

## Retraction

# Retracted: Diagnosis and Exercise Rehabilitation of Knee Joint Anterior Cruciate Ligament Injury Based on 3D-CT Reconstruction

### Complexity

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

- (1) Discrepancies in scope
- (2) Discrepancies in the description of the research reported
- (3) Discrepancies between the availability of data and the research described
- (4) Inappropriate citations
- (5) Incoherent, meaningless and/or irrelevant content included in the article
- (6) Manipulated or compromised peer review

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

In addition, our investigation has also shown that one or more of the following human-subject reporting requirements has not been met in this article: ethical approval by an Institutional Review Board (IRB) committee or equivalent, patient/participant consent to participate, and/or agreement to publish patient/participant details (where relevant).

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

### References

- [1] S. Zhang, "Diagnosis and Exercise Rehabilitation of Knee Joint Anterior Cruciate Ligament Injury Based on 3D-CT Reconstruction," *Complexity*, vol. 2020, Article ID 3690124, 13 pages, 2020.

## Research Article

# Diagnosis and Exercise Rehabilitation of Knee Joint Anterior Cruciate Ligament Injury Based on 3D-CT Reconstruction

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The joint capsule of the knee joint is attached to the edges of various articular surfaces and is thin and loose. Therefore, ligament reinforcement is needed to protect the knee joint and increase the stability of the joint. It plays a vital role in human activities. In this paper, a 3D-CT three-dimensional reconstruction method is used to reconstruct the ACL natural femoral imprint and double-bone tract. The relative positional relationship between the two center points is compared, and the law is summarized to guide the improvement of ACL anatomic double-beam reconstruction under arthroscopy. The 3D reconstruction results suggest that the bone layer in the anterior medial portion is the thickest, forming a peak, and the thickness of the bone layer in the posterior medial portion gradually decreases in a stepwise manner. The entire bone tissue in the anterior medial portion and posterior medial portion is integrated into one body. The tissues are connected as a whole, and the thickness is relatively uniform. The two parts of the bone tissues are not connected. The CF tissue was inserted into the bone tissue in a zigzag pattern. The changes of CF tissues in the anterior medial and posteromedial CF tissues were similar, and they were distributed stepwise from the inside to the outside. According to the bone and CF spatial structure and changing rules, ACL is divided into medial and lateral beams. According to this study, it can be summarized that (1) 3D reconstruction can clearly reconstruct the natural footprint of ACL femoral stops and postoperative osseous position and (2) 3D reconstruction can be used to evaluate the position of osseous postoperative ACL anatomic double-beam reconstruction. Arthroscopy double-beam reconstruction of ACL is instructive.

## 1. Introduction

With the increasing popularity of mass movements and the increasing incidence of traffic accidents, anterior cruciate ligament (ACL) injury is becoming more and more common, and research on it has received more and more attention from the academic community [1–3]. ACL is the core ligament that guides the movement of the knee joint. Its main function is to restrict the forward movement of the tibia, but it also plays a certain role in controlling the rotation of the knee joint, and the stress situation is complex [4]. The key part of its mechanical conduction, the tibia stop, has become the focus of biomechanical research of ligaments. Foreign scholars have reported that in animal experiments, the position of the ACL tibial plateau on the tibial plateau was moved forward and backward, and the tibial plateau and knee stability were significantly different,

suggesting the position of the tibial plateau and its restrictions [5]. The ability of the tibia to move forward and maintain the stability of the knee joint is closely related, but there is still no research report on the clear correspondence between the position of the ACL tibial stop and the ACL control force [6–9]. The connection point between the ligament and the bone is not a simple ligament bone connection, but a complex structure. The literature calls it a “stop point organ,” which can be divided into fibrocartilage stops (direct stops) and fiber stops (indirect stops). The ACL tibia stop is a typical fibrocartilage stop, including four regions, namely, fibrous tissue, uncalcified fibrocartilage (UF), calcified fibrocartilage (CF), and bone tissue. The structure mainly plays a role of stress buffering [10–12]. The domestic and foreign literature studies reporting the histological structure of ACL tibial junctions are mainly concentrated along the longitudinal axis of ACL. The purpose is

to observe the healing after surgical reconstruction. It is not a special continuous layer structure study.

The knee joint is the largest, most complex, and weight-bearing joint in the human body, and it is also the joint with the highest functional requirements of the human body. The joint capsule of the knee joint is attached to the edges of various articular surfaces and is thin and loose. Therefore, ligament reinforcement is needed to protect the knee joint and increase the stability of the joint. It plays a vital role in human activities. Ligaments are tough, band-shaped tissues connected between the femur and tibia. The knee ligaments mainly include anterior cruciate ligament (ACL), posterior cruciate ligament (PCL), medial collateral ligament (MCL), and lateral collateral ligament (LCL). The anterior cruciate ligament is the most important stabilizing factor. The anterior cruciate ligament starts from the anterior angle of the meniscus and anterior to the tibial intercondylar eminence, and ends behind the medial side of the femoral condyle. Its main functions include the following: restricting the forward movement of the tibia, preventing overextension of the knee joint, and preventing internal and external rotation of the tibia [13–15]. When the external force applied to the knee joint exceeds the anterior cruciate ligament tolerance, anterior cruciate ligament injury occurs. Anterior cruciate ligament injury has been common in traffic accidents and professional athletes in the past, but with the improvement of social living standards, sports-loving, as the number of ordinary people increases, knee joint sports injuries also increase. Among them, sports injuries such as anterior cruciate ligament rupture are more and more common in the general people. In Europe and the United States, anterior cruciate ligament injury occurs mostly in fierce sports such as basketball and football. In domestic studies, anterior cruciate ligament sports injuries are most common in basketball, football, and jumping sports. The damage of anterior cruciate ligament between men and women is also different, which is related to their sports hobbies, sports technology, and sports popularity requirements. Imaging evaluation plays a key role in the diagnosis, treatment choice, and follow-up of kidney stones. Over the years, as the incidence of urinary tract stones has increased and the understanding of disease processes has increased, imaging techniques have continued to evolve. CT urography (CTU) developed on the basis of CT is a method of injecting a contrast agent into a vein, using the secretory function of the kidney and using CT to observe the degree of filling of the contrast agent over time in the renal calamus, renal pelvis, ureter, and bladder, as shown in Figure 1. Obtaining continuous tomographic data and then three-dimensional reconstruction of the original image using a computer to obtain a three-dimensional urinary system image has become a more common inspection method in urology [16, 17]. Preoperative imaging has a crucial influence on the choice of the surgical method. However, the CTU examination results uploaded to the doctor's workstation by the radiology department currently only have 3D reconstructed images with several perspectives. The surgeon cannot perform more operations on the 3D reconstructed model and cannot meet the needs of the surgeon. In severe cases, the

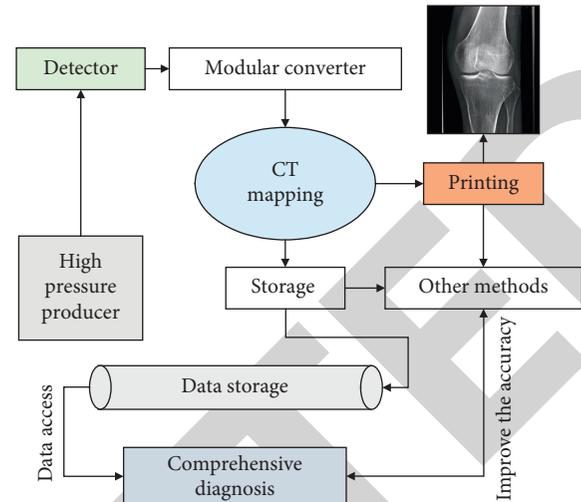


FIGURE 1: The schematic diagram of 3D-CT mapping used in the ACL detecting.

contrast agent cannot be well distributed in the pyloric renal pelvis, which may lead to poor CTU image quality, and some urinary tracts cannot be displayed. Doctors rely more on plain CT scans for preoperative planning, especially for complex situations. In more detailed preoperative planning, how to obtain better preoperative planning information is obviously the problem that the operator needs to solve first [18].

For medical images such as CT data reading and 3D reconstruction, part of the software comes from the CT machine of Siemens and other companies [19]. Usually, a machine corresponds to a software system, and individual users are generally unable to use it [20]. For external 3D reconstruction software, the current recognition is the Mimics software from the Materialise company [21]. The reconstructed model is highly consistent with the real situation. Through modular function settings, the operation is simple and easy to use, and it can directly interface with CAD, FEA, RP, and other data [22–24]. It is easy to process the model, and the software is constantly updated, and the algorithm is optimized to enhance the function. It has been widely used in orthopedics, stomatology, and other departments, mainly for individualized preoperative planning of implanted prostheses, etc., and can guide the operation in real time during the operation. 3D printing technology is an additive rapid prototyping technology. It was proposed by the Massachusetts Institute of Technology in the United States to form solids layer by layer according to a certain path [25]. With the development of materials, materials that can be used for 3D printing have also developed from traditional single solid powders such as metals and plastics to new hybrid materials such as liquids and gels. Different “inks” can be used to print different items. It has been applied in aerospace, medical, and other fields and has developed rapidly. In this paper, a 3D-CT three-dimensional reconstruction method is used to reconstruct the ACL natural femoral imprint and double-bone tract. The relative positional relationship between the two center points is

compared, and the law is summarized to guide the improvement of ACL anatomic double-beam reconstruction under arthroscopy. In addition, this study intends to perform a three-dimensional reconstruction based on the sequential tissue histological structure based on the clear tissue-stress correspondence reported in the literature, and then divide the functional bundle of the ACL, as well as the proposed positioning method for the inner center of the tibial tunnel in surgical reconstruction. It is a new method for the study of ACL function that is different from all previous reports in the literature and provides a new method and basis for future large sample research and animal experiment research.

In this paper, we firstly use the 3D-CT mapping methods to build an ideal ACL reconstruction scheme, and the innovation points can be listed as follows:

- (1) The 3D-CT three-dimensional reconstruction method is used to reconstruct the ACL natural femoral imprint and double-bone tract.
- (2) The relative positional relationship between the two center points is compared, and the law is summarized to guide the improvement of ACL anatomic double-beam reconstruction under arthroscopy.
- (3) The 3D reconstruction results suggest that the bone layer in the anterior medial portion is the thickest, forming a peak, and the thickness of the bone layer in the posterior medial portion gradually decreases in a stepwise manner. The entire bone tissue in the anterior medial portion and posterior medial portion is integrated into one body. The tissues are connected as a whole, and the thickness is relatively uniform. The two parts of the bone tissues are not connected. The CF tissue was inserted into the bone tissue in a zigzag pattern. The changes of CF tissues in the anterior medial and posteromedial CF tissues were similar, and they were distributed stepwise from the inside to the outside.
- (4) According to the bone and CF spatial structure and changing rules, ACL is divided into medial and lateral beams. According to this study, it can be summarized that (a) 3D reconstruction can clearly reconstruct the natural footprint of ACL femoral stops and postoperative osseous position and (b) 3D reconstruction can be used to evaluate the position of osseous postoperative ACL anatomic double-beam reconstruction. Arthroscopy double-beam reconstruction of ACL is instructive.

## 2. Materials and Methods

**2.1. General Information.** Among the patients undergoing three-dimensional reconstruction of the anterior cruciate ligament femoral junction treated in the affiliated hospital of Pingdingshan University from February 2018 to March 2020, 45 patients were selected, including 23 males and 22 females, aged 21 to 54 years, with an average of  $30.2 \pm 7.1$  years old (Table 1). All patients had no obvious history of

trauma to both knees, and those with knee joint swelling and pain were excluded. Patients with negative hyperextension test, lateral stress test, McMurray test, floater test, Lachman test, and knee drawer test were all negative. In addition, 45 subjects signed informed consent, and this study has been approved by the ethics committee of the hospital. In this study, a 64-row spiral CT scanner (240 mA, 120 kV) produced by GE of the United States was selected, the matrix size was  $512 \times 512$  pixels, the scan time was set to 5 s, the layer thickness was 5 mm, the window diameter was 360 mm, and the reconstruction interval layer thickness was 0.625 mm. The scan results were exported and stored in a workstation, and the 3D reconstruction software Mimics 10.01 produced by Materialise was used to construct the femur and ACL model and saved in format. Geomagic Studio12, the reverse engineering software manufactured by Geomagic, was used to analyze the SD data, implement image registration, and construct a three-dimensional solid model of cruciate ligament and attachment points of the knee joint through MRI and CT influence fusion methods. After the reconstruction of the model is completed, the femoral dead center is located according to the ACL three-dimensional model, and the ACL femoral dead center is identified and circled according to the morphological characteristics of the ACL attachment area. Geomagic software was used to record the area, long-axis angle, short distance, inner distance, back distance, short axis, and Changzhou of ACL femoral nodal points.

**2.2. Magnetic Resonance Scanning.** The magnetic resonance scanning was performed using a Siemens 3.0 T magnetic resonance instrument and an 8-channel knee joint coil. The subjects were supine with first entrance of their feet, and sagittal T1WI (repetition time (TR) 624 ms, echo time (TE) 17 ms), T2WI (TR 5069 ms, TE 113 ms), PDWI (TR 3155 ms, TE 33 ms), coronal T1WI (TR 614 ms, TE 16 ms), and PDWI (TR 3132 ms, TE 34 ms) sequence scanning were sequentially conducted. The T2-mapping imaging performed 5 echoes and 1 scanning through the SE sequence, and the sagittal scanning was conducted perpendicular to the tibial plateau. Scanning parameters were repetition time of 1500 ms, echo time of 12.4, 25.8, 39.1, 53.6, and 65.5 ms, number of layers of 24, layer spacing of 0.5 mm, field of view of  $16 \text{ cm} \times 16 \text{ cm}$ , matrix of  $368 \times 368$ , layer thickness of 5 mm, number of acquisitions of 1, flip angle of  $180^\circ$ , and acquisition time of 6.23 min. The scanning sequences were perpendicular to the sagittal plane, and the imaging data were transmitted to workstation for postprocessing to directly obtain T2-mapping pseudocolor image of the knee joint and the T2 value data measurement.

**2.3. Secondary Injury after Anterior Cruciate Ligament Rupture.** The anterior cruciate ligament of the knee joint is an important structure to maintain the stability of the knee joint's anterior and posterior rotation. If it breaks, it will seriously affect the function of the knee joint. If it is not treated in time, it will cause damage to the articular cartilage and meniscus, eventually leading to osteoarthritis happened.

TABLE 1: The general information of selected patients.

Group	Average age (years old)	Gender (male/female)	Disease duration (month)	Injury part		Patient's occupation				
				Left	Right	AL	SD	DC	FF	OO
ACL	30.2 ± 7.1	29/11	0.83 ± 0.12	18	22	13	11	8	5	3
Normal	28.2 ± 2.1	29/11	0.76 ± 0.07	18	22	13	9	10	6	2

Note: AL, athlete; SD, student; DC, dancer; FF, firefighter; OO, other occupation.

Studies have shown that the types of damage to the medial and lateral meniscus are more common after rupture of the anterior cruciate ligament, and the sites are mainly posterior horn injuries that can be sutured under the microscope. Most of the lesions need to be removed. The incidence of lateral meniscus tears is very stable and does not increase with the time after anterior cruciate ligament rupture. This suggests that anterior cruciate ligament injury may be accompanied by lateral meniscus injury. Incidence rate can rise to more than half within 1 month after anterior cruciate ligament rupture. Within 1 to 3 months after anterior cruciate ligament rupture, the patient is subjected to knee braking after trauma. Partial healing of the anterior cruciate ligament may cause the incidence of lateral meniscus tears was reduced to below 40%; the incidence of lateral meniscus tears increased to more than half within 3 months to 12 months after anterior cruciate ligament rupture. The incidence of fissures in the anterior cruciate ligament caused by lateral meniscus tears for more than 12 months remained at about 40%. There was no significant difference in each time period. The instability of the knee joint will cause damage to the medial meniscus [8]. The incidence of medial meniscus injuries within 3 months of anterior cruciate ligament rupture is about 30%; medial meniscus injuries lose 3 in the anterior cruciate ligament. The incidence rate is about 40% from a month to half a year; the incidence rate of medial meniscus injury in anterior cruciate ligament injury is more than half in half a year to one year, and the anterior medial meniscus injury occurs after cruciate ligament injury time exceeds one year. The rate can reach more than 60%, and the statistical analysis of each time period has statistical differences, as shown in Figure 2. It is suggested that the time after the cruciate ligament rupture is greater than half a year, and the probability of its medial meniscus injury will increase, indicating that after anterior cruciate ligament rupture, cruciate ligament reconstruction should be performed within 6 months to prevent secondary medial meniscus damage.

#### 2.4. Surgical Treatment of Anterior Cruciate Ligament Injury.

Anterior cruciate ligament reconstruction under knee arthroscopy is currently the preferred method for treating anterior cruciate ligament injury. Commonly used anterior cruciate ligament reconstruction includes single-beam reconstruction and double-beam reconstruction, anatomical reconstruction, and nonanatomical reconstruction [26–28]. Its current positioning method is anatomical reconstruction, including anatomical single-beam reconstruction and anatomical double-beam reconstruction. It also evolved from

the earliest nonanatomical reconstruction (nonanatomical single-beam reconstruction and nonanatomical double-beam reconstruction). The positioning of the bone canal is crucial in the process of anatomical reconstruction. First, see if you can see the broken end of anterior cruciate ligament injury to locate the femoral tract. If the broken end exists, you can use the method of central positioning of the broken end.

If the broken end does not exist, you can perform epiphyseal positioning. Resident Thallium and fasciatus are the main basis. The study found that about 80% of patients can only identify resident doctors, about 55% of patients can only identify fasciatus, and only about 50% of patients can identify both tadpoles at the same time. Anatomical studies of cadaver specimens vary. Therefore, not every patient can clearly identify the two in the knee joint. Chen Lianxu's experience is that he wants a better observation effect [29]. Arthroscopy can be accessed from the anterior internal approach and then use the hook to explore the stump of the anterior cruciate ligament to find the bulge and hard touch, as shown in Figure 3. Here, the AMB means the advanced material buffer used to improve the bone cross section. At present, most scholars insist on using single-beam reconstruction of anterior cruciate ligament. After long-term research and development, arthroscopic single-beam reconstruction of cruciate ligament has achieved satisfactory surgical results. However, due to the lack of single-beam reconstruction of anterior cruciate ligament in controlling the rotation stability of the knee joint, some scholars believe that double-beam reconstruction has obvious advantages in theory and advocate the use of double-beam reconstruction of anterior cruciate ligament [30]. However, whether the clinical efficacy of the double-beam reconstruction technique is better, the single-beam reconstruction technique has not been proved by large-scale clinical comparative trials. At present, there are mainly three kinds of grafts for anterior cruciate ligament reconstruction: allografts, autograft, and artificial ligaments. Discussion on the selection of anterior cruciate ligament grafts is mainly focused on the allograft and autograft. At present, for the selection of grafts, the comparison of the efficacy of autograft or allograft in anterior cruciate ligament reconstruction has no conclusion yet. Due to the relatively lack of reports on clinical research of synthetic grafts, and synthetic grafts have not been clinically validated due to factors such as their safety hazards and treatment effects, they are not currently the first choice by clinicians, so how to choose anterior cruciate ligament graft pair to the clinical treatment effect and clinical treatment plan has important influences [31–33]. For the graft, there are many choices for our doctors to consider,

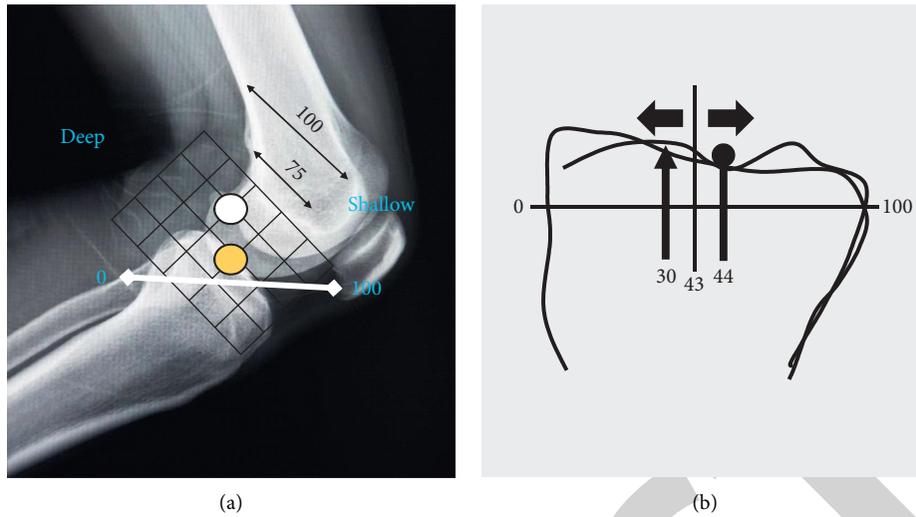


FIGURE 2: The ideal tibial bone tunnel positions for the secondary injury after anterior cruciate ligament rupture.

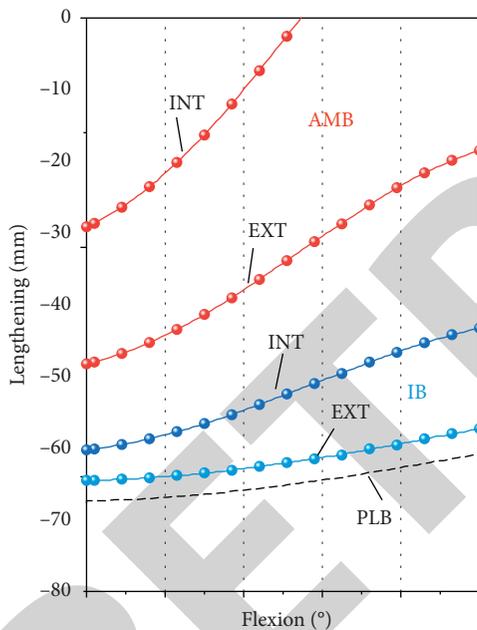


FIGURE 3: Mean length change patterns for the three ACL bundles during flexion, in internal (INT) and external (EXT) tibial rotation after surgical treatment of anterior cruciate ligament injury.

including the potential risk of infection, the hidden dangers of the need for a second surgery on the patient, and the mobility and stability of the knee joint after reconstruction. However, clinicians did not conduct too many screenings when selecting grafts due to various factors. At present, whether it is an allograft or an autograft ligament, its good clinical effect has been proven. However, the comparison of which type of graft to rebuild is preferred, which is inconclusive. For postoperative comparisons between autograft and allograft, the conclusions obtained in different studies are quite different. The main conclusions are divided into two types: one is that the choice of different grafts does not affect the function of the knee joint after patient

reconstruction, and the other is that patients who choose autograft reflect a better recovery of knee function, which may have potential infection risks and postoperative ligaments. Slow healing is the main problem for the choice of allografts, but it has been temporarily confirmed that the chance of rejection of allografts is not significantly different from that of autograft. Although autograft as a graft for reconstruction of knee ligament is still the first choice of most clinicians from the current research and clinical experience, it is important to note that the surgical effect of allograft and autograft is important. It is the surgical method chosen, how to treat the graft and the source of the graft, etc. These factors are also the main reasons affecting the effect of anterior cruciate ligament reconstruction. At the same time, allografts have a wide range of sources and are available in various sizes for clinical use. Selection, the operation during the operation is easy, and these advantages can shorten the operation time.

2.5. *Observation Indicators.* All data analysis was performed in the statistical software SPSS18.0. In this study, the count data were expressed as a percentage and tested. The measurement data were expressed as mean  $\pm$  standard deviation ( $\pm s$ ). Differences were considered statistically significant at  $P < 0.05$ .

### 3. Result Analysis

3.1. *Morphological Typing Results.* In this study, 45 patients with a total of 90 knees received 3D reconstruction analysis. The morphological classification showed that 44 knees were oval, 15 knees round, 16 knees crescent, 5 knees long, and 10 knees irregular. The oval shape is the most common, accounting for 48.89% of the total. Arthroscopy ACL reconstruction surgery is a common type of knee joint surgery. In the past, four-quadrant method, Takahashi method, and interpositional method were used to reconstruct the femoral tract, which cannot be applied in clinical promotion. With

the gradual popularization of the concept of anatomical reconstruction in recent years, due to the differences in the position, shape, and size of ACL femoral stops, it is very important to discuss how to implement effective 3D reconstruction of ACL femoral stop significance. Previous studies on ACL femoral nodal points were mostly performed on corpses. For example, Lorenz et al. used 12 corpses as samples for ACL anatomy analysis. Due to the limited number of samples and the age of the samples, the reliability of the ACL anatomy data obtained is low. The continuous development of clinical imaging technology has provided new ideas for the construction of ACL models. At present, a variety of knee joint models, such as anatomical models, mechanical models, and mathematical models, have appeared in clinical practice. Among them, the three-dimensional knee joint model based on MRI and CT technology has been widely promoted in clinic with its high degree of reduction, as shown in Figure 4. Relevant data show that the three-dimensional imaging of the knee joint can achieve multiplane and multiangle observation, thereby achieving good spatial positioning characteristics and providing reliable three-dimensional data for anatomical research. The angle is the same as the ACL femoral stop morphology plane suppression, which facilitates intraoperative osseous positioning.

In previous studies, knee functional braces were considered to be an integral part of exercise rehabilitation therapy, which can support the healing of ACL, improve the functional stability of joints, and restore normal kinematics. In different exercise rehabilitation stages, when performing exercise rehabilitation function exercises, the adjustable knee joint functional brace can adjust the knee joint activities in different ranges and has a supporting and protecting effect on the affected knee joint. In clinical exercise rehabilitation training after anterior cruciate ligament reconstruction, adjustable knee joint functional braces have been widely used. However, there are still different opinions on the effects of postoperative exercise rehabilitation training on whether or not a brace should be worn. A systematic review summarizes the related research of 28 braces. The research angle is to consider whether the braces can improve the kinematic function of the knee joint. The conclusion is that the literature does not currently recommend the use of knee function exercise rehabilitation after anterior cruciate ligament reconstruction braces, and it is believed that the use of knee functional exercise rehabilitation braces after anterior cruciate ligament reconstruction will not reduce postoperative pain and improve knee function. However, for patients after anterior cruciate ligament reconstruction, the main role of the knee functional exercise rehabilitation brace is first to support graft healing and maintain knee stability, and then to perform functional exercise rehabilitation training. In addition, some scholars believe that if the postoperative patients do not wear braces for protection, knee function cannot be recovered well during exercise rehabilitation. It is recommended that patients who undergo anterior cruciate ligament surgery need to wear braces within 1 to 3 months after surgery. In the early stage of exercise rehabilitation, the brace should be mainly

used to protect the knee joint. In the later stage of exercise rehabilitation, if there is a patient who needs to return to exercise, the choice of the brace should be mainly based on functional exercise.

CT technology covers the processes of projection data acquisition, data correction, and 3D image reconstruction, and finally obtains the 3D reconstruction image of the scanned object, and the input of 3D printing is based on the 3D volume data reconstructed by CT technology and represented by a triangular grid. As shown in the figure above, the entity is scanned by CT to obtain a multiangle projection data volume. After three-dimensional reconstruction, tomographic data are obtained. After format conversion, topography analysis and STL data export are performed; STL data are combined with 3D printing to print out samples. And we realize the structural information comparison between the original sample and the 3D printed sample.

### 3.2. Comparison of Left and Right ACL Femoral Stops.

There were no statistically significant differences in the measured data of ACL femoral dead points of the left and right knees of 45 subjects ( $P > 0.05$ ), as shown in Figure 5. Here, the bone section shows almost no difference on the left and right sides. The slight difference between 23.7% and 21.7% could be only the individual error. At present, CT imaging is used in the diagnosis of a large number of soft tissues, bone, and joint lesions. CT imaging is an ideal inspection method for bone and joint lesions. It can detect and reflect the small density differences of different tissues; MRI imaging has high spatial resolution rate, has significant advantages in imaging of small tissues or structures such as blood vessels, tendons, cartilage, and nerves, and has high diagnostic sensitivity and specific mockery for knee ligament rupture and meniscus injury. In this study, the knee joint MRI and CT data were collected, combined with the advantages of MRI imaging of soft tissue and CT for bone structure, and three-dimensional reconstruction of knee ACL and femur to obtain a three-dimensional model of knee joint, so as to fully reproduce knee ACL. Compared with the traditional ACL anatomy research method, the model constructed in this study can achieve accurate measurement of ACL anatomy data, and it is more accurate and reliable in confirming ACL femoral stops. Previous studies have shown that there is no significant difference in the morphological parameters of the left and right knees of knee specimens. For example, Dargel et al. performed ACL femoral measurement on the specimen. The length of the short axis was  $(10.31 \pm 1.45)$  mm, and the long axis was  $(17.01 \pm 1.83)$  mm. In this study, the measurement results of the knee ACL three-dimensional reconstruction model of 90 subjects showed that the left and right knees had no significant difference in parameters such as the long axis, short axis, area, and long-axis angle ( $P > 0.05$ ), which is basically consistent with the conclusions in related reports, indicating that the anatomical data obtained by 3D reconstruction of knee ACL given MRI and CT data have good reliability. Some studies have pointed out that the anatomical characteristics of ACL in knee joints are different between

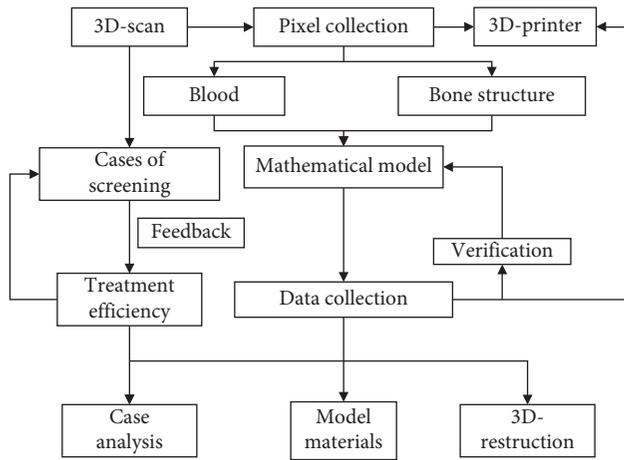


FIGURE 4: The schematic diagram for the process of 3D-reconstruction for bone tissues.

different races, genders, and ages. In this study, analysis of the ACL 3D reconstruction model data of subjects of different genders revealed that male ACL femoral stops were in terms of area, long-axis angle, distance, back distance, short axis, long axis, and other data. Both were significantly larger than females ( $P < 0.05$ ), suggesting that the impact of the patient's gender on the anatomy of the knee joint should be fully considered when formulating the knee joint reconstruction surgery under arthroscopy, so as to maximize the recovery of knee function of patients. In summary, there are anatomical characteristics of the knee joint anterior cruciate ligament femoral dead point, a certain individual difference. The combination of MRI and CI imaging data to achieve three-dimensional reconstruction can provide a reliable basis for the formulation of a surgical plan.

#### 4. Diagnosis and Exercise Rehabilitation of ACL Injuries

**4.1. Postoperative Recovery from Anterior Cruciate Ligament Injury.** Postoperative exercise rehabilitation is equally important in the treatment plan, and the specific process can be seen in Figure 6. Early scientific and reasonable exercise rehabilitation exercise treatment can promote graft healing and plastic reconstruction. At present, there is no consensus on the exercise rehabilitation treatment after anterior cruciate ligament reconstruction. It contains mainly conservative exercise rehabilitation treatment, intense exercise rehabilitation treatment, and individualized exercise rehabilitation treatment. Yasuda et al. advocate that the cycle of exercise rehabilitation is 1 year, and the patient starts the training of knee weight-bearing and activity in the second week after completing the anterior cruciate ligament reconstruction surgery. After training according to a conservative exercise rehabilitation treatment plan, the knee stability after reconstruction is good, but patients are prone to sequelae such as knee stiffness and poor joint mobility. Shellbourne et al. advocate that the treatment period for exercise rehabilitation is six months to nine months. Early in the postoperative period of anterior cruciate ligament

reconstruction, patients will begin training on knee weight bearing and mobility, which is a representative intense exercise rehabilitation treatment program. After exercise rehabilitation training, the patient can perform normal knee joint movements early after the operation; recovery of the knee joint activity is greater, and the incidence of knee complications can be reduced. However, some problems are prone to occur, such as loosened reconstructed grafts, even fractured grafts, and altered tunnels. The reason is that the degree of postoperative exercise rehabilitation activities is too strong, which may increase the relative activity of the graft in the bone canal. The Sharpey fibers formed early between the graft and the tunnel will be damaged, delaying the healing of the graft and the reconstruction stop, and even cause changes in the tunnel. The results of studies by foreign scholars show that patients with anterior cruciate ligament rupture reconstructed with autologous tendons (semiteadinosus and gracilis muscle) were divided into several groups of mutual control; one used a more intense exercise rehabilitation exercise treatment program, and for the other, a more conservative exercise rehabilitation exercise program was used for postoperative exercise rehabilitation, which is summarized in Table 2. On the plain radiograph of the knee joint 6 months after the operation, the changes in the tibial bone tract of the fierce exercise rehabilitation group were more obvious. The patients in the conservative exercise rehabilitation group had smaller changes in the tibial tunnel than the fierce exercise rehabilitation group. The intense exercise rehabilitation treatment will make the graft more active in the tunnel and, at the same time, will produce more severe cellular responses and inflammatory factors. With the development of sports medicine and exercise rehabilitation medicine, physicians have gradually realized that specific and effective exercise rehabilitation treatment programs must integrate all aspects of each patient to develop exercise rehabilitation training methods. In recent years, individualized exercise rehabilitation treatment programs have gradually started to rise, which requires professionals to be able to more accurately understand and master sports medicine and exercise rehabilitation medicine related knowledge. The patient first received a plain CT scan and then an MRI scan. The layer thickness was 2 mm, the layer spacing was 0.5 mm, the matrix size was set to  $512 \times 512$  pixels, and the number of excitations was taken twice. During the scan, the patient's knee joint was naturally straightened, and the external rotation was 10 to 15°. In order to enable the knee function to recover better and improve the shortcomings of conservative and intense exercise rehabilitation programs, exercise rehabilitation physicians need to formulate more individualized and targeted exercise rehabilitation treatment programs, which comprehensively analyze and consider all aspects of postoperative patients.

**4.2. The Role of Braces in Anterior Cruciate Ligament Injury.** In previous studies, knee functional braces were considered to be an integral part of exercise rehabilitation therapy, which can support the healing of ACL, improve the

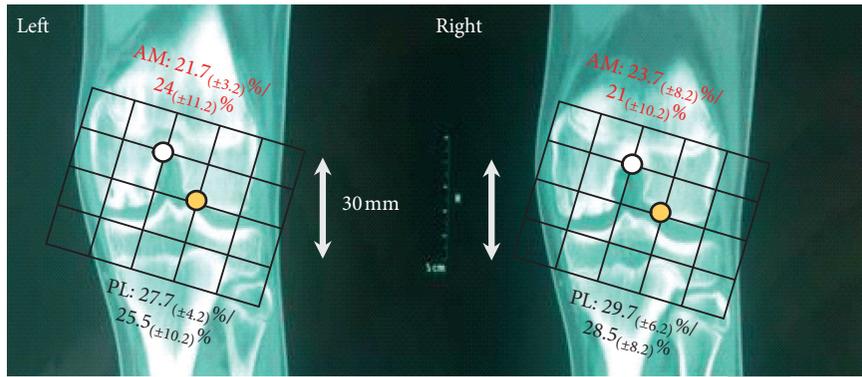


FIGURE 5: The ideal tibial bone tunnel positions for the left and right ACL femoral stops.

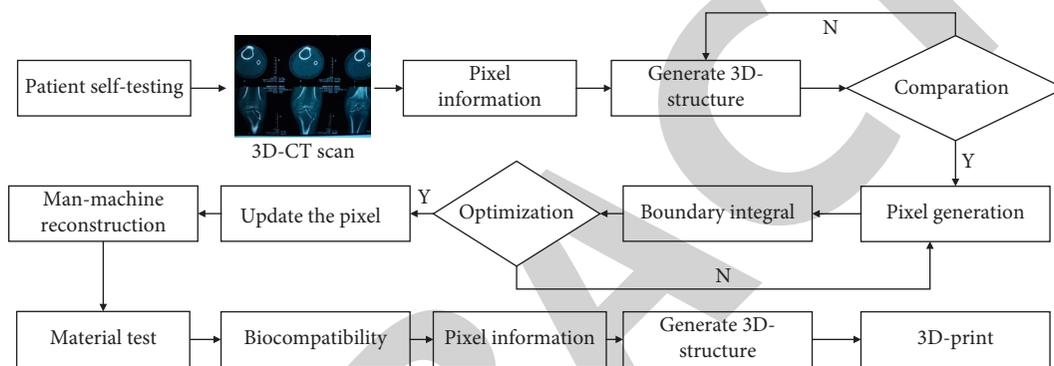


FIGURE 6: Analytical framework of application of 3.0 T MRI to knee joint sports injury assessment and exercise rehabilitation.

TABLE 2: Assessing grade results of knee joint sports injuries of patients in the 3.0 T MRI group ( $n$  (%)).

Knee sports injury	Level I ( $n$ %)	Level II ( $n$ %)	Level III ( $n$ %)
Meniscus injury	3 (30.00)	5 (50.00)	2 (20.00)
Ligament injury	4 (33.33)	6 (50.00)	2 (16.67)
Bone contusion	1 (12.50)	4 (50.00)	3 (37.50)
Articular cavity effusion	0 (0.00)	2 (66.67)	1 (33.33)

functional stability of joints, and restore normal kinematics. In different exercise rehabilitation stages, when performing exercise rehabilitation function exercises, the adjustable knee joint functional brace can adjust the knee joint activities in different ranges and has a supporting and protecting effect on the affected knee joint. In clinical exercise rehabilitation training after anterior cruciate ligament reconstruction, adjustable knee joint functional braces have been widely used. Here, the research angle could influence the growth rate of the bone section, so it could be easy to understand that it could also influence the kinematic function of the knee joint. However, there are still different opinions on the effects of postoperative exercise rehabilitation training on whether or not a brace should be worn. A systematic review summarizes the related research of 28 braces. The research angle is to consider whether the braces can improve the kinematic function of the knee joint. The

conclusion is that the literature does not currently recommend the use of knee function exercise rehabilitation after anterior cruciate ligament reconstruction braces, and it is believed that the use of knee functional exercise rehabilitation braces after anterior cruciate ligament reconstruction will not reduce postoperative pain and improve knee function. However, for patients after anterior cruciate ligament reconstruction, the main role of the knee functional exercise rehabilitation brace is first to support graft healing and maintain knee stability and then to perform functional exercise rehabilitation training. In addition, some scholars believe that if the postoperative patients do not wear braces for protection, knee function cannot be recovered well during exercise rehabilitation. It is recommended that patients who undergo anterior cruciate ligament surgery need to wear braces within 1 to 3 months after surgery. And the specific recovery comparison among different groups can be seen in Figure 7, and the details are summarized in Table 3. In the early stage of exercise rehabilitation, the brace should be mainly used to protect the knee joint. In the later stage of exercise rehabilitation, if there is a patient who needs to return to exercise, the choice of the brace should be mainly based on functional exercise.

Wearing a functional exercise rehabilitation brace after surgery can maintain knee stability, reduce postoperative pain, and protect the graft from injury without affecting the recovery of the patient's lower extremity strength. Although there is literature found that after the patient wears a brace

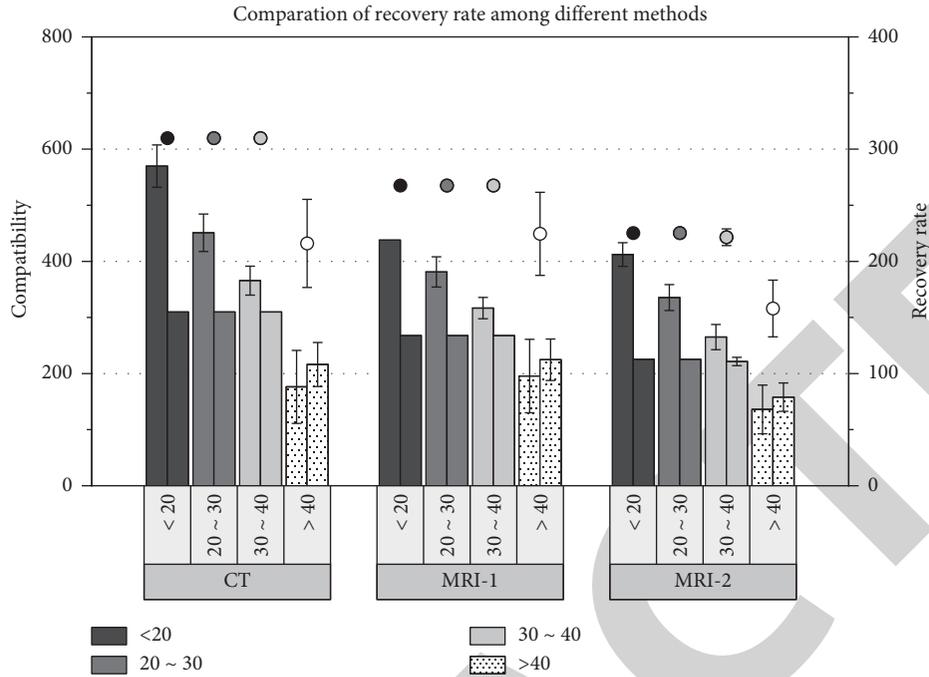


FIGURE 7: Compatibility and recovery rate at different recovery stages for different methods.

TABLE 3: Comparison of assessment results of different imaging methods on the exercise rehabilitation therapies of the three groups of patients.

Group	Level	<20	20~30	30~40	>40
CT	0	0 (0.00)	5 (12.50)	9 (22.50)	20 (50.00)
	I	10 (25.00)	13 (32.50)	15 (37.50)	12 (30.00)
	II	15 (37.50)	14 (35.00)	12 (30.00)	6 (15.00)
	III	13 (32.50)	8 (20.00)	4 (10.00)	2 (5.00)
MRI	0	0 (0.00)	3 (7.50)	8 (20.00)	14 (35.00)
	I	11 (27.50)	17 (42.50)	16 (40.00)	13 (32.50)
	II	14 (35.00)	11 (27.50)	10 (25.00)	9 (22.50)
	III	11 (27.50)	9 (22.50)	6 (15.00)	4 (10.00)
$\chi^2$		8.26	13.18	17.25	7.69
$P$		<0.05	<0.05	<0.05	<0.05

after surgery, in terms of exercise and stress, the affected side has an inconsistency with the unoperated healthy side. In addition, there are reports in the literature that patients wearing braces may affect the sense of postoperative pain. This may increase the difficulty of gait training or motor skills for patients in the late stage of exercise rehabilitation. Moreover, there are no cases in the literature that report that wearing protective functional braces early after surgery will lead to changes in the reconstruction of the patient's tunnel. There are still different opinions on the use of braces, but no literature has found any reports of anterior cruciate ligament surgery. Patients wearing the brace will aggravate pain, and the recovery of knee joint mobility and graft healing and plastic reconstruction of ligaments after surgery are not affected. Although there are many types of functional exercise rehabilitation braces in the market and the quality and price are quite different, we have found that the general knee functional braces have knee motion trajectories that are

simply hinge flexion and extension. The normal knee joint is a series of complex three-dimensional movements accompanied by rolling and sliding of femoral condyles and axial internal rotation of tibia. Therefore, these knee joint braces currently used in China do not conform to the physiological structure of our human knee joints. According to reports in the literature, after anterior cruciate ligament injury, the tibia advances to the femur, and the severity of the injury varies, and the relative displacement of the tibia varies. The anterior cruciate ligament injury of the knee joint resulted in the tibia advancing to the femur.

## 5. Discussion

*5.1. Comparison of 3D-CT and MRI Mapping in Assessing ACL Cases.* There are many research methods about the ACL-related injuries of ACL femoral stops, mainly divided into several groups by different scan methods (Table 4). Through the comparison of the data in Figure 8, it is found that different methods can obtain different distortion reconstruction for bone tissues, even the same method, and the results obtained are different. The author believes that there are two reasons: (1) the positioning of Blumensaat lines by different authors is not very accurate; (2) there may be differences between different groups, populations, and individuals, leading to different positions of ACL femoral centers in this control group. For the selection of subjects, patients with high incidence of ACL injury were selected.

Compared with previous studies, it has the following advantages: (1) this study can do a large sample study, excluding the shortcomings of the limited number of studies on corpses, older age; (2) there may be individual differences in ACL anatomic location. Different races and populations may have different anatomical positions of ACL. This study

TABLE 4: Comparison of assessment results of different imaging methods on the exercise rehabilitation therapies of the three groups of patients.

Reconstruction methods	CT group			1.5 T MRI group			3.0 T MRI group		
	3.0 T	AS	CR	1.5 T	AS	CR	CT	AS	CR
Meniscus injury	10	11	90.91	6	9	66.67	7	16	43.75
Ligament injury	12	14	85.71	11	16	68.75	16	10	40.00
Bone contusion	8	10	80.00	7	12	58.33	13	8	37.50
Articular cavity effusion	3	5	60.00	1	3	33.33	3	6	50.00

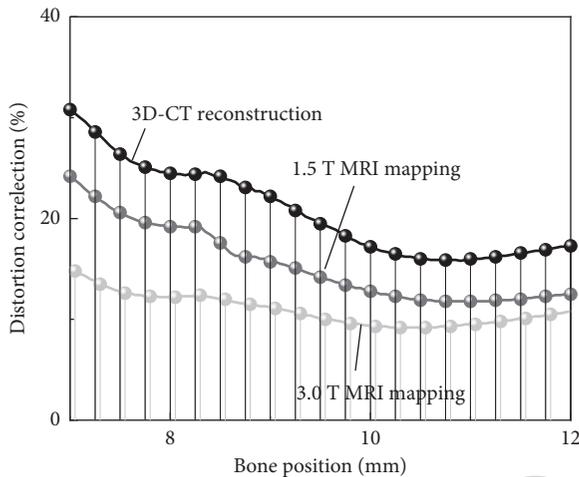


FIGURE 8: Distortion level for different reconstruction methods in at different recovery stages.

selected patients in the age group with high incidence of ACL injury in China, making the measured relative position of the center point more representative. The high-resolution DSCT thin-layer scan used by the author can clearly show the natural imprint of the ACL femoral dead point and the position of the double-bone tract after surgery, making it possible to reproduce the anatomical position of the ACL dead point before surgery. Intraoperative and surgical positioning and postoperative evaluation of the position of the bone canal help to improve the surgical operation, and truly achieve the purpose of restoring the anatomy as much as possible. The volume reconstruction technology used can reconstruct the points and surfaces in any direction that the author is interested in, so that the imprint and bone can be visualized in front of the eyes, and overcome the lateral femoral condyle of interest that the author could not observe on the conventional X-ray plain film. However, the relative position of the bony structure was measured on the three-dimensional model, and the soft tissue of the ACL attachment point at the femoral end was not reconstructed. Due to the irregular imprint of the ACL stop, the group was drawn on the imprint circle and the center point. It is inevitable that there are individual subjective differences, as shown in Figure 9. In this study, the most commonly used quadrant method is used to compare the relative positions of the center points of the experimental group and the control group. The advantage is that the results of this study can be compared with the results of related reports in the past. However, the Blumensaat line is not visible on the 3D model

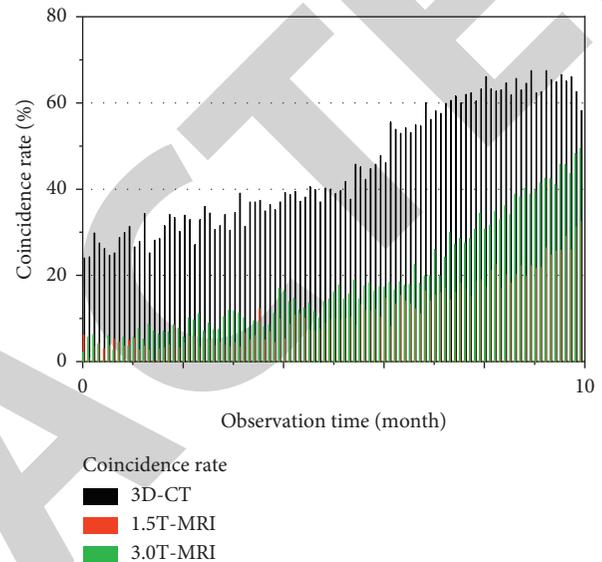


FIGURE 9: Coincidence rate for different reconstruction methods at different recovery stages.

of the image, and it is not a definite bone mark, as shown in Figure 10. Therefore, it is difficult to determine the Blumensaat line on the three-dimensional model. Different people inevitably have subjective individual differences when determining the position of the Blumensaat line.

**5.2. Biocompatibility of 3D-CT Modeling to Evaluate ACL and Related Cases.** The 3D-CT is a minimally invasive diagnostic method with high soft tissue resolution, which can clearly display bone lesions, and the characteristics of the images obtained by different sequences are different and can better identify and diagnose the type of injury. Using 3D-CT to diagnose knee joint sports injuries can obtain accurate diagnostic results and accurate classification, providing an accurate basis for forensic identification, as shown in Figure 11. Because the anatomical structure of the knee joint is more complex, the injury is wider, and the location of the injury is different, the impact on the function of the knee joint is also different. Therefore, in the process of identifying knee injuries, clinical forensics should analyze the patient's trauma history, injury mechanism, clinical characteristics, and imaging characteristics. In order to improve the accuracy of diagnosis, some injuries may cause complications because the knee joint is a weight-bearing joint and affected by factors such as improper function recovery training.

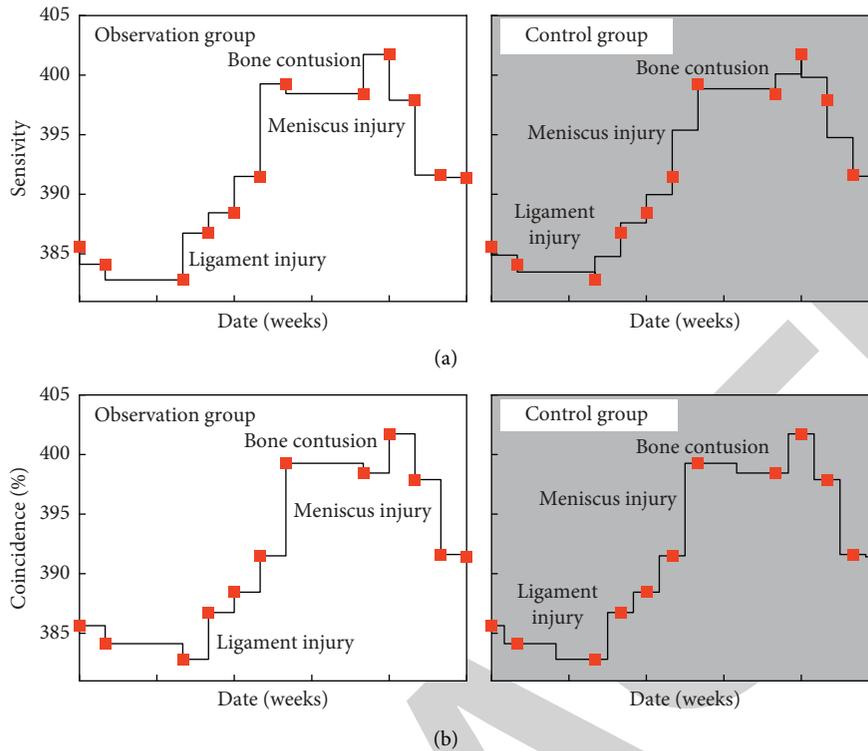


FIGURE 10: Sensitivity for different reconstruction methods at different recovery stages.

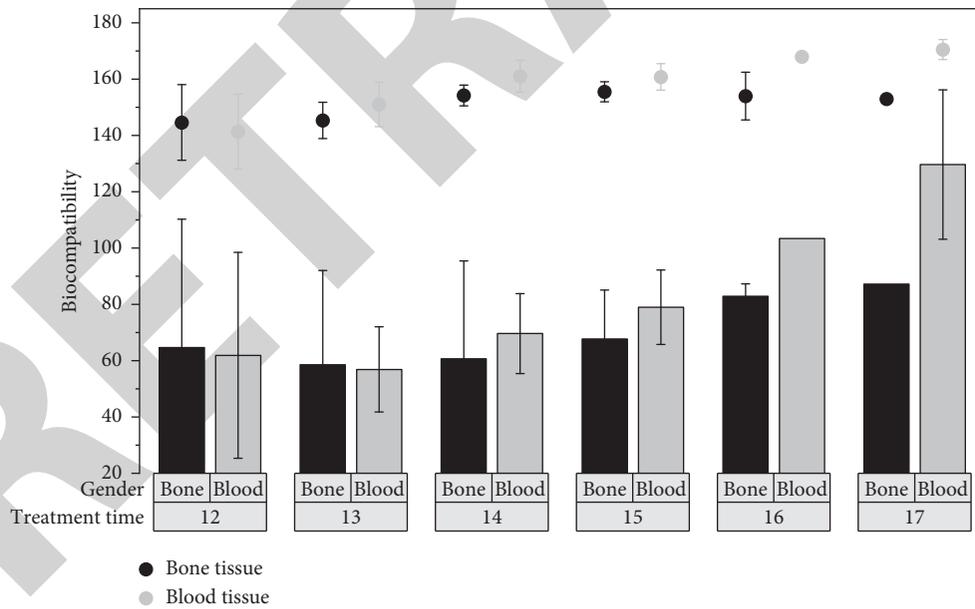


FIGURE 11: Biocompatibility of 3D-CT modeling to evaluate ACL and related cases in bone and blood tissues.

Therefore, when identifying them, they should be performed again after the patient's condition is stable and it is necessary to accurately grasp the best time for assessment, thereby ensuring the accuracy, objectivity, and impartiality of the conclusion of the assessment. In this study, all patients with anterior cruciate ligament injury were required to have the affected knee joint in an upright position and then take

X-rays from the side. Among them, the degree of advancement of the tibia relative to the femur was significantly different among different patients, and the tibia of some patients was significantly advanced relative to the femur. Later, it was reported in the literature that by scanning magnetic resonance imaging (MRI) of the knee joint, it was found that the degree of advancement of the lateral tibial

plateau to the lateral femoral condyle of patients with anterior cruciate ligament reconstruction failure was significantly increased. The results of this study further suggest that the clinical efficacy of anterior cruciate ligament reconstruction may be affected by the degree of advancement of the tibia relative to the femur after anterior cruciate ligament injury. Recently, a document reported by foreign scholars reported the role of soft tissues in maintaining the relationship between the normal position of the tibia and the femur, although the document confirmed the degree of forward displacement of the lateral tibia platform of the knee relative to the lateral femoral condyle in patients. When the anterior cruciate ligament is injured and the posterior horn of the lateral knee joint is damaged, it will increase significantly. However, there are no reports about the effect of bony structure on maintaining the relative position of tibia and femur after anterior cruciate ligament injury. At present, related literature has reported that one of the risk factors leading to anterior cruciate ligament injury is an increase in PTSA. Some literature studies have reported that through biomechanical studies, when the anterior cruciate ligament of the knee joint is injured, the displacement of the tibia relative to the femur will increase by about 6 mm forward with each increase of the tibial inclination of the tibia. Through the biomechanical model constructed by it, different foreign scholars have obtained similar experimental conclusions. However, at present, no scholars have proposed whether the relative position of the tibia relative to the femur will have different degrees of forward displacement after the anterior cruciate ligament injury in different patients.

## 6. Conclusion

In this paper, the 3D-CT three-dimensional reconstruction method is used to reconstruct the ACL natural femoral imprint and double-bone tract. The relative positional relationship between the two center points is compared, and the law is summarized to guide the improvement of ACL anatomic double-beam reconstruction under arthroscopy. The 3D reconstruction results suggest that the UF layer in the anterior medial portion is the thickest, forming a peak, and the thickness of the UF layer in the posterior medial portion gradually decreases in a stepwise manner. The entire UF tissue in the anterior medial portion and posterior medial portion is integrated into one body. The tissues are connected as a whole, and the thickness is relatively uniform. The two parts of the UF tissues are not connected. The CF tissue was inserted into the bone tissue in a zigzag pattern. The changes of CF tissues in the anterior medial and posteromedial CF tissues were similar, and they were distributed stepwise from the inside to the outside. According to the UF and CF spatial structure and changing rules, ACL is divided into medial and lateral beams. According to this study, it can be summarized that (1) 3D reconstruction can clearly reconstruct the natural footprint of ACL femoral stops and postoperative osseous position and (2) 3D reconstruction can be used to evaluate the position of osseous postoperative ACL anatomic double-beam reconstruction. In summary, the debate on how to reconstruct ACL will

continue, and the focus of everyone's debate is mainly on bone positioning and postoperative efficacy. Therefore, ACL surgery requires continuous improvement of surgical methods and surgical concepts.

## Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

## Conflicts of Interest

The author declares that there are no conflicts of interest.

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