ISAKOS 2011
Meniscal Repair and Reconstruction ICL #22
Agenda
19 May 2011  0730-0900

0730 – 0735
Introduction

0735-0750
Meniscus – Form and Function
Keith W. Lawhorn MD
Commonwealth Orthopaedics and Rehabilitation, USA

0750-0805
Treatment of Meniscal Tears - Indications and Techniques Paulo Roberto Pires
Rockett – Brazil

0805-0820
Meniscal Repair Avoiding Complications: Pearls and Pitfalls
Mark D. Miller, MD Professor, University of Virginia, USA Team Physician,
James Madison University

0820-0835
Meniscal Transplant – Fact or Fantasy?
Karl Fredrik Almqvist MD PhD
Department of Orthopaedic Surgery and Traumatology Ghent
University Hospital

0835 – 0850
Meniscal Scaffolds
P Beaufils MD
Orthopaedic Department
Versailles Hospital F 78150 Le Chesnay

0850 – 0900
Question and Answer
I. Epidemiology
   A. 60% cadaver over 65 years had degenerative meniscal tears
   B. Sports related injury responsible for 33% of all meniscal tears
   C. ACL tears are the most common concomitant injury

II. Anatomy
   A. Conforms to shape of femoral condyle during compressive loading and range of motion
   B. Dampens stress by distributing compression loads
   C. Converts axial compressive loads to radial tensile stresses in meniscal tissue
   D. 75% type I collagen
      1. Most arranged along longitudinal axis
      2. Oblique, radial and vertical fibers exist to create a scaffold meshwork
      3. Within meshwork: Water, mucopolysaccharides and proteoglycans exist
   E. Fibrochondrocytes
      1. Superficial – oval and spindle-shaped
      2. Deep – polygonal with dendritic projections
   F. Vascularity
      1. Peripheral 5mm – radial branches from pericapillary plexus of medial and lateral geniculate vessels
      2. Avascular zone – nourishment from passive synovial diffusion
      3. Watershed area or zone (central 1/3) - synovial diffusion and vascular “run-off” from periphery.

III. Biomechanical Functions
   A. Distribution of compressive loads uniformly in respective compartment
      1. Meniscus squeezed to periphery when loaded
      2. Radial displacement of meniscus resisted by hoop stress
      3. Radial tensile loads generated in the meniscus resisted mainly by longitudinal fibers
      4. Tears occur when radial strain exceeds capacity for meniscus to deform
      5. Tears displace the center of contact and decrease contact area
6. Pain secondary to meniscal tears due to adjacent capsular inflammation

B. Stability of knee
   1. Medial meniscus contributes to AP stability of knee in the unloaded state
   2. Lateral meniscus does not limit AP motion
   3. Loss of medial and lateral menisci can lead to 10-25% increase varus-valgus laxity

C. Lubrication or distribution of synovial fluid

   1. Patients with meniscal tears demonstrated significant proprioceptive loss
   2. Partial meniscectomy improved functional outcomes but NOT proprioception

IV. Meniscal Mobility
   A. Medial
      1. Translates 2-5mm
      2. Tethered by coronary ligament from deep MCL
   B. Lateral
      1. Translated 9-11mm
      2. Untethered

V. Understanding Meniscal Tears
   A. Repairable Tears (vascular rich zones)
      1. Peripheral 5mm of meniscus
      2. Meniscocapsular separations
      3. Longitudinal Tears
      4. Meniscal root tears
   B. Controversial Repairs
      1. Gray zone longitudinal tears (mid 1/3)
      2. Radial cleavage tears of lateral meniscus in young patients
         a. 35.7% healed by MRI
         b. 57% partial healing
         c. 7% no healing
   C. Meniscectomies
      1. Inner 1/3 tears
      2. Most radial cleavage tears
      3. Complex tears
      4. Degenerative Tears
         a. horizontal cleavage tears
         b. heterogeneous and increased signal in meniscal tissue
      5. Meniscectomies proportionally decrease contact area and increase contact stress on articular cartilage
      6. Complete radial tears severing entire rim results in complete loss of meniscal function similar to total meniscectomy
   a. Radial tears involving less than 60% of rim width did not affect the magnitude and location of the peak pressures
   b. Radial tears greater than 90% rim width increased magnitude and changed location of peak stresses
   c. Partial meniscectomies increased contact pressures
   d. Meniscal repair of radial tears did not restore peak pressures and location to normal

D. What is better? Repair or Meniscectomy (Stein, AJSM 2010)
   1. Medial Meniscectomy
      a. > 8 years follow-up – 60.0 % developed osteoarthritis
      b. Return to pre-injury activity level – 50%
      c. Faster return to sports activity
   2. Medial Meniscal Repair
      a. >8 years follow-up – 19.2% developed osteoarthritis
      b. Return to pre-injury activity level – 96.2%
   3. Functional outcomes better with successful meniscal repair despite faster return to activities with meniscectomies

Bibliography

1. Arnoczky, SP & Warren RF. Microvasculature of the human meniscus. AJSM 10:90-95, 1982
3. Bird MD & Sweet MB. Canals in the semilunar menisci JBJS 70B: 839, 1988
Cartilage defects are often associated with meniscal tears. If the involved knee joint has a meniscal deficiency, a restoration of the meniscus should be performed before any cartilage defect is treated. The meniscus plays an important role in the complex biomechanics of the knee joint. It has functions in load bearing, load transmission, shock absorption, joint stability, joint lubrication, and joint congruity. Removal of this important anatomical structure eventually leads to degenerative changes of the articular cartilage. Therefore, meniscal tissue should be preserved whenever possible. When the meniscus has been completely lost, transplantation of a meniscal allograft has been a therapeutic option with favorable results, in terms of pain reduction and functional improvement, in the medium and long-term results. These improvements are presumably due to an increase in contact area and thus a decrease in contact peak stresses compared with those in a meniscectomized knee. While decreases in contact stresses can result in pain relief and improved function, there is no reasonable proof that delayed meniscal transplantation prevents or slows cartilage degeneration in either compartment. Few medium-term or long-term reports on meniscal allograft transplantations are available. In our department a survival analysis was carried out at a minimum of two years after our first 100 procedures involving transplantation of a viable meniscal medial or lateral allograft. In this study, we presented the results of a survival analysis of the clinical outcomes of our first 100 procedures involving transplantation of viable medial and lateral meniscal allografts performed in ninety-six patients. Thirty-nine medial and sixty-one lateral meniscal allografts were evaluated after a mean of 7.2 years. Survival analysis was based on specific clinical end points, with failure of the allograft defined as moderate occasional or persistent pain or as poor function. An additional survival analysis was performed to assess the results of the sixty-nine procedures that involved isolated use of a viable allograft (twenty of the thirty-nine medial allograft procedures and forty-nine of the sixty-one lateral allograft procedures) and of the thirteen viable medial meniscal allografts that were implanted in combination with a high tibial osteotomy in patients with initial varus malalignment of the lower limb. Overall, eleven (28%) of the thirty-nine medial allografts and ten (16%) of the sixty-one lateral allografts failed. The mean cumulative survival time (11.6 years) was identical for the medial and lateral allografts. The cumulative survival rates for the medial and lateral allografts at ten years were 74.2% and 69.8%, respectively. The mean cumulative survival time and the cumulative survival rate for the medial allografts used in combination with a high tibial osteotomy were 13.0 years and 83.3% at ten years, respectively. Conclusions: Transplantation of a meniscal allograft can significantly relieve pain and improve function of the knee joint. Survival analysis showed that this beneficial effect remained in approximately 70% of the patients at ten years.
ISAKOS 2011
Meniscal Repair
Avoiding Complications: Pearls and Pitfalls

Mark D. Miller, MD
Professor, University of Virginia, USA
Team Physician, James Madison University

Critical Evaluation
- What are we talking about?
  - Definitions
- Do they work?
  - Results
- How much do they cost?
- Conclusion

Definitions
- Meniscal Repair = Re-apposing torn menisci
  - Goal: Reduce Arthritis risk (20% vs 60% for menisctomy - Stein 2010)
- Inside-Out Repair = Long needles placed through cannulas (inside) and captured through posterior incisions and tied over capsule (out)
- All-Inside Repair = No incisions (other than portals) used

What’s Available: Inside Out-Repair
- Standard suture
  - Absorbable (PDS)
  - Non-absorbable (Mersilene, Ethibond)
- UHMWPE Suture
  - 2-0 Maxbraid (Biomet)
  - 2-0 FiberWire (Arthrex)
  - 2-0 Orthocord (DePuy-Mitek)

What’s Available: All-Inside
- Suture passers/Hooks
- Rigid devices (Arrows, Darts, Staples)
- “Early” Tensionable
  - FasT-Fix (S&N)
  - RapidLoc (DePuy-Mitek)
- New tensionable (UHMWPE)
  - Ultra FasT-Fix (S&N) => FasT-Fix 360 (?)
  - RapidLoc A2 => OMNISPAN (DePuy-Mitek)
  - MaxFire (Biomet)
  - Meniscal Cinch (Arthrex)
  - CrossFix (Cayenne)

Medial Approach
- Skin incision—Behind MCL
- 3 cm incision
  - 1 cm proximal to joint line
2cm distal to joint line
- Incise Sartorius in line with fibers
- Deep—Bluntly dissect Medial Head of Gastrocnemius off posteromedial capsule
- Avoid Saphenous N/V
- Pass Suture

**Lateral Approach**
- Put knee in Figure 4 position to palpate the lateral collateral ligament
- Skin incision—Behind LCL
- 3 cm incision
  - 1 cm proximal to joint line
  - 2cm distal to joint line
- Interval—Between ITT and Biceps
- Deep—Bluntly dissect Lateral Head of Gastrocnemius off posterolateral capsule and retract it
- Protect the peroneal nerve

**All-Inside Repair Technique**
- Varies with each system
- Most include a “gun”
- Newer devices are tensioned with a knot pusher
- Knot cutter also utilized
- Steep learning curve and “technical simplicity” is a MAJOR factor for most devices.

**What about the newer Ultra High-Molecular Weight Polyethylene Suture?**
- In a porcine model Barber et al. did noncycled and cycled testing of meniscal repairs in two groups.
  - Vertical mattress suture
    - 2-0 Mersilene (Ethicon)
    - 2-0 Orthocord (DePuy-Mitek)
    - 0 Ultrabraid (S&N)
    - 2-0 FiberWire (Arthrex)
  - Devices (vertical orientation)
    - RapidLoc A2 (DePuy-Mitek)
      - *Note: This device never made it to the marketplace and was replaced with the OMNISPAN Meniscal Repair System*
    - Ultra FasT-Fix (S&N)
      - *Note: This device was to be replaced with the FasT-Fix 360, but its release was delayed and is not clinically available.*
    - MaxFire (Biomet)
    - CrossFix (Cayenne)
      - *Design more easily allows horizontal mattress placement*
  - Results:
    - Non-cycled testing
• Good (110-130N):
  • MaxFire
  • Orthocord suture
  • Ultra FaST-Fix
  • FiberWire suture
  • Ultrabraid suture
• Not as good (86N or less):
  • RapidLoc A2
  • Mersilene suture
  • CrossFix
• Cycled testing
  • Max load to failure after cycle testing:
    • Orthocord 223N
    • MaxFire 132N
    • Ultrabraid 126N
    • FiberWire 117N
    • Ultra FaST-Fix 110N
    • RapidLoc 108N
• Stiffness—no significant difference
• Cyclic displacement—ultrabraid suture showed more stretch than all other repairs.

Technical Simplicity and Complications
• Inside-Out Meniscal Repair—accurate and controllable but requires an experienced team and risks NV injury
• Rigid Implants—migration, breakage, chondral injury, synovitis, late failures
• FaST-Fix and Ultra FaST-Fix—technical problems with depth associated with N-V risk and ST entrapment, misfires. FaST-Fix 360 not clinically available (?)
• RapidLoc—single point fixation, chondral injury (tophat)
• RapidLoc A2—Taken off market before it ever was available.
• OmniSpan—Very difficult to tension and fails easily
  o Knot is on the backside of the meniscus
• MaxFire/Cinch—fragile

Results of Meniscal Repair: Inside-Out Repair
• Clinical results: 78% to 98.6% excellent
• Second Looks:
  o Cannon: 75% healed (82% in concurrent ACL recon group)
  o West Point: 81% satisfactory healing

Results of Meniscal Repair: Meniscal Arrow (Rigid Implant Poster Child)
• The Good
  • Kristen et al. randomized bucket handle tears <6mm from capsule into two groups (inside-out or Arrow) with repeat arthroscopy showing 10/13 healed in suture group and 15/17 in Arrow group.
  • Gill et al. showed that meniscal repair with the Arrow with concurrent ACLR resulted in 90% success after 2 years.
• The Bad—Arrow problems
  • Failure
  • Breakage
  • Inflammatory reaction
  • Cystic hematoma
  • Migration
  • Long Beach study showed 28% failure rate at 4.5 years of follow-up with reports of chondral scoring and fixator breakage
- UVA study showed that at longer follow-up, the success rate of the Arrow dropped (90.6% at 2.2 years and 71.4% at 6.6 years).
- The Ugly—Chondral injury!
  - Arrows (30% Chondral injury! [Jarvela 2010])

**Results: Braided Polyester Tensionable Devices**
- Minimal clinical results reported to date.
- Encouraging:
  - Billante, Miller, Diduch (2008): RapidLoc 87% success rate with ACLR
  - Tachibana (2010); 83% success
- Concerning:
  - DeHaan (2009): 22% FasT-Fix failure with ACLR
  - Brucker er al (2010): Devices may have stiffness inferior to rigid implants in shear loading (especially in mid-portion of meniscus).

**How much does it cost?**
- Braided polyester suture
  - 2-0 Ticron (USSC)  
    - $17 per suture
  - 2-0 Mersilene  
    - $65 per suture
  - 0 Ethibon (ethicon)  
    - $32 per suture
- UHMWPE suture
  - 2-0 Orthocord (DePuy-Mitek)  
    - $80 per suture
  - 2-0 FiberWire (Arthrex)  
    - $95 per suture
  - 2-0 Maxbraid (Biomet)  
    - $68 per suture
- Rigid Devices
  - $150-200 per implant
  - Disposable inserters, $100 each
- Braided Polyester Tensionable Devices
  - Mitek RapidLoc--$216 each, applier $135
  - S&N FasT-Fix--$280 each
- UHMWPE Tensionable Devices
  - Ultra FasT-Fix (S&N)--$310 each
  - RapidLoc A2 (DePuy-Mitek)—cost pending
  - MaxFire (Biomet)--$382, cutter $154
  - Meniscal Cinch (Arthrex)--$286
  - CrossFix (Cayenne)--$325 each
Treatment of Meniscal Tears - Indications and Techniques

Paulo Roberto Pires Rockett – Brazil

The interest in preserving the meniscus increased dramatically after the publication of long-term follow-up studies reporting degenerative changes following meniscectomy. The decision to repair the meniscus is based on a considerable of aspects, including patient age, activity level, tear location, tear configuration, duration of the tear, and the presence of associated injuries and, most importantly, the capacity of the tissue to heal (vascularity). The best candidate for meniscal repair is the young and active patient with an unstable vertical tear, measuring greater than 10 mm in length, and located in the peripheral 3 to 4 mm of the meniscus. Successful healing and outcomes are relatively predictable in this setting. Previous studies have reported substantial increases in success rates of meniscal repairs performed concomitantly with ACL reconstruction, compared to isolated meniscal repairs. The indications for a meniscal repair have been broadened including certain vertical white-white zone tears in young, active patients, as well as some more complex configurations, including radial and flap tears. Conditions that make a meniscal tear irreparable include degenerative, horizontal or complex tear configurations, unaddressed instability due to ACL deficiency.

First Generation: Open Technique

The first series of open meniscal repairs were reported by Dehaven and collaborators (1) in 1980, with long-term follow-up. After an initial exam with the arthroscope, the meniscus was approached and exposed through a capsular incision made posterior to the collateral ligament. This facilitated direct repair of the tear to the peripheral meniscal rim and capsule with horizontal or vertical mattress sutures. High long-term success rates were reported for repairs of vertical tears, especially in patients with ACL-stable knees. Techniques for the use of meniscal repair devices vary from system to system, but general principles must be followed to enhance suture success. Removal of any loose fragments or unstable meniscal tags, freshening of facing surfaces of the tear, and trephination may be used in addition to promote vascular ingrowth. Certain techniques have been used to stimulate a biologic healing response. These include synovial abrasion, trephination, and fibrin clot augmentation. The fibrin clot appeared to act as a chemotactic and mitogenic stimulus with filling of meniscal defects through the proliferation of fibrous connective tissue that modulated to fibrocartilaginous tissue. Once the tear site has been prepared, the tear must be adequately reduced and fixed with sutures. Postoperative protocol must be followed to protect the healing process, promote nutrition of the meniscal and chondral tissue, and restore joint function.

Second Generation: Arthroscopically Assisted Inside-Out, Outside-In and All Inside Technique

The inside-out technique was developed to decrease the risk of injury to posterior neurovascular structures. Several systems have been developed using long curved single or double-barrel cannulas. Absorbable or nonabsorbable 2-0 or 0 sutures attached to long flexible needles are passed through a cannula, directed through both fragments of the meniscus tear, and out the joint capsule. A second needle attached to the other end of the repair suture is passed in the same way creating either a vertical or horizontal mattress stitch. The sutures are retrieved through an extraarticular posterior incision protected with a large retractor. The knots are tied with the knee in only slight flexion over the capsule. Zone-specific cannulas can be used to access various portions of either meniscus and facilitate reduction of the tear and suture passage. A double-barreled cannula allows for faster and easier suture passage. However, the single-barreled cannula to be preferable for improved coaptation of the repair site, more accurate suture placement, and placement of vertical mattress suture configurations. The technique allows safe access to repair most of the meniscus. Far anterior tears are also difficult to access with this technique.

The outside-in technique developed by Warren (2), decrease the risks for neurovascular injury associated with inside-out repair. This technique is particularly useful for repairing tears of the anterior portion of the meniscus. A variety of suture configurations can be easily created, including vertical mattresses. This technique has also been applied to more difficult tear configurations, such as flap and radial tears. The major disadvantage of this technique is that it offers poor access to tears located in the posterior regions of the meniscus because passage of needles in this area endangers surrounding structures. An outside-in repair requires only 18-gauge spinal needles, a suture grasping device, and suture material. After tear preparation is completed, the meniscus is viewed with the scope and a spinal needle is introduced percutaneously through the meniscus, bridging the tear and exiting either through the superior or inferior surface centrally. Several variations of this technique have been described with the main difference being the method used to snare the suture once it is passed. Some use a metal snare passed through a second needle, whereas others use a folded nonabsorbable monofilament suture as a loop.
Suture is pulled back and the two ends of the first suture is tied over the capsule through a small accessory incision without a knot inside the joint. Some risk of neurovascular injury still exists. This technique is not appropriate for tears of the posterior horn. This technique is excellent for the treatment of anterior meniscal tears, with 90% of clinical success rates.

The all-inside meniscus repair is an entirely intraarticular method of suturing a meniscus under arthroscopic control. This method places sutures across the tear and ties intraarticular knots through an operative cannula, resulting in a vertically oriented suture repair that apposes the meniscus only and excludes the joint capsule. The initial generation of all-inside meniscal repairs was performed with the use of shuttle devices and arthroscopic knot tying. A posterior portal was necessary for tears involving the posterior horn. These methods were difficult to master, technically demanding, and extremely cumbersome.

Morgan’s technique (3) needs an 8 mm cannula by posteromedial or posterolateral approaches and it is limited at posterior horn, only the longitudinal and peripheral lesions, with a maximum of 3 mm from the meniscus synovial. A 70 ° arthroscope and special instruments, curved needles and knot pusher are needed.

The great advantage of Morgan's technique is to make the knot without transfixing the joint capsule, fixing only the meniscus. With this instrument, you can also hold the suture in the anterior horn of the menisci. It has the disadvantage of causing lesions with relative ease in the adjacent cartilage, and requires the use of monofilament.

Meniscal Viper (Artrex) is a device specifically designed for placement of all-inside sutures for posterior horn tears. It enables to place vertical mattress sutures more easily. It still requires arthroscopic knot tying and the device itself may be difficult to use in small or tight compartments because of its size (>6mm at the tip) (4).

Double-loop is all-inside technique used to suture longitudinal rupture of the posterior horn of the meniscus (5). A 5 mm cannula is used by posteromedial or posterolateral approach. The 30° or 70 ° optic arthroscope is positioned through the anterior approach, passing through the intercondylar notch. The suture fixes only the meniscal tissue without transfixing the joint capsule, removing the risk of neurovascular injuries and not compromising articular mobility. A flexible double-loop composed of a braided ace cable covered by nylon with a loop in each extremity allows the passage of suture thread through a straight, curved or hooked needle and perform the stitch intra-articularly with the knot located in the posterior region of the meniscus. The suture thread of the surgeon’s choice is passed through the flexible double-loop and the stitches fix only the meniscus.

The double-loop may also be used in the lesions in the area of the body and anterior horn with the modified outside-in technique using the same suture material of the double–loop.
Third Generation: Devices
To facilitate all-inside meniscal repair a number of specially designed implants have been developed. These include rigid, biodegradable implants, such as the meniscal arrow (Conmed Linvatec), Meniscal Dart (Arthrex), BioStinger (Conmed Linvatec), Meniscal Screw (Biomet) usually made from absorbable polymers.

The meniscal arrow was one of a few similar rigid meniscal repair devices that became available in the mid-1990s. It consists of a biodegradable dart-shaped implant that is deployed through a specially designed cannula. The device has barbs distally for fixation to the rim fragment and a widened head to compress the central fragment.

However, a high number of reported complications, breakage, injury due to implant abrasion cause chronic synovitis, refractory posterior joint line pain, diminished this fervor. Additionally, longer term clinical studies began to reveal a significant deterioration in outcomes with high failure rates and an unacceptably high frequency of complications.

Fourth Generation: All-Inside Technique with Sutures
In an effort to provide the convenience of the rigid implants while giving the strength of suture repair, combinations of sutures and rigid parts were developed. All-inside devices incorporates many of these technical advantages, with improvements aimed to enhance repair stability and avoid untoward implant-related complications. Generally, all-inside devices require simpler surgical techniques and shorter surgical times, and have reduced surgical risk because accessory incisions are not necessary.

The RapidLoc which incorporates a PLLA “backstop” that is connected by 2-0 Ethibond suture to a tensionable “top-hat”. Each device is placed using an introducer with a shield used to protect the chondral surfaces. Using the associated malleable retractor is essential to avoid getting the RapidLoc repair device hung up in the fat pad and inadvertently pulled out of the insertion needle. Advancing the straight or curved needle across the tear and deploying the back-stop, the tear can be reduced and compressed by tensioning the top-hat against the central superior surface.

Early outcome studies have reported acceptable outcomes using this implant; however, the risk for chondral injury remains and has been reported in the literature.

The Fas-T-Fix device is a modification of the T-Fix and offers both biomechanical and clinical improvements. This implant consists of two sequentially deployed 5-mm polymer bar anchors that are connected by a pre-tied 0-0 Ethibond suture. Available with straight, 22- degree curved, or reversed curved needles. This implant offers a number of advantages: First, only suture material is present in the joint; thus, the potential for chondral injury is low. The instrumentation allows for the safe placement of multiple suture constructs, including vertical mattress and oblique sutures. It should be recognized that there is a significant learning curve with this device and practice before its clinical application is essential. There are only a few clinical series to date evaluating this implant, but the initial outcomes have been promising. Furthermore, in a number of biomechanical studies, the Fas-T-Fix device has demonstrated equivalent strength to vertical mattress sutures and superior strength when compared with other all-inside devices.
More recently, new techniques have been developed aiming to further improve some aspects such as strength of the suture and the quality of the knot and the anchors of attachment. However, the biomechanical function of these new techniques has not been fully explored.

The newest version is the Ultra Fast-Fix (Smith & Nephew), launched in late 2007. Anchors possess poly-ether-ether-ketone (PEEK) or PLA suture number 0 Ultrabraid (molecular weight polyethylene is too high). The suture is stronger than previous models and not absorbable. The knot slides more easily and the set has a lower risk of breakage due to high resistance of new materials.

A reverse curved needle is designed for repairing tears on the inferior surface of the meniscus (8).

The MaxFire device consists of a 2–0 ultra–high molecular weight polyethylene suture utilizing Ziploop Technology to create a mattress stitch across the front of the meniscus. The anchors are made of # 5 polyester suture when tensioned form mulberry knots on the back side of the meniscus.

Meniscal Cinch is the newest device of Arthrex is a self-adjusting suture with two anchors. This device shows higher load to failure. The two low-profile PEEK implants are loaded with a pre-tied sliding knot 2-0 FiberWire suture. It gives surgeons the option of horizontal or vertical mattress repair.

In this technique, special attention should be given to never pull the trocar back into the cannula after it has been advanced, as this could prematurely deploy the implant. This device was recently added to the arsenal available in the market and is awaiting the results on the medium and long term to compare them with other techniques.

Contemporary all-inside repair systems have significantly decreased the level of technical skills required for a successful repair. There is currently no scientifically substantiated reason to believe that the choice of a particular repair technique would improve the outcome. It has not been shown thus far that a high failure load is associated with better clinical results (9).

The lack of randomized clinical trials prohibits one from making recommendations on using one particular all-inside meniscus repair device versus another. Prospective long-term follow up is important to determine the failure rates of all-inside meniscus repair devices (10).

References:
Meniscal Scaffolds

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Background
We all know the important biomechanical roles that the menisci play in shock absorption, force transmission, load distribution, stability and lubrication. Meniscectomy may be associated with cartilaginous deterioration with time. Meniscus reconstruction (using meniscus allograft, meniscus scaffold) is an attempt to solve this problem.

Meniscus scaffolds are degradable, biocompatible and porous acellular devices which act as a temporary matrix which provides a substrate to which cells can adhere, allowing tissue ingrowth. Of particular importance are the biomechanical properties of the matrix template since the template initially serves the biomechanical function of the meniscus. Thus, the initial biomechanical strength of the engineered template and the subsequent biomechanical properties of the regenerated and remodeled tissue must be adequate for the device to survive initially in the hostile environment of the knee, and then ultimately to function like meniscus tissue. Additionally, the scaffold must be conductive for cells as well as permeable to nutrients.

There are two scaffolds available on the market:
1- Actifit® (Orteq Sports Medicine, London UK) is a degradable, biocompatible and highly porous acellular scaffold made from a synthetic, aliphatic polyurethane. The Actifit polyurethane is composed of polycaprolactone soft segments and hard segments containing butanediisocyanate (BDI) and butanediol (BDO). The combination of soft segments with minuscule hard segments (approximately 2-3 nm) results in a strong and highly flexible material. Actifit has a high flexibility (400% strain at break) and suture pull out strength for optimum handling and implantation characteristics. The suture pull out strength of the fully hydrated Actifit scaffold at 50% of the product height is greater than 23 Newtons.

The Actifit polymer provides sufficient mechanical strength and slow and safe degradation (approximately 5 years) for tissue ingrowth and maturation.

2- the Menaflex™ Collagen Meniscus Implant or CMI, ReGen Biologics, Inc., Hackensack, NJ, USA. The
Menaflex Collagen Meniscus Implant is a porous collagen-glycosaminoglycan (GAG) matrix of defined geometry, density, thermal stability and mechanical strength. The CMI is composed of about 97% purified Type I collagen, the most commonly found protein in the body. The remaining portion of the CMI consists of GAGs including chondroitin sulfate and hyaluronic acid. The Type I collagen is isolated and purified from bovine Achilles tendons from animals originating in the United States. The collagen-GAG complex is chemically crosslinked to enhance in vivo stability and for ease of handling and implantation. The suture pull out strength of the fully hydrated CMI at 3 mm from the edge is greater than 20 Newtons, thus permitting the implant to be properly positioned in the joint and fixed with sutures to the host meniscus remnant. The Menaflex CMI is both cytoinductive and cytoconductive, and it resorbs as new meniscus-like tissue is formed.

Indications and Contra Indications

**Indications**

**Meniscus**
- Mainly symptomatic post meniscectomized knee ; rarely primary surgery
- With a stable rim and intact anterior and posterior horn insertions

**General**
- Patient under 50 years old
- Stable Knee or ACL reconstructed knee  knee ACL tear must be reconstructed.
- Cartilage less than ICRS grade III

**Contraindications**
- Complete meniscus loss.
- Repairable meniscus tear.
- Uncorrected ligamentous instability or insufficiency in the involved knee.
- Uncorrected grade IV (full thickness) degenerative cartilage lesions in the affected joint.
- Uncorrected malformations or varus axial malalignment in the lower extremity.
- Documented allergy to any product of animal origin. (Menaflex only)
- Systemic or local infection.

**Procedure**
Implantation is performed arthroscopically, using standard arthroscopic approaches.

1- The damaged portion of the meniscus is debrided back to the vascularized zone. It is of particular importance to keep the meniscus rim and the meniscal horns intact (ant and post)
2- The resulting meniscus defect is measured
3- The scaffold is cut to fit the void snugly, Actifit must be oversized by 10%.
4- It is fixed using hybrid devices (fast fix Smith et Nephew or similar devices) on the posterior and mid parts and out-in technique on anterior part. It is very important to also securely fix the scaffold to the posterior and anterior native meniscus
5- Microperforations or synovial scarifications can be considered to enhance bleeding and tissue ingrowth
6- ACL reconstruction should be performed when ACL tear is associated
7- Osteotomy could be considered when significant varus or valgus deformity is present.

Results

Actifit® (courtesy Dr Eva Lisa Henrichs MD Orteq Ltd, London UK)

Study description

The results of a 2 year clinical study (prospective, single-arm investigation in patients with irreparable medial or lateral meniscal tears or partial meniscus loss) performed in nine European centers are available. The study assessed safety, performance, tissue ingrowth and efficacy using: 1) MRI at 1 week, 3, 12 and 24 months post-implantation; 2) dynamic contrast enhanced MRI (DCE-MRI) at 3 months to assess tissue ingrowth; 3) gross examination, biopsy and histology at 12 months; and 4) clinical outcomes (IKDC, VAS, KOOS and Lysholm) at baseline, 3, 6, 12 and 24 months.

Results

52 patients (34 medial, 18 lateral) were treated with the scaffold. The patients were young (mean age, 30.8±9.4 years, range 16-50 years), and 88.4% had undergone 1 or 2 prior surgeries on the involved meniscus. The mean length of the meniscal defect was 47.1±10.0 mm (range 30-70 mm).

1) MRI scans at 24 months showed stable to improving articular cartilage grading in 37 of 40 subjects. There was no evidence of the scaffold causing cartilage damage.

2) DCE-MRI at 3 months showed tissue ingrowth in the peripheral half of the scaffold in 35/43 (81.4%) subjects.
3) All 44 biopsies were taken from the center of the free edge of the implanted Actifit® scaffold and showed fully vital material with no necrosis or cell death. The regenerated tissue showed meniscus tissue like characteristics specifically in relation to cellular morphology and ECM (Positive staining for collagen type 1 and fibrochondroblasts). It should be noted, however, that fully mature meniscus-like tissue was not expected nor observed at the 12 month timepoint.

4) The 2 year results show a clinically and statistically significant improvement from baseline for all clinical outcomes scores: VAS and IKDC, KOOS and Lysholm, n=39. The VAS pain score improved from baseline to 24 months in both medial and lateral configurations by 28.8 and 36.7 points respectively. Functional improvements were seen in IKDC scores in both medial and lateral configurations, with increases of 34.4 and 22.3 points respectively, and also on the Lysholm score, where the medial subjects improved by 25.7 points and the lateral subjects by 27.3 points.

All KOOS sub-scales also showed improvement from baseline to 24 months, with the following increases in scores, 16.8 (symptoms), 24.9 (pain), 18.4 (daily living), 35.4 (sports/recreation) and 27.2 (quality of life) n=39.

There were no serious adverse events related to the device (one serious adverse event of non-integration due to unknown causes). This safety profile was similar to that recorded in the literature for partial meniscectomy and meniscal repair.

These results demonstrate the biocompatibility, safety and efficacy of the Actifit® scaffold, as well as its potential to support ingrowth of meniscus-like tissue following partial meniscectomy.

No cartilage damage due to the scaffold was observed and stable or improved cartilage scores were demonstrated by MRI assessments up to 24 months. All 12 month biopsies showed no tissue necrosis/cell death and complete re-population by vital cells and tissue. The 24 month VAS, IKDC, KOOS and Lysholm results show the efficacy of the scaffold in the treatment of partial, irreparable, and painful meniscal tears.

Menaflex (Courtesy W Rodkey, Steadman Philippon Research Institute Vail, Colorado USA)

The authors prospectively determined Lysholm scores for function and Tegner scale scores for activity, and then we calculated Tegner index to determine the percentage of pre-injury activity level regained by
patients six years after partial meniscectomy alone versus placement of the Menaflex. Objective clinical examinations were carried out through two years after index surgery, and then subjective questionnaires were completed annually thereafter. A minimum follow-up of 24 months was available for all 145 patients. Average follow-up for both groups was 72 months. For both groups, average Lysholm scores improved significantly (p=0.0001) from preoperative to six years postoperative, but there was no difference between Menaflex CMI and meniscectomy only treatments at six years. Average Lysholm scores for both groups were unchanged from the 2-year findings. Average Tegner index for Menaflex CMI patients was 0.47; thus, six years after receiving the implant they had regained 47% of the activity which they had lost due to the original inciting injury. However, average Tegner index for the meniscectomy only controls was 0.22; thus, they regained only 22% of their lost activity. This difference was clinically and statistically significant (p=0.028). Average Tegner index for Menaflex CMI patients improved from 0.42 to 0.47 from two to six years, but Tegner index decreased for meniscectomy only controls from 0.29 earlier at two years to 0.22 at six years. The increase for the Menaflex CMI patients and the decrease for the meniscectomy only controls both were statistically significant (p<0.05).

Conclusion

Meniscus allograft and meniscus scaffold are the two current pillars of meniscus reconstruction. Both techniques are in fact complementary as the indications are different. Allograft for total meniscus loss and scaffold for partial meniscus loss with intact rim. Technique is very important to facilitate tissue ingrowth.

This technique is promising as demonstrated by clinical outcomes, MRI studies and biopsies.

Current scaffolds and techniques are probably an intermediate step, waiting for new biological improvements in the future.
Meniscal repair in athletes

**Current Trends in the Treatment of Meniscal Tears**

Dr.Edilson Thiele – Brasil
Dr.Carlos Stierling – Chile

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**Meniscal Functions**

- Dispels stress associated with axial loads
- It facilitates the transfer forces
- Secondary stabilizer of the knee (m. medial)
- Joint Lubrication
- Cartilage nutrition
- Propioception

**Menisci of the Knee**

- Serves a critical role in knee function
- Important functions:
  - Loading sharing
  - Shock absorption
  - Articular cartilage protection
- Preservation of the menisci is vital to long term function
- Repair surgery & transplants
- Once thought to be "useless structure"

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**Mechanical Consequences of Meniscectomy**

- Decreased contact areas
- Overload cartilage
  - 1/3 ➔ diminished contact 10% ➔ stress increased 65%
  - Total ➔ diminished contact 75% ➔ stress increased 235%
- Transmission of the load compartment (Walker, Corr 1975)
  - Lateral Meniscus- 70%
  - Medial Meniscus- 50%

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**Mechanical Consequences of Meniscectomy**

- Jorgensen (JBJS Br Jan 1987)
  - Total, open (n = 147)
  - Degeneration
    - 89% a 4.5 years
    - 9% at minimum a 14.5 years
    - More common in Lateral m.
    - Greater commitment than the general population
- Hoshikawa (AJSM Jan-Feb 1983)
  - Subtotal, open (n = 68)
  - F. u. 4.5 years prom.
  - International Athletes in competitive and recreational
  - Worse results in Group I
  - Worst: volleyball
- Roos (AJSM 1994)
  - Open total meniscectomy
  - Football players
  - Degeneration
    - 1.6% in control group
    - 4.2% in non-professional players
    - 15.5% professional players
- Fauno (Arthr. 1992)
  - N = 177, 77% up to 8 years FU.
  - 53% of degenerative changes
- Ranger (AJSM 1995)
  - N = 284, 4 years of FU.
  - 38% degeneration m. medial
  - 24% degeneration m. lateral
- Higuchi (Clin Orth 2000)
  - N = 82, 87% up to 12 years FU.
  - 34% higher in the operated knee degeneration
- Hoser (JBJS 2001)
  - N = 37, 78% up to 10 years FU.
  - 37% of degenerative changes
Meniscectomy partial: Consequence in athletes

- **Bonneux** *(Act Orth Belg 2002)*
  - Isolated lesions (n = 31, f. u. 8 años)
  - Good and excellent
  - 48,4% (IKDC)
  - 64% (Lysholm)
  - Tegner 7,2 à→ 5,7
  - 92,9% de of degenerative changes

- **Mariani** *(Knee surg, Sport Traumat, arthrosc Jun 2008)*
  - 5 professional football players with Knee varus
  - Lateral Meniscectomy à→ pain and
  - Condrolysis asociated with pósterolateral instability

Meniscal Suture

- **First Meniscal repair** Annandale 1885 *(Br Med J)*

- **Factors to consider:**
  - Pacient age
  - Type of tears
    - Location
    - Orientation
    - Size
  - Joint stability
  - Time evolución
  - Condral Commitement

- **Objetives:**
  - Preserving the function
  - Mantain integrity of articular cartilage

**Meniscal Suture**

Factors to Consider

<table>
<thead>
<tr>
<th>Location of the tear</th>
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<tbody>
<tr>
<td>Anterior/posterior</td>
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<td>Medial/lateral</td>
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<tr>
<td>Vascularity</td>
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<td>10-30% of meniscus</td>
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<td>Red-White</td>
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<table>
<thead>
<tr>
<th>Type of tear</th>
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<tbody>
<tr>
<td>Size of tear</td>
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<tr>
<td>Extent of tear</td>
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<td>Simple vs. complex</td>
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<th>Age and activities of patient</th>
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<tr>
<td>Level of Degeneration</td>
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"Not all meniscal injuries are reparaible"

- Age might not necessarily be an absolute factor in determining who is a candidate for repair, although with advancing age, predominantly irreparable
- Tear types (degenerative patterns) and a lack of tissue viability (attenuation and deformation) tend to result in more meniscal resections and less repairs.

"Not all meniscal injuries are reparaible"

- In general, in the short term, meniscal resection is associated with **less** recovery time and restrictions.
- Whereas in the long term, repair could be associated with a **more favorable** prognosis

"Not all meniscal injuries are reparaible"

- Technical issues could affect the decision of certain surgeons to ressect rather than repair, particularly in cases in which the procedural hassle of carrying out the repair and learning curve associated with placing a repair or suture device is deemed more difficult than removal
“Not all meniscal injuries are reparable”

- Concerns and questions regarding the true clinical success of repair and whether a repaired meniscus will ever heal and biomechanically function as normal have been raised by those who predominantly advocate resection over repair.

Surgical technique (gold standard inside-out)

- Prevent cartilage damage
  - Using LCM foot crust
- Have different methods of fixation
- Maximize healing
  - Check bleeding
  - Trefinacion
- Anatomical repair and compressive
- Stable fixation
  - (sutures or suture-based fasteners)

Results of meniscal suture

- Chang (AJSM Dec 2005)
  - Biomechanical evaluation (slip and point of failure)
  - Vertical suture (inside-out) over all within implant with suture (2nd gen)
- Kalliakmanis (Arthr 2008)
  - Randomized study (comparison of implants 2nd generation)
  - 86-92% healing
  - No significant differences

Meniscus Repair: Surgical technique

- Various procedures
  - Inside-out
  - Outside-in
  - All-inside
- Fixation type
- Extent of repair
- Concomitant procedures
  - ACL

Results of meniscal suture

- Higher failure rate than lateral meniscus.

- Bucket handle lateral meniscus in ACL reconstruction (Shelbourne, Arthr 2004)
  - Less pain in meniscal suture group vs meniscectomy

Results of meniscal suture

(AANA, San Diego 2009)

- Briggs et al
  - Inside-out
  - 90% success
    - Medial: 13% failure
    - Lateral: 4% failure
- Barber et al
  - Everything inside (FastT-Fix)
  - 83% success
  - Accelerated Rehabilitation
- Cohen et al
  - All techniques
    - Without ACL injury
    - 88.5% healing
Rehab Following Meniscal Repair
Healing Guidelines

- Meniscal Repair Healing & Strength
  - 50% @ 3-4 weeks
  - 80% @ 8-12 weeks
  - 100% @ 14-18 weeks

- Enhanced Healing Effect
  - Concomitant ACL reconstruction
  - Synovium response
  - Vascular enhancement

Rehab Following Meniscal Repair
Healing Guidelines

- Objectives:
  - Protect repair
  - Functional recovery
  - Prevent joint damage

- Accelerated protocol
  - (Barber, Arthroscopy 1994 y Shelbourne, Clin Sport Med 1996)
    - No increase fault
    - Quick recovery of range motion

Obrigado
Thanks