

Review Article

IMPLANT MATERIALS REVISITED

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Abstract:

Osseointegration is defined by the American Academy of Implant Dentistry as “the firm, direct and lasting biological attachment of a metallic implant to vital bone with no intervening connective tissue.” Different materials, such as platinum, silver, steel, cobalt alloys, titanium and alloys, acrylic, carbon, sapphire, alumina, tantalum, niobium, zirconia and calcium phosphate compounds have been used as dental implant material. This article reviews the implant materials which are routinely used in dentistry.

Key words: Implant; osseointegration; titanium

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Introduction

Replacement of missing tooth with various materials dates back to ancient period of Greek and Egyptian civilization where bone, carved ivory, shells, metal and even animal teeth were used. Many materials were introduced later on but unpredictable failures occurred with them due to the lack of firm attachment. In 1952, Dr Perr Ingvar Branemark developed a threaded implant design made of pure titanium that showed direct contact with bone. This phenomenon was called osseointegration, defined by the American Academy of Implant Dentistry as “the firm, direct and lasting biological attachment of a metallic implant to vital bone with no intervening connective tissue”. With the emerging concept of osseointegration, devices were designed to mimic as much as possible cell interactions that normally take place during bone remodeling. Currently the implant materials available are diverse. Different materials, such as platinum, silver, steel, cobalt alloys, titanium and alloys, acrylic, carbon, sapphire, alumina,

tantalum, niobium, zirconia and calcium phosphate compounds have been used as dental implant material.^[1]

The physical, mechanical, chemical and electrical properties of the basic materials components must always be fully evaluated for any bio-material application as these properties provide key inputs into the interrelated bio-mechanical analyses of function. Thorough knowledge of different biomaterials is required for their judicious selection and application in implantology.^[2]

Implant design is integral to successful surgical intervention. Ever-changing methods of fixation and materials are studied and used to help attain improved results while limiting adverse outcomes. The development of bioabsorbable implants is an important aspect of this dynamic field of implant design. There are many options available to the surgeon who is interested in using bioabsorbable materials. Bioabsorbable polymers are becoming more popular as implant materials. These implants have several

leverages over the traditional metallic implants including reduced stress shielding since the implants bear less load initially and gradually transfer the load as they degrade.^[3]

Design process

Design means to create according to a plan. The word design indicates a process, not an end product such as the particular shape or material of a dental implant. Shape and material are only two of the many considerations in the multivariable design problem for dental implants.

The design process is a generic approach to problem solving and consists of these steps:

1. Identification of a need
2. Definition of the problem (and sub-problems) to be solved
3. Search for necessary background information and data
4. Formulation of objectives and criteria
5. Consideration of alternative solutions to the problem
6. Analyses and evaluations of alternative solutions
7. Decision-making and optimization

Design has some identifying characteristics. A complicated design problem will usually be broken down into sub-problems, so these can be addressed separately and then considered together in reaching final solutions. Often, design must go forward even when there is missing or unknown information. In design, judgments about the quality of a solution are made by measuring performance against the stated goals, not the other way around.^[4]

Bioinert

The term bioinert refers to any material that once placed in the human body has minimal interaction with its surrounding tissue, examples of these are titanium, alumina.

Titanium and Titanium alloys Ti6Al4V

Titanium is one of the most biocompatible material due to its excellent corrosion

resistance. The corrosion resistance is due to formation of biologically inert oxide layer. It spontaneously forms tenacious surface oxide on exposure to the air or physiologic saline. Three different oxides are formed that is TiO (Anastase) , TiO₂ (Rutile) , Ti₂O₃ (Brookite). TiO is the most stable and most commonly formed on titanium surface. This oxide layers is self healing i.e. if surface is scratched or abraded during implant placement it repassivates instantaneously.

Zirconia

Zirconia ceramic implants somehow had a controversial history regarding their phase metastability, degradation in water lubricants in simulation studies and influence on friction and wear phenomena. But was used with success as implant material in 1960s. It has higher flexural strength, fracture toughness and high Weibull modulus, lower young's modulus and ability to be polished to a superior surface finish compare to alumina.^[2]

Bioactive

Bioactive refers to a material, which upon being placed within the human body interacts with the surrounding bone and in some cases, even soft tissue. Prime examples of these materials are synthetic hydroxyapatite, glass ceramic and bioglass.

Hydroxyapatite

It was successfully used as implant material in 1988 at North America and to begin with for repair of residual ridge resorption in 1970s. It is similar to the mineral component of bones and hard tissues in mammals. This material has capability to integrate in bone structure and support in growth of the bone. It is thermally unstable with low mechanical strength to withstand long term load bearing applications.^[2]

Comparison

Although metal implants have shown undoubted success when used for internal fixation of bones or soft tissue, these implants do have some problems. Metal implants are stiff and are permanent in nature. Thus, they tend to unload the tissues by load bearing and may necessitate removal because of the need for future surgery, migration of the implants over time, or irritation of the overlying tissues. Metal implants also interfere with radiologic imaging of the underlying skeleton. Bioabsorbable implants show promise with regards to these points in that they will degrade over time and gradually allow loading of the bone and soft tissues. They do not interfere with future surgery because they have been absorbed or can be drilled through. Furthermore, they do not require removal and are radiolucent on roentgenograms. We are currently seeing an increase in the development of these devices and find them as fixation rods, plates, pins, screws, suture anchors, and sutures.^[3]

Conclusion

A wide range of biomaterials is currently in use for implants. It becomes necessary to select apt biomaterial. Appropriate selection of biomaterials directly influences, clinical success and longevity of implants. Despite the popularity of these implants, reports of complications continue to appear in the literature.

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