Review Article

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CALCIUM ENRICHED MIXTURE CEMENT: A NOVEL BIOCERAMIC

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ABSTRACT:

Preservation of the natural tooth which reflects the general health of the patients, is one of the most valuable tool. Dental caries is the most prevalent dental disease requiring various conservative and endodontic treatment procedures in order to maintain the tooth in healthy condition. Endodontic material science has been revolutionized by advancements in bioceramic technology enhancing the treatment outcome for patients. Bioceramic materials have excellent biocompatibility with high osseoconductivity that render them ideal for endodontic care. Calcium enriched mixture (CEM) cement is one of the newly introduced bioceramic materials which have shown considerable clinical success over their early generations. This literature review focuses mainly on properties and applications of CEM cement in endodontics.

Keywords: Bioceramics, Calcium enriched material, Pulp therapy, CEM, Endodontic cement

INTRODUCTION:

Change is necessary. The challenge is not to avoid change, but to manage it. But change can be “for better or for worse”. Fortunately or unfortunately, we can experience both in endodontics. New materials have constantly been introduced to overcome the shortages of the previous ones.[1,2] Various materials have been developed to treat the dental problems like Calcium hydroxide, MTA etc but Till now, no ideal material is generated which is considered as the gold standard, since all the formulated materials have pros and cons and same applies for calcium hydroxide and MTA.

To overcome the limitations of these materials, various bio ceramics materials have been developed. 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.[3]

Recently, a new BIOCERAMIC endodontic cement has been developed having

different chemical composition namely calcium-enriched mixture (CEM).[4] A novel BIOCERAMIC material called CEM cement also known as new endodontic cement was introduced to dentistry by Asgary et al. in 2006. It has acceptable physical properties[5] (i.e., setting time <1 h, more flow, and less film thickness than MTA). When the CEM is mixed with water-based solution, it forms bioactive calcium and phosphate enriched mixture. Mixed CEM cement releases

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calcium and phosphate ions and then forms hydroxyapatite not only in simulated body tissue fluid but also in normal saline solution; the latter property is not seen with MTA.[6] The CEM can be handled well and sets in an aqueous environment exhibiting good handling characteristics. It also releases calcium and phosphorus ions from endogenous and exogenous ion sources[5] results in a rich pool of hydroxyl ions (OH−), calcium ions (Ca2+) and phosphate ions (PO4−). These elements are used in the process of hydroxyapatite (HA) production.[7]

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 (SO3)
- 8.49% wt. phosphorous pentoxide (P2O5),
- 6.32% wt. silicon dioxide (SiO2), and
- Minor components are aluminium trioxide (Al2O3) >sodium oxide (Na2O) >magnesium oxide (MgO) >chloride (Cl).

CEM differs chemically from MTAs and Portland cement, phosphorous is the major component of CEM.[8] CEM cement is a white powder consisting of hydrophilic particles that sets in the presence of water base solution. Hydration reaction of powder creates a colloidal gel that solidifies in less than 1 hour and form hydroxyapatite. 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 1ST hour.[9]

PROPERTIES

1. Physical properties

The physical properties of CEM are almost similar to that of MTA. This cement has a working time of 5 min and The setting time was found to be less than an hour (50 min) which is lesser than MTA.[9] It has an alkaline pH of 10.71 ± 0.19.[7] The greatest distribution of CEM particle size was within 0.5-2.5 µm range allowing penetration of particles into dentin tubules and therefore, providing a better seal.[10] It shows good handling properties. After mixing, it does not adhere to applicator and is easily adaptable.

2.Antibacterial and antifungal properties

Antibacterial activity of CEM cement is almost equal to CH while significantly greater than MTA.[11] It is because CEM cement contains greater potent antibacterial inhibitors than MTA. Torabinejad et al. and Asgary et al. evaluated activity of CEM cement against S. mutans, E.coli, Actinomyces and E. faecalis which showed that CEM cement is effective against all the strains

except E. faecalis.[12] The study done by Reyhani demonstrated adding 2% chlorhexidine gluconate (CHX) to CEM cement will increase antibacterial activity against Pseudomonas aeroginosa, E. faecalis, S. aureus and E. coli.[13] The antibacterial properties of the CEM cement may be due to the presence of alkaline earth metal oxide and hydroxides (e.g. CaO and calcium hydroxide, calcium phosphate, and calcium silicate) or due to the better diffusion property of the antibacterial component of cement.[12] CEM and MTA induce complete death of Candida albicans fungal cells after 24 h. This fungicidal effect may be due to the presence of calcium hydroxide and better diffusion property of antibacterial component of cement.[14]

3. Biocompatibility

Ability to release calcium ions during setting and the subsequent binding of calcium with phosphorus to form hydroxyapatite crystals is the reason of its biocompatibility. This is more likely to cause alterations in cellular enzymatic activity than to change the permeability.[7] Various Studies of CEM cement on peri-radicular tissue reaction showed that the material is capable of inducing hard tissue formation, mainly cementogenesis.[15] The cytotoxic potentials of CEM and MTA are almost equal and but significantly superior to IRM.[16] Studies have shown the presence of dystrophic calcification adjacent to the biomaterials which is an indication of their osteoinductive potential.[17]

4. Sealing property

The sealing ability of CEM is similar to MTA[4] and improves with storage in phosphate buffered saline solution.[18] MTA, unlike CEM cement, does not contain endogenous phosphorous. The smaller particle size of CEM may be related to its acceptable sealing properties. In the presence of an aqueous environment, CEM 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.[6] It can promote hydroxyapatite formation in saline solution also and may also aid in differentiation of stem cells and hard tissue formation.[19,20]

CLINICAL APPLICATIONS

1. Vital pulp therapy- Direct and Indirect Pulp capping

Vital teeth with complete/incomplete root formation after any type of pulp exposures are suitable candidates for VPT. The key factors for success of VPT is the vitality of the pulp, the presence of an adequate vascularization, creation of a three dimensional seal, acceptable antimicrobial properties, and biocompatibility. The CEM cement have good sealing ability, shows lower inflammation, improved thickness of calcified bridge, superior pulp vitality status. Studies of complete pulpotomy

treatment using CEM, MTA, and CH have shown that compared to CH, samples in the CEM group exhibited lower inflammation, improved quality / thickness of calcified bridge, superior pulp vitality status, and morphology of odontoblast cells.[21]

2. Apexogenesis and Apexification

Acceptable clinical / radiographic results were achieved, including the formation of a dental bridge below CEM and the closure of the tooth apex.[20] Cementogenesis, and dentinogenesis also occur in contact with CEM cement.

3. Perforation repair

Root and furcal perforations are common complications of endodontic treatment or post preparation. CEM cement is able to stimulate dentinogenesis it showed cementogenesis after perforation repair or surgery.[19]

4. Root end filling and Obturating material

A root-end filling and obturating material should seal the apex properly. The CEM cement has good apical sealing moreover biocompatibility, good clinical handling, antibacterial and low cytotoxic Effect.

5. Resorption repair

A chemical way of arresting or preventing acid attack on the root surface is to change the pH of the root surface and dentinal tubules to an alkaline pH, which can interfere with activities of odontoclast and osteoclast cells. CEM is an alkaline cement (pH > 10.5) with comparable antibacterial properties makes it a suitable material to stop the resorptive process.

6. In Regenerative endodontic treatment

Revascularization is a valuable treatment in immature necrotic teeth that allows the continuation of root development. CEM cement can be a good option for regeneration due to ability of cementogenesis, dentinogeneis and pdl regeneration. Several case reports, case series, and clinical studies have been published demonstrating successful results for this technique and material in treating immature necrotic teeth.[22,23]

DISCUSSION:

In the recent years we have witnessed significant changes in endodontic material science. Bioceramic materials are the dawn of a new era in dentistry. Their introduction into endodontics as mineralising materials has brought about enormous productive changes. The applications vary from their use for Pulp Capping, to apexogenesis, apexification, and furcation repair.[24] Bioceramics are biocompatible ceramic materials applicable for use in medicine and dentistry. They include alumina and zirconia, bioactive glass, glass ceramics, calcium silicates, hydroxyapatite and resorbable calcium phosphates, and radiotherapy glasses.[25]

Hermann in 1920, introduced calcium hydroxide (CH), since then it has been commonly used as an intracanal – inter appointment medicament. Various biological properties have been attributed to this substance, such as antimicrobial activity, tissue dissolving ability, inhibition of tooth resorption, and induction of hard tissue formation.[26] In aqueous solution, CH releases hydroxyl ions and produces a pH of 12.4, which is the antibacterial mechanism of this biomaterial.[27] Researchers found that using CH as an intracanal medicament can weaken the dentin compared to non treated teeth. They suggested that CH may affect the dentin structure by reducing its organic component, which may influence the mechanical properties of dentin.[28,11]

Mineral trioxide aggregate (MTA) was introduced in 1993 by Torabinejad and in 1998 it was approved for endodontic application. Portland cement is the major component of MTA and bismuth oxide is added for radiopacity. Initial pH of MTA is 10.2 and rises to 12.5 during the next three hours. MTA is used as a material for rootend filling, direct pulp capping, repair of root and furcation perforations, and also apexification.[29] MTA has also shown a weakening effect on dentin, probably due to breakdown of the protein structure caused by its alkalinity.[30]

A new endodontic cement, calcium enriched mixture (CEM) cement has different chemical composition from MTA but similar clinical applications. Results of recent studies indicate that mixed CEM cement releases calcium and phosphate ions and then forms hydroxyapatite. It can produce hydroxyapatite crystals from endogenous and exogenous ions sources. This cement has the similar biocompatibility and pH to that of MTA, with more efficient properties such as increased flow, but decreased working time, film thickness, and estimated price than MTA, good handling characteristics, shorter setting time, and no tooth staining.[5] The antibacterial effect of CEM cement is comparable to CH and greater than MTA.[11] Comparison of antifungal properties of CEM and MTA on Candida albicans has shown that both biomaterials induce complete death of fungal cells after 24 hours.[14] CEM cement has demonstrated similar results to MTA when used as pulp capping agent or furcation perforation repair.[31,32] It has also shown favorable results in pulpotomy of permanent molar teeth with established irreversible pulpitis and management of internal root resorption.[33] CEM cement has shown lower mean dye leakage than commercial types of MTA and IRM in dry root end preparations.[4,34] Highly acidic environment could impede the bond strength of CEM but in the pH values more than 5.4 this effect is modulated. As the pH value of abscess environment is about 5, this cement could be recommended for use in inflamed/infected tissues.[35]

CONCLUSION:

This novel bio-ceramic endodontic cement has shown promising results when used for VPT, furcation perforation repair, and management of internal and external root resorption. Compared to MTA it is similar in clinical applications but differ in composition moreover it has good biocompatibility, good handling properties, shorter setting time and no tooth staining. The cement is able to induce hard tissue formation, has antibacterial effect, and forms an effective seal against entrance of microorganisms. However, Further studies with a high level of evidence are required to confirm cost effectiveness, success rate and efficacy when compared with other materials.

REFERENCES:

1. Gandolfi MG et al. New Portland cement-based materials for endodontics mixed with articaine solution: A study of cellular response. J Endod 2008;34:39-44.
2. Tay KC et al. In vitro evaluation of a Ceramicrete-based root-end filling material. J Endod 2007;33:1438-43.
3. Best SM et al. Bioceramics: past, present and for the future. J Eur Ceram Soc. 2008;28:1319–1327.
4. Asgary S et al. Sealing ability of a novel endodontic cement as a root end filling material. J Biomed Mater Res A 2008;87:706-9.
5. Asgary S et al. The properties of a new endodontic material. J Endod 2008;34:990-3.
6. Asgary S et al. Effect of two storage solutions on surface topography of two root-end fillings. Aust Endod J 2009;35:147-52.
7. Utneja S et al. Current perspectives of bio-ceramic technology in endodontics: calcium enriched mixture cement - review of its composition, properties an applications. Restor Dent Endod 2014;39:1-13.
8. Mozayeni MA et al. Cytotoxicity of calcium enriched mixture cement compared with mineral trioxide aggregate and intermediate restorative material. Aust Endod J 2012;30:70-5.
9. Asgary S et al. Comparison of mineral trioxide aggregate's composition with Portland cements and a new endodontic cement. J Endod 2009;35:243-50.
10. Amini Ghazvini S et al. Ion release and pH of a new endodontic cement, MTA and Portland cement. Iran Endod J 2009;4:74-8.
11. Asgary S, Kamrani FA. Antibacterial effects of five different root canal sealing materials. J Oral Sci 2008;50:469-74.
12. Hasan Zarrabi M et al. Comparative evaluation of antimicrobial activity of three cements: new endodontic cement (NEC), mineral trioxide aggregate (MTA) and Portland. J Oral Sci 2009;51:437-42.

13. Reyhani MF et al. Effect of adding chlorhexidine gluconate to calcium enriched mixture (CEM). Afr J Microbiol Res 2014;8:2393-6.
14. Kangarlou A et al. Antifungal effect of calcium enriched mixture cement against Candida albicans. Iran Endod J 2009;4:101-5.
15. Asgary S, Ahmadyar M. Vital pulp therapy using calciumenriched mixture: An evidence based review. J Conserv Dent 2013;16:92-8
16. Asgary S et al. Cytotoxic effect of MTA and CEM cement in human gingival fibroblast cells. Scanning electronic microscope evaluation. N Y State Dent J 2012;78:51-4.
17. Parirokh M et al. A Comparative study of subcutaneous tissue responses to a novel root-end filling material and white and grey mineral trioxide aggregate. Int Endod J 2011;44:283-9.
18. Ghorbani Z et al. Microleakage of CEM cement in two different media. Iran Endod J 2009;4:87-90.
19. Asgary S et al. Periradicular regeneration after endodontic surgery with calcium-enriched mixture cement in dogs. J Endod 2010;36:837-41.
20. Nosrat A et al. Regenerative endodontic treatment (revascularization) for necrotic immature permanent molars: A review and report of two cases with a new biomaterial. J Endod 2011;37:562-7.
21. Tabarsi B et al. A comparative study of dental pulp response to several pulpotomy agents. Int Endod J 2010;43:565-71.
22. Banchs F, Trope M. Revascularization of immature permanent teeth with apical periodontitis: new treatment protocol? J Endod. 2004;30:196–200.
23. Ding RY et al. Pulp revascularization of immature teeth with apical periodontitis: a clinical study. J Endod. 2009;35:745–749.
24. Swarup S, Rao A. Bioceramics in pediatric endodontics. 1st ed. Trivandrum: Lambert Academic Publishing; 2013. pp. 53–68.
25. Nasseh A. The rise of bioceramics. Endodontic Practice. 2009;2:17–22.
26. Siqueira JF, Lopes HP. Mechanisms of antimicrobial activity of calcium hydroxide: a critical review. Int Endod J. 1999;32(5):361–69. [PubMed]
27. Kawamoto R et al. Change in elastic modulus of bovine dentine with exposure to a calcium hydroxide paste. J Dent. 2008;36(11):959–64.
28. Andreasen JO et al. Longterm calcium hydroxide as a root canal dressing may increase risk of root fracture. Dental Traumatology. 2002;18(3):134–37.
29. Sarkar NK et al. Physicochemical basis of the biologic properties of mineral trioxide aggregate. J Endod. 2005;31(2):97–100.

30. White JD et al. The effect of three commonly used endodontic materials on the strength and hardness of root dentin. J Endod. 2002;28(12):828–30.
31. Asgary S et al. A comparative study of histological response to different pulp capping materials and a novel endodontic cement. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2008;106:609–14.
32. Samiee M et al. Repair of furcal perforation using a new endodontic cement. Clin Oral Investig. 2009:Nov 4.[Epub ahead of print]..
33. Asgary S, Ehsani S. Permanent molar pulpotomy with a new endodontic cement: A case series. J Conserv Dent. 2009;12:31–6.
34. Asgary S et al. Sealing ability of three commercial mineral trioxide aggregates and an experimental rootend filling material. Iranian Endodontic J. 2006;1:101–5.
35. Fereshte Sobhnamayan et al. Effect of Acidic Environment on the PushOut Bond Strength of Calcium Enriched Mixture Cement. Iran Endod J. 2014 Fall; 9(4): 266–270.