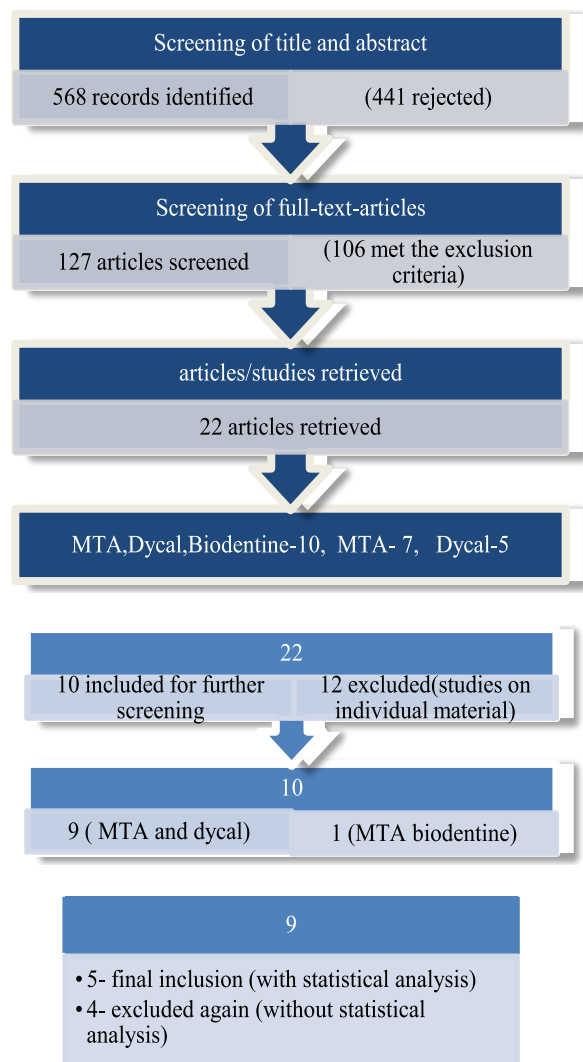


Figure 2: Screening of Articles

### Data extraction and quality assessment

Assessment of study quality was done according to CONSORT statement. Data was created by tabulating authors name, publication year, sample size, material used, clinical/radiographically/ histological examination, follow up period and success rate. Data was extracted from studies that fulfilled the inclusion criteria and entering into a computerized database. The extracted data included the name of the first author, year of publication,

sample size, type of study, results in terms of failure and success rate and follow-up duration. (Table 2)

Author's name-	No. of tooth	Type of study	Result	Follow-up
T.J Hilton et al (2013)	376-MTA (195) Dycal (181)	Clinical	Failure rate- MTA-19.7% Dycal-31.5%	2 years
J Mente et al(2010)	122	Clinical	Success rate- MTA-78% Dycal- 60%	27 months
Mariana agathi et al	86	Clinical	Success rate- MTA-90.3% Dycal-78.6%	24 months
Claudio et al (2006)	48-24 (MTA) 24 (Dycal)	Clinical, Radiographical and Histological	Success- MTA-23/24 Dycal-22/24	136 ± 24 days
Alieskandarizadeh et al(2011)	90	(C+H)	Inflammatory response and dentin bridge formation was compared.	90 days
MLR. Accornite	40	(C+H)	MTA = Dycal	60 days
Anujalkha et al	10	(C+H)	100% success	3 wks
D tuna et al	50	(C+H)	MTA = Dycal	24 mo.
Maria de laordes 2008	40	(C+H)	MTA > Dycal	60 days
AlicjaNowicka et al(2013)	28	C	MTA = biodentine	6 wk.
D tuna et al	50	(C+H)	MTA = Dycal	24 mo.
Maria de laordes 2008	40	(C+H)	MTA > Dycal	60 days
AlicjaNowicka et al(2013)	28	C	MTA = biodentine	6 wk.

Table 2: Comparative studies on MTA, Dycal and Biodentine showing data extraction and quality assessment

## Results

Meta-analysis- Software RevMan 5.2 was used for meta-analysis provided by Cochrane Collaboration (<http://ims.cochrane.org/rev-man>). For dichotomous form of data, relative risk (RR) and 95% confidence interval (CI) were calculated. Heterogeneity among the studies was calculated by both Chi square and I square tests. I square was 6% which shows the bias is minimum and there is no error in calculation or methodology except probability error that can't be avoided. The fixed

effect model was used to collect and analyze the data if homogeneity existed among studies. ( $P \geq 0.1$ ,  $I^2 < 50\%$ ) and if the assumption of homogeneity was rejected ( $P < 0.1$ ,  $I^2 > 50\%$ ), random effect model was used. Sample size of 5th study is very small. Hence cannot be considered in forest plot. Meta-analysis shows that result favors the use of MTA over Dycal as pulp capping. There is only one study available with Biodentine that follows all the inclusion criteria. So, we cannot analyze Biodentine statistically. Measurement of the outcome was based on binary data success/failure.

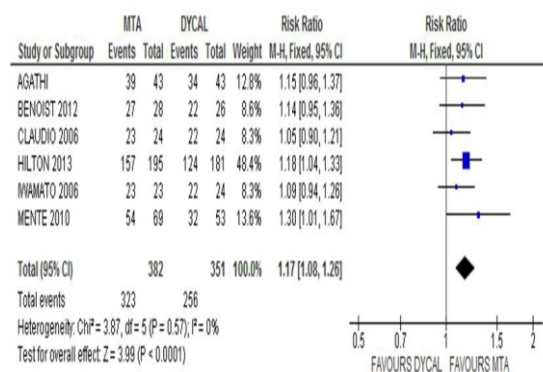


Figure 3: Forest plot

## Discussion

Direct pulp capping is now considered to be a predictive and preferred treatment over root canal treatment in day to day clinical practice which is a century old concept but with the advancement of material science, the concept of DPC is gaining popularity and success. Importance of preservation of pulp vitality can never be overstated. A vital pulp gives life to tooth and hence its preservation should not be ignored.

Dental pulp contributes to many important functions including secondary dentin formation, nutrition, defence and proprioception.<sup>1</sup> Both accidental/mechanical pulp exposure and exposure due to caries may carry irreversible damage to dental pulp if not treated properly. Direct pulp capping is considered successful if the tooth remains vital and dentinal bridge is formed within 75-90 days.<sup>11</sup> Mean dentinal-bridge thickness in the Biodentine is 211.56 mm and in MTA is 230.31 mm as reported in a study.<sup>14</sup> Interaction of Biodentine with dentine results into formation of a tag-like structures known as "mineral penetration zone".<sup>15-17</sup>

Calcium hydroxide has shown to be successful even when treatment was done under less-than-ideal circumstances in many studies. On the contrary its tunnel defects may act as a doorway for entry of microorganisms which may decrease the prognosis of the pulp. Additionally, its high pH of 12.5 of calcium causes liquefaction necrosis at the superficial layer of the pulp tissue.<sup>18</sup> patient age and the size or site of pulp exposure play a secondary role or are altogether irrelevant.<sup>19,20</sup>

Many studies have shown that MTA perform better than calcium hydroxide.<sup>21,22,23</sup> Whereas few studies have reported no significant difference between MTA and calcium hydroxide.<sup>24</sup>

Andriara De Rossi et al found that mineralized dentinal bridge formation was more in Biodentine group (96.8%) than with MTA (72.2%).<sup>25</sup> P Laurent in 2011 also when Biodentine induces an early form of reparative dentine synthesis when applied directly on pulp as it stimulates pulp cells for the secretion of TGF- $\beta$ 1.2, 67 whereas Swaroophegre et al in 2017 have done a clinical study using MTA and Biodentine as DPC agents in carious teeth to judge the clinical response of pulp dentine complex and follow up was done till 6 months. They found that MTA and Biodentine showed 91.7% and 83.3% success rate, respectively.<sup>12</sup>

Research on bioactive material and molecules is one of the thrust areas of development of novel bioactive material and molecules which have wide application in dentistry and biomedical field. Bioactive materials have capacity to interact with living tissues or system. The calcium-silicate based materials shown production of mineralized layer within the dentin, extending deep within the tissues which may favours mineral repair and re-construction process.

As meta-analysis is on top of evidence based dentistry, it provides the best results by statistically analyzing all the previous studies. Studies on MTA versus Dycal, it is thinkable that teeth capped with MTA, Biodentine or Dycal were in different patients, were treated by different operators, had a different preoperative conditions and MTA is far more expensive and requires some experience when applying it.

The follow up time of all the studies were different. Moreover, this meta-analysis was limited to studies with atleast 3 months of follow-up, as with less follow up duration, the results have limited representativeness for clinical outcome and long-term failures occur after 2 years or longer with DPC treatment. We cannot depend entirely on clinical findings as opposite results were seen in some studies with histological analysis. No statistical difference was seen between MTA and Biodentine in that particular study and also in other histological studies. Hilton et al. used the sample function of R Version 2.15 method for randomization whereas in all the other four studies, way of randomization was not described. Clearly Iwamoto et al. and Tuna et al. have used single blinding approach where clinicians were blind to material used. However, it is difficult to blind the practitioners to the materials used while DPC procedure as the manipulation and characteristics of materials are quite dissimilar.

### Conclusion

Based on available data at present, the results of this systematic review and meta-analysis revealed that use of MTA and Biodentine shows more promising results as compared to calcium hydroxide as a direct pulp-capping agent. Many predisposing factors such as cause of pulpal exposure, jaw involved, site of pulp exposure, tooth

location and age etc. can further influence the prognosis of treatment. Further clinical studies with large sample size and longer follow-up duration are needed for better understanding of these bio-mimetics materials.

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