Review

Biocompatible Materials in Dentistry

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Abstract:
This article presents a mini-review of biocompatible materials used in dental medicine.The main characteristic of biomaterials is that they do not cause any immunological reaction in the host, their use on living tissue is suitable. In general, biomaterials represent a broad field that is constantly being upgraded. This article presents four main groups of biomaterials (metals and metal alloys, dental ceramics, polymers, and composites), the most frequently used materials in dentistry, their improved versions, and innovations of biomaterials. The integration of novel biomaterials, such as nanoparticles, is also dis-cussed. Also, the article describes glass-ionomer cement, an irreplaceable material in pedi-atric dentistry, impression materials, sealers, luting materials, and other materials repre-senting essential parts of clinical work

Keywords: Biocompatibility; Metals and metal alloys; Dental ceramics; Polymers; Resin composites; Nanomaterials

1. Introduction

The main property that allows the use of a biomaterial on living tissue is biocompatibility, which refers to the material's ability to perform its intended function without causing harmful local or systemic reactions in the recipient of the material (Perroti et. al., 2017). Biomaterials in modern medicine have a huge range of applications such as biosensors, medical implants, systems that promote the healing or regeneration of human tissues, drug-delivery systems, etc. The applicability of biomaterials is defined by a long list of their characteristics. The most important properties of biomaterials are biocompatibility (non-toxic, non-carcinogenic, non-allergenic, etc.), desirable physical, chemical, and mechanical properties (tensile and yield strength, elastic modulus, corrosion, wear, and fatigue resistance), stable durability for some time, processable with available techniques (CAD/CAM systems, 3D printing,), sterilizable without changing his structure, accessibility, etc. (Kiran & Ramakrishna, 2021).

2. Topical materials in dentistry

The largest number of different materials in dentistry is applied in the field of prosthetic and restorative dentistry. In general, we can divide materials in dentistry into four main groups: metals and metal alloys, ceramics, polymers, and resin composites. Well-known aesthetic materials resin composites, which have replaced long-used amalgams, today are used for direct, indirect, and provisional restorations, veneers, core buildups, cement, and sealants (Sakaguchi, 2019). The properties of composites have changed significantly in a positive way by infiltrating the latest technology of using nanoparticles in the production of composites. The contemporary group of materials also includes compomers, which combine the advantages of composites and glass-ionomer cement (Sakaguchi & Mitra, 2019). The composition of composites also includes polymers, which have a major role in most areas of prosthetic and restorative dentistry. They are also components of impression materials, resin, glass-ionomer cement, dentin bonding agents, which enable a strong bond between the composite and the tooth structure (Sofan et al., 2017), pit and fissure sealants, and root canal sealants. The most commonly used polymer material is polymethyl methacrylate (PMMA). PMMA is a strong, tough, lightweight material (Rokaya et al., 2018), which is used for the fabrication of artificial teeth, dentures and denture bases, obturators, orthodontic retainers, occlusal splints, temporary or provisional crowns, and for repairment of dental prostheses (Zafar, 2020). To reduce bacterial and fungal colonization, different nanoparticles are incorporated into PMMA, such as silver or platinum nanoparticles (Rokaya et al., 2018). Polyetheretherketone (PEEK) has excellent properties and close elastic modulus to the bone, which their use makes possible in many fields of dentistry such as orthodontics for orthodontic wires, maxillofacial surgery for obturators (Hamsho et al., 2022), prosthodontics for fixed and removable prostheses, temporary abutments, etc. (Parate et al.,2023). Polymeric films (PMFs) are also used in dentistry. For example, coating the surface of hydroxyapatite, which is part of the tooth structure, with a copolymer containing 50% MPC (2-methacryloyloxyethyl phosphorylcholine) inhibits bacterial adhesion to the tooth surface (Rokaya et al., 2018). Glass-ionomer cements are important materials in pediatric dentistry and are the materials of choice in patients with high caries risk due to their ability to release fluorides. GIC is used in atraumatic restorative treatment, for small lesions, a temporary filling, open and closed sandwich technique, for cementing crowns and bridges, and as a liner or base in all deep lesions. There are two main groups of GIs: Conventional GIs and Resin-Modified GIs, also known as hybrid materials. Some nanoparticles were added to RMGIs to obtain nano ionomers (Sakaguchi &.Mitra, 2019) Impression materials in dentistry, which are used to copy oral tissue, can be divided into two main groups: elastic (polysulfides, addition and condensation silicones, alginate, polyether, and agar) and inelastic/rigid material (impression waxes, impression compound, zinc oxide eugenol) (Gupta & Brizuela, 2023). In endodontic therapy, sealers play an essential role in ensuring that the root canal system is properly sealed after cleaning and shaping. The most used sealer is zinc-oxide eugenol sealer. There are also glass-ionomer-based, calcium hydroxide-based, resin-based, and bio-ceramic sealers (Gasner & Brizuela, 2023). Gutta-Percha is a natural polymer with excellent sealing properties. The choice of luting materials depends on factors such as the type of restorations and the clinical situation. They could be classified as water-based (zinc-oxide eu-

genol, zinc-polycarboxylate,..) or resin-based luting cement (conventional and self-adhesive resin cement) (Leung et al., 2022). Metals and metal alloys are used in almost every aspect of dental practice, including the dental laboratory. The American Dental Association (ADA) describes three categories of dental casting alloys based on the content of noble metals: (1) high noble (Au-Ag-Pt), (2) noble (Ag-Pd), and (3) predominantly base metal (Ni-Cr, Co-Cr, and Ti-alloys) (Messer et al., 2002). In restorative dentistry, we use them as filling materials (amalgam), in prosthetics for the construction of metal cores of crowns and dental bridges, for the metallic framework of removable partial dentures, for dental implants, in orthodontics for orthodontic wires, brackets, etc. For example, stainless steel or titanium alloys are used for different dental instruments. Dental ceramics have excellent aesthetic properties, are chemically inert in the oral environment, and show high biocompatibility with oral tissues. They are used for various types of dental restorations, such as inlays, onlays, veneers, crowns, and bridges. Dental ceramics are mainly composed of crystalline minerals and glass matrix (Babu et al.,2015). The last classification system categorizes ceramic restorative materials into three families: (1) glass-matrix ceramics – which contain a glass phase (feldspathic ceramics, synthetic glass ceramics, glass-infiltrated ceramics), (2) polycrystalline ceramics – which contain only crystalline phase (alumina, zirconia), and (3) resin-matrix ceramics (hybrids) – which consist of an organic matrix highly filled with ceramic particles. The "Resin Nano Ceramic" contains nanoceramic particles bound in a highly cross-linked polymeric matrix. The hybrids are the most suitable materials for making crowns over implants where the periodontal ligament is lost (Bajraktarova-Valjakova et al., 2018). As preventive and intermediary materials, we utilize pit and fissure sealants (glass-ionomers and flowable composites), glass-ionomer cement for prevention of the progression of decay, calcium hydroxide cement, mineral trioxide aggregate (MTA), biodentine, fluoride-based materials (varnishes, mouth rinses, toothpaste, gels) (Marinho et al., 2003) and others. Calcium hydroxide is the material of choice in deep caries therapy. It is also used for direct and indirect pulp capping, as an intracanal medication, and in endodontic treatment of teeth with incomplete root growth (Sakaguchi & Ferracane, 2019). The most commonly used materials in oral and maxillofacial reconstructive surgery are metal and metal alloys (stainless steel, Co-Cr alloys, Titanium and Ti-alloys) (Pacifici et al., 2017) ceramics (zirconia and alumina for dental implants, calcium phosphate (CaP) for bone grafts), resorbable suture materials (gut, chromic gut, polyglycolic acid, and polydioxanone) and non-resorbable suture materials (silk and polyester) (Davis & Smith, 2023), hemostatic agents (hemostatic collagen, chitosan,..) (Scarano et al., 2023), tissue adhesives (e.g. cyanoacrylate) (Habib et al., 2013), resorbable and non-resorbable membranes and polymer materials. Titanium is the metal of choice in maxillofacial surgery due to its biocompatibility, which results in the formation of an oxide layer on its surface. Titanium is combined with other elements to create alloys suitable for the manufacturing of dental works (Ti-6Al-4V). Its ability to integrate Osseo has been used to make Ti-based implants, which represents the gold standard for endo-osseus dental implants. The materials used in periodontal regenerative therapy include bone grafts (e.g., hydroxyapatite, tricalcium-phosphate), membranes (resorbable and non-resorbable) which keep the soft tissue out of the periodontal or bony defects, growth factors and cell-based materials (cell sheets, stem cells) (Darby, 2011). There are four major metal alloys to produce elements in orthodontics (wires, bands, brackets): stainless steel, cobalt-chromium, NiTi, and beta-titanium alloys (Brantley, 2020). Nitinol, also called Nickel-Titanium-based shape memory alloy, is a wrought Ni-Ti alloy. Nitinol is widely used in orthodontics due to its unique properties, its shape memory, and super elasticity (Fernandes et al., 2011). Orthodontic brackets can also be ceramic, and adhesives are used to bond this element to the tooth. Polymers used in therapy are acrylic resins for mobile orthodontic devices, elastomeric materials for active elements (elastomeric ligatures, elastomeric chains and power chains, elastomeric O-rings), and others. Today, nanomaterials are part of almost every field in dentistry. They could be used in the diagnosis of malignant and precancerous lesions or periodontal diseases, for example, the use of gold nanoparticles (AuNPs) in the research of cancer diagnosis and therapy (Zhang et al., 2022).

Conflicts of Interest: The author declares no conflict of interest.

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