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Research Article

Tissue Engineering Properties of Nanomaterials and Their Performance Evaluation for Repairing Athletic Ligament Injuries in Sports Dance

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With the fast growth of nanotechnology, the usage of nuclear materials is becoming increasingly widespread, and the exposure of people, plants, and fauna to nanomaterials has become unavoidable. As scaffolds of biomaterials, nanomaterials are widely used in tissue engineering because of their good biocompatibility, noncytotoxicity, and noninflammatory reaction. In this paper, the tissue engineering properties of nanomaterials and their performance evaluation for repairing sports ligament injuries in dance sports were investigated. Sports ligament injury is a common sports disease, and ligament injury has a very serious impact on sports performance and sports life of athletes. In this paper, we takes football as an example, establishes a human body model of tendon-bone repair after anterior cruciate ligament reconstruction, evaluated the effect of injectable rhBMP-2 nanocontrolled release capsule on ligament bone tunnel interface repair, and evaluated from the scientific and biomechanical point of view. In addition, human ligament research and rabbit ligament supplementary experiment were carried out. In the study of human ligament, we selected 30 patients with unilateral polyarticular ligament injury caused by sports dance as the research subjects and randomly divided them into control group, experimental group, and blank group. The experimental group underwent the repair and reconstruction of rhBMP-2 nanocontrolled release capsule ligament. The results of human ligament study showed that the injectable rhBMP-2 nanocontrolled release capsules showed positive staining and uniform staining for ligament repair. The stiffness of the tender bony temple junction was 11.73%, 15.65%, and 50.59% greater in the test group than in the control group at 2, 4, and 8 weeks postoperatively, respectively.

1. Introduction

Ligaments connect bone to bone and are distinct fibrous tissues that either attach to the skin of the bone or fuse to the external shell of the articular bag to enhance the stabilization of the joint and prevent damage. Injury occurs when a ligament is stretched beyond its tolerance due to violence and nonphysiological activity. A partial injury to the ligament without causing a tendency to dislocate the joint is called a bruise. The ligament itself is completely ruptured, and the bone at its attachment site can also be avulsed, resulting in potential joint dislocation, subluxation, or even complete dislocation. Failure to treat ligament damage can lead to osteoarthritis. Therefore, its surgical repair and functional reconstruction are one of the most important research topics in the field of joint surgery. Although the development of modern surgery makes it possible for humans to replace damaged ligaments, there are still many problems. With the emergence of tissue engineering, a small number of tissue cells are used for in vitro culture and growth, adsorbed by highly biocompatible biological materials, degraded and absorbed in the body, and then inoculated into the body to form new vitality and related functions. Tissues are expected to achieve artificially activated toughness. The biological characteristics of seed cells, scaffolds, and biologically active factors are the three main themes of tissue engineering.

In the research of tissue engineering ligament, suitable seed cells must be selected. The seed cells must have the ability to form new tissues. These cells can be exogenous, or they can be recruited from the local environment of the transplant recipient. The exogenous cells should be easy to obtain and have little damage to the donor site. The ability of proliferation and differentiation is strong when cultured in vitro, and it can be effectively repaired in the recipient area [1, 2]. At present, it is believed that fibroblasts are a kind of "pluripotent cells," which have different migration rates, adhesion, proliferation, and collagen synthesis capabilities in different tissues, but whether they can effectively repair in the environment of joint fluid is still controversial. Since the autologous patellar tendon graft still undergoes a process of necrosis and strength weakening after transplantation, let alone fibroblasts, therefore, it is not suitable as a seed cell [3, 4]. The purpose of this paper is to evaluate the tissue engineering properties of nanomaterials and their performance in the repair of ligament injury in sports dance sports, in order to make a certain contribution to the repair of ligament injury.

The innovations of this paper are as follows: (1) the tissue engineering properties of nanomaterials and the basic knowledge of repairing sports ligament injuries are introduced. (2) Follow up 30 patients to understand the basic situation, infection situation, and calculate the morbidity rate. In order to improve the research results, a supplementary experiment was also performed on 26 rabbits to verify the performance difference between the reconstructed ligament and the native ligament. (3) Through the local application of nanocontrolled release capsules, BMP-2 can reconstruct the tendon-bone tunnel interface of the anterior cruciate ligament, form a tendon-like structure at the bone anchor point, and reconstruct the intramedullary canal.

2. Related Work and This Paper's Work

With the development of science and technology, materials science and biomedicine are more and more closely integrated, and nanomaterials have made great achievements in biological applications. This paper focuses on the research status of nanomaterials in tissue-engineered ligament research and evaluates the performance of nanomaterials in repairing ligament injury. In order to improve the strength, flexibility, and biomechanical properties of the tested female basketball players, Kahn and Xu prepared a training plan for sports injury prevention and conducted a control experiment. Compared with the anterior and posterior training ligaments in the control group, Kahn' and Xu's damage reduction plan can dramatically alter the mobility, power, and biomechanical characteristics associated with ACL damage and reduce an athlete's exposure to damage. However, in the research process, Kahn and Xu did not consider the difference of individual factors; so, the experimental results are not very reliable [5]. In order to further understand the mechanism of ACL injury, Bertona et al. investigated the occurrence of ACL injury in a large number of samples over the past 20 years and proved the relationship between the occurrence of ACL injury and dynamic knee alignment at the time of injury. Bertona' et al.'s research has not fundamentally solved the problem, and there is no data to show that the reliability is not high [6]. Malvasi et al. developed an online activity survey, which used a prospective method to record monthly participation in all major exercises related to the patient group. He conducted a reliability study by continuously enrolling 145 patients with ACL injury and retested the online activity survey two days after recording test answers. Malvasi et al.'s research methods are relatively new but lack of interpretable statistical analysis [7]. In order to explore the relationship between ACL-SRI score and strength and strength score after ACLR, Ithurburn et al. recruited 452 male athletes who underwent primary ACLR and conducted ACL-SRI questionnaire, isokinetic muscle strength test, and jumping test about 9 months after operation. In the research of Ithurburn et al., there is no objective view on the relationship between body strength and strength measurement; so, it needs further improvement [8].

3. Nanomaterials and Sports Ligament Injury

3.1. Nanomaterial Application. Nanomaterials include nanobiomaterials, which have the potential to become the core materials of biomaterials in the 21st century, which is due to the large number of fine nanostructures in their bodies. Nanomaterials can be divided into two levels: nano-ultrafine particle materials and nanosolid materials [9]. Nano-ultrafine particles refer to ultrafine particles with a particle size of 1-100 nm, and nanosolids refer to solid materials made of nano-ultrafine particles. And people are accustomed to control the composition or grain structure below 100 nanometers in length dimension called nanomaterials. In addition, nanobiomedical materials solve the urgent needs of high-performance tissue repair, organ replacement, disease diagnosis, and treatment [10, 11]. Nanostructure is a new system constructed or constructed according to certain rules on the basis of nanoscale material units [12]. It includes nanoarray system, mesoporous assembly system, and thin-film mosaic system.

Nanotechnology refers to the arrangement of atoms/molecules on the surface of nanoparticles through specific technical design to produce a special structure. And in the performance of specific technical properties or functions, such nanomaterials can be called nanotechnology [13]. Using nanotechnology to transform traditional tissue engineering materials, nanotissue engineering materials have unique biological characteristics, and the application research in the field of tissue engineering has attracted people's attention [14]. For example, nanoceramics, carbon nanowires, and nanometal materials are used for bone and cartilage tissue engineering; titanium nanomaterials, polylactic acid lactic acid nanomaterials, and nanofiber materials are used for artery tissue engineering; and peptide nanoskeleton and nanofiber are used for scaffold [15, 16]. At the same time, with the continuous advancement of science and technology, especially in the sunrise industry of the electronics industry, nanotechnology has been greatly developed. It mainly focuses on electronic composite films, using ultrafine particles to improve the electrical, magnetic, and magneto-optical properties of the film, as well as magnetic recording, nanosensitive materials, etc.

3.2. Application of Nanomaterials in the Bone and Cartilage Tissue Engineering. In nanophase ceramics, nanohydroxyapatite is a natural bone component; so, it can be used as a substitute for bone to achieve bone transplantation. They can promote the formation of mineralization. The composite material composed of hydroxyapatite nanocrystals and collagen is the tissue engineering material closest to the natural bone structure. The nanohydroxyapatite material is mixed with collagen at the ratio of 93 : 7, 83 : 17, and 81 : 19 to form a composite material with a density of 2.8 g/cm^3 [17, 18]. Through high-power electron microscopy, it can be observed that all composite materials and collagen structure are parallel, and their diameter and length are the same, 50-100 nm and 20 μm, respectively [19, 20]. In addition, zinc oxide can react with titanium and aluminum, promote the formation of collagen and precipitation of calcification, and finally strengthen the activity of alkaline phosphatase.

Cartilage is composed of cartilage tissue and its surrounding perichondrium, and cartilage tissue is composed of chondrocytes, matrix, and fibers. According to the different fibrous components contained in cartilage tissue, cartilage can be divided into three types: hyaline cartilage, elastic cartilage, and fibrocartilage. Among them, hyaline cartilage has a wider distribution and a more typical structure. By studying the formation and development of human bones, we can discover how the human body regulates and assembles collagen and can also figure out the growth mechanism of calcium phosphate crystals and the human body's healing mechanism. On this basis, following the idea of bionics, a nanocrystalline calcium phosphate collagen bone repair material was invented to simulate the process of biomineralization and self-assembly. The porosity of the material is about 80%, and the void size is mainly distributed between 100 and 400 μm [21]. The hydroxyapatite crystals of the material have a particle size of about 30 nm and grow in the gaps between the collagen fibers. It can be found that they are axisymmetric with the collagen fiber structure, and they have an asynchronous structure before, which is similar to natural bone and nanosynthetic bones. The bone cells obtained through this harvesting technology are very similar to normal human bone cells, and they have excellent ductility and softness, as well as excellent plasticity [22, 23].

3.3. Repair of Sports Ligament Injury. Ligaments connect bone to bone and are obvious fibrous tissues, either attached to the surface of the bone or fused with the outer layer of the joint capsule to strengthen the stability of the joint to avoid injury. Injury occurs when a ligament is stretched beyond its tolerance due to violence, resulting in nonphysiological activity. In the field of sports medicine, there is the most difficult problem; that is, in the network of relational ligaments, there are multiple ligaments injured, each ligament receives different degrees of damage, and the injury of multiple key ligaments destroys the stability of the knee [24]. When there is a nonphysiological movement in a certain direction, the ligaments that limit the movement of the knee joint to this direction must bear the brunt. The medial capsular ligament and medial collateral ligament are mainly damaged when the knee joint is externally rotated and abducted in the flexion position and is subjected to external violence. Severe cases can involve the anterior cruciate ligament and medial meniscus, which are the most common types of injury. Patients with multiple ligament injuries are very likely to suffer from medial and lateral meniscus injuries. Among them, the largest injury probability is the displacement of lateral and intra-articular ligaments, which will lead to dislocation and fracture of the joint. After ligament injury, there are usually small blood vessels rupture and hemorrhage, local pain, swelling, intraorganism hemorrhage, hematoma, joint swelling, movement disorder, and tenderness. On physical examination, the traction ligaments were found to be significantly painful, and if completely ruptured, the stability of the joint was reduced. Therefore, our goal in the future is to repair and reconstruct the ligament, which can fully help the establishment of bone and joint.

The knee joint is very unstable and usually has important nerve tissue (such as common peroneal nerve) and important blood vessels. One of the biggest difficulties is that it involves a variety of orthopedic disciplines, and a single doctor cannot effectively deal with orthopedic injuries in various disciplines, resulting in patients cannot achieve effective and timely treatment, which seriously hinders the athletes' sports career and subsequent normal life. At present, with the improvement of living standards, more and more young people like highly confrontational sports, such as football and basketball, which also increases the risk of joint ligament injury.

For the ligament damage that has occurred, if you do not intervene in time, it may lead to serious consequences. For example, it will cause knee instability. Secondly, it may accelerate the degradation of the patient's knee cartilage and eventually lead to the early appearance of osteoarthritis symptoms and will affect the quality of life of patients. Ligament injury should be treated early and fully repaired. If it is not treated in time, the joint will be repeatedly sprained, which will inevitably cause damage to articular cartilage, meniscus, and other important structures, resulting in premature aging of the joint and severe secondary traumatic arthritis. The key to its treatment lies in the repair of damaged ligaments. Partial tears can be directly sutured and repaired, while complete ruptures require surgery to transfer and reconstruct adjacent tendons, fascia, and other tissues. With the latest development of arthroscopic technology and the improvement of tissue library, arthroscopy is usually the next step in the reconstruction and repair of multiple knee ligament injuries. Excellent results have been achieved, and there is also a report of bilateral knee joint multiligament injury. One year after ligament reconstruction, the patient can return to leisure sports, but at the same time, there are still many issues that have not yet reached a consensus.

Due to the complex anatomical structure of the knee joint, it is usually difficult to reconstruct and repair multiple ligament injuries, and these ligaments also have strict requirements for the repair sequence. If the reconstruction sequence is not correct, the repair effect is great, which meets the requirements, but the reliability and plasticity of transplantation can be ensured after the correct sequence and steps. In order to meet the requirements of reconstruction procedures, surgeons provide a series of suggestions: first, repair KD-I ligament injury and rupture and tendon reconstruction and repair, then KD-II: ACL + PCL injury, then KD-III type: ACL + PCL + MCL or (PMC/PLC) damage, and finally, repair type KD-IV ACL + PCL + MCL + (PLC)/ LCL) is damaged.

The ideal knee reconstruction implant should have the advantages of high toughness, high strength, convenient operation and microfixation, easy access to materials, and minimal postoperative complications. In the existing materials, there is still a lack of materials to meet these requirements, which can only be met by allogeneic transplantation and tendon transfer. Autogenous tendon transplantation is transplanted through the existing tendon and ligament in the body, usually taking PA bone or rope tendon two parts. Allogeneic transplantation is to rely on the implantation of artificial ligaments to meet the requirements. For multiple ligament injuries of the joint, it is generally necessary to reconstruct and repair multiple ligaments; so, it is not possible to use self-transplantation, but only rely on the means of allogeneic transplantation.

4. Experimental Materials and Methods

4.1. Experimental Materials and Experimental Methods and Equipment-Related Drugs. In this experimental equipment, we used the following: antibacterial micro Qiao suture, electric drill, automatic dehydrator, basic surgical instruments, denture base tree, penicillin, pentobarbital sodium powder, and finally, denture base polymer and normal saline for injection.

4.2. Collection and Production of Patient Experimental Specimens. A total of 30 patients with unilateral knee multiligament injury caused by sports dance were included in this study, including 6 cases of ACL, PCL, and MCL injury, 4 cases of ACL, PCL, and PLC injury, 8 cases of ACL and PCL injury, 6 cases of ACL and MCL injury, and 6 cases of PCL and MCL injury. These patients were all of grade III injury. There were 12 cases of left knee injury, 18 cases of right knee injury, 20 cases of male, and 10 cases of female. The average age of patients was 35.35 ± 2.31 years (18-55 years). There were 17 cases of traffic accident injury, 4 cases of falling injury, and 9 cases of acute sports injury. The main clinical manifestations were severe pain, swelling, and instability of knee joint. The time from injury to operation was 7.0-14.0 days, with an average of 10.12 ± 1.35 days.

This experiment is divided into three groups: the experimental group, the control group, and the blank group. The experimental group uses rhBMP-2 nanocontrolled release capsules to repair and reconstruct the ligaments, and the control group uses the current mainstream biological equipment to repair and reconstruct the ligaments. Repair and reconstruction were performed, and the ligament in the blank group was not damaged.

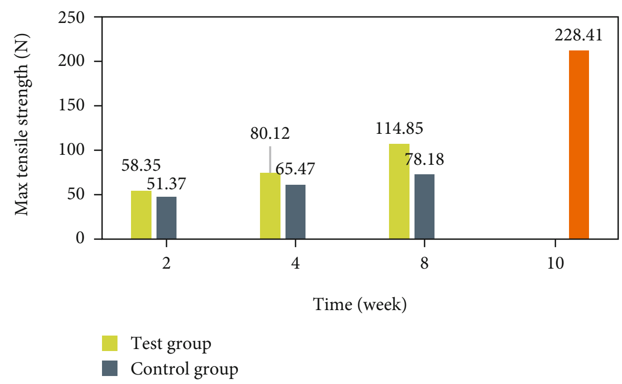

Figure 1: Maximum tensile strength histogram.

4.3. Collection and Production of Animal Experimental Specimens. In this study, we also selected 24 adult rabbits with knee joint disease and 2 adult rabbits without joint disease to conduct supplementary experiment. These rabbits all met the requirements of cleanliness level, weighing 3.29 ± 0.26 kg, which could adapt to reproduction and environment. One week before the experiment, they were put into a new feeding environment for normal feeding activities. After that, the animals were treated according to the "guidelines for the treatment of experimental animals." Methods were as follows: 24 rabbits (48 knees in total) were operated on with the common specimen of bilateral knee tendon bone tunnel interface, and the experimental animals were divided into groups.

The experimental group used rhBMP-2 nanocontrolled release capsule to repair and reconstruct the ligament, the control group used the mainstream biological equipment to repair and reconstruct the ligament, and the blank group was that the ligament was not damaged.

According to the normal management, it was stored in the refrigerator at -80°C. The normal fixation, demineralization, slicing, and dyeing preparations were used as the normal indexes of the control. At the second, fourth, and eighth postoperative weeks, experimental animals in the test and control groups were executed under overanesthesia, and the knee joints were similarly extracted.

Before the test, thaw at room temperature and immerse the sample in saline, the resin is hardened to remove the bone, and the tendon thread is used as the braided part of the tendon. The sample is fixed on the Instron 8874 mechanical tester. First, the pretreatment is completed; that is, a tensile force of 5 N is applied to the test piece for 30 seconds, and then a tensile test is performed until the ligament yields and breaks. Set the traction speed to 3 mm/min, calculate the stiffness, and record the displacement distance and load strength. The stiffness value of the tendon-tunnel channel interface refers to the ability of the tendon-tunnel channel interface of the knee joint to resist elastic deformation under force, and its elastic deformation the degree is this value. Generally, the slope of the linear section is calculated from the linear section of the load-displacement curve.

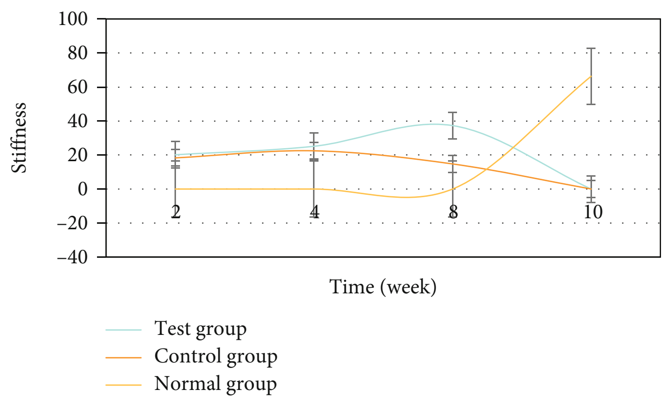

Figure 2: Stiffness histogram.

Table 1: Yamakado split type ($n = 8$, n).

Time		Tendon bone separation	Loose connective tissue link	Sharpey structure link	Direct link
	4 W	2	6	0	0
Test group	8 W	0	7	1	0
	16 W	0	1	7	0
	4 W	4	4	0	0
Control group	8 W	1	7	0	0
	16 W	0	2	6	0
	4 W	1	7	0	0
Blank group	8 W	0	4	4	0
	16 W	0	2	6	0

Tensile strength (N) is as follows: in a biomechanical tensile test, the maximum tensile strength at the tendon-bone tunnel interface of the knee joint sample can be a bearable value.

4.4. Experimental Analysis Method. Use IBM SPSS23.0 statistical software for statistical analysis. If the continuous variable presents a normal distribution, use the paired sample X^2 test.

$$X^2 = \sum \left(\frac{2(f0 - fc)}{fc} \right). \tag{1}$$

Among them, sending f_0 represents the actual number of times obtained, and f_c represents the theoretical number of times determined by the hypothesis.

If it does not conform to the normal distribution, please use the nonparametric test, the result is expressed as the median (interquartile range), and the difference is statistically significant, $P < 0.05$. Categorical variables are expressed in frequency (percentage) and tested using Fisher's exact probability method.

$$P = \frac{O_{1\bullet}!O_{2\bullet}!O_{\bullet 1}!O_{\bullet 2}!}{O_{11}!O_{12}!O_{21}!O_{22}!}, (N! = 1 \times 2 \times \cdots \times N). \tag{2}$$

The result shows that the variable matches the normal distribution, $P > 0.05$. Box plots are used to find outliers,

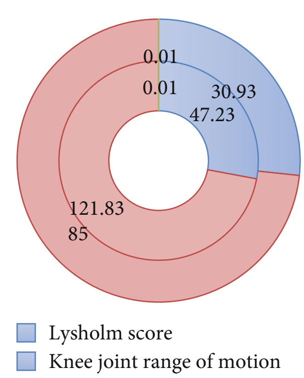

Figure 3: Lysholm score and range of motion of the knee joint before and after the last follow-up.

the categorical variable is Fisher's test, and $P < 0.05$ is considered statistically significant.

5. Experimental Results and Analysis

5.1. The Test Results of rhBMP-2 Nanocontrolled Release Capsule for Repairing Ligaments. The maximum tensile strength of tendon and bone tunnel interface in each group was as shown in Figure 1. The experimental group was repaired by rhBMP-2 nanocontrolled release capsule, the

Table 2: The results of the stability examination of the knee joint before and after the last follow-up.

Stability examination	Preoperative physical examination		Physical examination at the last follow-up		
	III degree positive	Negative	I degree positive	II degree positive	Negative
Front drawer test case (%)	24	0	3	3	18
Back drawer test case (%)	24	0	3	1	20
Lachman test case (%)	24	0	3	3	18
Flexion 30° eversion stress test example (%)	18	0	1	2	15
Flexion 30° varus stress test example (%)	4	0	1	0	3

control group was repaired according to the current mainstream surgical method, and the blank group was normal ligament without disease. The results showed that there was a significant difference between the experimental group and the control group at three time points after operation ($P < 0.005$).

As shown in Figure 1, the maximum tensile strength of the rhBMP-2 nanocontrolled release capsule for ligament repair is higher than that of the control group. Two weeks after the operation, there was no significant difference in the maximum tensile strength of the tendon-bone tunnel interface between the experimental group and the control group ($P > 0.005$). Eight weeks after surgery, there were significant differences in the maximum tensile strength of the tendon-bone tunnel interface among the three groups ($F = 219.32$, $P < 0.005$). The results show that the experimental group is better than the control group in terms of tensile strength, each group has been greatly improved, and the test values are very different.

The results of the postoperative study on the tendon tunnel interface stiffness are shown in Figure 2.

5.2. Composite Ligament Reconstruction ACL. According to Yamakado classification, the morphology was divided into tendon bone separation, loose connective tissue connection, Sharpey fiber structure connection, and direct connection. According to the Yamakado classification method, the morphological and histological observation was carried out at 4 W, 8 W, and 16 W. The results are shown in Table 1.

As can be seen from Table 1, in the use of rhBMP-2 nanocontrolled release capsules to reconstruct the joint ligaments (experimental group), after incising the skin, the implant was completely covered by the synovium, with bright luster, compact structure, superficial capillary growth, and joints light yellow glaze in the cavity. The interface between the ligament and the bone is wrapped in the new bone and becomes unified, and when the compression nail is removed, the ligament and the bone are firmly connected. In the current best-performing joint ligament reconstruction (control group), the surface of the implant is completely covered by synovium, the structure is compact, there are no blood vessels, and there are soft tissues around it. After removing the pin, the implant can be pulled out forcefully. In the unaffected normal joint ligaments (blank group), the surface is as smooth as normal tendons, and the ends are tightly connected to the bone tunnel.

All patients were followed up for 12-24 months (average 15.60 ± 2.65 months). All patients recovered well after operation. No knee instability and stiffness occurred. The postoperative follow-up results are shown in Figure 3.

It can be seen from Figure 3 that the active range of motion of the knee joint of 30 patients recovered significantly compared with that before the operation. At the last follow-up, the range of active motion of the knee joint increased to 121.83. Compared with 47.23 before operation, the difference was statistically significant ($P < 0.05$).

At the last follow-up, the positive rate of knee joint stability physical examination decreased significantly, and the difference was statistically significant ($P < 0.05$). The negative rate of anterior drawer test was 75%, and the positive rate was 25%. The positive rate of knee joint stability physical examination was shown in Table 2.

It can be seen from Table 2 that there are 3 cases of degree I positive and degree II positive; the negative rate of the back drawer test is 83.3%, and the positive rate is 16.7%, of which 3 cases are positive for degree I and 1 case is positive for degree II; the negative rate of Lachman test is 75%. The positive rate was 25%, of which 3 cases were positive for degree I and positive for degree II; 15 cases had no relaxation in the 30° flexion stress test, 2 cases of degree I relaxation, and 1 case of degree II relaxation, while the 30° buckling stress test was 0 cases. There were 3 cases of relaxation and 1 case of degree I relaxation. At the last follow-up, the Lysholm score of the knee joint reached 85.00 points, which was statistically different from 30.93 points before surgery ($P < 0.05$). IKDC rating at the last follow-up was as follows: 20 cases were normal (grade A), 8 cases were close to normal (grade B), and 2 cases were abnormal (grade C). The X-ray film and CT in the outpatient department after operation showed that the internal fixation and the bone canal were in good position, and the bone canal was not enlarged.

5.3. ACL Reconstruction in Animal Ligaments. Randomly select 3 groups (4 W, 8 W, 16 W) and divide them into the experimental group treated with rhBMP-2 nanocontrolled release capsules, the control group using the current mainstream surgery, and the normal diseased blank group, each with 4 mice The rabbit undergoes a CT examination. X-ray cross-sectional imaging of the rabbit femoral tunnel passes through the vertical axis. Each rabbit randomly selected 10 images and measured the CT value of the 1 mm^2 interface

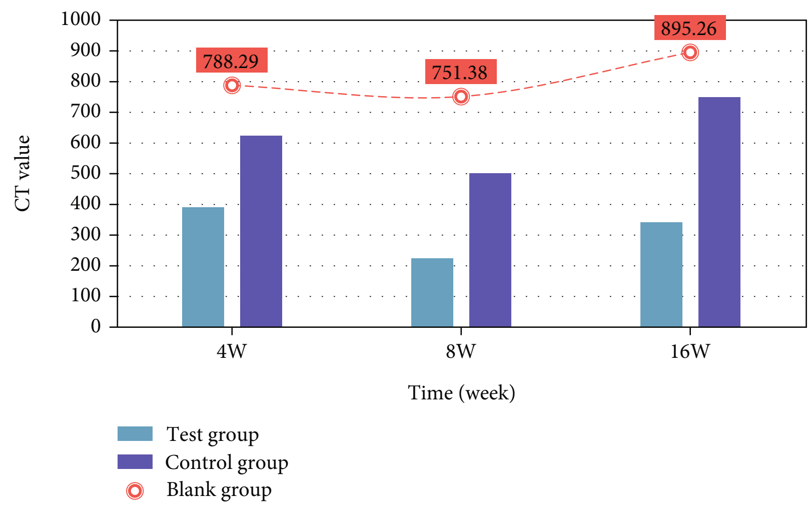

Figure 4: Detect CT value in different time periods.

between the screw and the bone. Measure the CT value of the 1 mm^2 area between the screw and the bone interface, use x and S to represent all the CT values measured in each group, and analyze the connection structure between the ligaments and the time of the bone in the day; after modification, the relative position of screw channel is shown in Figure 4.

It can be seen from Figure 4 that, similar to normal ACL, after the cruciate ligament is reconstructed, the nutrition needed by the implant is mainly provided by blood in the superficial synovial membrane, except for a small amount of synovial fluid in the joint cavity. Theoretically, this not only preserves the ligament stump and promotes the fusion of soft tissues and grafts but also an adequate blood supply also increases the nutrient supply of the graft, thereby allowing new synovial vascularization on the surface of the graft. Indicating that the reconstruction can be preserved, the survival rate of the ligament should be significantly higher than the unreserved stump group.

At the same time, the application of nanomaterials in tissue engineering is still in the early stage. Especially in biomedicine, most of the research is still in the stage of animal experiments, a large number of clinical trials are needed to confirm, and the biosafety of nanomaterials needs to be further improved. There are still many problems to be solved for clinical application: how to construct an ideal cell-nanomaterial interface, how to protect allogeneic biological tissues and cells cultured on nanoscaffold materials from being recognized and rejected by the recipient immune system, how to maintain the viability of cultured cells and maintain their function for a long time, and how to further improve the biocompatibility of nanomaterials.

6. Conclusions

The ligament is a bridge that maintains the close connection between bones. It is rich in elasticity and rich in collagen tissue. However, after the ligament is injured, it cannot be cured, and it is difficult to reach a healthy level. This also causes the joints to become extremely unhealthy: stable, but from causing serious damage to the relationship, the most causing deterioration and pain, the most typical cases of which are arthritis and meniscus injury. It is precisely because of this that we must reconstruct it, these reconstruction methods are mainly carried out through surgery, and most of them are through and means.

The experimental design of the ligament reconstruction model and the nanocontrolled release capsule manufacturing model is effective for basic research related to BMP-2 repairing the tendon-bone tunnel interface and can be used as a reference for experimental research models. In the early stage after injury and anterior cruciate ligament reconstruction, BMP-2 promotes the formation of a similar direct stagnant structure at the tendon-bone tunnel interface. Experiments show that rhBMP-2 can effectively promote and enhance the repair of the tendon and bone tunnel interface.

In this study, when the anterior cruciate ligament was reconstructed after knee injury, the injectable BMP-2 controlled release capsule was chosen when reconstructing the tendon-bone tunnel interface. The results showed that BMP-2 was performed after the reconstruction of the anterior cruciate ligament of the knee joint. After the reconstruction of the anterior cruciate ligament, the tendon tunnel interface helps to form a direct stop point, thereby improving the maximum tensile strength and stiffness of the tendon tunnel interface. This leads to improved pathophysiological properties and mechanical strength of the reconstructed ligament structure. In the next few years, nanoceramics in biomaterials will play a leading role in artificial bones, and inorganic and organic composite nanomaterials with various properties will also play a great role in interventional repair of ligament injuries. We will also conduct further in-depth research on this.

Data Availability

No data were used to support this study.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this article.

Acknowledgments

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