BIOMATERIALS USED TO BUILT DENTURES

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Abstract

Bone is a complex tissue, which requires mechanical stimulation to develop correctly in the body. An implant is a device that is placed within the confines of the body tissue. Biomaterials used in prosthetic devices are designed in order to be used in contact with biological tissues for a long period of time minimizing any adverse tissue reaction. Biomaterials must be chemically and mechanically biocompatible and their mechanical strength must be appropriate for the specific structural function.

Bone is a complex tissue, which requires mechanical stimulation to develop correctly in the body. An implant is a device that is placed within the confines of the body tissue. Any material that comes into contact with any bodily tissues must be biocompatible, but the requirements for a material that actually is inserted and enclosed within the tissues are more rigorous.

Implants are used to replace missing teeth by anchoring a prosthesis to the mandible or maxilla. The prosthesis may be a single crow or en entire denture. Stability is one of the major benefits derived from the placement of an implant – supported prosthesis.

Bone is composed of a cellular component and an extracellular matrix. The cellular component is made of osteoblasts, bone-forming cells, osteoclasts, bone-destroying cells, and osteocytes, bone-maintaining cells which are inactive osteoblasts trapped in the extracellular matrix. The matrix, which is responsible for the mechanical strength of the bone tissue, is formed by an organic and a mineral phase. The organic phase is mainly composed of collagen fibres and the mineral phase of hydroxyapatite crystals. A liquid component is also present.

Cortical bone is the more dense tissue usually found on the surface of bones. It is organised in cylindrical shaped elements called *osteons* composed of concentric lamellae. Trabecular bone is quite porous and it is organized in *trabecules* oriented according to the direction of the physiological load. The configuration of the trabecular structures is highly variable and it depends on the anatomical site.

Cortical bone is an *anisotropic* material, meaning that its mechanical properties vary according to the direction of load (Figure 1). Cortical bone is often considered an *orthotropic* material. Orthotropic materials are a class of anisotropic materials characterized by three different Young's moduli E_1, E_2, E_3 according to the direction of load, three shear moduli G_{12}, G_{13}, G_{23} and six Poisson's ratios v_{12}, v_{13}, v_{23}, v_{21}, v_{31}, v_{32}.

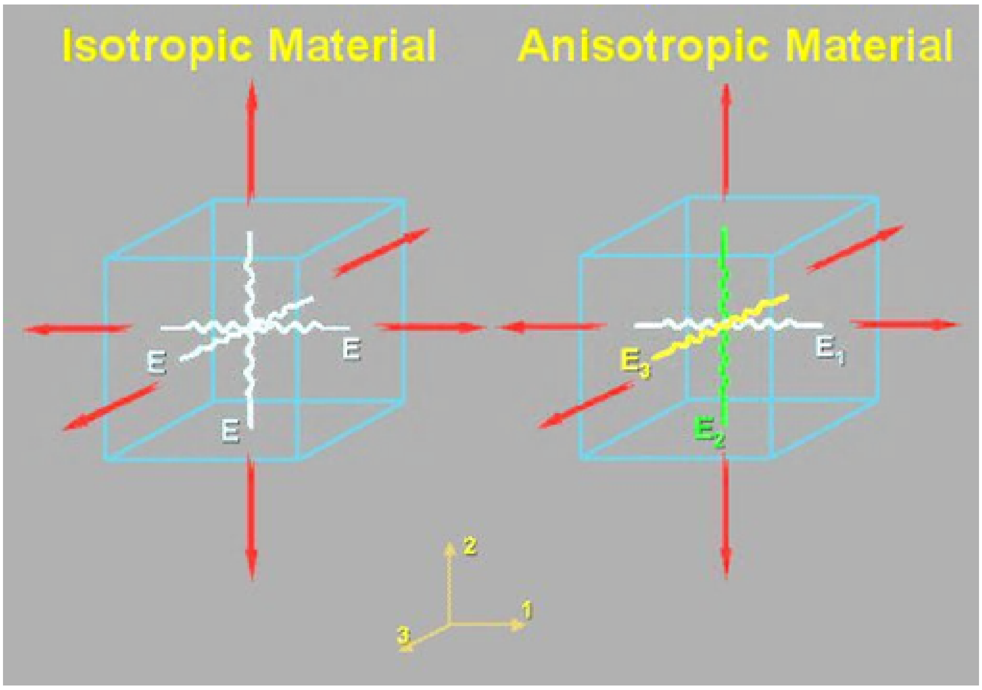

Figure 1: Comparison between the mechanical behaviour of isotropic and anisotropic materials

A few examples of elastic constants of cortical bone from different anatomical sites are reported in Tables 1,2.

	Corpus	Ramus
E_1 [Gpa]	10.93	11.77
E_2 [Gpa]	14.78	16.25
E_3 [Gpa]	18.89	20.42
G_{12} [Gpa]	4.24	4.8
G_{13} [Gpa]	5.13	5.72
G_{23} [Gpa]	6.27	6.67
v12	0.224	0.157
v13	0.295	0.292
v 23	0.275	0.273
v 21	0.276	0.211
v 31	0.501	0.5
v 32	0.28	0.033

Table 1: Average elastic constants of mandible bone in corpus and ramus

	Inferior	Lingual	Buccal
E_1 [Gpa]	10.63	10.85	11.04
E_2 [Gpa]	12.51	16.39	15.94
E_3 [Gpa]	19.75	18.52	18.06
G_{12} [Gpa]	3.89	4,59	4.31
G_{13} [Gpa]	4.85	5.45	5.2
G_{23} [Gpa]	5.84	6.49	6.45
v12	0.313	0.138	0.138
v13	0.246	0.338	9.322
v 23	0.226	0.332	0.294
v 21	0.368	0.178	0.257

v 31	0.465	0.572	0.518
v 32	0.356	0.357	0.326

Table 2. Average elastic constants of corpus cortical bone in inferior, lingual and buccal zones

The mechanical characterization of trabecular bone is even more difficult. The mechanical properties of trabecular bone as a whole are due to the mechanical characteristics of single trabecules and to its highly porous structure. Figure 2 shows the dependence of the Young's modulus of trabecular bone from bone density

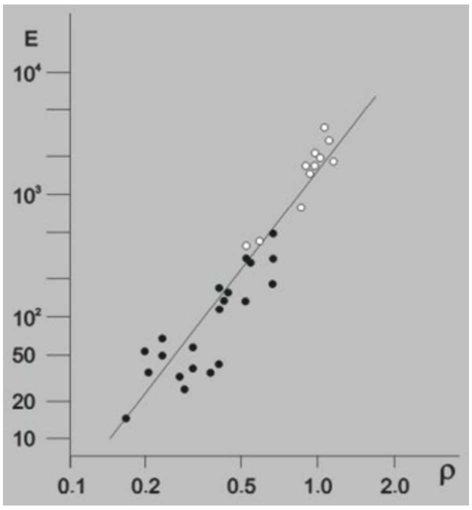

Figure 2: Young's modulus of trabecular bone as a function of density of bone. Bone density ρ is expressed in g/cm^3 and Young's modulus E in MPa.

Many types of the dental implants have been treated over the years. They have come in a variety of different shapes and have been made from a wide variety of materials. Many metals, such as platinum, silver, steel, cobalt alloys, and titanium, have been used, as have acrylic, carbon, sapphire, porcelain, alumina, zirconium, and calcium phosphate compounds.

Another type of dental implant has been used to repair defect in the mandible or maxilla or to enhance or augment the quality of the bone. Ceramic blocks or particles that can be shaped or packed into a void in the existing bone have been used with much success. These materials feel in and enhance the ability of the bone to support prosthetic devices. Bone grows into and through these particular materials and secure them in place. For hard tissue replacement, such tissue as the repair of bony defect, a porous ceramic implants, such as a calcium phosphate or silicate, may be seeded with cells capable to developing into new bone the help of added growth factors, such as bone morphogenetic protein, and surgically placed into the defect site. Other materials, such as freeze-dried bone, synthetic bone and collagen, and polylactic and polyglycolic acid copolymers, have been used as carriers of the growth factors. Glass-ceramics have been invaluable in dentistry for many years, but solubility and biocompatibility problems that have limited their use as biomaterials.

Biomaterials are designed to interface harmoniously with the patient's body. Typically these materials are used in prosthetic surgery. raditionally the tough 'biomaterials' developed for prosthetics uses have been quite different from the cell culture plastics used for tissue growth 'in vitro'. Increasingly, however, surface engineering is allowing us to adjust the properties of the materials used, so that tough biomaterials and delicate culture support media can express the same surface chemistry - if desired! Many of the materials being developed are 'hydrogels', polymers that are swollen with water and can resemble living tissues in their physical properties. The water content, water structure, phase morphology, polymer structure, biofunctionality and surface science ALL affect the biological performance of these materials in natural systems - which includes cells and the proteins and other materials they secrete. Biomaterials have been specifically designed or modified to interact appropriately with the body of the patient. In some instances we want to encourage the patient's cells to colonise the material, so that it becomes integrated with the body. In other instances, however, we may want the body to ignore the implant, so it does not become clogged with scar tissue.

Biomaterials used in prosthetic devices are designed in order to be used in contact with biological tissues for a long period of time minimizing any adverse tissue reaction. Biomaterials must be chemically and mechanically biocompatible and their mechanical strength must be appropriate for the specific structural function. Titanium and its alloys are the most common metallic materials used in dental implantology because of their high biocompatibility, low density, mechanical resistance and resistance to corrosion. Titanium has a low density compared to other metals: ρ = 4.5 g/cm^3. Its Young's modulus E has a value of about 100-110 GPa and it's ultimate strength σ_m is of about 300 MPa. The low density of titanium is such that its mechanical properties specific to density are much higher than those of other metals such as steel or aluminium. Titanium is often used in form of alloy. Alloy elements modify the microstructure of the material and thus its mechanical properties.

The body of the dental implant is in contacts with the bone and soft tissue interfaces within the submucosal regions. These contact zones within or along the bone surfaces provide the areas for mechanical force transfer (Bidez et al., 1986). Therefore, the implant –to - tissue interfaces become a critical area for force transfer and thereby the focal point for quality and stability of intraoral function.

The future materials for dental implants will most likely serve as intermediates that are used to produce engineered natural tissues rather than serve as final synthetic replacements.   Implants will be made from metal or ceramic.

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