Overview of Meniscus Injury Treatment

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Abstract. Meniscus injury, a common knee injury among all age of people, can be tear or rupture in the meniscal cartilage. It can be caused either by traumatic issues or degenerative issues happen on elder population. This passage addresses different types of injuries including longitudinal, transverse, radial, complex, and degenerative tears. And for each type of injury, it is studied on its epidemiology, methods of examinations, and repair and rehabilitations. Specifically, the structure of meniscus is closely examined in this essay to better examine the degree of injuries and the possible treatments or repair that can be done. Some examination techniques, such as MRI, X-rays, and physical examinations, and there is detailed explanation of some examinations work to examine if there are any injuries in meniscus. Additionally, this essay also investigates the different repair methods (surgical operations) by evaluating the advantages and drawbacks of each. In the end, it discusses some rehabilitation method for meniscus injuries recovery, including some exercises and strengthen the muscles to promote the stability in the joint, accelerating the rehabilitation process.

Keywords: Meniscus injuries, meniscus injuries examination, meniscus rehabilitation.

1. Introduction

As an important fibrous cartilage structure in the knee joint, the meniscus plays a role in cushioning, stabilizing and lubricating the joint [1]. However, due to the frequent movement of the knee joint, the meniscus is extremely vulnerable to damage. Meniscus injury refers to a tear or rupture of the meniscus caused by external force or degenerative change. This is common in athletes and older people [2].

1.1. Types of Meniscus Damage

Meniscus injury, mainly divided into the following five categories [3].

Longitudinal tear This is the most common type of tear. It usually occurs in the central to marginal part of the meniscus. The longitudinal tear may further develop into a "barrel handle" tear. This torn part moves like a barrel handle, causing the knee joint to get stuck.

Transverse tear This tear is usually less common. However, it often occurs in acute injuries, especially in rotational motion. These tears run across the fibers of the meniscus. It can lead to unstable joint movement.

Radiation tearing This tear radiates outward from the center along the meniscus. It tends to appear in the weak area of the meniscus. Radiation tears are more difficult to heal and require surgical intervention in most cases.

Complex tear It's a combination of multiple tear types. Usually, it is accompanied by extensive damage to the meniscus tissue. This type of injury is commonly seen in severe trauma, or chronic injuries that have not healed for a long time.

Degenerative tear This kind of tear is more common in middle-aged and elderly people. Because it is often associated with joint degeneration. Degenerative tears are usually smaller. Due to the decline in the overall quality of the meniscus, healing is more difficult.

1.2. Epidemiology and Number of Affected Areas

Meniscus injuries are widely present worldwide [4]. In particular, among athletes and middle-aged and elderly people, the incidence of incidence rate is high. Meniscus injury is the most common type of knee joint injury. It accounts for a large proportion of knee joint surgery cases. Every year, millions of people worldwide seek medical attention for meniscus injuries. Among them, many patients underwent surgical treatment [4]. For people engaged in high intensity running, jumping, and rotating sports (such as zoos), the incidence of meniscus injury is higher. Sports such as basketball, football, and tennis can easily cause damage to the meniscus [5]. The reason for this is due to the high-frequency use of the knee joint, as well as sudden movements such as rotation and emergency stop.

The occurrence of meniscus injury is closely related to factors such as gender, age, and weight.

In terms of age distribution, meniscus injuries often have different characteristics between young athletes and middle-aged and elderly people. For young athletes, acute traumatic injuries are more common. This is usually directly related to sudden movements or external forces during movement. In contrast, middle-aged and elderly people are more prone to degenerative meniscus injuries. As people age, the meniscus gradually loses elasticity and moisture, becoming more fragile. In daily activities, they are prone to tearing. Sometimes, even minor sprains or squatting movements can cause injuries. Obesity and knee joint deformities (such as O-legs or X-legs) are also factors that increase the risk of meniscus injury.

The anatomical location and affected area of meniscus injury may vary. The meniscus is divided into two parts: medial and lateral. The medial meniscus is more prone to injury. Due to the relatively fixed medial meniscus, its range of motion is limited. It often bears greater stress. Therefore, it is more susceptible to damage. Research data shows that medial meniscus injuries account for approximately 75% of all meniscus injuries. Relatively speaking, there are relatively few injuries to the lateral meniscus. The lateral meniscus is more flexible. However, due to its force characteristics, acute tearing can also occur during certain intense movements. Especially, it is more common in rotational motion. For athletes engaged in rotational and jumping sports, the proportion of injuries to the lateral meniscus has increased.

Among specific types of tearing, longitudinal tearing is the most common. Especially on the inner meniscus. This type of tear may further develop into a 'barrel handle like' tear (MacFarlane et al., 2017). It can cause the knee joint to get stuck. Lateral tearing is relatively rare and often occurs in acute injuries. This is damage caused by rotational movements. Radial tears extend outward from the center of the meniscus and usually occur in the weak areas of the meniscus. Complex tearing is a combination of multiple types of tearing. Therefore, it is often accompanied by extensive tissue damage. Usually, it is seen in severe trauma or chronic injuries that have not yet healed. Degenerative tearing is common in middle-aged and elderly populations. Due to the overall decline in the quality of the meniscus, the healing of this tear is difficult.

Meniscus injury has significant epidemiological characteristics. There are significant differences in injury risk and affected areas among populations of different age groups, genders, weights, and activity levels. Understanding these epidemiological characteristics is crucial for early prevention, accurate diagnosis, and effective treatment of meniscus injuries.

2. Anatomy of the Meniscus

2.1. Structure

The meniscus is a crescent-shaped fibrocartilage tissue present in the knee joint [6]. It is C-shaped and situated between the femur and tibia [7]. Both knees have two of these, known as meniscus. These are the medial meniscus and the lateral meniscus, respectively. The medial meniscus is kite-shaped and less mobile as compared to the lateral meniscus. This is because they are associated with the medial collateral ligament, and this makes their movement limited. The lateral meniscus is more circular and more flexible as compared to the medical meniscus. These muscles are not attached to the lateral collateral ligament; hence, in the course of movement, they have more flexibility in their movement. The structure of meniscus has water and collagen fibers, of which 70% are water. The rest consists of collagen fibers, proteoglycans, and cells. It is mainly type I collagen, and these fibers are strong and elastic in nature. This fiber has the ability to support and disseminate stress during the movement of the knee joint. The peripheral rim of the meniscus has a good blood supply as compared to the rest of the meniscus. Hence, after being injured, they have a certain level of self-recovery capacity. On the other hand, the inner part of the meniscus, which is the central area, does not have a blood supply. This is because this part depends on synovial fluid, through which nutrients are exchanged, and once this is damaged, it is difficult to repair. From the microstructure point of view, the meniscus has a surface fiber layer and an internal matrix layer. The surface fiber layer consists of tightly packed collagen fibers, which are capable of withstanding tensile stress. They also have the ability to resist shear forces, as observed during joint movement at the knee. The matrix layer is made up of sparsely arranged collagen fibers and reticular proteoglycans, which have the primary role of acting as a cushion and a damping system. Also, there are few fibrocartilage cells present in the meniscus in this study. It is mainly located in the matrix zone of the meniscus, and it is involved in the processes of synthesis and maintenance of the matrix of this structure.

2.2. Biomechanics

The meniscus is an important structure in the normal functioning of the knee joint. Its biomechanical properties define its potential to bear and transfer the stress of the knee joint, thus protecting the joint surface and providing joint stability. The meniscus has two functions, which include acting as a shock absorber as well as distributing stress. If the knee joint is subjected to the weight of the body, the meniscus is able to distribute the forces from the femur in a vertical manner and therefore prevent the pressure from being directly transferred onto the tibial plateau, thus preventing it from wearing out more than needed. Some studies also reveal that the meniscus has a capacity of supporting and transmitting loads in the knee joint of 50-70%. When the meniscus is torn or taken away, the mechanical stress that falls on the articular cartilage is greatly amplified, which may cause cartilage damage and cause the onset of osteoarthritis [8]. It is crucial as it helps in the stability of the knee joint as it is a part of the knee joint. Because of the intimate relationship between the medial meniscus and the medial collateral ligament, it has a large role in the stability of the knee joint during flexion and extension as well as rotation. Because of its high mobility, the lateral meniscus can offer adaptive support during multidirectional movements of the knee joint, therefore contributing to the stability of the joint. Furthermore, the meniscus also provides the knee joint with stability because it increases the contact area of the femoral condyle and the tibial plateau, which is important in the movements of the joint.

3. Diagnosis

It is important to establish the type of meniscus injury so as to treat it and restore the affected body part. In order to identify the type, location, and degree of meniscus injury, we have to apply several diagnostic procedures and techniques. Of them, the most widely applied diagnostic technique is magnetic resonance imaging (MRI).

3.1. MRI Imaging

MRI, which is short for magnetic resonance imaging, is the most reliable method for diagnosing meniscus injuries. It is well recognized in clinical practice. RI is a noninvasive technique for creating images. It can present clear images of the internal structure of the knee joint. The following are the images that are involved: meniscus, cartilage, ligaments, and bones. MRI has high-definition resolution. With the help of an MRI, the doctors can identify the type of tear, where it is situated, and how big it is. These pieces of information help them accurately assess the severity of the damage. MRI images can clearly display different types of tears, such as longitudinal tears, transverse tears, or complex tears [9]. This provides an important basis for developing follow-up treatment plans.

MRI provides detailed visualization of the internal structure of the knee joint. This achievement helps doctors accurately locate the site of meniscus injury. Given this, doctors can analyze the type and extent of the tear. MRI captures images of the knee joint from multiple angles, allowing even minor injuries to be detected. It clearly displays the relationship between soft tissue and bones. This effectively helps doctors comprehensively evaluate the health status of the knee joint. Most importantly, MRI is a non-invasive examination method. That is to say, it does not produce ionizing radiation and poses no radiation risk to patients. Therefore, it is particularly suitable for patients who require multiple examinations.

3.2. Other Diagnostic Tools

The diagnosis of meniscus injury can be achieved through various other diagnostic tools. These tools and methods also play an important auxiliary role in clinical practice. They help doctors further confirm the diagnosis and assess the degree of damage.

Physical examination is a fundamental step in diagnosing meniscus injury. Through a series of special physical tests, doctors can assess the stability, pain level, and range of motion of patients' knee joints. These tests can preliminarily determine whether there is damage to the meniscus and the approximate location of the damage. For example, the McMurray test applies pressure by rotating the knee joint, which can trigger pain or discomfort at the site of meniscus injury. This sound of a click may be an indication of a meniscus tear. Nevertheless, the reliability of clinical findings is rather low. It is especially the case in complex or minor tearing cases.

Secondly, it makes it possible to exclude bone lesions in the knee joint—fractures or arthritis—using X-ray. However, it cannot map soft tissues well, for instance, the meniscus of the knee joint. It is with this X-ray examination that the doctors can be able to eliminate other possible causes of pain in the knee joint [10]. It also gives information on joint space, bone spurs, and bone density, among other things. But X-rays are not able to reflect the state of the menisci. Hence, in managing meniscus injuries, more emphasis is placed on other techniques, and the role of X-rays is more supplemental than definitive.

Most of the examinations that are to be conducted on the patient are non-invasive, and one of them is an ultrasound examination. Over the past few years, ultrasound examination has been applied to the diagnosis of meniscus injuries. Ultrasound examination uses high-frequency sound waves to generate real-time images of the internal structure of the knee joint. This type of image can dynamically observe the movement of the knee joint. It is particularly suitable for diagnosing soft tissue injuries around joints, such as ligament or tendon injuries. Due to the meniscus being located deep within the knee joint, ultrasound still has limitations in displaying details.

Arthroscopy is an invasive but highly accurate diagnostic and treatment method. In arthroscopy, doctors insert the arthroscope into the interior of the knee joint through a small incision. In this way, the actual condition of the meniscus and other joint structures can be directly observed. Arthroscopy not only provides the most accurate diagnostic information. At the same time, it is also repairing the damage while discovering it. Therefore, for cases that are difficult to diagnose definitively through other non-invasive methods, arthroscopy is a highly effective option. However, arthroscopy has a certain degree of trauma and there is also a certain recovery time after surgery. Therefore, it is usually used as a last resort.

CT scan (computed tomography) is less commonly used in the diagnosis of meniscus injury. CT is mainly used for imaging bone structures. It can display in detail the skeletal structure and its pathological conditions, such as fractures or osteoarthritis. But for soft tissues, especially meniscus, the resolution of CT is not as good as MRI. CT scans can provide supplementary information in some complex cases.

4. Arthroscopic Meniscus Repair and Rehabilitation

Arthroscopic meniscus repair is a commonly used surgical method for treating meniscus injuries [11]. The characteristics of high efficiency and fast recovery. During the surgery, the doctor repaired the torn meniscus using arthroscopic techniques [12]. This method can restore the normal function of the knee joint. It is worth noting that the postoperative rehabilitation process is equally crucial. It affects the patient's recovery speed and also relates to the long-term effectiveness of the surgery.

4.1. Arthroscopic Techniques

The repair techniques mainly include the following methods.

Medial repair is a method suitable for repairing the middle or posterior part of the meniscus. The doctor starts from the inner side of the knee joint, passes the suture through the meniscus, and knots and fixes it on the outer side. It provides a stable fixation effect. However, it usually involves surrounding soft tissues. Therefore, postoperative recovery requires close observation.

Lateral repair techniques are commonly used to repair anterior meniscus tears. The doctor threaded the suture through the meniscus from the outside of the knee joint and knotted it on the inside. Compared with medial repair, it has less interference with the knee joint structure. Meanwhile, the postoperative recovery of this method is relatively simple.

And full internal repair is the most modern method. It is suitable for repairing meniscus in various positions. The doctor fully inserted a specially designed fixation device into the knee joint through arthroscopy. Because this method does not require knotting, it reduces postoperative discomfort. It causes minimal trauma and quick postoperative recovery. However, there are high requirements for surgical equipment and techniques.

Suture technology is designed for complex or large tears. Sometimes, it is necessary to use suturing to stabilize the repair. Doctors use suturing techniques to reconnect the torn edges of the meniscus, promoting healing. It is very effective in maintaining the integrity and function of the meniscus. However, postoperative recovery often requires a longer time.

Arthroscopic meniscus repair has strong advantages. It has minimally invasive and precise features. Due to the small surgical incision, the patient experiences less postoperative pain. The recovery speed of such wounds is often fast, and the risk of postoperative infection is also low. This technology also allows doctors to detect other potential issues, such as cartilage damage or ligament tears. It can be processed together to improve the overall effectiveness of the surgery.

4.2. Rehabilitation Protocols

The goals and methods of each stage in the rehabilitation process are different. In the early postoperative period of 0 to 2 weeks, the focus is on reducing knee joint swelling. Patients usually need to wear braces to secure their knee joints. Under the guidance of a doctor, patients can engage in mild activities. This helps promote blood circulation. Meanwhile, it can also reduce the risk of blood clot formation. Ice compress and raising the affected limb are also common measures. They can control swelling and relieve pain. It is worth noting that weight-bearing activities should be avoided as much as possible during this stage.

The recovery period is 2 to 6 weeks. As the pain and swelling decrease, the focus of rehabilitation shifts to restoring the range of motion of the knee joint. Physical therapists will guide patients to engage in gentle flexion and extension exercises. These connections can help restore knee joint function. Mild muscle strengthening training will also gradually be added, such as isometric contraction training for the quadriceps femoris. It can enhance the stability of the knee joint.

During the intensive period of 6 to 12 weeks, the goal of rehabilitation training is to restore full range of motion of the knee joint. At the same time, we also hope to further enhance muscle strength. At this point, patients can gradually increase their exercise intensity. Participate in low impact aerobic exercises such as cycling and swimming. Balance and coordination training are also allowed, as they can prepare for returning to daily activities.

Some other exercises that patients are recommended to do for slow rehabilitation. For example, calf stretch, with the back knee straight, requires the patients to face a wall with their hands on the wall, putting one leg a step behind the other leg and with the toes pointing forward [13][14]. Keeping the back leg straight and your back heel on the floor, bend the front knee and gently bring the hip and chest toward the wall until there is a feeling of stretch in the calf of the back leg. Hold the position for 15-30 seconds and repeat 2-4 times (MyHealthAlberta). Besides stretching, some exercises that strengthen the muscles are also necessary. Calf raises can be done simply by the patients themselves by slowing rising onto the toes and then slowly return to the starting position [15]. Patients would feel a strong stretch and tension in the muscles in the back of the lower legs (Campbell). This type of exercises helps to strengthen patients' calf muscles, promoting the rehabilitation process after the meniscus injury.

12 weeks or more after surgery is the period of return to exercise. During this period, the focus of rehabilitation training is to help patients return to high-intensity exercise or labor. The training content includes strength training, agility training, and sports specific skill training. The entire rehabilitation process requires guidance from professionals. Because this is the only way to ensure the maximum recovery of knee joint function.

5. Repair Strategies

Different types of meniscus tears require different repair strategies. Vertical tearing is usually achieved through suturing techniques. This method can effectively restore the integrity of the meniscus. Especially in areas with good blood supply [16]. Horizontal tearing typically involves larger areas of damage. It requires partial excision of damaged tissue or fixation through suturing. This can prevent further expansion. Complex tearing and barrel handle tearing involve multiple types of tearing, making repair difficult. Usually, they require a combination of suturing and partial resection techniques. Careful evaluation of the overall function of the meniscus is necessary to ensure the stability of the repaired knee joint (Englund et al., 2012).

6. Conclusion

In the field of repairing meniscus injuries, current technologies have advantages but also limitations. Arthroscopic meniscus repair is a minimally invasive surgery. With its precision and efficiency, it is widely recognized. It can effectively repair various types of meniscus tears. This method can reduce postoperative pain and shorten recovery time for patients. However, this surgery still faces significant challenges in handling complex types of tears, such as barrel handle tears and complex tears. The healing effect of partially torn areas (such as areas with poor blood supply) after repair is poor. Meanwhile, the risk of postoperative recurrence still exists. How to choose the best repair strategy and further optimize the rehabilitation plan still requires more research.

Expert consensus points out that in future research and practice, there is an urgent need to further explore the development of personalized treatment plans. Especially in preoperative evaluation and intraoperative decision-making. New biomaterials and tissue engineering technologies are considered important directions for the future treatment of meniscus injuries [17]. This direction may significantly improve the regeneration ability and repair effect of meniscus. With the advancement of imaging technology, early diagnosis and precise positioning will provide better basis for treatment. This can improve the success rate of surgery and the long-term prognosis of patients.

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