Chapter

Bioceramic Cements in Endodontics

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Abstract

New bioceramic calcium silicate endodontic cements have been recently introduced in the market. They are biocompatible materials that stimulate mineralization. Its dimensional stability is similar to the Fillapex MTA with greater thickness and solubility than AH Plus (Dentsply, DeTrey, Konstanz, Germany) as it is water based. Stored in dispensed syringe, it has a pre-mixed consistency. They are used with the single cone obturation technique because they have properties that are changed when heated. They were developed by inducing bioactivity on the surface of the material when in contact with tissue fluids. An improvement in the osteoblastic differentiation of the cells of the periodontal ligament, induction of remineralization of the dentin, and excellent antimicrobial properties have also been associated with these cements. These properties make these cements an excellent alternative in the attempt to obtain a three-dimensional obturation of the Root Canal System (SCR).

Keywords: endodontics sealers, bioceramics, biocompatibility, bioactivity, MTA, calcium silicate, root canal obturation

1. Introduction

Recently introduced in the form of sealant cements, bioceramic endodontic cements are biocompatible compounds obtained by various chemical processes. They exhibit excellent biocompatibility properties due to their similarity to the biological process of hydroxyapatite formation and to the ability to induce a regenerative response from the periapical tissues [1]. In endodontics, bioceramic materials are mainly found as repair cement [2] and endodontic cement [3], for these materials showed interaction with and response to the stimulation of living tissues, they reached relevance to be studied.

According to Cheng et al. [4], bioceramics exhibit remarkable biocompatibility properties due to their similarity to the biological process of hydroxyapatite formation and the ability to stimulate a regenerative response. They present osteoinductive capacity as they absorb osteoinductive substances when in contact with bone healing process.

First-generation bioceramic cements known as MTA became popular in endodontics and were initially indicated as a retrobuturing material. Later, new indications for its use were developed such as direct pulp capping of permanent teeth, pulpotomy of deciduous teeth, specification, and repair of surgically and non-surgically root perforations. In addition to these indications, MTA can be applied in other clinical situations such as the coronal plug after endodontic obturation; in the repair of vertical root fractures; prior to the internal bleaching of the dental element, as temporary restorative material; repair of root perforations. Its properties have been modified in order to obtain the excellent properties already well established of the MTA such as biocompatibility, high pH, no reabsorption, increase of root resistance, low cytotoxicity, non-contracting, and chemical stability in an endodontic sealant cement of root canal that is easy to work inside the root canals [5].

Bioceramics are currently represented through restorative materials in the field of oral health, more precisely in endodontics. These bioceramic nanoparticulate cements have three presentations: the EndoSequence Root Putty Putty (ERRM Putty), in dense form; EndoSequence Root Repair Material Paste (ERRM Paste), which comes arranged in a syringe by having fluid constitution; and more recently, EndoSequence Root Repair Material [6–9].

For the closure of dentinal tubules, the use of bioceramic cements has been widely indicated. This material homogeneously seals the voids between the obturator material and the dentin walls. Its bioactivity favors bone repair and neoformation by interacting with periapical tissues.

2. Clinical properties

Among the clinical properties of endodontic cements are the endodontic repair capacity, and for this reason, it must be biocompatible, radiopaque, antibacterial, dimensionally stable, easy to handle, and should not be affected by blood contamination [11]. Some of the favorable properties of bioceramics in endodontics are their physical chemical properties, such as the release of Ca^{2+}, pH, and radiopacity [12]. The bioceramic sealing ability is excellent, as it promotes satisfactory sealing [13, 14], as well as the capacity to increase the resistance of the sealed teeth [15]. It shows a greater adhesion to the root canals, which can be seen when the endodontic retreatments are present in the longer residues [16], requiring longer clinical work time [17].

According to manufacturers' specifications, bioceramics have antibacterial activity, alkaline pH, radiopacity, and excellent biocompatibility. Its physical, chemical, and biological properties are the main characteristics for its application in dentistry. It is a biocompatible material, non-toxic, and chemically stable in biological environment. This material also has the advantage of bioactivity, that is, it is capable of forming hydroxyapatite during the hardening or prepping process, exerting influence on the bond between the dentin and the obturator material. Besides, it hardens when exposed to a humid environment, making the local dentinal tubules ideal, since the water from inside the tubules causes the cement to hydrate, promoting the reduction of the solidification time that results in the formation of hydroxyapatite [1].

According to Trope et al. [8], the various forms of bioceramics are similar in composition (calcium silicates, zirconium oxide, tantalum oxide, and monobasic calcium phosphate), having excellent mechanical, biological, and manipulative properties. In addition to being hydrophilic, they are also insoluble, radiopaque, and aluminum free. The working time is over 30 min and the holding time is around 4 h under normal conditions, depending on the amount of moisture available. EndoSequence BC RRM Fast Set Putty cement has been recently launched presenting all the properties of the original product, but with a formula that promotes a faster setting time (approximately 20 min).

3. Biocompatibility

During endodontic obturation, the cements come into contact with the periradicular tissues, which lead to the risk of a possible systemic toxicity [12], hence the great importance of biocompatibility. The materials EndoSequence Root Repair Material (ERRM) [11, 12], BioAggregate and iRoot [18], ProRoot MTA and MTA-Angelus [12], and EndoSequence BC sealer [19, 20] showed acceptable biocompatibility, not having induced critical cytotoxic effects [21].

Giacomino et al. [10] conducted a study to compare the biocompatibility and osteogenic potential of EndoSequence BC Sealer (Brasseler, Savannah, GA) and ProRoot ES (Johnson City Dental Specialties, Johnson City, TN) compared to Roth (Roth International, Chicago, IL) and AH Plus (Dentsply DeTrey). A precursor murine osteoblast lineage (IDG-SW3) was exposed to various concentrations of each of the cements for 7 days. Biocompatibility was determined by luminescence assay based on the quantification of adenosine triphosphate (Cell-Titer-Glo [Promega, Madison, Wisconsin]). The osteogenic potential was determined by fluorescence microscopy of the expression of DMP-1. Data were analyzed with bidirectional analysis of variance or univariate analysis of variance with the post hoc Bonferroni test. Both bioceramic cements have excellent biocompatibility even at high concentrations. On the other hand, cell death was detected when Roth and AH Plus were used in concentrations 100× lower than the bioceramic groups. It is important to note that both bioceramic cements significantly increased osteoblastic differentiation, although greater responses were observed with the EndoSequence BC Sealer. Concerning these results, DMP-1 expression, robust increase of osteogenic gene expression, and superior mineral deposition were shown. Osteoblastic differentiation and function were significantly impaired when Roth cement or AH Plus was used. Therefore, they concluded that the EndoSequence BC Sealer and ProRoot ES were significantly more biocompatible and promoted osteoblastic differentiation, a bioactivity not found in AH Plus and Roth cements.

4. Bioactivity

Bioactive materials can be used to repair diseases or damage to bone tissue and can remain in place indefinitely. An indication of bioactivity is the ability to develop a stable binding with living tissues in contact with simulated body fluid solution [22] via deposition of hydroxyapatite on the surface of a substrate [23].

The bioactivity of endodontic bioceramic materials was confirmed in the Bioaggregate [21], EndoSequence Root Repair Material [21], Pro RootMTA [21], and iRoot SP [24].

After the SCR closure, direct contact between the obturator material and the periapical tissues occurs, such as the periodontal ligament (PDL) and the bone, making a three-dimensional hermetic sealing to prevent recurrent infections of the periapical space, both of endodontic or coronal origin. This seal may be mechanical with materials that provide an airtight seal, but may also be of biological origin. In this case, the filling material induces the formation of hard tissue through the cells of the periodontal ligament, isolating the root canal from the surrounding tissues and stimulating the healing processes of damaged apical tissues [25].

According to Camps et al. [26], tricalcium silicate-based materials have a recognized bioactivity property, that is, the ability to induce hard tissue formation in both the dental pulp in the periapical region. In this regard, interactions of newly developed tricalcium silicate (BioRoot, Septodont, Saint Maur Des Fosses, France) with apical tissue were compared with a standard zinc oxide-eugenol cement (Pulp Channel Sealer [PCS]; SybronEndo Orange, CA). Cell viability was investigated by direct contact between human periodontal ligament (PDL) cells and BioRoot or PCS. For this, the extracted human incisors were sectioned at the enamel-cement junction; root canals were prepared, sterilized, and filled with lateral condensation with both materials. The root apexes were submerged in the culture medium for 24 h. These conditioned media were used to investigate their effects on human PDL cells. BioRoot had less toxic effects on PDL cells than PCS and induced a higher secretion of angiogenic and osteogenic growth factors than PCS. Given the results of the present study, it is suggested that calcium silicate cement (BioRoot) has a higher bioactivity than zinc oxide eugenol cement (PCS) in human PDL cells.

According to Niu et al. [27], a particularity of tricalcium silicate-based materials is their potential to express bioactivity, which is considered an important property for bone binding capacity. In this sense, Moinzadeh et al. [28] conducted a study to evaluate the interaction of EndoSequence BC RRM (Brasseler USA, Savannah, GA) in contact with simulated blood and tissue fluids, as these materials come into direct contact with the periapical region. These materials are hydrophilic; therefore, its properties improve in the presence of moisture, either from the periodontal ligament or dentinal tubules. However, specific environmental conditions may modify the material configuration. The reaction of tricalcium silicate with tissue fluids led to the formation of calcium hydroxide, and this was evident in the mass in contact with water and Hank's balanced salt solution. In this case, there was also the formation of globular crystals synonymous with hydroxyapatite formation. The material in contact with blood had a non-crystalline surface with additional peaks of calcium, phosphorus, and chlorine. However, in vitro material evaluation may not be representative of the clinical situation, because carbon dioxide present in the bloodstream leads to the formation of calcium carbonate rather than hydroxyapatite reported in in vitro studies.

5. Cytotoxicity

All endodontic treatment will be impaired if the sealing cement is irritating to the tissues of the periapical region, causing larger inflammation or promoting large tissue necrosis, which may lead to reduction in apical repair capacity. Hence, the great importance of knowing the biocompatibility and cytotoxicity of obturator cements [21]. The cytotoxicity of endodontic cements can cause cell degeneration and delay healing due to the direct contact of the cements with the periapical tissues [29]. Cements with satisfactory biocompatibility must have low or no toxicity to the periapical tissues.

When compared to their cytotoxicity, some bioceramic cements exhibit minimal levels of cytotoxicity (EndoSequence Root Repair Material) and Mineral Trioxide Aggregate (MTA) [11]. In a study by Fayyad [30] that compared cytotoxicity, some bioceramic cements exhibited minimal levels of cytotoxicity (EndoSequence Root Repair Material) and Mineral Trioxide Aggregate (MTA) of two materials, BioAggregate and iRoot (Innovative Bioceramix, IBC, Vancouver, Canada) on human fibroblast MRC-5 cells found that both showed acceptable biocompatibility and that the cytotoxic effect of the materials was concentration dependent.

According to Candeiro et al. [12], comparing the characteristics of biodegradable EndoSequence sealer with AH Plus, bioceramic cement presented lower cytotoxicity and was unlikely to damage the genetic information inside a cell compared to AH Plus.

The results involving the biological response of MTA Fillapex (Angelus, Londrina, Brazil) seem to be conflicting. This cement showed high cytotoxicity and genotoxicity, shortly after the manipulation. Another study reported that when implanted into subcutaneous tissue in rats for a period of 90 days, it remained toxic [31]. However, another study has shown that despite these initial toxic effects in the early stage the cytotoxicity of Fillapex MTA decreases over time, exhibiting activity adequate to the stimulation of the formation of hydroxyapatite crystals in cultured human osteoblast cells [29].

According to Damas et al. [2], bioceramic cements have several applications and some studies have shown that cytotoxicity levels are identical.

6. Antimicrobian activity

Much research has been conducted proving the relationship between microorganisms and periodontitis, as well as the presence of endodontic biofilm in the process of periapical diseases. Thus, during root canal treatment, the main objective is sanitation through chemical-mechanical preparation [32], which may be associated with intra-canal medication, ending with the three-dimensional obturation. As is known, the total eradication of bacteria in all root spaces is not always achieved due to the limitation of the mechanical action of the instruments. Ideally, the obturator materials should have an antimicrobial component to assist in the process of eliminating residual microorganisms within the dentinal tubules [33].

Bukhari and Karabucak [34] carried out a study to test the antibacterial activity of bioceramic cement compared to AH Plus (Dentsply International Inc., York, PA) in a biofilm composed of 8-week-old *Enterococcus faecalis* adhered to surfaces using a model of dentin infection. The surfaces of the unirradicular intact extracted canals were infected by *E. faecalis* biofilm. Cement AH Plus and EndoSequence BC Sealer (Brasseler USA, Savannah, GA) were placed on the wall of the root canal of the specimens during a period of 24 h and another of 2 weeks in humid conditions at 37°C. Infected samples incubated without shutter cement for similar periods were used as negative controls. In order to test the sealing cements, the specimens were labeled with fluorescence viability staining and confocal laser scanning microscopy to evaluate the proportions of dead and living bacteria in the canal walls during the determined periods. The EndoSequence BC Sealer significantly killed more *E. faecalis* in biofilm bound to channel surfaces when compared to AH Plus and control at both time points (P, 0.05–0.0005). In this sense, they concluded that the EndoSequence BC Sealer exhibited significant antimicrobial ability in the presence of dentin for up to 2 weeks in an 8 week old *E. faecalis* biofilm, compared to the AH Plus cement.

7. Color change

The aim of endodontic interventions is to prevent and treat apical periodontitis. However, the esthetic result is equally important, especially in the anterior region. Pulpal therapy procedures, such as direct pulp capping, repair of perforations, and regenerative endodontics involve the placement of materials in the coronal third of the tooth, which may have potential for discoloration [35]. In this sense, Kohli et al. [36] carried out a study with the objective of evaluating the in vitro tooth discoloration induced by bioceramic materials, EndoSequence RRM and BD in comparison with other materials used during endodontic treatment, such as gray MTA (GMDTA, Dentsply, York, PA, USA). The aim of this study was to evaluate in vitro the biomarker-induced coronal tooth discoloration, EndoSequence RRM and BD, in comparison with other materials used during endodontic treatment, such as gray MTA (GMTA); MTA white (WMTA, Dentsply), triple antibiotic paste

(TAP), and AH Plus sealant (AH+, Dentsply). Visual discoloration was observed in all specimens in the GMTA, WMTA, and TAP groups over 7 days, which increased over time. Significant coronary tooth discoloration was caused by TAP, GMTA, and WMTA, but not by BD, RRM or RRMF at the end of the experiment.

Discoloration of the crown such as the one present in the MTA is one of the disadvantages of restorative cement used in dentistry. This has to be taken into account when repairing furcation injuries or in cases where pulp protection is required. According to the literature, the bismuth oxide present in the MTA composition reacts with the residual sodium hypochlorite that remains inside the dentinal tubules after mechanical chemical preparation, resulting in dark precipitations and staining of the tooth. In the composition of the EndoSequence, the zirconia oxide is the opacifier used, preventing the unwanted darkening [37].

According to Kholi et al. [36], the bio-based materials Biodentine (Septodont, Saint-Maur-des-Fosses, France), ERRM, EndoSequence, ERRM putty (Brasseler, Savannah, GA), RMF, EndoSequence ERRM fast set paste (Brasseler), and AH+, AH Plus sealer (Dentsply), when left in the pulp chamber for periods of up to 6 months do not induce color change in the tooth structure. Alsubait et al. [37] compared the potential for discoloration of the Endosequence Bioceramic Root Repair Material Fast Putty Set (ERRM) and ProRootMTA (PMTA) by placing them on the crown of extracted human teeth for a period of 4 months and found progressive discoloration in teeth when treated with PMTA, whereas those with ERRM had no change in color stability.

8. Mechanism of action

The bioceramic cement is hydrophilic; therefore, it uses water present in the dentin tubules to initiate the firming reaction. The hydration of the material decreases the working time, consequently the amount of water mixed can reduce the time required; but the bioceramics only harden when present in a humid environment. After hydration, the calcium silicate gel and the calcium hydroxide are produced by the calcium silicate present in the mixture. Calcium hydroxide reacts with phosphate ions and produces hydroxyapatite and water. The continuous interaction of calcium silicate and water leads to the formation of hydrated calcium silicate [38]. The amount of water in the reaction is a critical factor in controlling the rate of hydration. The pH is similar when compared to the reaction time of calcium hydroxide. As this is highly alkaline, it reaches a value of 12.8 during the placement time, decreasing progressively over a period of 1 week [2]. The pH is affected by the release of calcium ions and by alkalinizing the medium, a condition that can influence the repair, besides promoting the mineralization process and its concentration. The release of hydroxyl ions can alter the dissociation [12].

Candeiro et al. [12] carried out a study with the purpose of evaluating the physicochemical properties of a bioceramic. Radiopacity, pH, calcium ion release, and flowability were studied and compared with AH Plus® cement (resin-based cement). The radiopacity and flow were evaluated by using ISO 6876/2001 standards. For the analysis of the radiopacity, metal discs with 10 mm diameter and 1 mm thickness were used and were covered with sealer cement. The flowability test was performed with 0.005 ml of cement on a glass plate. The release of calcium ions and pH were evaluated in periods of 3, 24, 72, 180, and 240 h with a spectrometer and pH meter, respectively. Radiopacity was then found to be significantly lower than AH Plus®, pH analysis, and calcium ion release were significantly higher than AH Plus®, and it was demonstrated that there were no significant differences in flowability. Thus, the bioceramics present values of radiopacity and fluidity within the limits of ISO standards and the other physicochemical properties analyzed show very favorable values for a sealant cement.

9. Marginal adaptation/sealing capacity

According to Shokouhinejad et al. [39], the marginal adaptation of the EndoSequence Root Repair Material (ERRM) was similar to that of the MTA. However, bioceramic-based cements when compared with resin-based cements (AH PLUS) exhibited more regions containing gaps. Bioceramic endodontic cements also showed infiltration results similar to MTA. In relation to sealing and its ability, the Bioceramic Root-end Repair (BCRR) is equivalent to the MTA [13]. Antunes et al. [14] reported that MTA and BioCeramic Root Repair Material (BC-RRM) showed similar sealing ability.

To what concerns bioceramics and the hydration of the material during the setting process, the formation of hydroxyapatite crystals occurs between the surface of the material and the dentin wall, which can provide adequate sealing and marginal adaptation in this region [19, 40, 41].

Antunes et al. [14] evaluated the sealing capacity of MTA cement and EndoSequence BC RRM-Fast Set Putty in an ex vivo study, in roots of 60 instrumented lower central incisors, which were sectioned in the apical region and ultrasonic tip retroinstruments, and using a new model of bacterial nutrient infiltration. Retrograde obturation was performed with the MTA and BC-RRM Putty in two sets of teeth. In the MTA group, 50% of viable species were detected while in the Putty BC-RRM group, 28% of the samples were positive for cultured bacteria. However, in the comparison analysis of the quantitative or presence/absence of bacteria, no significant difference was identified between the groups, leading the authors to conclude that the cements studied have similar sealing capacity.

10. Resistance of union

The ability of a root canal sealer to adhere intra-radicular dentin through micromechanical retention or resistance to friction is advantageous in maintaining the integrity of the sealant interface and dentin during mechanical stresses caused by flexion of the teeth, surgical procedures or preparation of the space for intra radicular retainers [42]. It has been shown that the release of calcium and hydroxyl ions from calcium silicate-containing material results in the formation of a layer of hydroxyapatite when it comes in contact with the fluids of the dentinal tubules. The formation of this interfacial layer develops a chemical bond between calcium and dentin walls [43]. Therefore, it is expected that the bioceramic cements, which are based on a calcium silicate composition, have the potential to chemically adhere to the dentin.

Shokouhinejad et al. [44] conducted an investigation to compare the bond strength of bioceramic (EndoSequence BC Sealer) and resin cement AH Plus in the presence and absence of smear layer. Uniradicular ex vivo specimens were used in this experiment using 5.25% sodium hypochlorite and 17% EDTA protocols for smear layer removal and in the other specimens no debris removal protocol, only 5.25% sodium hypochlorite irrigation. The modes of adhesion strength and failure were evaluated. No statistically significant differences were found between the groups filled with gutta percha and AH Plus sealant and gutta percha and bioceramic sealant. The presence or absence of smear layer does not appear to significantly affect the bond strength of filler materials.

Shokouhinejad et al. [45] evaluated the bond strength of EndoSequence BC endodontic cement (Brasseler USA, Savannah, GA) when used with gutta-percha in the presence or absence of moisture within root canals. The mean bond strength of EndoSequence BC sealant and filler in the wet channels was significantly higher than that of the dry 1 week. In contrast, there was no significant difference between dry and wet root canals at 2 months. In the dry channels, the adhesion strength increased significantly over time, while in the wet, the difference was not significant. The presence of moisture inside the root canals increased the bond strength of EndoSequence BC cement in 1 week. However, no difference was found between the bond strength of EndoSequence BC cement in the presence or absence of moisture in the root canals at 2 months.

11. Endodontic reintervention

According to Oltra et al. [16], recently new bioceramic sealant cements have been marketed and are being used in endodontic practice. However, these bioceramic cements have limited research related to their removal ability during endodontic re-interventions.

Uzunoglu et al. [46] evaluated the removal capacity of three different endodontic cements iRoot SP (bioceramic cement), MTA Fillapex (sealant based on MTA), and AH-26 (epoxy resin) from the root canal system. Channel filler was removed with ProTaper Universal Retreatment PTR. The time to reach the working length has been recorded. The roots were sectioned longitudinally and each half was evaluated using a stereomicroscope. Three observers scored every third of all specimens. In the GP/MTA Fillapex single cone group, the time required to reach working length was significantly shorter. The remaining filler material in the apical and middle thirds of the groups was similar. None of the tested cements can be completely removed from the root canal system.

Oltra et al. [16] analyzed the ability to remove two BC sealer endodontic sealants compared to AH Plus using microcomputer tomographic analysis. Computed tomography was performed before and after obturation and retreatment and then analyzed for residual material volume. The specimens were sectioned longitudinally and the digitized images obtained with the microscope. In the present experiment, significant differences were found, since less root canal filling material was associated with the AH Plus group when using chloroform as a solvent when compared with the others. BC Sealer samples represented using chloroform as the solvent had better results than those removed without chloroform. The results of the present experiment demonstrate that the BC Sealer group presented significantly more residual obturator material than the AH Plus group, regardless of whether the two cements were associated with the use of solvent for their removal.

Zuolo et al. [17] evaluated the effectiveness of the TRUShape system (Dentsply Tulsa Dental Specialties, Tulsa, OK) compared to Reciproc (VDW, Munich, Germany) in unblocking channels filled with two different sealants and the working time required to achieve working length. A tomographic microcomputer was used to evaluate the removal of obturation material. The average volume of remaining obturator material was similar when comparing the two file systems. However, in the groups filled with bioceramic, the percentage of remaining obturator material was higher than in the groups filled with Pulp Canal Sealer. The clearance was faster in the groups that were filled with Pulp Canal Sealer when compared with bioceramics. There was no difference in the percentage of remaining shutter material when comparing file systems. However, Reciproc was faster than TRUShape.

12. Fracture resistance

It is commonly believed that endodontically treated teeth are more fragile and more prone to fracture than vital teeth [47]. There are several factors that affect the strength of endodontically treated teeth: excessive tooth loss due to caries or trauma, dentin dehydration, access cavity preparation, instrumentation, excessive pressure during root filling, and preparation of intraradicular pins [48]. Reinforcement of the remaining tooth structure after endodontic procedures is one of the main objectives of rehabilitation. It has been suggested that the bioceramic cements may adhere to the dentinal surface of the root canal, strengthening the remaining dental structure, contributing to the long-term success of an endodontically treated tooth [49].

Topçuoğlu et al. [15] analyzed the strength of the values necessary to induce root fracture of teeth filled with three different endodontic sealants. Each specimen was then subjected to fracture testing using a universal testing machine at a speed of 1.0 mm/min (−1) until the root was fractured. The force required to fracture each specimen was recorded, and the data were statistically analyzed. The fracture values of the groups filled with bioceramic and gutta percha, and sealant based on epoxy resin and gutta percha, were significantly higher than those of group MTA and gutta percha. No significant differences were found between the bioceramic and epoxy resin groups, the Endosequence BC and AH Plus cements increased the strength of the values required to induce a root fracture of uniradicular premolars.

13. Conclusion

Based on the literature, it can be concluded that the bioceramic cements have satisfactory working properties, are easy to handle, and have excellent antimicrobial action and alkaline pH. They demonstrate ability to release calcium ions promoting adaptation and marginal sealing, shorter setting time, biocompatibility, acceptable cytotoxicity, and induce the osteoblastic differentiation of the cells of the periodontal ligament and remineralization of the dentin. They can also be used in humid environment and are easily removed in cases of reintervention, have good dentin adhesion, increasing root resistance to fracture, and do not cause coronary discoloration. All of these properties show that bioceramic cements are favorable to their use.

However, new research and studies are necessary so that further answers and alternatives about the product may be found in order to favor their use in dentistry.

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