Overview of Meniscal Tear and Management Using All-inside Techniques

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Article History: Received: 26.06.2023 **Revised:**04.07.2023 **Accepted:** 22.07.2023

ABSTRACT

Meniscal tears are the most common knee injuries and seen in patients of all ages due to several causes: degeneration, trauma, and discoid meniscus. Treatment options for meniscal tears fall into three broad categories; non-operative, meniscectomy or meniscal repair. Many tears can be treated non-operatively. The goal of treatment is to minimize the symptoms and protect the joint from further injury while it heals. Arthroscopic techniques have evolved to improve morbidity. However, there are few clinical outcome studies in the peer-reviewed literature that compare the use of these approaches. Meniscal repair has been introduced to preserve knee function and limit the accelerated degenerative changes associated with meniscal tissue resection. Arthroscopic meniscal repair techniques are continuing to evolve. Most studies to date comparing the healing rate of inside-out to all-inside meniscal repair techniques are confounded by associated anterior cruciate ligament reconstruction or deficiency. Meniscal repair is now being touted as a viable and effective alternative. Meniscal repair aims to achieve meniscal healing while completely avoiding the adverse effects of partial and total meniscectomy. All-inside meniscus repairs are becoming more common with the invention of meniscal arrows, darts, screws, staples, and other suture devices. The aim of the present study was to review the various all-inside surgical interventions used in the treatment of meniscal tears.

Keywords: Meniscal Tear; Arthroscopic Repair; All-inside Technique

DOI:10.48047/ecb/2023.12.10.993

Introduction

The menisci have an important role in knee function. Long-term follow-up studies showed that virtually all meniscectomized knees develop arthritic changes with time. The meniscus has functions in load bearing, load transmission, shock absorption, joint stability, joint lubrication, and joint congruity. Because of these functions, meniscal tissue should be preserved whenever possible **(1)**.

The menisci are wedge shaped fibrocartilagenous structures located between the femoral condyles and tibial plateau. The medial meniscus is "U" shaped covering around 60% of the medial compartment whereas the lateral meniscus is more "C" with a shorter distance between its anterior and posterior horns covering 80% of the lateral compartment. Meniscal tears are often classified according to their orientation. Longitudinal tears are more common medially, whereas radial tears are more frequently seen laterally **(2)**.

Meniscal tears are the most common pathology of the knee with a mean annual incidence of 66 per 100000. Historically it was believed that the menisci served no functional purpose and they were often excised with open total meniscectomy. Previous studies have shown that function of the knee was directly related to the amount of meniscal tissue that remained**(1)**.

The two most common causes of a meniscus tear are due to traumatic injury and degenerative processes. Isolated meniscal tears occur due to rotational or shearing forces placed across the tibiofemoral joint, especially when an increased axial load is placed through the menisci. Such scenarios include positions with increased degrees of closed kinetic chain flexion (kneeling, squatting), lifting/carrying heavyweights, and activities requiring rapid acceleration/deceleration, change of direction, and jumping **(3)**.

The lateral menisci are much more mobile than are the medial menisci, and this is reflected by the higher rate of medial side injuries. This may be due to the fixed meniscus being less able to compensate for joint forces and rotations during movement **(4)**.

A traumatic impact to the knee can also result in either isolated meniscal tears or tears occurring concomitantly with bony lesions or damage to the primary stabilizing ligaments of the knee, such as the anterior cruciate ligament (ACL) and MCL. Relatively less force is required to create tears in those with degenerative changes of the menisci, typically seen in adults over the age of 40y/o, often with concomitant osteoarthritis (OA) **(5).** Moreover, long-term follow-up studies showed that virtually all meniscectomized knees develop arthritic changes with time**(3)**.

- **Symptoms:**

Meniscal tears can cause a range of symptoms, including pain localizing to the joint line, swelling, clicking, catching, locking, and the classic "giving away" of the knee. They are more commonly seen in men as compared to women, with up to 80% of all meniscal tears being reported in men. Many patients have also reported waking up from sleep due to the pain. This can be explained by the possible scenario of a tender medial aspect of the knee colliding with the other knee while the patient rolls over in his sleep. It is common to see meniscal injuries in conjunction with damage to structures such as anterior cruciate ligament (ACL), posterior cruciate ligament, or other bony injuries **(6)**.

- **Types of meniscal tears**

Meniscal tears are categorized by both their shape and location when visualized on (MRI), in which high-intensity intra meniscal signals communicate with at one articular surface on an otherwise black-appearing meniscal tissue. Horizontal (cleavage) tears run parallel to the tibial plateau through the mid-substance of the meniscus. They are more likely to occur in people over 40y/o with underlying degenerative changes, in the absence of a distinct inciting event. Longitudinal (vertical) tears run perpendicular to the tibial plateau and parallel to the long axis of the meniscus. Radial tears run perpendicular to both the tibial plateau and long axis of the meniscus, originating from the inner free edge of the meniscus. Complex tears involve some combination of horizontal, longitudinal, or vertical tears **(Figure 1)**. In contrast, displaced tears involve either complete detachment of a piece of meniscus or flipping of a piece of the meniscus that is still attached to the rest of the meniscal body. Bucket-handle tears are fragments of complete longitudinal tears that migrate centrally over the remaining menisci. Parrot-beak tears are radial tears with partially detached fragments. Flap tears are partially detached fragments of horizontal tears **(7)**.

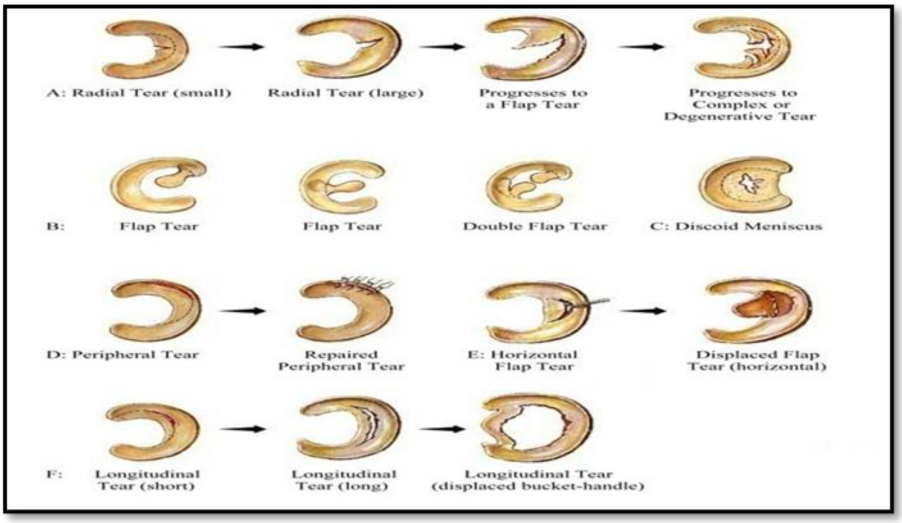

Figure (1) Meniscal tear types [(7)].

- **Clinical examination & Diagnosis:**

The orthopedic surgeon should effectively correlate clinical information, radiological images, and his/her clinical expertise to devise an individualized management plan for the meniscal tear. The severity of the symptom seldom corresponds to the type and location of the tear. Detailed history-taking along with thorough clinical examination may not always clinch the diagnosis, and hence radiographic and arthroscopic evaluations should be conducted for confirmation of the diagnosis.Complete examination of the lower extremity is required. The uninvolved leg is used as the reference for comparison with qualitative and quantitative findings of the involved leg**(8)**.

Stability tests are done to rule out concomitant injuries. There are several provocative maneuvers by creating compression and/or shearing forces on the torn meniscus between the femoral and tibial surfaces **(9).**

A meta-analysis of three physical examination tests (McMurray's, Apley's, and joint line tenderness) in 18 studies presented heterogeneous results with large inter-study differences. Pooled sensitivity and specificity were 70% and 71% for McMurray's, 60% and 70% for Apley's and 63% and 77% for joint line tenderness (JLT). They concluded that "No single physical examination test appears to accurately diagnose a torn meniscus **(10)**.

In the McMurray's test, patient lies on back while pressure is placed on the outside of the knee by the doctor. The leg is rotated and pain and/or a click within the joint indicate a meniscal injury. McMurray's test is positive if a pop or a snap at the joint line occurs while flexing and rotating the patient's knee **(11)**.

Apley's test is performed with the patient prone, and with the examiner hyperflexing the knee and rotating the tibial plateau on the condyles **(10)**.

Ideally, an imaging modality should accurately show any meniscal lesions in such a way that the best treatment option can be chosen **(12).**

An anteroposterior weight-bearing view lateral view and Merchant patellar view should be obtained to rule out degenerative joint changes and fractures**(9).**

Magnetic Resonance Imaging (MRI) continues to be the imaging modality of choice, with sensitivity and specificity for diagnosing meniscus tears being as high as 93% and 88%, respectively **(13)**. MRI has become the gold standard investigation for meniscal tears. However, owing to its non-invasive nature and high reliability index, MRI is being excessively "medicalized" and being routinely advised in cases where confirmation with an MRI is deemed unnecessary. For instance, patients already diagnosed with severe osteoarthritis on plain X-rays and exhibiting meniscal mechanical symptoms can be safely assumed to have a meniscal tear, and an MRI in such situations does not necessarily change the course of treatment, which would usually be medical management **(14)**.

The gold standard for confirming the diagnosis of meniscal tear is an arthroscopic examination. Placement of the arthroscope in the posteromedial or posterolateral compartment may be necessary to assure that peripheral posterior horn tears are not missed**,** check quality of meniscal tissue and type of meniscal tear. The final determination whether to resect or repair a tear is often made at the time of arthroscopy**.** Nevertheless, indications for arthroscopy should be therapeutic, not diagnostic in nature **(15)**.

Management of Meniscal Tears:

There are many strategies reported for the management of meniscal tears, some are traditional and some modern ones. The management decision depends upon several factors; such as patient's age, level of physical activity, lifestyle, health status, associated risks, location, type of lesion, tissue quality, etc. An orthopedic surgeon should gather all information of history, examination, radiological findings, and clinical expertise to finalize a management decision **(13)**.

Over the last two to three decades, great emphasis has been laid on meniscal repair and preservation. The aim is to preserve as much of the meniscus as possible and to avoid meniscectomy. To achieve this, the repair techniques have evolved substantially, with open meniscectomy becoming almost obsolete and arthroscopic techniques being developed consistently. Various arthroscopic techniques such as outside-in, inside-out, and all-inside have been extensively published, with all-inside and inside-out techniques being the most preferred by orthopedic surgeons around the globe **(16).**

Other treatment options include meniscal allografting. Although a complex procedure, 10-year follow-up survival stood at a promising 89.2%. Less complex and minimally invasive procedures such as meniscal scaffolds have also been recently approved by the FDA. Scaffolds are available off the shelf and are designed to allow in-growth of tissue on to the scaffold to mimic physiological replacement. Another promising option is a partial meniscal substitute, which is designed to re-establish load distribution across the knee joint, thereby providing a chondroprotective property **(17).**

- **Meniscal Repair**

Tear pattern, geometry, site, vascularity, size and stability, tissue quality, knee alignment and associated pathology and surgery must all be considered. Age is not an absolute determining factor. Finally, patient's preference must be considered after thorough counseling regarding procedural risks versus benefits, recovery, and rehabilitation as well as the outcomes and natural history of selected treatment options **(18)**.

Patient issues, including recovery time and retear risks, could play a role in certain cases in which a quicker and more predictable return to work or sport is preferred. Technical issues and learning curve could affect the decision of certain surgeons to resect rather than to repair. The natural history of the knee after partial meniscectomy might in fact be quite benign. Load transmission, contact stresses, tibiofemoral patholaxity are all altered by the excision of the meniscus. Meniscal repair has favorable outcome, in over 70% to 90% of patients, at extended follow up. Meanwhile, discussing the long-term risks and prognosis after meniscal resection surgery could be valuable **(18)**.

Arthroscopic repair techniques can be divided into 4 categories: inside-out techniques, outside-in techniques, all-inside techniques, and hybrid techniques that combine multiple techniques **(7)**.

All-Inside meniscal Repair Technique

All-inside repairs have been traditionally carried out using suture hooks. Since the introduction of self-adjusting suture devices representing the next generation of all-inside meniscal repair devices, the surgeon can use these devices for meniscal repair **(Figure 2)(19)**.

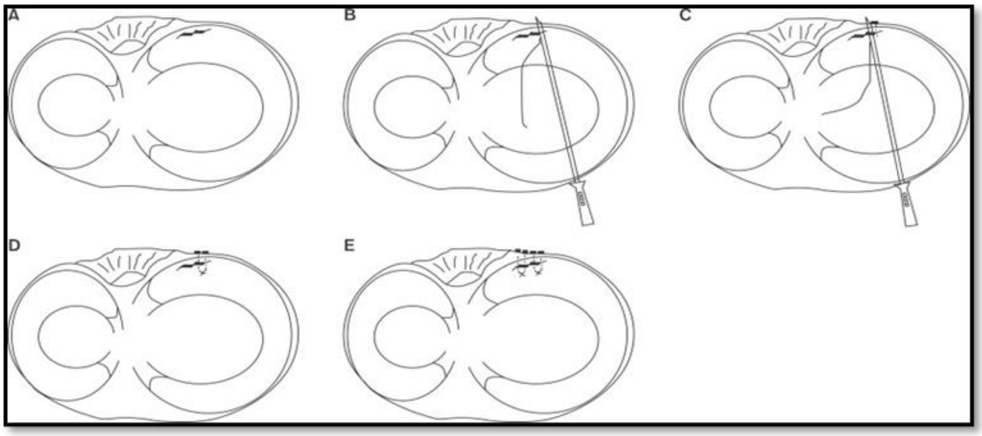

Figure 2: All-inside repair technique. (A) A longitudinal tear on the posterior horn is identified. (B) A suture device with self-locking knot system is passed through the tear site. (C) After fixing the first bar on the joint capsule, the suture device is passed to fix a second bar. (D) The knot can slide and be cut with a knot cutter. (E) Two horizontal sutures are performed with another suture device [(19)].

Currently, various suture-based fixators are available, and most of the fixators are based on a reverse-barbed fishhook design that maintains apposition and reduction of the torn fragments. The principle is the same as that of the inside-out repair technique **(6)**.

The advantages of all-inside repair with suture devices include ease of use, avoidance of an accessory incision, shorter operating time, and less risk to neurovascular structures **(7)**.

The disadvantages are meniscal or chondral damage from manipulation of the devices, implant migration, foreign body reactions, and higher cost **(18)**. Care must be taken while introducing the fixator to aim needle away from neurovascular structures and to set the needle depth penetration at 14 or 16 mm using a depth penetration limiter **(20)**.

- ***First-Generation All-Inside Repairs***

The first generation of all-inside repairs was described by Morgan and used curved suture hooks through accessory posterior portals to pass sutures across the tear. Sutures were then retrieved and tied arthroscopically. The technique was technically demanding, and it continued to place the neurovascular structures at risk. It was subsequently abandoned with the development of second-generation **(21)**.

- ***Second-Generation All-Inside Repairs***

The second generation of all-inside meniscal repairs introduced the concept of technique-specific devices placed across the tear and anchored peripherally. The prototype of this generation was the T-Fix (Smith & Nephew, Andover, Massachusetts), which consisted of a polyethylene bar with an attached No. 2-0 braided polyester suture, deployed through a sharp needle or cannula to capture the peripheral meniscus or capsule. Adjacent sutures were then secured with arthroscopic knots pushed onto the meniscal surface. Meniscal repair was now achievable through the standard anterior arthroscopic portals without the need for accessory incisions and with minimal risk to neurovascular structures when performed properly. The device confirmed that it was possible and safe to repair the meniscus by deploying an anchor across the tear and into the periphery of the meniscus and capsule. However, the technical drawbacks of the device were the need for arthroscopic knots with potential chondral abrasion and the inability to tension the knots after placement **(21).** Early results were encouraging, with short-term success rates of 80% to 90%. Despite the early results, the desire for a simpler device with improved compression across the meniscal repair led to the development of third-generation devices **(22).**

- ***Third-Generation All-Inside Repairs***

The third generation consisted of an explosion of bioabsorbable meniscal repair devices, including arrows, screws, darts, and staples. Most of these devices were composed of the rigid poly-L-lactic-acid (PLLA), which retains its strength for up to 12 months and requires 2 to 3 years or more to completely resorb. The most commonly used device was the Meniscal Arrow (Linvatec, Largo, Florida) because of its ease of insertion and early success rates. The current version of the meniscal arrow (Contour Meniscus Arrow) has a low-profile head and is barbed along the entire length of the implant shaft to improve fixation strength **(Figure 3)**. It is composed of a faster-resorbing self-reinforced copolymer 80L/20D,L PLA, which retains its strength for up to 24 weeks and then gradually resorbs. When seating the arrow across the meniscal tear, one must embed the head of the arrow into the meniscus to reduce the risk of chondral damage **(21).**

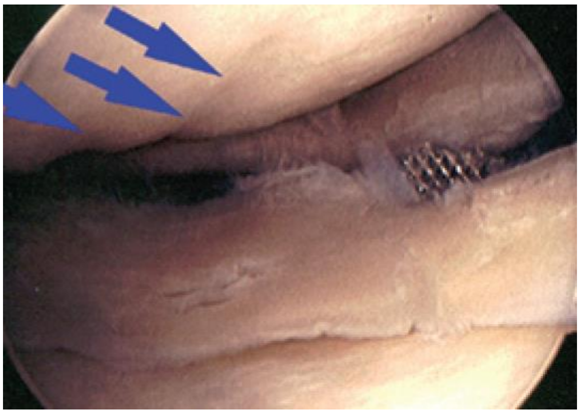

Figure 3: Chondral damage secondary to meniscal arrow [21].

Numerous device-specific complications have also been reported with the meniscal arrow, including transient synovitis, inflammatory reaction, cyst formation, device failure, device migration, and chondral damage. Because of the deterioration of results and numerous complications, the rigid third-generation devices have generally fallen out of favor**(21).**

- ***Fourth-Generation All-Inside Repairs***

The concerns discussed above, combined with the lack of adjustable tensioning, led to the development of the fourth and current generation of all-inside meniscal repair devices. These devices are flexible, suture based, and lower profile, and they allow for variable compression and retensioning across the meniscal tear. The 2 prototypical devices available include the FasT-Fix (Smith & Nephew) and the RapidLoc (Mitek, Westwood, Massachusetts) (**21).** The FasT-Fix is composed of 2 suture anchors (5 mm) connected by a No. 0 nonabsorbable polyester suture with a pretied slip knot **(Figure 4).** A newer version of the FasT-Fix (FasT-Fix AB) is available with absorbable PLLA anchors. A depth-limiting sleeve on the inserter may be precut to any desired length, with 12 to 13 mm generally considered a sufficient length and safe in proximity to the neurovascular structures **(23).**

The curved or straight inserter, with both anchors loaded, is introduced into the joint and advanced across the tear. After deploying the first anchor, the needle inserter is withdrawn from the meniscus but maintained in the joint. The second anchor is advanced to the tip of the inserter, which is then advanced across the meniscus a second time and deployed. The anchors and resultant suture bridge may be placed in a vertical or horizontal mattress configuration, simulating inside-out suture repairs. The pretied slip knot is advanced with a push-pull technique to apply variable compression across the tear. The suture is then cut; alternatively, it may be left in place until all devices are placed to allow for retensioning **(21).**

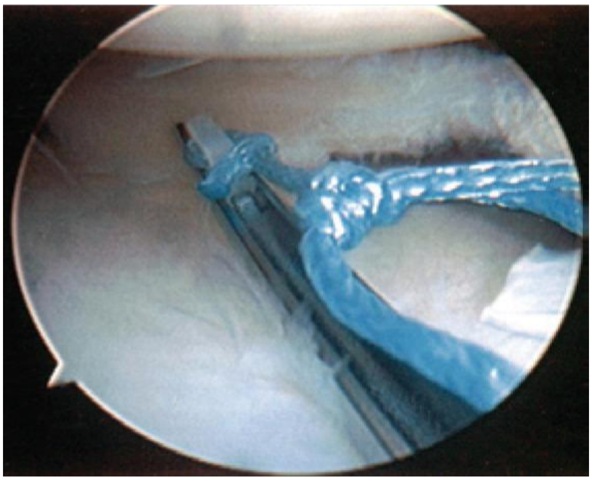

Figure 4: FasT-Fix meniscal repair device. The needle inserter, with both anchors loaded, is in position for the first pass across the meniscus tear [21].

One of the primary advantages of the FasT-Fix is the ability to place a suture-based device in vertical mattress configuration. Unfortunately, the device can be difficult to place posteriorly; it can also misfire, break, and get tangled **(23).**

Compared to the FasT-Fix, the RapidLoc provides even greater ease of insertion. It is composed of a smaller absorbable "backstop" anchor connected to a "tophat" by a No. 2-0 absorbable or nonabsorbable suture. The tophat was originally composed of PLLA but is now available in polydioxanone (PDS) in efforts to further reduce the risk of chondral damage, given that it resorbs rapidly. The device is available with a 0°, 12°, or 27° curved inserter, which is introduced into the joint and across the meniscal tear in a single pass. A silicone hub on the inserter limits the insertion depth to 13 mm. The anchor is deployed and the inserter is removed. The pretied slip knot and tophat are advanced into position with a knot pusher to provide variable compression against the backstop anchor. The tophat should dimple the meniscal surface **(21)**. Biomechanical studies have demonstrated favorable results with both these devices. Strength and load-to-failure characteristics were reported to be not only comparable to mattress suture constructs, but also significantly better than earlier- generation devices **(24).**

Contraindications

Contraindications for the procedure include degenerative meniscus body tear **(Figure 5)**, meniscus extrusion, diffuse chondral lesions >2° according to the International Cartilage Repair Society, varus/valgus knee >5°, and knee instability without ligament reconstructions **(25).**

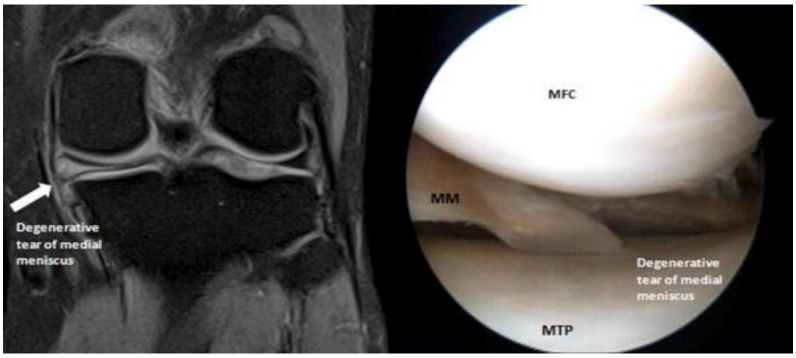

Figure 5: Degenerative medial meniscus (MM) tear revealed on the MRI scan: (empty meniscus body indicated by arrow) and during arthroscopy in the left knee joint with the arthroscope introduced through the anterolateral viewing portal. (MFC, medial femoral condyle; MTP, medial tibial plateau)**(25)**.

Rehabilitations after Meniscal Repair

Following the surgery, many patients are placed into a knee brace for the first one to six weeks. Crutches are also necessary for one to six weeks. Most patients are allowed to move the knee within a few weeks after surgery to help prevent any stiffness. Pain is usually managed with medications. Physical therapy will help regain the motion and strength of knee. Therapy lasts between three and six months **(6)**.

The rehabilitation is based on several goals: allowing the tissue to heal; regaining motion; regaining strength; and return to sports. There has been no generally accepted consensus regarding rehabilitation protocols after meniscal repairs. While some authors recommend accelerated rehabilitations with early range of motion (ROM) exercises and weight bearing, other authors recommend restricted rehabilitation **(26)**.

CONCLUSION:

All-inside meniscal repair has gained widespread popularity over recent years. The devices and techniques have rapidly evolved, resulting in increased ease of use and reduced surgical times and risk to the neurovascular structures. Despite these advances, inside-out suture repairs remain the current gold standard, with proven long-term results. All-inside techniques must continue to be compared to inside-out meniscal repair.

No Conflict of interest.

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