

Recommendations for Repair of Three Types of Anterior Cruciate Ligament Injuries with Combined Specific Meniscal Injuries

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Abstract. Anterior cruciate ligament (ACL) injury plays an important role in affecting the stability of the knee of patients. ACL injuries often have meniscus injuries. When ACL is combined with special types of meniscus injuries, there are still research gaps on the therapeutic effect of ACLR. The article analyzes the impact on ACLR in terms of its injury mechanism and treatment for three specific types of meniscus: ramp lesions, bucket-handle tear (BHT), and root injury. It is not necessary to repair stable ramp lesions, nor does it affect the rate of recovery of motion. ACL injuries, combined with meniscal BHT, usually result in significant knee instability, causing further damage to the meniscus and articular cartilage and affecting ACLR outcomes. Therefore, simultaneous repair is recommended. If ACLR is performed over three months after injury, the timing positively correlates with the medial meniscus tear rate. BHT during simultaneous repair can lead to the risk of postoperative arthroplasty surgical revision. When combined with root injury, root tears which happened in lateral meniscus after ACLR lead to increased tibial anterior translation, and posterior root tears of lateral meniscus can further disrupt the ACL stability of reconstructed knee joint. Repairing posterior lateral meniscal root tears with good short-term clinical results is recommended.

Keywords: Ramp Lesion, Bucket-Handle Tear, Root Injury, Meniscal Injuries, Anterior Cruciate Ligament Injury.

1. Introduction

The knee is a joint that is prone to injury during sports. There are many structures around the knee that stabilize the joint, and the ACL is significant to it. However, because the ACL is so fragile compared to other ligaments in the knee, ACL injuries have become a very common type of sports injury among patients. In the U.S ACL rupture's rate of occurrence is about 1/3000 in the general population and 6/10,000 in soccer players. In a census of active athletes in China, the incidence of ACL rupture was found to be 0.43% [1].

Compared to simple ACL injuries, they are often combined with injuries to other tissues within the knee joint, and the most common is meniscal injury. The survey indicated that among 861 patients with knee injuries, meniscal tears (38.4%) and ACL injuries (20.2%) were more common [2]. There are 100,000 to 200,000 ACLR ruptures each year in the U.S, with up to 130,000 cases complicated by meniscal tears. ACLR combined with meniscal injury can lead to knee instability, interfere with daily activities and sports, and cause further damage to intra-articular structures. Therefore, once an ACL rupture has occurred, it must be repaired immediately. A general consensus is that ACLR should be considered for reconstruction of the damaged knee. Different types of meniscal injuries may be associated with different types of ACL injuries. The occurrence of compound injuries may be gender-related and the incidence of injury increased in the elderly and overweight population. The type of injury may have different implications for surgery and prognosis. For example, if the tear occurs in the longitudinal direction and is not complete or if it occurs in the longitudinal direction but the tear

site is structurally stable, there is little impact on the joint. Therefore, it can be left untreated. In addition, the root and BHT should be repaired promptly.

The medial meniscus is wider in length, better in thickness, and shorter in distance from tibial plateau than lateral one. As ACL function declines, medial is closer to tibial and femoral surfaces making it more exposed, therefore continued unstable knee motion can exacerbate medial damage. It is necessary that determining which stage of the meniscus injury the patients who have ACL injury is to determine if the meniscus needs to be repaired first in order to more effectively restore the ACL injury and knee function. For ACL injuries complicated by certain types of meniscus injuries, there are some differences regarding whether different types of meniscus injuries should be repaired along with ACLR, whether a stable meniscus injury repaired together will adversely affect the patient's prognosis, and the extent to which simultaneous repair will affect the patient's prognosis? In this study, we examined the mechanism, treatment, and prognostic impact of three unique meniscus injuries that may occur concurrently with ACL injuries.

2. Special meniscal injuries and characteristics of ACL injuries combined with meniscal injuries

2.1. Characteristics of ramp lesions and ACL combined injury

2.1.1 Overview of ramp lesions

A injury in the knee's posterior corner of the C-shaped meniscus near the synovial membrane edge is called a ramp lesions. The ramp region is located in the knee joint's posterior internal region of the knee joint, and combines the posterior horn of the medial meniscus with the joint capsule's synovium [3]. They usually occur after injuries to the ACL. They are often missed because they cannot be detected by routine anterior arthroscopy. Ramp lesions does not heal naturally, and further injury can develop vertically toward the body and head of the meniscus, resulting in more severe bucket lesions and possibly even mixed lacerations that degrade the stability of the entire posterior horn of the meniscus of the knee joint. Therefore, when the ACL is injured and the ramp region is also damaged, the ramp region should be actively repaired in ACLR to reinstate the stability of the knee joint [3].

2.1.2 Ramp treatment

Most studies believe that early surgical repair can regain the normal structure of the meniscus more fully, maintain the stability of the knee joint. It can also reduce aggravation of articular cartilage injury and meniscus injury. Without timely and effective treatment, knee instability and secondary injury of other normal structures in the joint cavity could occur, thus affecting the stability of ACLR grafts [3].

Preoperative MRI and/or arthroscopy can determine the ACL injury, articular cartilage, and meniscus condition. During the operation, arthroscopic fresh wound treatment technology, fast-fix suture technology and other technologies can be used for treatment. The treatment was carried out by arthroscopic fresh wound treatment technology, fast-fix suture technology, double posteromedial approach suture hook suture method, and other technologies [3].

2.1.3 Characteristics of ACL injuries combined with ramp lesions

Under normal physiological conditions, the stability of the knee joint is mainly maintained by structures such as meniscus and ACL [3]. There is a biomechanical correlation between the ACL and the medial meniscus posterior horn, which together can limit the anterior movement of the tibia.

Anatomically, the medial meniscus is attached to the MCL (medial collateral ligament) and has less range of motion than the lateral meniscus. In addition, the posterior horn of the medial meniscus can limit the posterior movement of the tibial condyle. This special anatomical structure makes the ACL secondary to injury due to increased pressure load after ramp injury [3].

In terms of function, Stephen et al. found that ramp lesions of the medial meniscus would affect the rotational and forward stability of the knee joint. A 90N forward stress applied at 30 degrees of knee flexion enlarge the tibial forward range by 3.9mm. An external rotation torque of 5 N·m was

applied to the knee joint. When ACL injury and medial meniscus ramp lesions co-existed, the external rotation of the knee joint increased to 2.5°. After ramp lesions repair, the external rotation angle of knee joint will be reduced [3].

2.2. Characteristics of BHT and ACL combined injury

2.2.1 Overview of BHT

Meniscal bucket handle injury, also known as a meniscal BHT, is one unique form of longitudinal tear which is very common and has a wide range of tears. If the tear in posterior horn of meniscus continues to extend anteriorly to the meniscus, it may result in a loss of structural integrity of the meniscus. The torn meniscus fragments often become lodged in the intercondylar fossa of the knee, shaped like a bucket handle. It accounts for approximately 10% of meniscal injuries and often occurs in young people engaged in physical work and sports, often leading to knee interlocking and seriously affecting knee function, with medial meniscal BHT being more common [5].

2.2.2 BHT treatment

Although BHT is unique in terms of meniscal injuries, the treatment of BHT continues to follow the same treatment methods and guidelines for general meniscal injuries, with two treatment modalities: suture and resection. The torn part of the meniscus is explored with a probing hook. BHT is repositioned with a probing hook. The free meniscus is shaped and trimmed. The section is freshly treated with a meniscal scraper, and the anterior corner of meniscus can be sewn using an inside-out or outside-in approach. For the body and posterior horn, the sutures are closed using either the fast-fix method or meniscal-cinch sutures method. Arthroscopic meniscoplasty or resection was once a common treatment for bucket handle like tears, but continuing such treatment can cause degeneration of knee joint. In this situation, knee joint will have osteoarthritis at the end. Therefore, most of the menisci that can be repaired with sutures are advocated to be left in place. Removal of the displaced medial block is only an option when suturing is impossible.

2.2.3 Characteristics of ACL injuries combined with BHT

ACL injuries usually happened with BHT, a compound sports injury that often results in significant knee instability, moreover it also can cause further negative results on meniscus and articular cartilage. In MRI images, BHT may appear as an "empty collar knot sign", "fragment displacement sign", "double posterior cruciate ligament sign". Aydingoz et al. argued that all cases of ACL tear with BHT have a clear history of knee joint trauma. According to the data, most knee joint structural injuries are caused by shear violence [6]. Posterior horn of meniscus is an important irreplaceable structure that limits the continued forward motion of the tibia after cruciate ligament rupture. Therefore both posterior horns may produce supraphysiological loading and are at high risk of tearing. This risk is more likely to occur in the medial posterior horn, where the occurrence of medial BHT is three times higher than in the lateral meniscus.

2.2.4 Overview of root injury

There are generally several types of fractures in the roots of meniscus: (1) traumatic tears, which usually occur in young patients who love to be active, accompanied by tear injuries that can also occur with lateral ligaments; (2) Degenerative tearing, usually manifested as an internal tear, with the posterior root occupying the majority, caused by chronic wear mechanisms, such as the elderly long-term from squatting position to standing position

2.2.5 Root injury treatment

The treatment of meniscus root injury is divided into meniscus root repair, meniscectomy and non-surgical treatment. A large number of studies have shown that meniscectomy and non-surgical treatment lead to the incidence of osteoarthritis as high as 99.3% and 95.1% %, much higher than the 53.0% incidence of a meniscus repair, and the incidence of total knee replacement with meniscus root

repair was 15% lower than that of the other two treatments. Therefore, meniscal root repair should be used now from all angles.

The meniscal root repair technique involves separating the root, placing at least two sutures over the remaining meniscus attachment, and attempting to reposition it to a more anatomical location. In some cases, the posterior horn of the meniscus may need to be released from the scar tissue to reposition it.

2.2.6 Characteristics of ACL injuries combined with root injury

A large number of studies have shown that, if left untreated, lacerated semilunar roots can lead to biomechanical changes in joints and accelerate the degeneration of articular cartilage. This is because the tear of the semilunar plate root will lead to increased pressure on the contact between the articular cartilage and the joint, thus leading to the early onset of the degeneration process [7]. In addition, posterolateral semilunar plate tear (PMLRT) can increase anterior tibial displacement and anterior tibial displacement. Thus, untreated PMLRT can cause long-term disorganization and increased stress after ligament reconstruction, resulting in untreatability [8].

3. Repair of ACL injury with combined meniscus injury

3.1. Ramp lesions and ACLR

Ramp injury is classified as stable and unstable. It is generally accepted that stable ramp lesions during ACLR have no clinical benefit for stable injuries. For unstable injuries, the ramp lesions are preferred to be repaired during ACL treatment.

3.1.1 Stable ramp lesions

It is generally believed that repair of Ramp lesions does not contribute to ACLR regarding the range of motion, muscle function, and prognosis. Meniscus repair usually results in further limitation of knee flexion angle and reduced weight-bearing capacity. In addition, meniscus repair surgery has certain trauma, which makes later ACL rehabilitation difficult [9]. From the perspective of joint range of motion, the peak flexion and extension torques were examined six months after ACLR surgery by Wenning et al. They found that patients who underwent ACLR surgery and meniscus surgery have no significant differences from those who underwent isolated ACLR. In terms of muscle function, it was found that repair of unilateral meniscus during ACLR did not impact the muscle strength of quadriceps and hamstrings 6-8 months after surgery [10]. Regarding prognostic activity performance, Albayrak et al. studied Sixty-six young patients. The first group is young patients with ACL rupture and stable medial meniscus clivus lesion injury, and the second group is with isolated ACL rupture. It was found that the rate of recovery of physical exercise (84.8% vs 90.1%) and the level of recovery of physical exercise were similar (75% vs 78%) in the two groups [11]. George pointed out in his study that, after ACLR, not all ramp lesions will increase the stability of the knee joint [12]. Therefore, surgeons should realize that repairing stable ramp lesions is not absolutely necessary and will not affect the speed of the recovery process in clinical practice. Meniscus repair should be used as a standard of care for meniscus lesions accompanying ACLR [9].

3.1.2 Unstable ramp lesions

If the unstable ramp lesions are not repaired, the biomechanical changes of the knee joint caused by the unstable ramp lesions may become the inducement of the re-injury. D'Ambrosi suggested that when repairing all unstable ramp lesions of the medial meniscus during ACLR, the surgeon could decide to repair it according to the patient's condition [13]. Similarly, Zeman suggested a combination of surgical techniques for repairing unstable ramp lesions using tendon grafts with ACLR could improve clinical outcomes [14].

3.2. Bucket handle Tear with ACLR

ACL injury and meniscal BHT usually result in significant knee instability. An unstable knee during sports could cause further damage to the meniscus and articular cartilage. Therefore, to slow down the degeneration of the joint, ACLR and BHT are recommended to be repaired together. ACLR of the damaged knee is also performed promptly. In the past, the meniscus was mostly treated in one stage, and the ACL was reconstructed electively, but there is a growing number of studies showing that staged surgery often leads to longer meniscal tears or even re-tears after suturing. Therefore, it is recommended that the ACL be repaired arthroscopically at the same time as the meniscus. Subtotal resection of the medial meniscus is not recommended because it increases the joint load on the lateral side and raises the risk of OA. For example, Özgür Başal et al. stated that if hemiplanar concavity is preserved, all neglected chronic locked BHT in combination with chronic ACL rupture need to be repaired together regardless of the length of surgery and most patients can return to preoperative activity levels within eight months after surgery [14]. Apostolos et al. recommended ACLR within three months after injury to the ligament and also noted that delayed ACLR surgery that was greater than three months in duration would show a higher correlation with incidence of medial tears [15]. Delayed ACLR brings a potentially high risk of damage to meniscus and cartilage. Therefore, in cases of ACL injury combined with BHT, the meniscus should be treated aggressively with sutures so that patients would benefit from the early reconstruction. BHT occurs with concurrent repair leads to a risk of postoperative arthrodesis for surgical revision, and arthrodesis is greater (although not significant) with meniscal sutures than meniscectomy.

3.3. Influence of root injury on ACL reconstruction

Tang et al. studied the effects of lateral meniscus heel repair and anterior cruciate ligament reconstruction on knee stability. In the present study, anterior tibial displacement (ATT) was increased by approximately 1 mm with lateral meniscus tear after ACL reconstruction, whereas meniscus repair resulted in anterior muscle reduction and tibial ligament relaxation under precompression. In the simulation test of the data, comparing the anterior cruciate ligament that underwent meniscus posterior root tear repair with those that did not, it was also found that meniscus repair reduced the ATT of the tibia under preload, and there was no difference when compared with the good knee joint. This further indicates that the tear of the posterior root of the lateral meniscus would aggravate the disorder of the knee after ACL reconstruction, and the repair of the posterior root of the meniscus can help improve the stability of the knee [16].

The management of posterior root injury to the lateral meniscus has been discussed among surgeons. Surgeons have previously advocated non-surgical treatment of such tears. However, recent reports have shown good short-term clinical results with posterolateral semilunar root tear repair. Meniscal avulsion is one of the most common meniscal injuries. Semilunar root avulsion is repaired by threading the suture through the posterior root, drilling a tibial tunnel, and fixing the extracted suture to the tibial cortex. LaPrade et al. reported the good effect of using extractive suture to repair the semilunar plate root of tibia, which significantly improved the postoperative prognosis of patients [17]. At the same time, Forkel et al. found that there was no significant difference in pressure reduction between anatomical fixation and fixation through the ACL tunnel when using cadavers. On the basis that there is no significant difference between the two, this paper suggests that bone marrow canal surgery is the better method, because the technique is minimally invasive and does not require additional bone tunneling.

4. Conclusions

Experiments show that anterior cruciate ligament injury is often accompanied by meniscus damage. They are very important structures for the stability and function of the knee joint.

Treatment of ramp lesions requires a discussion of stable versus unstable injuries. For unstable ramp lesions, it is generally believed that the repair of this type of ramp lesions has a positive effect

on ACLR. For example, the range of motion of the knee joint will be restored and the stability of the muscles around the joint will be increased. The reason for this is that the ACL and meniscus work together to maintain the stability and mobility of the knee joint, and they promote each other. However, for stable ramp lesions, most researchers currently suggest that repair of this injury has no positive effect on ACL function recovery, or the positive effect is so small that it is clinically negligible.

Although current studies suggest that suture repair of BHT may increase the risk of arthrolysis, most studies specify that BHT presenting after an ACL injury should be repaired in a timely and contemporaneous manner. Staged repair of ACLR combined with BHT, or the use of meniscectomy for combined injuries, should be avoided. The potential risk of OA development can have an irreversible impact on the patient's quality of life, therefore, all types of BHT should be positively repaired compared to ramp injury. There is still a large gap in the assessment of motor rate, gait, and prognosis after simultaneous repair of ACLR and BHT.

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