

Ceramics are non-metallic inorganic materials with a broad range of composition. They are usually processed by mixing the particulates of the material together with water and an organic binder. The mixture is then pressed into a mould to obtain the desired shape, dried to evaporate the water and the binder burned out by thermal treatment. Firing or sintering at a very much higher temperature then densifies the residual material. The final microstructure of the ceramic is greatly dependent on the thermal process applied, the maximal temperature reached and the duration of the thermal steps. There are five types: glass, plasma-sprayed polycrystalline ceramic, vitrified ceramic, solid-state sintered ceramic and polycrystalline glass-ceramic. Other factors such as the purity of the powder, the size and distribution of the grains, and the porosity are important in determining the mechanical and biological properties. The extended use of bioceramics in medicine is related to their excellent biocompatibility as a result of their high level of oxidation.

Ceramics used in orthopaedic surgery are classified as bioactive or inert according to the tissue response when implanted in an osseous environment. The bioactivity of a material can be defined as its ability to bond biologically to bone. An inert ceramic merely elicits a minor fibrous reaction. In clinical practice, inert fully-dense ceramics are used as bearings in total joint replacements because of their exceptional resistance to wear and their tribological properties. By contrast, bioactive ceramics are employed as coatings to enhance the fixation of a device or as bone-graft substitutes because of their osteoconductive properties.

This review discusses the clinical applications of ceramics in orthopaedic surgery and the future trends in their design.

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Sliding ceramics. The most widely used bearing couple in total joint replacements remains metal-on-polyethylene. The long-term survival of the artificial joint, however, is impaired by the wear of its components which ultimately leads to osteolysis around the implant secondary to an inflammatory response induced by wear debris occurring from both the articulating and non-articulating surfaces. Of the different types of particle found in the membranes surrounding the loosened components, polyethylene debris has been identified as a major factor inducing activation of macrophages which leads to the production of bone-resorbing cytokines with resultant loss of bone stock, especially in the young and active population.¹ Pierre Boutin² first introduced ceramics in orthopaedics in the early 1970s in order to eliminate or reduce complications related to polyethylene.³ They are mainly used in total hip arthroplasty as femoral heads articulating against polyethylene, and as cups in the alumina-on-alumina combination.

Because of their relatively brittle nature, fracture of ceramic femoral heads has been, along with cost, the main limitation to their expanded use world-wide. The risk of fracture, however, has been virtually eliminated because of a great improvement in the manufacturing process with increased purity and density, improvement in the size and distribution of the grains and better quality control. Accurate fixation of the ceramic ball to the femoral stem through a well-designed Morse taper avoids critical stresses in the head and a better surgical technique has been developed. It is difficult to determine the actual incidence of fracture, the frequency of which is very variable. When the above conditions are optimised, however, the rate has been evaluated as 0.02% for alumina heads and 0.03% for those of zirconia.⁴ These figures indicate that fracture of the ceramic head is no longer an important issue, and in our opinion should not be a relevant argument against its use.

Alumina ceramic. Dense alumina of surgical grade is obtained by sintering alumina powder at temperatures between 1600 and 1800°C. The resultant material is in its highest state of oxidation, allowing thermodynamic stability, chemical inertness and excellent resistance to corrosion. Improvement in the manufacturing process has lowered the size and distribution of the grains, which are major factors in avoiding the propagation of cracks and fracture. Alumina