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Review paper

Ceramics for oculo-orbital surgery

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Abstract

Ceramics are an extremely versatile class of materials with an extraordinarily broad spectrum of applications, ranging from building industry to medicine. Ceramics began to be systematically investigated as implantable biomaterials in the 1950s and soon revealed surprising properties. Orthopaedics and dentistry are the preferred areas of surgical applications of ceramics, due to their suitable strength for load-bearing applications, wear resistance (*e.g.* alumina and alumina/zirconia composites) and, in some cases, bone-bonding ability (*e.g.* hydroxyapatite and bioactive glasses). Another clinical field where ceramics are playing a significant role is oculo-orbital surgery, a highly interdisciplinary medical area that focuses on the management of injured eye orbit, with particular regard to the repair of orbital floor/wall fractures and/or the placement of orbital implants after removal of a diseased eye. Especially in the latter case, implants are not intended for bone repair but have to be biointegrated in soft ocular tissues; therefore, suitable ceramics for this application are required to go beyond the "traditional" bone-bonding ability. This article provides a picture of the currently-used ceramics for such applications and explores new emerging perspectives, highlighting the promises for the future disclosed by the recent advances in nanobioceramics science.

Keywords: Calcium phosphates; Alumina; Bioactive glass; Nanoceramics; Orbital floor repair

Contents

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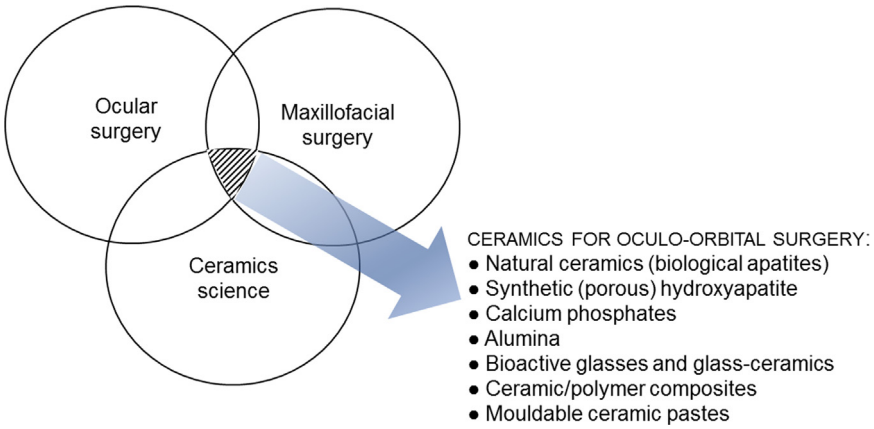

Fig. 1. Overview of biocompatible ceramics used in oculo-orbital surgery.

1. Context of application

Oculo-orbital surgery (OOS) is a highly interdisciplinary clinical specialty that involves the tight collaboration between maxillofacial and ocular surgeons, with the aim of treating critical patients affected by orbital diseases. Our face and eyes are often the first card that we present to others; therefore, traumas or pathological diseases involving damage to eye orbit region are associated to important societal and psychological issues, including self-acceptance. Recent advances in surgical techniques and biomaterials science allow even dramatic cases to be successfully treated with excellent postoperative outcomes. In this regard, some types of biocompatible ceramics have been proven to be particularly suitable and effective in OOS for the repair of orbital floor (wall) traumatic fractures and as orbital implants for anophthalmic patients (Fig. 1).

External, traumatic impacts to midface, such as blunt injuries, can lead to orbital blowout fractures in the inferior or medial thin orbital wall (bone thickness within 200–500 μm) as a result of the abrupt increase in intraorbital pressure [1]. A fracture of the orbital floor commonly causes herniation of the orbital content (fat and soft tissues) into the maxillary sinus located underneath, usually accompanied by enophthalmos[1] and/or hypoglobus[2]. Timing of repair, modality of surgical intervention and type of implanted materials used for bone grafting are all critical issues that strongly affect the overall outcomes of orbital floor fracture treatment [2,3]. Basically, the scope of the implant is to act as a bone graft ensuring structural support at the bone defect site (fracture); the implanted material is often designed as a porous scaffold to promote bone ingrowth and a safe anchorage to surrounding host tissues [4]. In this regard, porous hydroxyapatite (HA) and HA/polyethylene (PE) composite plates are the most commonly used biomaterials for orbital floor and wall repair.

In the case of severe trauma to the ocular globe, infections non-responsive to pharmaceutical therapy or intraocular malignancy (*e.g.* retinoblastoma in children), removal of the diseased eye have to be considered [5]. Orbital implants, often designed as porous spheres of HA, alumina or PE, are placed in the patient's anophthalmic socket at the time of evisceration[3] or enucleation[4] in order to allow adequate volume replacement and transmit good motility to the ocular prosthesis [6,7]. Surgical implantation can be facilitated by wrapping[5] the implant within a sheet of a smooth material, which is particularly recommended for the implants, such as those made of HA, characterized by an irregular, rough surface that could erode the conjunctival layer. The motility of the aesthetic ocular prosthesis can be improved by placing a titanium peg in the front of the orbital implant in order to guide the prosthesis movement in accordance to that of the orbital implant. It has been demonstrated that infections following implant exposure[6] are more amenable to treatment in porous implants compared to non-porous ones (*e.g.* silicone or poly(methyl methacrylate) (PMMA) solid sphere), as vascular ingrowth helps to anchor the implant *in situ* and permits immune surveillance via blood supply.

2. Repair of the eye orbit bone

The goal of an orbital floor (wall) implant is to repair the fractured eye orbit bone, lifting the ocular globe into its correct

[1]Recession of the ocular globe within the orbit. This disease may be acquired as a result of trauma (e.g. blowout fracture of the eye orbit bone) or related to postoperative complications of OOS.

[2]Downward displacement of the ocular globe; its aetiology and symptoms are quite similar to those observed for enophthlamos.

[3]Evisceration involves the removal of the contents of an eyeball, with the sclera and muscle attachments left intact (the orbital implant is therefore inserted in the scleral envelope).

[4]Enucleation involves the removal of the ocular globe from the orbital socket, together with the scleral envelope and a portion of the optic nerve, while the conjunctiva, Tenon's capsule and extraocular muscles are usually spared; this procedure is necessary in the case of ocular cancer spread to the sclera.

[5]Preoperative strategy that involves the wrapping of an orbital implant within a sheet of a smooth material, with the aim of facilitating its placement within the soft tissues of the eye socket, diminishing tissue drag and helping precise fixation of the rectus muscles to the implant surface. Wrapping is particularly recommended for porous orbital implants in order to provide a physical barrier over their slightly irregular porous surface. Suitable wrapping materials include scleral autografts and allografts, bovine pericardium and synthetic polymeric meshes.

[6]Break in the conjunctiva overlying the orbital implant, which may predispose to extrusion of the entire implant. Poor surgical technique, excessively large implant size and implant infection may all contribute to this postoperative complication.