RESEARCH PROGRESS IN REPAIRING ALVEOLAR BONE DEFECT

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ABSTRACT

Alveolar bone is the most active bone in the human body which is highly malleable. It can change with masticatory pressure and can be reconstructed with the movement of the teeth. After the tooth is lost, the bone will be absorbed and even disappear. On the thinner side of the alveolar wall, tooth extraction will lead to the formation of bone fenestration or fracture. In this paper, the research progress of alveolar bone defect repair was reviewed from the perspective of understanding the characteristics of alveolar bone and the selection of repair materials.

INTRODUCTION

In recent years, the increasing medical and medical costs associated with bone diseases have brought about many adverse effects on people's lives and the economy. The improvement of the quality of life has extended the average life expectancy, and the world population is also facing the crisis of aging. More and more skeletal and muscular diseases are emerging, such as fracture, scoliosis, osteoporosis, bone infection or bone tumor, congenital bone defects, oral and maxillofacial diseases, osteoarthritis, and other diseases. In the above diseases, oral and maxillofacial bone defects caused by trauma, tumor or congenital malformation are quite common bone diseases, which have a significant impact on patients' quality of life. It is difficult for large bone defects to heal on their own, and intervention is needed to promote healing. It is difficult for large bone defects to heal on their own, and intervention is needed to promote healing. At present, bone transplantation is the main clinical method to treat large bone defects. Although bone grafting has been used in clinical practice for decades and its effect has been widely recognized, it still has many shortcomings and limitations. It is necessary to research better biomaterials to replace bone grafts and bring a new chapter for the treatment of bone defects in human beings.

Repair effect of autologous bone on alveolar bone

Autologous bone is derived from the patient's own body, which contains a large number of active osteoblasts and osteoblasts as well as various cytokines in the bone matrix. For example, bone morphogenetic proteins can induce osteoblasts to differentiate into osteoblasts. Autologous bone transplantation can avoid immune rejection caused by difference in histocompatibility. However, bone resorption occurs during the healing process. Osteoclast infiltration can be seen in the lacunae, which results in a change in the volume of bone tissue and a decrease in bone density and height [1].

There are three main types of autologous bone repair materials: cortical bone fragments, bone blood clots, and a mixture of cancellous bone and cortical bone. Fragmented cortical bone is prone to osteonecrosis due to its large granules (about 1559.6μm x 183μm, so bone blood clots and mixture of cancellous bone and cortical bone are now widely used [2].

Repair effect of allograft bone on alveolar bone

Allograft bone mainly includes freeze-dried bone, demineralized freeze-dried bone and frozen bone. Most of them come from cadaver bones. After a series of degreasing, demineralization, guanidine hydrochloride and X-ray treatment, their immunogenicity is greatly reduced, which can reduce the rejection reaction after bone transplantation, but also lose the

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osteointegration. Liu J, et al. [3] applied autologous bone, frozen bone, and lyophilized bone to the treatment of bone defects in sheep. 3 months later, it was observed that in terms of osteogenic effect, frozen bone was close to autologous bone. However, frozen bone transplantation will face the problem of bone graft absorption caused by immune response. The osteogenic effect of freeze-dried bone was not ideal, but its antigenicity was low, and it had a good bone guiding effect. Therefore, lyophilized bone is now used as a standing product in bone Banks of various countries. However, in the use of lyophilized bone, people still faced some difficulties, such as certain immune rejection reaction, strong tissue response, more postoperative exudation, poor ability to fight infection and so on.

Repair effect of artificial bone substitutes on alveolar bone
Bone substitutes are artificially extracted or synthesized materials. These materials have good biocompatibility, good compressive strength and hardness. The main types are as follows:

**Artificial ceramic bone substitutes and composites**

**Hydroxyapatite (HA)**

HA is the main component of vertebrate bones and teeth. More than 96% of the inorganic content in human enamel is HA. HA has excellent biocompatibility and can be used as a bone or tooth inducer. However, due to the lack of bone induction activity and low degradation rate, HA is difficult to be completely replaced and utilized by the organism. So many scholars have improved on HA. Barboza EP et al. [4] combined HA with bone morph ogegetic protein (BMP), which showed osteoinductive activity. Viglia G et al. [5] have refined HA to nanoscale with a similar microstructure to that of natural bone. Nanoscale size is more conducive to degradation and absorption. There are many researches on composite materials containing HA, including non-degradable n-HA/polyethylene, n-HA/nimes, n-HA/polyacrylic acid and degradable n-HA/polyanhydride with collagen, gelatin, chitosan, polylactose, polyanhydride, etc. [6] Chinese scholars had also made a comparison between autogenous bone and collagen hydroxyapatite for repairing mandibular defects. The results showed that collagen hydroxyapatite had good osteogenic effect and could promote the growth of new bone earlier. This practice also relieves the psychological burden and pain of bone removal from the two operations. [7]

**Calcium phosphate bone cement (CPC)**

Calcium phosphate cement is an artificial apatite material with biological activity. Compared with common bone cement, it has good biocompatibility, no heat generation during solidification and crystallization, high compressive strength and no interference to CT and MRI imaging [8]. Compared with the traditional hydroxyapatite, it has more advantages in shaping and preparation. As a new type of bone tissue repair material, CPC has attracted the attention of scholars all over the world. However, the application of CPC in clinical practice has been limited due to its brittleness, lack of mechanical properties, slow degradation, and lack of osteoconductivity.

**Bioactive glass (BG)**

Bioactive glass is a kind of glass system based on Na₂O-CaO-SiO₂ and fused together with P₂O₅ or MgO, SiO₃, Na₂O and K₂O as additional components. This is an absorbable material, especially the nano-sized BG with high biocompatibility. The bone tissue around BG particles grows faster and the newly formed bone is denser than that around HA particles.

**Inorganic salt extracted from heterologous bone**

Bio-Oss bone meal is a kind of biological bone mineral obtained from the removal of organic components from calf bone. It has natural clearance and strong mechanical strength. Because the chemical and inorganic components of Bio-Oss are similar to the structure of human bone tissue, they can provide calcium and phosphorus ions for the formation of new bone. The natural pores in its internal structure, which help stabilize the clot, can be absorbed slowly. As a bone filling material, Bio-Oss will not cause immune rejection in human body [8]. Although it has good bone conductivity, it lacks bone growth and osteoinduction, because the Bio-Oss bone meal lacks active components such as osteoblasts and growth factors. Wei P et al. [9] filled the complex of platelet-rich fibrin (PRP) and Bio-Oss bone meal into the bone defect to accelerate the formation of new bone. In particular, the transfer growth factor-β can enhance the chemotactic and dividing ability of the osteoblasts precursor and inhibit bone tissue absorption and osteoclast formation, which just makes up for the defect of Bio-Oss bone meal.

**Artificial polymers and their compounds**

Polymer materials have better mechanical properties and self-curing properties. Collagen and chitosan in bone repair materials are natural materials. Synthetic materials mainly include Poly methyl meth acrylate (PMMA), polyactic acid, polyglycolic acid, etc. [10]. As a bone repair material, PMMA has been used in about 20 million cases worldwide. As a bone repair material, PMMA has been used in about 20 million cases worldwide. Artificial bone substitute material has a wide range of sources, and good histocompatibility. But they only have bone conductivity without inducing the activity of bone regeneration. After contacting with the host bone, they underwent transformation and absorption, and finally form the bond bone strengthened by the autogenous bone and the substitute material. Finally, the combination of autogenous bone and substitute material was formed. Most of the combined bones have good compressive strength and a certain absorption rate, which is affected by particle size, porosity, chemical composition and other conditions. It needs to be combined with bone-induced bioactive factors to achieve better results.

**Tissue engineering techniques**

Tissue engineered bone is a promising new bone repair material at present [14], which can simulate the natural process of bone repair, accelerate bone regeneration, and minimize the immune response and carcinogenicity. The scaffold material allows the osteoblasts to adhere and grow, which is beneficial for the material to be transplanted into the body and absorbed. Calcium phosphate ceramic is a kind of bone bioactive ceramic material, whose physicochemical properties meet most of the requirements of ideal tissue engineering carrier material, and it is an ideal material at present. About bioactive proteins, the
growth factors that play an important role in bone cell formation are as follows: bone morphogenetic protein, fibroblast growth factor, transforming growth factor-insulin like growth factor, enamel matrix protein and colony stimulating factor, platelet derived growth factor, etc. Although great progress has been made in the research and clinical application of tissue-engineered bone, there are still problems in the research of basic science, the treatment of ethical issues and the improvement of clinical application.

**Future perspectives**

More than 40 years of research and exploration have been carried out in various ways to provide patients with a fuller and higher quality alveolar bone for better functional recovery and aesthetic appearance. No matter how the bone defect is repaired, it is essential to stimulate or induce its own osteogenic potential and to provide the materials, space and environment needed for osteogenesis. In clinical practice, it is necessary to adopt a simple attitude, take safety and effectiveness as the premise, and the cost should be low, in line with the ethical requirements, so that patients can accept it.

**References**