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Development Status and Application of Tricalcium Phosphate in Oral Clinical Treatment

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Abstract

Tricalcium phosphate (TCP) substitutes have been used as synthetic bone gap fillers in dental and orthopaedic applications because of their biocompatibility and high mechanical stiffness. Tricalcium phosphate (TCP) can be divided into low temperature phase β-TCP and high temperature phase α-TCP, among which β-TCP is one of the best materials to meet the requirements of bone tissue engineering scaffold. During bone regeneration, β-TCP exhibits absorbable characteristics and is completely replaced by new bone tissue after stimulating bone formation. Pure β-TCP is a fragile white solid whose color may change due to the presence of impurities. β-TCP is one of the most attractive alternatives to bone graft due to its synthetic properties, bone conduction, bone induction, and cell-mediated reabsorption. It has been proposed as a vehicle for topical application of drugs (bone morphogenetic proteins, antibiotics) to defect sites and has been widely used in dental and orthopedic bone regeneration applications. In this paper, the application of β-TCP in oral clinic and the new research progress at home and abroad are reviewed, providing a theoretical basis for the future application of β-TCP in oral routine diagnosis and treatment.

Keywords

Tricalcium phosphate, Oral clinical, Development status and application

Introduction

TCP is a porous bioceramic material with absorbability and biocompatibility. The material gradually degrades and is replaced by bone tissue. In this way, it acts as a scaffold for bone growth [1]. The microstructure (Ca/P ratio) of β-TCP in TCP replacement materials is very close to that of natural bone tissue, and it has good biodegradability and bone conductivity. When β-TCP was injected into the space of segmental bone defects, the rate of bone healing increased. This calcium phosphate ceramic has been widely used as a substitute for autograft in bone grafts and has excellent bone conductivity and absorbability when used to fill bone defects. During bone regeneration, β-TCP exhibits absorbable characteristics and is completely replaced by new bone tissue after stimulating bone formation.

This paper reviews the new progress and application of β-TCP in oral routine diagnosis and treatment, aiming to make β-TCP more widely known by stomatologists [2].

1. The application of β-TCP in oral and maxillofacial extratology

1.1 Field of bone defects:

Bone defects caused by oral and maxillofacial trauma and excision of cysts are often recovered by bone transplantation. Bone insufficiency or bone defects due to oral trauma, periodontal disease, or tumors often limit the successful outcome of denture restoration and implant implantation. Bone defects not only increase the likelihood of later infection, but also affect the shape and quality of the jaw. Although autologous transplantation is considered the gold standard for bone defect repair, it is limited by increased incidence at the donor site, limited availability, and invasive harvesting procedures. Allografts provide enhanced bone conduction while allowing the use of large and varied bone chunks, but they also carry a high risk of potential infection, nonunion, fatigue fractures, and rejection [2]. At present, β-TCP is one of the most commonly used and effective artificial bone graft substitutes. It is not only bone conductive, but also bone conductive. These properties, combined with its cell-mediated reabsorption, allow the bone defect to regenerate completely. Its clinical outcomes are sometimes considered "unpredictable."

1.2 Field of dental Surgery:

Bone defects caused by oral and maxillofacial trauma and excision of cysts are often recovered by bone transplantation. Bone insufficiency or bone defects due to oral trauma, periodontal disease, or tumors often limit the successful outcome of denture restoration and implant implantation. Bone defects not only increase the likelihood of later infection, but also affect the shape and quality of the jaw. Although autologous transplantation is considered the gold standard for bone defect repair, it is limited by increased incidence at the donor site, limited availability, and invasive harvesting procedures. Allografts provide enhanced bone conduction while allowing the use of large and varied bone chunks, but they also carry a high risk of potential infection, nonunion, fatigue fractures, and rejection. At present, β-TCP is one of the most commonly used and effective artificial bone graft substitutes. It is not only bone conductive, but also bone conductive. These properties, combined with its cell-mediated reabsorption, allow the bone defect to regenerate completely. Its clinical outcomes are sometimes considered "unpredictable." [6].

2. Application of β-TCP in the field of dentistry and endodontics

When the pulp is due to caries, trauma or iatrogenic stimulation (such as accidental exposure during caries removal of carious tissue), it is often needed to cover the pulp to soothe the pulp and promote the formation of pulp and dentin complex. Studies have shown that the combination of β-TCP and collagen hybrid construction is beneficial to the adhesion and proliferation of human dental pulp stem cells, thus promoting the differentiation of odontoblast cells [14]. It can be seen that β-TCP can be used as a pulp capping agent in pulp capping surgery. It is believed that with the deepening of future research, β-TCP will have more biological characteristics in dentistry and endodontics [2].

3. Application of β-TCP in the field of oral implantology

The treatment of bone defects has been a major clinical problem in the field of oral implantology. The GBR technique is a surgical procedure that uses a barrier membrane with or without granular bone graft or bone replacement to mechanically protect blood clots and isolate bone defects from the surrounding soft tissue, thus providing a secluded space for bone forming cells used for bone regeneration. The GBR membrane is placed at the interface between the soft tissue and the bone defect. Therefore, porous and rough microstructure are key parameters for this application, in addition to the above properties, whose nutrients, oxygen and bioactive substances are diffused through both sides of the membrane. The underside of GBR membrane contacting bone side should have a rough microstructure with high surface area to better interact with bone cells and provide bone cell adhesion and proliferation. The membrane used in GBR is a key factor in determining the ultimate repair effect, as it acts as a barrier to prevent the migration of rapidly proliferating epithelial and connective tissue to the defect area, thus providing sufficient space for cells with osteogenic potential to promote bone regeneration. Studies have shown that not only improves the mechanical strength of membrane, and due to its inherent biological activity, promote the in vitro and in vivo osteogenesis is reasonably the degradation rate of beta TCP composite membrane, adjustable

mechanical properties and excellent bone tissue regeneration, will be the dental, craniofacial surgery and orthopedic medical clinical application in the field of a promising option [4, 10].

4. Application of β-TCP in the field of orthodontics

White spots around the brackets are one of the most common complications during orthodontic treatment and the most easily recognized in clinical practice. These injuries are usually due to the accumulation of more biofilm in the area. Long-term retention of plaque due to the irregular surface of the orthodontic device and the lower pH conditions produced by caries-causing bacteria present in the mouth. Some studies have shown that adding β-TCP nanoparticles doped with antibacterial agent to the orthodontic bond bracket can significantly inhibit the growth of bacteria. β-TCP nanoparticles added with antibacterial agent did not affect the physical and chemical properties of orthodontic adhesive. β-TCP nanoparticles added with antibacterial agents are expected to be used as a new type of orthodontic bonding bracket. It has good mechanical properties and good caries inhibition potential [7].

5. Conclusion

Tricalcium phosphate (TCP) has two crystal structures: low-temperature β-TCP and high-temperature α-TCP. β-TCP has good biocompatibility, degradability and bone conductivity, and is widely used in bone defect repair, guided bone regeneration and other fields. However, its hydrophilicity, wettability and degradation mechanism still need further study. B-TCP can be absorbed, phagocytic and degraded by periodontal macrophages, osteoclasts and lymphocytes, and is currently widely used in clinical and basic research in the field of jaw defect repair and reconstruction. Nano-b-tcp has an extremely high void ratio, which is beneficial to the microcirculation and cell metabolism of pulp and periodontal tissue, and can be used to eliminate root tip inflammation, promote root tip cementum regeneration and periodontal reconstruction, which has an important application value. Therefore, β-TCP has a broad application prospect in oral routine diagnosis and treatment. At the same time, β-TCP also has shortcomings and deficiencies. It is believed that with the continuous research of basic research and clinical work in the future, oral clinicians will skillfully select appropriate indications, so that β-TCP can be applied in clinical more standard.

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