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CALCIUM SILICATE SEALERS IN ENDODONTICS

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ABSTRACT

Calcium silicate-based cements are dental cements or root canal sealers that are prepared based on a composition of calcium and silicate. They were introduced in the 1990's as a promising dental substitute capable of adequately meeting wide range of clinical requirements. These cements have superior sealing ability, bioactivity and marginal adaptation which make them suitable for different dental treatment application.

KEYWORDS: Calcium silicate, Endodontic sealers, Bioceramics, Bioroot RCS, Calcium silicate-based sealers, BioRoot RCS, iRoot SP, Endosequence BC, Bio-C, Endoseal MTA, Total fill BC.

INTRODUCTION

Cements based on calcium and silicate are widely used in dentistry due to their excellent biocompatibility and sealing ability for various clinical applications like apical plug formation in cases with open apex, perforation repair, pulp capping and root end filling.[1,2] Root canal sealers based on calcium silicate have also been developed due to their favourable biological characteristics.[3,5] iRoot SP introduced in 2007 was the first calcium silicate based endodontic sealer and since then several other products based on calcium silicates have been developed.[6]

Calcium silicate-based cements come under an important subset of biomaterials termed –'Bioceramics'.[7]

Biological properties of calcium silicate-based sealers (CSBS) are based on release of calcium hydroxide as by-product upon hydration reaction.[8,10] Also, since they are stable under humid conditions[8] and are thus called as hydraulic sealers.[10]

CSBS comprises of a group of premixed CSBS which requires external water supply and a group of two components CSBS with internal water supply[6] although both the groups exhibit same setting reaction.

First reaction is a hydration reaction represented as either of the two shown below:

$2\ [3\ CaO \cdot SiO2] + 6\ H2O \rightarrow 3\ CaO \cdot 2SiO2 \cdot 3\ H2O + 3\ Ca(OH)2$

$2\ [2\ CaO \cdot SiO2] + 4\ H2O \rightarrow 3\ CaO \cdot 2SiO2 \cdot 3\ H2O + Ca(OH)2$[11]

This reaction is followed by a precipitation reaction forming calcium phosphate

$7\ Ca(OH)2 + 3\ Ca(H2PO4)2 \rightarrow Ca10(PO4)6(OH)2 + 12\ H2O$[6]

This review article discusses about some of the promising CSBS sealers available in the market which includes iRoot SP, EndoSequence BC (Brasseler, Savannah, GA, USA), BioRoot RCS (Septodont, Saint-Maur-des -Fossés, France), Bio-C sealer (Angelus, Londrina, PR, Brazil), Total Fill BC Sealer (FKG Dentaire, La Chaux-de-Fonds, Switzerland) and Endoseal MTA (Maruchi, Wonju, Korea).

Composition

Major component in CSBS are calcium silicates which forms a porous hydrate that sets into a solid network. Various phases of calcium silicate hydrate include radial acicular calcium silicate hydrate crystals, porous colloidal calcium silicate hydrate gel, hexacalcium aluminate trisulphate crystals, calcium monocarboaluminate or calcium monosulfoaluminate and calcium hydroxide crystals.

Although all the products differ in their composition their setting reactions are comparable. One of the major differences observed is in the type of delivery between premixed products having external water supply (body

fluid) and two component products having internal water supply.

Properties

Physical Properties

1) Radio Opacity

Presence of Zirconium oxide imparts radio opacity to CSBS. iRoot SP,[12-14] BioRoot RCS,[10] Endoseal MTA,[10,14,16] Endosequence BC,[12] Totalfill BC[13] and Bio-C sealer[12,17] fulfil the ISO norm ISO norm 6876:2012 for adequate radio opacity >3mm aluminium thickness although radio opacity compared to resin-based AH Plus sealer is lesser for CSBS. Bio C sealer showed comparable radio opacity to Totalfill BC sealer.[17]

2) Water Sorption and Solubility

Calcium hydroxide formed as by-product of hydration reaction of CSBS affects the water sorption and solubility compared to conventional resin-based sealers. Favourable biological properties of CSBS is due to their solubility and water absorption but this also decreases the dimensional stability of CSBS and thereby their sealing quality.[6,18,19] solubility of calcium silicate-based sealers is higher than that of epoxy resin-based sealers. iRoot and BioRoot RCS satisfied the ISO norms,[25] but several articles state that solubility of iRoot and BioRoot RCS are more than 3%.[21,22,23] Solubility of EndoSequence BC,[24] were in line with ISO 6876/2001 whereas Similar solubility, but a higher dimensional change was observed in Endoseal MTA as compared to AH Plus.[16]

3) Flowability and Film Thickness

Flow characteristics are determined by the viscosity of the sealer and marks the ability of sealer to penetrate into irregularities in root canal system. According to the norms of ISO 6786/2001, a root canal sealer should have a flow rate of not less than 20mm.[7] Endo sequence BC Sealer presented flow of 26.96.[12] Sealers iRoot SP,[12,13,24] BioRoot RCS,[10] Endoseal MTA,[14,16] and were also reported to fit the standards of ISO for both flowability and film thickness although BioRoot RCS failed to meet the standards for flow and film thickness according to one study.[25] Bio-C sealers and Totalfill BC met the standards of ISO for flowability while Bio C sealer had higher flow than the latter.[17]

4) Microleakage

Sealing ability of calcium silicate sealers varies among different studies based on the experimental techniques and equipments that are being used although conventional resin-based sealers provide equal or better sealing ability than CSBS in most of the studies. However, in some studies using dye penetration technique resin-based sealers showed greater penetration than CSBS.[26,27] According to one study, resin-based sealer showed better seal after 7 days while CSBS showed better seal than former after 4 weeks which led to the conclusion that CSBS showed better seal after complete setting.[28]

Biomineralization is an important characteristic related to leakage of CSBS.[9] Presence of a mineral infiltration zone where recrystallisation of hydroxyapatite crystals take place resulting in formation of calcite crystals [31] can reduce marginal gap and porosity in CSBS.[32,33] Some studies conversely states that apatite deposition does not reduce leakage due to its porous shape.[30] Use of EDTA and NaOCl as final irrigation can also improve the seal by improving the bond strength and creating alkaline environment for hydration respectively.[34,35]

5) Tooth Discoloration

According to the study by Barbosa et al, calcium silicate cements containing bismuth oxide showed maximum color alteration after revascularisation as compared to calcium tungstate and zirconium oxide.[36]

Biological Properties

1) Antibacterial effect

Antimicrobial effect of sealers is mainly based on their ability to release Ca and increase pH[7] This occurs during the hydration reaction of CSBS. Several studies have shown that CSBS have antimicrobial efficacy higher than conventional resin-based sealers.[37] Hydrophilicity is another important factor that determines antibacterial effect of sealer by reducing the contact angle of the sealer and increasing sealer penetration into the dentinal tubule. Endoseal MTA showed a stronger antibacterial effect against E. faecalis due to higher level of metal oxides[39] BioRot RCS showed long term antimicrobial activity.[38] iRoot SP eradicated bacteria faster than resin-based sealers however the antibacterial effect of most of the sealers were lost after 7 days.[40]

2) Bioactivity

The incorporation of Ca and Si by intertubular dentine may be regarded as an indicator of a material's bioactivity. CSBS can induce hard tissue formation in both the periodontal ligament and bone and can be assessed in terms of alkaline phosphatase activity, alizarin red staining, and mineralization-related gene expression.[41,42] iRoot SP demonstrated osteogenic potential through osteoblastic differentiation of PDLCs,[43] and human pulp cells had increased mineralization in the presence of BioRoot RC.[44] Calcium release from calcium silicate sealers is thought to promote osteoblastic differentiation and calcium nodule formation.[45]

3) Biocompatibility

CSBS have shown higher cell viability than conventional resin-based sealers,[29] although it cannot be concluded which calcium silicate sealer is the most biocompatible. According to a study, BioRoot RCS was considered more biocompatible than iRoot SP and Endoseal MTA. Despite the similar chemical characteristics of CSBS they showed different cytocompatibility,[46] which could be attributed to the presence of unknown fillers and thickening agents. Most of the studies have shown that

CSBS are biocompatible and non-cytotoxic although some studies have proven otherwise.[47] but this difference can be due to the varying experimental conditions and techniques.

CONCLUSION

Physical and biological properties of sealers play a major role in successful root canal filling. Although these physical properties of calcium silicate-based sealers meet ISO recommendations, they are either less favourable or comparable to conventional resin-based sealers. However, CSBS have consistently been reported to be biocompatible, non-cytotoxic, and non-genotoxic. They have good antimicrobial properties that are comparable to those of epoxy resin sealers and most importantly they are bioactive and stimulate hard tissue formation, which is the main advantage of this material.

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