Research progress of biomedical polymer materials in bone tissue engineering

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Abstract. Defects, defects and dysfunctions caused by disease, surgery or aging are among the most important threats to human health. Although organ transplantation and surgical reconstruction rehabilitation treatment measures have saved or prolonged a small number of lives, they still have shortcomings and limitations. Biomedical polymer materials have great potential in bone tissue engineering, and with the progress of material science, molecular biology, medicine and other fields, their application in bone tissue engineering is becoming more and more extensive. This paper introduces the types and polymer properties of biomedical polymer materials in bone tissue engineering, and introduces and prospects the current development of biomedical polymer materials in the field of bone tissue engineering.

Keywords: tissue engineering, biomedical polymer materials, bone tissue.

1. Introduction

Bone defect is a common clinical problem in the world, which is often caused by congenital causes, diseases, trauma and so on [1]. Clinically, bone defect diseases are common and complicated, and the existing methods of repairing bone defect are insufficient, bone tissue engineering is the most promising new method in recent years, and the use of bio-polymer materials to replace the defect of human body parts has become an advanced treatment of bone defects [2]. As the most important branch of polymer, medical polymer materials are used in diagnosis, treatment, repair and replacement to improve and restore the function of biological tissues and organs. Medical polymers and their products are also increasingly used in clinical practice due to their unique compatibility and non-toxic properties [3]. This article reviews the application of common medical polymer materials in bone defect repair, and analyzes the advantages and disadvantages of various materials, in order to provide clinical suggestions for the clinical application of polymer materials to repair bone defect. This study has a strong clinical significance, can provide clinical decision-making, bone defects for the treatment of this common serious orthopedic disease to make a huge contribution.

2. Characteristics of biomedical polymer materials

The most common medical polymer materials are: silicone; Plexiglass nylon polyester; Compounds such as polytetrafluoroethylene. Therapeutic polymer materials have high purity and chemical resistance; The use must demonstrate its stability and resilience to the organism [4]; The substance in the body must be able to combat its biological toxicity, if it is resistant to the action of blood and various enzymes, then

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it is non-toxic; It must have non-cancerous and non-toxic biochemical properties; Must be easy to digest and flexible, with heat resistance [5]. Before the sixties of the twentieth century, people used existing polymer materials to find materials suitable for the biomedical field according to needs, but in practice, it was found that many problems such as coagulation and inflammation were difficult to solve, and people realized the need to combine all factors [6]. From the beginning, medical polymer materials should be manufactured in accordance with the objective requirements of medical applications, especially the requirements of biocompatibility [7]. Therefore, good biocompatibility is necessary for biopolymer materials, which mainly include histocompatibility and hemocompatibility.

2.1. Tissue compatibility

Histocompatibility requires that medical polymer substances be absorbed by the human body without adverse reactions to tissues and cells. When medical supplies and tools enter specific areas of the body, local tissues respond to external stimuli [8]. In severe cases, tissue necrosis occurs. During long-term installation, the substance will be surrounded by lymphocytes; It is surrounded by fibroblasts and collagen fibers, forming a fibrous sheath that separates normal tissue from the implanted material [9]. If it stabilizes and adapts to the tissue, the enclosing membrane will be slightly thinner, i.e. the enclosing membrane will not expand, indicating that the material is absorbed by the body and is non-toxic to the tissue [10].

2.2. Blood compatible

Therapeutic substances used in the body inevitably come into contact with blood, and if the blood touches the outer surface of the implant, it can trigger hemolysis and clotting, which in turn leads to thrombosis [11]. Therefore, when using medical devices, the compatibility of substances in the blood cannot be ignored. When high molecular weight substances interact with blood according to the surface properties of the substance, different plasma proteins will adhere to the surface of the exosome to varying degrees, resulting in platelet adhesion or dysfunction [12].

3. Application of biomedical polymer materials in bone tissue engineering

The raw materials of biomedical polymer compounds have been widely studied in the field of medical polymer materials, and the research on biomedical polymers has also attracted widespread attention [13]. At present, there are three main types of medical polymers used to manufacture bone tissue: microbial polymers; Natural and chemical polymers [14].

3.1. Microbial synthesis of medical polymer materials

Polyhydroxy butyrate (PHB) is a type of polyhydroxy butyrate (PHB) that is stored in microorganisms under unbalanced growth conditions. It has not only the same properties as polymer materials, but also the same bioavailability, biomedical properties; It also shows excellent results and immunity [15]. PHB is responsible for the production of tissues and is the best choice for tissue engineering due to its good combination with body composition and chemicals [16].

3.2. Natural medical polymer materials

Chitinin is a natural polymer compound whose biosynthesis occurs naturally after cellulose. It is widely found in the cell walls of insects, crustaceans and fungi [17-18]. Chitosan is a product of deacetylation of chitin and is its most important chemical product. Chitosan substances are highly toxic. The non-antigenic properties of chitosan are important in slowing cell proliferation and promoting tumor and connective tissue formation. In vitro, Liu Gengyan and his colleagues studied the effects of chitosan on osteoblast developmental differentiation and bone formation. Experiments have shown that chitosan promotes the early formation of bone cells and accelerates bone formation. Experiments on in vitro bone fibroblasts prepared with chitosan/calcium phosphate cotton and platelet growth factor have shown that cell maturation, division, and growth of cotton matrix can induce new bone formation [19-20].

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Collagen is the main component of mammary glands, bones, cartilage, muscles and tendons and is the most abundant animal protein. In addition to supporting and protecting cells, collagen is closely related to cell adhesion, growth, and phenotypic expression. Collagen has the following properties:

(1) Good biocompatibility;

(2) digestion and absorption capacity;

(3) Antigenicity can be eliminated after treatment;

(4) promote tissue recovery;

(5) No foreign body reaction.

3.3. Synthetic medical polymer materials

The microstructure, mechanical properties and deterioration time of artificial medical polymer materials can be designed and customized in advance. With controlled conditions, good reproducibility and mass production can be carried out on demand, making it the most widely studied and used scaffold among tissue engineering materials.

The most widely studied and widely used polymer solvent compounds are oils and fats, including polylactic acid (PLA), polyglycolic acid (PGA), polycaprolactone (PCL) and their copolymers. LA, PGA and their copolymers are well suited for tissue engineering. The decomposition rate of PLA and PGA copolymers can be controlled as needed by adjusting the ratio of the two monomers, and can be completed by 3D printing various physical models suitable for clinical use, forming solvents, and layering. Vacanti reports that for the first time, chondrocytes are inoculated in vitro using PGA and PLA as substrates, and new cartilage is obtained through tissue engineering. Although polylactic acid is a non-toxic biopolymer with degradation products, cell interaction is very poor. Liu Yangchuan et al. chose lecithin and polyline combined with PGA+PLA. Studies have shown that it can significantly improve the hydrophilicity and viability of stem cells. Fika et al. found that arginine-glycine-aspartic acid (RGD) peptides were used to prepare polylactic acid-arginine (PLAL) copolymers for the growth of aortic endothelial cells [21-22]. Cannizaro studies have shown significant improvements in cell viscosity and proliferation compared to a control group without peptides.

Polyanhydride (PA) was originally developed in the form of textile fibers, but its hydrolytic properties hindered further research and development. Aliphatic polyhedroids are completely destroyed within a few days, while aromatic polyhedroids take years to completely decompose. By changing the ratio of monomers to polyhedroids, polyhedroids with decomposition times ranging from one week to several years were designed and developed. Ataxia synthesized the copolymer of anhydride and tetraic acid, respectively, using 1,6 dicarboxyphenoxyhexane and benzenetetraic acid as components of acid anhydride, and used this copolymer as a carrier for osteocytes. In the experiment, the copolymer is shaped into a disc shape and integrated with the osteoblast line MC3T3-E1. The results showed that the cells were well tolerated and morphologically normal.

4. Conclusion and outlook

Among the various tissues and organs produced by tissue engineering, osteochondral tissue engineering may be the first to enter the clinical application stage, which has good development potential and clinical value. However, to be widely used in clinical practice, there are still many problems that need to be solved. The search for newer, more effective biodegradable materials as carriers needs to continue. When the existing materials are used as extracellular matrix materials for bone tissue engineering, there are certain deficiencies, and the process and manufacturing technology of cell support materials are not very mature in the industry. Therefore, when selecting tissue engineering cell support materials, it is necessary to fully consider the advantages and disadvantages of various materials, and adopt appropriate methods to combine a variety of materials into composite materials, and the continuous progress of material processing technology will surely achieve ideal tissue engineering extracellular matrix materials and be widely used in clinical practice.

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