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EVALUATION OF THE USE OF BIOCERAMICS IN ENDODONTIC MANAGEMENT, LITERATURE REVIEW

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ABSTRACT

Bioceramic materials are at the forefront of modern dentistry: they are easy to use and promote the healing of pulpal and periapical tissue. Their use in endodontics is categorized by setting mechanism, consistency, and composition. Pastes and Sealers are developed and available for use in combination with gutta-percha, and putties are designed for use as the sole material, in comparison with mineral trioxide aggregate (MTA). Dentists can choose among many premixed bioceramic materials, according to their needs. The vast majority show properties similar to MTA and which conform to those expected of a bioceramic material. The Pubmed, Embase, NCBI, and Cochrane databases were searched for studies of bioceramics in endodontic management. Both clinical and laboratory studies as well as *in vitro* studies were considered. Studies conducted in recent years and the past highlight the several potentials of bioceramics, although most of these studies confirmed staining when Portland Cement (PC) is used.

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Introduction

Bioceramics refers to biocompatible ceramic compounds that are used in direct contact with living tissue, obtained by various chemical processes. Bioceramic materials are currently available in putty forms, paste, and sealer, and can be either premixed or require manual mixing. They have a variety of clinical applications, tend to not be well understood, and are fairly new to endodontics by clinicians.

Due to their similarity with biological hydroxyapatite, bioceramics exhibit excellent biocompatibility properties. They produce different compounds during the hydration process, such as hydroxyapatites, and can cause liver tissue to regenerate. They are biocompatible and have antibacterial properties [1] due to precipitation *in situ* after the material has set (as this phenomenon leads to bacteria sequestration). Indeed, bioceramics contain nanocrystals with diameters ranging between 1 and 3 nm which prevent bacterial adhesion [2].

Traditional obturating methods do not provide the best seal: they shrink after having been set, have little or no adhesion to dentin, and are not dimensionally stable when in contact with moisture, which will likely lead to leakage over time and/or dissolution. On the other hand, mineral trioxide aggregate (or MTA) does not have a sensitivity to blood contamination or moisture [3]. It slightly expands as it sets, is dimensionally stable, and is insoluble [2]. Due to its high pH, while it sets, it has antibacterial properties and is biocompatible [4]. It is a favorite for pulpotomies, perforation reparation, pulp caps, root-end fillings, and obturation of baby teeth with open apices [5]. The quality of the root canal filling in these situations may be affected by the presence of moisture.

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There are advantages to using bioceramics: they have excellent biocompatibility due to their similarity with biological hydroxyapatite, as well as a natural osteoinductive capacity because they absorb osteoinductive substances when in the vicinity of a bone healing process. They also function as a regenerative scaffold, where the resorbable lattices provide a temporary framework that is eventually dissolved as tissue is regenerated. Bioceramics are a reliable hermetic seal that chemically bonds with the tooth structure and has good radiopacity [6, 7]. When apatite crystals are constituted with fluoride ions, the resulting material also has antibacterial properties [8].

The purpose of this review is to review different methods of bioceramics used in endodontic management.

Materials and Methods

For the selection of articles, PubMed database was used and the following keys were used in the mesh ((“Bioceramics "[Mesh]) AND (“and endodontic management” [Mesh]) OR (“Bioceramics and endodontic management Mesh])).

Concerning the inclusion criteria, the articles were selected based on the inclusion of one of the following topics: Bioceramics and endodontic management recent diagnosis and treatment.

Exclusion criteria were all other articles, which did not have one of these topics as their primary endpoint.

Around 90 publications were chosen as the most clinically relevant out of 1,202 articles indexed in the previous two decades, and their full texts were evaluated. A total of 31 of the 90 were included after a thorough examination. Additional research and publications were found using reference lists from the recognized and linked studies. Expert consensus recommendations and commentary were added where relevant to help practicing physicians assess cirrhosis most simply and practically possible.

Results and Discussion

The long-term success of endodontic treatment depends on the complete removal of bacteria and filling the root canal system perfectly. However, most of them are unable to provide complete protection despite antimicrobial properties being an important element in an endodontic sealer. Indeed, MTA Angelus, MTA Dentsply, and Portland cement have been proven to stop the growth of P. aeruginosa, while calcium hydroxide is useful against B. fragillis and P. aeruginosa. However, there has been no proof for the effectiveness of these materials on E. faecalis, and E. coli under anaerobic conditions [9].

Root canal filling (obturation) is an operation that is performed after the microbial control phase to entomb what is left of the bacteria inside the root canal system, hopefully guaranteeing against reinfection from the oral cavity by preventing the influx of fluids [4]. A combination of sealer and core combinations should be used, which include gutta-percha, resin-based, and silver cones materials in conjunction with root canal sealers, bioceramic (BC) materials, and mineral trioxide aggregate (MTA) products. MTA cement is composed of tricalcium silicate, tricalcium aluminate, and dicalcium silicate, with an additional radiopaque compound known as bismuth oxide. The material comes in white or gray, the gray color is caused by the iron ions, which were then eliminated to get the white version [10]. MTA sets by hydration, obtaining hydrated calcium silicate and calcium hydroxide. It's biological integration is because of the calcium ions, which when in contact with phosphate ions (naturally present in the body), form hydroxyapatite [1]. It appears that the release of calcium hydroxide is the reason behind the antibacterial role of MTA cement, which explains the similar reactions caused by calcium hydroxide pastes. MTA cement also has a strong alkaline pH with antibacterial properties [1, 10]. Techniques for the use of MTA sealer include capillary condensation, wherein the vapor is absorbed into the porous medium to the point where pore spaces are filled with condensed liquid [11].

Portland Cement (PC) was patented in 1824; it was obtained from a mixture of Portland (UK) limestones and silicon-argillaceous materials [12]. According to Vivaan *et al*., MTA is more soluble than white PC [13], and it also shows better washout resistance than MTA [14]. However, MTA is more structured than PC after hydration and displays better bioactivity [15]. Both grey and white PC release calcium ions and display the formation of hydroxyapatite crystals [16]. Similar to MTA, PC has antifungal and antibacterial properties against Staphylococcus aureus, Micrococcus luteus, Candida albicans, Enterococcusfaecalis, Staphylococcus epidermidis, and Psuedomonasaeruginosa [17].

Calcium hydroxide cement is also used for direct pulp capping. Indeed, the complete removal of infected dentin in deep cavities could cause direct exposure of healthy pulp through openings of the pulp chamber. In certain conditions, the opening can be sealed using calcium hydroxide cement. Pulp vitality is the benchmark for the success of this treatment.

The use of bioceramic material during treatment results in bone healing and the elimination of clinical symptoms. Indeed, bioceramic materials can be successfully used in conjunction with gutta-percha or by themselves. However, the presence of moisture is likely to affect the root canal filling’s quality as well as the clinical result. Also, when extrusion/leakage into the periapical tissues is likely, bioceramic materials are a good choice that may cause damage to vital structures like the inferior alveolar nerve or the maxillary sinus.

Bioceramic materials have multiple advantages over MTA in dentistry. Indeed, remixed bioceramic materials have better clinical handling properties, as MTA has been reported by clinicians to be difficult to handle [5]. MTA also has potential for staining dentin, as shown in multiple studies [18, 19], clinical investigations [20, 21], and case reports [22, 23]. These have concluded that discoloration is caused by both white and gray MTA. As for bioceramic products, there are no reports as of yet that they cause staining to the dentin. On the other hand, studies have reported that bismuth oxide (the radiopacifier in MTA)

[23, 24] may increase the MTA cytotoxicity because it does not encourage cell proliferation [25]. Bioceramics, rather, use tantalum pentoxide and zirconium oxide as opacifiers [24].
Heavy metals presence is also another potential issue with MTA. Indeed, it was reported that microleakage was equivalent in canals obturated with iRoot SP and in canals filled with AH Plus sealer [26]. Similar microleakages were reported with the use of sealers that contain epoxy resin, methacrylate resin, and calcium hydroxide, as well as AH Plus and iRoot SP [27].

Conclusion

While MTA was the figurehead for bioceramic materials since then material advances have regularly been made to overcome its disadvantages and improve it overall. Bioceramics have several applications both in restorative dentistry and endodontics. It is important to have up-to-date knowledge about new bioactive materials to select the most suitable material for the clinical situation. Bioceramics also have their usefulness in prosthetics – implants, prostheses, prosthetic devices, etc. are coated with bioceramic material to improve their biocompatibility [28]. Bioceramic materials also have been used in surgery – joint replacements, sinus obliteration, alveolar ridge augmentation, filling of surgical bone defects, and correction of orbital floor fractures are all situations that call for these materials. They naturally have endodontic uses, such as sealers, obturation, resorption, apexification, pulpotomy, perforation repair, retrograde filling, and regenerative endodontics. Their restorative uses are as a substitute for dentin, dentin remineralization, dentin hypersensitivity, and pulp capping [6].
Most studies show that bioceramic materials are biocompatible, bioactive, and antimicrobial, with sealing properties are similar to MTA. Some *in vitro* studies have declared that these materials potentially increase fracture resistance. It is not clear if these results have any influence on clinical success even though these studies are promising: this question can only be answered by studies that are well-designed and have prospective outcome.

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