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Properties of a Tricalcium Silicate Based Sealer

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Abstract

Tricalcium silicate based materials are gaining popularity in various dental fields and the area of endodontics is no exception. Sealers based on tricalcium silicate aim at an interaction with the root canal wall, alkalinity with potential antimicrobial activity and the ability to set in a wet field. Recently, a tricalcium silicate sealer containing povidone and polycarboxylate (BioRoot™ RCS) was introduced, which is shown to have high bioactivity, strong alkanising property, apatite forming ability and adequate radioopacity. This article aims to review about the physical and biological properties of this novel calcium silicate based sealer.

Keywords: Tricalcium Silicate, BioRoot, Sealer, Biomineralisation

Introduction

A successful root canal filling is achieved after the microbial control phase of treatment with the objective of entombing the residual bacteria within the root canal system, preventing the inflow of apical fluids and avoid reinfection from the oral cavity. A variety of core and sealer combinations have been used, including silver cones, gutta-percha, and resin-based materials. Traditional obturating methods fail to provide an effective seal. They exhibit shrinkage while setting, fail to adhere to the dentin, and are dimensionally unstable when they come in contact with moisture, leading to dissolution and leakage over time. In recent years, new materials have been developed that overcome some of these shortcomings. The development of bio-ceramic based root canal sealers is one such innovation. Bioceramics with a perfect combination of sealing ability and biocompatibility and possessing favourable characteristics closer to that of an ideal root canal sealer, have shown promising results.[1]

Notably, among them, BioRoot™ RCS (Septodont, Saint-Maur-des Fosses, France) is the latest mineral-based endodontic sealer marketed since February 2015.A powder/liquid hydraulic tricalcium silicate based cement

(Gilles & Oliver 2012)which benefits from both Active Biosilicate Technology and Biodentine. The Active BioSilicate Technology is free of monomers and in contrast to 'Portland cement'-based materials, it confirms the medical grade level of purity of the calcium silicate content with the absence of any aluminate and calcium sulfate.[2]

The BioRoot powder contains tricalcium silicate, povidone and additionally zirconium oxide as biocompatible radiopacifier and a hydrophilic biocompatible polymer for adhesion enhancing; the liquid is an aqueous solution of calcium chloride and polycarboxylate, calcium chloride being a setting modifier and a water reducing agent.[2]

Properties - Physical Properties

Solubility: BioRoot™ RCS has less solubility than AH Plus and MTA Fillapex instantly after immersion in water but its solubility was higher over time when analysed with resin-based sealers [5.] Immersion in phosphate buffered saline enhanced the BioRoot™ RCS solubility in the long term.The solubility improves the biological properties of the sealer. [3]

Setting time: The final setting time of BioRoot™ RCS was presented to be 324 (±1) minutes which was shorter than that for AH Plus.[3] However when used with warm vertical compaction obturation techniques the setting time of BioRoot™ RCSreduced considerably [2].The interaction with a moist environment prolonged the setting time significantly[4]. Similar to that, in another study, the final setting time of BioRoot RCS was shown to be 300 (±1) 5 min longer than the manufacturer's information (<240 min).[5]

Flow and film thickness: Lower flow and higher film thickness (than the limits specified by ISO 6976; 2012 recommendations[7]) are shown by BioRoot™ RCS.[5] The ISO recommendations are intended for inert sealers unlike the BioRoot™ RCS.

Radiopacity: The radiopacity of BioRoot™ RCS was shown to be greater than the lower limit specified by ISO6876;2012 [7] and similar to that of AH Plus and MTA Fillapex In one study, it showed a radioopacity of 5.18mm Al [5] while in the other it was shown to be about 9 mm Al which is similar to Endosequence BC sealer and higher than for MTA Fillapex [4].

Bioactive and Biological Properties

Calcium ion release BioRoot™ RCS was shown to release high levels of calcium in solution, which is much higher than other similar sealer types. Moreover, the amount of release of Ca ions is almost double than that leached by Endosequence BC sealer and ten times as than that by MTA Fillapex for the same time periods under the same conditions[4] In another study, Ca release started directly after sample immersion , reduced during the setting time but remained significantly high until 28 days, signifying long term activity.[5]

Alkalizing activity (pH) BioRoot RCS elevated the pH of the immersion water considerably more than the other materials for the first 14 days of immersion. Its pH was approximately 11–12 for the first 14 days, then after 28 days the pH reduced to 8.7, but alkalization was still present; in particular, the alkalizing activity was significantly higher than MTA Fillapex for the first 14 days of immersion.[5]

Biomineralization: Deposition of phosphates on the surface of tricalcium silicate based materials has been reported after the contact with dentine and tissue fluids [(8-10).] The interaction of dentine and Biodentine™ has been well documented. A chemical bond is achieved through a mineral infiltration zone at the material to tooth interface [11] Similarly, BioRoot interacts with dentin along the root canal wall and forms a hybrid layer which is rich in

mineral. The bonding of BioRoot™ RCS is postulated to be chemical in nature. This property is important for sealers as bonding of the sealer to the root canal dentine helps with sealer stability and leads to less microleakage. [12] The mineral infiltration zone and the sealer tags ensure sealer adaption and bonding to the root canal dentine. The tags and mineral rich zone were more evident in the coronal portion than in mid- root and apically. This could be attributed to reduced effectiveness of smear layer removal techniques in middle and the apical 3rd and by inadequate action of the ethylene diamine tetracetic acid (EDTA) [13] A phosphate buffered saline root canal dressing has been suggested to improve the bonding of the sealer to root canal wall.[13]. This would lead to availability of phosphate ions thus enhancing the bonding at the interface. The deposition of calcium phosphate has also been implicated in the increased push-out bond strength of tricalcium silicate-based root canal sealers [1]

Antimicrobial properties When compared to MTA Fillapex and AH Plus, BioRoot™ RCS showed the greatest antimicrobial activity. It leaches high levels of calcium in solution thus maintains a high pH. It exhibits optimal antimicrobial properties as indicated by the elimination of microorganisms in the dental tubules. Its activity is enhanced when using ethylene diamine tetracetic acid (EDTA) irrigating solution, however it is effective when water is used as final irrigating solution. [19]

Biocompatibility BioRoot™ RCS shows fine biocompatibility since direct contact induced proliferation and attachment of periodontal cells [15] Elution from BioRoot™ RCS and even direct seeding of cells over the materials showed high cell proliferation. Migration of periodontal ligament stem cells was observed to be higher with it and the cells maintained their mesenchymal phenotype [16] This is supported by another study testing the elutions from tricalcium silicate-based sealers with AH Plus. As far as BioRoot was concerned , no DNA double-strand breaks were observed in a one day evaluation when analysed with other resin- and silicate-based root canal sealers[17]. BioRoot™ RCS did not compromise the mineralization potential of pulpal A4 stem cells. Also,the cytotoxicity was lower than Pulp Canal Sealer[18] and showed less toxic effects on periodontal ligament cells and induced a higher secretion of angiogenic and osteogenic growth factors [15]

Biological seal BioRoot™ RCS interacts with the dentine along the root canal wall and forms a hybrid layer along the dentine which is rich in mineral.The bonding of is postulated to be chemical in nature as opposed to the sealer tags reported for resin-based sealers [12]

Obturation with It

BioRoot™ RCS should be used with cold obturation techniques. Application of heat during warm vertical compaction will lead to the evaporation of water from the sealer thus modifying the flow and film thickness of the material [2]. More recently single cone obturation techniques are being suggested for hydraulic sealers. If the solid cone is matched to the size of the preparation, the single cone obturation technique provides similar obturation quality to the warm vertical compaction [20]. This sealer is recommended for use with single cone techniques or lateral condensed gutta-percha [2] The choice of sealer should be considered when selecting the obturation technique. The retreatability of BioRoot™ RCS sealer used in conjunction with gutta-percha in single cone obturation technique was better compared to AH Plus as less sealer remnants and shorter retreatment times were observed [21]

BioRoot™ RCS was affected by the irrigation protocol used as mentioned above. Irrigation with EDTA showed the highest antimicrobial properties compared to other irrigants[19]

Advantages

BioRoot RCS is a bioactive material, shows nucleation of carbonated apatite deposits in connection to its continued ability to release calcium ions and to basify the environment The material solubility enhances the reaction of the material with environmental ionic exchange thus favouring a biological response. The BioRoot™ RCS is highly antimicrobial and the use of EDTA enhances its antimicrobial activity. Apart from that, excellent sealing ability with gutta percha as well as dentin, easy obturation and handling and great flowabilty distinguishes it from other materials. The data support the potential of bioactive tricalcium silicate sealers to promote periapical healing, bone regeneration and sealing by mineralization and apatite deposition at the root canal wall interface.

Conclusion

The evolution of sealers from the conventional to the most recent Bioroot RCS have the predilection to change the perception the way sealers have been used in the near future. This sealer was not developed to conform to the classical recommendations of hermetic seal as it aims to create an environment within the root canal that enhances biological activity and maintains antimicrobial activity. With this new approach of root canal filling, these biomaterials have opened a new dimension on how a sealer can also have the propensity toward mineralization through the formation of hydroxyapatite crystals. However, more clinical investigations will be necessary in the future to confirm this new vision of a simpler root canal obturation.

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