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Degenerative meniscus: Pathogenesis, diagnosis, and treatment options

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factory to conservative therapy, arthroscopic partial meniscectomy can provide short-term gains regarding pain relief, especially when combined with an effective, regular physiotherapy program. Patients with clear mechanical symptoms and meniscal pathology may benefit from arthroscopic partial meniscectomy, but surgery is not a guaranteed success, especially with concomitant articular pathology. Ultimately, the long-term outcomes of either treatment arm provide similar results for most patients. Further study is needed regarding the short and long-term outcomes regarding conservative and surgical therapy, with a particular focus on the economic impact of treatment as well.

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Key words: Meniscus; Degenerative joint disease; Meniscal tear; Osteoarthritis; Arthroscopy

Abstract

The symptomatic degenerative meniscus continues to be a source of discomfort for a significant number of patients. With vascular penetration of less than one-third of the adult meniscus, healing potential in the setting of chronic degeneration remains low. Continued hoop and shear stresses upon the degenerative meniscus results in gross failure, often in the form of complex tears in the posterior horn and midbody. Patient history and physical examination are critical to determine the true source of pain, particularly with the significant incidence of simultaneous articular pathology. Joint line tenderness, a positive McMurray test, and mechanical catching or locking can be highly suggestive of a meniscal source of knee pain and dysfunction. Radiographs and magnetic resonance imaging are frequently utilized to examine for osteoarthritis and to verify the presence of meniscal tears, in addition to ruling out other sources of pain. Non-operative therapy focused on non-steroidal anti-inflammatory drugs and physical therapy may be able to provide pain relief as well as improve mechanical function of the knee joint. For patients re-

Core tip: The healing potential of chronic degenerative menisci remains poor. Persistent hoop and shear stresses create complex tears in the posterior horn and midbody. Conservative treatment with anti-inflammatory medications and physical therapy may provide pain relief and improve mechanical knee function. For patients refractory to conservative therapy, arthroscopic partial meniscectomy can provide short-term pain relief when combined with a physiotherapy program. Surgery, however, is not a guaranteed success, especially in the presence of articular pathology. Long-term outcomes of surgical or non-surgical treatment have been shown to be similar for most patient subsets.

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INTRODUCTION

Of the multitude of etiologies for knee pain, meniscal degeneration plays a significant role. The meniscus degenerates microscopically and macroscopically with the aging process, resulting in pain and knee dysfunction. This paper reviews the degenerative process of the meniscus as well as diagnostic modalities and treatment options.

ANATOMY

Gross anatomy

The human menisci are C-shaped or semicircular fibrocartilaginous structures with bony attachments on the tibial plateau. The menisci are essential for joint stability, shock absorption, distribution of contact forces, joint lubrication, and proprioception^[1]. The medial meniscus is C-shaped, approximately 3 cm wide, and 4 to 5 cm long^[2]. The posterior horn is larger than the anterior horn and various studies have described the different bony attachments. The anterior horn of the medial meniscus generally has a firm, bony attachment. Studies have shown that 3%-14% of medial menisci have no bony attachment for the anterior horn^[3,4]. The insertion of the posterior horn lies anterior to the posterior cruciate ligament. The capsular attachments of the medial meniscus onto the tibia are known as the coronary ligaments, with a thickening along the midportion referred to as the deep medial collateral ligament^[5].

The lateral meniscus is semicircular in shape and covers a larger portion of the tibial articular surface than the medial meniscus. It is approximately 3 cm wide and 3 to 4 cm in length^[2]. The lateral meniscus is anchored anteriorly and posteriorly; however, the capsular attachment is not as well developed as the medial side. As a result, there is increased translation and movement of the lateral meniscus throughout all ranges of motion^[6]. The anterior horn inserts just adjacent to the anterior cruciate ligament. The posterior horn inserts behind the intercondylar eminence, anterior to the insertion site of the posterior horn of the medial meniscus. The posterior horn also has meniscofemoral ligaments known as the ligament of Humphries and ligament of Wrisberg, which connect posterior horn to the lateral aspect of the medial femoral condyle^[7].

Microstructure and composition

Water makes up approximately 70%-75% of the normal meniscus^[8]. The dry weight is comprised of collagen (60%-70%), noncollagenous proteins such as elastin (8%-13%), and proteoglycans (1%). The majority of collagen is type I (90%) with type II, III, V, and VI making up smaller amounts^[8,9]. The orientation of collagen fibers is predominantly circumferential. A smaller amount of radially oriented fibers are located at the surface. In addition, a collagen fibrillar network organized into a mesh like matrix is at the surface to aid in distribution of shear forces^[8,9].

Fibrochondrocytes are the predominant cell type in

the meniscus, producing collagen and its extracellular matrix^[8,9]. Along the inner avascular zone, cells are morphologically similar to articular chondrocytes; on the periphery, cells are more similar to fibroblasts. Arnoczky *et al.*^[10] demonstrated that the outer 10% to 30% of the medial meniscus and 10% to 25% of the lateral meniscus is vascular. The medial and lateral geniculate arteries form a perimeniscal capillary plexus that supplies the outer surface of the menisci. The menisci have intrinsic innervation, which is most abundant on the periphery and the anterior and posterior horns^[9]. Proprioception is believed to be obtained from free nerve endings that are activated on the anterior and posterior horns during flexion and extension of the knee^[11,12].

Tear types

Meniscal tears can be classified as acute or degenerative. Acute tears are from excessive force applied to a normal knee and meniscus. This is different from a degenerative tear, which results from repetitive normal forces acting upon a worn down meniscus. Tears can also be described based on pattern and location. These tear patterns include vertical longitudinal, oblique, transverse (radial), horizontal, meniscal root, bucket-handle, and complex. Tears can be located in the avascular or vascular zone (*i.e.*, white, red-white, red-red), which influences healing potential either spontaneously or after surgical repair^[13]. Degenerative tears generally have a complex tear pattern and are predominantly found in the posterior horn and midbody^[14]. Previous studies have shown an increase in articular cartilage changes in the presence of degenerative meniscal tears^[15,16]. In 44 patients, Mesiha *et al.*^[17] showed that degenerative meniscal tears were associated with the presence of Outerbridge II chondral degeneration more than 85% of the time, compared to 12% for flap tears and 0% for longitudinal tears. Likewise, in a prospective study of 497 consecutive knee arthroscopies in patients with meniscus tears, Christoforakis *et al.*^[18] found that patients with complex or horizontal tears were significantly more likely to have Outerbridge types III and IV chondral lesions. Additionally, patients with complex tears were significantly more likely to have a second chondral lesion than patients with flap, radial, or bucket handle tears. The literature; however, is not conclusive. In a multicenter cohort study, Badlani *et al.*^[19] showed that the rate of medial meniscus degenerative tear was not significantly higher in those who developed osteoarthritis. However, meniscal extrusion and tears with a large radial involvement were, in fact, significantly associated with osteoarthritis. Osteoarthritis and degenerative meniscal tears share many of the same risk factors and biological processes. Therefore, it is difficult to definitively determine if one condition precedes the other, or if they both occur independently and/or simultaneously.

DIAGNOSIS

Presentation

Degenerative meniscal pathology typically presents as

knee pain accompanied by mechanical symptoms. Patients are typically over the age of 30 and often complain of insidious onset of symptoms with no known traumatic event. One should have a low threshold to consider meniscal injury in patients with knee osteoarthritis; Wang *et al*^[20] diagnosed a 40% concomitant prevalence determined by arthroscopy. Typical mechanical symptoms include painful clicking, popping, locking, catching, and giving way. In addition, Lange *et al*^[21] found meniscus tears to result in decreased walking endurance and balance performance.

Physical exam

Several findings are suggestive of meniscus injury including joint line tenderness, positive McMurray's test, locking, and palpable or audible clicking. The examiner should also examine the contralateral knee for comparison. Initial visual inspection of the knee should investigate for evidence of infection or trauma, such as erythema, wound, ecchymosis, or gross deformity. Patients with degenerative meniscus pathology rarely present with joint effusion, unlike after acute meniscus or ligamentous injury. Range of motion may be decreased due to a physical block caused by displaced meniscal material. Most often, passive and active range of motion is full and equivalent to the contralateral knee. With range of motion, clicking may be heard or felt; this is suggestive of meniscal pathology, although osteoarthritis, patella-femoral syndrome, and loose bodies also cause this sign. Joint line tenderness and a positive McMurray test are described as highly suggestive of meniscus injury, though study results vary regarding their sensitivity and specificity. Joint line tenderness sensitivity ranges from 63%-87%, while specificity ranges from 30%-50%^[22,23]. A positive McMurray test has a sensitivity of 32%-34% and specificity of 78%-86%^[22,23]. Ercin *et al*^[24] found physical examination by an experienced practitioner to have better specificity (90% *vs* 60%), positive predictive value (95% *vs* 83%), negative predictive value (90% *vs* 86%), and diagnostic accuracy (93% *vs* 83%) than MRI for medial meniscal tears. They assert that physical examination is sufficient to diagnose a meniscus tear and proceed with arthroscopy. Currently, however, most surgeons choose to obtain advanced imaging prior to arthroscopy.

Radiology

Radiographic examination of the knee is of limited value in the patient suffering from degenerative meniscal pathology, as the menisci are not visualized with standard radiography. This modality is primarily used to exclude other sources of knee pain, such as osteoarthritis, which frequently occurs concurrently with meniscal degeneration. Traditionally, sonography has had low utilization as a tool in the diagnosis of degenerative meniscal pathology. However, De Flaviis *et al*^[25] reported dynamic ultrasound to have 82% sensitivity for detecting degenerative meniscus changes based upon findings of border irregularity, cystic cavities, or calcification. Rutten *et al*^[26] reported a sensitivity, specificity, and accuracy of sonography in the depiction of meniscal cysts as 97%, 86% and 94%,

respectively. The accuracy of ultrasound is dependent on technologist skill. In addition, sonography cannot examine deep structures of the knee with high accuracy. In centers where dynamic sonography is available and the patient's clinical presentation is specific for meniscal pathology, ultrasound presents a viable cost saving option.

Ultimately, magnetic resonance imaging (MRI) is the gold standard for soft-tissue imaging of the knee. MRI has an accuracy of 90%-95% for detecting meniscal injury^[27]. Meniscal structure is well evaluated on proton density and T1 sequencing, while pathology is best identified on T2 sequencing. MRI signal changes indicative of meniscus pathology are graded I through III^[28]. Grade I signal change is intrasubstance, globular, and does not intersect the articular surface. Grade II signal change is intrasubstance, linear, and does not intersect the articular surface. Grade I and II signal changes represent intrasubstance degeneration in adults or vascularity in children. Traditionally, grade I and II changes were not thought to correlate with a true tear. However, recent studies have found that some grade II changes may represent a true tear^[29]. Grade III changes intersect the superior or inferior articular surface, or both, and represent a true tear. von Engelhardt *et al*^[29] evaluated the sensitivity and specificity of 3 Tesla MRI using arthroscopy as the reference standard. It was found that accuracy varied based upon lesion grade. Grade I lesions identified by MRI were not associated with a torn meniscus at arthroscopy. In 24% of patients with a Grade II lesion, a true tear was identified by arthroscopy. Grade III lesions had an overall sensitivity and specificity of 79% and 95%, respectively: 86% and 100%, respectively, for the medial meniscus, and 57% and 92%, respectively, for the lateral meniscus. It should be noted that an MRI obtained postoperatively may be less accurate secondary to post surgical changes^[27]. One must always remember to evaluate and treat the patient based upon the clinical presentation along with diagnostic findings, not by imaging alone. Fukuta *et al*^[30] found a 50% incidence of grade III signal changes in clinically asymptomatic patients over the age of forty with osteoarthritis. Thus, the finding of a meniscal tear on MRI in a patient without clinical symptoms should not prompt the surgeon to proceed with arthroscopy.

TREATMENT

Conservative and surgical modalities can be utilized in the treatment of the painful degenerative meniscal tear. No matter the method, the ultimate goal remains the same: to relieve acute symptomology and limit future recurrence. Nonoperative therapy is often times the mainstay of treatment, while surgical procedures are reserved for patients with symptoms resistant or recurrent to conservative management.

Non-operative therapy

The initial focus of non-surgical supportive care is the relief of knee pain. Patients should limit activities that instigate or exacerbate symptoms, however complete rest is

not advised, as stiffness may result. Patients often present with incomplete symptom relief after non-steroidal anti-inflammatory drug (NSAID) use on an as-needed basis. If tolerable, such cases may warrant routine use over a period of up to 6 wk. Muscle relaxants and analgesics can also be used, although usually for a shorter period of time. Physical therapy and rehabilitation is a central aspect of conservative treatment, with exercises focused on maintaining range of motion (ROM), improve hip and hamstring flexibility, increase quadriceps and hip strength, and retain knee proprioception. Gait therapy, whether by exercise or supportive orthoses, may also improve knee function and provide pain relief^[31]. A supervised exercise regimen lasting 8 to 12 wk, when combined with a home program, can provide immediate short-term benefits. In a small series, Østerås *et al.*^[32] reported that with 36 sessions over a 3 mo period improved pain scores, quality-of-life scores, and reduced anxiety at 3 mo follow-up. Stensrud *et al.*^[33] described a 3 mo protocol focused on dynamic neuromuscular training, which resulted in improved patient-reported outcomes and muscle performance up to 1 year. Physiotherapy can also reduce mechanical symptoms in addition to providing pain relief. In a prospective trial, 52 patients with degenerative meniscal tear underwent an exercise regimen; mechanical symptoms and knee pain were significantly reduced at final 2 year follow-up, even despite some advancement of osteoarthritic degeneration^[34]. The benefits of physical therapy, even with radiographic evidence of worsening degeneration, has been found in studies with up to 3 year follow-up^[35,36]. Herrlin *et al.*^[37] followed 47 patients in a prospective trial up to 5 years. Visual analog scale (VAS) scores and knee function significantly improved at 2 and 5 years, however no difference was found between these two follow-up points. Ultimately, a regimented physiotherapy program can reduce knee pain and improve function in the presence of degenerative joint disease progression.

Arthroscopic partial meniscectomy

While non-operative therapy provides some degree of symptom relief over the long-term, these benefits may wane with continued meniscal degeneration^[38]. In such patients, arthroscopic partial meniscectomy can be effective in improving patient quality of life. A thorough arthroscopic examination of the chondral surfaces, joint spaces, and menisci are critical to document cartilage health, identify loose bodies, and localize meniscal tears. Partial meniscectomy attempts to debride the unstable degenerative tear in order to create a stable tear or a smooth rim of the remaining meniscus. The surgeon is tasked to remove the meniscal tear while simultaneously maintaining as much healthy meniscus as possible. Meniscectomy undoubtedly alters joint biomechanics; excessive debridement may lead to unnecessary load-induced chondral wear and shear-induced subchondral fracture, furthering joint and meniscal degeneration^[39]. Relief from knee pain and improvement of function can be obtained quickly, as soon as 3 mo post-operatively^[32]. Yim *et al.*^[34] found significant improvement in knee pain, knee function,

and patient satisfaction scores in 50 patients at 2 years after arthroscopic partial meniscectomy; these results, however, were tempered by the finding that there was no difference at final follow-up in comparison with non-operatively treated patients. In another prospective study, Herrlin *et al.*^[37] noted significant improvement in VAS and knee function scores up to 5 years post-operatively. They also found that a significant portion, one-third, of patients treated non-operatively required arthroscopy secondary to incomplete pain relief. Similar to Yim *et al.*^[34], however, Herrlin *et al.*^[37] found no difference in pain and function scores at any point between operatively and nonoperatively treated patients. At this juncture, the long-term value of arthroscopic partial meniscectomy compared to non-operative physiotherapy is unknown.

Post-operative rehabilitation

Most surgeons recommend a program of physical therapy post-operatively to reduce pain and swelling, promote full range-of-motion, and improve knee function. Modalities such as icing, joint mobilization, and massage can provide short-term pain relief and reduce swelling^[40]. Beyond the immediate postoperative symptoms, extensor weakness remains the primary concern after surgical treatment of the degenerative meniscal tear. Moffet *et al.*^[41] described the importance of physical therapy focused on extensor weakness, findings significant benefits in 31 patients. Østerås *et al.*^[42] described a specific 3 mo postoperative rehabilitation program in a prospective study utilizing bicycling, resisted quadriceps exercises, and squats. They noted better pain relief, knee function, and strength at 1 year compared to patients without postoperative physiotherapy. Even with dedicated rehabilitation, recovery or preoperative extensor strength may take 4 to 6 wk, and can still be deficient compared to the non-operative extremity^[43]. This discrepancy may place the active patient at risk for injury on return to sporting activity. Generally, the active patient may return to practice at 80% strength, typically 3 to 6 wk postoperatively, and return to game competition at 90% strength, typically 5 to 8 wk postoperatively^[40,44].

CONCLUSION

The symptomatic degenerative meniscus continues to be a source of discomfort for a significant number of patients. Patients with clear mechanical symptoms and meniscal pathology may benefit from arthroscopic partial meniscectomy, but surgery is not a guaranteed success, especially with concomitant articular pathology. Patient history, physical examination, and radiographic imaging are critical to determine the true source of pain, meniscus or cartilage degeneration, and to eliminate other potential aggravants. Non-operative therapy focused on NSAID anti-inflammatories and physical therapy may be able to provide pain relief as well as improve mechanical function of the knee joint. For patients refractory to conservative therapy, arthroscopic partial meniscectomy can provide short-term gains regarding pain relief, es-

pecially when combined with an effective, regular physiotherapy program. Ultimately, the long-term outcomes of either treatment arm provide similar results for most patients. Further study is needed regarding the short and long-term outcomes regarding conservative and surgical therapy, with a particular focus on the economic impact of treatment as well.

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