

Meniscus Injury and Management.

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Abstract: The management of meniscus injuries in adult is still controversial. In recent years there has been increase awareness of the biomechanical and functional importance of the meniscus. This has resulted in the treatment modalities to evolved from total meniscectomy at one extreme to partial meniscectomy and meniscus repair and finally meniscus transplant at another. There are very few randomized trials comparing different treatment modalities. Furthermore, the assessment tools of the outcome are numerous, some focusing on imaging, others on physical examination, the so called objective outcome measures and others on questionnaires. Hence it is difficult to compare the results shown by different authors. It is now clear that the subjective outcome measures have a higher validity and reliability than the objective ones. There is no definitive answer regarding which of the treatment modality is best because the confounding factors are numerous e.g. difference in patients weight, occupation, hobbies, different surgical techniques, associated injuries, different outcome measures used. But it is worthwhile reviewing the recent literature. In our article, after a brief review of the anatomy and function of the meniscus, we focus on the different modalities of treatment meniscus tears and their outcome.

ANATOMY AND FUNCTION

The menisci are two semilunar wedges in the knee joint positioned between the femur and the tibia. Most meniscal tissue is avascular and depends on passive diffusion and mechanical pumping to provide nutrition to the fibrocytes within the meniscal substance and therefore, cannot repair itself if the tear is in an avascular portion of the meniscus.¹ Arnoczky and Warren¹ have demonstrated the important vascular anatomy of the menisci. The limited peripheral blood supply originates from the medial and lateral inferior and superior geniculate arteries. Branches from these vessels give rise to a perimeniscal capillary plexus within the synovium and joint capsule, which in turn, supplies the meniscus periphery. Various zones of the meniscus are described based on the blood supply: the red zone is the well vascularized periphery, the red-white zone is the middle portion with vascularity peripherally but not centrally, and the white zone is the central avascular portion. This tenuous blood supply has been implicated in the limited healing potential of the meniscus. The only time a meniscus will repair itself is if the injury is located in the periphery of the meniscus, where it has a vascular supply. A short (<1cm) stable tear that is limited to the outer 20% of the meniscus could heal itself with a brief period of immobilization. They are essentially extensions of the tibia that act to deepen the articular surface of the otherwise flat tibial plateau to accommodate the relatively round femoral condyles. The menisci provide several integral elements to the knee function, including load transmission, shock absorption, joint lubrication, and friction reduction, protection from daily joint wear, joint nutrition and stability. Hence their lesions can lead to osteoarthritis.² The meniscus has nutritive as well as lubricating properties in the knee joint as well.³ Fifty percent of the compressive load in the knee is transferred by the menisci in extension, while up to 85% is transferred at 90 degree of flexion. The collagen orientation makes this possible by converting compressive forces to tensile forces. Load and forces are distributed across a much larger surface area because of the menisci.⁴ The complete removal of the meniscus can result in progressive knee arthritis.

PATHOGENESIS

Traumatic meniscal tears occur frequently in young and active people. A sudden change in direction while running, forceful squatting, twisting the knee, or application of external forces to the knee e.g.,

rotation, varus, valgus, or hyperextension, subjects the meniscus to tension, compression, and shear. Tension, compression, or shear forces that exceed the strength of the meniscal matrix in any direction i.e., circumferential or radial, tear the tissue. Acute traumatic injuries of normal meniscal substance usually produce longitudinal or transverse tears, although the morphology of tears can be quite complex⁵ and the configuration of tears due to overloading of normal meniscal tissue depends strongly on the direction and the rate of stretch. Unlike acute traumatic tears through apparently normal meniscal tissue, degenerative meniscal tears occur in association with age-related degenerative changes in the tissue. These degenerative tears are most common in individuals older than 40 years of age. Often, these individuals do not recall a specific injury, or they recall only a minor load applied to the knee. Degenerative tears often have complex shapes or may appear as horizontal clefts or flaps, as though they were produced by shear failure. Multiple degenerative tears often occur within the same meniscus. These features of degenerative meniscal tears suggest that at least sometimes, they result more from age-related changes in the collagen-proteoglycan solid matrix than from specific acute trauma.

EPIDEMIOLOGY

A meniscus tear can be located in any location, and in any conceivable pattern. Anterior horn tears are unusual. Tears typically begin in the posterior horn and progress anteriorly. Patients with sports injuries are usually in mid thirty years, and account for approximately 33% of cases. Patients with non-sporting injuries are in fourth decade of life, and account for approximately 39% of cases. Patients with an indefinable injury have a mean age of 43 years, and account for about 29% of cases. There is a 4:1 male to female ratio in these tears, and approximately 2/3 of all cases occur in the medial meniscus. It should also be noted that associated ACL tears were found in 47% of the patients in sports injuries and in 13% of the non-sporting injuries. In the no-injury group, there were no ACL tears.^{6,7} In chronic ACL injuries medial meniscus tear occurrence is 36%, lateral meniscus tear occurrence is 22% and both menisci tear occurrence is 16%.⁸

CLASSIFICATION

The meniscus tears are classified based on their location, tear pattern and appearance. Location based classification is self explanatory viz: tears in red-red zone, in red-white zone and in white-white zone.

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This is also important for treatment and prognosis point of view. Horizontal tear, radial tear and complex tears are based on the patterns of the meniscus tears. Based on the appearance, the meniscus tears are classified as bucket handle tear, flap tear, parrot beak tear, incomplete tear, complex tear and longitudinal tear (Fig.1).

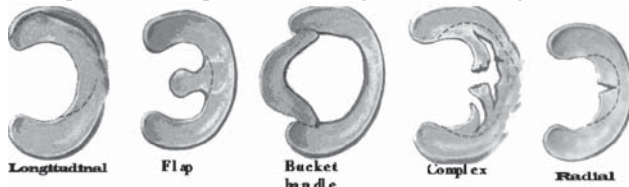


Figure 1: Figure showing different types of meniscal tears

DIAGNOSIS

One or the other form of history of injury is present in majority of patients coming with meniscus tears more so among youngsters. Trivial form of injury viz: twisting of knee while walking or jerk on knee while walking on uneven surface or getting up from sitting posture may cause meniscus tears in elderly persons. Pain of knee joint, is the common form of presentation. Swelling of knee may or may not be present. Locking of knee if present signifies massive meniscus tear with displacement giving to mechanical symptoms. Joint line tenderness, positive bounce test, McMurray's and Apley's grinding tests are helpful clinical signs to diagnose meniscal tears. MRI is helpful to diagnose the types and location of meniscus tears and any other associated injuries.

NONOPERATIVE VERSUS OPERATIVE MANAGEMENT

Failed conservative management in patients having pain and/or locking of the joint are the usual candidates for surgery.⁹ Arthroscopic surgery is the method of choice to treat a tear, as there are currently no medications, braces or physical therapy treatments that have been shown to promote healing in avascular tears. The decision is made to either remove or repair the tear based on the location and size of the tear. If there is a vertical tear at the rim near the meniscal blood supply, it is desirable to repair the meniscus by approximating the torn edges of the meniscus to allow for healing and preventing these edges getting caught in the joint. Note that if the tear is located in an avascular portion of the joint, a meniscectomy will most likely need to be performed.¹⁰ The main factors in the decision making of conservative Vs surgical management are the nature of the patient's symptoms and whether the patient can afford a period of observation (patient's occupation, hobbies).¹⁰

SURGICAL PROCEDURE

Partial Vs Total

Partial meniscectomy is associated with shorter operating times, a faster recovery, superior post operative functional scores, and better subjective assessment of outcome as compared with that of total meniscectomy. But no reduction in the incidence of post operative osteoarthritis has been demonstrated in the short term. The only prospective randomized long term follow up comparing partial and total meniscectomy showed better functional results of partial resection. However it did not show better results with regards to the development of radiological OA.¹¹ Andersson and Karlson¹² report that the frequency of radiographic changes 14 years after meniscectomy is related to the size of the meniscus removed, but the grades of these changes are low and have little influence on activity

and knee function. Burks et al reported 88% good to excellent results of arthroscopic meniscal resection in 146 patients with isolated meniscal injury. Results were based on the Lysholm score, satisfaction index at an average follow up of 15 years.

Open Vs Arthroscopic

There is not much evidence available from randomised trials to establish whether arthroscopic surgery is better than open surgery. The choice of method depends on a surgeons' experience and patient preference with the two methods, but the potential of a skilled application of arthroscopy to limit the damage to knee structures and enhance the rate of recovery makes arthroscopy an attractive option. Many investigations have directly compared the results of arthroscopic and open technique for meniscal resection showing that outcome with the former is better than with both open partial and total meniscectomy.

With better understanding of the benefits of preservation of intraarticular structures, the new measuring stick for interpretation of results after arthroscopic meniscectomy is meniscal repair.

REPAIR OF MENISCUS

During the last decade the approach to meniscal repair has significantly evolved and continues to expand. This is mainly because of the recent advances and continuing work which have contributed to a greater understanding of the anatomic structure, biomechanical function, and importance of meniscal tissue in joint load distribution, stability, and congruence as well as cartilage homeostasis and proprioception.¹³ The indications for meniscal repair include the position and pattern of the tear, the age of the tear, the age of the patient, their expected compliance with postoperative instructions and their activity levels and occupation. Traditionally meniscal repair is reserved for young, compliant patients with acute (< 8 weeks) peripheral longitudinal tears which lie within the vascular zone of the meniscus and occur in otherwise stable or concomitantly reconstructed knees. Repaired meniscal tears heal if there is adequate blood supply. Recent studies have demonstrated that meniscal repair can be successfully achieved with tears in less vascular zones (White-White tears), more complex geometric configurations, and isolated tears in younger patients (discoid variants).¹⁴ The potential to biologically augment these at risk repairs has been reported and continues to increase. A stable knee is also important and increased healing rates have been seen with repairs done at same time as ACL reconstruction.¹⁵ The location of the tear in the knee can also influence the outcome of meniscal repair. There is a higher rate of healing in the medial meniscus than in the lateral meniscus. This is likely because the lateral meniscus is more mobile than the medial meniscus. In addition, there is less vascularity in the periphery of the lateral meniscus because of the presence of the popliteal hiatus.¹⁶ There is currently no reliable treatment option that addresses tears located in the inner two third of the meniscus, although repair of tears in this area have been attempted.¹⁷ Kocabey et al¹⁸ repaired 29 menisci in the red-red zone and 26 in the red-white zone with excellent results at 12 months. Some authors¹⁷ have reviewed the healing potential of tears extending into the avascular zone in patients age 40 years or older and in patients aged 20 years and younger. In the older cohort, 93% of tears were asymptomatic for tibiofemoral joint symptoms. On second look arthroscopy, only one out of six tears was completely healed, two were partially healed, and three had failed. Comparable results were obtained with the younger patient cohort.

SURGICAL TECHNIQUES

Meniscus repair can be achieved by numerous techniques including

open and arthroscopic-assisted inside-out methods as well as arthroscopic outside-in and all-arthroscopic meniscus repair methods.¹⁹⁻²¹ The arthroscopic-assisted inside-out meniscus repair technique popularized by Henning has enjoyed the most clinical experience and documentation in the literature.²⁰ It has been referred to as the “gold standard” against which more recent techniques have been compared based on published biomechanical studies that have documented superior repair construct strength using single and double vertical mattress suture configurations.²²⁻²⁶ It may be better considered a benchmark against which newer all-arthroscopic methods may be compared. Although inside-out repairs are associated with the potential for optimal repair strength, disadvantages include extended operative times, the need for accessory incisions, open dissection, and potentially more postoperative pain and morbidity related to stiffness and neurovascular injury .

IMPLANT FIXATORS

Many meniscal repair devices are now available that enable an all-arthroscopic approach to stabilizing tears. These devices have made meniscal repair truly arthroscopic, easier, quicker, associated with less surgical dissection (no accessory incisions), less pain and less need for operating room assistance. It is necessary to emphasize that precise indications must be adhered to when using these all-arthroscopic fixator devices to repair meniscal tears. The more rigid first-generation implant devices based on a reverse-barbed fish hook design (with or without crossbar anchors or screw threads) are indicated only for repair of vertical longitudinal red-red and red-white meniscal tears located in the posterior horn of the menisci. This is because these devices reduce and hold the meniscal tear site apposed by achieving purchase on both sides of the torn meniscal fragment. Unequal “barb” or “screw” distribution due to improper insertion positioning or placement in more complex or peripheral tears can lead to device failure through pull-through or pull-out. The technique of repairing meniscal tears using fixators is similar for most devices in that after preparation of the tear site, and potentially provisional reduction, the tear distance from the periphery is assessed and measured, which allows selection of the appropriately sized fixator length. The fixators are inserted perpendicular to the tear, bridging (preferably equally) the two meniscal fragments and stabilizing them with the device held in place by the barbs, threads, or cross bar. It is essential that there be enough meniscal tissue on both sides of the tear in order for the device to function optimally. Extreme care must be taken to ensure that the fixator head is parallel to the joint surface and seated flush or countersunk to the surrounding surface of the meniscus to reduce the chance of articular cartilage injury. Suture-Based Devices The various implant fixators that have been introduced share a similar design in that they function for the most part as relatively rigid devices that bridge a meniscus tear site in the manner of a “straight pin” reducing and holding the tear edges apposed to allow for healing. Due to early case reports of problems of foreign body synovitis, retained and painful fragments and chondral scuffing and injury, as well as published laboratory studies indicating that many of these devices provide inferior fixation strength compared to vertical mattress suture configurations, improved designs have been sought.^{27,28} In response to these concerns and in the interest of reducing morbidities and increasing biomechanical strength, second-generation devices have been released that incorporate all-arthroscopic techniques and hybrid bioabsorbable fixator/anchor and suture constructs. Several of these newer self-adjusting suture devices are based on the arthroscopic delivery of extended resorption or nonabsorbable braided polyester suture across the tear site using pretied, sliding knot configurations that allow for clinching of the

interposed and interconnected suture between two anchoring implants.

REPAIR AUGMENTATION METHODS

Use of it is mainly indicated in cases of isolated (no concomitant ACL reconstruction) meniscus repair in which concerns exist regarding healing, (ie, avascular tears, complex tears, or bucket-handle tears associated with a deformed tissue edge) then augmentation techniques to enhance vascularization and improve the biological milieu should be considered. Authors have earlier established that meniscus repair performed at the time of ACL reconstruction is associated with a higher healing rate than isolated repair.²⁹ Studies have demonstrated that meniscus healing relies on vascular access and ingrowth, production of a chemotactic and mitogenic fibrin clot or matrix that supports an inflammatory fibrovascular scar and a reparative fibroblastic proliferative healing response.³⁰ Several methods may be used to mechanically enhance the vascular supply and locally enrich and concentrate the fibrin clot scaffold.³¹

TREPINATION

Trepination involves creation of small vascular access channels using a 22-gauge spinal needle in the meniscus. The needle is placed through the portals of the skin and pierces the periphery of the meniscus at 5-mm intervals traveling radially through the meniscus and tear site. Caution should be taken to avoid piercing the meniscal surface, and overpenetrating and further injuring the tissue. Trepination promotes vascular access channels, enabling capillary ingrowth from the more vascularized peripheral tissues to the otherwise avascular inner third of the meniscus.³²

FIBRIN CLOT TECHNIQUE

It includes insertion of an exogenous autologous fibrin clot is based on the concept of promotion of tear site healing by introducing a concentrated autologous platelet-rich matrix with associated biological factors that may act as chemical mediators for tissue repair and as well as an adherent mechanical scaffold. Various methods for preparation and insertion of a fibrin clot have been reported and clinical evidence has documented increased healing rates in isolated tears and avascular treated with fibrin clot.³¹

PLATELET-RICH FIBRIN MATRIX

Much attention has been given recently to refined techniques that produce a more concentrated and volume stable fibrin matrix that is rich in trapped platelets and associated growth factors (platelet-derived growth factor, transforming growth factor beta, epidermal growth factor, fibroblast growth factor, vascular endothelial growth factor and endothelial cell growth factor).

REPLACEMENT OF MENISCUS

Indicated in cases where meniscus tears cannot be successfully repaired Meniscus transplantation has been shown to be an acceptable procedure for younger patients.^{33,34} The primary candidate is a patient younger than age 50 years who has had a total meniscectomy and who either has pain in the tibiofemoral component, arthroscopic evidence of articular cartilage deterioration or both. Contraindications are advanced knee joint arthrosis, with flattening of the femoral condyle, concavity of the tibial plateau and osteophytes that prevent anatomic seating of the meniscus allograft; axial malalignment, knee joint instability; knee arthrofibrosis; muscular atrophy; and prior joint infection.

POSTOPERATIVE PROTOCOLS

Patients are placed in a postoperative brace or knee immobilizer in

the operating room locked in extension to facilitate ambulation and transferring.³⁵ It is discontinued when the patient has adequate leg control usually within three weeks. Weight is allowed in extension initially on crutches and then advanced as comfort allows with full weight-bearing encouraged when pain and effusion subsides and quadriceps firing is adequate usually at 3 to 4 weeks. Range of motion 0°-90° is encouraged immediately on postoperative day one. Progression of motion particularly in terminal flexion is encouraged depending on the repair site, size, geometry, and strength. Large, deformed, bucket-handle tears extending through to the posterior horns and considered "at risk" repairs are progressed more slowly over the first 2 months from the standpoint of terminal flexion and loading and squats beyond 90°. A functional rehabilitation protocol is followed progressing each patient dependent on comfort with range of motion, restoration of strength, and ultimately ability to perform agility and functional as well as sport-specific drills. Return to sports is usually at 4 to 6 months when appropriate functional goals are reached and the patient no longer has point tenderness over the repair site.

COMPLICATIONS

The problems encountered with the use of arthroscopic fixators includes pull-out and pull-trough device failure with migration and breakage, cystic hematoma, foreign body reaction, transient soft-tissue inflammation, and chondral injury.³⁶ The issue of chondral abrasion secondary to meniscal implant fixators is particularly worrisome and has prompted a trend towards using lower profile devices as well as newer hybridized suture-based systems. All arthroscopic repair techniques are associated with significant learning curves.

RESULTS

Many Authors have published outcomes after meniscal repair for the various discussed techniques.

Open repair

DeHaven et al¹⁹ reported 100% retrieval of 33 patients, average age 18.9 years, average 10.9 year follow-up (range: 10.1-13 years) treated with open meniscal repair and noted a 79% long term survival rate.

Inside Out

Early reports of results after the inside-out repair technique were reported by Scot et al²⁰ in 260 repairs performed in 240 patients, average age 22 years, average follow-up of almost 2 years. Concomitant ACL reconstruction was performed in 80% of cases. The results indicated that 62% of repairs were healed on arthroscopic second look or by arthrogram compared to 17% incompletely healed and 21% not healed. Of note, based on clinical and subjective evaluation, 92% were stable and 80% returned to active sports. In a comprehensive review of 117 consecutive inside-out repairs by Cannon²⁹, 90 patients were reported: 68 repairs with concomitant ACL reconstruction and 22 isolated repairs.²⁵ Overall rate of clinical success was 82% with 93% of the ACL associated cases successful compared to 50% of the isolated cases.

Outside-in

Outside-in technique results have been published by Rodeo²¹ who found that in 90 patients, average age 25 years, average follow-up of 46 months (range: 36-89 months), overall 87% had a successful outcome. 17 Failure was noted in 38% of the unstable knees, 15% of the stable knees, and 5% of the ACL-reconstructed knees.

Implant fixators

The vertical FasT-Fix group had been found to be better with comparatively less displacement (primarily repair site gapping) and greater relative stiffness.³⁷

Results of 280 meniscal repairs (RapidLoc [DePuy Mitek, Raynham, MA] in 88 patients, T-Fix [Acufex Microsurgical, Mansfield, MA] in 85 patients, and FasT-Fix [Smith & Nephew Endoscopy, Andover, MA] in 92 patients) were evaluated by Kalliakmanis et al. They found that these meniscal repair systems appeared to be safe and effective and provided a high rate of meniscal healing both in patients with complex tears and in patients with tears located in Cooper radial zone 2.³⁸

Petsche et al³⁹ reported on a single surgeon's experience with the Meniscus Arrows in 29 patients, average age 29 years, average follow-up 24 months after meniscal repair surgery. He found a 7% incidence of failure and in 5 patients, mild subcutaneous irritation was noted, which resolved within 3 to 7 months. Sgaglione²⁸ reported on a consecutive series of 109 meniscal repairs performed using an all-arthroscopic hybrid technique using the Meniscus Arrow and the T-Fix system. The study group was followed prospectively; average patient age was 28 years (range: 15-49 years) and the average follow-up 3.2 years (range: 2-4.4 years). The Meniscus Arrow was used exclusively for the repair in 55% of patients while Arrows and the T-Fix were used in 45% of patients. An associated ACL reconstruction was performed in 72 (60%) patients while an isolated repair was performed in 37 (40%) patients. All isolated repairs were treated with an autologous fibrin clot technique. No difference was noted in outcome between the Arrow alone group compared to the hybrid group. The overall failure rate, defined as the need to return for meniscal surgery, was 5.5% with the isolated repair patients noted to have 4 failures (10.8%) while in the ACL reconstructed patients; there was a failure rate in 2.7% (2) patients.

SUMMARY

Proper patient selection is the key for a successful meniscal repair. The patients must be thoroughly explained regarding the procedure and prognosis. As the techniques and devices continue to improve, the decision to select one technique or techniques over another should ultimately be based on the sound evaluation and experience associated with a particular device and its safety and potential efficacy. All repair methods are associated with their own particular learning curves. In general, meniscal fixators and implants should be used for vertical, longitudinal red-white tears that are not peripheral detachments and are associated with at least a 2-3 mm rim width to provide optimal tissue contact. Newer all-arthroscopic suture-based systems as well as inside-out or outside-in suture may be best used for repair of more complex tear patterns or less vascular tears with less optimal tissue viability or with significant deformity or deformation as seen in large displaced bucket-handle tears. In addition in cases of peripheral capsular detachment of the meniscus or in repairing meniscal allografts, suture should be used.

FUTURE PROSPECTS

Molecular biology, polymer science, gene therapy and bioactive proteins that augment repair mechanisms are the prospects on which the future depends to provide improved biological solutions for meniscal repair and increased capability to regenerate meniscal tissue.^{40,41} Harnessing growth factors through control of dosing, delivery and release mechanisms have been shown to enhance healing, speed up recovery and simplify postoperative protocols.⁴² Gene-modified tissue engineering methods are also being investigated

to enhance meniscal healing.⁴³

REFERENCES

1. **Arnoczky SP, Warren RF.** The microvasculature of the meniscus and its response to injury: An experimental study in the dog. *Am J Sports Med.* 1983; 11: 131-141.
2. **Englund M.** The role of the meniscus in osteoarthritis genesis. *Rheum. Dis. Clin. North Am.* 2008; 34: 573-579.
3. **Wojtyls EM, Chan DB.** Meniscus structure and function. *Instr. Course Lect.* 2005; 54: 323-330.
4. **Walker PS, Erkman MJ.** The role of the menisci in force transmission across the knee. *Clin. Orthop. Relat Res.* 1975; 184-192.
5. **Bray RC, Dandy DJ.** Meniscal lesions and chronic anterior cruciate ligament deficiency: Meniscal tears occurring before and after reconstruction. *J Bone Joint Surg Br* 1989; 71: 128-30.
6. **Cimino PM.** The incidence of meniscal tears associated with acute anterior cruciate ligament disruption secondary to snow skiing accidents. *Arthroscopy* 1994; 10: 198-200.
7. **Binfield PM, Maffulli N, King JB.** Patterns of meniscal tears associated with anterior cruciate ligament lesions in athletes. *Injury* 1993; 24: 557-61.
8. **Naranje S, Mital R, Nag H, Sharma R.** Arthroscopic and magnetic resonance imaging evaluation of meniscus lesions in the chronic anterior cruciate ligament-deficient knee. *Arthroscopy* 2008; 24: 1045-1051.
9. **Turman KA, Diduch DR.** Meniscal repair: indications and techniques. *J. Knee. Surg.* 2008; 21: 154-162.
10. **Messner K, Gao J.** The menisci of the knee joint. Anatomical and functional characteristics, and a rationale for clinical treatment. *J. Anat.* 1998; 193 (Pt 2): 161-178.
11. **Hede A, Larsen E, Sandberg H.** Partial versus total meniscectomy: a prospective randomized study with long term follow-up. *J Bone Joint Surg Br.* 1992; 74: 118-20.
12. **Andersson-Molina H, Karlsson H, Rockborn P.** Arthroscopic partial and total meniscectomy: A long-term follow-up study with matched controls. *Arthroscopy* 2002; 18: 183-189.
13. **Sgaglione N.** Meniscus repair update: current concepts and new techniques. *Orthopedics.* 2005; 28: 3: 280-7.
14. **Rubman MH, Noyes FR, Barber-Westin SD.** Arthroscopic repair of meniscal tears extending into the avascular zone. A review of 198 single and complex tears. *Am J Sports Med.* 1998; 26: 87-95.
15. **Tenuta JJ, Arceiro RA.** Arthroscopic evaluation of meniscal repairs, factors that affect healing. *Am J Sports Med.* 1994; 22: 6: 797-802
16. **Adams S, Randolph M, Gill T.** Tissue engineering for meniscus repair: The journal of knee surgery. 2005; 18: 1: 25-31.
17. **Noyes FR, Barber-Westin SD.** Arthroscopic repair of meniscal tears extending into the avascular zone in patients younger than 20 years of age. *Am J Sports Med.* 2002; 30: 589-99.
18. **Kocabe Y, Nylund J, Isbell W, Caborn N.** Patient outcome following T-Fix meniscal repair and a modifiable, progressive rehabilitation program, a retrospective study. *Arch Orthop Trauma Surg.* 2004; 124: 9: 592-6.
19. **DeHaven KE, Lohrer WA, Lovelock JE.** Long term results of open meniscal repair. *Am J Sports Med.* 1995; 23: 524-530.
20. **Scott GA, Jolly BL, Henning CE.** Combined posterior incision and arthroscopic intra-articular repair of the meniscus. An examination of factors affecting healing. *J Bone Joint Surg Am.* 1986; 68: 847-861.
21. **Rodeo SA.** Arthroscopic meniscal repair with use of the outside-in technique. *Instr Course Lect.* 2000; 49: 195-206.
22. **Zantop T, Eggers KA, Weimann A, Hassenpflug J, Petersen W.** Initial fixation strength of flexible all-inside meniscus suture anchors in comparison to conventional suture technique and rigid anchors: biomechanical evaluation of new meniscus refixation systems. *Am J Sports Med.* 2004; 32: 863-869.
23. **Barber FA, Herbert MA, Richards DP.** Load to failure testing of new meniscal repair devices. *Arthroscopy.* 2004; 20: 45-50.
24. **Borden P, Nylund J, Caborn DN, Pienkowski D.** Biomechanical comparison of the Fast-Fix meniscal repair suture system with vertical mattress sutures and meniscus arrows. *Am J Sports Med.* 2003; 31: 374-378.
25. **Becker R, Schroder M, Starke C, Urbach D, Nebelung W.** Biomechanical investigations of 21. different meniscal repair implants in comparison with horizontal sutures on human meniscus. *Arthroscopy.* 2001; 17: 439-444.
26. **Barber FA, Herbert MA.** Meniscal repair devices. *Arthroscopy.* 22. 2000; 16: 613-618.
27. **Sgaglione N.** New generation meniscus fixator devices. *Sports Med Arthro Rev.* 2004; 12: 1-16.
28. **Sgaglione NA.** Meniscus repair: update on new techniques. *Techniques in Knee Surgery.* 2002; 1: 113-127.
29. **Canon W, Vittori J.** The incidence of healing in an arthroscopic meniscal repairs in anterior cruciate ligament-reconstructed knees versus stable knees. *Am J Sports Med.* 1992; 20: 176-181.
30. **Port J, Jackson DW, Lee TQ, Simon TM.** Meniscal repair supplemented with exogenous fibrin clot and autologous cultured marrow cells in the goat model. *Am J Sports Med.* 1996; 24: 547-555.
31. **Henning CE, Yearout KM, Vequist SW, Stallbaumer RJ, Decker KA.** Use of the fascial sheath coverage and exogenous fibrin clot in the treatment of complex meniscal tears. *Am J Sports Med.* 1991; 19: 626-631.
32. **Okuda K, Ochi M, Shu N, Uchio Y.** Meniscal rasping for repair of meniscal tear in the avascular zone. *Arthroscopy.* 1999; 15: 281-286.
33. **van Tienen TG, Hannink G, Buna P.** Meniscus replacement using synthetic materials. *Clin. Sports Med.* 2009; 28: 143-156.
34. **Pasa L, Pokorny V, Kalandra S, Melichar I, Bilik A.** Transplantation of deep frozen menisci. *Acta Chir Orthop. Traumatol. Cech.* 2008; 75: 40-47.
35. **Sgaglione NA, Steadman JR, Shaffer B, Miller MD, Fu FH.** Current concepts in meniscus surgery: resection to replacement. *Arthroscopy.* 2003; 19: 161-188.
36. **Jones HP, Lemos MJ, Wilk RM, Smiley PM, Gutierrez R, Schepsis AA.** Two-year follow-up of meniscal repair using a bioabsorbable arrow. *Arthroscopy.* 2002; 18: 64-69.
37. **Nylund J, Chang H, Kocabe Y, Nawab A, Brand J, Caborn DN.** A cyclic testing comparison of Fast-Fix and RapidLoc devices in human cadaveric meniscus. *Arch. Orthop. Trauma Surg.* 2008; 128: 489-494.
38. **Kalliakmanis A, Zourntos S, Bousgas D, Nikolaou P.** Comparison of arthroscopic meniscal repair results using 3 different meniscal repair devices in anterior cruciate ligament reconstruction patients. *Arthroscopy* 2008; 24: 810-816.
39. **Petsche TS, Selesnick H, Rochman A.** Arthroscopic meniscus repair with bioabsorbable arrows. *Arthroscopy.* 2002; 18: 246-253.
40. **Sapleton TW, Ingram J, Katta J, Knight R, Korossis S, Fisher J, Ingham E.** Development and characterization of an acellular porcine medial meniscus for use in tissue engineering. *Tissue Eng Part A* 2008; 14: 505-518.
41. **Kon E, Chiari C, Marcacci M, Delcogliano M, Salter DM, Martin I, Ambrosio L, Fini M, Tschon M, Tognana E, Plasenzotti R, Nehrer S.** Tissue engineering for total meniscal substitution: animal study in sheep model. *Tissue Eng Part A* 2008; 14: 1067-1080.
42. **Tumia NS, Johnstone AJ.** Promoting the proliferative and synthetic activity of knee meniscal fibrochondrocytes using basic fibroblast growth factor in vitro. *Am J Sports Med.* 2004; 32: 915-920.
43. **Goto H, Shuler FD, Lamsam C, et al.** Transfer of LacZ marker gene to the meniscus. *J Bone Joint Surg Am.* 1999; 81: 918-925.

DRUG PROFILE

Naftopidil

Background: In the past Alpha- AR blockers were mainly used as anti hypertensive agents. Around 1980, prazosin was introduced in quinazoline group which are selective α_1 receptor blocker. During various scientific studies the effectiveness of α_1 - AR blocker on BPH was discovered but major limitation of their applications are prominent first dose hypotension. Tamsulosin was introduced which is uro selective α_1A - receptors blocker. There are less episodes of postural hypotension with tamsulosin as compared to old α_1 -AR blockers. Around 1990, Naftopidil was developed as a novel anti hypertensive agents but failed to show satisfactory effects on blood pressure. Later on various molecular studies proved that Naftopidil is a $\alpha_1D/1A$ receptors blocker useful in patients of BPH. **Pharmacodynamics: Uroselectivity:** Naftopidil was found to be more potent for the V_{1D} - adrenoreceptor (AR) than for other V_1 -AR subtypes. It has approximately 17 fold higher selectivity for the $V_1 D$ -AR than for the V_{1b} subtypes so it has fewer effects on peripheral blood vessels and less chance of postural hypotension and dizziness. Alpha 1- adrenoreceptors in the urethral smooth muscle are mainly the α_1A subtype. Naftopidil has a high affinity for α_1D -AR, which is used for the treatment of LUTS associated with BPH; Naftopidil is assumed to improve urinary flow by relieving urethral pressure, which is elevated by the sympathetic nervous system, because it antagonistically suppresses the noradrenaline- induced contraction of human prostatic urethral smooth muscle. **Pharmacokinetics:** After oral administration 80%-90% dose is rapidly absorbed. The absolute bioavailability is approximately 17-20% after oral administration of 50 mg Naftopidil. The time to peak plasma concentration is approximately 0.5-1 hour post dose. If Naftopidil is given on full stomach time to peak plasma concentration is delayed but no effect on absorption and bioavailability. The steady state volume distribution (VD) of Naftopidil is 2-3.3 l/kg; plasma protein binding ranges from 70-90%. After hydroxylation in liver which yields two active metabolites 1) (phenyl) hydroxyl- naftopidil (PHN), 2) (naphthyl 1) hydroxynaftopidil (NHN). The metabolic conversion of Naftopidil is primarily consists of conjugation with glucuronidate and sulphate, whereas hydroxylation, demethylation and ether cleavage are less prominent. The pharmacological inactive metabolites of Naftopidil are mainly eliminated in urine. While pharmacologically active metabolites (PHN, NHN) are excreted in faeces. The renal clearance rate of Naftopidil is 9-11 ml/min/kg. **Indication:** Naftopidil is indicated in the treatment of BPH associated with lower urinary tract symptoms. **Dose and Administration:** The recommended dose of Naftopidil is 50mg once in a day. The dose adjustment is necessary in patients with liver impairment; no dose adjustments is needed in patients receiving hemodialysis. Adverse Effects include dizziness, abnormal ejaculation and, less frequently headache, asthenia, postural hypotension, palpitations and rihintis. Nausea, vomiting diarrhoea, and constipation can occasionally occur. Hypersensitivity reactions syncope has been reported rarely. **Drug Interactions:** Antihypertensive medication and nitrates: Co administration causes increased risk of hypotension/postural syncope.