The Journal of
Maharashtra Orthopaedic Association
March - 2008

Arthroscopic Meniscal Surgery

Dr. Deepak Agrawal,
Dr. Darshan Pardiwala,

Arthroscopy & Sports Medicine Service, Department of Orthopaedics,
King Edward VII Memorial Hospital, Mumbai.

Meniscal injuries arising from both athletic events and activities of daily living are common. Occurring in isolation or in association with ligamentous injury, meniscal tears can result in marked physical impairment and often require surgical intervention for symptom resolution. Treatment depends on tear pattern, vascularity, and an assessment of tissue quality. Surgical decisions for the treatment of meniscal injury are based on patient history and an understanding of meniscal structure, function, and pathology. When feasible, meniscal repair should be done in an attempt to maintain meniscal integrity and prevent long-term degenerative changes that occur after meniscectomy. When meniscal repair cannot be done or is contraindicated, partial meniscectomy may be considered, with the goal of retaining as much viable meniscal tissue as possible. When severe injury makes the meniscus irreparable and total meniscectomy is required, meniscal transplantation can be considered if symptoms referable to the meniscectomized joint are present.

❖ Anatomy ❖

Gross features : The menisci are semicircular fibrocartilaginous structures with bony attachments at the anterior and posterior aspects of the tibial plateau. The remainder of the medial meniscus is firmly attached to the joint capsule. The capsular attachment of the medial meniscus on the tibial side is referred to as the coronary ligament. The lateral meniscus is also anchored anteriorly and posteriorly through bony attachments and has an almost semicircular configuration. It covers a larger portion of the tibial articular surface than does the medial meniscus. Discoid variants have been reported with an incidence of 3.5% to 5%, most being the incomplete type. A variation in the posterior horn attachment includes the Wrisberg variation of discoid lateral meniscus, in which the posterior horn bony attachment is absent and the posterior meniscofemoral ligament of Wrisberg is the only stabilizing structure. The anterior meniscofemoral ligament of Humphry runs from the posterior horn of the lateral meniscus anterior to the posterior cruciate ligament and inserts on the femur. The remaining attachments of the lateral meniscus to the tibia are through the capsule but are not as well developed as the attachments on the medial side. This lack of development allows for increased translation of the lateral meniscus throughout a range of motion. Three-dimensional MRI has demonstrated 11.2 mm of posterior excursion of the lateral meniscus and 5.2 mm of the medial meniscus during knee flexion. Posterior and lateral to the posterior bony insertion of the lateral meniscus lies the popliteus tendon. The area surrounding this tendon is known as the popliteal hiatus.

Microstructure and biochemistry : The fibrocartilaginous structure of the meniscus has a varied architecture of coarse collagen bundles. Scanning electron microscopy has revealed the orientation of collagen fibers to be mainly circumferential, with some radial fibers at the surface and within the midsubstance. This orientation allows compressive loads to be dispersed by the circumferential fibers, while the radial fibers act as tie fibers to resist longitudinal tearing. At the surface of the meniscus, fiber orientation is more of a mesh network or random configuration, thought to be important in the distribution of shear stress. Collagen

is 60% to 70% of the dry weight of the meniscus. The majority of collagen (90%) is type I, with types II, III, V, and VI present in much smaller amounts. Elastin accounts for approximately 0.6% of the dry weight of the meniscus and noncollagenous proteins, for 8% to 13%.

Blood Supply & neuroanatomic finding : At birth, the entire meniscus is vascular; by age 9 months, the inner one third has become avascular. This decrease in vascularity continues to age 10 years, when the meniscus closely resembles the adult meniscus. In adults only the outer 10% to 30% of the meniscii are vascular. This vascularity arises from the superior and inferior branches of the medial and lateral genicular arteries, which form a perimeniscal capillary plexus. At the popliteal hiatus, the meniscus is relatively avascular secondary to a lack of penetrating vessels and synovial fringe. Because of the avascular nature of the inner two thirds of the meniscus, cell nutrition is believed to occur mainly through diffusion or mechanical pumping. Neural elements are most abundant in the outer portion of the meniscus. The anterior and posterior horns of the meniscus are innervated with mechanoreceptors that may play a role in proprioceptive feedback during extremes of motion.

❖ Functions of the Meniscus ❖

The menisci are important in many aspects of knee function, including load sharing, shock absorption, reduction in joint contact stresses, passive stabilization, increasing congruity and contact area, limitation of extremes of flexion and extension, and proprioception. Many of these functions are achieved through the ability of the menisci to transmit and distribute load over the tibial plateau. The findings of joint space narrowing, osteophyte formation, and squaring of the femoral condyles after total meniscectomy confirm the importance of the meniscus in joint protection.

The medial and lateral menisci transmit at least 50% to 70% of the load when the knee is in extension; this increases to 85% with 90° of knee flexion. These loads are well distributed when the menisci are intact. Removal of the medial meniscus results in a 50% to 70% reduction in femoral condyle contact area and in a 100% increase in contact stress. Total lateral meniscectomy causes a 40% to 50% decrease in contact area and increases contact stress in the lateral compartment to 200% to 300% of normal. With the decrease in contact area within the joint, stresses are increased and are unevenly distributed. This results in increased compression and shear across the joint.

The meniscus is one half as stiff as articular cartilage and also plays a role in shock absorption. The shock absorption capacity of the normal knee is reduced by 20% after meniscectomy.

The menisci also play a key role in enhancing joint stability. Medial meniscectomy in the ACL-intact knee has little effect on anteroposterior motion, but in the ACL deficient knee, it results in an increase in anterior tibial translation of up to 58% at 90° of flexion. The posterior horn of the medial meniscus is the most important structure resisting an applied anterior tibial force in an ACL-deficient knee.

❖ Epidemiology ❖

The mean annual incidence of meniscal tears in a US study was 60 to 70 per 100,000. Meniscal tears are more common in males; the male:female ratio ranging from 2.5:1 to 4:1. More than one third of all tears are associated with an ACL injury. Degenerative types of meniscal tears commonly occur in men in their fourth to sixth decades. Meniscal pathology in women is rather constant after the second decade of life. Younger patients are more likely to have an acute traumatic event as the cause of their meniscal pathology. In patients with acute ACL injury, lateral meniscus tears occur more frequently than do medial meniscus tears. In patients with chronic ACL-deficient knees, however, medial meniscus tears are more prevalent. Meniscal injury is also frequent in the setting of tibial plateau fracture; 47% patients in one study had a meniscal tear associated with the fracture.

❖ Clinical Features ❖

History : The onset of symptoms and mechanism of injury are often clues to the diagnosis.

In isolation, meniscal tears often occur during a twisting injury or hyperflexion event, and they may present with acute pain and swelling. Complaints of locking or catching may be present but also may be secondary to other pathology, such as chondral injury or patellofemoral chondrosis. Loss of motion with a mechanical block to extension is commonly the result of a displaced bucket handle meniscal tear and usually requires acute surgical treatment. Degenerative tears of the meniscus tend to occur in older patients (>40 years), frequently with an atraumatic chronic history of mild joint swelling, joint line pain, and mechanical symptoms. These tears are often associated with some degree of chondral damage.

Physical Examination : Inspection should be done to assess for joint effusion, quadriceps muscle atrophy, and any joint line swelling that may occur with a parameniscal cyst. Range of motion must be assessed to determine whether a mechanical block to extension or loss of flexion is present. Numerous specialized tests have been described that may aid in making the diagnosis of meniscal tear. These include joint line tenderness, the McMurray test, the Apley's grinding test, and others. Clinical studies to evaluate these tests have documented mixed results with regard to their usefulness. Joint line tenderness is the best clinical sign of a meniscal tear, with a 74% sensitivity and 50% positive predictive value. On McMurray test, the finding of a medially based thud with rotation and flexion is the only sign to correlate well with meniscal pathology. This finding had a specificity of 98% but a sensitivity of only 15%. In spite of the poor reliability of these tests done in isolation, clinical evaluation remains a very useful tool in the diagnosis of meniscal pathology.

❖ Imaging Studies ❖

Radiography : A standard series of plain radiographs including a 30° PA flexion weight-bearing view of both knees, a true lateral radiograph, and a Merchant or sky-line view is extremely important in defining bony pathology and evaluating the knee for joint space narrowing. Because articular cartilage wear often is more advanced in the posterior aspects of the femoral condyles, the 30° or 45° postero-anterior flexion weight-bearing view is more sensitive than standard standing views for detecting early joint space narrowing.

Magnetic Resonance Imaging : The advantages of MRI in evaluating the patient with a suspected meniscal tear include its noninvasive nature, the ability to assess the knee in multiple planes, the absence of ionizing radiation, and the capacity to evaluate other structures within the joint. The limitations are its relatively high cost and the potential for misinterpretation or error because of technical inadequacies of the study or variability in interpretation. With improved technology and increased experience in reading MRIs, the accuracy of detection of meniscal tears is 95%.

The normal appearance of the meniscus on MRI is that of a uniformly low-signal structure. Areas of increased signal within the meniscus occur in children and increase with age in adults. These intrasubstance changes are seen frequently and are a common cause of overreading meniscal tears on MRI scans. The meniscus grading system delineates grades 0, I, II, and III [Fig. 1]. Only grade III changes

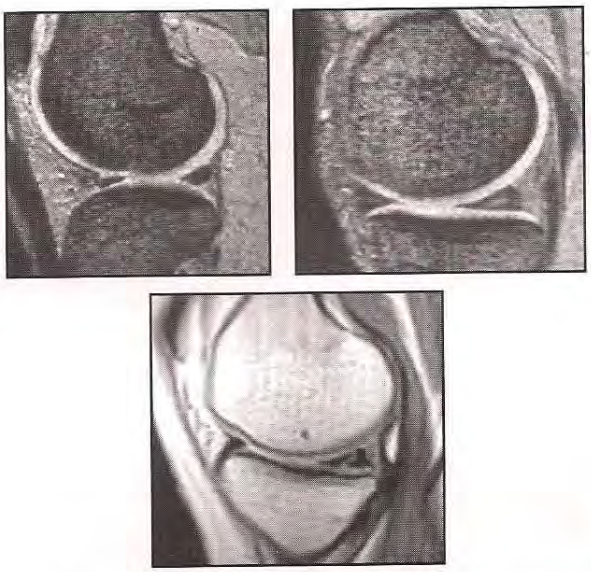

Fig. 1 : Grading scale for meniscal tears on MRI. Grade 0 is a normal meniscus. Grades I and II have an intrameniscal signal that does not abut the free edge. Grade III has a signal change that abuts the free edge of the meniscus, indicating a meniscal tear.

(low signal intensity that abuts the free edge of the meniscus) are consistent with meniscal tearing. Other anatomic structures adjacent to the meniscus, such as the intermeniscal ligament and the hiatus of the popliteus tendon, can be a cause of confusion in reading MRI scans.

❖ Classification of Meniscal Tears ❖

Meniscal tear classification can be based on the pattern of the tear seen at arthroscopy or on the etiology of the meniscal injury. The two etiologic categories are tears from excessive application of force to a normal meniscus and tears occurring from normal forces acting on a degenerative structure.

Commonly described patterns of meniscal tear include vertical longitudinal, oblique, complex (including degenerative), transverse (radial), and horizontal. With increasing age, degenerative complex tears are more frequently seen, with most meniscal pathology found in the posterior horns.

- Vertical longitudinal tears can be complete (ie, bucket handle tears) or incomplete and most often occur in younger individuals. These tears are most commonly associated with ACL injury. Bucket handle tears [Fig. 2] usually begin in the posterior horn and are often unstable and can cause mechanical symptoms or true locking of the knee. The medial meniscus is more commonly affected, likely because its more secure attachments to the tibial plateau make it susceptible to shear injury.
- Oblique tears, often called flap or parrot beak tears, can occur at any location but are most often found at the junction of the posterior and middle thirds of the meniscus [Fig. 3]. Symptoms may result from the free torn edge of the flap catching in the joint and producing traction on the meniscocapsular junction. Propagation of the tear also may occur in this manner.

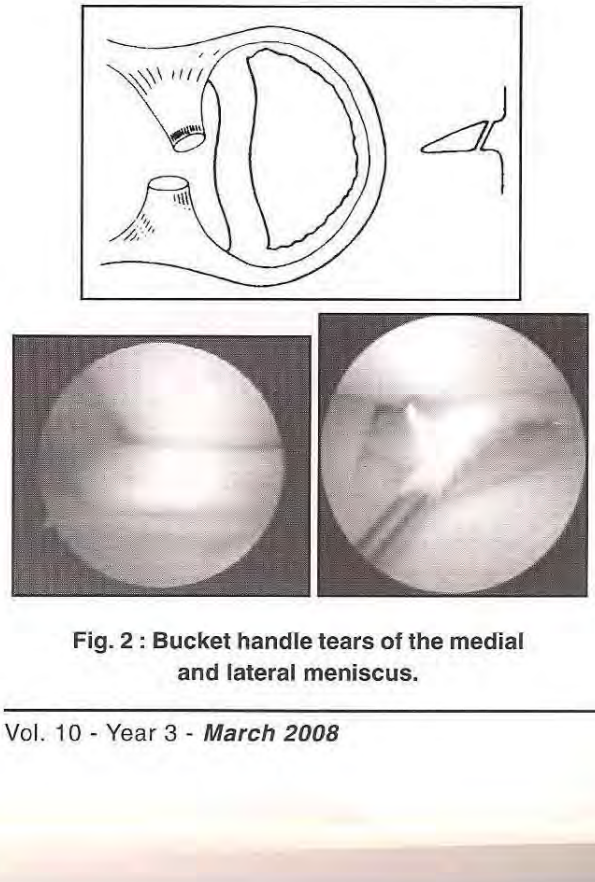

Fig. 2 : Bucket handle tears of the medial and lateral meniscus.

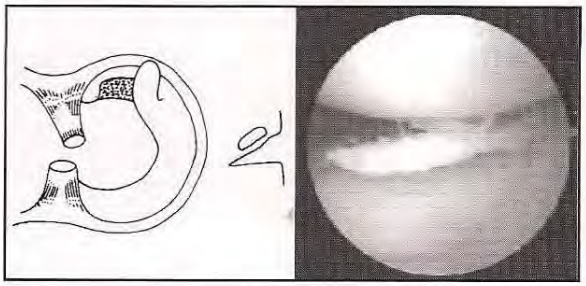

Fig. 3 : Oblique tear often called flap tear at the junction of the posterior and middle third of the medial meniscus.

- Complex or degenerative tears occur in multiple planes and are more common in older age groups and are often associated with degenerative changes of articular cartilage in the knee.
- Transverse or radial tears [Fig. 4] are typically located at the junction of the posterior and middle thirds of the medial meniscus or near the posterior attachment of the lateral

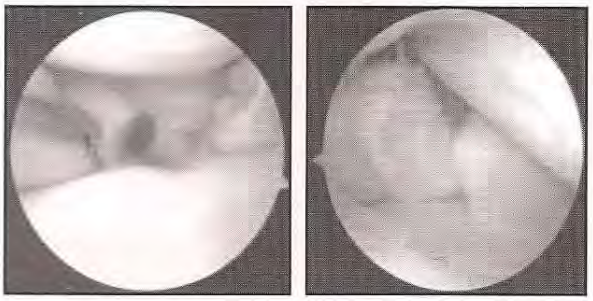

Fig. 4 : Transverse or radial tears of the posterior horn of the medial meniscus.

meniscus. They may be asymptomatic but can propagate across the entire meniscus if the edges catch within the joint. Complete radial tears disrupt the circumferential fibers of the meniscus and result in a loss of load-bearing function.

- Horizontal tears are believed to begin near the inner margin of the meniscus and extend toward the capsule and result from shear forces generated by axial compression. Meniscal cysts are often associated with horizontal tears and can be symptomatic because of localized swelling [Fig. 5]. Pathologically, these cysts appear directly connected to the meniscus and are filled with a gel-like material biochemically similar to synovial fluid. Symptoms include joint line pain, and the cysts are often palpable on physical examination at or below the joint line.

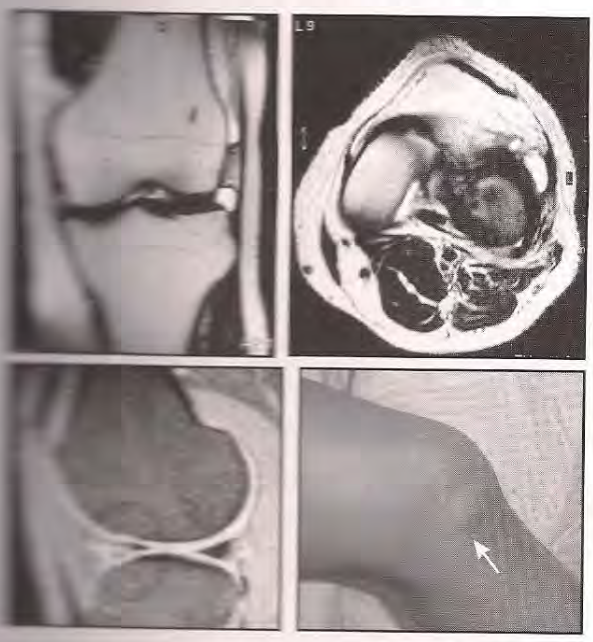

Fig. 5 : A meniscal cyst associated with a horizontal cleavage tear of the lateral meniscus.

❖ Indications for Arthroscopic Treatment ❖

The surgical indications for arthroscopic treatment of isolated meniscal pathology include :

1. Symptoms of meniscal injury that affect activities of daily living, work, or sports.
2. Positive physical findings of joint line tenderness, joint effusion, limitation of motion, and provocative signs, such as pain with squatting or a positive McMurray test.
3. Failure to respond to nonsurgical treatment, including activity modification, medication, and a rehabilitation program.
4. Absence of other causes of knee pain identified on imaging studies.

In the setting of ACL injury, the surgical treatment of meniscal pathology is most often done concurrently with ACL reconstruction. Surgical timing is most often dictated by issues related to ACL surgery, such as range of motion, swelling, quadriceps muscle function, and associated ligament injuries. Loss of motion because of a displaced meniscal tear may necessitate urgent treatment.

❖ Surgical Treatment ❖

The gold standard for confirming the diagnosis of meniscal tear is an arthroscopic examination. During arthroscopy, the meniscocapsular junction can be probed and the superior and inferior surfaces examined. Placement of the arthroscope in the posteromedial or posterolateral compartment may be necessary to assure that peripheral posterior horn tears are not missed. Once a meniscus tear is identified and defined, a decision regarding surgical options needs to be taken.

(A) No Treatment

Not all meniscal tears cause symptoms or problems. Certain tears do not require treatment because they heal spontaneously or remain asymptomatic. These include short (<10 mm), stable vertical longitudinal tears; stable partial-thickness tears (<50% of the meniscal depth) on the superior or inferior surface; and small (<3 mm) radial tears. In a stable knee or in a knee with a reconstructed ACL, these tears may heal spontaneously or remain asymptomatic. The technique of simple rasping and/or trephination may enhance the healing potential of these tears and should be considered.

(B) Resection

Many meniscal tears encountered during surgery do not fall into the repairable or spontaneously healing categories. These types of tears usually require partial meniscectomy to remove unstable fragments, eliminate any locking and catching, and decrease the pain associated with unstable meniscal fragments. When treating tears that are not suitable for repair, resection techniques that strive to remove nonfunctional tissue should be used, preserving as much viable tissue as possible to minimize the effect on joint mechanics.

Total Meniscectomy

Although infrequent today, total meniscectomy was previously a commonly performed procedure. However, in 1948, Fairbank described the potential damaging effects of total meniscectomy, and as long-term results have become available, this procedure has fallen out of favor.

Partial Meniscectomy

To avoid the sequelae of total meniscectomy, partial resection of the meniscus is advocated when repair is not feasible. The general guidelines for arthroscopic resection that apply to most resectable meniscal lesions are:

1. All mobile fragments that can be pulled past the inner margin of the meniscus into the center of the joint should be removed.
2. The remaining meniscal rim should be smoothed to remove any sudden changes in contour that might lead to further tearing.
3. A perfectly smooth rim is not necessary. Repeat arthroscopy has shown rim remodeling and smoothing at 6 to 9 months.
4. The probe should be used repeatedly to gain information about the mobility and texture of the remaining rim.
5. The meniscocapsular junction and the peripheral meniscal rim should be protected [Fig. 6]. This maintains meniscal stability and is vital in preserving the load transmission properties of the meniscus.

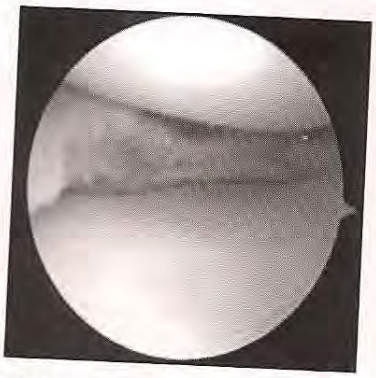

Fig. 6 : Partial menisectomy : the meniscocapsular junction and the peripheral meniscal rim should be protected.

6. To optimize efficiency, both manual and motorized resection instruments should be used. Manual instruments allow for more controlled resection, while motorized instruments remove loose debris and smooth frayed fragments.
7. In uncertain situations, more rather than less intact meniscal rim should be left to avoid segmental resection, which essentially results in a total meniscectomy.

There is a marked difference in results comparing arthroscopic partial meniscectomy with open total meniscectomy (90% versus 68% good and excellent results, respectively). Studies of arthroscopic partial meniscectomy reported 80% to 90% satisfactory clinical results with, however, only short-term follow-up (< 2 years). Return of joint function and a decrease in pain were common outcome measures. The major advantages over both open partial and total meniscectomy included decreased hospitalization, shorter recovery time, and a reduction in patient care costs. However, a number of long-term studies have questioned whether partial meniscectomy is, in fact, a benign procedure. Studies show that osteoarthritic radiographic changes occur in 53% of knees that underwent partial meniscectomy compared with 27% of the untreated contralateral knees at 8-year follow-up. These changes do not necessarily correlate with subjective postoperative results because 86% to 91% of patients have good or excellent clinical outcomes. Other studies evaluating meniscectomy in older patients

reconstruction. Success rates are lower for isolated repairs. Complications related to repair include neurologic injury, postoperative loss of motion, recurrence of the tear, and infection

Nonfixation Healing Enhancement

The healing of expectantly treated meniscal tears (when formal repair is not considered necessary), may be improved through neovascularization techniques applied around the meniscal tear. Techniques such as synovial abrasion and meniscal trephination have been described to enhance healing. Synovial abrasion is intended to produce a vascular pannus that will migrate into the meniscal tear and help produce a reparative response.

Trephination of the meniscus is a technique in which a series of horizontally oriented holes is made using a spinal needle through the peripheral aspect of the meniscus. These vascular access channels allow proliferation of fibrovascular scar from the channel into the tear site. In one study in which multiple trephinations were used to treat incomplete meniscal tears in the peripheral and middle third of the meniscus, a 90% success rate was reported.

Meniscal Bed Preparation

When formal repair is to be undertaken, the meniscal bed must be prepared before fixation devices are placed across the tear. A 3.5 mm shaver blade or meniscal rasp is used to debride the loose edges of the tear. Rasping of the synovial fringe is helpful in achieving synovial bleeding and pannus formation. For tears extending into the avascular zones, trephination of the peripheral rim with a spinal needle should be considered, and for complex tears with avascular extension, the addition of exogenous fibrin clot may be beneficial.

Open Repair

Open repair is most useful in peripheral tears in the setting of either multiple ligament injuries (which may require open collateral ligament repair or reconstruction) or tibial plateau fracture. Direct suturing of a peripheral tear with either absorbable or nonabsorbable sutures may be the most effective means of treating these injuries. The rate of repair

success is high, likely because of the acuteness of the injury, the peripheral nature of the tear, and the associated hemarthrosis.

Arthroscopic Repair

The three basic suture techniques are inside-out, outside-in, and all-inside. Other arthroscopic repairs using bioabsorbable implants and suture devices / anchors are also available.

Inside-out technique : Double-armed sutures [Fig. 7] with long flexible needles are positioned with arthroscopically directed cannulas. A medial or lateral incision is required to retrieve suture needles as they exit the joint capsule. Proper positioning of incisions and appropriate dissection down to the capsule are necessary to minimize the risk of neurovascular injury. Advantages of this technique include its ability to treat nearly all types of tears and the excellent fixation it affords. Disadvantages include the potential risks to neurovascular structures and the need for accessory incisions.

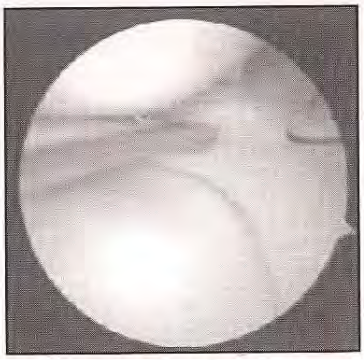

Fig. 7 : Horizontal mattress meniscal suture repair achieved using the inside-out technique.

Outside-in technique : It involves the passage of an 18-gauge spinal needle across the tear from outside to inside the joint followed by passage of a No. 2-0 prolene suture into the joint through the needle and brought out through an anterior portal, where a knot is tied in the suture. This knot is then pulled back into the joint against the meniscus to hold it in a reduced position. The free ends of adjacent sutures are tied over the joint capsule through small incisions cleared of soft tissue through blunt dissection. A modification of this technique is to use parallel needles [Fig. 8] with a suture passed through one and a wire snare through the other to retrieve the free end of the suture. The ends are once again tied over the capsule through small skin incisions. The outside-in technique is most readily applicable to tears involving the anterior and middle thirds of the meniscus. With middle and posterior tears, this technique may put neurovascular structures at risk.

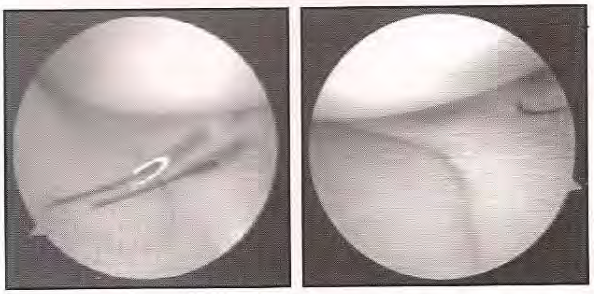

Fig. 8 : The outside-in technique for meniscal repair.

All-inside technique : The all-inside suture technique involves placement of the arthroscope into the posteromedial or posterolateral compartment of the knee, the creation of posteromedial or posterolateral working portals, and the use of curved cannulated suture-passing hooks. Arthroscopic knot-tying techniques are used to approximate the meniscal tissue.

Nonsuture and hybrid suture techniques: All-inside meniscus fixation devices have been developed that obviate the need for additional incisions. The Bionx meniscus arrow and Inion meniscus screw [Fig. 9] are made of self-reinforced

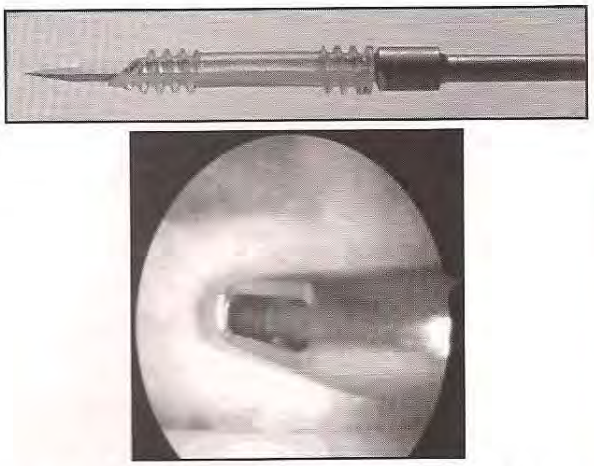

Fig. 9 : The all-inside meniscus repair technique using bioabsorbable meniscal screws.

poly-L-lactic acid, and allow for compression of vertical longitudinal tears. Although biomechanical testing of peripheral vertical tears demonstrates that fixation strength using these devices is not as secure as with vertical sutures, clinical studies utilizing these devices have demonstrated good clinical efficacy.

An additional all-inside technique utilizes a specially designed suture anchor (T-Fix suture bar) that is placed through the meniscus. A suture is fixed to the bar that anchors itself against the peripheral rim of the meniscus. Sutures from adjacent anchors are tied arthroscopically using intra-articular knot-tying techniques.

Rehabilitation

Restriction of hyperflexion after meniscal repair and other partial weight bearing or weight bearing with brace locked in extension are common modifications of ACL rehabilitation protocols associated with meniscal repair. When done in addition, meniscal repair rehabilitation has traditionally been relatively conservative, with protected weight bearing and restrictions on range of motion being common.

Meniscal Replacement

Meniscal allograft transplantation may provide a treatment option when meniscus salvage is not

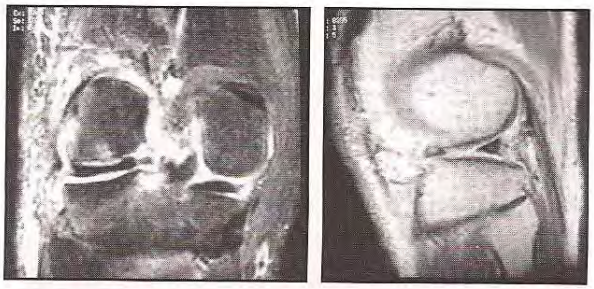

Fig. 10 : Lateral meniscus allograft transplantation in *a young sportsman having undergone two prior lateral* meniscus resection surgeries. On follow-up MRI note union and revascularization of meniscal margins with no evidence of graft shrinkage.

possible or when a previous total meniscectomy has been done [Fig. 10].

❐ ❐ ❐