

Current concepts related to the use of bioceramic materials in Dentistry

Conceitos atuais relacionados ao uso dos biocerâmicos na Odontologia

Conceptos actuales relacionados con el uso de materiales biocerámicos en Odontologia

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Abstract

Endodontics is the specialty that covers the control of inflammation of the root canal, the etiology, diagnosis, prevention and therapeutic intervention of diseases associated with the pulp. The objective of the present study is to highlight the current concepts related to the use of bioceramic materials in dentistry. This is a literature review article, developed through a bibliographic survey in the databases Medline, PubMed, Scielo and Periodicos CAPES. The present study showed a gradual increase in research related to bioceramic cements, which may attribute this interest to the importance of having a constant search for improvement of the techniques and materials used to recover oral health. In addition, a broad clinical applicability of these materials in Endodontics was highlighted, due to the evidence found regarding the advantageous properties, such as their excellent biocompatibility, ability to bond to dentin, good radiopacity, better handling conditions, appropriate setting time, bactericidal activity, bioactivity and still, do not cause stains in dental structures, characteristics sought for a restorative material to be efficient.

Keywords: Biocompatible materials; Endodontics; Silicate cement.

Resumo

A endodontia é a especialidade que abrange o controle de inflamações do canal radicular, a etiologia, o diagnóstico, a prevenção e a intervenção terapêutica das doenças associadas à polpa. O objetivo do presente estudo é evidenciar os conceitos atuais relacionados ao uso de materiais biocerâmicos em odontologia. Foi desenvolvida uma revisão da literatura através de um levantamento bibliográfico nas bases de dados Medline, PubMed, Scielo e Periodicos CAPES. O presente estudo evidenciou um gradativo aumento nas pesquisas relacionadas aos cimentos biocerâmicos, podendo atribuir esse interesse à importância de se ter uma constante busca por aprimoramento das técnicas e dos materiais utilizados para recuperar a saúde bucal.

Além disso, destacou-se uma abrangente aplicabilidade clínica desses materiais na Endodontia, em virtude das evidências encontradas quanto às propriedades vantajosas, tais como sua excelente biocompatibilidade, capacidade de união à dentina, boa radiopacidade, melhores condições de manipulação, tempo de presa apropriado, atividade bactericida, a bioatividade e ainda, não causam manchas nas estruturas dentárias, características buscadas para que um material restaurador seja eficiente.

Palavras-chave: Materiais biocompatíveis; Endodontia; Cimento de silicato.

Resumen

La endodoncia es la especialidad que abarca el control de la inflamación del conducto radicular, la etiología, diagnóstico, prevención e intervención terapéutica de las enfermedades asociadas a la pulpa. El objetivo de este estudio es destacar los conceptos actuales relacionados con el uso de materiales biocerámicos en odontología. Se desarrolló una revisión de la literatura a través de una encuesta bibliográfica en las bases de datos Medline, PubMed, Scielo y Periodicos CAPES. El presente estudio mostró un incremento paulatino de las investigaciones relacionadas con los cementos biocerámicos, lo que puede atribuir este interés a la importancia de tener una búsqueda constante de mejora de las técnicas y materiales utilizados para recuperar la salud bucal. Además, se destacó una amplia aplicabilidad clínica de estos materiales en Endodoncia, debido a la evidencia encontrada en cuanto a propiedades ventajosas, como su excelente biocompatibilidad, capacidad de adhesión a la dentina, buena radiopacidad, mejores condiciones de manipulación, tiempo de fraguado adecuado, Actividad bactericida, bioactividad y aún no provocar manchas en las estructuras dentales, características buscadas para que un material restaurador sea eficaz.

Palabras clave: Materiales biocompatibles; Endodoncia; Cemento de silicato.

1. Introduction

Endodontics is the specialty that covers the control of inflammation of the root canal, the etiology, diagnosis, prevention and therapeutic intervention of diseases associated with the pulp. Each phase of endodontic therapy is considered equally important for the clinical success of the treatment, considering the interdependence of each stage. However, greater emphasis should be placed on the obturation phase as it is essential for the success of the traditional therapeutic approach. The three-dimensional filling of the canal system will be essential to prevent an infection or recurrence of infection (Werlang, 2016; Veiga, 2017).

Advances in the health area have provided endodontics with a significant improvement of new filling materials, with the gutta-percha cone being the most widely used solid material globally in endodontic restorations, requiring association with an endodontic cement because it does not have adhesive capacity, so that it provides the hermetic seal essential to recover the integrity of periradicular tissues (Veiga, 2017). The interest in studying the newest bioceramic cements used in endodontic therapy arose from the need to compile and analyze various scientific researches that present conclusive results regarding the advantages and disadvantages, the types available, as well as the clinical properties of these materials (Werlang, 2016).

There are several studies that prove the clinical success of mineral trioxide aggregate (MTA) in dental procedures. However, new bioceramic materials have been developed in order to overcome the disadvantages of MTA, maintaining the equivalence of positive characteristics. Therefore, this study seeks to contribute to endodontists and other professionals in the field regarding the options that replace MTA, as it is considered the gold standard in several studies, in comparison with new (Al-Haddad & Azis., 2016; Veiga, 2017). Therefore, the objective of the present study is to highlight the current concepts related to the use of bioceramic materials in dentistry.

2. Materials and Methods

This is a literature review article, developed through a bibliographic survey in the databases Medline, PubMed, Scielo and Periodicos CAPES. The search strategy used was “Biocompatible Materials”; “Endodontics” and “Silicate Cement”. Thirty articles published between 2008 and 2020 were selected, based on the following inclusion criteria: availability of the full text, publication in Portuguese, English and Spanish, clarity in the methodological details used and articles that focused on strategies for the use of bioceramics in endodontics.

3. Results and Discussion

Bioceramic cements are materials used in medicine and dentistry due to their relevant composition. They arose through the association of calcium silicate and calcium phosphate, their main characteristics are biocompatibility (presenting antimicrobial action against some microorganisms, such as *E. faecalis*) and low toxicity; they are also considered chemically safe in the biological environment, in addition to being hydrophilic, using the humidity of the

dental tubules to initiate and complete the prey reaction. Another frequent use for bioceramic materials is in orthopedic treatments, such as replacements of joints or tissues, as well as for coating metallic implants in order to improve their biocompatibility (Al-Haddad & Azis., 2016).

The first biomaterial based on calcium silicate (HCSC) patented for endodontic applications was the Mineral Trioxide Aggregate (MTA). The attention received by the material is attributed to its significant sealing capacity, biocompatibility, regenerative capacity and antibacterial properties. However, there are some disadvantages associated with the use of MTA that include long setting times, difficulty in handling and the possibility of staining the tooth structure (Guo, 2016).

In order to remedy the deficiencies of the materials that were already present on the market, the mineral trioxide aggregate (MTA) was introduced in the North American market in the late 1990s. Since then, MTA has been widely studied and, even today, it presents itself as a gold standard in comparison to the newest bioceramic cements. In addition, there are several studies that prove the clinical and radiographic success of treatments performed with MTA, in the most diverse types of procedures (Galarça, 2018).

The MTA has several clinical applications, ranging from its use in conservative therapies to root fractures, as well as sealer in perforations, pulp capping and restorative material in several surgeries. Being widely studied for decades, adding new chemical compositions over time, however, even today, it needs new improvements to achieve a result of excellence (Duarte, 2018). This material is commonly used in endodontic therapy, but it has disadvantages and limitations that have led many researchers to seek to improve its handling characteristics; which also influenced other manufacturers to develop alternative materials (Silva, 2015).

In this perspective, Sequeira (2018) addressed, in their studies, that, in 2009, a new tricalcium silicate cement, Biodentine (BD), became commercially available, showing good biocompatibility with gingival fibroblasts and dental pulp cells. It has also been suggested that Biodentine promotes cell differentiation and restorative dentin synthesis. Still according to them, compared to the MTA, this new material presented better characteristics, dealing with handling in the clinical environment, since it completes its setting time in 12 minutes, allowing restorative procedures to be performed in a single session, in addition to less depigmentation of the teeth, when performed after one year.

MTA (ProRoot MTA) and MTA Angelus are known to present the possibility of tooth discoloration due to the presence of the radiopacifying agent bismuth oxide, a fact that

becomes a limitation in the use of this material, considering the negative effect on patients' aesthetics, therefore, it is necessary to use an alternative material as a radiopacifier in the composition of the MTA (Souza, 2015).

In summary, bioceramics are synthesized, biocompatible minerals obtained through various chemical processes. Its biocompatibility properties are due to its similarity with the biological process of hydroxyapatite formation and the consequent ability to promote a regenerative reaction in the human body. During the bone healing process, they are able to absorb osteoinductive substances, due to the intrinsic osteoinductive capacity (Galarça, 2018). Dentistry is a science that is constantly improving and developing new techniques that seek to improve the therapeutic models already used. In this sense, the development of materials with bio-regenerative properties is extremely important for vital pulp therapies and regenerative endodontic procedures (Sequeira, 2018).

With regard to the types of bioceramic cements used in endodontics, these can be divided by composition, setting mechanism and consistency. All sealants used today are composed of powder, catalyst, liquid or base, and the professional must mix the two ingredients in the chair, and then apply it to the root canal system (Lim, 2015).

The first MTA formula was marketed in two types, white and gray, being basically composed of dicalcium silicate, tricalcium silicate, tricalcium aluminate, and bismuth oxide, it is the most widespread biomaterial in endodontic treatments because it has a clinical and superior to previous materials (Souza, 2015). In several studies, the excellent biocompatibility properties in vitro and low cytotoxicity have been proven, as well as its association with a better clinical result when used for direct pulp capping, pulpotomy or apexification.

The ability to induce cell binding, proliferation and differentiation of dental pulp stem cells and stem cells from the apical papilla has also been found to be able to produce mineralized tissue (Sequeira, 2018). ElReash (2019) brings in his research a new MTA formula (trade name "MTA - HP" Angelus PR Brasil) created in order to remedy the main disadvantages of the old composition; its base remains calcium silicate, but it has undergone several improvements in its properties with a new powder formula and with the liquid organic plasticizer, which promoted a shorter setting time, low solubility and better handling. In addition, calcium tungstate began to be used as a radiopacifier and, after the removal of bismuth oxide, no discoloration was found in the teeth.

Biodentine is a new cement developed based on tricalcium silicate, which, by incorporating an improved bioactivity and biocompatibility of calcium silicates, produces an optimized formula, making it better than other calcium silicate cements, with their

applications in Endodontics and Restorative Dentistry (Meligy, 2019). Biodentine can be considered a second generation bioceramic cement, combining the biocompatibility of MTA with more efficient characteristics, with a significantly shorter setting time, good handling characteristics and without changing the color of the teeth, in addition to being able to induce the formation of tissue, has antibacterial effect and an effective seal against the entry of microorganisms (Ambu, 2017).

Several studies prove the effectiveness and the advantages that Biodentine has over other materials, among them, its ability to induce the formation of mineralized foci soon after its application, being able to observe the significant increase in the secretion of TGF- β 1 (transformation factor of beta growth 1) of pulp cells that cause angiogenesis, recruitment of progenitor cells, cell differentiation and mineralization. In addition, other research shows that the compressive strength and surface hardness of Biodentine are superior to those of MTA, this characteristic being attributed to the low water / dust ratio, as well as the low solubility (Galarça, 2018).

EndoSequence BC Sealer endodontic cement was recently launched, it is a pre-manipulated, injectable bioceramic, with good radiopacity and white in color and has a differentiated ability to take prey only in contact with moisture, making its ideal use when present in dentinal tubules (Valentim, 2016). In summary, the endodontic bioceramic cement Endosequence BC Sealer is one more option of material for filling the channels and its main advantages are its physical-chemical and biological properties; it has alkaline pH, high release of calcium ions, adequate radiopacity, flow capacity, as well as antibacterial activity, biocompatibility and repair of hard tissue (Martins, 2017).

Werlang (2016) presents in his research the properties and prerequisites of an ideal filling cement: (i) it must have biocompatibility; (ii) be radiopaque; (iii) be capable of removal with common solvents; (iv) be adherent to dentin; (v) be bactericidal or bacteriostatic; (vi) have an alkaline PH; and (vii) be bioactive, so that, during the setting time, hydroxyapatite formation is possible (Veiga, 2017). In order to evaluate the physical-chemical properties and determine a standard in the research of materials, it is essential to develop methods and a set of appropriate tests, so it is essential to follow these specifications (standardized procedures) in the development of any research. Thus, in order to evaluate the properties of endodontic cements, ISO 6876: 2001 and the American Dental Association (ADA) define the tests that must be performed, such as: flow, radiopacity, solubility, setting time, among others (Veiga, 2017; 2018).

Another characteristic conferred to bioceramic cements, also called hydraulic cements, is their ability to promote the regeneration of pulp tissue and to form mineralized tissue attributed to the release of calcium ions, due to the transformation generated when in contact with water, from the which forms calcium hydroxide and calcium silicate hydrate (Koutroulis, 2019). It is worth mentioning that the restorative material will be considered biocompatible when it comes in contact with the tissue and does not trigger an adverse reaction, such as toxicity, irritation, inflammation, allergy or carcinogenicity (Al-Haddad & Aziz 2016).

Bioceramic cements also stand out for their similarity to hydroxyapatite, which allows the formation of a chemical bond with the dental structure, in addition to the capacity for regenerative response in the human body (Lima, 2017). Another common characteristic of bioceramic cements, presented by the manufacturers, is its hydrophilic property, with a low contact angle, facilitating the flow through the channel walls, creating a mechanical connection that allows a better sealing and adaptation, preventing microinfiltrations (Ribeiras, 2015).

Veiga (2017) exposes the link between toxicity and the setting time of an endodontic cement, which should allow an adequate working time for the professional, as prolongation can cause its solubilization by periapical tissues and cause toxicity. Thus, the ideal setting time for an endodontic cement should allow adequate working time and should not be extended to avoid damaging the seal; however, it should not be too short, as the shorter working time can hinder the filling technique. Considering the importance of adhesion of filling cement for the success of endodontic treatment, as well as the complete filling and sealing of the root canal, radiopacity is essential for the dentist to visualize the behavior of the cement in the canal on the radiograph and the possible need for another intervention. for correction (Werlang, 2016).

4. Conclusion

The present study showed a gradual increase in research related to bioceramic cements, which may attribute this interest to the importance of having a constant search for improvement of the techniques and materials used to recover oral health. In addition, a broad clinical applicability of these materials in Endodontics was highlighted, due to the evidence found regarding the advantageous properties, such as their excellent biocompatibility, ability to bond to dentin, good radiopacity, better handling conditions, appropriate setting time,

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