

Functional and Anatomic Characteristics of the Menisci

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The menisci are fibrocartilagenous structures that optimize the function of the knee joint. Their lesion affects negatively its biomechanical function. There is no consensus with regards to the optimal treatment of meniscal lesions in children, even though, the amount of literature has increased in the past years. This is quiet true, specially in the case of symptomatic discoid menisci and their treatment; in which a wide variety of options could be found but with uncertain long term outcomes.

The aim of our study was to present an update of the literature with regards to the meniscal pathology in children, taking into account its functional and anatomic characteristics, development, clinical manifestations, diagnosis modalities and treatment options.

The menisci are intra-articular fibrocartilagenous structures which optimize the joint function¹. They have a half-moon shape and present a wedge shape in the concave of its transversal section². This shape could be seen since the eight week of the embryonic period³, presenting the adult characteristics at the 14th weeks, with a prominent vascularization and cellularity which will be decreased by the hand of maturation¹. There is an abundant extracellular matrix which has a 70% of water, collagen type I, proteoglycans and elastin³ in which few cells (fibrochondrocytes) are embedded.

With regards to its ultra-structural architecture, the great majority of bundles are circumferential which confers compression forces support. There are also radial bundles that give stability to the prior ones and help to support longitudinal tension. Finally, there is a superficial layer with a disorganize distribution which shares the stress⁴ (Figure 1).

The menisci are inserted into the tibia through their horns (anterior and posterior) and periferically to the joint capsule². The medial menisci has little mobility in comparison to the lateral one due to anchors to the posterior oblique's fibers of the medial collateral ligament^{2,5}. Tensile forces act into the menisci moving them to the periphery, making the longitudinal bundles of collagen support traction forces between both horns. Shear stress isn't well tolerated, this fact explains the longitudinal injuries observed during childhood⁶.

The menisci are stabilized by different ligaments such as: Winslow ligament (Figure 2), coronary ligaments and menisco-femoral ligaments (Wrisberg and Humphrey) (Figure 3). The Popliteal tendon also contributes, adding an anchor to the lateral menisci in its posterior border².

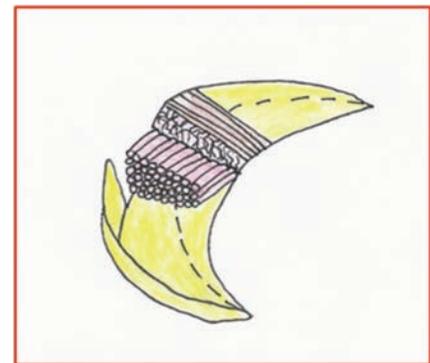


Figure 1. Microscopic structure of the meniscus.

The parameniscal plexus irrigates the menisci through branches from the superior, inferior, lateral and medial geniculate arteries¹ in a radial direction from the periphery⁶ (Figure 4).

At ten year old, the vascularization pattern is like in adulthood¹; in which, 10%-30% of the

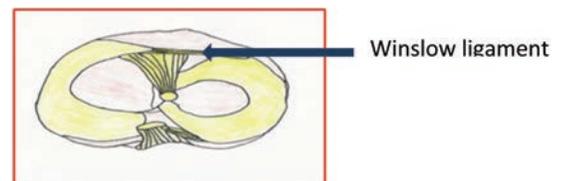


Figure 2. Transverse ligament of the knee (Winslow ligament)

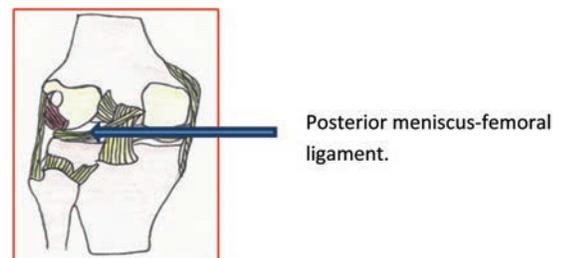


Figure 3. Posterior menisco-femoral ligament.

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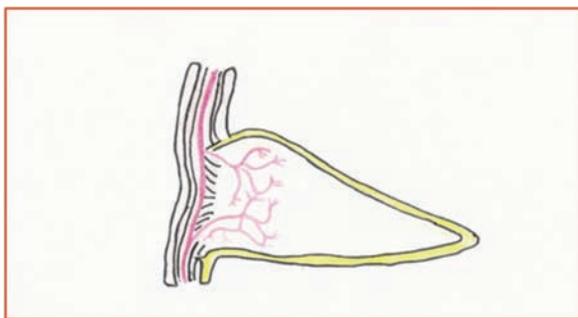


Figure 4. Cross section of meniscus vascularization.

periphery in the medial menisci is irrigated and 10%-25% in the case of the lateral menisci⁷. This is important to bear in mind because injuries in the periphery has a greater healing potential than the ones localized in avascular zones^{2,4,6,8}. The innervation of the menisci has a similar pattern as the vascularization⁶.

The menisci have several functions⁹ such as:

1. **Load sharing:** This is its main function, and it's possible due to the configuration of the collagen bundles. About 50%-70% of the body weight is transmitted through the menisci during knee extension and could be up to 85%-90% while the knee is in flexion. These are mobile structures that maintain joint congruency during knee flexion¹⁰.
2. **Secondary stabilizers of the knee:** They compensate the incongruence between the articular surfaces of the femur and tibia. When the ACL is incompetent, the posterior horn of the medial meniscus, prevents anterior translation of the tibia, most of all during knee flexion¹¹⁻¹³.
3. **Absorption of compression loads:** Due to its viscoelastic properties, they attenuate the impacts during walking and running⁵.
4. **Lubrication and nutrition of the joint cartilage:** Enhance the production of synovial fluid, especially in children younger than 10 years of age, where there is a synovial layer¹.
5. **Proprioception:** Due to the presence of mechanoreceptors and nervous endings, they have an important role during pain perception and acquisition of protective reflexes^{14,15}.

Meniscal injuries during childhood

Two clinical settings should be distinguished, since they require different treatment strategies: Injuries in a normal menisci and discoid meniscus.

Normal meniscus

The real incidence of injuries during this period of life is difficult to estimate. Injuries are rare in kids younger than 10 years-old, being more common during the adolescence when high performance sports activities begin, with 90% of these injuries occurring during sports activities⁷. The mechanism of injury is a combination of rotation and extension of the knee, where the meniscus is trapped between the joint surfaces⁵.

The medial meniscus is affected more often than the lateral one. The pattern of lesion differs from adults; in young kids, meniscal detachments are more common, however, during adolescence, up to 90% presents with a longitudinal injury (bucket handle injuries)^{5,6}. It's important to highlight the fact that, almost two thirds of these lesions are associated with ACL injuries⁷.

Diagnosis

Less than 60% of meniscal lesions can be clinically diagnosed acutely due to difficulty in doing a physical exam in a very young patient⁷. Pain in the joint line and inflammation after traumatism are common findings⁷. At this age, one third of hemarthros are due to meniscal tears, maybe because peripheral injuries are more common¹⁶. Clinical maneuvers have low sensitivity and specificity⁶. The accuracy of the MRI is similar to the clinical assessment¹⁷.

Complementary imaging that could help with the diagnosis:

- A. **Plain x-rays:** Usually is normal, but is useful to differentiate from others potential intra-articular lesions like : osteochondral fractures, spine tibial lesions, and other etiologies of hemarthros¹⁶.
- B. **MRI:** This is the "gold standard" for diagnosis of meniscal tears, but it should be used in a rational way and never consider like a routine test. Its interpretation is difficult in kids, because, its common to observe signal changes in the posterior horns of both menisci that could be misread like a lesion; the one's that involve all the thickness of the meniscus should be considered as tears^{7,17} (Figure 5).

Treatment

We have to conserve the meniscus as much as possible if we want to avoid a future degenerative process of the knee joint¹⁶.

Conservative treatment: Small lesions, less than 5 mm, within the avascular zone; they used to be stable and in most cases asymptomatic. Longitudinal tears less to 10mm in the vascular zone used to heal spontaneously¹⁴. Immobilization



Figure 5. Signal change in posterior horn of the medial meniscus.

should be used for at least 6 weeks, follow by rehabilitation program and avoiding sport activities for 12 weeks from the diagnosis of the lesion⁷.

Surgical treatment: The majority of lesions are extensive and need surgical treatment, basically partial meniscectomy or fixation⁷.

Partial meniscectomy: This is used when there is an irreparable tear, with good short term outcomes, but with radiological degenerative changes at 5 years. It's difficult to control the amount of resection when an arthroscopy is performed^{7,18,19}.

Meniscus fixation: This option should always be kept in mind due to the theoretical healing potential of the meniscus in this age period. The healing period is about 10 weeks when the vascular zone is repaired. This approach is of particular interest when a longitudinal lesion over 10mm or unstable tears are found (Figure 6).

Non weight bearing should be kept for 3 to 6 weeks and avoid knee flexion of more than 90° for about 3 months. Sport activities could be reassumed after 4 months of surgery, achieving a 90% rate of healing. Unfortunately, there are no long-term outcome studies of meniscal sutures as well as sutures within the avascular zone in this group of patients^{7,16} and the results are quiet variable^{20,21,22}.

Discoid meniscus

This is a congenital anatomic variant²³ characterizes by the lack of the usual half-moon shape, adopting a discoid one¹⁸ with a subsequent higher percentage of tibial coverage. There is also a decrease of the meniscus thickness, which alters the normal loading share in the affected knee compartment²⁴. It was first described by Young²⁵ in 1889; however, Watson-Jones in 1930 was the first who contributed with a possible relationship between this type of meniscus and knee symptomatology²⁶.

Its real incidence is difficult to estimate due to a high number of asymptomatic cases, but it has been estimated in 0.5% to 17%¹⁸. There is an increase incidence within the Asian people due to unknown reasons. In the majority of cases its localized in the lateral compartment of the knee and up to 20% of the cases could be bilateral^{18,24,28}.

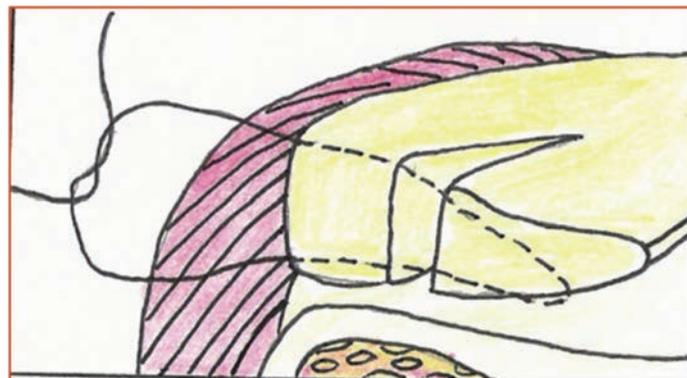


Figure 6. Meniscal suture.

Etiology

Nowadays, it seems that the discoid meniscus could have a congenital origin and that the hypermobility observed in the cases with lack of posterior attachments would be secondary to the congenital absence of menisco-tibial ligaments or to the development of instability due to abnormal loads within the capsule-meniscal union^{5,18,29,30-32}. The fact that there are some familial cases, supports its congenital origin²⁴.

Classification

The Watanabe and Takeda³³ classification is widely used and describe three types:

Complete: This is the most common type, described in up to 80% of cases and its characterized by a complete coverage of the tibial surface (Figure 7).

Incomplete: A variable size could be seen with a lower percentage of coverage of the tibial surface in comparison with the complete type (Figure 8).

These two types have normal posterior meniscotibial attachments.

Wrisberg ligament: This is a meniscus without posterior attachments, except for the posterior meniscofemoral ligament, this makes it extremely mobile. It's shape is not necessarily discoid, being more similar to a normal meniscus (Figure 9).

Dickhaut & De Lee³⁴ established a relationship between the Watanabe classification and symptomatology. They found that the complete and incomplete types were used to be asymptomatic, unless a tear was associated; however, the

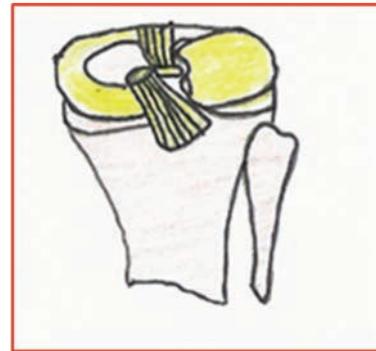


Figure 7. Complete discoid meniscus.

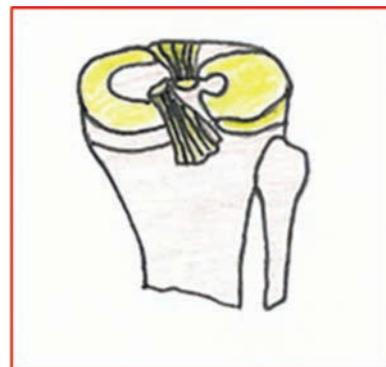


Figure 8. Incomplete discoid meniscus.

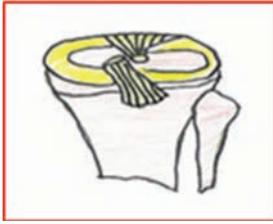


Figure 9. Wrisberg variant.

Wrisberg ligament type was used to be associated with the “snapping knee syndrome”.

Jordan et al³⁵ established a new classification based on clinical and arthroscopic findings :

Stable: This type correlates with the complete and incomplete types described by Watanabe; and its stability is based on the presence of posterior menisco-tibial attachments independently of the posterior menisco-femoral ligament. The treatment is similar to a classic meniscal tear.

Unstable: This is the symptomatic discoid meniscus and correlates with the Wrisberg ligament type. It has hypermobility due to lack of posterior attachments. Its shape could be normal or discoid.

Clinical findings

The discoid meniscus by itself is not a source of pain, but its tendency to be injured and cystic degeneration, makes it to be symptomatic during childhood^{34,37}. The unstable type tends to be symptomatic and presents a “popping sound” at the end of knee extension^{24,38} due to subluxation of the posterior horn, sometimes associated with pain and joint effusion. During physical examination, a block of knee extension could be found, which can be presented during walking. Sometimes, a ledge at the level of the joint line could be felt when the knee is between 10°-20° of extension due to reduction of the subluxated lateral meniscus²⁴.

Davidson et al¹⁸ in his series of 34 patients with discoid meniscus found that the most frequent symptom reported was pain.

It has also been reported a possible relationship between the presence of a discoid meniscus and the risk of osteochondritis dissecans development due to an alteration of loads distributions^{24,39}.

Diagnosis

A high index of suspicion is needed based on clinical findings and complementary images studies such as:

Plain x-rays: A weight bearing AP view may show indirect signs²⁴, like: widening of the lateral compartment, flattening of the lateral femoral condyle, hypoplasia of tibial spine, fibula head elevation (Figure 10).

Arthrography²⁴: A bigger meniscus could be seen reaching the intercondylar notch. This technique, is not longer use.

MR^{24,30,40}: Different findings could be found according to the view. In a sagittal view, continuity of the meniscus between the anterior and posterior horns in three or more 5mm slides could be seen (Figure 11).

Whereas in the coronal view a greater lateral-medial diameter will be seen, associated to a decrease thickness (Figure 12).

However, there are some disadvantages such as: Difficult to identify the menisco-femoral ligaments and the unstable type with normal shape.

Arthroscopy: The main advantage of this technique is the possibility to identify unstable types with normal shape, allowing a definitive treatment during the same surgical procedure. In many cases the arthroscopic findings are incidental^{34-36,41,42}.

Treatment

This is a controversial topic; since there are different approaches that could be adopted depending on^{18,24,30,43}:



Figure 10. Plain x-rays of a patient with discoid meniscus.

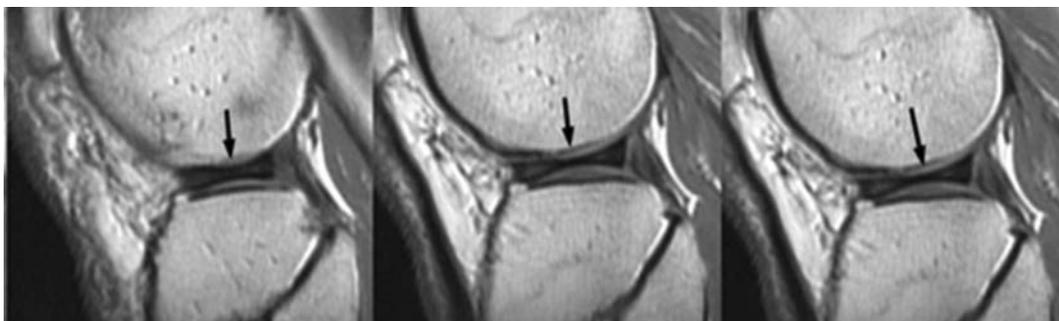


Figure 11. T1- weighted sagittal views of a discoid meniscus.



Figure 12. T1- weighted coronal views showing an increased medial-lateral diameter of a discoid meniscus.

Meniscus type, age, associated meniscal tear, characteristics and duration of symptoms.

Non-surgical treatment: This is indicated when the patient has sporadic “snapping” without other symptoms associated and when it’s an incidental findings during an MRI or arthroscopic procedure. Also in patients with recent symptomatology, an initial functional rest, with or without immobilization and proprioceptive as well as quadriceps strengthening exercises are recommended^{18,30,43}.

Total meniscectomy: It has been demonstrated that a total meniscectomy increases local loads up to 235% and decreases the surface contact in 75% within the corresponding compartment. However; there are some studies, that show better results with total meniscectomies than partial meniscectomies in lateral discoid menisci, with some adaptation of the knee to the new stress environment^{18,43}. This could be a good option in cases with the Wrisberg variant in which a partial meniscectomy is not possible² and in children below 12 years old with degenerative menisci lesions⁵⁵. In the long term outcome, there are variables results, showing degenerative changes in 0% to 100% of cases^{18,23,28,43,44}.

Partial meniscectomy: This is the best treatment in almost all cases. It has a theoretical biomechanical advantage over total meniscectomy. It’s consider a first line treatment in patients over 12 years old, and in general in any patient in which the meniscus could be preserved^{18,43,44}. This technique can also affect the proprioception of the knee, fact to be taken into account if we want to choose an alternative such as menisci transplant⁵⁷. When peripheral lesions are associated, their suture have very good short term outcomes (more than 2 years follow up)⁴⁵. There are different types of suture techniques such as: inside-out; outside in and all-in; as well as different types of sutures which may offer an additional advantage when they are use in this group of age. Which technique to use, will depend on surgeon’s experience as well as type of menisci lesion^{12,46}. Ahn et al⁴⁶ reported a series of 28 knees in which a lateral discoid menisci was associated with a peripheral lesion in which an outside-in suture technique was used to repair anterior horn lesions, an inside-out technique for central lesions and an all inside technique used for posterior horn lesions; with good results at final follow up⁴⁵.

Menisci transplant: This is a good indication in patients in which symptoms persist after total/partial meniscectomy, without evidence of degenerative joint changes. It has been shown a positive effect with regards to knee proprioception¹⁴.

Osteochondral lesions and discoid menisci: It has been observed a relationship between lateral discoid meniscus and osteochondritis dissecans, with incidences as high as 15% - 18% after meniscectomies. There is no a clear etiology for this relationship, being described a traumatic, mechanical or vascular origin. This lesion has been localized in a central (AP view) and posterior (lateral view) position⁴⁷. The majority of cases have been treated surgically without homogeneous outcomes⁴⁷⁻⁴⁹.

Meniscal Cysts

These are very uncommon with an incidence of about 1,5% in the lateral meniscus and less than 0.5% in the medial meniscus⁴¹. Usually are found during the third or fourth decade of life, but when they are identified in patients under 16 years-old, they are associated with a non-discoid meniscus. These cysts are commonly associated with meniscal injuries, most of all horizontal tears⁴² (Figure 13).

The associated pain is not explain by itself, it’s believe to be secondary to the meniscal tear³⁶. Usually they are localized at the external joint line, like a hard mass. It’s more evident with the knee between 15°-90° of flexion and it’s not seen when the knee is totally extended. The differential diagnosis could be made with cystic degeneration of the iliotibial band, proximal tibio-fibular joint ganglions, lipomas⁴² and specially with the protrusion of a meniscal fragment from a bucket handle tear.

The treatment is based on a partial meniscectomy and decompression of the cystic lesion³⁶. Due to a high recurrence rate, when the cysts are big, it’s recommend to perform an open cystectomy and arthroscopic repair of the meniscal tear^{41,42}. Arthroscopic meniscal repair is sufficient for small lesions.

Conclusions

Knowledge of the development, structure and biomechanics of the menisci will allow us to better understand their lesions and its effects into the normal function of the knee. Based on

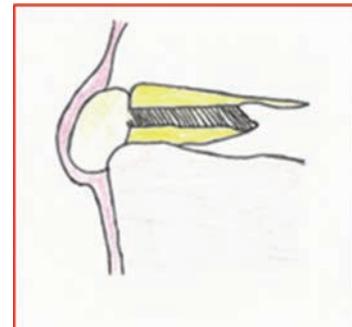


Figure 13. Lateral meniscal Cyst.

this, a wide variety of treatment options could be taken into account.

In patients in which a meniscal lesion is suspected by means of physical findings, having an image test such as an MRI is a very useful tool to define the type of lesion, associated lesions and anatomical variants.

The actual treatment trend is the use of arthroscopic techniques; the majority focused on partial meniscectomies and suture techniques. The outcomes reported within the different studies are heterogeneous, which don't allow us to use a unique technique for all cases.

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