The current trend in innovative bioactive materials for dental and orthopedic applications

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INTRODUCTION: Bioactive materials for the repair and regeneration of human bone tissue, as well as for the restoration of teeth, are the focus of numerous studies in the field of biomaterials. Orthopaedic surgeons anticipate that bioactive materials have the potential to facilitate the formation of new apatite-like crystals upon contact with body fluids, promoting the development of new bone tissue under *in vivo* conditions. On the other hand, dentists expect that bioactive materials have the potential for remineralization of partially demineralized enamel and dentin. In the preceding years, the Bioceramic Materials Group, founded within the Department of Inorganic Chemical Technology at the Faculty of Technology and Metallurgy, University of Belgrade (FTM-UB), conducted extensive research on the advancement of bioactive and biocompatible materials with adequate mechanical properties, designed for application in dentistry, orthopaedics, maxillofacial surgery, and also bone tissue engineering (BTE).

EXPERIMENTAL: Different forms of bioactive materials were processed starting from nanostructured mesoporous calcium hydroxyapatite (HAp), synthesized by controlled precipitation and hydrothermal method, and mesoporous bioactive glasses (BAG), synthesized by sol-gel method, doped with various cations and anions. Calcium phosphate dental inserts and potential solo implants in maxillofacial region were obtained by isostatic pressing of HAp nano-powders, followed by sintering by different techniques. Calcination of multi-ion-doped calcium-deficient HAp powders enabled a phase transformation into α-tricalcium phosphate (α-TCp), known for its binding properties. Doped α-TCp, combined with polymeric materials and Ag and BN nanoparticles possessing antimicrobial properties, was the basis for the development of innovative bioactive dental cements. Three types of bioactive scaffolds were developed: bioceramic scaffolds obtained by the replica technique based on multi-ion doped HAp, β-TCP and BAG, additionally coated with polymers; polymer-based scaffolds created by combining various hydrogels with the BAG, β-TCP, and HAP as nano-fillers; metallic scaffolds modified through the deposition of biodegradable polymers, doped BAG, β-TCP, and HAP nanoparticles.

RESULTS AND DISCUSSION: Calcium phosphate dental inserts exhibited fracture toughness within the range of human dentin, as well as a strong bond with dental composites and adhesives, thereby ensuring the restoration of teeth with satisfactory mechanical properties. The dental cements demonstrated high bioactivity, biocompatibility, along with appropriate rheological, mechanical, and antimicrobial properties. Bioactive ceramic scaffolds for application in BTE with optimal macro-porosity and suitable biocompatibility were successfully fabricated, and biodegradable polymeric coatings significantly enhanced their mechanical properties. Macroporous hydrogels based on poly(methacrylic acid)/gelatine interpenetrating network exhibiting appropriate swelling behavior, while their mechanical properties were improved by the incorporation of bioactive nano-fillers. The greater antimicrobial properties and bioactivity of 3D-printed titanium scaffolds were achieved by the formation of multi-layered bioceramic coating composed of nanoparticles of doped HAp and ZnO.

CONCLUSIONS: Owing to the achieved mechanical and biological properties, the obtained bioactive materials show significant potential for application in dentistry, biomedicine, and bone tissue engineering.

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