Meniscal injuries in athletic children

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Introduction

Meniscal injuries in athletic children have become a recurrent issue for pediatric orthopedic surgeons. They appear especially frequently in children partaking in pivoting sports, of which football (soccer) is a prime example. There is a male predominance, especially in children aged 8 years and older. In fact, Isolated meniscal injuries are more frequent in the pediatric population than in adults.

Meniscal injuries have become more frequent in pediatric orthopedics: On the one hand, children are increasingly being introduced to pivoting sports at earlier ages. On the other hand, MRI, a medical imaging modality not based on ionizing radiation, has become more accessible and easily makes the diagnosis of meniscal injury. The pediatric orthopedic surgeon is thus frequently interrogated on the management of such injuries, interrogations that may intensify by the patients' clubs and/or trainers who are eager to see young athletes return to their previous level of activity.

In this chapter, isolated meniscal tears on a stable knee will be distinguished from those associated with a ruptured anterior cruciate ligament (ACL), and thus on an unstable knee. These two injury patterns are different on the pathophysiological level, and in each of these two entities, the clinical specificities, the different management strategies (primarily surgical) and their results, all of which are to be considered in relation to certain elements (type of lesion, age of patient, etc…), will be detailed. Furthermore, meniscal injuries on congenital meniscal pathologies, such as a discoid meniscus, will not be discussed, even though these abnormalities are often detected as a result of a sports-related accident.

1. Isolated meniscal injuries on a stable knee

The difficulty in the management of isolated meniscal tears is their diagnosis. Treatment is primarily surgical, even though it is sometimes possible to attempt conservative treatment for small, acute lesions .

a. Epidemiology

Similar to ACL ruptures, meniscal tears occur as a result of a sudden twisting movement on a hyperflexed knee. 80 to 90% of these injuries occur as a result of a sports injury: football (soccer), basketball, rugby, or skiing [1-6]. In fact, 50% of patients aged between 7 and 18 years presenting with a posttraumatic hemarthrosis of the knee have a meniscal injury [7].

The exact prevalence of these injuries remains to be elucidated, although isolated meniscal lesions are known to be more frequent in skeletally immature children than adults, even though the meniscal tears in general are less frequently found on stable knees compared to unstable knees [5,6,8-11]. Meniscal injuries are encountered most frequently in adolescents [6,11,12] and are rare in children without congenital abnormalities. Meniscal tears may rarely appear in children younger than 8 years [13,14]. Multiple types of meniscal lesions may be encountered, with simple longitudinal and bucket handle tears being the most frequent, followed by horizontal and complex tears. Radial tears and meniscal root avulsions are less common [5,6,11,12].

b. Diagnosis

- Clinical

A meniscal tear should be suspected in children presenting with pain at the femorotibial joint line that increases in the kneeling position with difficulty passing to the standing position. Children may feel a blocking sensation that may be permanent or intermittent, with a sensation of popping (sign of meniscal instability) or a limitation in knee range of motion [1,3,5]. Mild hemarthrosis is usually present initially.

Physical examination should assess for joint effusion and compare the range of motion to the contralateral knee in search of a deficit in flexion, flexion contracture or more frequently a deficit in hyperextension.

Figure 1: *Ruler sign indicating a deficit in hyperextension of the right knee.*

Injuries to the medial meniscus elicit pain on forced varus of the knee or the figure-of-four maneuver, and are relieved with forced valgus, and vice versa for the lateral meniscus. The Beighton score determines the laxity of the knee, which constitute a risk factor for meniscal injury [2]. Specific meniscal tests are then realized:

1. Palpation of the anterior, middle, and posterior horns of the medial and lateral menisci.
2. McMurray test: repeatedly passing from flexion to extension with external rotation and valgus for medial meniscal tears, and internal rotation and varus for lateral meniscal tears.

Figure 2: *McMurray test: repeatedly passing from flexion to extension with external rotation and valgus for medial meniscal tears, and internal rotation and varus for lateral meniscal tears.*

3. Apley Grind test (GT): The child is placed prone, the knee is flexed to 90° and is then pressed against the examination table with external rotation for medial meniscal tears and internal rotation for lateral meniscal tears.

Figure 3: *Apley Grind test (GT): The child is placed prone, the knee is flexed to 90° and is then pressed against the examination table with external rotation for medial meniscal tears and internal rotation for lateral meniscal tears.*

4. Thessaly test (TT): difficult to realize in the pediatric population, the child is asked to stand on a single leg with the knee flexed to 20°. The patient is then asked to turn to the left and then to the right thereby causing external rotation of the knee to test for medial meniscal tears and internal rotation to test for lateral meniscal tears.

Figure 4: *Thessaly test (TT): difficult to realize in the pediatric population, the child is asked to stand on single support with the knee flexed to 20°. The patient is then asked to turn to the left and then to the right thereby causing external rotation of the knee to test for medial meniscal tears and internal rotation to test for lateral meniscal tears.*

According to the literature [3,15], these specific tests have a very low sensitivity (average 40%) but high specificity (>80%) in children. As a result, they should be taken into account only if they are positive. In children with lateral meniscal injuries, a discoid meniscus must always be ruled out [16].

- Medical imaging

Conventional radiographs have little value in the diagnosis of meniscal injuries, although they are systematically ordered in patients presenting with pivoting injuries of the knee. Their utility is in eliminating other lesions, such as osteochondral injuries, Segond fractures, and tibial eminence fractures [3]. The diagnosis of a meniscal injury is generally made on MRI, as was described in the previous chapter. Care should be taken not to misdiagnose a normal variant as a pathological finding. In fact, increased signal intensity of the posterior horn of the medial meniscus or of the popliteal hiatus of the lateral meniscus is often of vascular nature and may be mistaken for a horizonal tear of the medial meniscus or a vertical tear of the posterior horn of the lateral meniscus, respectively [17].

The diagnosis of a meniscal injury is thus made by associating the above described symptoms and physical exam in conjunction with imaging findings as to avoid misinterpreting a physiologic vascular increased signal of the posterior horn of the medial meniscus as a meniscal injury in a patient presenting with femoral patellar pain.

b. Treatment

• Conservative treatment

Acute, short meniscal tears may benefit from conservative treatment with limb unloading and abstention from pivoting sports, especially in tears of the peripherally vascularized “red/red” zone [3]. These patients require close follow-up with both physical and MRI exams. Follow-ups should be arranged at a minimum of 3-month intervals before allowing progressive return to high-risk sports. Anatomically, longitudinal tears measuring less than 10mm may be managed conservatively [3].

• Operative treatment

The majority of meniscal tears must be sutured, either because the diagnosis has been delayed (thus proving that the tear did not heal), or due to a complex meniscal injury or an extended bucket handle tear leading to an increased risk of joint instability [4,5,8,9,11,12].

> Principles of treatment:

- Unstable lesions must be repaired. Instability may be diagnosed clinically by a sensation of clicking, blocking or limited range of motion, or on arthroscopy by testing the meniscal tear with a probe.

- Regardless of the location of the injury, conserving as much of the meniscal tissue as possible is primordial, and no tear should be considered unrepairable, even those in the avascular "white/white" zones [6,10-12,18]. The only exceptions to this rule are radial tears, which are exceptional in children.

> Techniques:

Certain rules must be followed:

- Begin by preparing and debriding the edges of the tear with a rasp. In meniscocapsular separations, the meniscal edges as well as the capsule should be debrided.
- Heavy non-absorbable braided suturse (e.g. Mersuture 1) should be used, since the healing time of a meniscal tear is generally longer (4-6 months) than the absorption-time of absorbable sutures.
- Privilege vertical or oblique mattress sutures over horizontal mattress sutures due to their higher biomechanical resistance [19,20].
- Do not place sutures too close to the lesion in order to include a maximum of meniscal tissue within the suture [20].
- In extended bucket handle tears, "total knots" can be used: the knots are passed over the superior edge of the meniscus towards the inferior edge thus grabbing the free edges (figure 5) [18,20].

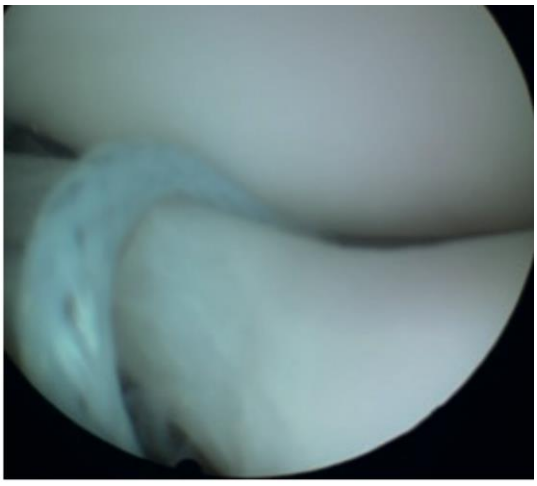

Figure 5: "*Total knot" grabbing the free edges of the meniscus.*

- Multiply the sutures (separated by 5mm intervals) for better tension distribution between the different sutures while tightening them.

Dedicated devices for meniscal repair can be found, and each medical device company advances its own "unique and revolutionary" product. Regardless, 3 types of suture techniques should be differentiated based on the type of knot: from the outside to the inside

of the knee (outside-to-inside), from the inside to the outside of the knee (inside-to-outside), or completely intraarticular (all-inside).

Our preferred techniques will be detailed depending on the location of the meniscal tear (figure 6):

Figure 6: *three different techniques of meniscal suture:* from the outside to the inside of the knee (outside-to-inside) for the anterior horn, from the inside to the outside of the knee (inside-to-outside) for the body, or completely intraarticular (all-inside) for the posterior horn.

- Tears of the anterior horn of the meniscus are often repaired by an outside-to-inside approach. Using arthroscopy, a hollow needle is first introduced in an ascending fashion through the tear. A heavy non-absorbable braided suture is then passed through the lumen of the needle. A second needle is passed in the same direction, placed either 5mm more lateral to the previous or, if a “total knot” is desired, passing through the other side of the meniscus. The suture is then passed through the lumen of the second needle using either a prefabricated lasso system or a handmade lasso fashioned out of non-braided suture loop (e.g. size 0 PDS suture). The suture bridges the tear within the joint with both ends exiting the skin. A small vertical cutaneous incision is made between the exit points of the suture ends. The sutures are then drawn subcutaneously using an arthroscopic hook and passed through the newly created skin incision. Under arthroscopic guidance, the knots are made against the joint capsule using a slip knot. Slip knots allow better tension distribution between the different knots. For tears with a very anterior extension where laxity of the joint capsule in this area may be problematic, it is preferable to secure the knot on an anchor placed over the anterior tibial epiphysis (meniscopexy) in order to avoid loosening.

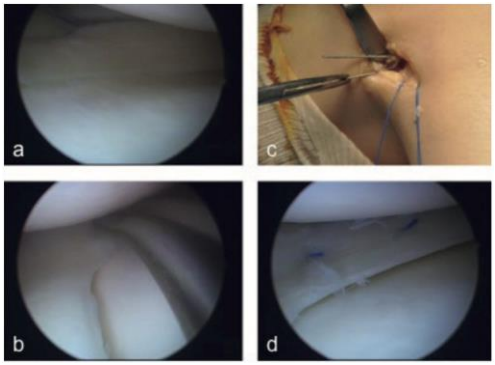

Figure 7: *Inside-to-outside technique. a: debridement of the lesion using a rasp. b: Insertion of the canula and then the needle through the tear. c: extraction of the needles and sutures through a skin incision at the level of the lateral meniscus in order to avoid the common fibular nerve. Note that the free ends of the first suture are extracted anteriorly, and the needles of the 2nd suture are extracted posteriorly. d: the two knots after tightening against the capsule.*

- Tears of the body of the meniscus are repaired by an inside-to-outside approach (figure 7). A curved suture cannula is passed through the opposite portal (anteromedial portal for the lateral meniscus and anterolateral portal for the medial meniscus), with the convexity of the cannula facing the cruciate ligaments. One hand is used to apply the distal end of the cannula against the meniscus in a slightly descending fashion (for a vertical mattress suture) at its anterior-most edge. A heavy non-absorbable braided suture is passed through the eye of a long needle that is adapted to the cannula, and the needle is passed through the cannula with a needle driver, passing through the meniscal tears and exiting the skin. The cannula must always face anteriorly in order to avoid the needle passing too posteriorly. In lateral meniscal tears, the needle must exit anterior to the fibular head as to avoid damaging the common fibular nerve. The needle and one end of the suture are passed through the skin, and the other end (still inside the cannula) is once again passed through the eye of the needle. The cannula containing the suture is then moved under arthroscopic guidance at least 5mm away from the first meniscal entry point either laterally or to the other side of the meniscus (if a “total knot” is desired) all the while maintaining the same direction. The needle and the second end of the suture are finally passed once again through the cannula and through the meniscal tear and the skin in a manner similar to the previously described. Similar to the outside-to-inside technique, the suture bridges the tear within the joint and its ends lie outside the skin. As previously described, the suture is passed through a small vertical skin incision with the help of an arthroscopic hook. The sutures are tied under the skin incision via arthroscopic guidance with a slip knot, and the knots are applied against the joint capsule. For tears of the lateral meniscus where the sutures are made relatively close to the fibular head, the cutaneous incision is extended in order to ensure the passage of the sutures in front of the biceps femoris tendon, thus avoiding the common fibular nerve. This suturing technique is preferred since it allows a solid fastening of the knot on the joint capsule [4,18]. The use of a cannula also aids in the reduction and stabilization of bucket handle tears. Finally, in the particular case of horizontal tears

of the lateral meniscus with an associated meniscal cyst, a direct lateral approach at the level of the cyst may be beneficial in order to excise the cyst during meniscal repair.

- Tears of the posterior horn of the meniscus are usually inaccessible by the inside-to-outside approach, since the exit points of the needles are too posterior and run the risk of neurovascular damage. The all inside technique (figure 8) is preferred in such cases. Its advantages are ease of use, lower neurovascular risk, and limited number of cutaneous incisions [21]. Nevertheless, this suturing technique is considered less robust than the previous two, since it is supported by a non-absorbable anchor that is theoretically applied against the meniscal wall of the posterior capsule. In reality, the exact position of the anchor in the posterior soft tissues and its mechanical value are unknown. As a result, the anchors risk loosening and floating within the knee joint if the sutures fail.

  In the all-inside technique, disposable industrial devices are generally used: The needle is passed vertically through the meniscal tear at a mean depth of 18mm (20mm in older adolescents and 16mm in younger children), the first anchor is deployed, the needle is removed from the meniscus and moved 5mm from the first meniscal entry point either laterally or to the other side of the meniscus (if a “total knot” is desired) and then passed through the meniscal tear, the second anchor is deployed, and the needle is removed from the knee. In order to bring the two anchors closer together and lock the knots, continued traction is applied on the ends exiting the skin with a counterpressure being applied on the meniscus with a hook, and eventually liberating one of the two sutures linking the two anchors. The suture is then cut flush with the meniscus.

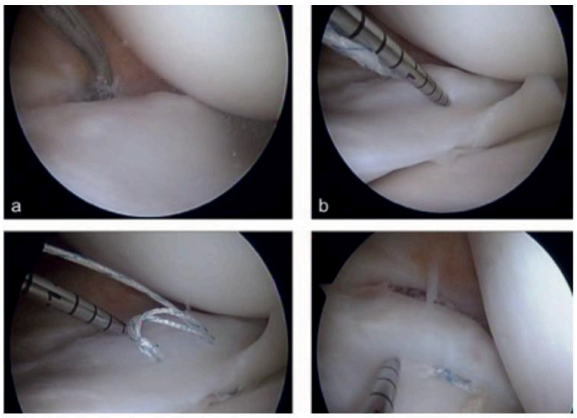

Figure 8: *All-inside technique. a: preparation and debridement of the tear using a rasp. b: the first suture is passed through the meniscal tear; the first anchor is deployed behind the meniscus. c: two anchors are placed; the two sutures are spaced 5mm apart. d: appearance of the first knot under tension and preparation of the second knot.*

> postoperative management: immobilization by with a knee immobilizer with the knee in extension for a period of 6 weeks. The knee may be mobilized from 0 to 60° by a physiotherapist 3 times per week in the immediate postoperative period. If the lesion was considered as unstable during arthroscopic hook examination, the patient must be placed non-weight-bearing with crutches for 6 weeks. Physical exercise is prohibited for a period of 4 to 6 months depending on the expected stability of the meniscal repair.

d. Results

Healing rates in patients operated for meniscal repair are still debated and depend extensively from the complexity of the lesion and the quality of the repair. Although postoperative follow-up MRI is rarely obtained in patients with a doubtful clinical follow-up, it is actually estimated that healing rates are around 80% in children, compared to 30% in adults [2,4,6,8,10-12,18,22]. A team at Mayo Clinic recently published their results of isolated meniscal repairs (on stable knees) in 32 children and adolescents with a mean follow-up of 17.6 years: The functional International Knee Documentation Committee (IKDC) score significantly increased from 65.3 preoperatively, to 92.3 at final follow-up, independently from the complexity of the lesion, although there was a significantly higher percentage of early failure requiring revision surgery in complex lesions (80% failure rate) compared to simple lesions (18.2% failure rate) and bucket handle tears (47% failure rate) [11]. A recently-published systematic review including 8 studies and 287 patients on the outcomes of meniscal repair (of which 60% were on unstable knees with an associated ACL tear) in children aged younger than 18 years confirms the previously-reported good functional results, with most patients being asymptomatic at final follow-up regardless of the type and location of the lesion or type of suture used [6]. Finally, a systematic review of the same 8 studies (287 patients and 301 meniscal lesions) also reported a good mean postoperative Lysholm functional score ranging from 85 to 96, a mean failure rate of 17.3%, and a low complication rate (1 incidence of temporary paralysis of the common fibular nerve and 1 septic arthritis) [12]. Children generally have high meniscal plasticity: as a result, when treating a chronic dislocated bucket handle tear, the free edge of the torn meniscus can be easily reduced since the dislocated portion will remodel and thin out over time (figure 9).

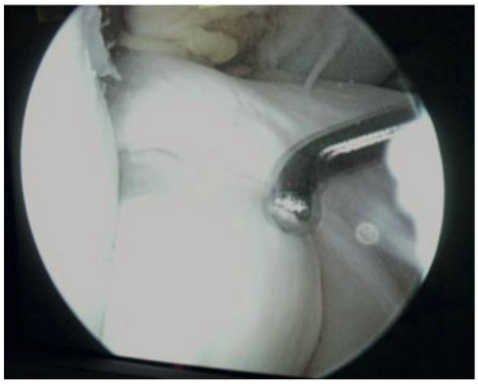

Figure 9: *reduction of a chronic bucket handle tear, the thick free edge showing remodeling and progressive thinning.*

As a result, all meniscal tears in children and adolescents should be sutured. Meniscectomy is an extremely detrimental procedure that must be avoided. For pediatric orthopedic surgeons, meniscal tears that are believed to be beyond the surgeon's expertise must be referred to a colleague (even an adult orthopedic surgeon) rather than be removed.

2. Meniscal tears on an unstable knee

a. Epidemiology

A study published in 2011 reported a 10-year increase in the prevalence of ACL injuries in children and adolescents and, with it, an unavoidable increase in the prevalence of meniscal tears [23]. In a study by Stracciolini, ACL tears represented up to 10% of sports injuries in 13 to 17-year-olds [24]. In fact, ACL injuries increase the risk of synchronous meniscal lesions, but also metachronous tears due to chronic instability of the knee [25].

In a study on secondary meniscal injuries in patients with a ruptured ACL, Raad et al. found a high prevalence of rugby and football (soccer) players and a relationship between meniscal tears and high BMI, attempted functional treatment, and delay until surgery [26].

Meniscal tears with concomitant ACL injuries were discussed during the 2017 symposium of the Francophone Arthroscopy Society which was centered around ACL injuries in children and adolescents. In a prospective study titled "ACL injuries – open physes", the authors found that 48% had associated meniscal tears. The lateral meniscus was injured in 49% of cases (posterior horn: 83%; anterior horn: 0%, body of meniscus: 10%, body and posterior horn: 7%). The medial meniscus was injured in 51% of cases (posterior horn: 86%, posterior horn and body: 7%, body: 7%, anterior horn: 0%). Tears were vertical in 60% of cases, bucket handle tears in 12%, horizontal tears in 10%, radial tears in 5%, and complex tears in 13%.

In a retrospective study "ACL injuries – open physes", the authors found meniscal tears in 24% of cases (medial meniscus 62%, lateral meniscus 19%, both menisci 19%).

The percentage of meniscal tears in patients with a defective ACL thus varies depending on the study and dictates the indications for surgical intervention, with some studies reporting meniscal tears in up to 85% of ACL deficient knees [27]. These differences may be explained by the delays until surgical management in some studies (1 year for Ramski et al. [28]), which increases the incidence of meniscal injury, especially the medial meniscus [27,29]. Contrarily, in patients operated in the acute setting, a lower incidence of secondary meniscal injuries was found.

In a prospective study "ACL injury – closed physes", the authors report meniscal tears in 49% of patients with ACL ruptures who were operated, with once again a predominance of injury to the medial meniscus.

In fact, ruptures of the ACL lead to a specific pattern of meniscal injury: injuries of the medical meniscal ramp, initially described as a posterior meniscocapsular injury of the medial meniscus [30]. Some studies have recently suggested that these injuries may be associated with lesions of the attachment of the meniscotibial ligament on the posterior meniscal horn. These injuries are often difficult to identify on MRI due to patient positioning with the knee in extension. The prevalence of these injuries depends on the authors and ranges from 24 to 28% in children and adolescents with a ruptured ACL [30,31].

Peltier et al. found that injury to the meniscal ramp increases anterior tibial translation, rotation and pivot-shift [32], and increases instability [33]. As a result, Stephen et al.

recommend repairing the meniscal ramp simultaneously with the ACL, due to its potential implication in persistent instability of the knee [34]. If left untreated, increased instability of the knee would lead to higher strain on the newly repaired ACL.

b. Diagnosis

The most frequently reported symptoms in the context of an acutely unstable knee after an exaggerated valgus moment and external rotation include pain and episodes of locking or pseudo-locking. The physical exam would also search for:

- Classic signs of instability: anterior/posterior drawer test, Lachman test, positive pivot-shift test.
- Signs of meniscal pathology: joint line tenderness on the medial or lateral side, positive McMurray test, pain on the Apley and Thessaly tests.

The physical exam may be particularly difficult to perform in the acute phase, especially in bucket handle tears. In this case, the patient must be reassessed in 2 to 3 weeks.

Conventional radiographs of the knee are not particularly useful, although findings of a Segond fracture (avulsion of the anterolateral ligament) are pathognomonic of an ACL tear.

MRI is the modality of choice and would allow a complete assessment of the entire knee:

- ACL rupture: complete rupture of the ACL, signal anomalies, Blumensaat angle superior to 10°.
- Injuries secondary to ACL rupture: bone contusion, anterior drawer sign from anterior tibial translation
- Meniscal injury especially of the posterior horn, dislocations of bucket handle tears within the intercondylar notch with a classic double PCL sign.

c. Treatment

Patients are most often seen at a distance from the acute incident. In fact, indications for the emergent treatment of ACL are limited.

As such, meniscal tears associated with an ACL injury discovered on MRI must prompt the immediate repair of the meniscus. In fact, the finding of a meniscal lesion is the main indication for concomitant ACL reconstruction. Moreover, ACL tears are not known to spontaneously heal, and the secondary knee instability that is caused by such an injury would prevent any meniscal tear from healing, even when repaired.

Nevertheless, not all meniscal tears should be systematically repaired: partial-thickness tears of the posterior horn of the lateral meniscus are generally concomitant with the ACL injury. These tears are frequently encountered and have a high potential for healing in the absence of renewed episodes of knee instability. If these tears are found to be stable during hook testing or solely partial thickness, repair is generally not necessary.

Surgical management is undergone via arthroscopy, under a tourniquet, and under general anesthesia. In children, the technique used for ACL reconstruction generally depends on the surgeon's preferences and skeletal maturity.

Meniscal repair in unstable knees generally follows the same principles as in isolated meniscal tears: tears measuring 10mm or more must be repaired, while those measuring less may be simply debrided. Different suturing techniques are summarized depending on the location of the tear:

- All-inside technique (previously fast-fix) for injuries to the posterior horn.
- Inside-to-outside technique (previously Acufex) for injuries to the body of the meniscus.
- Outside-to-inside technique (previously Meniscus Mender) for injuries to the anterior horn.

Although the inside-to-outside technique by non-absorbable sutures requires a lateral counter incision on the knee, it remains the gold-standard treatment in terms of suture stability.

Injury to the meniscal ramp also requires arthroscopic repair. The diagnosis is usually made on MRI and the tear is classified according to Thaunat's system, although the type of injury may be accurately established only after arthroscopic examination [35]. Injuries of the meniscal ramp are generally identified by a sequential arthroscopic approach, including a transcondylar (passing between the PCL and the medial femoral condyle) and posteromedial approach. Visualization of meniscal ramp injuries may be simplified by using a 70° arthroscope. A needle, placed through a posteromedial approach, may be used to elevate the meniscus from the distal end of the ramp and assess its integrity (figure 10).

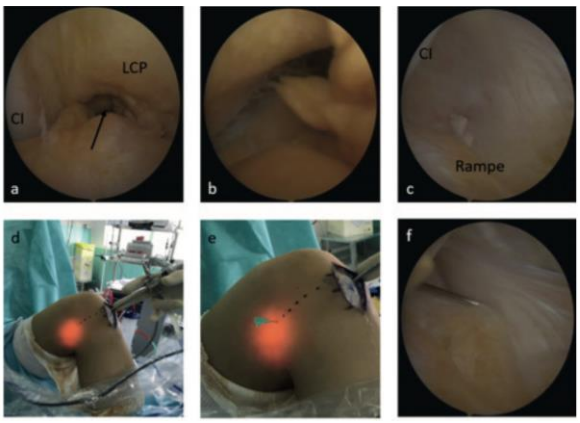

Figure 10: *Exploration of the medial condylar ramp. a: the transcondylar approach is made between the medial femoral condyle (MC) and the posterior cruciate ligament (PCL, arrowhead). b: Arthroscope advancement (arrow). c: exposition of the posteromedial aspect of the knee with the ramp underneath. d: introduction of the needle by a posteromedial approach over transilluminated area. e: penetration of the needle at the level of the joint line (dotted) at its posterior aspect. f: once the posteromedial space has been breached, the needle may elevate the soft tissues from the extremity of the ramp thus evaluating the tears.*

The tear is prepared and debrided using a shaver or rasp through a posteromedial approach. Through the same approach, a 45° dedicated hook is introduced facing to the right for the left knee (and vice versa for the right knee). This dedicated hook, also known as a Kuntscher awl, is used to pierce the meniscus from the bottom-up, passing completely through the tear. The lasso system is then released, and the suture is passed through the awl and the lasso. The suture is fastened onto the lasso and the awl is removed leaving both ends of the suture protruding from the skin. A slip knot is then made (figure 11) while pulling on one strand and lowering the knot onto the meniscal tear. Once the knot is in place, it is locked with a couple of throws and finally a surgeon's knot. The free ends of the suture are then severed under arthroscopic guidance, and its stability is tested using a hook.

In extensive meniscal tears that have been treated with sutures, a strict postoperative regimen must be followed: No weight bearing for 6 weeks while wearing a knee brace and mobilizing with crutches or a wheelchair. Anticoagulants are prescribed based on the patient's pubertal status (menarche in girls, and appearance of pubic hair in boys). Following immobilization, physiotherapy may prove useful as an aid for ambulation, reinforcement of the quadriceps and hamstrings, and recuperation of knee range of motion. Physical training and knee hyperflexion are contraindicated for 4 months postoperatively.

As for return to all types of sports (including pivoting), most authors recommend particular care be taken postoperatively in children, with return to sports note being authorized before 12 months postoperatively, sometimes even 14 months in younger patients. In fact, this delayed return to sports stems primarily from the slower ligemantization of the graft seen on MRI in children compared to adults, but also from an increased risk of ACL failure from early return to sports [36,37].

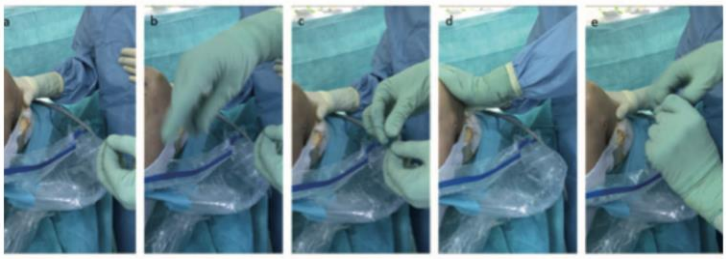

Figure 11: *Slip knot tightened deep into the operative field. a: the left hand holds both strands as the suture is passed in the lesion, the right strand being the longer one. b: the right strand is passed three time around these two. c: the right strand is then passed from the top to the bottom through the preformed loop and held between the thumb and index of the left hand. d: while the assistant stabilizes the knee, the left hand pulls on its strand and the knot slips and is lowered until reaching the lesion area. e: The knot is the fastened by a throw and a two surgeon's knots (bulky knots must be avoided, especially in a smaller knee, in order to reduce subcutaneous irritation).*

d. Results

Outcomes of meniscal repair in children have been inconsistent in the literature: In a multivariate analysis, Ferrari et al. reported healing rates of 33 to 100% in children treated with meniscal repair [6].

Adults treated with both meniscal repair and ACL reconstruction simultaneously have shown superior results when compared to patients with isolated meniscal injury. In children, these differences are less evident, as was shown in a study by Yang el al. [38]. Moreover, meniscal healing is more difficult to assess in children, and some patients may be completely asymptomatic and show no signs of meniscal healing on imaging [22].

Lucas et al. found that up to 68% of patients treated with isolated meniscal tears and who were treated by sutures showed signs of healing, whereas Krych et al. reported that up to 74% of patients with both a meniscal tear and an ACL injury showed signs of healing [10,39]. Thus, outcomes between children and adults seem comparable, although studies directly comparing meniscal healing rates between isolated meniscal tears and meniscal tears associated with ACL injuries in children are still lacking.

Concerning the repair of the meniscal ramp, data on the outcomes remain scarce. In one systematic review, Alessio-Mazolla et al. found a failure rate of 8.3% in these cases [40].

Conclusion

The dogma of meniscal preservation is more appropriate than ever in children. Meniscal tears must be identified, and MRI must be abundantly prescribed. The majority of these injuries must be repaired by sutures via arthroscopy, an intervention requiring a high level of expertise. Meniscectomy is contraindicated in children or must be limited to the debridement of small unrepairable tears. Meniscal repair is justified by its good outcomes in children, and by the absolute necessity of preventing the development of early osteoarthritis as early as young adulthood.

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