Journal of Dental Sciences and Education

Review

DOI: 10.51271/JDSE-0005

Premixed calcium silicate-based cements: a literature review

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Cite this article: Batur M, Yeniçeri Özata M. Premixed calcium silicate-based cements: a literature review. *J Dent Sci Educ*. 2023;1(1):23-26.

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Submit Date: 18/03/2023 **Accept Date:** 29/03/2023

ABSTRACT

In dental treatment procedures such as exposure of the pulp, root perforation, apexification or revascularization due to traumatic injuries, it is very important to ensure the tissue repair process. In this way, the formation of a mineralized barrier can be induced. The most commonly used material for this purpose is MTA. However, its disadvantages are the long curing time, difficult manipulation and the need to apply moist absorbent cotton after the process. Pre-mixed calcium silicate cements (CSC), which allow easy application, have become very popular in recent years. This review aimed to compare and present the literature on pre-mixed CSC.

Keywords: Calcium silicate based cement, premixed cement, bioceramics

INTRODUCTION

Calcium silicate-based cements (CSC) are materials that have proven their success in dentistry due to their odontogenic/osteogenic properties.[1] They are chemically stable and biocompatible materials that can maintain pulp vitality due to these properties. These materials can be classified as follows (**Table 1**);[3]

Table 1. Classification of calcium silicate-based cements
Bioinert - which do not interact with biological systems, e.g. alumina and zirconia
Bioactive - which exhibits interactions with adjacent tissues, e.g., bioactive glass and glass ceramics
Biodegradable – which ultimately replace or are incorporated into tissue, e.g. calcium silicates

CSCs contain di-calcium and/or tri-calcium and/or tetra-calcium silicate phases in their basic mechanisms of action during the hydration process. Pre-mixed CSCs have superior mechanical and biological properties due to the content of calcium silicate, zirconium oxide, tantalum oxide, calcium phosphate and fillers. These bioceramics are hydrophilic and require moisture from the surrounding tissue. They are classified according to their consistency with similar ingredients:[4]

1. Syringe form
2. Paste form
3. Fast-setting paste form

Some advantages of pre-mixed CSCs over other bioceramics can be listed as follows:[5]

1. Since it is a ready-to-use product, the factor of user error that may occur during mixing is eliminated.
2. It is homogeneous.
3. It is used as needed and wastage of material is avoided.
4. The possibility of cross-contamination is reduced.
5. It is easy to manipulate.

Due to these advantages, pre-mixed CSCs can be used for pulp capping, perforation repair, pulpotomy, retrograde filling and root canal filling.[6] Many different pre-mixed calcium silicate cements are available on the dental market (**Table 2**).

Table 2. Pre-mixed calcium silicate-based cements and their contents		
Pre-mixed CSC	**Manufacturer**	**Content**
EndoSequence BC RRM	Brasseler USA, Savannah, GA.	Tricalcium and dicalcium silicate, calcium sulfate, tantalite, zirconia and proprietary organic liquid
NeoPutty	NuSmile, Houston, TX, USA.	Tricalcium and dicalcium silicate and aluminate, tantalite, proprietary organic liquid and stabilizers
Bio-C Repair	Angelus, Londrina, PR, Brazil.	Calcium silicate, calcium aluminate, calcium oxide, zirconium oxide, iron oxide, silicon dioxide
TotalFill BC RRM	FKG, La Chaux-de-Fonds, Switzerland.	Tricalcium Silicate, Dicalcium Silicate, Zirconium Oxide, Tantalum Pentoxide, Calcium Sulfate.
iRoot BP	Innovative Bioceramics, Vancouver, Canada.	Calcium silicate, calcium phosphate, calcium sulfate, zirconium oxide, tantalum pentoxide

Endosequence Root Repair Material

Endosequence root repair material is available in premixed and ready-to-use injectable or compactable paste form[7] (**Figure 1**). While monocalcium phosphate in its content is involved in the formation of hydroxyapatite, tantalum oxide and zirconium oxide are responsible for radiopacity. It is reported that the fluid in the dentinal tubules affects the

physiology of the hardening of the material, and the setting time is stated to be 2-4 hours.[8] Its advantages include high pH and lack of shrinkage during washing and setting.[9]

Figure 1. EndoSequence BC RRM

It has been shown that the setting time of EndoSequence BC RRM increases and its microhardness decreases as the ambient humidity increases. It has been reported that the setting time in a 100% humid environment at 37°C is up to 168 hours.[10] Although the manufacturer claims a compressive strength of 70-90 MPa, a study found that the strength of the material is 40-50 MPa, and this value is similar to that of MTA.[11] The nanoparticles contained in EndoSequence BC RRM facilitate the penetration of the material into the dentinal tubules. In addition, the material is predicted to be mechanically bonded to the dentin thanks to the moisture in the dentin tubules, reducing its shrinkage potential and maintaining its stability.[12]

An in vitro study reported that EndoSequence BC RRM, used as a retrograde filling material, showed similar properties to MTA in terms of marginal adaptation and sealing.[13] It was shown that EndoSequence BC RRM, prepared with physiological saline solution, formed hydroxyapatite-like precipitates, and the calcium ion ratio and pH value released in association with hard tissue formation were similar to MTA.[8] Similarly, it was reported that the push-out bond strength of the material was similar to that of MTA.[14]

Cytotoxicity studies on gingival fibroblasts, mouse fibroblasts, human dermal fibroblast, periodontal ligaments, and osteoblast cells reported that EndoSequence BC RRM showed similar biocompatibility compared to MTA.[10]

It is suggested that the antibacterial effect of EndoSequence BC RRM on *Enterococcus faecalis* is similar to that of MTA, and this effect is due to the high pH of the material during curing.[15]

NeoPutty

NeoPutty (NuSmile, Houston, TX, USA) is a bioceramic material with an extremely fine structure and a pre-mixed anhydrous organic liquid. The product is packaged ready for use and does not require mixing16 (**Figure 2**). The pulp begins to harden with moisture from the dentinal tubules or apically.[17,18] The setting time of this material after exposure to atmospheric humidity is unknown.[17] However, according to the manufacturer, the setting time is approximately 4 hours at 37°C and the working time is over 1 hour at room temperature.[19] NeoPutty has been shown to be more biocompatible and longer shelf life than EndoSequence BC RRM.[18] It has also been reported that NeoPutty is less affected by atmospheric humidity than EndoSequence BC RRM.[17] According to the manufacturer, NeoPutty is more radiopaque than NeoMTA 2 (8.4 mm aluminium equivalent).[19] A previous study showed that the NeoPutty's shear strength was not superior to the NeoMTA-2.[18] Another study reported that NeoPutty had lower bond strength to dentin walls than Biodentine. The reason for this has been shown to be that the high viscosity of pre-mixed bioceramic is too high to penetrate deeply into the dentinal tubules.[16]

Figure 2. NeoPutty

A study evaluating cytotoxicity showed that NeoPutty EndoSequence BC is more biocompatible than RRM.[16] NeoPutty was found to be mildly cytotoxic to human dental pulp stem cells and human periodontal ligament fibroblasts when mixed with bioinert material such as polytetrafluoroethylene (Teflon).[17]

Bio-C Repair

Bio-C Repair (Angelus, Londrina, PR, Brazil) is ready-to-use a new silicate-based material (**Figure 3**). Its application is similar to MTA.[20] It has an excellent consistency that allows much better ease of use compared to MTA.[21] The manufacturer states that it has a maximum setting time of 2 hours, a pH of about 12, radiopacity greater than 7.0 mm Al, ease of application, and does not cause coloration.[22] An in vitro study reported that Bio-C Repair to have similar cytotoxicity, biocompatibility and biomineralization to MTA Repair High-Plasticity and MTA-Angelus.[20] Stem cells in the periodontal ligament also showed similar pH values with Bio-C Repair and Bio-C Sealer, but Bio-C Repair showed greater cell viability and cell adhesion. Bio-C Repair also showed excellent cytocompatibility with ProRoot MTA and Biodentine on human dental pulp.[23]

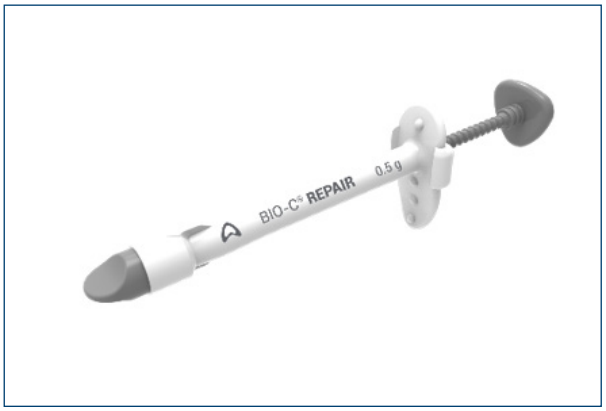

Figure 3. Bio-C Repair

TotalFill BC RRM

There are three different forms of bioceramic materials as paste, putty and sealer (**Figure 4**). Calcium phosphate, which increases the formation of hydroxyapatite, is available in TotalFill BC RRM as a monobasic adjunct agent.[24] TotalFill BC RRM, a pre-mixed bioceramic-based material, is a new material recently introduced to compensate for the poor handling properties of MTA and Biodentine.[25] The setting time of TotalFill BC RRM is at least 2 hours in normal situations.[26,27] A previous study reported that TotalFill BC RRM has high radiopacity, rapidly alkalizes the environment in the first hour during the sitting of the material, and has an average pH of approximately 10.3 on day.[28] This alkaline environment promotes apatite formation and deposition.[26] Another previous study reported that TotalFill BC RRM showed less microleakage in root canal walls compared to Biodentine and MTA.[25] A study testing surface microhardness in an acidic environment found that TotalFill BC RRM had lower surface microhardness compared to ProRoot MTA and Biodentine.[28] According to the manufacturer, it begins to set when exposed to ambient humidity without mixing. The working time is more than 30 minutes.[27]

Figure 4. Paste, putty and sealer form TotalFill BC RRM

iRoot BP

The setting time after exposure to moisture is 2 hours.[29] A previous study showed that apoptotic iRoot BP and MTA have a similar proportion of apoptotic cells.[30] Another study reported that iRoot BP showed greater cellular viability than MTA.[31] iRoot BP Plus shows antimicrobial effect against *Streptococcus mutans*, *Staphylococcus aureus* and *Enterococcus faecalis*.[32]

Figure 5. iRoot BP

CONCLUSION

Pre-mixed CSCs appear to have comparable properties to Biodentine and MTA. Considering the ease of use of these materials, manipulation can be increased by shortening working times in pedodontic, endodontic and restorative procedures. In addition, efficiency increases with the reduction of seating time.

ETHICAL DECLARATIONS

Informed Consent: All patients signed the free and informed consent form.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

Financial Disclosure: The authors declared that this study has received no financial support.

Author Contributions: All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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