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Diagnosis and Treatment of Common Knee Injuries: A Review

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Abstract: The knee joint is one of the largest and most complex joints in the human body, and it plays a vital role in normal physiological activities, responsible for weight bearing and the realization of limb flexion and extension. Since the knee joint is in the middle of the lower limb, between the two largest lever arms of the body, it needs to withstand greater pressure in daily activities, which makes the knee joint more susceptible to injury. In recent years, the number of patients suffering from knee injuries has been increasing, prompting the medical community to explore and innovate in the diagnosis and treatment of knee injuries, with a variety of new diagnostic methods and treatments emerging. The purpose of this review is to systematically organize and sort out the current literature related to the diagnosis and treatment of common knee injuries. In this process, we will focus on reviewing and analyzing the diagnosis and treatment of three common knee injuries, namely, patellofemoral joint pain syndrome, meniscus injuries, and anterior cruciate ligament (ACL) injuries, with the aim of providing valuable references and lessons for clinical practice.

Keywords: knee injury, PFPS, meniscus, ACL

1. Introduction

Patellofemoral pain syndrome (PFPS) is one of the most common factors contributing to knee pain in adolescents as well as adults under the age of sixty. Through an in-depth retrospective study and analysis of an orthopedic database of more than 30 million patients in the U.S. between 2007 and 2011, researchers estimated the prevalence of PFPS to be approximately 1.75 million patients, a figure that represents approximately 6% of the total number of patients studied [1]. Another common injury is a meniscus injury. With the increasing frequency of participation in sports and the continued development and widespread use of advanced imaging techniques such as magnetic resonance imaging (MRI), the incidence of meniscal injuries has shown a gradual increase. The incidence of meniscal tears is conservatively estimated to be about sixty cases per 100,000 people; however, this figure is likely to be much lower than the actual incidence, and the true situation may be grossly underestimated [2]. The last injury to be described is the ACL injury. In the United States, the number of anterior cruciate ligament (ACL) injury cases that occur each year is between 200,000 and 250,000 cases [3]. Approximately one-quarter of these ACL injury cases occurred in minors under the age of eighteen. Although, overall, males have a higher incidence of ACL injuries, due to their greater involvement in contact and team sports, the relative risk of ACL injuries in females is two to eight times higher than in males [4].

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The core objective of this review is to systematically sort out and summarize the diagnostic methods and treatment strategies for the above common knee injuries, and to explore the specific implementation paths and application points of these methods. Through detailed literature review and analysis, this study is expected to provide scientific and comprehensive guidance and support for patients suffering from similar knee injuries, and at the same time, based on the progress of existing research, to make reasonable predictions and prospective analysis of the future development trend and potential target direction of the related fields, with a view to providing valuable references and inspirations for the subsequent clinical practice and scientific research exploration.

2. Patellofemoral pain syndrome (PFPS)

The patellofemoral joint, comprising the patella and femoral trochanter, is crucial for knee extension and deceleration. The patella functions as a leg lever, diminishing the force needed by the quadriceps muscles to extend the knee. The joint's stability relies heavily on the coordinated action of various anatomical structures, including the quadriceps muscle, patellar tendon, medial oblique femoral muscle, and several ligaments and supportive bands.

Patellofemoral pain syndrome (PFPS) is a prevalent source of knee pain among younger individuals and adults under sixty. An analysis of an orthopedic database containing records of more than thirty million patients in the United States from 2007 to 2011 revealed that 1.75 million people were diagnosed with PFPS, accounting for approximately 6% of the total cases [5].

2.1. Diagnosis

A common knee ailment known as patellofemoral pain syndrome (PFPS) is characterized by discomfort around or in the front of the knee. This pain often intensifies during weight-bearing activities such as climbing or descending stairs, running, or keeping the knee bent for extended periods, like when standing up after prolonged sitting. Individuals may also experience increased pain or stiffness when their knees are flexed for extended durations while seated. It is important to collect information about past knee injuries and surgeries, current exercise routines, and any recent alterations in activity levels. PFPS is frequently classified as an overuse injury of the knee. In rare cases, patients might experience knee buckling. This phenomenon is attributed to quadriceps muscle weakness or pain, causing a momentary loss of muscle tone, rather than actual joint instability [6].

PFPS is usually associated with overuse of the knee but can also result from other factors such as muscle strength imbalances or biomechanical abnormalities.

It is important to note that PFPS does not usually result in knee flexion, and if it does, it may be due to a transient loss of muscle tone due to quadriceps weakness or pain. Knee interlocking and clicking sounds are usually not consistent with PFPS, and these symptoms may indicate other problems within the knee, such as meniscal tears or other cartilage damage. Therefore, if these symptoms are present, further testing and diagnosis may be needed to rule out other potential knee problems.

2.2. Treatment

Physical therapy and medication are the primary approaches for treating PFPS. Initially, treatment should focus on alleviating pain. Experts recommend limited rest, applying ice, and using pain-relieving medications to reduce discomfort.

Studies have examined the effectiveness of various pain medications, including NSAIDs, glucocorticoids, and glycosaminoglycan polysulphates. However, a 2004 Cochrane review on PFPS pharmacological treatments found the evidence to be of inferior quality and inconclusive [7].

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Due to the diverse potential causes of PFPS, treatment plans should be tailored to each patient. While individuals should avoid activities that worsen symptoms, they should strive to maintain some level of physical activity.

According to a Cochrane review, individuals who engage in exercise experience superior pain alleviation in both the short and long term, during rest and activity, compared to those who do not. Exercise programs should focus on the hip, trunk, and knee areas. However, there is a lack of high-quality evidence to recommend one specific type of exercise over others [8].

3. Meniscus injury

The knee joint's tibial surface features two crescent-shaped structures called menisci, positioned on the medial and lateral aspects. The meniscus periphery is thicker and rigidly attached to the joint capsule, while the middle portion is thinner and unattached. Minor injuries to the meniscus edge can self-repair due to adequate blood supply, but central ruptures are challenging to heal because of poor vascularity. Meniscus removal may result in the synovium regenerating a thinner, narrower fibrocartilaginous structure with potentially reduced functionality. A healthy meniscus increases the tibial plateau's concavity and cushions the femur's internal and external condyles, thereby improving knee stability and shock absorption.

Meniscal injury rates are on the rise, partly due to increased sports participation and the rapid advancement and widespread adoption of imaging technologies like MRI.

Research indicates that knees with documented meniscal damage tend to experience accelerated cartilage degeneration, which can precipitate the onset of osteoarthritis at an earlier stage. According to a study conducted by Jarraya and colleagues, over 75% of individuals suffering from symptomatic osteoarthritis were found to have sustained meniscal injuries [9].

Meniscal injuries rank among the most frequent sports-related injuries encountered in everyday medical practice. As a result, the prompt identification and proper treatment of these injuries have become an increasingly significant focus in orthopedic studies.

3.1. Diagnosis

The main diagnostic modalities for meniscus injuries include clinical diagnosis by a physician and diagnosis with the help of MRI.

MRI remains the preferred imaging technique for diagnosing meniscal tears, boasting a high sensitivity of up to 93% and specificity of up to 88% [10].

The McMurray test is a clinical technique used to identify meniscal tears. During this procedure, the doctor methodically rotates the patient's knee. A positive outcome is indicated by the presence of clicking or popping noises accompanied by pain during the knee's rotation [11].

Another clinical assessment for diagnosing meniscal injuries is the Apley grinding test. In this examination, the patient assumes a prone position with their knees flexed at a right angle. The physician then conducts medial and lateral rotations of the knee while applying a distraction force. This process is then repeated, but with compression instead of distraction. A meniscal tear is suspected if the patient experiences a decreased range of rotation and increased pain when the knee is rotated and compressed [12].

Routine assessment of meniscal tears typically does not involve plain radiographs. However, in specific circumstances like chondrocalcinosis, the use of plain radiographs is advised [13].

3.2. Treatment

Several factors influence the approach to treating meniscal tears, including the patient's age, overall health, symptoms, and the tear's characteristics. For tears in the well-perfused area of the meniscus,

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specifically the red/red zone or peripheral region encompassing 30% of the medial meniscus and 25% of the lateral meniscus, conservative management is advised [14].

Prior to 1960, open meniscectomy was the standard surgical intervention for meniscal tears[15].In 1969, Ikeuchi performed the first arthroscopic repair, which led to the subsequent development and improvement of various arthroscopic techniques[16].Nevertheless, recent research has definitively demonstrated that the results following an APM are not superior to those after a sham or placebo surgery[17].Currently, arthroscopic partial meniscectomy (APM) ranks among the most common orthopedic procedures performed globally.

Meniscus repair has emerged as a widely accepted and effective alternative. The main goal is to promote meniscal healing while avoiding the potential negative effects associated with partial or complete meniscectomy. Another option is partial meniscus replacement, which aims to normalize load distribution within the knee joint, thereby protecting the cartilage.

Recent studies highlight the importance of the meniscus and the risk of early-onset osteoarthritis due to meniscal insufficiency. As a result, orthopedic surgeons have shifted their approach from removal to preservation, repair, and reconstruction of as much meniscal tissue as possible when treating meniscal injuries.

4. ACL injury

The anterior cruciate ligament (ACL) plays a crucial role in maintaining knee stability by preventing the tibia from moving forward and controlling the knee's rotational movement. ACL injuries are among the most frequent and severe knee traumas, often leading to fluid accumulation within the joint, muscle wasting, and a notable decrease in athletic capabilities.

ACL injuries are the most prevalent type of ligament damage in the United States [18]. Sports that involve quick directional changes, rotational movements, and landing on one leg, as well as those requiring frequent and abrupt deceleration, are more likely to result in ACL tears. These sports include basketball, soccer, rugby, volleyball, alpine skiing, lacrosse, and tennis.

Around 50% of ACL injuries happen alongside damage to other knee structures, such as adjacent ligaments, menisci, or the cartilage covering the bone surface [19].

ACL injuries often have a significant impact on an athlete's career and pose a serious challenge to athletes and sports enthusiasts worldwide.

In the United States, these injuries impact more than 200,000 people each year, and in Europe, they have an incidence rate of 1 in 3,000, leading to annual costs that exceed $7 billion [20].

4.1. Diagnosis

The diagnostic approach to ACL injuries usually involves the patient's self-description as well as the physician's assessment of the severity of the injury using diagnostic physical tests and medical imaging with MRI.

Individuals experiencing ACL ruptures frequently report hearing or sensing a pop in their knee, followed by inflammation, intense discomfort, and joint unsteadiness. A physical assessment is a standard approach for evaluating ACL injuries and plays a crucial role in the diagnostic procedure.

The anterior Lachman test (LT), anterior drawer test, and pivot-shift test (PST) are the most employed physical examinations for assessing ACL integrity [21].

In many cases, a physical examination suffices to identify an ACL injury. Nevertheless, supplementary tests might be necessary to eliminate other potential causes and evaluate the injury's extent. X-rays may be required to exclude bone fractures. However, X-rays are unable to visualize soft tissues such as ligaments and tendons. In contrast, an MRI can reveal the full extent of an ACL injury and indicate damage to other knee structures, like cartilage [22].

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MRI offers a thorough imaging evaluation of the knee's ligaments and menisci, enabling clarification of the ACL's condition and detection of additional knee injuries.

Research in the field has shown considerable variation in MRI's reported effectiveness for identifying ACL tears, with sensitivity ranging from 63% to 100% and specificity from 68% to 100% [23].

This inconsistency can be explained by the slightly angled orientation of the ACL as it traverses the knee joint, and the difficulty in capturing the entire ligament within a single MRI scan's true sagittal plane [24].

Additional studies have shown that MRI can surpass clinical examinations in accuracy, identifying ACL tears that were not detected during physical evaluations but later confirmed through arthroscopic procedures [25].

4.2. Treatment

The main differences between non-surgical and surgical treatment approaches lie in the performance of ACL reconstruction, the rehabilitation protocol, and guidance for future sports participation. Physicians typically advise patients on the most suitable treatment option for their specific case.

To make well-informed treatment decisions, it is crucial to comprehend the clinical outcomes of both approaches. Patients who choose conservative management must undergo physical therapy to enhance the strength of the muscles around the knee, with a focus on the quadriceps femoris and hamstring muscles. However, without surgical intervention, the knee remains unstable and susceptible to additional injury [26].

Neuromuscular electrical stimulation (NMES), blood flow restriction training, psychosocial support, and early contralateral lower extremity conditioning are some of the new and exciting rehabilitative tools that are becoming increasingly popular in the rehabilitation process after ACL reconstruction.

ACL reconstruction is a widely used treatment option following ACL injury. It is estimated that 200,000 ACL reconstructions are performed yearly in the United States alone. This figure is expected to increase due to the growing participation of teenagers and young adults in sports activities [27].

For ACL reconstruction, the patellar tendon (PT or BPTB graft) and hamstring tendon (HT) are the two most frequently utilized autografts. Most randomized controlled trials (RCTs) and meta-analyses support the consensus that both graft types yield excellent outcomes, with no significant differences in functional results or activity levels [28].

During the initial stages of ACL reconstruction (ACLR) recovery, Kinesio taping has been utilized as a supportive measure. A single randomized controlled trial has shown that Kinesio taping, when used alongside standard rehabilitation, can help alleviate subjective pain and reduce swelling [29].

5. Conclusion

Patients with PFPS often experience increased pain when sitting for extended periods of time or when walking downstairs, and pain on squatting is the most sensitive finding on physical examination. Examining the patient's gait, posture, and shoes can help explore the cause of PFPS.PFPS treatment includes rest, short-term application of NSAIDs, and physical therapy to strengthen muscle groups such as the hip flexors. Patellar kinesioplasty provides short-term pain relief, but the evidence is insufficient to recommend its routine use. Surgery is the last option after other treatments have failed.

The diagnosis of meniscus injury needs to be confirmed by a combination of history, clinical examination, and MRI. Conservative treatment has a role, but partial meniscectomy remains the mainstay procedure. Over the past three decades, meniscal repair has grown in popularity and has been proven to be a more effective alternative. Today, meniscal repair is mostly recommended for

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repairable tears, especially in young active patients. Some meniscal implants have good long-term results, but acute injury efficacy has yet to be proven. Research on meniscal regeneration techniques is promising, and regenerative medicine is the way forward.

The diagnosis of ACL injury relies on clinical tests such as the anterior Rahman test, and in severe cases, it is accompanied by inflammation. Physical evaluation is a routine means of diagnosis, but X-ray and MRI are also essential to provide detailed anatomical information, which can help in the development of treatment programs. In terms of treatment, surgical repair is not the only option; conservative treatment with a strict rehabilitation program is also sufficient. The main goal of surgery is to enhance knee stability, which can be improved with appropriate neuromuscular therapy. Regardless of the treatment chosen, patients should be aware that the risk of future knee pathology and osteoarthritis remains high, especially after returning to high-risk rotational activities. It is critical to analyze the severity of the injury and provide the best treatment plan for the patient to achieve a satisfactory outcome, and further research is needed to achieve a good patient prognosis.

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