Meniscal Injuries in Children and Adolescents: Diagnosis and Management

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Abstract

Isolated meniscal injuries are uncommon in children under the age of 14, but the frequency increases thereafter. Meniscal tears in children are frequently associated with congenital meniscal abnormalities, while those in adolescents are often associated with ligamentous injuries of the knee. The combination of recurrent and often dramatic popping and intermittent episodes of locking has been termed the "snapping knee syndrome." This symptom complex is almost invariably associated with a discoid meniscus. Although double-contrast arthrography has proved to be a reliable diagnostic technique, magnetic resonance imaging is now the modality of choice. Treatment options for meniscal injuries in young patients should reflect a preference for repair over excision. The long-term clinical results of total meniscectomy in children have demonstrated a high incidence of degenerative joint disease. Partial excision may provide better results. The efficacy of meniscus transplantation in the skeletally immature knee, although attractive, is as yet unproved and is therefore not an acceptable treatment option.

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A great deal of attention has recently been given to the management of meniscal injuries, prompted by the resurgence of attention to the biomechanical importance of the menisci to the knee joint as well as the blossoming technologic advances of arthroscopy. Although meniscal injury significantly increases in frequency with age, it is by no means rare in the skeletally immature patient. There are, however, two features that characterize meniscal injuries in children. They tend to occur in association with ligamentous injury, and, when isolated, they tend to occur within a congenitally abnormal meniscus, such as a discoid meniscus.

In this article, I will review the pertinent anatomy and embryology of the meniscus, describe the relevant biomechanics, outline the epidemiology of meniscal injury in children and adolescents, characterize the clinical presentation, and present options and recommendations for treatment.

Anatomy and Embryology

Arising from the differentiation of mesenchymal tissue within the limb bud, the meniscus becomes a clearly defined structure by the 8th week of fetal development. By the 14th week, the meniscus has assumed its adult relationships with the rest of the knee. During embryologic development, the blood supply of the meniscus enters from the periphery and extends throughout the entire width.[1] This fetal relationship of a totally vascularized meniscus is present even at birth, but by the 9th month post partum, the inner (central) third will be avascular. By adulthood, only the peripheral 10% to 30% will receive a blood supply (Fig. 1).

Densely cellular at birth, the meniscus becomes progressively less so with age. The fibrochondrocyte is the major matrix-producing cell of the meniscus. Two morphologic types of fibrochondrocytes exist: oval or spindle-shaped cells, which are found primarily about the superficial regions of the meniscus, and polygonal, more cartilage-like cells, which are found mainly in the deeper regions. The collagen is predominantly type I, but small amounts of types II, III, V, and VI are also present. Most of the collagen fibrils are arranged in a circumferential pattern. There are, however, some radial, oblique, and verti-

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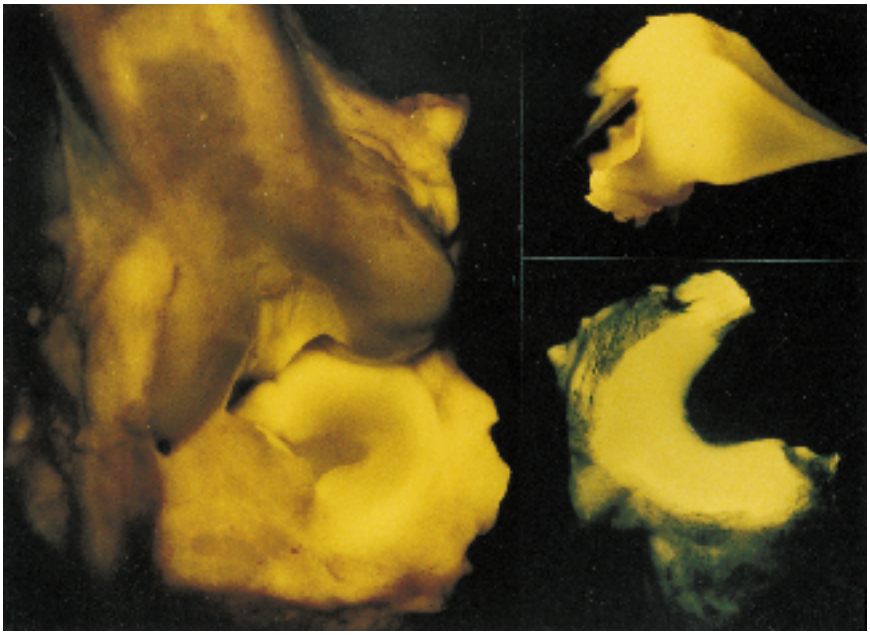

Fig. 1 A premortem intravenous injection of fluorescein dye illustrates the extent of perfusion in the normal canine meniscus **(left** and **top right)**. **Bottom right**, A premortem intra-arterial injection of India ink further highlights the extent of vascularity. (Reproduced with permission from Fanton GS, Andrish JT: Meniscofluoresis: An aid in determining the prognosis of meniscal tears. *Cleve Clin Q* 1983;50:379-383.)

cally directed fibers. The proteoglycans—the large aggrecan molecules composed of chondroitin sulfate and keratan sulfate chains and the smaller proteoglycans biglycan and decorin—are present in much lower concentrations in the meniscus than in the articular cartilage.[2]

Biomechanics and Function

It is now well established that the meniscus plays an important role in the biomechanical function of the knee joint. Although the meniscus may contribute to the nutrition of articular cartilage by enhancing synovial-fluid distribution and also provides a secondary restraint for knee stability, perhaps the most important and clinically relevant role played by the meniscus is to share load bearing with the articular cartilage. The presence of a meniscus effectively increases the articular contact area and thus lowers the load per unit area on the weight-bearing articular cartilage. The circumferential arrangement of the collagen fibers increases the ability of the meniscus to support hoop stress. Approximately 50% of the articular contact area of the medial compartment of the knee is shared by the medial meniscus, and 70% of that of the lateral compartment is shared by the lateral meniscus. After meniscectomy, contact stress may increase by 235%, and contact area may decrease by 75%.[3]

It is important to remember that the menisci are not stationary structures. Fu and others have demonstrated that both menisci translate with flexion and extension of the knee.[4] The medial meniscus translates about 2 to 5 mm on the tibia, and the lateral meniscus translates about 9 to 11 mm. This obligatory translation allows the menisci to more accurately accommodate to the rolling/gliding movement of the femur on the tibia with flexion and extension of the knee.

Epidemiology

As is the case with much of the epidemiologic documentation of injuries in the pediatric population, the data are sparse and often inadequately controlled. The true incidence of meniscal tears in children is unknown, but they are distinctly unusual under the age of 10 years unless associated with a discoid meniscus. Longitudinal tears account for 50% to 90% of meniscal injuries in the young.[4]

Stanitski et al[5] have reported their experience with arthroscopy in knees with acute hemarthrosis in adolescents and children. They found that meniscal injuries in the preadolescent group (ages 7 to 12 years) accounted for 47% of the knee injuries. Thirty percent involved the lateral meniscus, and 70% involved the medial meniscus. One of the medial meniscus tears was associated with a torn anterior cruciate ligament. Fifty-seven percent of the tears were peripheral. In the adolescent group (ages 13 to 18 years), meniscal injuries accounted for 45% of the knee injuries, and 36% of these were associated with torn anterior cruciate ligaments as well. Fifty percent of the tears were peripheral. Twelve percent of the meniscal injuries were to the lateral meniscus, and 88% involved the medial meniscus.

Diagnosis

As with most medical conditions, the history and physical examina-

tion can be helpful in establishing the diagnosis of meniscal injury in a child or younger adolescent. The torn discoid meniscus presents with its own characteristic and often dramatic findings, which will be discussed later. The torn nondiscoid meniscus usually presents with medial or lateral pain. The pain is related to activity and is relieved with rest. Swelling may be a part of the clinical picture, and mechanical symptoms of locking and giving way may be present. With an injury of a non-discoid meniscus, antecedent trauma is usually described by the patient.

The physical examination is characterized by joint-line tenderness. However, in children, anteromedial or anterolateral joint-line tenderness is just as frequently due to other causes, such as osteochondritis dissecans and patellofemoral stress syndrome. Provocative tests, such as the McMurray test and the Apley grind test, may be positive, with a sensitivity of 58% but less specificity. Joint effusions are usually present at some time in the course of the clinical presentation.[6]

Plain radiographs are of little benefit in establishing the diagnosis of meniscal injury, other than to rule out other conditions that can mimic a torn meniscus, such as osteochondritis dissecans or a loose body. Characteristic features on plain radiographs have been described in association with discoid menisci. These include widening of the lateral joint space, squaring of the lateral femoral condyle, cupping of the lateral tibial plateau, and hypoplasia of the lateral tibial spine (Fig. 2).[7]

Fu and Baratz[4] reviewed the literature and found that double-contrast arthrography has reported accuracy rates of 60% to 97% in the diagnosis of meniscal injury and that accuracy in diagnosis has been greater in the medial meniscus than in the lateral meniscus.

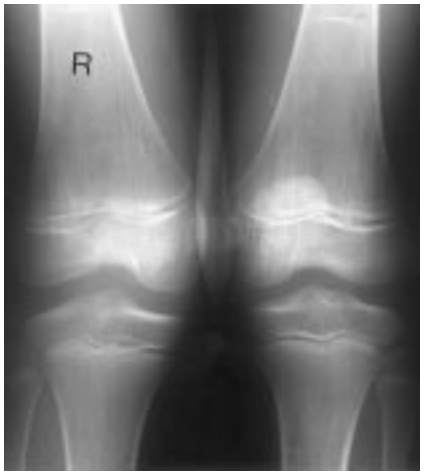

Fig. 2 Plain radiograph of a young patient with typical snapping knee syndrome of the right knee demonstrates widening of the lateral joint space and hypoplasia of the lateral tibial spine. (Reproduced with permission from Fanton GS, Andrish JT: Meniscofluoresis: An aid in determining the prognosis of meniscal tears. *Cleve Clin Q* 1983;50:379-383.)

Nevertheless, magnetic resonance (MR) imaging has become the imaging procedure of choice. This test is highly sensitive and specific for meniscal injury, with reported accuracy rates of 93% to 98% for the medial meniscus and 90% to 96% for the lateral meniscus.

The most direct method of establishing a diagnosis of meniscal injury is arthroscopy of the knee joint. This examination must include adequate and careful probing of the meniscus. It is sometimes difficult to detect tears of the posterior horns, especially of the medial meniscus; the use of accessory portals may be required.

Treatment

Injuries to the Nondiscoid Meniscus

As with injuries of adult menisci, the surgeon generally has three choices in the treatment of meniscal injuries in the young patient. The tear may be surgically repaired, excised, or left alone. Stable peripheral tears measuring 10 mm or less in length that involve the outer 10% to 30% of the meniscus and that are manually displaceable by less than 3 mm may generally be left alone.[8] Fenestration, rasping, or debridement of the free edges of the tear may enhance healing by improving vascular access. Clinical follow-up of these tears suggests a favorable outcome and supports the current preference for meniscus preservation as the objective of treatment. Other tears that may be left alone are partial stable tears and small radial tears measuring 3 mm or less.

Certainly the issue of meniscal repair is nowhere more applicable than in the young individual. The well-known potential for healing and tissue repair in children and adolescents and the recognized biomechanical importance of the meniscus support repair of the meniscus if it is at all reasonable. The fact that most meniscal tears in the young patient are longitudinal and frequently peripheral bolsters this recommendation. Although this discussion is not intended to be a review of the technique of meniscus repair, a reasonable recommendation might be that peripheral tears of the meniscus involving the outer 10% to 30% that are unstable, as evidenced by manual displacement by more than 3 mm at arthroscopy, and that are without a complex or degenerative component should be considered for repair. Depending on the bias of the surgeon, however, somewhere between 5% and 90% of meniscal tears in young patients will be suitable for repair. At our institution, the great majority of meniscal repairs are performed in knees undergoing anterior cruciate ligament reconstruction.

Meniscus excision is rarely total. The standard of care now is the arthroscopic partial excision, performed with the hope that preservation of any meniscal tissue will offer some preservation of function and thus prevent premature degenerative arthritis. The long-term outcome of partial meniscectomy is still unknown, but some studies suggest better results than with total meniscectomy. It should be remembered, however, that the biomechanical effects of partial meniscectomy are highly variable. For instance, removing a small bucket-handle tear of the meniscus will increase the articular contact stress by 65%,[3] and removing 75% of the posterior horn may increase the level of articular contact stress to that seen after total meniscectomy.[4] Manzione et al[9] reported on the outcome in young patients with an average age of 14.8 years at the time of meniscectomy and found that only 25% were without symptoms after 5 years, and 80% had radiographic changes as well.

Because meniscus preservation is so attractive for the young patient in particular and because of the improved techniques of arthroscopic repair, meniscus-allograft transplantation has been considered an alternative treatment for meniscal injury in the young patient. However, published reports of clinical trials are scarce and uncontrolled. The prevailing wisdom considers the young patient with minimal degenerative joint disease to be the best candidate. The studies reported in the literature show that this type of patient has the best outcome.

A meniscus allograft may be fresh,[10] deep-frozen or lyophilized,[11] or cryopreserved.[12] Sterilization is problematic. Viral transmission—particularly human immunodeficiency virus (HIV) transmission—is a concern. Even with a reported risk of HIV transmission from a properly screened donor of 1 in 1 million cases, parents and patients are reluctant to accept this risk. Freeze-drying will kill the virus, but it results in a shrunken graft. Irradiation with a 2.4-Mrad dose will kill most pathogens, but this dose will also kill the cells (probably not a problem) and alter the mechanical strength of the collagenous structure (with an ill-determined effect on outcome).

In summary, as there are no published reports of the outcome of meniscus transplantation in children and adolescents in the literature, meniscus transplantation has not yet been demonstrated to be an accepted option for the management of the meniscus-deficient knee in the skeletally immature patient.

Meniscal Cysts

Although uncommon, cysts associated with meniscal tears occur in adolescents as well as adults. Such cysts are usually found in conjunction with horizontal or cleavage-plane tears of the meniscus and are most often associated with the lateral meniscus. The diagnosis may be quite obvious, or it may be subtle. Pain is the most common presenting complaint. The pain is related to activity and is located about the joint line. Most often there is a paucity of mechanical symptoms, and the presence of swelling is inconsistent. The young patient is often unaware of swelling either inside or outside of the joint.

A cyst may not be readily apparent at first look. The presence of an effusion can suggest intra-articular abnormalities. A mildly positive McMurray test that elicits pain but no "pop" can also suggest a stable meniscal lesion. The cyst may not be apparent when the patient is lying supine with the knee in extension. If both knees are flexed together and the contour of the joint lines is examined carefully, however, the cyst is usually de-monstrated. Palpation will demonstrate joint-line tenderness extending to include the outline of the cyst, which may extend and ex-trude over the proximal tibia. Particularly when the lateral me-niscus is involved, the cyst may be found to extrude under and about the distal iliotibial band.

An incidentally detected asymptomatic meniscal cyst requires no treatment. If pain is a problem, however, active management is required. If the cyst is well defined, aspiration and injection of a corticosteroid can sometimes provide relief. Unfortunately, this is most often only a temporary solution, which runs counter to my usual reluctance to inject a corticosteroid about joints in young patients. Operative management therefore becomes a consideration.

Traditional teaching once proposed that excision of the meniscus would also result in resolution of the meniscal cyst. In children and adolescents, however, this does not work. Pain will persist, and further attention to the cyst itself will then be required. Open exploration with careful identification of the communication between the cyst and the meniscus, ligation and excision of the cyst, and debridement of the meniscal tear usually gives a good result. Good outcomes have also been recently reported after arthroscopic debridement of the cyst through the defect within the meniscus tear.[13] Our experience supports this approach as well.

Discoid Meniscus and Snapping Knee Syndrome

The snapping knee syndrome has an interesting presentation. Usually, a young child, under 10 years

of age, is brought to the doctor's office because of intermittent experiences of rather dramatic popping and snapping within the knee that seem to occur spontaneously and often leave the child apprehensive or in momentary pain. As often, however, the child will be temporarily apprehensive about using the extremity but without obvious pain. The examination in the office can usually quite easily reproduce a dramatic "clunk" within the knee during a McMurray test with flexion/extension and circumduction. The knee will seem to momentarily shift or subluxate. The parents are frequently more alarmed by the event than the young patient. This clinical presentation is sometimes dramatic enough to accurately establish the diagnosis of a congenital discoid meniscus.

In the older child or adolescent, the clinical presentation of a discoid meniscus is more variable. In this population, the presenting complaints often include the typical symptoms found in tears of nondiscoid menisci. Pain, swelling, and even mechanical symptoms of giving way and locking are found. There is also the occasional adolescent who has the typical presentation of snapping knee syndrome as described in younger patients.

There are two schools of thought regarding the etiology of the discoid meniscus. Smillie[14] attributed this variant to failure of resorption of the central portion of the meniscus during embryologic development. However, Kaplan[15] studied the embryologic development of the meniscus in humans and many other species and found that at no stage of embryologic development was there a discoid structure found within the knee. Kaplan further documented variations in the attachment patterns of the posterior horn of the lateral meniscus by means of the meniscofemoral ligaments of Wrisberg and Humphry. He hypothesized that the development of a discoid meniscus is always due to failure of attachment of the meniscotibial (coronary) ligaments of the posterior horn. With the only attachments being the meniscofemoral ligaments, the hypertrophic and discoid changes found were considered to be secondary to the instability of the meniscus during development.

Watanabe devised a classification system for the discoid lateral meniscus[16] (Fig. 3). Type I menisci are described as complete, with the meniscus generally extending across the entire lateral tibial plateau. Type II menisci are considered incomplete. The central portion of the meniscus extends farther across the tibial plateau than normal, but not completely. At arthroscopy, visualization of a compartment with a type I lesion may be very difficult because the bulk of the meniscus can block the entry of the scope. With a type II lesion, however, visualization of the compartment of the knee is usually not a problem, but it is still clear that the meniscus is wider than normal. With both type I and type II menisci, the coronary ligament attachments are intact. A type III meniscus is also referred to as the Wrisberg-ligament type. In this type, there is a deficiency of attachment of the posterior-horn meniscotibial ligaments, as Kaplan

Fig. 3 Watanabe classification of the discoid lateral meniscus. Note that type III, the Wrisberg-ligament type, lacks attachment of the posterior horn of the meniscus to the tibia.

described, resulting in instability of the posterior horn, which is secured only by the meniscofemoral ligaments (Fig. 4).

Although the true incidence of discoid menisci in children is not known, Vandermeer and Cunningham[17] have estimated that the incidence is 3.5% to 5% in the Anglo-American population and higher (15% to 20%) in the Asian population.

As noted, the snapping knee in the young child (up to 10 years of age) is almost pathognomonic of a discoid meniscus. Most often, this is the Wrisberg-ligament type. The clunk felt is considered to be the result of subluxation of the posterior horn, which may occur with either extension or flexion. Locking can occur, and joint-line tenderness may accompany a joint effusion. The plain radiograph is usually unremarkable. As mentioned earlier, however, subtle plain-radiographic abnormalities have been described. Although arthrography has an established record of accuracy, MR imaging is presently the most popular and accurate imaging modality available.[18] Its only shortcoming is that sedation may be required for studies of very young children.

Fig. 4 The meniscofemoral ligament of Wrisberg (arrow) is clearly identified in this MR image of the knee.

Typical injury patterns have been described for the three types of discoid menisci in the Watanabe classification. For types I and II, the most common pattern is longitudinal, with horizontal tears being a close second. For type III (Wrisberg-ligament type) injuries, the posterior horn may be bulbous but is usually not discoid. There may be complex or degenerative tears, but more typically there is no tear at all. Any of the three types of menisci may have radial, bucket-handle, or complex tears (Fig. 5).

No treatment is required for the asymptomatic discoid meniscus encountered incidentally. For the symptomatic patient with a type I or II discoid meniscus, arthroscopic debridement of the central portion is performed with contouring of the remaining, more normal rim. Hayashi et al[19] have pointed out that the frequency of recurrent tears can be significantly reduced if the remaining rim is reduced to 6 to 8 mm. Peripheral tears in the vascularized zone in type I and type II menisci should be repaired, and the central portion should be saucerized to create a more normal form and size.

Type III discoid menisci traditionally have been managed with total meniscectomy. Recently, good results have been reported with meniscal repair. Although there is considerable technical difficulty involved in reattaching the posterior horn of the lateral meniscus when there is no remaining meniscus rim, the published techniques should be followed and meniscus repair should be the preferred treatment.[20,21]

Three groups of researchers have reported on the outcomes of treatment of discoid menisci in children and adolescents. Pellacci et al[22] reported no poor outcomes in 47 patients, but did note that partial excision was associated with better results than total excision. Vandermeer and Cunningham[17] reported that of 25 patients with discoid menisci, 55% had satisfactory results, but 28% required further surgery for recurrent symptoms and tears. Kurosaka et al[23] reported on a 20-year follow-up of patients who underwent total lateral meniscectomy and found good subjective results in more than 90%, although an alarming 75% had radiographic changes of degenerative joint disease.

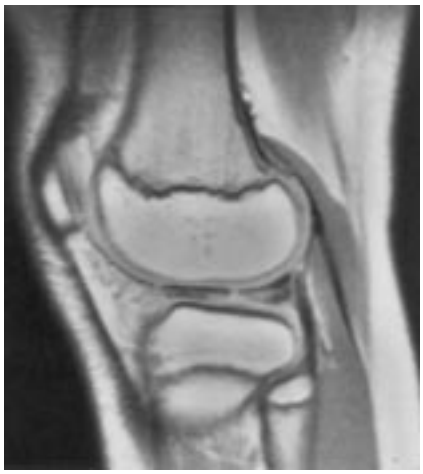

Fig. 5 This MR image of the knee depicts a complex tear of a discoid lateral meniscus. The presence of both cleavage-plane and radial components was confirmed at the time of arthroscopic debridement.

Summary

Isolated meniscal injuries in children are uncommon. Meniscal injuries in the adolescent are frequently found in conjunction with significant ligamentous injury of the knee. The principles of management of injuries of the nondiscoid meniscus in the child are no different than in the adult, with the

exception that a preference for repair should influence decision making. The snapping knee syndrome in the young child is pathognomonic for an unstable discoid meniscus. Treatment options for the discoid meniscus are directed toward saucerization and debridement but with preservation of enough of the meniscus to maintain a semblance of normal biomechanical function.

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