Intervention Progress of Anterior Cruciate Ligament (ACL) Reconstruction in Knee Osteoarthritis Caused by ACL Injury

Xuanwei Zhang*

Department of rehabilitation therapy, Shanghai Normal University TIANHUA College, Shanghai, China

*Corresponding author: 15050440232@xs.hnit.edu.cn

Abstract. In recent years, as the number of people exercising has increased, so has the number of sports injuries, including traumatic osteoarthritis caused by Anterior Cruciate Ligament ACL injury. Traumatic osteoarthritis is a disease caused by trauma to or around the joints. It is primarily distinguished by articular cartilage degradation and ossification, which can lead to pathological changes of periarticular ligaments, synovial inflammation and joint instability, mainly causing joint pain, dysfunction, including premature joint degradation and other clinical symptoms. Any age and age group can occur, generally to young adults more common. The treatment of ACL injury is generally divided into emergency care, surgical treatment, drug treatment, and non-surgical treatment. If patients have ACL injury combined with medial knee ligament injury, or combined with posterior cruciate ligament injury and lateral ligament injury, surgical repair is generally selected for treatment, or ligament reconstruction is selected for treatment. For patients with obsolete injuries, more treatment means of ligament reconstruction should be considered. The therapeutic effect of ACL reconstruction on post-traumatic osteoarthritis is still controversial. This article aims to review the relationship between ACL injury and the pathogenesis of post traumatic knee osteoarthritis, in order to provide assistance for the treatment of Osteoarthritis of the knee caused by a severe injury.

Keywords: Traumatic osteoarthritis, anterior cruciate ligament reconstruction, ligaments, articular cartilage.

1. Introduction

Post-traumatic osteoarthritis is a degenerative, hyperplastic, ossifying disease of articular cartilage caused by trauma, which is different from the conventional osteoarthritis. Common clinical joint pain, joint mobility limited dysfunction. Affect patients' normal life activities.

Anterior Cruciate Ligament (ACL) injury may be one of the top five risk factors for post-traumatic osteoarthritis. ACL injuries can easily lead to knee damage and are usually seen in young people. Evers, Bob J et al reported in the August 22, 2022 issue of Frontiers in Medicine, Posttraumatic Knee Osteoarthritis: Inflammation and Hematoma's Crucial Role in Disease Progression. The knee injury leads to posttraumatic osteoarthritis in 25-50% of patients [1]. Snoeker, Barbara et al. employed Cox regression to anticipate future diagnoses of traumatic osteoarthritis of the knee in damaged and uninjured individuals in a long-term cohort study using Skorner's population-based healthcare data. The review discovered that in young individuals, knee injury raised the likelihood of eventual diagnosis of knee OA by roughly six times, with cruciate ligament damage, meniscus rupture, and intraarticular fracture having the greatest risk[2].Most patients with anterior cruciate ligaments may develop knee osteoarthritis in middle age or even younger.

Current interventions for traumatic osteoarthritis include exercise therapy, corrective therapy, medication, physical therapy, ultrasound, and infrared therapy. Surgical treatment and osteotomy, joint fusion. However, the current treatment lacks the characteristics of symptomatic treatment and has certain limitations.

According to the investigation, it is found that early traumatic osteoarthritis cannot be prevented, so from the perspective of anterior cruciate ligament reconstruction, this may be a breakthrough to produce a new treatment model. Assuming that patients after ACL reconstruction can recover their basic functions earlier, by evaluating the results of patients' self-report(IKDC 2000, KOOS, Tegner, and VAS), recurrence rate, rehabilitation time necessary to resume everyday and physical activities,

short-term (Rolimeter, LSI, I, Isoforce), and the development degree of osteoarthritis, short-term (Isoforce, Rolimeter, and Isoforce) (6 weeks, 3 weeks, 6 and 9 months and 1 year) [3].

This paper systematically reviews the previous treatment methods of knee osteoarthritis caused by ACL injury, and compares whether ACLR is really effective from the research results. Although there have been a series of clinical studies on traumatic osteoarthritis in China, there are few studies on the treatment of knee osteoarthritis. The purpose of this study is to determine whether or not surgical repair of ACL may successfully minimize the risk of osteoarthritis in patients who have suffered trauma.The injury caused by anterior cruciate ligament will seriously affect the knee function of patients. ACLR is now widely regarded as the treatment of choice for bringing back knee stability and enhancing knee function. [4].

2. How to Diagnose ACL Injury and Rupture?

38 patients (29±8 years old, 21 males) were prospectively followed up after acute anterior cruciate ligament injury and before ligament reconstruction. A total of 54 patients were recruited. Under the condition of knee load accounting for 25% of the total weight, exercise MRI was performed, and static images were obtained under the condition of complete extension and bending 30. Each patient's lateral difference (SSD) between the bent and extended positions of the tibia was calculated. Using statistical shape modeling algorithm based on principal component analysis, 20 shape features of tibia and femur were independently extracted from preoperative scanning. Accord to that statistics of data experiment. A variety of bony features of tibia and femur were observed. This may be connected to anterior cruciate ligament damage and aberrant knee kinematics following anterior cruciate ligament replacement[5]. The impact of patients' fluctuating clinical symptoms on bone morphology with ACLR and patients without ACLR will be one of the future research directions. This will be done in order to determine whether or not reconstruction can help improve the motor function of patients who have knee osteoarthritis.

In order to accurately diagnose the rupture of anterior cruciate ligament, clinicians will combine the patient's medical history, clinical examination and MRI information. ACL rupture is usually accompanied by meniscus, cartilage or other knee ligament injury. Extra care should be given to the accurate diagnosis of accompanying major injuries. ACL rupture is usually accompanied by ligament sprain, meniscus tear, bone marrow lesion, articular cartilage injury and intra-articular fracture. Injuries to the LCL and the PCL occur at a rate that is considered to be rather low. Injuries to the MCL, and injuries to the meniscus, also known as meniscus tears, are more prevalent and often occur during activity and exercise.

2.1. History

The commonness of patients with passive knee instability, joint pain, joint effusion and motor coordination disorder.

2.2. Clinical Examination

Evaluation of ACL should be place as soon as possible after damage; however, this is often hindered by swelling and discomfort. The first step in the assessment should be to watch how the patient walks and to make sure they are in a relaxed position when they are on the examination table [6]. A rupture of ACL may be diagnosed by the use of a variety of clinical tests. The Lachman test is the clinical diagnostic test that provides the highest level of accuracy, followed by the front drawer test and the pivot displacement test. When performed correctly, the comprehensive examination of the knee may detect an ACL damage with a high degree of accuracy, with a sensitivity of 82% and a specificity of 94%, respectively. The probability ratio of a positive examination is 25, whereas the likelihood ratio of a negative examination is just 0.04. All the Lachman test, the front drawer test and also the pivot displacement test are always used to detecte the ACL tear, which are considered as the most accurate [7].

2.3. Magnetic Resonance Imaging

The primary research tool that is utilized to diagnose ACL injuries is MRI. Moreover, it is able to diagnose the associated meniscus damage, bone contusion, and rupture in the collateral ligament. For patients with suspected rupture of anterior cruciate ligament, MRI has the following values: (1) adjuvant with uncertain clinical diagnosis; (2)a component of the examination that goes along with knee injuries, particularly those that are more challenging to clinically identify (such as meniscus and cartilage injuries)[8].

3. Why does ACL Rupture Contribute to Knee Osteoarthritis?

The rupture of ACL has evidence-based basis, including the changes of motor muscles and nerves and the inflammatory reaction of cytokines in joints.

3.1. Exercise and Neuromuscular Changes

Biomechanical research shows that 85% of the knees undergoing ACLR surgery have abnormal tibial rotation during the walking posture, but the opposite knee has not experienced this situation. In view of the fact that anterior cruciate ligament also plays an important role in knee proprioception, knee rupture may lead to insufficient detection of dynamic joint stabilizers (quadriceps femoris and hamstrings), which may lead to joint instability [9].Therefore, the combination of the above kinematic changes may contribute to the early emergence of radiologically obvious OA in ACLR.

After the anterior cruciate ligament is torn, quadriceps femoris atrophy will occur. Just around half of individuals who had ACLR achieved their normal strength level within two to five years after treatment. Biceps weakness after ACLR is closely connected to the decrease of X-ray joint line in OA patients after trauma. This relationship was seen in patients who had undergone ACLR.

3.2. Inflammatory Effect

Proteinases (MMP-1, MMP-2, and MMP-13), inflammatory cytokines (TNF-alpha, IL-1beta, and MMP-1) all rose sharply after ACL rupture [10].Tumor necrosis factor α is related to the increase of apoptotic casing enzyme pathway in chondrocytes. In the days after the rupture of anterior cruciate ligament, chondrocyte apoptosis increased. Although the level of cytokines in healthy knees decreased slowly with time, the knee with ruptured anterior cruciate ligament continued to have detectable quantities of these cytokines for as least a year after the damage.

It has been demonstrated that the mechanical activation of chondrocytes during the process of ACLR will result in a change in their gene expression. Degradation enzymes like MMP, which aid in the breakdown of extracellular matrix proteins including glycosaminoglycan and collagen, will then be activated as a result of this alteration. According to studies, the rise in MMP levels in the knee will persist for a considerable amount of time after anterior cruciate ligament rupture. It will lead to the continuous degradation of glycosaminoglycan and collagen after one year [11]. Although chondrocytes have a certain ability to respond to ACL tear, the catabolic cascade of MMP may exceed the threshold of chondrocyte regeneration ability. Therefore, this mechanism can promote the emergence of post-traumatic OA after anterior cruciate ligament rupture.

Studies have been done to determine if the inflammatory and catabolic cascade that occurs after a rupture in ACL may be pharmacologically countered in the acute stage of injury. These experiments were carried out in an attempt to find out whether this is possible. The level of IL-1 was shown to be higher in patients whose anterior cruciate ligaments had ruptured, and there was a correlation between the amount of IL-1 and the degree of cartilage damage [12]. As a result, one of the objectives of any future therapy should be to bring the amount of IL-1 down. Patients who got an early IL-1Ra injection following an anterior cruciate ligament rupture reported improved outcomes compared to individuals who received a placebo injection. In a different piece of research, Lattermann and colleagues investigated the influence that saline had on the results of joint puncture and corticosteroid injection [13]. The scientists discovered that the findings reported by patients did not alter, but they did detect

that the collagen breakdown products following corticosteroid injection were much fewer than those after placebo injection. This was the finding that stood out to them the most. These preliminary investigations seem to suggest that the management of early inflammatory response after ACLR may minimize early articular cartilage degradation.

The effect of inflammatory reaction has been proved to greatly prevent the incidence of osteodystrophy. The combination of biological media may play an important role in preventing the development of early post-traumatic OA such as ACLR. In the near future, the greatest opportunity to treat post-traumatic OA may appear in the form of some injected molecules. Caspase inhibitors can be used to reduce apoptosis immediately after impact. By minimizing the spread of cell death, this may lessen the effects of any local cartilage impact damage that may have occurred. By interfering with the inflammation and catabolism of IL-1, medications like "Diacerhein" may reduce the function of inflammatory mediators like IL-1 [14]. This is possible since "Diacerhein" is one of these drugs.

4. What is the Optional Timing of ACL Surgery?

"early reconstruction and structured restoration" is one school of thinking, while the other is "structured restoration with delayed rebuilding only when required" [14].Studies have shown that early ACLR can reduce the incidence of early OA in patients with anterior cruciate ligament defects, and these patients intend to continue activities involving avoidance and rotation. Shelbourne et al. The relationship between the loss of range of motion and the development of OA in a continuous ACL reconstruction queue of at least 5 years. They found that the prevalence of OA was 39% in people without full range of motion, and 53% in people with lower range of motion than normal limbs [15]. Loss of range of motion and poor subjective outcomes after ACL repair were both shown by the same author. Consequently, it is possible that the greatest outcomes for patients may be achieved via a standardized system established.

5. What is the Improvement after ACL Reconstruction?

5.1. Muscle Strength of Lower Limbs

15 patients with anterior cruciate ligament injury (8 males and 7 females and 15 controls (7 males and 8 females). Measure hip flexor, extensor, abductor and abductor; Knee joint stretcher and flexor; Ankle joint-flexor vegetative and-flexor strength (Nm/kg). The results of the investigation confirmed the previous findings, that is, the knee extensor and flexor muscle weakness after operation of injured limbs were more serious than those of uninjured limbs. The weakness of these muscles may damage the stability of the knee joint. The reconstruction of anterior cruciate ligament seems to be offset during postoperative rehabilitation.

5.2. Inhibition of Inflammation

Delaying the progression of OA is thought to be possible with anti-inflammatory measures [16]. HPT is a novel medicine for the treatment of OA due to its anti-inflammatory effect that slows the development of the disease's underlying structure. Human chondrocytes in osteoarthritis may have their inflammatory response to IL-1 greatly reduced by HPT. The results of this research showed that HPT stimulated ECM production in cartilage and suppressed the expression of TNF—induced inflammatory genes. Lipopolysaccharide-induced inflammation in RAW 264.7 cells may be attenuated by HPT via the activation of the Nrf2/HO-1 pathway and the downregulation of the NF-B pathway [17]. Inhibiting NF-kB and setting off the Nrf2/HO-1 pathway, HPT was shown to reduce inflammation brought on by IL-1 in human OA chondrocytes. The activation of TNF- is a feature of the ACLT model. As an added bonus, ACLT's capacity to restore joint stability may also reduce the production of inflammatory cytokines (TNF-), which in turn slows the development of OA. HPT has been demonstrated in the past [18] to slow the progression of OA caused by the DMM model.

According to our findings, the inflammatory response of the ACLT-induced OA model may be greatly reduced by HPT treatment [18]. The progression of articular cartilage degradation may also be slowed by HPT therapy, and cartilage defects of the knee joint in rats can be greatly restored, and the cartilage thickness can be enhanced [16].In a nutshell, the results of this research suggest that HPT has promise as a treatment for osteoarthritis [15].

Inflammation is responsible for the perpetuation of post-traumatic osteoarthritis. Studies have found that inflammation can be perpetuated through persistent activation of inflammatory factors, which may lead to joint development resulting in traumatic osteoarthritis. The acute and subacute phases can lead to a balance of pro- and anti-inflammatory [19]. Interventions for traumatic osteoarthritis can be achieved by interfering with the acute phase for anti-inflammatory purposes.

6. What are the SpecificAspects of Follow-up Clinical Evaluation?

Clinically, people should strengthen the evaluation of follow-up and investigate and study according to the real situation of patients after several years of reconstruction.

6.1. IKDC Evaluation

IKDC: International knee documentation Committee. IKDC score can be applied to all kinds of knee joints. It is not specifically aimed at sports or knee instability, but comprehensively evaluates the subjective symptoms and objective signs of the knee joint system. Based on the IKDC score, functional assessment at 2 years post-ACL reconstruction classified 47 patients as IKDC A, 60 patients as IKDC B, 18 patients as IKDC C, and 1 patient as IKDC D. Long-term follow-up data revealed that 23.3% of patients were in normal physiological and clinical conditions (IKDC A), 47.9% of patients were in near-normal physiological and clinical conditions (IKDC B), 23.3% of patients were in abnormal conditions (IKDC C), and 5.5% of patients were in severely abnormal clinical conditions (IKDC D). On the other hand, 75 percent of patients were considered to be either excellent or good. Long-term follow-up revealed an average subjective IKDC score of 78. In the subjective IKDC questionnaire, discomfort and increasing swelling of the knee joint due to high load are explained by clinical anomalies based on the patient's score. Moreover, in the objective IKDC examination, lower outcomes were shown for those with apparent extension abnormalities, intermittent intra-articular effusion development, or unexpected differential relaxation [20].

6.2. Tegener Evaluation

Measurement tool for determining physical exertion. Twelve patients (16.4%) dropped out of or never resumed exercise at the final follow-up; nevertheless, 75.6% of patients really did exercise, and they kept up the great work with the follow-up (55 out of 73). Also, the percentage of students taking part in interscholastic competition fell from 65.3% to 18.5%. Overall, 45 patients (61.8%) reported a deterioration in their performance. A few 19 patients (26.3% of the total) reported that they had experienced these modifications as a direct result of the surgical procedure. The primary causes for the shift in sports attendance are social and professional issues [20].

There were no indications of deterioration in the pre-traumatic radiological evaluation performed by Kellgren and Lawrence. During a two-year observation period, the rate of osteoarthritis deterioration accelerated dramatically [20]. In spite of the fact that the data demonstrates excellent scores over the lengthy period and sufficient knee stability, age - related changes increase with time, and the onset of osteoarthritis is inevitable.

So far, the research reports can't prove that the risk of knee osteoarthritis after trauma will be reduced. Half of the people who underwent ACLR suffered from KOA 12-14 years later. After ACLR, the occurrence of OA was explained by abnormal tibial anterior displacement and abnormal tibial rotation in walking posture (85% of the operated knees). The X-rays of patients who received early ACLR (average 5 days after ACL rupture) for 32-37 years were significantly lower than those who had never experienced ACL rupture. However, the percentages of OA, patellofemoral OA and knee

symptoms with radiologic evidence were the same in the two groups. During the 15-year follow-up, 23% of patients with knee ACLR had OA, and if ACLR was non-anatomical, the proportion would increase to 44% [21]. Not only that, in the investigation, it was found that knee injury would occur after anterior cruciate ligament reconstruction.

7. Summary

Post-injury osteoarthritis and ACL reconstruction is a hotly contested issue.Through the research and investigation in recent years, it is roughly summarized that the ACLR can reduce the occurrence of KOA when the knee joint is always stable. But only if the knee joint remains stable. The occurrence of traumatic osteoarthritis of knee joint is caused by various complex factors. There is insufficient evidence that anterior cruciate ligament reconstruction reduces the risk of knee osteoarthritis. In the early intervention of knee osteoarthritis, ACLR takes up little importance in the later rehabilitation. There are few clinical studies in China showing that ACL can prevent KOA. ACLR has less advantage in OA prevention than non-surgical treatment. ACLR technique can not fully restore the condition before functional injury. But there are two sides to the evidence-based evidence, and the current study is still in the middle. Based on the summary of previous studies, people can continue to guide the formulation of ACL reconstruction protocols and apply them to clinical practice to observe other improvements.

References

[1] Evers, Bob J et al. “Post-traumatic knee osteoarthritis; the role of inflammation and hemarthrosis on disease progression.” Frontiers in medicine vol. 9 973870. 22 Aug. 2022

[2] Snoeker, Barbara et al. “Risk of knee osteoarthritis after different types of knee injuries in young adults: a population-based cohort study.” British journal of sports medicine vol. 54,12 (2020): 725-730.

[3] Boer, Barbara C et al. “Self-reported functional recovery after reconstruction versus repair in acute anterior cruciate ligament rupture (ROTOR): a randomized controlled clinical trial.” BMC musculoskeletal disorders vol. 19,1 127. 20 Apr. 2018.

[4] Krause, Matthias et al. “Operative Versus Conservative Treatment of Anterior Cruciate Ligament Rupture.” Deutsches Arzteblatt international vol. 115,51-52 (2018): 855-862.

[5] Lansdown, Drew A et al. “Variations in Knee Kinematics After ACL Injury and After Reconstruction Are Correlated With Bone Shape Differences.” Clinical orthopaedics and related research vol. 475,10 (2017): 2427-2435.

[6] Cimino, Francesca et al. “Anterior cruciate ligament injury: diagnosis, management, and prevention.” American family physician vol. 82,8 (2010): 917-22.

[7] Solomon DH, et al. The rational clinical examination. Does this patient have a torn meniscus or ligament of the knee? Value of the physical examination. JAMA. 2001;286(13):1610-1620.

[8] Filbay, Stephanie R, and Hege Grindem. “Evidence-based recommendations for the management of anterior cruciate ligament (ACL) rupture.” Best practice & research. Clinical rheumatology vol. 33,1 (2019): 33-47.

[9] Scanlan SF, Chaudhari AMW, Dyrby CO, Andriacchi TP. Differences in tibial rotation during walking in ACL reconstructed and healthy contralateral knees. J Biomech. 2010;43(9):1817–22.

[10] Haslauer CM, Elsaid KA, Fleming BC, Proffen BL, Johnson VM, Murray MM. Loss of extracellular matrix from articular cartilage is mediated by the synovium and ligament after anterior cruciate ligament injury. Osteoarthritis Cartilage. 2013;21(12):1950–7.

[11] Harkey MS, Luc BA, Golightly YM, et al. Osteoarthritis-related biomarkers following anterior cruciate ligament injury and reconstruction: a systematic review. Osteoarthritis Cartilage. 2015;23(1):1–12.

[12] Marks PH, Donaldson MLC. Inflammatory cytokine profiles associated with chondral damage in the anterior cruciate ligament deficient knee. Arthroscopy. 2005;21(11):1342–7.

[13] Lattermann C, Jacobs CA, Bunnell MP, et al. A multicenter study of early anti-inflammatory treatment in patients with acute anterior cruciate ligament tear. Am J SportsMed. 2016;45(2):325–33.

[14] Norris, Rory et al. "The effect of anterior cruciate ligament reconstruction on the progression of osteoarthritis." The open orthopaedics journal vol. 6 (2012): 506-10.

[15] Shelbourne KD, Urch SE, Gray T, Freeman H. Loss of normal knee motion after anterior cruciate ligament reconstruction is associated with radiographic arthritic changes after surgery. Am J Sports Med. 2012;40(1):108–13.

[16] Robinson W. H., Lepus C. M., Wang Q., Raghu H., Mao R., Lindstrom T. M., et al. (2016). Low-grade Inflammation as a Key Mediator of the Pathogenesis of Osteoarthritis. Nat. Rev. Rheumatol. 12 (10), 580–592. 10.1038/nrrheum.2016.136

[17] Ren H., Hao J., Liu T., Zhang D., Lv H., Song E., et al. (2016). Hesperetin Suppresses Inflammatory Responses in Lipopolysaccharide-Induced RAW 264.7 Cells via the Inhibition of NF-Kb and Activation of Nrf2/HO-1 Pathways. Inflammation 39 (3), 964–973.

[18] Xie J., Zhang D., Lin Y., Yuan Q., Zhou X. (2018). Anterior Cruciate Ligament Transection-Induced Cellular and Extracellular Events in Menisci: Implications for Osteoarthritis. Am. J. Sports Med. 46 (5), 1185–1198.

[19] Lieberthal, J et al. "Inflammation in joint injury and post-traumatic osteoarthritis." Osteoarthritis and cartilage vol. 23,11 (2015): 1825-34.

[20] Struewer, Johannes et al. "Knee function and prevalence of osteoarthritis after isolated anterior cruciate ligament reconstruction using bone-patellar tendon-bone graft: long-term follow-up." International orthopaedics vol. 36,1 (2012): 171-7.

[21] Rodriguez-Merchan, E Carlos, and Carlos A Encinas-Ullan. "Knee Osteoarthritis Following Anterior Cruciate Ligament Reconstruction: Frequency, Contributory Elements, and Recent Interventions to Modify the Route of Degeneration." The archives of bone and joint surgery vol. 10,11 (2022): 951-958.