

Bone Defect and fracture repair

Ceramic-based bone graft substitutes

Among different ceramic based graft substitute materials, calcium phosphate based ceramics such as hydroxyapatite (HA), β -tricalcium phosphate (β -TCP) and bioactive glass are used quite substantially for long time.

Calcium phosphate ceramics introduced more than three decades ago are considered as bioactive bone substitutes. The paste or injectable calcium phosphates cement offers the advantage of being freely mouldable and adaptable to bone defects.

Calcium hydroxyapatite (HA)

The most unique property of HA material is chemical similarity with the mineralized phase of bone; this similarity accounts for their osteoconductive potential and excellent biocompatibility. Hydroxyapatite (HA) as a synthetic material, usually used as coating for dental and orthopedic implants, but there is limited in use due to its moderate to low solubility within the body and mechanical properties that differ from surrounding tissue and bone. Doped HA with manganese and/or zinc as bone substitute have been tried and resulted in faster resorption

During recent years, there have been efforts in developing doped bioceramics materials to enhance their mechanical and biological properties. Recently, due to the diverse role of Zinc (Zn) in biological functions, it has been considered as one of the preferable candidates to develop HA in doped form. The slow release of Zn incorporated into an implant material can accelerate the recovery of a patient by promoting bone formation around the implant. On the other hand, fluoride substituted apatite has attracted much attention due to its extensive performance relating to the stability of apatite and also for its preventive role in dental carries.

Tricalcium phosphate implants have been used for two decades as synthetic bone void fillers in orthopaedic and dental applications. The small particle size and interconnected sponge like microporosity are believed to improve osteoconductive properties and promote timely resorption concomitant with the process of remodeling

Bioactive glass has been widely used for filling bone defects alone and in combination with autogenous and allogenic cancellous bone graft. In experimental cancellous bone defects in rat models, bioglass was found

biocompatible, and the filler effect was greater with bioactive glass than with autogenous bone

Dental Filling Composites and Cements

Dental composite resins have been used for restoration in anterior teeth and have also become commonly used to restore posterior as well as anterior teeth. The composite resins consist of a polymer matrix and stiff inorganic inclusion. The inorganic inclusions confer relatively high stiffness and high wear resistance upon the material. Moreover, by virtue of their translucence and an index of refraction similar to that of dental enamel, they are cosmetically acceptable. The inorganic inclusions are typically barium glass or silica [quartz, SiO_2]. Inclusions, also called fillers, have a particle size from 0.04 to 13 μm , and concentrations from 33 to 78% by weight. The matrix consists of bis-GMA, an additional reaction product of bis(4-hydroxyphenol), dimethylmethane, and glycidyl methacrylate. Since the material is mixed and then placed in a prepared cavity to polymerize, its viscosity must be sufficiently low and the polymerization must be controllable. Such low-viscosity liquids as triethylene glycol dimethacrylate (TEGDMA) are used to lower viscosity, and inhibitors like butylated trioxytoluene (2,4,6-tri-tert-butylphenol, BHT) are used to prevent premature polymerization. Polymerization can be initiated by a thermochemical initiator (e.g., benzoyl peroxide) or by a photochemical initiator (benzoin alkyl ether), which generates free radicals when subjected to ultraviolet light to initiate free radical polymerization. In view of the greater density of the inorganic filler phase, 77 wt% filler corresponds to a 55 vol%.. Dental composites are considerably less stiff than natural enamel (which contains >97% mineral). One cannot easily obtain such high concentrations of mineral particles in synthetic composites.

The particles do not pack densely. Moreover, the viscosity of unpolymerized paste increases with particle concentration. Too high a viscosity will prevent the dentist from adequately packing paste into a cavity. The use of surfactants will lessen this problem. The thermal expansion of dental composites exceeds that of teeth. There is also some contraction (up to 1.6%) during polymerization, which is thought to contribute to leakage of saliva, bacteria, among other things, at the

interfacial margins. Such leakage can in some cases cause further tooth decay. For some materials this contraction is counteracted by swelling due to absorption of water in the mouth. Use of colloidal silica in so-called “microfilled” composites allows these resins to be polished, which cuts down on wear and plaque accumulation. However, it is more difficult to make these with a high fraction of filler, since the tendency for high viscosity of unpolymerized paste must be counteracted. Excessively high viscosity is problematical since it prevents the dentist from adequately packing paste into the cavity; the material will then fill crevices less effectively. All dental composites exhibit creep, which may result in indentation of a restoration, but wear seems to be a greater problem. Dental composites tend to become brittle and relatively weak under tension. Moreover, they are subject to mechanical fatigue, so that they can fail at stress levels below static fracture strength. Their use is thus restricted to certain types of dental restorations. The “packable” or condensable dental composites have been introduced as better alternatives to amalgam in restorations of posterior teeth, and they can be packed more easily into a prepared cavity and will produce tighter contacts between restored teeth. The elastic modulus of these composites ranges from about 9.5 to 21 GPa. A variety of filled resin-based cements, with 65 to 74 wt% filler, is available to attach dental crowns to the remaining tooth structure. A high modulus is considered beneficial in the ability of the cement to prevent the loss of a crown. Dental composite resins are now established as restorative materials for both anterior and posterior teeth and as cements. The use of these materials is likely to increase as improved compositions are developed and in response to concern over the long term toxicity of silver–mercury amalgam fillings. Nanoparticle composites may be an attractive alternative to dental composites as fillers and adhesives. The main problem here is dispersion of nanoparticles, which can possibly be solved by treating the filler (ceramic particles) with acid and surfactants.