

## Review Article

Open Access, Volume 3

# Elastomer in vascular tissue engineering research progress of scaffold materials for constructing tissue engineered blood vessels

Jianming Yuan\*

Clinical Medical Laboratory Department, Wuxi Ninth People's Hospital, Wuxi, Jiangsu, China.

\*Corresponding Author: Jianming Yuan

Clinical Medical Laboratory Department, Wuxi Ninth People's Hospital, Wuxi, Jiangsu, China.  
Email: 13921286577@163.com

Received: Dec 01, 2023

Accepted: Dec 21, 2023

Published: Dec 28, 2023

Archived: www.jjgastro.com

Copyright: © Yuan J (2023).

## Introduction

As we all know, the main purpose of tissue engineering scaffolds is to provide a good environment for the growth of cells and tissues, and gradually degrade with the construction of tissues, providing cells and tissues for new space. Tissue engineering scaffold material is the focus of tissue engineering research. It has good development prospects and potential economic benefits, and has gradually become one of the most developed industries.

### Requirements for scaffold materials in tissue engineering:

The behavior of cells in organs or tissues is not only determined by the internal gene sequence of cells, but also affected by external environmental factors, that is, the interaction between cells and extracellular matrix. It is well known that extracellular matrix can not only promote the growth of cells, play a protective role, but also make it interact with cells, adjust the morphology of cells, and then have a certain impact on cell survival and proliferation. In the whole tissue engineering research, reasonable design and preparation is helpful to the adhesion and

## Abstract

This paper first introduces the requirements of tissue engineering for scaffold materials, and then analyzes the available scaffold materials, hoping to provide help for the research of tissue engineering vascular scaffold materials, and then promote the rapid development of tissue engineering industry.

**Keywords:** Tissue engineering; Vascular scaffold materials.

proliferation of seed cells, which is a very important material. The extracellular matrix consists of balanced proteoglycans, glycoproteins and filamentous collagen fibers [1]. In general, the best extracellular matrix has the following characteristics, specifically:

- (1) It has good biocompatibility, which can effectively reduce the occurrence of inflammation and toxicity.
- (2) It has strong absorbability and can be absorbed by its own tissues [2].
- (3) It can form a variety of three-dimensional structures and maintain a certain shape after entering the body.
- (4) The chemical properties and microstructure of the surface can promote cell adhesion and growth to a certain extent.
- (5) The degradation rate can be adjusted reasonably according to the actual situation.

### Scaffold materials that can be used

**Natural materials:** In general, natural polymers mainly include collagen, fibrin and so on [3]. They have high biocompatibility and cell recognition signals, which can help cells to adhere and proliferate. Natural materials are widely recognized for their objective price, wide variety and biocompatibility [4].

**Collagen itself:** In general, collagen is present and abundant in mammalian bodies. In the actual evolution of collagen, the original amino acid sequence is not disordered. Therefore, the scaffolds made in this way have good biocompatibility and no antigenicity, which are approved by FDA and widely used in hemostasis, wound recovery and tissue regeneration rust inducer. The signal skin sequence of collagen can play a certain role in recognition, help cells recognize scaffold materials, and make the phenotype and activity of cells more coherent. For example, bovine type I collagen has been widely used in tissue engineering scaffolds [5]. Ye et al. Used collagen as the scaffold material of tissue engineering, successfully constructed tissue-engineered heart valve, and implanted it into sheep pulmonary valve, which also achieved certain good results [6]. According to the relevant investigation, it was found that the size of the biomaterial cardiac patch made of collagen scaffold material did not change substantially after implantation, with good elasticity and high contractility. In the tissue-engineered myocardial tissue made of liquid collagen, myocardial cells can be evenly distributed in the whole band, and have good tensile properties. The nucleus is long spindle, similar to the natural mature myocardial tissue. Collagen is used as raw material to establish tissue engineering scaffold by rapid prototyping, which can design and process materials by computer, and promote the smooth development of tissue engineering scaffold.

**Fibrin:** Fibrin is the most widely used biomaterial in the development of medical materials [7]. As a part of the natural extracellular matrix, fibrin has a good role in mediating intercellular signal transduction. Fibrin alone can form fibrin gel with three dimensional network structure under the influence of thrombin. The fibrin gel formed by polymerization can promote cell adhesion, proliferation and secretion of more matrix by releasing B transforming factor and platelets, and has strong biocompatibility. In addition, fibrin gel has a strong molding ability, which can reduce thrombin concentration and prevent fibrin polymerization, thus providing time for gel formation. Such fibrin gel is usually derived from the blood of the body. It can effectively reduce the occurrence of immunogenicity and is a better extracellular matrix material [8]. Fibrin gel composite chondrocytes were combined with thymus free skin. After 12 weeks of observation, the new cartilage was transparent cartilage, and the wet weight of aminoglycan and cartilage was similar to that of normal cartilage. Compared with the traditional artificial bone/BMP, fibrin can better absorb cartilage defects, but it has the problem of poor mechanical strength [9].

**Chitin:** Chitin is a kind of natural polysaccharide which is only lower than cellulose, and mainly exists in insects, crustaceans and so on. Chitin and its derivatives are an important part of lower animals and plants, and are also positively charged polymers. They are non-toxic and non-irritating, and can be used in artificial skin and surgical suture [10].

**Hyaluronic acid:** Hyaluronic acid, also known as hyaluronic acid, is mainly present in animals, human tissues and extracellular matrix, and is high in aqueous humor, synovial fluid, skin and umbilical cord. In addition, hyaluronic acid is a natural macromolecular straight chain polysaccharide, which is recognized as a natural moisturizing factor. Hyaluronic acid macromolecules are easily degraded to produce H<sub>2</sub>O and CO<sub>2</sub> [11]. At present, hyaluronic acid is a kind of medical material with high absorption molecules, which is widely used in ophthalmic surgery, joint disease treatment and so on. In addition, if the condition is neutral or acid is mild, a kind of material with low absorption rate and slow degradation rate is obtained, which has certain mechanical properties and can be used in bone tissue materials.

**Silk:** Silk, one of the natural polymer materials, has stronger mechanical properties. Compared with the traditional artificial synthesis, silk has better biocompatibility and can degrade polymer better. It is widely used in the development of medical industry. For example, silk fibroin based surgical suture has no antigenicity in human body and will not form thrombosis. It is a kind of natural biological fiber with good biocompatibility and mechanical properties. To some extent, the anticoagulant property of silk fibroin film can be improved by ion treatment on the surface of the film and combining with sulfonic acid group. In China, silk fibroin membrane has been made into tubular materials and applied in the construction of artificial blood vessels, which has achieved good results [12].

**Gelatin:** The application of gelatin sponge in tissue engineering scaffold material [13], combined with homologous rat myocardial cells, can establish a fluctuating patch with physiological function. The patch can be replaced by the anterior wall of rat right ventricular outflow tract. With the degradation of the scaffold material, the patch becomes thinner, and inflammation may occur after surgery. After a period of time, the scaffold material will degrade, the inflammation will disappear, and the patch will root and it beats according to the beating of the heart.

### Synthetic polymer materials

**Polylactic acid and its copolymers:** As we all know, polylactic acid is a kind of poly (lactic acid) with three isomers. It can be degraded in the body to form lactic acid, which is the metabolic product of sugar. However, after degradation, PLA can form light glycolic acid, which can guarantee the metabolism of the body. These polymers are thermoplastic plastics, which can be processed into various structural shapes by extrusion and solvent casting. They have the characteristics of non-toxic and biocompatibility. They are widely used in food and drug management in the United States, and become the main materials for medical suture and display scaffold. Poly (lactic acid) (PLA), poly (light glycolic acid) and their copolymers are the most widely used extracellular matrix materials for tissue engineering, but there are some limitations. Specifically speaking:

(1) Hydrophilicity and cell adsorption capacity are relatively poor. However, the scaffold can be pre wetted by ethanol in two steps, so as to improve the hydrophilicity and ensure that the cells can be evenly spread on the surface of the scaffold, which can help increase the number of fibrovascular endothelial cells after body transplantation [14].

(2) There is aseptic inflammation. After the use of polylactic acid and poly (light glycolic acid), patients will have non-specific aseptic inflammation, and the relative molecular weight degradation products can be increased to a certain extent. If the average molecular weight of polylactic acid is less than 20ku, the incidence of aseptic inflammation is higher. At present, most people think that the main reason of aseptic inflammation is due to the direct relationship between acid degradation products and polymer degradation. Therefore, the combination of calcium carbonate, sodium bicarbonate and polymer can reduce the pH value and effectively reduce the occurrence of aseptic inflammation.

(3) Insufficient mechanical strength.

(4) The residual organic solvents in polymers are toxic, which can easily lead to fibrosis and the decrease of immune capacity of surrounding tissues.

**Poly acid blending:** The polymerization of Fusic acid is an important part of polyacid. It is connected with acid and is unstable in water. It is easy to hydrolyze into fusidic acid. At the present stage, there are many kinds of polyacids, such as aliphatic cluster polyacids and polyphthalamic acid ligands, which are relatively active and unstable in water. Fatty acid clusters may degrade in a few days, while aromatic polyacids may degrade completely in a few years. Combining the characteristics of the two organically, the composition of the two monomers in the main chain is configured according to a certain proportion, which can effectively control the performance of the material and explain the speed [15].

**Polybutyric acid:** Polybutyric acid is generally isolated from bacteria, and then found in many bacteria, such as local bacteria, red Spirillum, etc. Polybutyric acid (PBA) is a kind of biodegradable material with good biocompatibility [16]. It can be used in medium and long-term controlled-release drugs because of its long degradation time. Embedding fibronectin in polybutyric acid can promote the adhesion of polybutyric acid materials to cells.

**Poly (coumarin):** According to a large number of studies, a highly porous polyalkane foam has been developed. The degradation product is poly (B) -3 light butyric acid, which is shaped by small particles. It is usually detected by phagocytic cells, osteoblasts and polycarbonate foams in vitro. The biocompatibility of poly urethane is found. The final result is phagocytic cells and osteoblasts, which are all normal. There is no cell damage in [17]. Compared with the tissue culture in poly (ethylene propylene), the cell adhesion and proliferation of PCU were better. The degradation product of poly (coumarin) is based on the fact that acid can phagocytize macrophages, and osteoblasts have certain phagocytic capacity, and can also be used as nerve conduit materials. Chondrocytes cultured in poly urethane foam showed that the cells had good adhesion and phenotype, and grew well on the surface and pore size of the material [18].

**Nano polymer scaffold materials:** Nanotechnology is to manipulate atoms and molecules in 1-100 nm space, so as to process and design materials, and finally form products; or to conduct in-depth research on materials, and to be familiar with the motion laws and characteristics of molecules and atoms. Nano block materials have been prepared by inert gas agglutination, and the concept of nanomaterials has been put forward. With the development of nanotechnology, it has been widely used in tissue engineering, mainly as scaffold materials. Nanoma-

terials have unique advantages, as scaffold materials can promote cell growth and tissue regeneration. In addition, the pore diameter of porous polymer scaffolds is closely related to cell adhesion, growth and proliferation [19]. Although natural multi empty extracellular matrix has many advantages, it also has some disadvantages. Specifically speaking, it is easy to cause the occurrence of allogeneic diseases [2]. Immune response is easy to occur. In order to effectively avoid the occurrence of the above situation, the relevant staff through the particle precipitation technology and phase separation technology to synthesize porous polymer materials similar to animal collagen, such as polylactic acid, polyglycolic acid, etc. with the deepening of research, polylactic acid and agarose or inorganic salt particles are combined, while phase separation technology is also integrated into other processes, gradually. Four kinds of nanofiber scaffolds have been formed, which are uniaxial tubular macroporous structure, orthorhombic macroporous network structure, spiral tubular macroporous structure and multilayered macroporous structure. These scaffolds can not only promote cell adhesion, localization and proliferation, but also be affected by the migration and distribution of cells by the micro structure, so that the information between cells can be transmitted faster, and it can be made according to the actual situation Shape restoration [20].

## Conclusion

In a word, tissue engineering is a new and developing subject, which can provide help for people's healthy life and life extension. The ultimate goal of tissue engineering scaffolds is to be used in clinical practice, so we need to fully consider the performance of materials, and then provide convenience for surgery, that is, whether the materials need to be disinfected, whether the implantation is simple, whether it can be mass-produced, etc. It is fundamental to study tissue engineering materials to have clinical value and effective tissue engineering scaffold. Therefore, the integration of cell engineering and biomaterials can promote the rapid development of tissue engineering industry.

**Funding:** The study was supported by "the B Project of Wuxi Association for Science and Technology (KX-23-B49, KX-23-B89)".

## References

1. Guan Y, Yang B, Xu W, Li D, Wang S, Ren Z, Zhang J, Zhang T, Liu X, Li J, Li C, Meng F, Han F, Wu T, Wang Y, Peng J. Cell-Derived Extracellular Matrix Materials for Tissue Engineering. *Tissue Eng Part B Rev.* 2022; 28(5): 1007-1021.
2. Wu Xiaotong, he Er, Liu Laijun, Li Chaojing, Wang Lu, Wang Fujun. Research progress of tissue engineering scaffolds based on polycaprolactone fiber. *Chinese Journal of Biomedical Engineering.* 2020; 39 (05): 611-620.
3. Aljohani W, Ullah MW, Zhang X, Yang G. Bioprinting and its applications in tissue engineering and regenerative medicine. *Int J Biol Macromol.* 2018; 107(Pt A): 261-275.
4. Wang Zhihao, Zhang Boyou, Ma Jun, Shi Hongcan. Research progress of trachea vascularization in tissue engineering. *International Journal of Biomedical Engineering.* 2019; (03): 245-249.
5. Salvatore L, Gallo N, Natali ML, Terzi A, Sannino A, Madaghiele M. Mimicking the Hierarchical Organization of Natural Collagen: Toward the Development of Ideal Scaffolding Material for Tissue Regeneration. *Front Bioeng Biotechnol.* 2021; 9: 644595.

6. Pan Xingna, Pu Lei, Li Yaxiong, Hou zongliu, Jiang Lihong. Research progress on scaffold materials and seed cells for constructing tissue-engineered blood vessels. *Hainan Medical Journal*. 2017; 28 (03): 446-450.
7. Melly L, Banfi A. Fibrin-based factor delivery for therapeutic angiogenesis: friend or foe?. *Cell Tissue Res*. 2022; 387(3): 451-460.
8. Liu Xuqian, Wang Jie. Research progress of tissue engineered vascular scaffold materials. *Medical Review*. 2016; 22(19): 3813-3817.
9. Wang D, Xu Y, Li Q, Turng LS. Artificial small-diameter blood vessels: materials, fabrication, surface modification, mechanical properties, and bioactive functionalities. *J Mater Chem B*. 2020; 8(9): 1801-1822.
10. Yang Fei, Xiao Dongqin, Chen Zhu, Feng Gang. Research progress in the construction of complete tissue-engineered intervertebral disc scaffold materials. *Western Medicine*. 2016; 28(08): 1181-1185.
11. Pan Xingna, Li Yaxiong, Jiang Lihong. Research and progress of tissue engineering vascular scaffold materials. *China Tissue Engineering Research*. 2016; 20(34): 5149-5154.
12. Yin Lihua, Wang Lin, Yu Zhanhai. Application progress of silk fibroin as scaffold materials for tissue engineering. *Journal of Biomedical Engineering*. 2014; 31(02): 467-471.
13. Merk M, Chirikian O, Adlhart C. 3D PCL/Gelatin/Genipin Nanofiber Sponge as Scaffold for Regenerative Medicine. *Materials (Basel)*. 2021; 14(8): 2006.
14. Wu Xinyi. Research progress on scaffold materials and seed cells for tissue-engineered keratoprosthesis. *Journal of Otorhinolaryngology, Shandong University*. 2011; 25(05): 79-81 + 88.
15. Scaffold materials in the construction of tissue engineering blood vessels. *Chinese Tissue Engineering Research and Clinical Rehabilitation*. 2010; 14(29): 5492.
16. Julinová M, Šašinková D, Minařík A, Kaszonyiová M, Kalendová A, Kadlečková M, Fayyazbakhsh A, Koutný M. Comprehensive Biodegradation Analysis of Chemically Modified Poly(3-hydroxybutyrate) Materials with Different Crystal Structures. *Biomacromolecules*. 2023; 24(11): 4939-4957.
17. Yin mingdy, Zhao Zhengkai, Zhang Jian. Construction of tissue-engineered vascular scaffold with different materials: characteristics and effects. *Chinese Journal of Tissue Engineering Research and Clinical Rehabilitation*. 2010; 14(16): 2958-2962.
18. Mao J, Huang L, Ding Y, Ma X, Wang Q, Ding L. Insufficiency of collagenases in establishment of primary chondrocyte culture from cartilage of elderly patients receiving total joint replacement. *Cell Tissue Bank*. 2023; 24(4): 759-768.
19. Li Chunmin, Wang Zhonghao. Application and progress of scaffold materials in vascular tissue engineering. *Chinese Journal of Modern General Surgery*. 2009; 12(09): 788-790.
20. Fan Xiaoli, Zou Yuanwen. Characteristics of scaffold materials in tissue engineered blood vessel construction. *Chinese Journal of Tissue Engineering Research and Clinical Rehabilitation*. 2009; 13 (29): 5732-5734.