Meniscal Repair

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The beginnings of arthroscopy go back to 1918. Professor Kenji Takagi of Tokyo University first successfully arthroscoped a human knee using a cystoscope and the knee of a cadaver. By 1936, Takagi had developed a way to obtain color pictures and video of the interior of the knee joint. Dr. Eugene Bircher became the first to use arthroscopy on live patients.
History of Meniscal Repair

- First open meniscal repair was performed by Annandale in 1885.
- First arthroscopic repair was performed in 1969.
- Meniscus repair did not receive widespread attention and acceptance until the last 2 decades.
History

- Thomas Annandale British surgeon, born February 2, 1838 died December 20, 1907.
- An operation for displaced semilunar cartilage British Medical Journal, 1885, 1: 779. London,
The focus of treatment has shifted toward preservation and repair of the meniscus whenever possible.
Meniscal Anatomy

- Fibrocartilagenous
- Crescent shaped; triangular in cross-section
- Anterior horns attached to each other by the small transverse anterior intermeniscal ligament
- Lateral meniscus is more circular; medial meniscus more C-shaped
- Anterior horn of lateral meniscus & post horns of both menisci attach to the intercondylar eminence
Meniscal Anatomy

- Popliteus muscle is attached to lateral meniscus
- Semimembranosis is attached to medial meniscus

**Blood supply**
- From branches of the lateral, middle & medial genicular arteries
- Vascular synovial tissue from the capsule supplies the peripheral 25% of meniscus
- Medial meniscus has better blood supply than lateral
Meniscal Anatomy

**Constituents:**
- *Type 1 collagen fibers arranged radially & longitudinally (circumferential)*
  - Longitudinal fibers - dissipate hoop stresses in the meniscus
  - Radial fibers & longitudinal fibers - allows menisci to expand under compressive force
- *Proteoglycans*
  - Trapped within collagen fibers to absorb energy
Mechanics of the meniscus

- The compression of the menisci by the tibia and the femur generates outward forces that push the meniscus out from between the bones (Hoop Stress). The circumferential tension in the menisci counteracts this radial force.
- These hoop forces are transmitted to the tibia through the strong anterior and posterior attachments of the meniscus.
- This hoop tension is lost when a single radial cut or tear extends to the capsular margin and that in terms of load-bearing, a single radial cut through the meniscus is equivalent to meniscectomy.
Functions of the meniscus

1. Stability
2. Shock absorption
3. Lubrication
4. Prevents synovial impingement
5. Limits extremes of flexion & extension
6. Transmits loads across the joint
7. Reduces contact stresses
8. Proprioception
Type of meniscal tears

• Meniscal tears can be either traumatic or degenerative in nature.

• Degenerative tears can be found in as much as **60% of the population over age 65**.

• The majority of meniscal tears affect the medial meniscus and tend to involve the posterior horn.

• Meniscal tears are either partial or full thickness and stable or unstable.
The effect of menisectomy

- King’s (1936) research highlighted the importance of the meniscus. Using a canine model, the amount of degenerative change after meniscectomy was related to the amount of meniscus removed.
- Fairbank (1948) observed degenerative radiological changes after meniscectomy.
- 10 to 15 years after an arthroscopic partial medial meniscectomy, the operated knee is 16-33% more likely to have degenerate radiological changes, compared with the control knee.
The effect of meniscectomy

- The menisci increases the surface area for femoral-tibial load-transmission.
- With only one third of the meniscus removed, as with partial meniscectomy, there has been shown to be an estimated 65% increase in articular contact stress.
- Total meniscectomy may increase peak loads up to 235%.
- In the ACL-deficient knee the menisci, specifically the posterior margins aid in stabilizing the knee from anterior translation.
WHY DON’T WE REPAIR MORE OFTEN?

**Meniscal repair**
- Difficult
- Time-consuming technique
- Special training and equipment.
Who is a candidate for Meniscal repair?

Location
- The ideal type of Meniscal tear to consider repairing is the peripheral tear.
- Most commonly the tear is in the red on white region, which also has an acceptable successful repair rate when bioabsorbable devices are used.
Who is a candidate for meniscal repair?

**Morphology of the tear**

**Size**
- The short tear of 1-2 cm has a better successful repair rate

**Appearance**
- The vertical longitudinal tear is ideal for repair
- Don’t consider repairing degenerative horizontal cleavage tears or flap tears
Who is a candidate for meniscal repair?

**Patient factors**

- Non compliant patient should not be considered for repair
- The younger patient has a higher success rate. The older patient often has the type of degenerative tear that is non repairable.
- The rehab must be modified to avoid flexion in the immediate post-op period
Best candidate for meniscal repair is the young compliant patient with a 2 cm long peripheral longitudinal meniscal tear. You should always consider a meniscal repair, rather than a menisectomy in the young athlete to protect his articular cartilage for the future.
Open Repair:

advantage of better preparation of the tear site
only the most peripheral of tears in the red-red zone are amenable to this technique because of exposure and accessibility

Long-term follow-up of open meniscal repairs has revealed success rates ranging from 84% to 100%.
The techniques of meniscal repair.

- **Arthroscopically assisted:**
  - Inside-out technique:
    - First described by Henning
    - Utilizes zone-specific cannulas to pass sutures through the joint and across the tear. The sutures are swaged onto flexible needles.
    - A small posterior joint line incision is used to retrieve the sutures and tie directly on the capsule.
Arthroscopically assisted:

- Outside-in techniques:
  - described by Warren, Morgan and Casscells
  - involve passing sutures percutaneously through spinal needles at the joint line across the tear, and then retrieving the sutures intra-articularly. A small incision is then made at the joint line, where the protruding suture ends are retrieved and tied directly on the capsule.
  - A potential disadvantage of the outside-in technique is difficulty in reducing the tear and opposing the edges while passing the sutures.
The techniques of meniscal repair.

Arthroscopically assisted:
- All-inside technique
  - suitable for repairs of the far posterior horns
  - implantable anchors, arrows, screws, and staples
Specific complications include saphenous neuropathy (7%), arthrofibrosis (6%), septic arthritis (1%) and peroneal neuropathy (1%).

Implants have been associated with breakage, cyst formation, chondral damage and transient posterior knee pain.
D. Kohn and W. Siebert, Meniscus suture techniques: A comparative biomechanical cadaver study. *Arthroscopy* 5 (1989), pp. 324–327. Vertical sutures show 2-4x the failure strength when compared with knot-end techniques, and 1-2.3x the failure strength when compared with horizontal techniques.

R. Seil, S. Rupp and D.M. Kohn, Cyclic testing of meniscal sutures. *Arthroscopy* 16 (2000), pp. 505–510. no difference between the failure strength of vertical or horizontal techniques
vertical sutures produce less tissue gapping under cyclical loading conditions.


Horizontal and knot-end techniques failed primarily by pulling out of the tissue, while the vertical technique failed via suture failure.

Failure strength of horizontal sutures showed no difference with variation in suture material

Vertical sutures showed a statistically significant difference between the failure loads using different suture materials.

Vertical sutures were significantly stronger than horizontal or knot-end techniques ($P < .0001$).


Vertically oriented sutures show significantly higher initial fixation strengths when compared with knot-end or horizontal techniques.
Literature review
Single device studies

  No statistical difference existed between the pullout strengths of horizontal sutures and Arrows in bovine menisci.
  concluded that the Meniscus Arrow has approximately half the failure strength of vertical sutures.
  These results correspond roughly with previous conclusions that Arrows have a failure strength approximately equal to horizontal sutures.

**Bionx-funded study**

**2-0 Ti-Cron sutures**

No statistical difference was seen between the vertical and horizontal suture groups.

The mode of failure was suture failure.

16-mm Arrows were found to be significantly weaker than the suture techniques ($P < .05$).

The length of Arrow did have an impact on pullout strength; as expected, 13-mm Arrows and 10-mm Arrows showed lower fixation strength ($P < .05$). This difference was attributed to the number of barbs available to grasp meniscal tissue.
Literature review
Single device studies

  
  Like vertical sutures, the obliquely oriented sutures are thought to capture a larger number of circumferential collagenous fibers, allowing stronger tissue fixation.

  
  tissue gapping occurs at comparatively lower forces with the Arrows, which could impair the healing process.

published the first study examining multiple meniscal repair devices as well as standard suture techniques.

Eleven different repair methods were tested

- Double vertical stitch failed at (113 N).
- Single vertical stitch failed at (80 N)
- The Biostinger (57 N),
- Horizontal mattress stitch (56 N)
- T-fix device (50 N).
- The Meniscus Arrow (33 N)
- No difference in failure strength was found between crossbow or manually inserted Arrows

- The Clearfix screw (32 N),
- The Sdsorb staple (31 N),
- The Mitek repair system (30 N),
- The Biomet staple (27 N).

The vertical sutures failed at 73.9 ± 6.6 N.
The horizontal sutures failed at 63.2 ± 9.8 N.
The Arrows failed at 44.3 ± 10.9 N.
The Staples failed at 17.8 ± 4.1 N.

- Vertical sutures (202 ± 7 N)
- Horizontal sutures (170 ± 12 N, *P* < .03),
- T-fix anchors (95.9 ± 7.5 N, *P* < .0001)
- Meniscus Arrows (99.4 ± 7.5 N, *P* < .0001).

- analysis of tissue gapping

vertical sutures require significantly higher loads to produce 1.0 mm of tissue gap. when compared with horizontal sutures, the Arrow and the T-fix respectively.

No statistical difference between horizontal or vertical sutures.

No statistical difference between suture materials.

Vertical sutures were better than horizontal sutures in meniscal gapping.

examined the performance of multiple repair devices under cyclical conditions in human menisci and the levels of displacement

- Stinger (1.7 ± 0.5 mm)
- vertical sutures (1.8 ± 0.6 mm)
- T-Fix (2 ± 1.3 mm)
- horizontal sutures (3.2 ± 1.2 mm)
- Arrow (3.3 ± 1.3 mm)
- Mitek Meniscal (5.6 ± 1 mm)
Literature review
Absorption profile


  Permanent sutures are recommended over absorbable sutures as PDS, which appear to absorb too quickly to allow sufficient time of meniscal apposition for successful healing.


  - Initial fixation strength of the Bionx Meniscus Arrow (57.7 ± 13.8 N) was equal to the 2-0 PDS vertical suture (51.7 ± 2.7 N) and significantly higher than all other devices (*P* < .05).
  
  - After 6 weeks of hydrolysis, none of the devices showed significant decreases in fixation strength.
  
  - At 12 weeks, the PDS based devices showed significant weakening.

- 74 arthroscopic meniscal repairs evaluated by second-look arthroscopy
- 4 months were required for visual evidence of meniscal healing to appear.
- All asymptomatic repairs were fully or partially healed; clinical evaluation gave no false-negative results.

reported that the 6-month follow-up evaluation of 20 patients with T-fix repaired medial menisci reported showed that 90% of patients returned to preinjury activity levels.


21 meniscal repairs using the T-fix suture anchor with a minimum of 1-year follow-up evaluation.

Avascular zone 2 repairs showed significantly lower healing rates than the peripheral zone.
Literature review
Clinical outcomes


  - 26 repairs
  - follow-up time of 16.7 (range, 12–22) months.
  - An average of 2.8 Arrows per tear were used
  - 88% of patients were clinically rated as good or excellent.
  - Complications included infection, hemarthrosis, and Arrow-induced irritation.

The authors conclude that despite its increased cost, Arrows are an attractive alternative to traditional techniques because of the shorter surgical time, easier technique, and decreased risk of neurovascular injury.

- 92 meniscus repairs using sutures, Meniscus Arrows, and T-fix suture anchors.
- follow-up time of 21 months
  - sutures alone had higher clinical success rates (78.6%)
  - Arrows (56.5%)
  - T-fix devices (57.1%).

*The overall complication* rate was 11.3% included two isolated broken Arrows as well as two Arrows causing synovitis and articular cartilage damage.

- **39** repaired menisci
- **follow-up time of 29.7 months (minimum, 24 months).**
- **2** clinical failures requiring a second operation
- No failures were reported in subgroups requiring concomitant ACL reconstruction
- **12 patients (31.6%)** reported transient soft-tissue irritation or tenderness that generally resolved in 12 months.
  - **Two** of these patients required removal of subcutaneous Arrow fragments.
  - **Two** others with recurrent symptoms required repeat surgery and partial meniscectomy.

37 repaired menisci using the Mitek Meniscal Repair System. Follow-up time of 12 months clinical success rate of 86%. Failures occurred in the middle third of the meniscus (red-white zone).

Seventeen patients underwent repeat arthroscopy at 6 to 8 weeks for an ACL reconstruction the repaired menisci were still reduced and stable to probing.

Complications included subcutaneous device migration as well as grade II chondromalacia of femoral condyle in an area corresponding to repair device.
Conclusions

- Vertical sutures are superior to both horizontal and knot-end techniques.
- Meniscus Arrow has less initial fixation strength than suture techniques.
- Vertical sutures were superior to all other techniques, while the Bio-stinger and T-fix were equal to horizontal suture techniques.
Conclusions

- PDS suture absorbs too quickly for adequate meniscal healing
- Follow-up studies on these repair devices have generally shown a clinical success rate of 86% to 95%
- If an absorbable device is used, it should retain its strength for at least 4 months
- Only vertical sutures, horizontal sutures, and the Bionx Arrow have sufficient biomechanical and clinical data to support use.
Conclusions

- These devices have considerably simplified surgical technique and decreased surgical risk and are therefore an attractive alternative to sutures.
- Poorly indicated tears still do not carry a good prognosis for healing.
- Surgeons may be tempted to treat more complex meniscal tears with these new, simple devices, but healing rates for complex or avascular tears remain poor.