JOURNAL OF HEALTHCARE SCIENCES
Volume 2 Issue 5 2022, Article ID: JOHS2022000431
http://dx.doi.org/10.52533/JOHS.2022.2502
e-ISSN: 1658-8967

Review

Advantages and Types of Bioceramics in Endodontics

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Received: 22 May 2022, Accepted: 24 May 2022, Published: 26 May

Abstract

The exponential rise of endodontics is aided by advancements in endodontic material sciences. Bioceramics are one of the most recently developed materials in endodontics, and they have completely transformed the field. Bioceramics are biocompatible ceramic materials or metal oxides with improved sealing properties, as well as antibacterial and antifungal activity, that are used in medicine and dentistry. The response to bioceramic technology in endodontics has been overwhelmingly positive. As more dentists think about the procedure, they are seeing not just the obvious advantages in endodontics, but they are also wondering how this technology may be used to other elements of dentistry. The purpose of this research is to review the available information about the advantages and types of bioceramics used in field of endodontics. Within the living environment, bioceramics are safe and compatible, non-toxic, non-shrinking, and chemically stable. Another benefit of such materials is their capacity to generate hydroxyapatite and, as a result, form a connection with dentin. Because of their interaction with periapical tissues, bioceramics contain bioactivity that aids bone healing and neoformation. Bioceramics have evolved into an important component of today's oral health care delivery systems. The entire extent of the possibilities is only now becoming apparent. Bioceramics are advantageous because of their biological compatibility and antibacterial capabilities however, in future more clinical studies need to be conducted and published to signify the importance of use of bioceramic materials in endodontics.

Keywords: *bioceramics, endodontics, advantages, compatible, dentistry*

Introduction

Due to the introduction of new procedures and technical advancements, the area of endodontics is continually developing. The exponential rise of endodontics is aided by advancements in endodontic material sciences. Bioceramics are one of the most recently developed materials in endodontics, and they have completely transformed the field. Ceramics are non-metallic inorganic materials created by heating raw minerals to high temperatures (1). Bioceramics are biocompatible ceramic materials or metal oxides with improved sealing properties, as well as antibacterial and antifungal activity, that are used in medicine and dentistry. They have the ability to operate as human tissues or to regrow and promote natural tissue regeneration. Bioactive glass, glass ceramics, calcium silicates, hydroxyapatite, and resorbable calcium phosphates, and radiotherapy glasses are among them (2, 3).

Bioceramic materials are divided into different categories: Bioinert which are defined as the bioceramics that do not interact with biological systems, Bioactive which are tissues that can interact with surrounding tissue through interfacial interactions and Biodegradable, soluble, or resorbable which are the replaces or is absorbed into tissue over time. This is especially true for lattice frameworks. Glass and calcium phosphate are bioactive materials that engage with the tissue around to promote the formation of more durable tissues. Bioinert materials like zirconia and alumina elicit a minimal response from the surrounding tissue, implying that they have no biological or physiological effect (4).

The response to bioceramic technology in endodontics has been overwhelmingly positive. As more dentists think about the procedure, they are seeing not just the obvious advantages in endodontics, but they are also wondering how this technology may be used to other elements of dentistry. Bioceramic technology has transformed not only endodontics, both surgically and non-surgically, but it has also begun to shift the treatment strategies for patients. Now more teeth can be saved in a predictable way due to the intervention of bioceramic technology which also enhances their long-term prognosis. The possibility of preserving the natural dentition has resurfaced (5).

Due to their closeness to biological hydroxyapatite, they have excellent biocompatibility qualities. They have intrinsic osteoinductive capacity because of their potential to absorb osteoinductive substances if a bone healing process is present, they have intrinsic osteoinductive capacity. Serve as a regenerative scaffold made up of resorbable lattices that provide a framework for the body to regenerate tissue. Ability to make a chemical bond with the dentition and also have significant radiopacity (6, 7). Antibacterial qualities as a result of in-situ precipitation following setting, which results in bacterial sequestration. Bioceramics are porous powders that contain nanocrystals with sizes of 1-3 nano metre that inhibit germs from adhering to them. Fluoride ions are sometimes found in apatite crystals, and the resulting nanomaterial is antimicrobial (8).

Sealants, obturation, perforation repair, reverse filling, pulpotomy, resorption, apexification, and regenerative endodontics are all examples of endodontic uses. In both endodontics and restorative dentistry, bioceramics have a wide range of applications. It is critical to have current understanding of these novel bioactive materials to identify the most appropriate material for various therapeutic scenarios. Biodentine Sealers - Endo CPM Sealer, MTA Fillapex, BioRoot RCS, TechBiosealer. Calcium silicate based – Cements – Portland Cement, Mineral trioxide aggregate (MTA), Biodentine Sealers – MTA Fillapex, BioRoot RCS, TechBiosealer. A mixture of calcium silicates and calcium phosphates based on calcium phosphates/tricalcium phosphate/hydroxyapatite - iRoot BP, iRoot BP Plus,iRoot FS, EndoSequence BC Sealer, Bioaggregate, Tech Biosealer, and Ceramicrete are all the various types of bio-ceramic materials used in endodontics (9). Recently, with new advancements and technology the use of bio-ceramic materials use in endodontics has increased. The purpose of this research is to review the available information about the advantages and types of bioceramics used in field of endodontics.

Methodology

This study is based on a comprehensive literature search conducted on April 13, 2022, in the Medline and Cochrane databases, utilizing the medical topic headings (MeSH) and a combination of all available related terms, according to the database. To prevent missing any possible research, a manual search for publications was conducted through Google Scholar, using the reference lists of the previously listed papers as a starting point. We looked for valuable information in papers that discussed the information about the advantages and types of

 http://dx.doi.org/10.52533/JOHS.2022.2501

bioceramics used in endodontics. There were no restrictions on date, language, participant age, or type of publication.

Discussion

In the 1990s, bioceramic-based materials were first used in endodontics as retrograde fillings, subsequently as root healing cement, root canal sealers, and coatings for gutta-percha cones. The physicochemical and biological features of bioceramic materials have the potential to be advantageous in endodontics. Within the living environment, bioceramics are safe and compatible, non-toxic, non-shrinking, and chemically stable. Another benefit of such materials is their capacity to generate hydroxyapatite and, as a result, form a connection with dentin. MTA has become the gold-standard material for a wide range of clinical situations since the emergence of bioceramic materials into clinical endodontics and is perhaps the closest to the ideal reparative material due to its excellent physicochemical and biological properties (10).

Endodontic bioceramics are not affected by moisture or blood contamination, making them method agnostic. They have a modest expansion and are dimensionally stable. They are hard when set, allowing complete compaction of a final restoration, and insoluble over time, guaranteeing a good long-term seal. The hydration reaction, which first generates calcium hydroxide and subsequently dissociates into calcium and hydroxyl ions, causes the pH to rise over 12 during the setting process. As a result, the material possesses antibacterial qualities when it is not set. It is biocompatible and even bioactive once fully set (11).

Types of bio-ceramic materials used in endodontics

MTA is a biocompatible dental material that can be used on oral and dental tissues. MTA is a radiopaque cement made from commercial Portland cement and bismuth oxide powder. It was designed for dental root healing in endodontic treatment. MTA is utilized in apexification to create apical plugs, root canal therapy to heal root perforations, internal root resorption treatment, and pulp capping. In the last ten years, the MTA has found a home in dentistry, where it is particularly useful in conservative and endodontic procedures. Because of its great compatibility, the MTA might be used as a cement, and it has a mechanism comparable to calcium hydroxide, making it an effective antibacterial (12) .

Few clinicians are aware that original MTA is a traditional bioceramic material with heavy metals added. MTA is among the most well-studied materials in dentistry (13, 14). It has all of the features of bioceramics, including higher pH values when unset, biocompatibility and bioactivity when set, and a good seal over time. It does, however, have significant drawbacks. It necessitates mixing, which generates a lot of waste, is difficult to handle, and is tough to dislodge out from root canal once established. Both grey and white MTA stain dentin clinically, owing to the material's heavy metal composition or the incorporation of blood pigment during setting. Finally, MTA is difficult to apply in narrow canals, rendering it unsuitable for use as a sealer with gutta-percha. New MTA formulations or additions have been used to try to solve these problems. These formulations, however, have an impact on MTA's mechanical and physical properties (15, 16).

MTA, or first-generation bioceramic cements, gained popularity in endodontics. New indications for its usage were later established, including direct pulp capping of permanent teeth, pulpotomy of deciduous teeth, and the specification and repair of surgical and non-surgical root perforations. MTA can also be used in various clinical settings, such as the coronal plug following endodontic obturation; in the repair of vertical root fractures; as a temporary restorative material prior to internal whitening of the dental element; and in the treatment of root perforations. Its features have been tweaked to achieve the MTA's advantageous characteristics of biocompatibility, high pH, no reabsorption, increased root resilience, low cytotoxicity, non-contracting, and chemical stability in a root canal endodontic sealant cement that is simple to work with inside the canals (17).

Biodentine is a bioceramic material of the second generation. It has qualities similar to MTA so may thus be utilized for all the MTA-related applications. Its benefits over MTA include a faster set time which is about 10–12 minutes and a compressive strength comparable to dentin. One important drawback is that it is triturated for 30 seconds in a fixed quantity, resulting in waste in the great majority of endodontic instances where just a tiny amount is necessary (18, 19). Since its introduction in 2009, Biodentine, a prominent and modern tricalcium silicate-based dentine repair and replacement material, has been examined in a variety of ways. Despite a few contradicting results, the research usually recommends this product in terms of physical and therapeutic features. Biodentine holds potential for clinical dental operations as a biocompatible and readily

http://dx.doi.org/10.52533/JOHS.2022.2501

handled substance with a short setting time, while further evidence is needed (20).

Biodentine treatment does not necessitate any surface conditioning, and restorative closure is accomplished by micromechanical retention as biodentine enters the dentin tubules and forms tag-like structures. Biodentine can be carved and moulded like genuine dentin after it has hardened. It can also be combined with various adhesives before being finished with composite resin for the final restoration. Biodentine has a wide range of clinical uses as a permanent bulk dentin replacement in endodontics, restorative dentistry, and paediatric dentistry as a prospective replacement material for formecresol, according to various published clinical trials, histology of human teeth, and clinical cases (21). Findings of a follow-up study revealed that for the treatment of persistent periapical lesions, conventional endodontic therapy following surgical intervention with the installation of biocompatible material like biodentine had a positive effect on the treatment success (22). Results of a 3-year prospective study concluded that for posterior restorations, biodentine could be used as a dentine alternative under composite (23).

Moisture from the surrounding tissues is required for premixed bioceramics to solidify. The advantages of premixed sealant, paste, and putty are uniform consistency and less waste. All the bioceramics in this blend are hydrophilic. iRoot injectable and iRoot root canal sealer were developed by a Canadian research company in 2007. It is a premixed, fully prepared and ready to use calcium silicate-based substance. These endodontic pre-mixed bioceramic materials have been marketed and in use since 2008. The chemical makeup of all three types of bioceramics such as calcium silicates, zirconium oxide, tantalum oxide, calcium phosphate monobasic, and fillers is comparable, and they have similar mechanical and biological qualities as well as superior handling properties (11). Calcium phosphate cement is a grafting substance that is bioactive and biodegradable in powder and liquid form. It primarily sets as hydroxyapatite when combined. Calcium phosphate cement has been shown to be a promising material for grafting applications in both in vivo and in vitro research. Calcium phosphate cement can be used to obturate the entire canal (24).

BioAggregate is a pure white biocompatible nanoparticulate powder made up of bioceramic nanoparticles which is below 2 microns. Tricalcium silicate and dicalcium silicate are the main ingredients, however it is an aluminate-free bioceramic material. Tantalum pentoxide, which is even more chemically inert than bismuth oxide, is employed as a radiopacifying agent. One reason for the stated biocompatibility and lower risk of tooth discolouration could be because of this (25). EndoBinder, a novel calcium aluminate-based endodontic cement, was created with the goal of keeping the qualities and therapeutic applications of MTA while eliminating its disadvantages. EndoBinder is made with high purity, removing residues of free magnesium oxide and calcium oxide, which cause material expansion and tooth darkening, as well as ferric oxide, which causes tooth discoloration (26). There are various other bioceramic materials that are used in field of endodontics.

Advantages of bioceramic materials in endodontics

Bioceramics has evolved into an important component of today's oral health care delivery systems. The entire extent of the possibilities is only now becoming apparent. Bioceramics are advantageous because of their biological compatibility and antibacterial capabilities. In several surgical and endodontic treatments, bioceramics provide new therapy alternatives for better prognosis. It outperforms many commonly used materials, including calcium hydroxide. Bioceramics are undergoing research to increase their qualities so that they can be used more broadly (24). Due to their closeness to biological hydroxyapatite, they have excellent biocompatibility qualities. They have intrinsic osteoinductive capacity and have ability to produce an excellent hermetic seal, make a chemical link with the tooth structure, and have exceptional radiopacity as a regenerative framework of resorbable lattices that give a framework that is later disintegrated as the body rebuilds tissue (27).

There are two significant advantages to using bioceramic materials as root canal sealers. For starters, their biocompatibility keeps the surrounding tissues from rejecting them. Second, bioceramic materials contain calcium phosphate, which improves sealer-to-root dentin bonding by increasing the setting capabilities of bioceramics and resulting in a chemical composition and crystalline structure akin to tooth and bone apatite materials (28). Bioceramic cement can be used to close dentinal tubules in a variety of situations. Bioceramics can seal the spaces between the dentinal walls and the obturating substance uniformly. Because of their interaction with periapical tissues, bioceramics contain bioactivity that aids bone healing and neoformation (29). There are very limited clinical studies available regarding the use of bioceramics in endodontics. In future more clinical and experimental based research

http://dx.doi.org/10.52533/JOHS.2022.2501

studies should be conducted to highlight the importance of use of bioceramic materials in endodontics.

Conclusion:

There has been an increase in the use of bioceramic materials in endodontics, such as cements and sealers, and clear evidence of its therapeutic effects is observed over time. However, further research in the area is needed. More clinical studies need to be conducted and published to signify the importance of use of bioceramic materials in endodontics.

Disclosure

Statement:

The authors declare no conflict of interest.

Funding:

No funding.

Ethical consideration:

Non applicable.

Data availability:

Data that support the findings of this study are embedded within the manuscript.

Authors' contribution:

All authors contributed equally to the drafting, writing, sourcing, article screening and final proofreading of the manuscript.

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