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Pediatric meniscal injuries: Current concepts

Ajay Asokan, Anouska Ayub, and Manoj Ramachandran

Abstract

Meniscal pathology is widely prevalent in the adult population, secondary to acute trauma and chronic degeneration. It is less commonly seen in children, although its incidence is rising. The true prevalence in children remains unknown, as pathologies such as discoid menisci often go undiagnosed, or are found only incidentally. The rising incidence can be attributed to increased participation in sports at younger ages, both in intensity and frequency, with potentially year-round competition. Meniscal tears lead to pain and mechanical symptoms in the short to medium term, but more significantly, have been shown to lead to compartmental chondral degeneration and early arthritis in the long term. With advancing arthroscopic techniques, and children's propensity for better healing, osteoarthritis secondary to meniscal pathology is a potentially preventable problem. This article discusses meniscal injuries in children and adolescents and their management.

Keywords: Meniscus, discoid, meniscal injuries

Introduction

Meniscal pathology is widely prevalent in the adult population, secondary to acute trauma and chronic degeneration. It is less commonly seen in children, although its incidence is rising.[1] The true prevalence in children remains unknown, as pathologies such as discoid menisci often go undiagnosed, or are only found incidentally. The rising incidence can be attributed to increased participation in sports at younger ages, both in intensity and frequency, with potentially year-round competition.[2] Meniscal tears lead to pain and mechanical symptoms in the short to medium term, but more significantly, have been shown to lead to compartmental chondral degeneration and early arthritis in the long term.[3] With advancing arthroscopic techniques, and children's propensity for better healing, osteoarthritis secondary to meniscal pathology is a potentially preventable problem. This article discusses meniscal injuries in children and adolescents and their management.

Epidemiology

Historically, pediatric meniscal injuries were thought to be rare pathologies, mostly associated with a discoid meniscus. However, through increased awareness and improved screening, acute tears in normal meniscal tissue have been identified. Nonetheless, the true overall prevalence remains unknown, as discoid menisci are often asymptomatic and therefore remain undiagnosed.

A number of risk factors have been identified for pediatric meniscal injuries. They are more commonly seen in adolescent males. Injury to the meniscus is more likely to come about during high-energy contact sports; therefore, participation in such activities is identified as a risk factor. Sports with contact, as well as frequent pivoting action such as football, netball, rugby, and skiing, have a significant association with these injuries.[4] Male adolescents have a higher body mass index (BMI) and muscle mass than younger children and female adolescents, which ultimately leads to greater momentum traveling through the knee leaving them more susceptible to injury. Finally,

Department of Paediatric Orthopaedic Surgery, The Royal London Hospital, London, UK

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Corresponding Author:
Ajay Asokan, Department of Paediatric Orthopaedic Surgery, The Royal London Hospital, Whitechapel Road, Whitechapel, London E1 1FR, UK.
Email: ajay.asokan@nhs.net

concomitant anterior cruciate ligament (ACL) injuries are both associated with, and can cause, meniscal injuries. The pivoting mechanism of injury seen in ACL injuries often cause a medial meniscal tear. The instability created with ACL injuries, if not repaired, reconstructed or rehabilitated correctly, can later lead to a new meniscal injury or propagation of a co-existing tear from the index injury. Younger children with meniscal injuries are often noted to have a discoid meniscus, generally presenting with an atraumatic history and symptomatic knee.

To further evaluate these risk factors, in 2019, Jackson et al.[5] performed a large case series of 880 pediatric patients with meniscal injuries that underwent subsequent arthroscopic surgery. They found 63% of patients were male. Peripheral tears were most likely to heal by the time of intervention, and vertical tears were most likely to propagate to bucket-handle tears. While previous research has found a significant percentage of meniscal tears in children were isolated injuries (71%–100%), Jackson et al. found that the majority of their patient group had associated lesions, with only 38% of meniscal tears occurring alone. ACL ruptures were seen in around 46% of patients, more commonly in male patients (50% in male patients vs 40% in female patients).[5,6] In this study, over half were amenable to meniscal repair (53%) as opposed to partial meniscectomy. Of those which underwent repair, 91% were performed using an all-inside technique. Overall, in this large series, 25% were found to have a discoid meniscus. Mitchell et al.[2] performed a review of 1082 meniscal injuries seen in high-school athletes. They noted an injury rate of 5.1 per 100,000, with a higher rate seen in competitive matches rather than in practice. They found a similar male-to-female ratio, with 68% of injuries seen in males, but did note in gender-comparable sports such as football—the injury rates were higher for females over males. Contact sport was the most common mechanism, and concomitant ACL injuries were seen in 36.9% of cases.[2]

Pediatric meniscal anatomy

The menisci are load sharing structures which exist to distribute the contact stresses across the tibio-femoral joint surfaces. This intimate relationship between two large weightbearing surfaces leaves it susceptible to injury. Tears are often described in their relation to the periphery, due to the tenuous blood supply to the meniscus. The menisci are supplied by a peripheral pre-meniscal capillary plexus which arises from the geniculate arteries. At birth, this supply is provided to the entire meniscus, but decreases with age. By nine months, the peripheral two-thirds remain vascularized, decreasing to 10%–30% by the age of 10 which remains moving into adulthood. This vascular distribution gives rise to the "red and white zones" describing a tear in the well-vascularized "red zone," non-vascular "white zone," or a vascular watershed—the "red-white zone." The improved vascularity is a key contributor in children's ability to heal their meniscal injuries.[7,8]

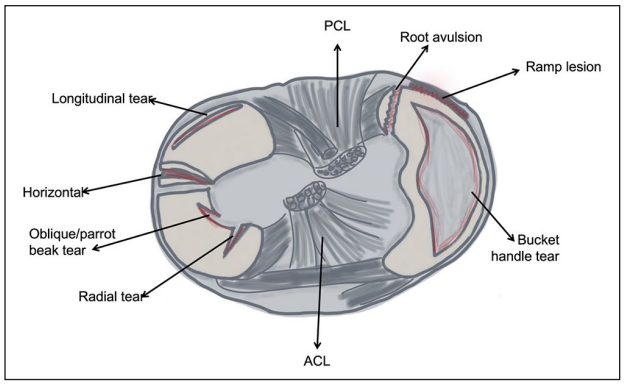

Figure 1. Representation of all meniscal tear patterns.

Etiology

The menisci are particularly susceptible to injury during pivoting activities, when the knee is loaded in flexion with a sudden twisting movement placed upon it. This is due to the orientation of the fibers which make up the meniscus. It is primarily made up of circumferential fibers which reduce the hoop stresses placed upon it, with additional radial and randomly orientate fibers. The variety of tear patterns is represented in Figure 1, with complex multi-directional tears found most commonly (28%), after which vertical tears are next commonly seen (16%).[9] The direction of the tear is important, as is the orientation of the meniscal fibers, as both are key considerations for meniscal repair and affect potential propagation of the tear. In particular, radial tears result in a tear perpendicular to the circumferential longitudinal orientation of meniscal collagen bundles, which therefore defunctions the entire meniscus, as it cannot generate hoop stresses to disperse axial load. This increases contact pressures at the tibio-femoral joint, and ultimately accelerates osteoarthritis.

A discoid meniscus is one of abnormal morphology and is thicker, disk shaped, and covers a larger area of the tibial plateau. The Wrisberg-variant discoid lateral meniscus is also unstable and abnormally mobile, due to a lack of posterior ligamentous attachment.[10] Discoid menisci are relatively less vascular due to their size, and have fewer, more irregularly orientated collagen fibers.[8,11] This leaves them more susceptible to injury than a normal meniscus, and less likely to heal without intervention.[7,12] Generally, tears occur through repetitive microtrauma over a sustained period, and show mucoid fibrinous degeneration. They are overwhelmingly seen in the lateral meniscus (97%), and the true prevalence remains unknown as they can remain asymptomatic. It should be noted normal menisci are never discoid in shape during development, and so a discoid

meniscus represents a congenital variant rather than a failure of development.[8,13,14]

Ahn et al.[15] described a magnetic resonance imaging (MRI) classification for discoid meniscal tears, which serves to help surgical planning, as discussed below. They describe tears with respect to meniscal shift—a concept in which a peripheral longitudinal tear in either the posterior or anterior horn may lead to displacement or "shift" of the meniscus either anterocentrally or posterocentrally, respectively. In addition, there may be no shift, or a central shift corresponding to posterolateral corner loss.

Common examination findings

Acute meniscal injuries classically present with an effusion and joint line tenderness. They may also include mechanical symptoms, such as clicking, snapping, or a locked knee.[16] Specific tests can help identify the pathology including the modified McMurray's test, which applies a valgus or varus force with external or internal rotation of the tibia sequentially, while extending the knee and palpating the joint line. Pain in the medial or lateral joint line upon testing is indicative of meniscal injury. In addition, the Apley grind test can also help delineate the pathology and is performed with the patient prone and knee bent to 90°. The knee is then loaded axially, with medial and lateral rotation of the tibia under load which produces pain in an injured meniscus. This is a provocative test which should be used sparingly in children. MRI examination is the key investigation for meniscal pathology; however, it should be noted, false positives may occur due to hypersignal in the meniscus as a result of increased vascularity in children and therefore interpretation ideally should be by pediatric musculoskeletal radiologists.

As described, discoid menisci are often undiagnosed and only found incidentally if they remain asymptomatic. However, they can cause a "snapping knee" syndrome, as the discoid meniscus is unstable due to lack of posterior ligamentous restraint as in the Wrisberg discoid variant, or due to either a tear of the posterior body affecting the ligamentous attachment, of a mid-meniscal tear that propagates posteriorly. The snap is caused when the unstable meniscus displaces then reduces as the knee moves from flexion to extension.[16] There may be a characteristic bulge in the lateral compartment during knee flexion. Imaging on plain radiographs may also show characteristic signs of a discoid meniscus, including widening of the lateral joint space (most commonly lateral meniscus affected) and flattening of the lateral femoral condyle, as seen in Figure 2.[17]

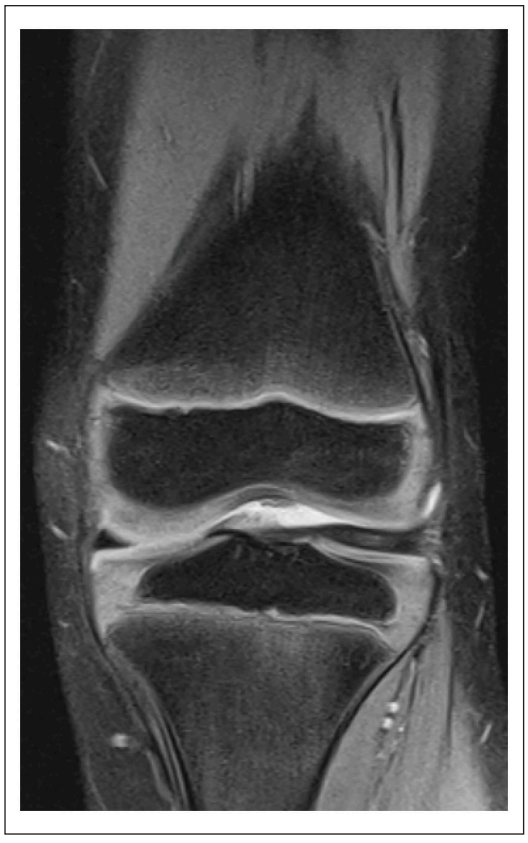

Figure 2. T2-weighted MRI demonstrating lateral discoid meniscus in coronal plane. Typical features including flattened lateral femoral condyle, widened lateral joint space, and cupping of lateral plateau.

Treatment

Children display greater healing potential than adults with meniscal tears, but this requires early recognition and appropriate treatment. The surgical management of meniscal injuries may be divided into four categories: Retention, Repair, Resection, and Replacement.

Retention

The overall guiding principle in any meniscal tear is to preserve as much tissue as feasible. The majority of pediatric meniscal tears are symptomatic and usually require surgical intervention; however, a subsect of injuries exist which do not require surgical intervention.[18] Asymptomatic meniscal tears and discoid menisci do not require surgical intervention. Even if a discoid meniscus is found incidentally during arthroscopy, it is recommended not to intervene unless symptomatic, as the anatomy of the native knee has likely adapted to the presence of the discoid meniscus.[17] Small radial tears ($\leq$3 mm) do not require intervention as they often do not cause significant symptoms and are unlikely to propagate. Similarly, tears along the periphery in the "red-red zone" which are undisplaced and stable do not require intervention as they have excellent healing potential in children. If non-operative treatment is chosen, pivoting sporting activities should be avoided for a duration of 12 weeks.[19]

Repair

Most pediatric meniscal tears will require repair. As arthroscopic techniques have advanced, instruments have become finer, with new techniques and devices introduced to aide in the repair of meniscal tears in smaller knees. Acute tears are more likely to heal following repair and are easier to manipulate intra-operatively, with better outcomes seen if repaired within eight weeks of injury.[20] Unstable or displaced peripheral tears have better blood supply with improved healing potential and so efforts to repair them rather than resect should be attempted. Meniscal tears are often associated with concomitant ACL injuries. Whether the ACL is addressed or not, the increased instability leads to propagation of meniscal tears, and so the tear should be repaired in these cases.

A number of techniques for meniscal repair exist. The "inside-out" repair is performed by passing a suture arthroscopically through the meniscus extra-articularly to lie superficial to the capsule, using an arthroscopic meniscal needle. An additional posteromedial or lateral incision is required to visualize the capsule and tie down the meniscal suture. This is used for tears in the posterior two-thirds and bucket-handle tears. Although it continues to remain the gold-standard of meniscal repair, it has the morbidity of an additional incision and potential neurovascular injury. The "outside-in" approach is particularly useful for anterior horn tears and ramp lesions, which would otherwise be inaccessible from a purely arthroscopic approach. A needle is passed from extra-articular into the joint through the meniscal tear, and a suture is passed through the needle. A looped suture is passed through a second spinal needle which is placed extra-articularly into the joint and is used to retrieve the first suture. This is then tied on the surface of the capsule to secure the meniscus. Although "inside-out" repair remains the gold-standard, the popularity of "all-inside" techniques has significantly grown with multiple options available such as the FasT-Fix (Smith & Nephew, Watford, UK) and FibreStitch (Arthrex, Florida, USA). These are pure arthroscopic systems, which negates the need for an additional incision but are still bound by the restrictions of arthroscopic access. They rely on an anchor which is passed behind the peripheral rim of meniscus and allows the suture being passed through the tear to reduce and hold the meniscal tear in place. This of course means a peripheral rim is required; therefore, if meniscus-capsular repair is required, then alternative methods need to be utilized. Finally, meniscal root tears require repair to limit meniscal extrusion. This is often performed with an all-inside horizontal mattress, but if there is detachment of the root, transosseous suture fixation is required.

Meniscal repairs require a period of protected weightbearing and range of movement to facilitate healing. Generally, partial weightbearing and avoidance of deep flexion is prescribed for four to six weeks. Return to running is expected around three months, with return to contact or pivot sports at six months.[1,6,16,20]

Meniscal repairs have been shown to demonstrate excellent functional outcomes with low failure rates. Liechti et al.[20] performed a systematic review of 301 meniscal tears and found mean postoperative Lysholm scores ranging between 85.4 and 96.3, and mean postoperative Tegner activity scores ranging from 6.2 to 8. They also reported concomitant ACL reconstruction in 52% of meniscal repairs. It should be noted however repairs can fail which may result in further surgery, as described by Patel et al.,[21] in their evaluation of 907 index meniscal procedures, where 83 patients (9%) required repeat surgery at a mean of 23.3 months, postoperatively. Re-tears are more commonly seen in complex and bucket-handle tears, and the risk for further surgery needs to be appropriately counseled to patients. Jackson et al. found a 36% reinjury rate, with the highest proportion occurring in those with a medial meniscal tear with concurrent ACL injury, with 11% of females and 8% of males requiring revision operative intervention.

Resection

Meniscal preservation and repair should be attempted wherever possible; however, some tears are not amenable to repair, thus requiring resection. Examples of this include chronic displaced tears, in which the tissue begins to degenerate and remodel to a point where the quality of the tissue cannot hold a suture repair and does not reduce back to its anatomical location. In addition, tears in the "white" avascular zone have poor likelihood of healing, and thus may be better served through limited resection to remove any unstable flaps and prevent the need for re-repair. Finally, complex tears which are multi-directional, may not allow sutures to adequately hold the repair, or have too high a risk of failure, and so require resection.

Symptomatic discoid meniscus tears were traditionally resected entirely, as surgeons believed the tissue to be inferior quality which would not heal.[22] Some surgeons continue this practice today; however, the trend has been toward saucerization and repair and stabilization if necessary.[23] The aim is to create a stable peripheral rim of tissue between 6 and 8 mm, performed with an arthroscopic biter augmented with a meniscus-to-capsule suture if unstable.[17,23]

Replacement

In significant meniscal loss, subsequent chondral degeneration is almost definite.[24] To stop or slow down this progression, it is important to reduce the contact stresses within the knee. Meniscal allograft transplantation (MAT) is a well-investigated procedure in the adult population and shown to be clinically effective in slowing the degenerative process.[25] However, because the necessity for MAT

in children is uncommon, there is a scarcity of data on survivability and clinical prognosis.[24,26] Middleton et al.[24] reported a series of 23 pediatric patients who underwent MAT in a single center and were found to have improved Lysholm scores from 57.9 to 87.6, Tegner activity score from 2 to 5, and IKDC score from 40.6 to 78.6 at 5 years. They also concluded that surgery on asymptomatic knees with previous meniscal surgery should not be performed in children. No incidence of graft failure was reported. Riboh et al.[26] reported a series of 36 patients at 2-year follow-up had significantly improved functional outcome scores and a meniscal re-operation rate of 6%.

Conclusion

Meniscal tears in children are an increasingly common pathology which can lead to avoidable long-term morbidity if appropriately diagnosed and managed. Improvements in access to MRI, subsequent referral to surgical expertise, and improved arthroscopic techniques have allowed expansion of treatment from adults to children, and improved overall outcomes. It is important to remain vigilant for such injuries, and appropriately counsel patients and parents on treatment options including risk of re-injury. Salvage procedures including MAT are rarely indicated in children but have been shown to have favorable outcomes, although the evidence remains limited to date.

Author contributions

A.As. performed the literature review, wrote and edited the manuscript. A.Ay. produced the figures, wrote and edited the manuscript. M.R. edited the manuscript, provided conceptual design, and supervised the study.

Declaration of conflicting interests

The author(s) declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: M.R. maintains a leadership role on the surgical advisory board of Orthopaediatrics Inc, which has no influence on this manuscript. The remaining authors report no conflicts of interest.

Ethical statement

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ORCID iD

Ajay Asokan https://orcid.org/0000-0003-1351-5401

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