# Direct Pulp Capping with Calcium Hydroxide or Mineral Trioxide Aggregate: A Meta-analysis

*Zhaofei Li, MDS,* Lihua Cao, MDS,* Mingwen Fan, DDS,* and Qingan Xu, DDS, PhD*†*

## Abstract

**Introduction:** The purpose of this study was to compare the effectiveness of mineral trioxide aggregate (MTA) and calcium hydroxide (CH) as pulp capping materials in humans by means of a meta-analysis. **Methods:** The PubMed, Cochrane Library, Embase, and Web of Knowledge databases were used in the literature search from their establishment date until December 7, 2014. Studies that met the inclusion criteria were accepted, and necessary information was extracted by 2 authors independently using a standardized form. The success rate, inflammatory response, and dentin bridge formation were evaluated. **Results:** Thirteen studies met the inclusion criteria. There was no significant heterogeneity between studies, so a fixed-effects model was used. The MTA treatment groups showed a significantly higher success rate compared with CH-capped groups (randomized controlled trials: odds ratio [OR] = 2.26; 95% confidence interval [CI] = 1.33–3.85; $P = .003$; retrospective nonrandomized trials: OR = 2.88; 95% CI, 1.86–4.44; $P < .00001$). MTA was superior to CH in terms of the absence of an inflammatory response as well as dentin bridge formation, with the OR being 4.56 (95% CI, 2.65–7.83) and 3.56 (95% CI, 1.89–6.70), respectively. **Conclusions:** MTA has a higher success rate and results in less pulpal inflammatory response and more predictable hard dentin bridge formation than CH. MTA appears to be a suitable replacement of CH used for direct pulp capping. *(J Endod 2015;41:1412–1417)*

## Key Words

Calcium hydroxide, direct pulp capping, meta-analysis, mineral trioxide aggregate

From *The State Key Laboratory Breeding Base of Basic Science of Stomatology (Hubei-MOST) and Key Laboratory of Oral Biomedicine of Ministry of Education (KLOBM) and †Department of Endodontics, School and Hospital of Stomatology, Wuhan University, Wuhan, China.

Address requests for reprints to Drs Qingan Xu and Mingwen Fan, KLOBM, School and Hospital of Stomatology, Wuhan University, Wuhan 430079, China. E-mail address: xuqingan@whu.edu.cn and fmw@whuss.com

0099-2399/$ - see front matter



http://dx.doi.org/10.1016/j.joen.2015.04.012

Direct pulp capping (DPC) is performed when a healthy pulp has been inadvertently exposed from traumatic injury or by iatrogenic means (1). During DPC, a medicament is placed directly over the exposed site and thus can stimulate the healing process. If successful, it will preclude the need for further treatments (2) (eg, root canal therapy). The most frequently used material for DPC in clinical treatment is calcium hydroxide (CH), which was introduced to the dental profession in 1921 and has been considered the "gold standard" of direct pulp capping materials for several decades (3, 4).

CH has outstanding antibacterial properties, which can minimize or eliminate bacterial penetration and subsequent irritation of pulpal tissue (5). The clinical success rate can be tracked for years by using this agent. However, CH exhibits some obvious disadvantages including pulp surface inflammation and necrosis after pulp capping; the presence of tunnel defects in the dentin bridge, which fails to provide a hermetic seal to the underlying pulp against recurring infection because of microleakage; high solubility in oral fluids; lack of adhesion; and degradation over time (2, 6–9).

As a result of the aforementioned disadvantages, a number of new materials have been tested during the last 2 decades as alternatives to CH. Recently, mineral trioxide aggregate (MTA) has become a popular alternative for CH, which is composed of calcium oxide in the form of tricalcium silicate, dicalcium silicate, tricalcium aluminate, and bismuth oxide for radiopacity (10). Histologic studies and *in vitro* trials report favorable results regarding the chemical and physical properties, antibacterial activity, biocompatibility, and sealing properties of MTA (11–13).

There appear to be differences in pulpal tissue reaction to MTA compared with CH in direct pulp capping. Dentin bridge formation with MTA seems to be more homogenous (fewer tunnel defects) and more localized than that formed with CH (14–17). Histologic evaluations of exposed pulp tissue from animals capped with MTA have shown the formation of a thicker dentinal bridge with a lower inflammatory response, hyperemia, and pulpal necrosis compared with CH (18, 19). Thus, MTA might be a good material of choice for dental pulp capping procedures. Despite its many advantages, MTA has some drawbacks such as discoloration potential, difficult handling characteristics, long setting time, and the difficulty of its removal after curing (20). A search of the literature showed the absence of a meta-analysis comparing the effectiveness of MTA and CH as pulp capping materials in humans.

The aim of the present meta-analysis was to compare the effectiveness of MTA and CH on direct pulp capping in humans in terms of success rate, inflammatory response, and dentin bridge formation, which can provide the basis for clinical application.

## Materials and Methods

### Search Strategy

In the present study, PubMed, the Cochrane Library, Embase, and the Web of Knowledge were used as the electronic databases (last search updated on December 7, 2014). The following key words were used for an initial search conducted on PubMed: (mineral trioxide aggregate) AND (calcium hydroxide) AND (direct pulp capping) with the application of the following limit: English language. The same key words and search limit were used on the Cochrane Library, Embase, and the Web of Knowledge. Additional search methods included a manual review of the reference lists of relevant studies.

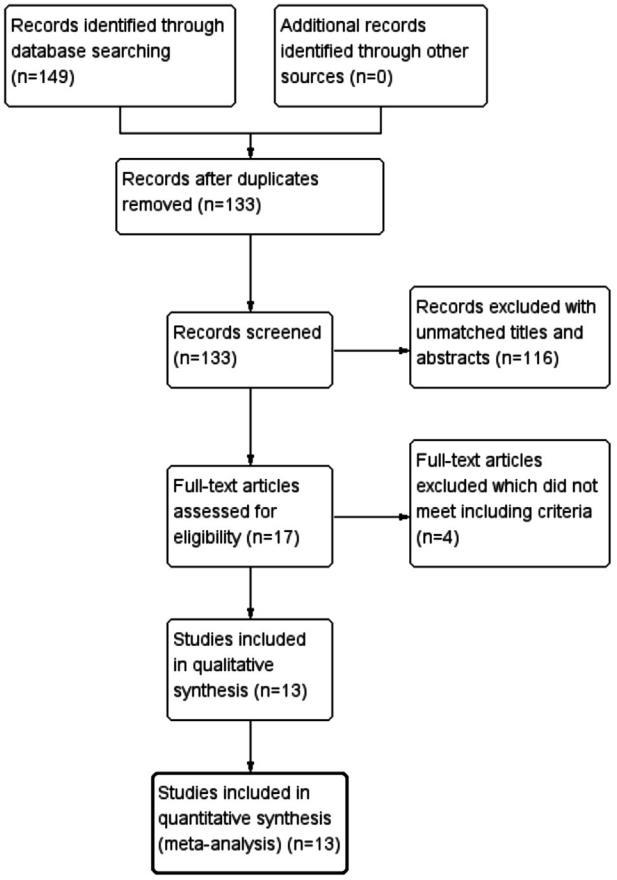


**Figure 1.** A flow diagram of the included studies.

## Inclusion and Exclusion Criteria

Articles were included in the meta-analysis if they met all the following criteria:

1. The design type of studies were randomized controlled trials (RCTs) or retrospective nonrandomized trials (RNTs).
2. The direct pulp capping treatment was performed in human permanent teeth *in vivo*.
3. The studies compared MTA versus CH.
4. The success rate, inflammatory response, and dentin bridge formation were recorded.

Exclusion criteria were as follows:

1. Studies were performed *in vitro*.
2. Experimental studies were performed in animals or in human primary teeth.
3. The absence of a comparison of the 2 materials.

Abstracts, conference reports, and studies with insufficient information were also excluded.

## Data Extraction

Studies that fulfilled the inclusion criteria were processed for data extraction. Two authors independently extracted the necessary information using a standardized form. Discrepancies were resolved by discussion and consensus. The following information was extracted from each study: name of the first author, year of publication, country of origin, study design, the number of teeth, teeth type, success rate, inflammatory response, and dentin bridge formation. If studies involved multiple groups, only the control and experimental groups associated with this study were extracted.

## Methodological Quality Appraisal

Assessment of the quality of included studies is essential for a proper understanding of meta-analytic results. Thus, the quality assessment of individual RCT studies was performed using the Cochrane Collaboration's tool for assessing risk of bias. The quality of each RNT study was assessed according to the methodological index for nonrandomized studies.

## Statistical Analysis

Different study categories were analyzed separately. Odds ratios (ORs) and 95% confidence intervals (CIs) were used to compare the treatment results between MTA and CH. The standard chi-square test and $I^2$ statistic were used to test for heterogeneity among studies; $P < .1$ or $I^2 > 50\%$ suggested the presence of heterogeneity. If heterogeneity existed between studies, a random-effects model was used; otherwise, a fixed-effects model was used. Finally, publication bias was assessed by performing funnel plots qualitatively. All analyses were performed using Revman 5.0 statistical software (The Cochrane Collaboration, Oxford, UK).

**TABLE 1.** The Characteristics of the Included Studies

| Author | Year | Country | Study design | No. of teeth | Teeth type | Age range (y) | No. of MTA | No. of CH | Minors score |
|---|---|---|---|---|---|---|---|---|---|
| Accorinte (21) | 2008 | Brazil | RCT | 40 | Premolars | 15–30 | 20 | 20 | — |
| Accorinte (22) | 2008 | Brazil | RCT | 40 | Premolars | 15–30 | 20 | 20 | — |
| Aeinehchi (23) | 2003 | Iran | RCT | 14 | Third molars | 20–25 | 8 | 6 | — |
| Cho (24) | 2013 | Korea | RNT | 175 | Patients | — | 70 | 105 | 17 |
| Eskandarizadeh (25) | 2011 | Iran | RCT | 90 | Premolars | 14–21 | 60 | 30 | — |
| Hilton (26) | 2013 | US | RCT | 358 | Patients | >7 | 183 | 175 | — |
| Iwamoto (27) | 2006 | US | RCT | 45 | Third molars | 18–60 | 22 | 23 | — |
| Mente (28) | 2010 | Germany | RNT | 122 | Patients | 8–78 | 69 | 53 | 19 |
| Mente (29) | 2014 | Germany | RNT | 229 | Patients | 7–78 | 170 | 59 | 21 |
| Min (30) | 2008 | Korea | RCT | 19 | Third molars | 21–50 | 9 | 10 | — |
| Nair (31) | 2008 | Switzerland | RCT | 33 | Third molars | 18–30 | 20 | 13 | — |
| Parolia (32) | 2010 | India | RCT | 24 | Premolars | 15–25 | 12 | 12 | — |
| Swarup (33) | 2014 | India | RCT | 20 | Premolars | 11–15 | 10 | 10 | — |

CH, calcium hydroxide; MTA, mineral trioxide aggregate; RCT, randomized controlled trials; RNT, retrospective nonrandomized trials.