

REVIEW ARTICLE



## Calcium enriched mixture cement: A review

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### Abstract

Nothing is more valuable than preservation of the natural tooth, which reflects the general health of the patients. Dental caries is the most prevalent dental disease, which needs various endodontic treatment procedures in order to maintain the tooth in healthy condition. With the advancement in material sciences, various new materials had evolved in dentistry. One such material is calcium enriched mixture cement that is a class of dental materials conciliates excellent biocompatibility with high osseo conductivity that render them ideal for endodontic care. The present article gives the overview of newly developed novel endodontic cement.

**Keywords:** Biocompatibility, calcium-enriched mixture cement, dental caries, osseo conductivity

### Introduction

The quest to search for an ideal material is never ending especially in the field of material sciences. Since the evolution of dentistry, various materials are hypnotized, formulated and applied both *in vivo* and *in vitro* and standardized in order to obtain maximum benefit from the material. Till now in the field of material sciences, no ideal material is generated which is considered as the gold standard, since all the formulated materials have pros and cons. In the search of newer bio-ceramic materials, calcium enriched mixture (CEM) cement has emerged, which was first introduced by Asgary *et al.* in 2006.<sup>[1]</sup>

Basically bio-ceramic materials can be divided as:

1. Bioinert: Non-interactive with biological systems
2. Bioactive: Durable tissues that can undergo interfacial interactions with surrounding tissue
3. Biodegradable: Soluble or resorbable: eventually replaced or incorporated into tissue.

The properties of bio-ceramics are very advantageous to material science. Excellent biocompatibility, osseo conductivity property, ability to form excellent hermetic seal, chemical bond to the tooth structure, insolubility in tissue fluids, good radiopacity and easy handling characteristics have led to the widespread use of these materials in the area of endodontic.<sup>[2]</sup>

### CEM Cement

A novel endodontic material called CEM cement also known as new endodontic cement was introduced to dentistry by Asgary *et al.* in 2006 for its application in various endodontic procedures. CEM cement is believed to be similar to mineral trioxide aggregate (MTA), but with better physical properties. The clinical application of this cement is similar to the MTA. When the CEM is mixed with water-based solution, it forms bioactive calcium and phosphate enriched mixture.

Mixed CEM cement releases calcium and phosphate ions and then forms hydroxyapatite not only in simulated body tissue fluid but also in normal saline solution; the latter of which is unlike MTA.<sup>[3]</sup> In addition, this novel cement releases calcium and phosphorus ions from indigenous sources result in a rich pool of hydroxyl ions (OH<sup>-</sup>), calcium ions (Ca<sup>2+</sup>) and phosphate ions (PO<sub>4</sub><sup>-</sup>). These elements are used in the process of hydroxyapatite (HA) production.<sup>[2]</sup>

### Composition

CEM cement is composed of different calcium compounds. The major components of the powder are:

- 51.75% wt. calcium oxide (CaO),

- 9.53% wt. sulfur trioxide (SO<sub>3</sub>)
- 8.49% wt. phosphorous pentoxide (P<sub>2</sub>O<sub>5</sub>),
- 6.32% wt. silicon dioxide (SiO<sub>2</sub>), and
- Minor components are aluminium trioxide (Al<sub>2</sub>O<sub>3</sub>) > sodium oxide (Na<sub>2</sub>O) > magnesium oxide (MgO) > chloride (Cl).

CEM differs chemically from MTAs and Portland cement, phosphorous is the major component of CEM.<sup>[4]</sup> Under scanning electron microscope (SEM) study, the presence of calcium, phosphorous and oxygen ion on the surface of CEM cement was almost similar when compared to that of surrounding dentin. Hence, this finding shows that the composition of CEM cement is similar to dentin. Since HA is the main component of dentin; therefore, similarity in composition between CEM cement and dentin might help the cementogenesis despite the presence of high level of phosphorous in CEM cement. It seems reasonable to suspect that the presence of low concentration of phosphate ions in CEM cement media is probably due to its reaction with released calcium ion to form hydroxyapatite in the 1<sup>st</sup> h.<sup>[5]</sup>

### Properties

#### 1. Physical properties:

The physical properties of CEM are almost similar to that of MTA. Setting expansion of CEM cement expansion (0.075 ± 0.032 mm) doesn't differ significantly from that of MTA (0.085 ± 0.042 mm). The material also exhibited reasonable film thickness (174 ± 25 µm) and flow (14 ± 1 mm), which were statistically different from MTA (452 ± 63 µm and 10 ± 0.79 mm, respectively). The slight expansion and reasonable flow and film thickness of CEM can ensure an effective seal after setting, and reduce the subsequent leakage. The setting time of CEM was found to be less than an hour (50 min), and shows alkaline pH of 10.71 ± 0.19.<sup>[2]</sup>

#### 2. Biological properties:

##### a. Antibacterial and antifungal properties:

Various studies have been evaluated to check the antibacterial efficacy of CEM cement against the common endodontic pathogens and results indicated that the antibacterial activity of CEM cement is almost similar to that of calcium hydroxide but better than MTA. Torabinejad *et al.* and Asgary *et al.* evaluated CEM cement against *Streptococcus mutans*, *Escherichia coli*, *Actinomyces* and *Enterococcus faecalis* and have concluded that CEM cement is effective against all the strains except *E. faecalis*.<sup>[5]</sup>

The antibacterial properties of the CEM cement may be possibly because of the presence of alkaline earth metal oxide and hydroxides (e.g. CaO and calcium hydroxide, calcium phosphate, and calcium silicate) which undergoes hydration reaction results in the formation of calcium hydroxide, which further dissociates into calcium and hydroxyl ions, thus increasing the pH and calcium ion concentration. An increased pH may reversibly or irreversibly inactivate cellular membrane of the microorganism, resulting

in a loss of biological activity. Another possible explanation is the antibacterial component of cement has better diffusion property.<sup>[6]</sup>

Asgary *et al.* evaluated the CEM cement against *Candida albicans* and concluded that it is effective in inhibiting the growth of *C. albicans* strains. A possible explanation for the fungicidal effect may be due to the presence of calcium hydroxide and better diffusion property of antibacterial component of cement.<sup>[7]</sup>

##### b. Biocompatibility:

The biocompatibility of CEM has been associated with its ability to release calcium ions during setting, and the subsequent binding of calcium with phosphorus to form hydroxyapatite crystals. This new biomaterial is more likely to cause alterations in cellular enzymatic activity than to change the permeability, which facilitates healing.<sup>[2]</sup>

Various *in vivo* and *ex vivo* studies have been performed to check for the cytotoxicity of the material. Mozayeni *et al.* evaluated the cytotoxicity of CEM cement with MTA and intermediate restorative material (IRM) on mouse fibroblast using enzyme-linked immunosorbent assay and MTT assay and CEM cement demonstrated favorable cell viability compared to MTA and IRM.<sup>[4]</sup>

In a recent study, histological evaluation of MTA and CEM cement shown that MTA induces cellular necrosis, unlike the CEM cement. Another significant finding was the presence of dystrophic calcification adjacent to the biomaterials, which is an indication of their osteo-inductive potential. Studies of CEM cement on peri-radicular tissue reaction demonstrated that the material is capable of inducing hard tissue formation, in particular, cementogenesis.<sup>[8]</sup>

The biological mechanism by which CEM cement stimulates hard tissue formation is thought to be the result of several properties, i.e. sealing ability, biocompatibility, high alkalinity, antibacterial effect, hydroxyapatite formation, and similarity to dentine.<sup>[2]</sup> Various studies of CEM cement on the pulpal response have shown that cement has ability to induce the dentinal bridge formation when compared with MTA. Some studies demonstrated superior quality and thickness of dentinal bridge formation when compared with MTA.

Under the SEM study, dentinal bridge formation had shown three different zones. The outer aspect was composed of CEM in direct contact with newly formed hard tissue. In the middle portion, a dentin-like bridge with irregular dentinal tubules was identified. The pulpal or inner aspects exhibited predentin layer, which was similar to normal condition. Young odontoblasts-like cells were differentiated, and they elaborated collagen matrix and predentin layer.<sup>[9]</sup>

##### c. Microleakage:

The sealing ability of the material is considered as an

important factor when it is used as the root end filling material. The ideal material should prevent the ingress of microorganism and their by-products into periradicular tissue. Various studies have done to compare the sealing ability of CEM cement with MTA and IRM. The results of the study have shown the superior sealing ability of CEM compared to MTA and IRM. The possible explanation for excellent sealing may be due to its handling characteristics and chemical properties.

Other possible hypothesis may be:

- I. CEM cement provides good handling characteristics. Once mixed, this cement does not adhere to the applicator and is easily adaptable.
- II. Saliva increases the wetting of the dentinal walls, enabling adaptation of CEM cement within irregularities of root canal walls, and also facilitates its penetration into the dentinal tubules.
- III. Slight setting expansion of CEM cement also contributes to the better adaptation of material to the root-end cavity walls.<sup>[10]</sup>
- IV. High percentage of small particles (0.5-2.5  $\mu\text{m}$ ) in this material supports this cement's access to dentinal tubules with inner diameter range of 2-5  $\mu\text{m}$ .<sup>[1]</sup>
- V. In the presence of an aqueous environment, this biomaterial produces large amount of hydroxyl, calcium, and phosphate ions which leads to HA formation and thus provides an additional seal at the interface of the material and cavity walls.<sup>[3]</sup>

Clinical application:

1. Direct pulp capping
2. Indirect pulp capping
3. Pulpotomy
4. Root end filling material
5. Furcation perforation repair
6. Apexification
7. Repair of root Resorption
8. Apexogenesis

Advantages:

- a. Economical,
- b. Shorter setting time,
- c. Good handling characteristics,
- d. Better flow,
- e. Less film thickness and
- f. Ability to form hydroxyapatite
- g. Ability to induce cementum i.e. cementogenesis.

## Conclusion

This novel bio-ceramic endodontic cement has shown promising results because of their good biocompatibility and better physical properties and has overcome several disadvantages of MTA cement. The cement is similar to MTA in its properties and clinical application but differ from it only in its composition that has more of phosphorous content in CEM cement. However, futuristic application of CEM cement for its various clinical applications and success needs a high level of research. Further studies are required to confirm biocompatibility, cost effectiveness, and physical property are superior when compared with other cements.

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