"TO STUDY THE FUNCTIONAL OUTCOME OF TRANSTIBIAL PULL OUT TECHNIQUE FOR POSTERIOR MENISCAL ROOT TEAR IN EARLY OSTEOARTHRITIS"

Submitted by

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I hereby declare that this dissertation entitled "**TO STUDY THE FUNCTIONAL OUTCOME OF TRANSTIBIAL PULL OUT TECHNIQUE FOR POSTERIOR MENISCAL ROOT TEAR IN EARLY OSTEOARTHRITIS**" is a bonafide and genuine research work carried out by me under the guidance **of DR. S.S NANDI**, MBBS, M.S, Professor & HOD, Department of Orthopaedics at BLDE (Deemed to be University) Shri B. M. Patil Medical College Hospital and Research Centre, Vijayapura.

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ABSTRACT

Introduction: Osteoarthritis (OA) of the knee is a prevalent degenerative condition affecting various structures of the knee joint, with meniscal root tears being a significant yet often undiagnosed contributor to its progression. This study evaluates the impact of early surgical repair using the transtibial pull-out technique on meniscal root tears in patients with early osteoarthritis.

Methods: A prospective study was conducted at BLDE (Deemed to be University) Shri B. M. Patil Medical College, Hospital & Research Centre, Vijayapura, from August 2022 to December 2024. A total of 35 patients (aged 40-55) underwent arthroscopic meniscus posterior horn root repair. Patient demographics, injury history, clinical and radiological findings and intra-operative findings were documented. VAS and WOMAC scores were assessed pre-operatively and at 3, 6, and 12 months post-operatively.

Results: The study included 35 patients (77.1% female, 22.9% male). Age distribution was as follows: 42.9% were below 45 years, 37.1% were between 45-49 years, and 20% were over 50 years. Right limb involvement was observed in 60% of cases. 42.9% had a history of trauma. Intra-operatively, type 2 tears were found in 48.6%, type 4 in 8.6%, and type 5 in 42.9%. VAS scores significantly decreased from a mean of 7.26 pre-op to 2.11 at 12 months post-op (P = 0.001). WOMAC scores also significantly decreased from a mean of 45.54 pre-op to 4.80 at 12 months post-op (P = 0.001). MRI findings showed 20% of cases involved the lateral meniscus and 80% involved the medial meniscus.

Conclusion: Early surgical repair of meniscal root tears using the transtibial pull-out technique significantly improves functional outcomes and reduces pain in patients with early osteoarthritis. These findings support the importance of early diagnosis and intervention in managing meniscal root tears to slow the progression of osteoarthritis.

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LIST OF ABBREVIATIONS

OA- Osteoarthritis

BMI- Body Mass Index

MM- Medial meniscus

PM- Posterior meniscus

MTL- Meniscotibial ligament

MFC-Medial femoral condyle

MPRTs- Medial meniscus posterior root tears

LPRTs- Lateral meniscus posterior root tears

MPRA- Medial meniscus posterior root attachment

LPRA- Lateral meniscus posterior root attachment

MARA-Medial meniscus anterior root attachment

LARA-Lateral meniscus anterior root attachment

SONK- Spontaneous osteonecrosis of the knee

SIFK- Subchondral insufficiency fracture of the knee

ACL- Anterior cruciate ligament

PLC- Posterolateral corner

SA- Suture anchor repair

TA- Transtibial pull-out repair

PMMR- Posterior medial meniscus root

MMPRT- Medial meniscus posterior horn root tear

ATT- Anterior tibial translation

VAS- visual analogue scale

WOMAC- Western Ontario and McMaster Universities Arthritis Index

IKDC- international knee documentation committee

K-L- Kellgren-Lawrence

MRI- Magnetic resonance imaging

PPV- positive predictive value

NPV- negative predictive value

INTRODUCTION

Osteoarthritis of knee is one of the most prevalent degenerative diseases affecting the musculoskeletal system. This condition impacts the entire knee joint, affecting structures such as the articular cartilage, subchondral bone, synovium, ligaments, and meniscus. The global prevalence of OA knee is estimated to be 16.0% . Incidence is 203 cases per 10,000 person-years. It affects 10% of men and 13% of women over 60 years of age.[1,2]

The meniscus is a fibrocartilaginous, crescent-shaped structures with triangular cross sections that cover 70% of the articular surface of the tibial plateau. It is a fundamental component of the intricate biomechanical system of the knee. By increasing the contact surface area and ensuring even weight distribution across the articular surfaces, the meniscus plays a critical role in dispersing and absorbing the force load on weight bearing.

Meniscal root tears, sometimes referred to as a "silent epidemic," are difficult to diagnose and, if left untreated, can progress rapidly to osteoarthritis (OA). They frequently remain undetected and account for 10–21% of all meniscal tears. A meniscal root tear can occur as a whole root avulsion or as a radial tear within 9 mm of the root attachment. These tears result in meniscal extrusion and altered load distribution, which increases contact pressure and can cause insufficiency fractures (previously known as spontaneous osteonecrosis of the knee{SONK}, now termed subchondral insufficiency fracture{SIFK}). These tears also impair the meniscus's ability to convert tibiofemoral loads into hoop stresses.[3,4]

In addition, medial meniscus posterior root tears (MPRTs), which are 5.8 times more likely to be associated with knee chondral abnormalities than lateral meniscus posterior root tears (LPRTs), are 10.3 times more likely to occur in conjunction with ACL tears. Up to 21.5% of posterior horn medial meniscus tears are thought to be caused by medial meniscus posterior root tears, which are predominantly seen in middle-aged women and frequently degenerative.[5]

Meniscus damage alters the load distribution pattern and increases the risk of compartmental instability. Early osteoarthritis develops as a result of these alterations that harm the articular cartilage. [6,7]

Osteoarthritic knees can also result in a spontaneous meniscal tear and extrusion through breakdown and weakening of meniscal structure.[8]

Historically, meniscal root tears were treated with total or partial meniscectomy to achieve short-term benefits. Currently, suture anchor repair (SA) and transtibial pull-out repair (TP) are two current methods for refixing the tears in the posterior meniscus root (PMMR).[9]

Root repairs have been reported to be the treatment of choice that improves clinical outcome, decreases meniscal extrusion and slows down the onset of degenerative changes.

Transtibial repairs of meniscal root tears have a reportedly low failure rate, with an observed revision rate of 6.7% .[10,11,12]

Arthroscopic transtibial pullout is the technique used most commonly for achieving adequate root fixation.

The purpose of this study is to review the scant literature on meniscal root tears and to investigate the impact of early surgical repair using the transtibial pull-out technique on reducing the progression of osteoarthritis (OA) in conjunction with VAS and WOMAC scoring system.

AIM

To study the comparison between functional outcomes before and after transtibial root repair for the treatment of posterior horn root tears of meniscus in early osteoarthritis.

REVIEW OF LITERATURE

Fox AJ, Bedi A, Rodeo SA conducted a study on the basic science of human knee menisci: structure, composition, and function in 2012 and interpreted that the menisci of the knee joint are crescent-shaped wedges made of fibrocartilage that distribute axial strain, absorb shock, and lubricate the knee joint in addition to increasing stability to the femorotibial articulation. Meniscal injuries are known to be a major cause of musculoskeletal morbidity. Maintaining the menisci's unique composition and organisation is essential to its preservation.[13]

Fairbank T.J. conducted a study in 1948 in London, involving 107 patients who underwent meniscectomy following which the knee joint experienced ridge formation, joint space narrowing, and femoral condyle flattening. This affected the joint's mechanics and lead to early degeneration.[14]

Mesiha M et al., 2007 studied on pathologic characteristics of the torn human meniscus and found that Patient age had a significant effect on the cellularity of the torn meniscus. Menisci from people over 40 years of age may be more susceptible to degeneration and retear following repair than menisci from younger patients due to their lower cellularity.[15]

A study conducted by Englund M et al., 2007 on the Effect of meniscal damage on the development of frequent knee pain, aching, or stiffness concluded that any correlation that exists between meniscal injury and the onset of persistent knee pain in middle-aged and older persons appears to be due to the fact that OA is the cause of both pain and meniscal damage rather than a direct cause and effect relationship.[16]

In 1987, Crues 3rd JV et al., did a study on meniscal tears of the knee. Before surgery, 277 menisci in 144 knees were examined with magnetic resonance (MR) imaging. MR imaging is helpful in the non-invasive preoperative screening of suspected meniscal tears and can distinguish between surgically significant and nonsignificant meniscal lesions.[17]

In a study done by Miao Y et.al[18] Diagnostic values of 3 methods for evaluating meniscal healing status after meniscal repair in 2011 on 89 menisci found that the meniscal healing was most reliably determined by second-look arthroscopy. The diagnostic utility of clinical examination for menisci healing was clearly limited. PD and T1 had higher sensitivity on MRI examinations, whereas T2-weighted sequences had clearly higher specificity and accuracy. The adoption of many sequences in combination could increase the diagnostic value.

Baker BE et.al[19] reviewed meniscal injuries and its association with sports in1985 and concluded that men are three times more likely than women to suffer meniscal injuries that require surgery (61 per 100,000 individuals), according to a survey of meniscectomies done in Syracuse, New York, between 1973 and 1982. Comparing lateral meniscus injuries (19%) to medial meniscus injuries (81%), the former were far more common. Football (75% medial), basketball (75% medial), wrestling (55% medial), skiing (78% medial), and baseball (90% medial) were the sports with the highest variation, according to the study. Interestingly, meniscal injuries on the medial and lateral sides were nearly equally prevalent in wrestling. In comparison to male skiers, female skiers had an equivalent or increased risk of meniscal injuries, while basketball players were more likely to sustain injuries to their right knee.

In 1998, a study was done by Barrett GR on outcome after meniscus repair. The study found that meniscus repair is beneficial for peripheral meniscus tears in individuals 40 years of age and older, despite the modest number of symptomatic patients. The clinical outcomes of 86.5% of patients were satisfactory, which is comparable to findings in younger populations. According to the study, the position and kind of the tear—rather than the patient's age—are crucial variables in a successful repair, particularly when ACL reconstruction is involved.[20]

A 10 year long-term outcome of isolated arthroscopic meniscal repair was studied by Johnson MJ et al., 1999 did a retrospective analysis on a single surgeon's sequential series of 50 meniscal injuries that were surgically treated by arthroscopy in 48 individuals. A follow-up time of 10 years, 9 months was typical. The results of this study indicate that knees with isolated meniscal tears may benefit from arthroscopic meniscal repair in the long run, both clinically and radiographically.[21]

In 1995, a study conducted on 54 knees by Eggli.S et.al.,[22] on long-term results of arthroscopic meniscal repair for isolated meniscus tears suggested that arthroscopy repair is a useful treatment for isolated meniscal tears, despite the 27% overall failure rate in this series. The first six months following repair are when most breakdowns happen. Tears that are treated with non-resorbable suture material and those that occur in the outer third of the meniscus show noticeably higher healing rates. We currently highly discourage utilising resorbable sutures by themselves. In 90% of the menisci that had healed, the clinical long-term examination revealed normal knee function. In injuries with Grade 3 and 4, MRI signals are persistent and make it difficult to assess meniscal recovery.

Longo UG et al.,[23] did a study on knee osteoarthritis after arthroscopic partial meniscectomy where the prevalence and progression of radiographic changes after 5 to 12 years compared with contralateral knee in New York, USA. Researchers looked at 57 patients (38 men and 19 women) who had pre- and postoperative weight-bearing radiography and followed up for five to twelve years. They discovered that patients in the group with degenerative tears, obesity, and overweight had a higher risk of developing osteoarthritis (OA) in the patellofemoral and tibiofemoral compartments following meniscectomy.

Bedi A et al., studied the Dynamic contact mechanics of the medial meniscus as a function of radial tear repair and partial meniscectomy in 2010 and concluded that the treatment of radial meniscal tears aims to prevent future degenerative disease by preserving the meniscus whenever possible. Historically, radial tears that reach the periphery have been thought to significantly reduce meniscal hoop strength, effectively functioning like a total meniscectomy. Consequently, partial meniscectomy, which involves removing the damaged and unstable portion of the meniscus, has been the primary surgical approach. While traditional teachings suggested that only peripheral and longitudinal tear patterns could heal after reduction and repair, recent findings indicate that other tear configurations can also heal if the meniscal rim is properly prepared, carefully sutured, and biologically augmented. It remains uncertain whether there is a specific "critical size" of radial tears in the medial meniscus that leads to harmful biomechanical effects in the affected compartment.[24]

Terzidis IP et al., conducted an arthroscopic evaluation on meniscal tear characteristics in young athletes with a stable knee which concluded that vertical tears, particularly the bucket-handle tear, seem to occur most frequently in athletes with isolated meniscal lesions. While 23.2% of the tears were in the vascular zone, the majority of the tears were localised in one radial zone. When it came to kind, location, and side, the frequency of meniscal lesions in sports where a large number of female athletes competed was comparable to that of male competitors. Knowing that the position and kind of meniscal tears in an isolated athlete's knee differ from those in an ACL-deficient knee can help determine which surgical approach is most likely for that athlete.[25]

Persson F et al., studied the risk of symptomatic knee osteoarthritis after arthroscopic meniscus repair vs partial meniscectomy vs the general population. In this study patients were identified from 1998 to 2010 in southern Sweden and followed up till 2015. They concluded that there was a 25-50% reduction in consultation rate for osteoarthritis(OA) of knee after meniscus repair in comparison to Arthroscopic partial meniscectomy(APM). In contrast to the general population, the consultation rate for knee OA following repair remained at least twice as high.[26]

A study done in 2010 on 58 patients by Kim SB et al., based on Medial meniscus root tear refixation and found out that an MRI and second-look arthroscopy revealed sound healing with restoration of the meniscus's hoop tension, and arthroscopic pullout repair of a medial meniscal reconstruction produced noticeably superior clinical and radiologic outcomes than partial meniscectomy. We suggest that medial MRT can be effectively treated with this approach.[27]

Englund M et al., studied the Impact of type of meniscal tear on radiographic and symptomatic knee osteoarthritis and concluded that at 16-year follow-up, there is a significant risk of radiographic and symptomatic tibiofemoral OA in patients with isolated meniscal tears treated with minimal meniscectomy. Degenerative meniscal lesions and large resections were related with worse outcomes. We propose that meniscal tears with degenerative characteristics could be linked to early OA, and that these tears indicate the onset of the condition.[28]

A cohort study was conducted in 2007 on Meniscal tear as an osteoarthritis risk factor in a largely non-osteoarthritic knee by Ding C et.al - Significantly, meniscal tears are linked to radiographic OA prevalence, loss of cartilage volume, cartilage defect, and altered bone size. This suggests that, in non-OA subjects, meniscal tears appear to be an early event in the disease process and may be a risk factor for articular structural changes and damage to knee cartilage.[29]

In 2015, Matheny LM et al., conducted a study on Posterior meniscus root tears and found that the preoperative functional scores and activity levels of the individuals in this study were low. An ACL tear was more common in patients with lateral meniscal root injuries. The likelihood of a knee articular cartilage defect with an Outerbridge grade 2 or greater chondral defect was increased in patients with medial meniscal root tears. This study supports the notion that accurate diagnosis of meniscus root tears requires a thorough evaluation of concurrent injuries.[30]

In 2015, LaPrade RF et al., conducted a study on recent advances in posterior meniscus root repair techniques and said that repairing a posterior meniscal root tear is essential due to the adverse effects of meniscal root deficiency. Biomechanical studies indicate that the transtibial pullout repair can restore tibiofemoral contact mechanics. However, enhancements in the transtibial pullout and suture anchor techniques are needed to prevent nonanatomic displacement post-repair. Early clinical outcomes are inconsistent, likely because some patients included in studies were not ideal candidates for meniscal root repair. Meniscal root repair is advisable for patients without advanced osteoarthritis (grade 3 or 4), joint-space narrowing, or malalignment.[31]

The transtibial pullout repair is preferred due to its technical simplicity and its ability to facilitate a more accurate and reproducible anatomic root repair. Future biomechanical research should focus on optimizing both the transtibial pullout and suture anchor techniques. Additionally, prospective comparative clinical studies are necessary to evaluate the effectiveness of current and future repair techniques.[31]

A study on biomechanical evaluation of the transtibial pull-out technique for posterior medial meniscal root repairs using 1 and 2 transtibial bone tunnels was done by LaPrade CM et al., in 2015 which inferred that in a human cadaveric model, similar biomechanical properties were observed between transtibial pull-out repairs using either one or two transtibial bone tunnels. Both repair methods exceeded the 3-mm threshold for nonanatomic displacement. The study suggests that the newly proposed version of the transtibial pull-out repair technique, which employs a second transtibial tunnel to potentially restore more of the posterior medial meniscal root, was nearly identical in performance to the current standard technique using a single transtibial tunnel. As the significance of repairing meniscal root tears becomes more widely acknowledged, further research on new iterations of both techniques is needed to reduce the risk of displacement caused by early motion during the initial postoperative rehabilitation period.[32]

Geeslin AG et al., conducted a cadaveric study assessing the Influence of lateral meniscal posterior root avulsions and the meniscofemoral ligaments on tibiofemoral contact mechanics- In this study ten fresh-frozen cadaveric knees were tested under six different conditions (1: intact; 2: lateral meniscal posterior root avulsion; 3: root avulsion with deficient meniscofemoral ligaments (MFLs); 4: condition 3 with ACL tear; 5: condition 4 with ACL reconstruction; 6: ACL reconstruction with root repair) at five flexion angles (0°, 30°, 45°, 60°, and 90°) under a 1000-N axial load. The meniscofemoral ligaments help protect the lateral compartment from alterations in contact mechanics when a lateral meniscal posterior root avulsion occurs. However, significant changes occur when both the lateral meniscal root is avulsed, and the MFLs are deficient. Combining ACL reconstruction and lateral meniscal root repair restores mean contact pressure and area to their intact state. This combined approach is recommended for such injuries to prevent or slow down the progression of lateral compartment arthritis.[33]

A retrospective study on non-operative treatment of degenerative posterior root tear of the medial meniscus was done in 2010 by Lim HC, Bae JH, Wang JH, Seok CW, Kim MK at Korea University College of Medicine, Guro Hospital. They examined thirty patients with medial meniscus degenerative posterior root tears in order to look back at the clinical outcomes of non-operative treatment. Non-steroidal anti-inflammatory medications were administered daily for 8–12 weeks, along with twice-weekly, minimum, supervised physical therapy for a duration of 8 weeks, as non-operative treatments. Within three months, the majority of patients had a reduction in both the intensity and frequency of their mechanical pain. In summary, our research showed that in the majority of patients with degenerative posterior root tears of the medial meniscus, non-operative therapy resulted in symptomatic alleviation and functional improvements during a brief follow-up period. At the 12-month follow-up, the clinical outcome had improved; however, at the final follow-up, it had decreased to a level that was still better than the original scores.[34]

Jung YH et.al in 2012 conducted a case series at Eulji Medical Centre, Seoul, Korea on All-inside repair for a root tear of the medial meniscus using a suture anchor. In this study a suture anchor was used to do an all-inside repair on thirteen individuals who had a medial meniscus root tear. The McMurray test, joint line discomfort, and subsequent magnetic resonance imaging (MRI) were the physical examination criteria used for the postoperative evaluation of meniscal health. Tegner activity level and Lysholm knee score were used to conduct functional evaluations. Six months after surgery, follow-up MRI scans were acquired to assess the repair of the root tear and quantify the extrusion of the medial meniscus midbody. This study showed relief in symptoms following meniscal root surgery with a suture anchor.[35]

35 patients were investigated by Furumatsu T et al., at Okayama University Graduate School, Okayama, Japan in 2017 for Meniscal extrusion following medial meniscus posterior root tear. In this study, the absolute and relative MMEs at this early period were 3.0 mm and 32.7%, respectively. The subacute and chronic phases saw increases in absolute MME of up to 4.2 mm and 5.8 mm, respectively. Additionally, in the subacute and chronic phases, relative MME increased to 49.2% and 60.3%, respectively. This investigation showed that both the absolute and relative MME gradually rose in the brief time following the onset of symptomatic MMPRT. According to our findings, it might be crucial to diagnose the MMPRT accurately soon after it starts in order to stop the MME from increasing after it does.[36]

Feucht MJ et al., conducted a study on biomechanical comparison between suture anchor and transtibial pull-out repair for posterior medial meniscus root tears in 2014 and concluded that the suture anchor technique provided superior biomechanical properties compared with the transtibial pull-out repair technique under cyclic loading conditions and load-to-failure testing. Both repair techniques were significantly weaker. This finding underlines the need for a slow rehabilitation program after repair of the PMMR to avoid early failure.[37]

A prospective comparison study on arthroscopic suture anchor repair versus pullout suture repair in posterior root tear of the medial meniscus was conducted by Kim JH et.al at Centre for Joint Disease, Department of Orthopaedic Surgery, School of Medicine, CHA Bundang Medical Centre, Sung-Nam Si, South Korea. In this study 51 patients were included and followed up for 2 years and the results suggest that both the suture anchor repair and pullout suture repair groups experienced considerable functional improvement for the posterior root tear of the medial meniscus. Once the root area has fully healed, reducing meniscal extrusion appears to be the best way to maintain its protective function against the advancement of cartilage degeneration.[38]

In Steadman Philippon Research Institute, Vail, Colorado, USA, Cinque ME et al., in 2017 researched about the Two-tunnel transtibial repair of radial meniscus tears versus inside-out repair of vertical meniscus tears. Twenty-seven patients underwent 2-tunnel transtibial pullout repair for radial meniscus tears and 33 patients underwent inside-out repair for vertical meniscus tears. Significantly better clinical results were obtained with two-tunnel repair of radial meniscus injuries. Based on early clinical findings and biomechanical testing, two-tunnel repair of radial meniscus tears is a promising treatment option for this injury pattern.[39]

A study on outcomes of an anatomic transtibial pull-out technique for Posterior meniscal root repairs done in 2017 by LaPrade RF et al., at at the Steadman Philippon Research Institute, Vail, Colorado, USA concluded that regardless of age or meniscal laterality, outcomes following posterior meniscal root surgery showed a considerable improvement in the postoperative period, and patient satisfaction was high. Patients under 50 years old and those who received medial rather than lateral root repairs experienced similar results. Improved function, reduced discomfort, and increased activity following transtibial double-tunnel pull-out meniscal root repair may help postpone the advancement of osteoarthritis in the knee.[40]

Chung KS et al., in Korea conducted a 5-to 10-year follow-up study on survivorship analysis and clinical outcomes of transtibial pullout repair for medial meniscus posterior root tears. 91 patients were included, and clinical outcomes were assessed based on a comparison of patient preoperative Lysholm scores and their scores at the final follow-up. Based on mid- and long-term follow-up assessments, transtibial pullout repair showed a high clinical survival rate among medial meniscus posterior horn root tear (MMPRT) patients and the patients showed clinical improvement.[41]

A multi-centre study including 45 patients to analyse the prospective consecutive clinical outcomes after transtibial root repair for posterior meniscal root tears was conducted by Krych AJ et al., in 2022. At two years after surgery, transtibial root repair for medial and lateral posterior meniscal root rips showed noticeably better clinical results. Ages greater than or equal to 50 years old and meniscal extrusion had a detrimental influence on patient activity level, although higher age, increased BMI, cartilage status, and meniscal extrusion did not significantly affect short-term functional outcomes (IKDC) (Tegner).[42]

A meta-analysis of clinical and radiographic outcomes of posterior horn medial meniscus root repairs has been done by Chung KS et al., in 2016 at Korea came with a conclusion that the benefits of medial meniscus posterior horn root tear(MMPRT) repair, including the improvement of the Lysholm score, the reduction of meniscal extrusion (mm), the advancement of the Kellgren-Lawrence (K–L) grade, and the cartilage state based on the Outerbridge classification, were examined by pooling pre- and post-operative data. When compared to the preoperative status, MMPRT repair produced statistically significant improvements in the post-operative clinical subjective evaluations. It did not entirely stop the progression of arthrosis, given the frequency of K–L grade progression and cartilage state. Although there was a decrease in meniscus extrusion, it was not statistically significant. These findings suggest that repair has positive effects on MMPRT.[11]

Steineman BD et al., did a study on loosening of transtibial pullout meniscal root repairs due to simulated rehabilitation in 2019 on 16 cadaveric knees. This study demonstrated that both single- and double-tunnel meniscal root repairs experienced considerable, irreversible loosening during rehabilitative loading. Additionally, root repairs progressively moved under stress rather than achieving equilibrium movement after 10,000 cycles. More research is necessary to fully comprehend the impact this progressive, irreversible loosening has on knee mechanics. Furthermore, to ascertain the degree to which patients are vulnerable to repair loosening, research should be done on the kind and quantity of meniscal root repair healing during the rehabilitation period. Clinical Relevance: Rehabilitative loading caused unrecoverable and progressive loosening of root repairs, showing the importance of healing before loading. Investigations on the effects of loosening on mechanics and the quality of repair healing at weight bearing are necessary to better understand the clinical implications.[44]

In 2018, Hevesi M et al., in Department of Orthopaedic Surgery, Mayo Clinic, Rochester studied Medial meniscus root repair: a transtibial pull-out surgical technique- When compared to partial meniscectomy and nonoperative care, medial meniscus root repair has been shown to have positive results in a subset of patients, including decreased incidence of osteoarthritis and total knee arthroplasty. When repairable, it is recommended because patients who receive nonoperative therapy or a partial meniscectomy have poor subjective results and quality-adjusted life years.[45]

In 2019, a study on Utilization of Transtibial Centralization Suture to Minimize Extrusion and Restore Tibiofemoral Contact Mechanics for Anatomic Medial Meniscal Root Repairs in a Cadaveric Model by Daney BT et al., delt with concerns about meniscal extrusion following a medial meniscal root repair, incorporating a centralization suture that can help reduce pathological extrusion and improve joint contact mechanics. Both the anatomic transtibial pull-out root repair and the same repair with centralization techniques were most effective in restoring knee contact mechanics and reducing meniscal extrusion, compared to root tear and nonanatomic repair conditions initially. There were no significant differences in contact pressure or extrusion magnitude between the anatomic repair alone and the repair with centralization. Extrusion was best measured in the coronal plane at the posterior border of the MCL for unloaded knees, though the degree of extrusion increased when the knee was loaded and flexed to 90°.[46]

In 2020 Dean RS, DePhillipo. N.N, Monson JK, LaPrade RF studied a surgical technique on Peripheral stabilization suture to address meniscal extrusion in a revision meniscal root repair and inferred that the use of a peripheral stabilization suture through an additional transtibial tunnel at the apex of the posterior horn may help prevent additional extrusion of the meniscal tissue outside the joint.[47]

Kim JH et al., in 2021 conducted a study at Sungkyunkwan University School of Medicine, Seoul, South Korea based on a whip running suture technique used in Arthroscopic transtibial pull-out repair of medial meniscus posterior root tear and inferred that successful outcomes in repairing medial meniscus posterior root tears (MMPRTs) depend on adequately reducing the extruded meniscus. Suture cutout at the suture-meniscus interface can lead to displacement, making it essential to minimize meniscus extrusion and optimize the medialization force from pull-out repair. This suture technique effectively reduces the extruded meniscus by applying more force directly to the posteromedial capsule and medial meniscus (MM). The running suture shares the load, minimizing cutout at the stump without immobilizing the MM or disrupting its fibres, restoring normal hoop tension. Accurate visualization of the MM root is possible using trans-septal and posteromedial portals. Limitations include potential suture abrasion, micromotion in the tibial tunnel, and cutout risk with multiple penetrations, which can be mitigated with proper techniques and precautions.[48]

In a recent study done in 2022, based on the slip knot technique for arthroscopic meniscal root repair by Chen HY, Lin KY at Kaohsiung Veterans General Hospital, Taiwan found that the biomechanical and clinical studies show that anatomic repairs of meniscal posterior root tears enhance knee function, normalize joint kinematics, and delay degeneration. However, healing outcomes are inconsistent, with varying rates of complete, partial, and failed healing. While numerous surgical techniques have been proposed, no single method has emerged as optimal. Complex sutures exhibit higher maximum loads but may not be practical in vivo. Suture tape techniques are promising due to their higher load capacity and reduced displacement. The described technique offers benefits such as using standard anterior portals, a straightforward one-step locking loop, minimized iatrogenic injury risk, and enhanced stability with Fiber Tape. It also promotes healing and preserves tibial bone stock. Limitations include persistent meniscal extrusion, interference with tibial tunnels in concurrent procedures, and potential suture cutout in fragile tissue. Further studies are necessary to confirm this method's effectiveness.[49]

In 2022, Li H, Nie S, Lan M conducted a study comparing the transtibial pull-out technique and the arthroscopically assisted meniscus root reconstruction with gracilis autograft at Department of Orthopaedic Surgery, Jiangxi Provincial People's Hospital, People's Republic of China. This study showed that the visual analogue scale (VAS), Lysholm, and international knee documentation committee (IKDC) scores all showed statistically substantial improvements ($P<0.001$ in both groups). Furthermore, at the conclusion of follow-up, the meniscus root healing rates, Lysholm score, and IKDC score significantly improved in the arthroscopically assisted reconstruction with gracilis autograft group compared to the transtibial pull-out repair group ($P < 0.05$).[50]

EMBRYOLOGY

Between the eighth and tenth week of foetal development, the menisci developed into a distinguishable, recognisable structure.. They form a connection between the cruciate ligaments and the surrounding joint capsule after originating from a condensation of the intermediate layer of mesenchymal tissue. During their development, the menisci are initially rich in cells and blood vessels. Blood vessels move to the periphery of the menisci as a result of a gradual loss in cell density and an increase in collagen content. These changes happen as the joint experiences motion and weight-bearing stress. The most notable histological changes take place between the ages of 1 to 3 years, coinciding with a child's attainment of ambulatory capabilities.[51]

ANATOMY

The knee joint consists of a medial and lateral component that are positioned between the tibial plateau and the corresponding femoral condyle.[56] The anterior and posterior segments of each meniscal curvature are referred to as a "horn," and the central region of the curvature is called the "body." The menisci are fibrocartilaginous, crescent-shaped structures that have a wedge-like cross-section. They assist the stability of the knee joint, distribute loads throughout the joint, deepen the tibial plateau, and absorb shocks..[52-54]

Menisci have a concave upper surface that matches the convexity of the femoral condyle and a flat lower surface that matches the relatively even tibial plateau in order to improve alignment between the rounded femoral condyle and the flat tibial plateau. By increasing the area of contact between the flat tibial plateau and the rounded femoral condyle during joint movement, this wedge-shaped form minimises peak pressures on the articular cartilage surfaces and allows for effective distribution of axial stresses across the joint..[55]

Together with the meniscofemoral ligaments, the main stabilising ligaments are the transverse ligament, the medial collateral ligament, and attachments at the anterior and posterior horns. The posterior horn of the lateral meniscus and the posterior cruciate ligaments insertion point on the medial femoral condyle are connected by these ligaments, also referred to as the ligaments of Humphrey and Wrisberg. Although only 46% of people have both ligaments, everyone has at least one of them.[57]

Consequently, a compromised meniscus can hasten degenerative alterations, and even removing as little as 10% of it can foster the onset of chondral lesions and diminish both subjective and objective clinical outcomes. Beyond mitigating pressures on articular cartilage, the menisci serve as secondary knee stabilizers. The medial meniscus primarily aids in anteroposterior translation, whereas the lateral meniscus helps resist rotational forces.[55]

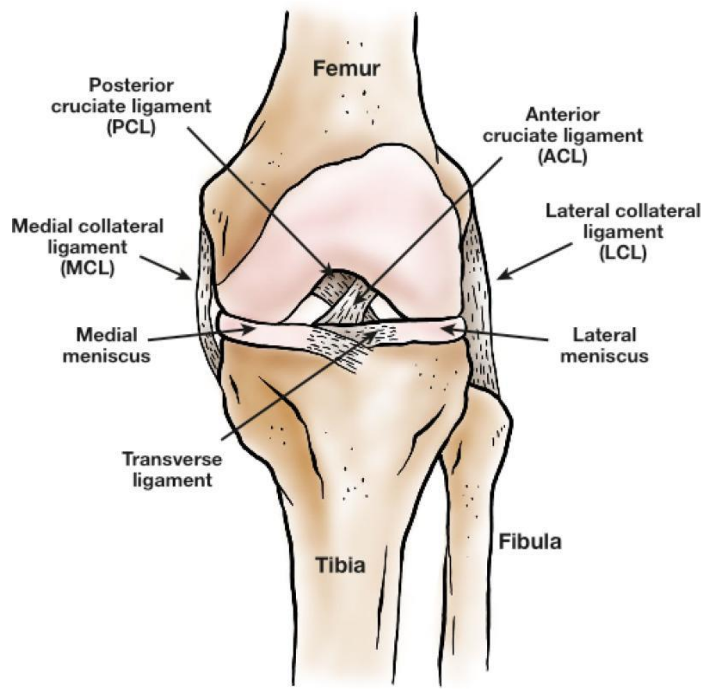


Figure 1: Anatomy of knee joint. [57]

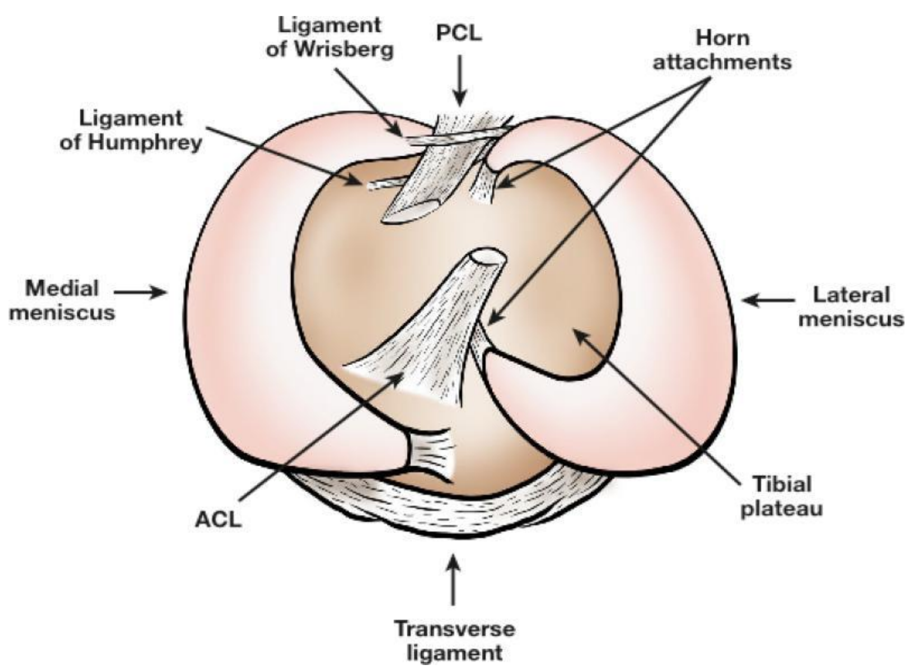


Figure 2: Meniscus anatomy: The ligaments of Humphrey and Wrisberg, which attach the meniscus to the femur, are seen in this view of the tibial plateau. The menisci are connected to one another via the transverse ligament. The meniscus is fastened to the tibial plateau by the horn attachments..[57]

MEDIAL MENISCUS:

The dimensions of the C-shaped medial meniscus are roughly 45.7 mm in length and 27.4 mm in width..[58]

The medial meniscus can be segmented into five zones. These include the anterior root attachment (zone 1), the anteromedial zone situated between the posterior border of the anterior root and the anterior border of the superficial medial collateral ligament (zones 2A and 2B), the part of the meniscus adjacent to the superficial medial collateral ligament (zone 3), the posterior horn (zone 4), and the posterior root (zone 5). The most common location for meniscal tears and meniscal repairs is zone 4.[59-61]

Between 51 and 74% of the surface area of the medial tibial plateau is occupied by the medial meniscus..[62]

LATERAL MENISCUS:

The lateral meniscus is 'U' shaped and measures approximately 35.7 mm in length and 29.3 mm in width.[58]

The lateral meniscus can be segmented into six zones. These zones include the anterior root (zone 1), the anterolateral zone located between the anterior root and the anterior border of the popliteal hiatus (zones 2A and 2B), the popliteal hiatus (zone 3), the posteroinferior popliteomeniscal fascicle (zone 4), the ligamentous zone (zone 5), and the posterior root (zone 6).[61]

Between 75 to 93% of the surface area of the lateral tibial plateau is covered by the lateral meniscus..[62]

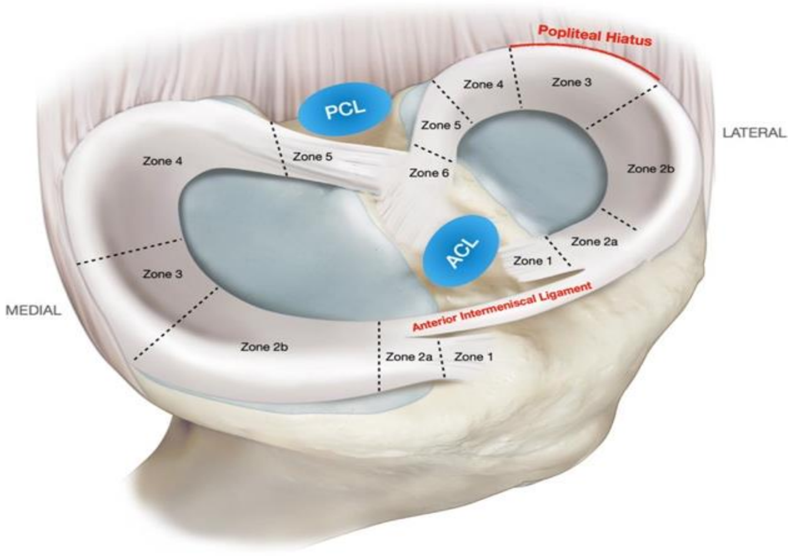


Figure 3: Medial and Lateral meniscus zones and relevant anatomy.[61]

ROOTS OF MENISCUS:

The meniscal roots are ligament-like structures featuring fibrocartilaginous entheses.[63]

Every root attachment is made up of "supplementary" fibres that encircle a dense, central fibre attachment. seen as "shiny white fibres," which can be discovered in the roots of the anterior and posterior.[64] These glossy white fibres are found in the posterolateral and posteromedial areas of the root attachment sites for both posterior roots, according to Ellman et al. They contribute 37.4% of the natural root attachment strength and make up 46.5% of the attachment surface area..[65]

Intact meniscal roots are crucial for maintaining the meniscus's biomechanical function, allowing it to convert axial loads into hoop stresses, prevent extrusion, and reduce the load on the articular cartilage. Significant extrusion from the joint occurs when a meniscal root is avulsed because it is unable to transfer compressive loads into hoop stresses..[66,67] The effects are similar to the stresses in a knee following a total meniscectomy and ultimately cause osteoarthritis to progress quickly..[68]

The anterior inter-meniscal ligament, which is 33 mm long and 3 mm wide, joins the anterior horns of the medial and lateral menisci.[8] Some speculate that the ligament may have a neurological function in the knee's sensory function and stabilise meniscal translation during knee movement..[69]

ATTACHMENTS TO POSTERIOR HORN OF MEDIAL MENISCUS:

The posterior meniscocapsular attachment, posterior meniscotibial ligament, posterior oblique ligament, deep medial collateral ligament, and the semimembranosus muscle are among the important anatomical structures that are examined when looking at the attachments of the posterior portion of the medial meniscus. The length of the posterior horn of the medial meniscus is 21.3 mm on average. To attach to the posterior horn of the meniscus, the posterior capsule joins forces with the medial meniscotibial ligament. A disruption in this area, called a ramp lesion, can lead to translation of the medial meniscus with varus/valgus stress and anteromedial rotatory instability.[70]

The location where the medial meniscus attaches to the tibia is known as the medial meniscus posterior root attachment (MPRA). When repairing a tear in the medial posterior meniscal root, it is important to concentrate on the densest fibres of the MPRA rather than the centre of the entire attachment area because these densest fibres form a footprint that suggests using a 6 mm diameter zone for placing a surgical tunnel to ensure effective repair..[73]

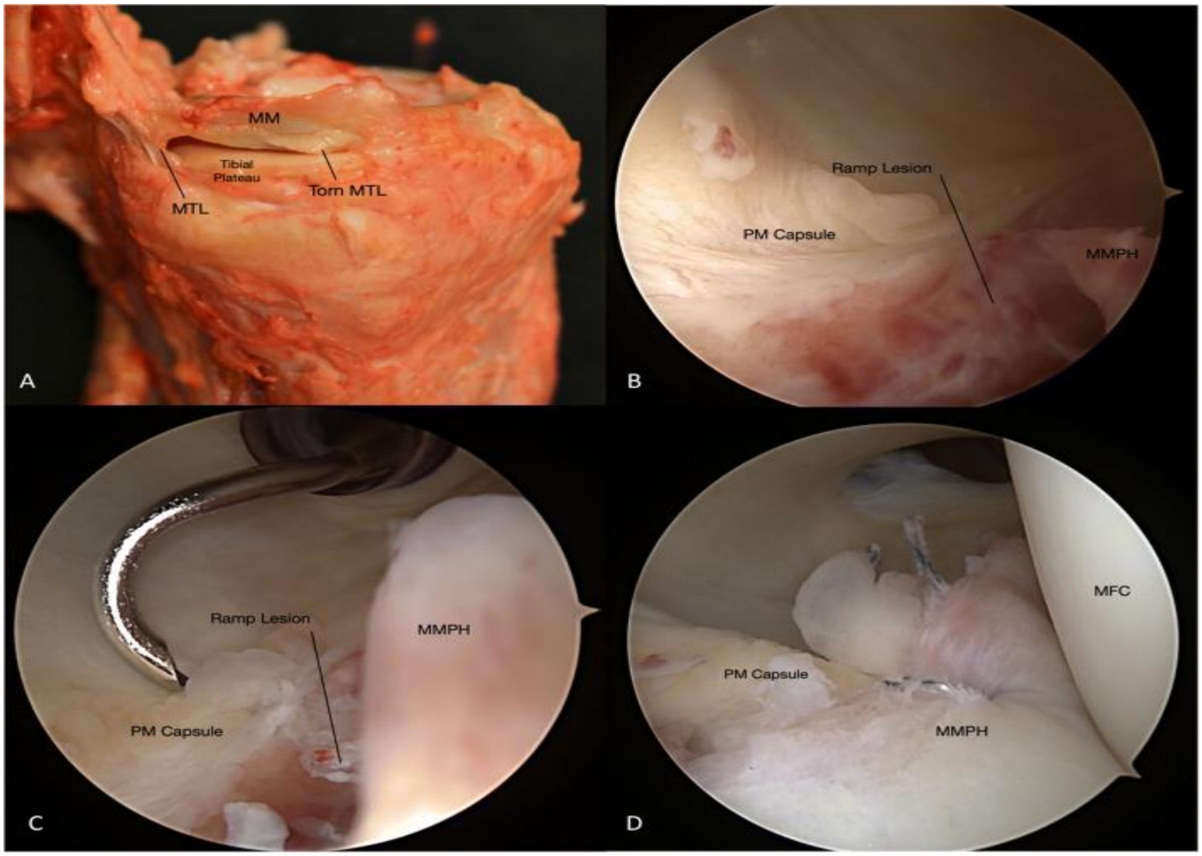


Fig 4: A ramp lesion, or damaged meniscotibial ligament, is seen in a cadaveric right knee specimen at the posterior horn of the medial meniscus. The meniscotibial ligament (MTL), medial meniscus posterior horn (MMPH), medial femoral condyle (MFC), medial meniscus (MM), and posteromedial (PM) are important anatomical features.[73]

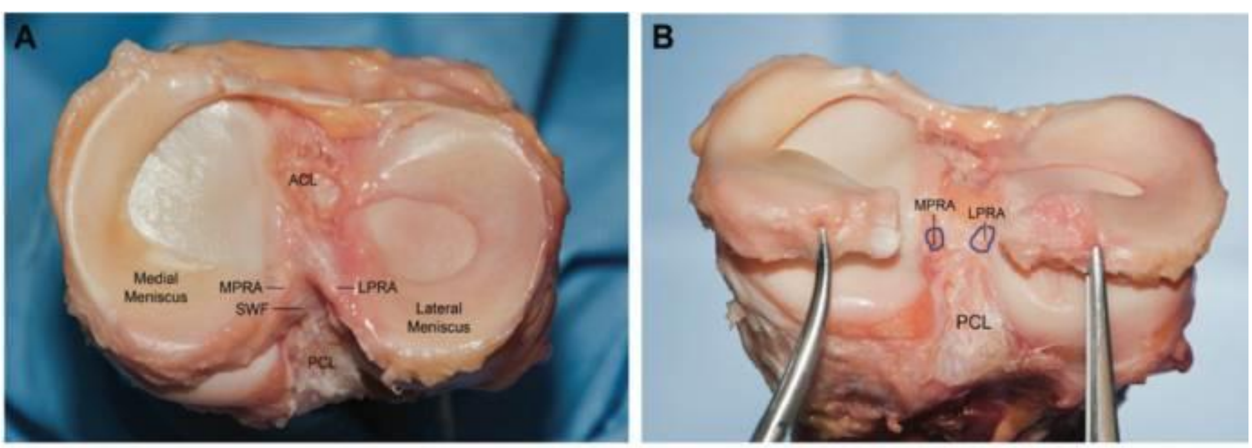


Fig 5: Tibial plateau in a human corpse, seen from the superior (A) and posterior (B) views. In (A), the MPRA and LPRA appear intact; in (B), they are detached. [73]

ATTACHMENTS TO POSTERIOR HORN OF LATERAL MENISCUS:

As the lateral meniscus is more mobile than the medial meniscus and lacks the distinct thickenings of the medial meniscotibial ligament, tears in its posterior horn are more challenging to treat. The lateral meniscus can move more freely since this ligament is missing near the popliteal hiatus. The meniscofibular ligament, meniscofemoral ligament, and popliteomeniscal fascicles are structures that adhere to the lateral meniscus..[71]

The popliteomeniscal fascicles prevent the lateral meniscus from moving medially. Damage to these structures can lead to medial subluxation of the meniscus, knee pain, and mechanical symptoms like locking, often occurring alongside ACL and posterolateral corner (PLC) injuries.[71]

The lateral meniscotibial ligament, which controls the lateral meniscus's external rotation and forward and backward mobility, is assisted by the meniscofibular ligament. It may also serve as a secondary constraint on the knee's varus and external rotation..[8]

The anterior Humphrey ligament and the posterior Wrisberg ligament are the two meniscofemoral ligaments. The posterior cruciate ligament is passed behind by the Wrisberg ligament and in front by the Humphrey ligament.[8] They connect the lateral meniscal posterior horn to the lateral edge of the medial femoral condyle and help prevent lateral meniscus extrusion while providing secondary restraint to posterior tibial translation.[8,72]

The footprint of the densest fibres of the LPRA indicates the use of a 7mm reattachment diameter for repairing a root avulsion of the lateral posterior meniscal root.[73]

ATTACHMENTS TO ANTERIOR HORN OF MEDIAL MENISCUS:

The medial meniscus anterior root attachment (MARA) is 27.5 mm anterior to the medial tibial eminence apex.[74] The MARA's footprint measures 110.4 mm^2. The MARA may sustain iatrogenic damage during intramedullary tibial nailing procedures due to its anatomical position along the anterior border of the medial tibial plateau.[64]

ATTACHMENTS TO ANTERIOR HORN OF LATERAL MENISCUS:

An area of 140.7 mm2 makes up the LARA's footprint. The insertional fibres of the LARA and ACL overlap and interdigitate when they insert into the tibial cortex, indicating a very close anatomical relationship. They share an insertional overlap of 40.7% of the ACL tibial insertion and 63.2% of the LARA. Because of this, LaPrade et al. noted that although the importance of a tear happening at the LARA is still unknown, they did suggest that a modest iatrogenic injury of the LARA during reconstruction of the ACL may not be prevented.[64,74]

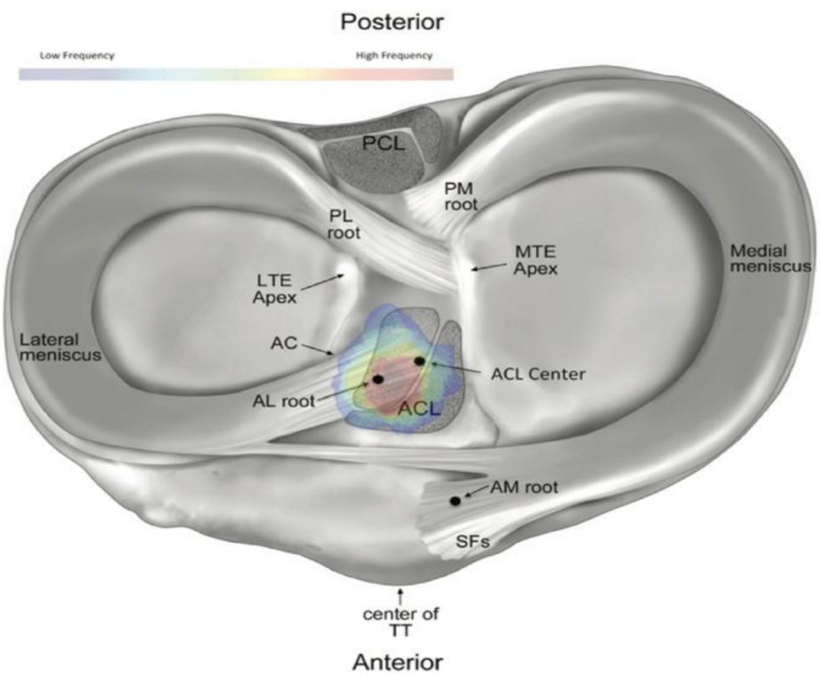


Fig 6: LaPrade et al. noted the "danger zone" for the ACL reconstruction at the tibial insertion of ACL and LARA. [64]

BLOOD SUPPLY:

The menisci receive blood supply from branches of the medial inferior, lateral inferior, and middle geniculate arteries, which form a peri-meniscal capillary plexus that penetrates the knee joint capsule. Twenty to thirty percent of the medial and twenty to twenty-five percent of the lateral meniscus peripheries are supplied by this plexus, but the avascular central meniscus depends on synovial fluid diffusion for nourishment. The endo-ligamentous vessels that are created by capillary loops supply the anterior and posterior meniscal roots.[75]

The menisci are supplied by two vascular distributions: radially, branches from the peri-meniscal vascular plexus penetrate the meniscal stroma, with the medial meniscus exhibiting better coverage in the anterior horn and midbody and 10–30% penetration in comparison to the posterior horn. The lateral meniscus consistently penetrates the radial space by 10–25% in all areas. On the femoral and tibial surfaces of the menisci, a vascular synovial fringe also spreads. In the anterior horns, this fringe covers up to 100% of the femoral surface and 50% of the tibial surface, with a lesser extent in the posterior horns and midbody. There are no radial arteries or vascular fringes at the popliteal hiatus.

Three vascular zones are identified in the meniscus: the vascular peripheral red-red zone, the intermediate red-white zone, and the avascular central white-white zone. Healing potential is impacted by this zoning: tears in the red-white and red-red zones have acceptable healing potential and are frequently reparable, but tears in the white-white zone have historically required a partial meniscectomy because of their poor healing ability. Recent research, however, indicates that the white-white zone might be more conducive to healing than previously believed because of the presence of vascularization and multipotent mesenchymal stromal progenitor cells, which suggest that biologic augmentation in repair may be beneficial, especially in young, healthy, and active patients. Meniscal tears in the white-white zone can be repaired with considerable clinical benefits, according to additional research.[76]

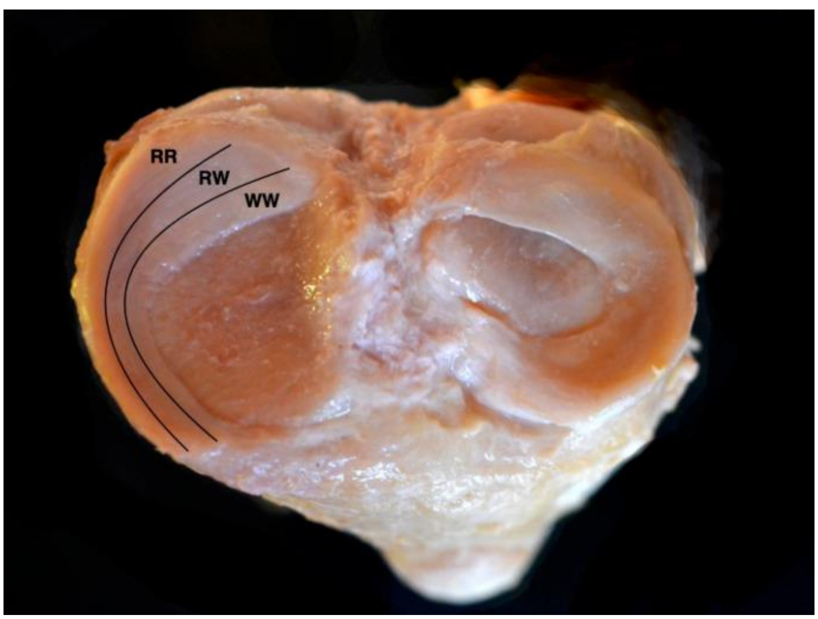


Fig 7: Showing zones of meniscus based on its vascularity[76]

NERVE SUPPLY:

The knee joint is innervated by the posterior articular branch of the posterior tibial nerve, the terminal branches of the obturator and femoral nerves, and other nerves. The common peroneal nerve's recurrent peroneal branch innervates the lateral part of the capsule. After passing through the capsule, these nerve fibres follow the vascular supply to the anterior and posterior horns, as well as the peripheral part of the menisci, which is where the majority of the nerve fibres are located.[76]

BIOMECHANICS OF MENISCUS

The forces transmitted across the meniscotibial articulation are always less than those across the meniscofemoral articulation when axial compressive loads are converted into radial tangential stresses known as hoop stresses, which put tensile stress on the collagen fibrils that are orientated circumferentially. This is demonstrated by axial loads across the knee. As a result, the menisci experience circular traction due to the fixation to the tibial plateau via the meniscal roots. This conversion reduces the compressive loads experienced by the chondral cartilage of the knee. Thus acts as a shock absorber.[76,77,78]

The meniscus extrudes out of the joint space when a meniscal root attachment is damaged, causing axial compressive pressures to no longer be distributed as tensile hoop stresses inside the meniscus. This pathological alteration modifies the knee's kinematic loading profile, resulting in an increase in mean and peak tibiofemoral contact pressures, sometimes known as "point loading," and a decrease in contact area, which damages the articular cartilage. A meniscal-root deficient knee has a biomechanical profile similar to that of a total meniscectomy.[82]

Anatomical reattachment of the avulsed root restores key metrics of the loading profile to values indistinguishable from the root-intact condition, as shown by biomechanical models of meniscal root repair. Nonanatomic repairs result in inferior outcomes and are biomechanically equal to the root-avulsed state. Additionally, the menisci function as secondary knee stabilisers, particularly the posterior roots such as the LPRA, which provide stability against the anterior tibial translation (ATT).

MECHANISM OF INJURY:[80,81]

Meniscal root tears can present either acutely or chronically and are generally characterized by patient age.

In younger individuals, these tears usually result from a traumatic event, such as during sports, often involving a rotatory blow to a flexed knee. These injuries commonly occur alongside other ligament tears.

In older adults, meniscal root tears tend to develop chronically due to degeneration, typically triggered by low-energy activities like squatting or kneeling and are usually isolated incidents.

Medial meniscal root tears usually occur on their own, whereas lateral root tears frequently accompany ACL injuries.

The most common location for injury is the posterior horn of meniscus with longitudinal teras being the common type.

CLASSIFICATION OF MENISCUS TEARS

Various classifications of menisci tears have been proposed based on type of tear, etiology, location and other factors.

But most used classification is based on the type of tear found intra-operatively:

1. Horizontal tears

2. Radial or oblique tears

3. Longitudinal tears

4. Variations- Flap tears, Complex tears and Degenerative meniscus tears.

LaPrade et al., devised a classification system for meniscal root tears, categorizing them into five types:[79]

- **Type 1**: Partial, stable tears within 1 cm of the root attachment site without concurrent meniscal body tears. These account for 7% of cases.
- **Type 2**: The most common type, these are complete radial tears within 9 mm of the root attachment site, further divided into:
- **Type 2A**: 0 to < 3 mm from the centre, comprising 38% of root tears.
- **Type 2B**: 3 to < 6 mm from the centre, making up 16.9% of root tears.
- **Type 2C**: 6 to 9 mm from the centre, constituting 12.7% of root tears.
- **Type 3**: Longitudinal or circumferential "bucket handle" tears with complete detachment within 9 mm of the root attachment, representing 5.6% of cases.
- **Type 4**: Complex oblique tears within 9 mm of the root attachment with complete detachment, occurring in 9.9% of cases.

- **Type 5**: Bony avulsion fractures where the root attachment is entirely avulsed from the tibial plateau, also comprising 9.9% of cases.

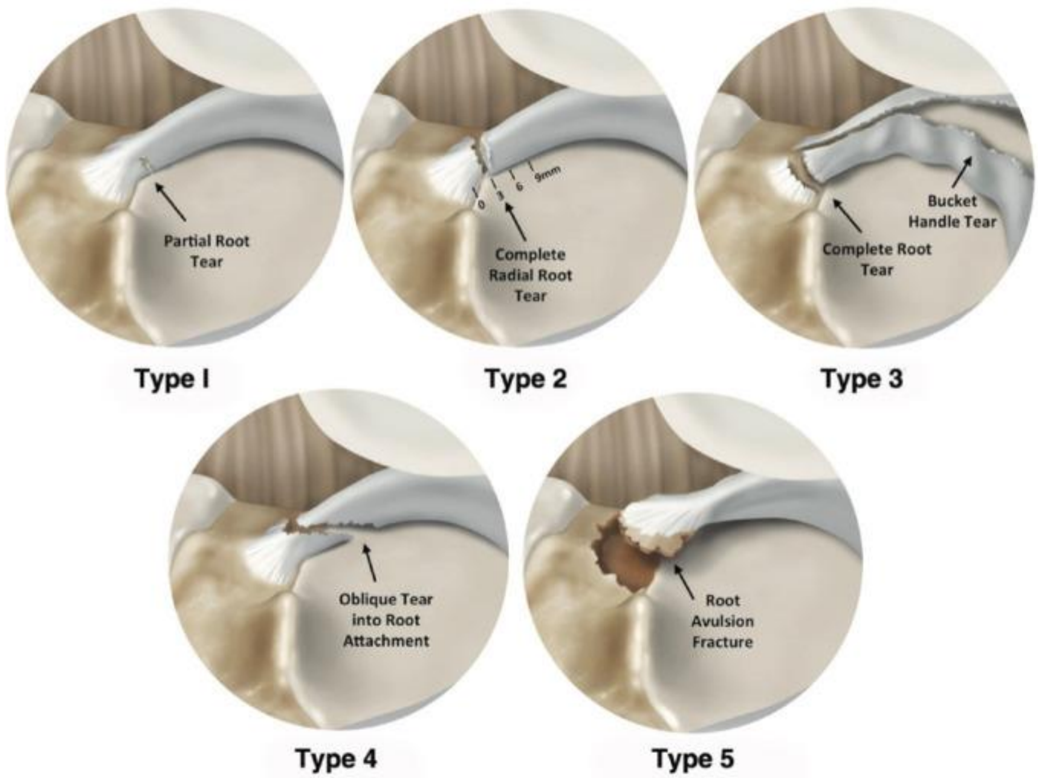


Fig 8: Types of posterior horn root tears[79]

CLINICAL EVALUATION OF MENISCUS TEARS:[83]

It involves taking a thorough history from the patient, inspection, palpation, and range of movements.

Patients with meniscal tears usually present with symptoms such as pain along the joint line, swelling, snapping or clicking, catching, locking and instability.

They may also present with complaints of difficulty in squatting (e.g. Using an Indian style toilet, yoga exercises), sitting cross-legged, climbing stairs. These are usually seen in patients with degenerative tears.

Numerous people have also mentioned that the discomfort caused them to wake up from sleep. This may happen if the patient rolls over while they are sleeping and the sore medial aspect of their knee bumps against the opposite knee.

Physical examination findings for the knee may include limited range of motion, joint line discomfort, a palpable click or snap, and the presence or absence of effusion.

TESTS FOR MENISCAL TEARS:[84,85]

1. **BRAGARD TEST**: This is used to assess tenderness along the joint line in suspected meniscus tears:

   Medial Meniscus Tear:

   Manoeuvre: External rotation of the tibia with knee extension.

   Effect: By moving the medial meniscus anteriorly and closer to the joint line, this manoeuvre increases the area that feels painful to the touch along the medial joint line.

   Lateral Meniscus Tear:

   Manoeuvre: Internal rotation of the tibia with knee extension.

   Effect: This manoeuvre brings the lateral meniscus closer to the joint line, increasing tenderness along the lateral joint line upon palpation.
   In both cases, the opposite manoeuvres (internal rotation with flexion for medial meniscus tear and external rotation with flexion for lateral meniscus tear) generally decrease tenderness because they move the respective meniscus away from joint line.

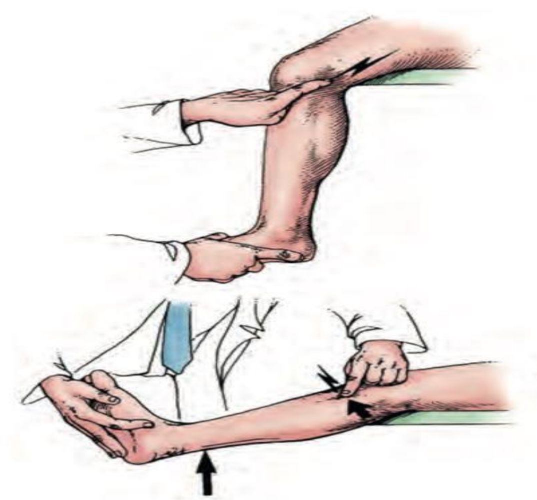


Fig 9: Bragard test

2. **MCMURRAY'S TEST**: This is done with the patient supine and relaxed. The examiner grasps the heel and the joint line of the knee, flexes the knee maximally, and rotates the tibia externally with valgus stress for the medial meniscus or internally and varus stress for the lateral meniscus. The knee is then extended while maintaining the rotation and the stress. A positive test results in a pop or click, and reproducible pain during the range of motion is noted.

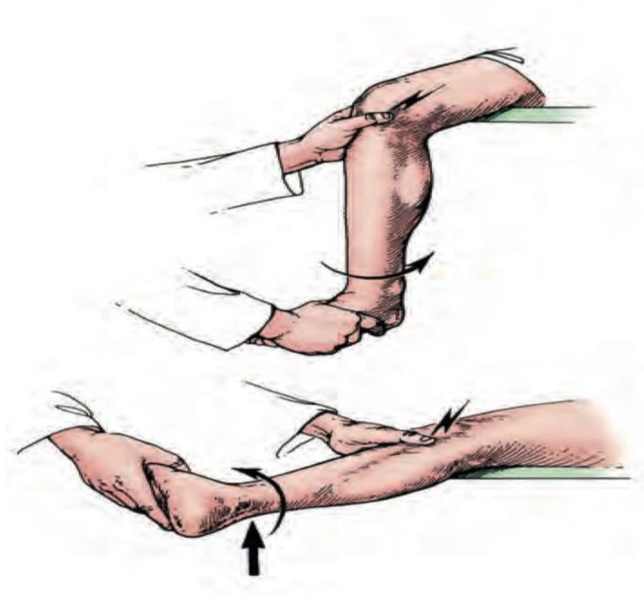


Fig 10: McMurray's test

3. **APLEY'S GRINDING TEST:** It is performed with the patient prone, and the knee flexed to 90 degrees. The examiner stabilizes the patient's thigh and then rotates the tibia laterally and medially, first with distraction followed by compression, noting any excessive movement, restriction, or discomfort.

   Increased pain or rotation with distraction suggests a ligamentous injury, while increased pain or decreased rotation with compression indicates a meniscus injury.

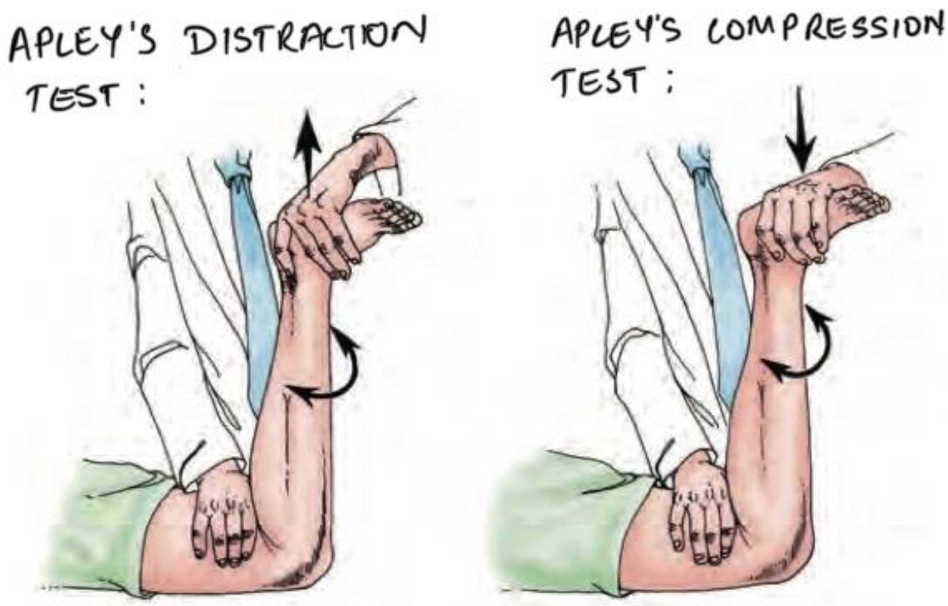


Fig 11: Apley's grinding test to differentiate between ligamentous and meniscal injury

4. **THESSALY TEST:** The examiner holds the patient's outstretched hands for support as the patient stands flat on one leg. The patient flexes the knee to 5° and rotates the femur on the tibia medially and laterally three times, maintaining 5° flexion. This is first done on the uninjured leg for practice, then repeated at 20° flexion. A positive test for a meniscus tear is indicated by medial or lateral joint line discomfort or a sense of locking or catching in the knee.

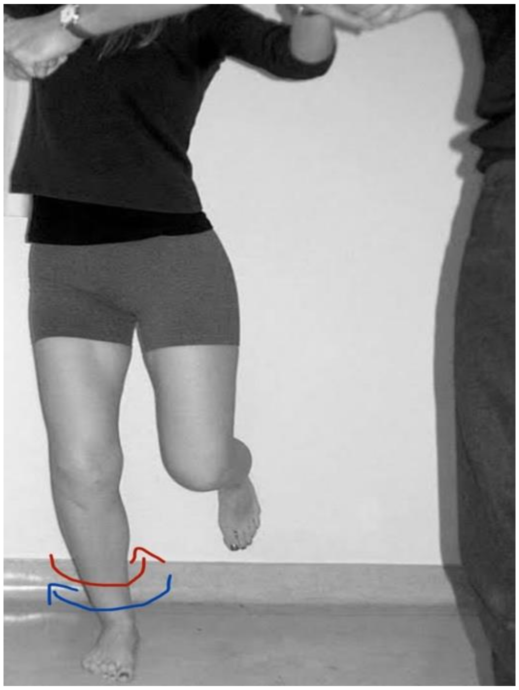


Fig12: Thessaly test

5. **BOHLER TEST:** This helps diagnose medial meniscus tears with a varus stress causing increased pain due to compression.
   For lateral meniscus tears, a valgus stress produces similar pain.

6. **DUCK WALK:** Increases compressive force on the posterior meniscus horns, eliciting pain if there's a tear.

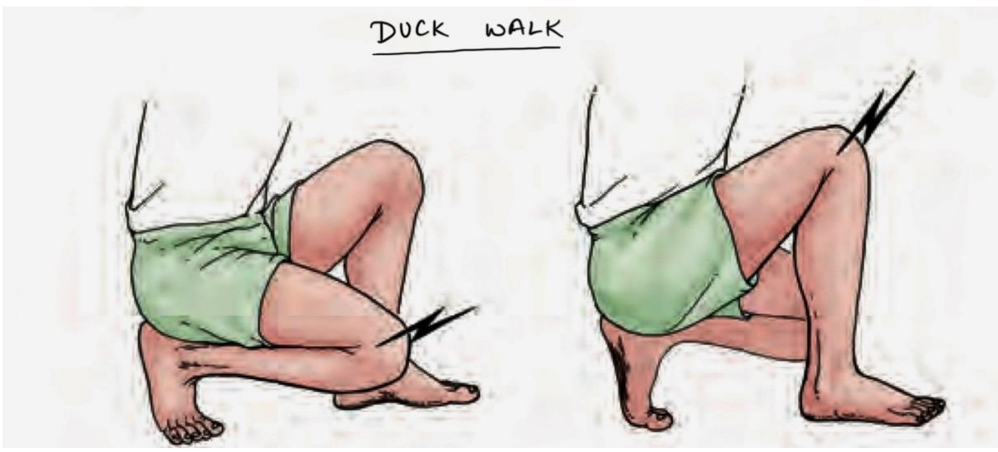


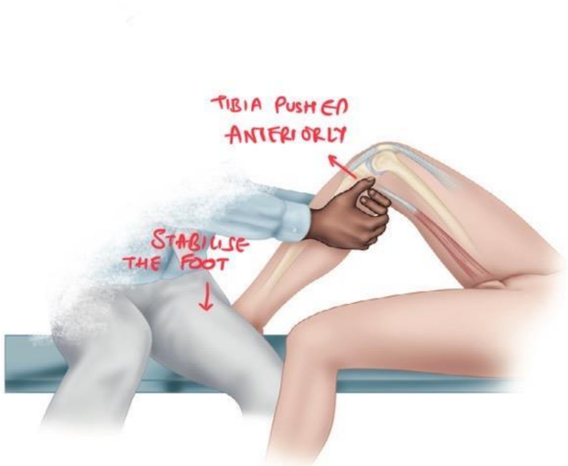
Fig 13: Duck walk

The results of the McMurray and Apley tests are frequently positive, with specificities of 57–98% and 80–99%, respectively, and sensitivities of 10–66% and 16–58%. The Thessaly test is the most useful clinical diagnostic for meniscal injury. It has a 90% sensitivity and 98% specificity in identifying meniscal lesions, despite being infrequently used and taught.[86]

Studies by DePhillipo et al. showed LPRA tear rates of 12.2% in primary ACL reconstructions and 20.5% in revision ACL reconstructions. LPRA tears result in increased anterior tibial translation and internal rotation, detected through Lachman's and pivot shift tests. Patients with varus alignment are more susceptible to medial meniscal root tears.

Others special tests are done to rule out ligament injuries such as:

- Anterior drawer test
- Lachman's test
- Posterior drawer test
- Valgus and Varus stress test



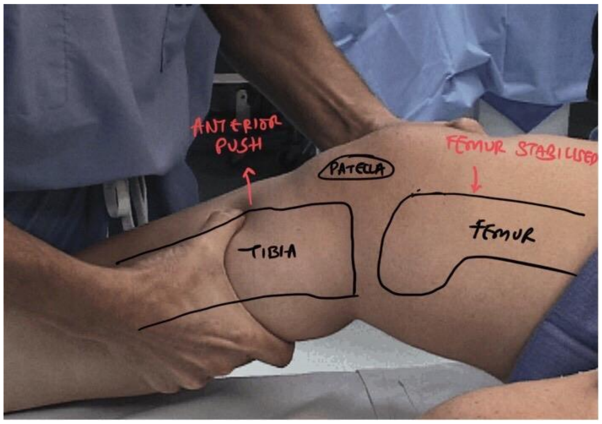


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Fig 14: Tests for ACL - First is Anterior drawer's test and second is Lachman's test;

RADIOLOGICAL FINDINGS

PLAIN X-RAY OF KNEE (AP AND LATERAL VIEWS)

Fig 15: Medial condyle of femur is depressed (arrow)[84]

It is crucial for diagnosing meniscal lesions, even in young patients with clear symptoms. Older meniscal lesions (2-3 months) may show periosteal deposits or spurred margins on the ipsilateral tibial plateau, known as Rauber's sign. Spurs can curl or thicken the cortical margins. Indentations on the medial or lateral tibial plateau with sharp sclerotic margins on AP radiographs indicate a meniscal cyst. A discoid meniscus is linked to a flat intercondylar prominence. Chondrocalcinosis, which affects the menisci as well as the cartilage and synovium of the whole joint, is suggested by calcifications in the joint space.[84]

MRI OF KNEE

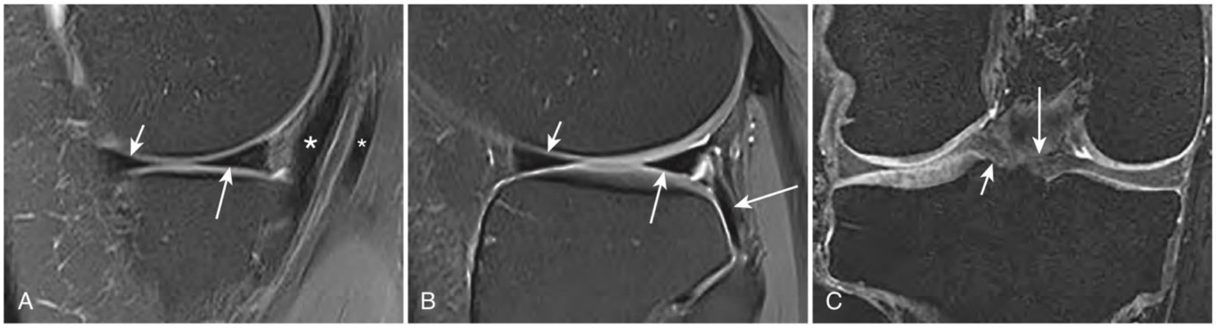


Fig 16:[84] A- Sagittal section showing normal triangular shape. Posterior horn is larger than the anterior. Larger asterisk denotes semimembranosus and smaller on is semitendinosus.

B- Showing medial meniscus.

C- Coronal image through the posterior aspect of knee joint

Despite these challenges, meniscal root tears can sometimes be directly visualized on MRI. Type 5 tears, also known as "meniscal ossicles," can be identified on standard anteroposterior and lateral radiographs. Increased awareness and improved diagnostic methods for MRI have enhanced the sensitivity, specificity, and predictive values for diagnosing meniscal root tears.[87]

To evaluate a meniscal root injury, T2-weighted sequences are commonly used, including coronal, sagittal, and axial imaging.

Using 3.0 T MRI, LaPrade and Ho discovered that the diagnostic sensitivity was 77%, specificity was 73%, positive predictive value (PPV) was 22%, and negative predictive value (NPV) was 97% in a recent prospective level II investigation. In their findings, they observed a greater sensitivity for MPRT.[88]

When an MPRT is suspected, MRI evaluation should focus on three main signs:

1) linear high signal intensity perpendicular to the meniscus at the meniscal root (radial tear) in the axial plane.

2) A vertical linear defect at the meniscal root (truncation sign) associated with medial meniscal extrusion over 3 mm.

3) An absence of normal meniscus signal in the sagittal plane (ghost sign).

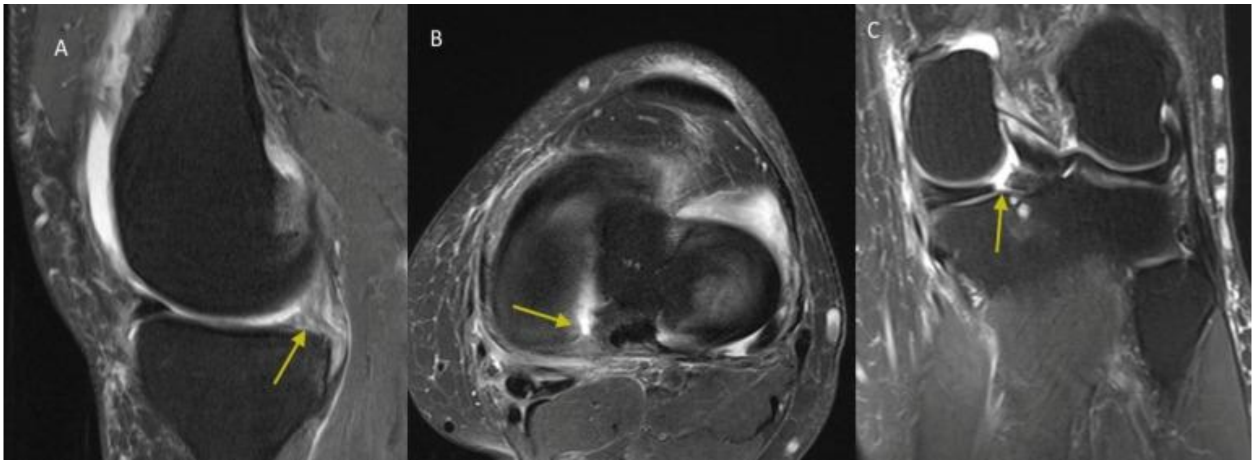


Figure 17: Showing "Ghost sign" suggesting posterior horn of medial meniscus root tear in sagittal, axial, and coronal views.[89]

On mid-coronal imaging, extrusions exceeding 3 mm are strongly linked with articular cartilage degeneration, severe meniscal degeneration, and tears at the meniscal root.

Figure 18: Meniscal extrusion of >3mm[90]

Using preoperative imaging to diagnose meniscal root tears might be difficult. Arthroscopy confirmation through root attachment probing continues to be the gold standard. As a result, every arthroscopy routinely involves probing the meniscal root attachments.

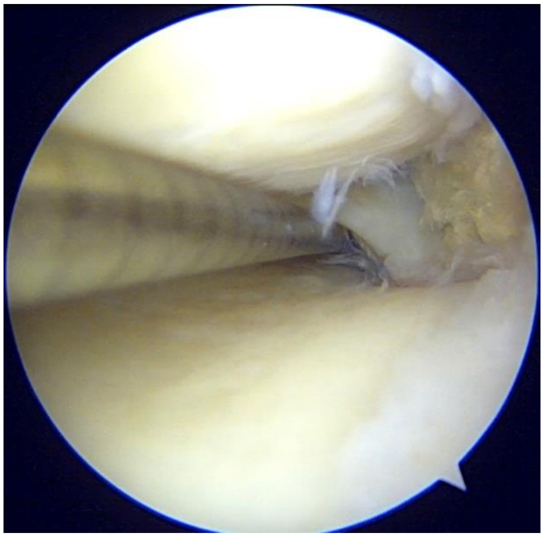


Fig 19: Shows probing of root posterior horn of meniscus

INSTRUMENTATION

Arthroscopic ACL reconstruction requires some specialized equipment's for arthroscopy of knee and for the procedure itself.

- Camera
- Television monitor
- Light source & fibre-optic cable
- Endoscope (4mm, 30 degrees)
- Shaver system and hand piece
- Pneumatic Tourniquet

Instruments needed for surgery include:

- 2.4 mm drill tip guide pins
- Trocar (5 mm)
- Cannula
- Probe
- Meniscus punch
- Burrs and shaver system (motorized instruments)
- Tibial aimer
- Cannulated reamers (4.5 to 10 mm)
- Femoral aiming guide (6-7mm off-set)
- Depth-gauge
- Graft preparation board
- Meniscal jig
- Meniscal sleeve
- Suture retriever
- Knot pusher

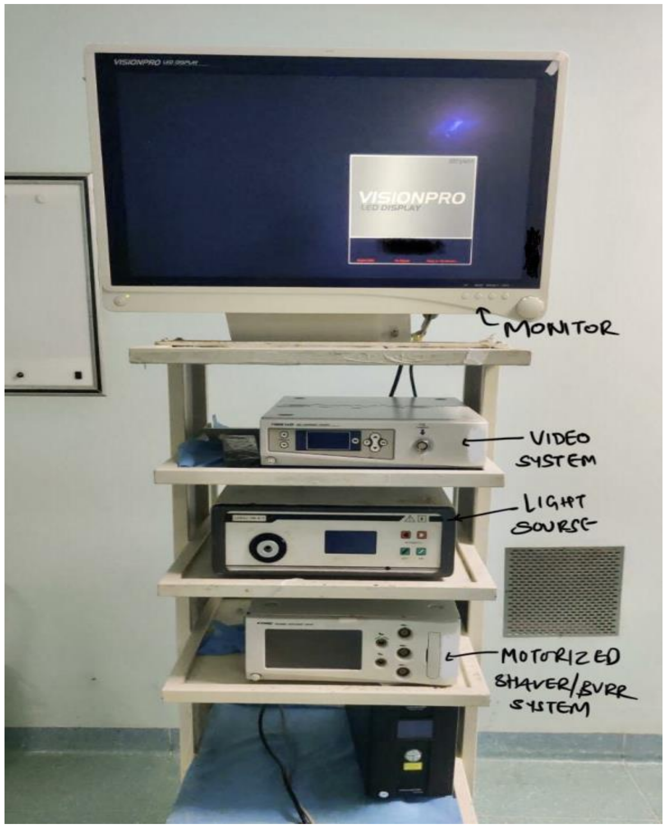


Fig 20: Video, light and motorized device system

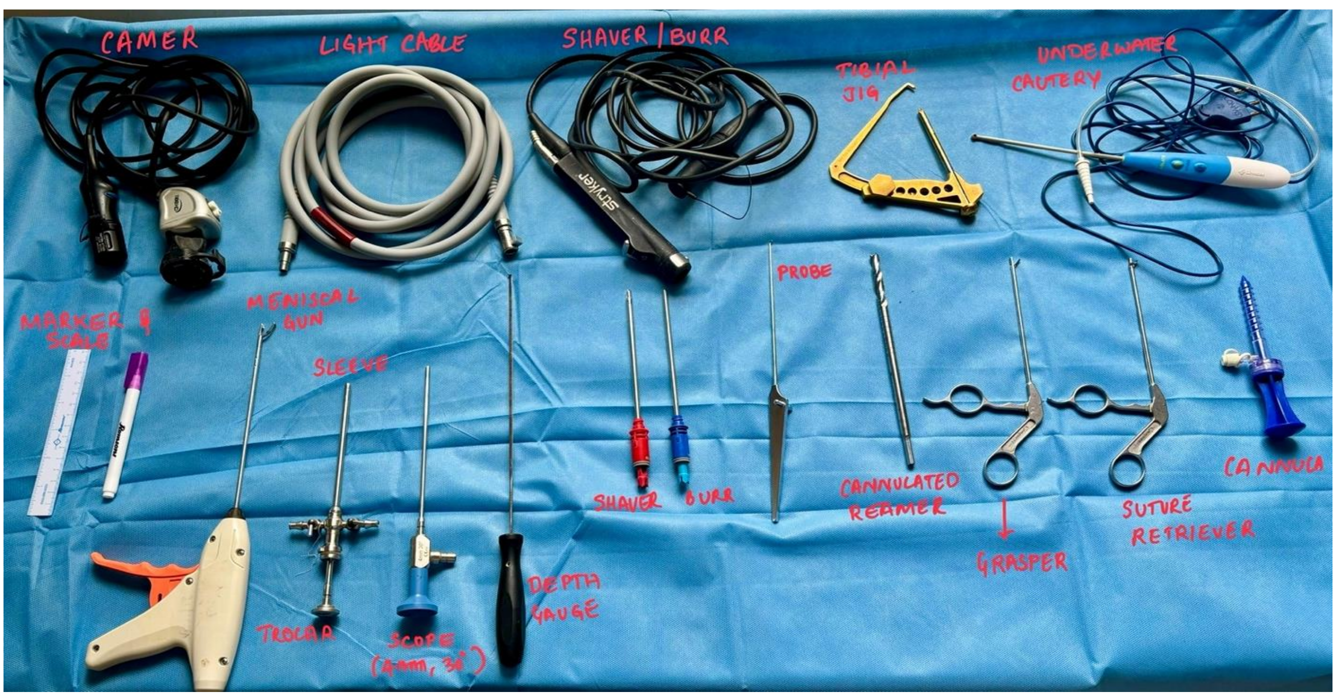


Fig 21: Showing specialised instruments used for arthroscopic meniscus root repair .

TREATMENT[32,35]

The approach to treating meniscal root tears depends on a careful evaluation of the injury, patient-specific factors, and the condition of the knee cartilage.

The main goal of surgical repair is to restore normal joint pressures and movements, and to delay the onset of osteoarthritis (OA).

There are three common treatment options for meniscal root tears: non-operative treatment, partial meniscectomy, and surgical repair.

Factors influencing meniscal treatment decisions include:[84]

- Patient Age: Repair is preferred for children and very young patients. Older patients with osteoarthritis of knee (Kellgren-Lawrence Grade 1 and 2).
- Location: Preservation of the lateral meniscus is prioritized due to its crucial role in joint function, as extensive resections can lead to lateral compartmental osteoarthritis. Medial meniscus tears, benefit more from extensive resection to prevent retearing and avoid further surgery
- Clinical and radiological Correlation
- Extent of tear: Small, acute tears can be treated conservatively. Larger tears (>1.5 cm) should be resected or repaired. Tears near the free edge or in the central zone are less likely to heal than those in the vascularized peripheral zone.
- Associated Lesions: Concurrent cartilage damage and instabilities (e.g., ACL deficiency) reduce the success rate of meniscal treatment. Stability must be restored, preferably in the same surgical session, to maintain repair results.
- Activity Level: Repair is ideal for occasional athletes and young patients with acute tears. However, it poses challenges for competitive and professional athletes due to the need for prolonged rehabilitation and activity restrictions.

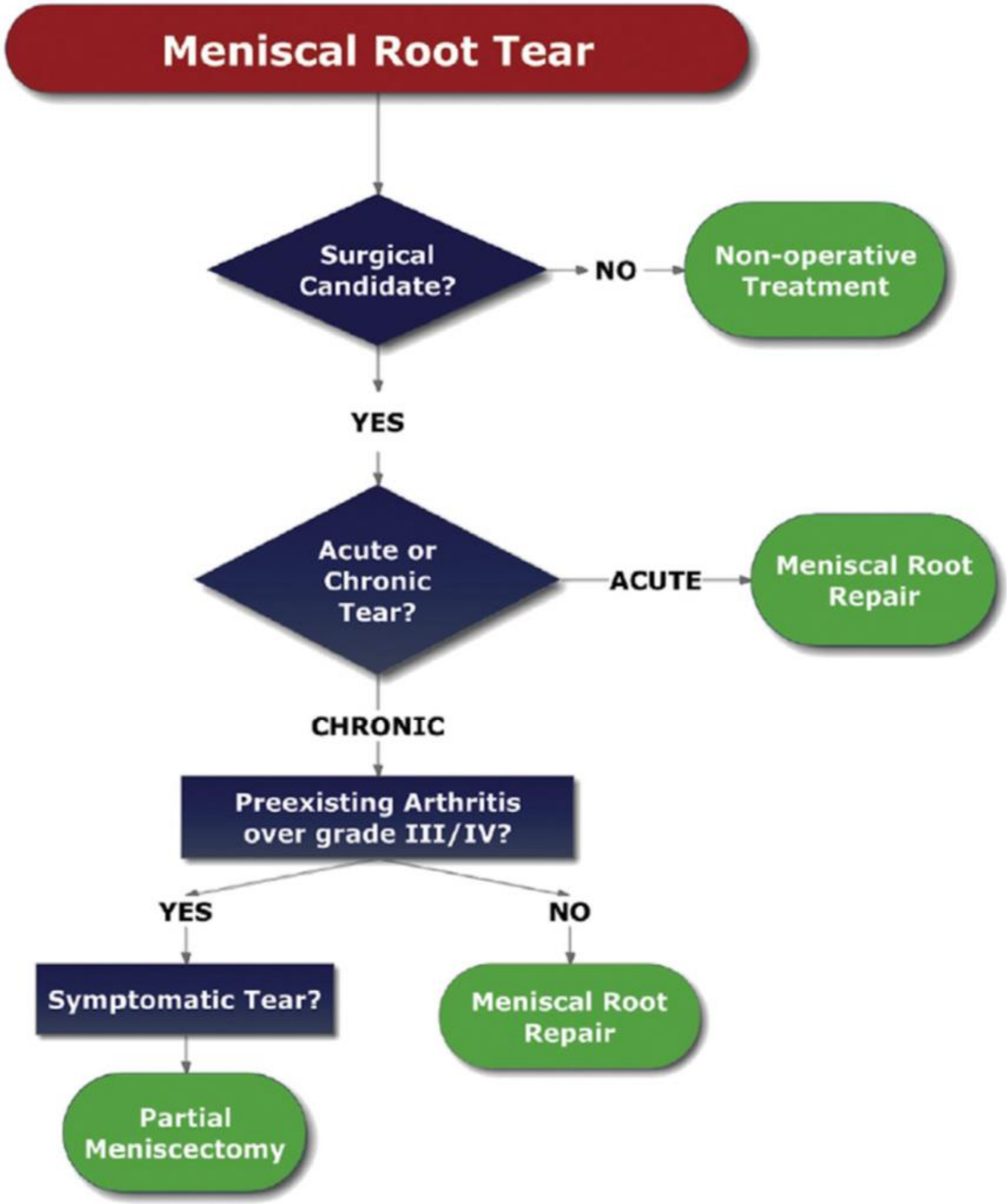


Fig 22: Flowchart on planning the treatment of meniscus posterior horn root tears.[93]

NON-OPERATIVE

Conservative treatment for meniscal root tears focuses on symptom management, using analgesics, NSAIDs, and ice to alleviate pain.

Older patients or those contraindicated for surgery might benefit from an unloader brace, particularly for medial meniscal root tears. However, nonoperative treatments do not address mechanical symptoms or delay the progression of osteoarthritis (OA) commonly associated with meniscal root tears. Surgical repair generally yields favourable patient outcomes and biomechanical studies highlight the importance of intact meniscal roots for knee function. Despite the benefits of surgical repair, it is contraindicated in patients with advanced age, significant OA(Kellgren-Lawrence grades 3-4), varus alignment over 3 degrees, and high BMI.[91]

OPERATIVE PROCEDURE

MENISCECTOMY:[92]

Partial or subtotal meniscectomy can benefit patients with advanced degenerative changes and persistent mechanical symptoms, such as pain, locking, and who haven't responded to conservative treatments.

This procedure often provides short-term relief but is associated with long-term negative effects, including a rapid progression to osteoarthritis (OA). Total meniscectomy significantly increases peak tibiofemoral contact pressure by 61% and decreases contact surface area by 48%, leading to joint degeneration.

Outcomes for partial meniscectomy are similar to nonoperative treatments for medial meniscus tears.

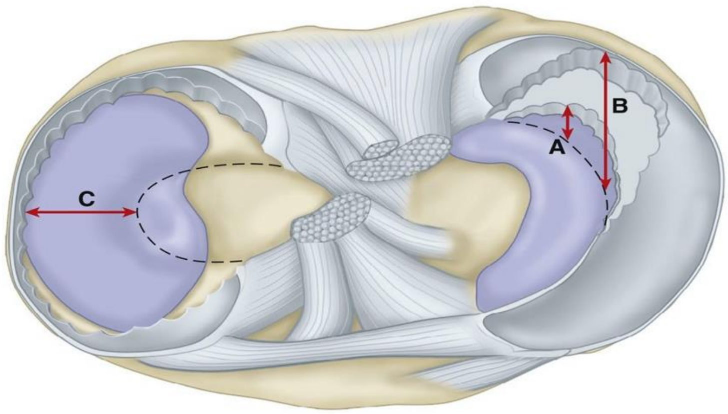


Fig 23:[85] A: Partial meniscectomy; B: Sub-total meniscectomy; C: Total meniscectomy.

MENISCUS REPAIR:

In order to prevent meniscus damage and osteoarthritis (OA), anatomic repair of the meniscal root should be tried whenever possible. The exceptions to this rule are cases where the patient is not a good candidate for surgery (due to significant comorbidities or advanced age), diffuse Outerbridge grade 3 or 4 OA of the ipsilateral compartment, non-symptomatic chronic meniscal root tears, and/or significant limb malalignment that cannot be corrected concurrently. Suture anchor repair and transtibial meniscal root repair are the two most often utilised repair methods.[93]

The line that separates the central and posterior sections of the medial tibial plateau is positioned laterally and anteromedially to the site of the medial meniscus posterior root insertion. The more degenerated central cartilage is separated from the less degenerated posterior portion by this line. Less compression loads are placed on the posterior than on the central portion of the medial meniscus because the posterior margin of the medial tibial plateau, where it is situated, slopes downward. The "meniscal track," a landmark used in arthroscopy to identify the medial meniscus posterior root attachment, is described in this technical note. Using the PCL and the meniscal track's demarcation line, it is simple and accurate way to determine the medial meniscus posterior root footprint.[94]

SUTURE ANCHOR REPAIR:

Theoretically, suture anchor repairs are advantageous because they prevent distal fixation, which raises the chance of suture failure from abrasion, and they remove the requirement for tibial bone tunnels, which can complicate ligament reconstructions.[95]

Suture anchor repair, which uses an all-inside approach and one suture anchor with two sutures, can be used to treat medial meniscal root rips. Using a high posteromedial portal, an anchor is placed for an MPRT at the meniscal root anatomic footprint. Two vertical sutures are then used to reattach the root. The majority of patients who have undergone this technically challenging procedure have grade 3 medial collateral ligament injuries.[96]

Using an auxiliary posteromedial portal, arthroscopic suture anchor repair for meniscal root injuries was first documented by Engelsohn et al. Using common arthroscopic knot-tying methods from the anteromedial portal, these repairs were tensioned. They discovered that appropriate anchor placement in knees with ligamentous stability required a high posteromedial portal. The high posteromedial portal is positioned behind the medial femoral condyle and approximately 4 cm above the joint line in posterior horn medial meniscal root tear repairs. A double-loaded metal suture anchor is inserted, and the sutures are passed through a suture hook and shuttle. The best direction and position for suture anchor placement, however, have not yet been determined by research.[97,98]

TRANSTIBIAL/ TRANSOSSEUS PULL-OUT REPAIR:

According to Kim et al., a suture passer with a shuttle is used to pass two non-absorbable sutures through the medial meniscus root. Following the creation of a 5-mm tibial bone tunnel using an ACL guide, these sutures are subsequently removed and tied over an anteromedially positioned screw and washer.[99]

The use of a posterior transseptal portal to enhance root visualisation was first introduced by Ahn et al. Using an ACL guide via the posteromedial portal, they drill the tunnel, run the sutures over a post, and then tie the sutures.[100]

A trans-osseous procedure was also described by Marzo and Kumar, however it did not make use of posterior auxiliary portals. Rather, they drilled a 7-mm tunnel with an ACL guide, knotted their sutures over a washer, and assisted suture passage using a commercial suture passing device.[101]

The method of creating a tiny intraosseous socket with an Arthrex Inc., Naples, Florida, USA, Flip Cutter retrograde reaming device was first described by Nicholas et al. By using this technique, less tibial bone is taken, which is advantageous for simultaneous cruciate restorations requiring several bone tunnels.[102]

Currently, the senior author favours a trans-osseous suture repair tied over an anteromedial tibia button to treat a posterior horn meniscal root rupture. This technique makes use of an additional posteromedial portal to facilitate suture passage in addition to two typical arthroscopy gates. According to Johannsen et al., anatomical placement of the posterior root bone tunnels for root avulsions is achieved by using newly discovered arthroscopy landmarks, which are based on directional components referenced from the apices of the tibial eminences.[103]

Fig 24: Illustrating the repair of a meniscal posterior root tear (MPRA) using a transtibial pull-out technique[103]

A curved suture passer is usually utilised by the surgeon to introduce a nitinol wire through a cannula in order to shuttle two sutures via an auxiliary posteromedial portal for a posterior horn medial root rupture. A bone tunnel is then formed at a specific anatomical site. After that, the sutures are inserted anteriorly to posteriorly. After cycling the knee, the sutures are fastened over a button on the proximal tibia's anteromedial surface.[103]

The biomechanical characteristics of various suture methods for transtibial pull-out repair of posterior horn medial meniscal root injuries have been the subject of recent research. In a cadaveric investigation, Kopf et al., assessed three regularly used fixation techniques: a modified Kessler stitch, a loop stitch, and two basic stitches. The study included 64 severed human meniscus roots. The modified Kessler stitch was determined to have the highest primary fixation strength in the study. Nevertheless, none of the methods could completely restore the strength of the original root, which led the authors to recommend a cautious and gradual postoperative rehabilitation strategy.[104]

More recently, Feucht et al., investigated suture strength in a biomechanical porcine model using four different techniques: two simple sutures, two modified loop sutures, modified Mason-Allen, and horizontal mattress. They found that the modified Mason-Allen technique performed the best biomechanically, with the two simple suture procedures coming in second, in terms of cyclic loading and load-to-failure testing.[105]

In a biomechanical investigation of suture methods for transtibial meniscal tears, Nakama et al. found that tibiofemoral kinematics were successfully restored to within acceptable bounds using single-row and double-row suture configurations, as well as the vertical mattress and cross-stitch techniques.[106]

TYPE OF FIXTION DEVICES

1. Suture disc
2. MR-Fix
3. Endo button

Fig. 25: Suture disc

Fig. 26: MR-Fix

Fig. 27: Endo button

POST-OPERATIVE REHABILITATION PROTOCOL

Following a transtibial pull-out meniscus root repair, the below must be followed for a speedy recovery and an excellent outcome.

0-2weeks :- Strict non-weight bearing walker mobilization for 6 weeks

- Use of Long knee brace/ Extension brace.

- Quadriceps strengthening started from first day (static), dynamic and Straight leg raise as per tolerated, electric stimulation if poor strength of quadriceps.

- Mobilisation of Patella (superior-inferior and Medio-lateral direction)

- Ankle pumps

- Passive range of motion exercises from 0º to 90º flexion started on Day 1 of surgery.

After 2 weeks:-Knee flexion can be increased as tolerated.

After 6 weeks:- Full weight-bearing begins progressively.

After 4 months:- Deep leg presses and squats exceeding 70º of knee flexion.

After 6 months:- Running, Jogging, Swimming.

POST OPERATIVE COMPLICATIONS

EARLY:

- Pulmonary Embolism if torniquet time is extended above limit
- Haematoma collection at graft harvest site
- Infection
- Implant or instrument breakage causing metallises

DELAYED:

- Decrease in ROM due to arthrofibrosis
- Deep vein thrombosis
- Residual pain due to CRPS, unattended meniscal cysts, femoral condyle articular surface laceration by drilling.
- Lack of quadriceps and/or hamstrings strength due to inadequate rehabilitation
- Extension lag
- Synovitis causing repetitive effusion of knee

MATERIALS AND METHODOLOGY

We have done a "Prospective study" conducted in BLDE (DEEMED TO BE UNIVERSITY) Shri B. M. Patil Medical College, Hospital & Research Centre, Vijayapura from 1st August 2022 to 31st December 2024.

In our study, 35 patients were involved, of whom 8 (22.9%) were male and 27 (77.1%) were female. 15 patients (42.9%) sustained injury. A minimum of 12 months and a maximum of 17 months of follow-up achieved.

The Randomisation of this study was done through Lottery method.

All middle-aged patients who presented to the orthopaedic outpatient departments at the BLDE (DEEMED TO BE UNIVERSITY) Shri B. M. Patil Medical College, Hospital & Research Centre, Vijayapura with complaints of knee pain, difficulty walking and performing regular tasks were examined thoroughly. The affected knee was assessed after the unaffected knee was checked.

A thorough history was taken and clinical examination was performed. Local examination included inspection, palpation and range of movement assessment.

To identify the meniscus injury, the following particular tests were carried out:

1. McMurray's test
2. Apley's grinding test
3. Thessaly test

Ligament injury assessment was done:

1. Valgus & Varus-stress test (Collateral ligaments)
2. Lachman's and anterior drawer test (ACL)
3. Posterior Drawer (PCL)

Regular X-rays of the afflicted knee were taken in both lateral and anteroposterior views.

For confirmation, an MRI of the knee was performed in every case where meniscal injury was suspected.

INCLUSION CRITERIA:

- Patients aged between 40 to 55 years.
- Clinical examination and radiographic confirmation for osteoarthritis changes.
- Clinical and MRI confirmed posterior meniscal root tears.
- Non-traumatic and traumatic meniscal root tears in patients without severe degeneration
- (Kellgren- Lawrence grade 1 & 2)
- Patients willing for treatment and giving informed and written consent.

EXCLUSION CRITERIA:

- Patients aged below 40 years and above 55 years.
- Uncorrected varus or valgus malalignment (>3 degrees)
- Osteoarthritis of knee (Kellgren- Lawrence grade 3 & 4)
- Multiple Ligament injuries of knee.
- Associated neurovascular injury.
- Diffuse articular cartilage changes International Cartilage Regeneration and Joint Preservation Society (ICRS) grade 3 & 4.
- Patients medically unfit for surgery.

SAMPLING

SAMPLE SIZE CALCULATION:

With anticipated proportion of Meniscal root tears 10% to 21% [4], the study would require a sample size of 35 subjects with 95% level of confidence and 10% absolute precision.

Formula used $$n = \frac{z^2\, p*q}{d^2}$$

Where Z= Z statistic at α level of significance

d^2= Absolute error

P= Proportion rate

q= 100-p

STATISTICAL ANALYSIS:

The data obtained will be entered in a Microsoft Excel sheet, and statistical analysis will be performed using statistical package for the social sciences (Version 20).

Results will be presented as Mean ±SD, Median and interquartile range, frequency, percentages and diagrams.

The Randomisation of this study will be done through the Computerised or Lottery method.

PRE OPERATIVE WORK-UP:

Individuals diagnosed with clinically and radiologically verified meniscal posterior horn root tears were admitted to the Orthopaedics Department of the BLDE (DEEMED TO BE UNIVERSITY) Shri B. M. Patil Medical College, Hospital & Research Centre, located in Vijayapura. Pre-anaesthetic examinations and routine testing such complete blood counts, blood sugar levels, CXRs, and electrocardiograms were performed.

PRE-OPERATIVE REHABILITATION:

- The knee joint's pre operative strength & ROM recorded.
- Patients were taught static and dynamic quadriceps exercises while they were waiting for surgery.
- Post-operative rehabilitation was explained to all patients.

CONSENT:

Each participant in this study received a detailed explanation of their injury, diagnosis, treatment options, complications associated with non-operative care and surgical intervention, intraoperative & post-op complications, damage to structures nearby, infections & movement restrictions.

All study participants gave their consent before getting surgery. Prior to the operation, all consents were obtained. The benefits and drawbacks of the treatment were thoroughly addressed to patients and attenders. Ratio of risk to benefit was explained.

SURGICAL TECHNIQUE

In each case, a preoperative dose of ceftriaxone + sulbactam(1.5 g) is administered as a preventive antibiotic measure.

In our study, position of the patient was supine. Side post over the upper 1/3rd of affected thigh to prevent abduction and a post fixed on table to keep the knee in 70-90 degrees of flexion.

Under ascetic precautions spinal/epidural anaesthesia was given.

After soft padding, a pneumatic tourniquet was applied at the proximal thigh. Before inflating tourniquet, limb is elevated and exsanguination done.

Fig 28: Positioning of patient.

SKIN MARKINGS:

Both femoral condyles, patella, patellar tendon, tibial tuberosity and tibia plateaus are marked. Surgeon should draw landmarks & portals to make sure the portals are positioned appropriately.

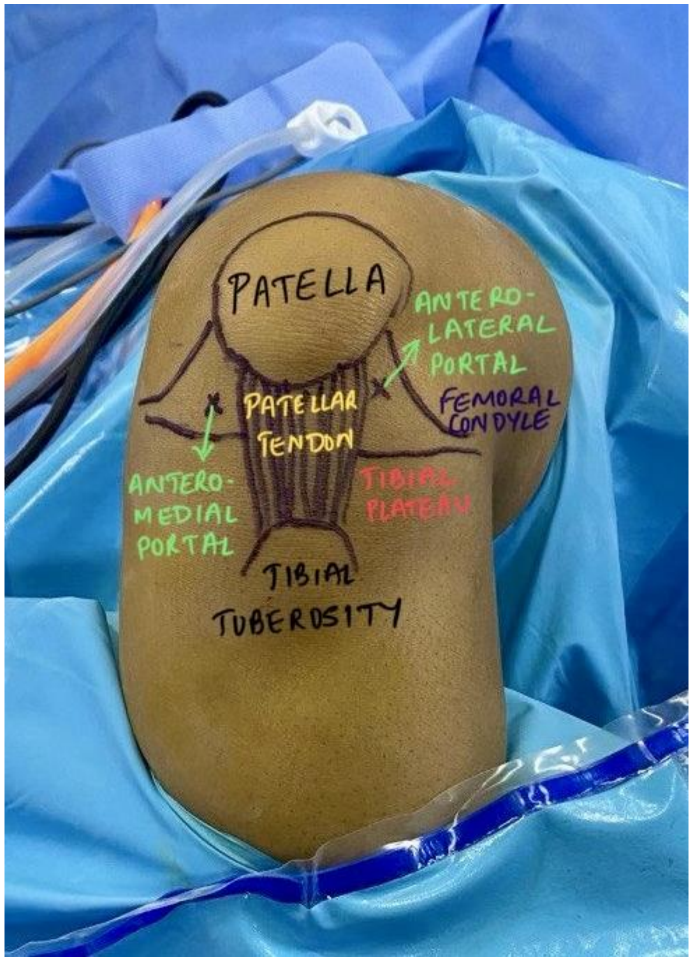


Fig 29: Skin markings

ARTHROSCOPY PORTALS:[108]

Antero-lateral portal: The surgeons usually perform diagnostic arthroscopy through this portal. With the exception of PCL & anterior horn of lateral-menisci, through this portal, you may see practically all of the knee joint's internal structures. This portal is situated 1 cm lateral to the patellar tendon and 1 cm superior to the lateral joint line. The inferior pole of the patella should be around 1 cm distal from the level of the portal.

Antero-medial portal: It is primarily utilised to provide additional views of lateral-compartment & to use probe to palpate the medial & lateral compartments. It is useful in instrumentation and inserting a cannula. The portal is positioned 1 cm medial to the patellar tendon, 1 cm distal to the inferior pole of the patella, and 1 cm superior to the medial joint line. A spiral needle can be inserted percutaneously and used to limit the exact location of the portal while being seen through the antero-lateral portal.

DIAGNOSTIC ARTHROSCOPY:

After skin marking, anterolateral port (viewing portal) is created with no. 11 blade at the level of the inferior pole of the patella, directly lateral to the patellar tendon, when the knee is flexed 90 degrees. Next, the scope is put in for diagnostic arthroscopy. Normal saline is used to insufflate the joint, and a 30 degree arthroscopy camera is used to see it. All intra-articular structures were visualised for any abnormality. Posterior horn of meniscus root tear is identified.

The anteromedial (working) portal is then established when all abnormalities have been noted. Probing is done to confirm the diagnosis.

Debridement of hypertrophied synovium, articular cartilage from the posterior aspect of medial or lateral femoral condyles.

Pie-crusting of the medial collateral ligament using an 18G needle was done in case of a tight medial compartment which helps in widening it. By applying valgus load close to full extension (5°–10° flexion angle), the posterior horn of the medial meniscus can be better visualised.

Fig 30: Intraoperative finding of posterior of meniscus root tear.

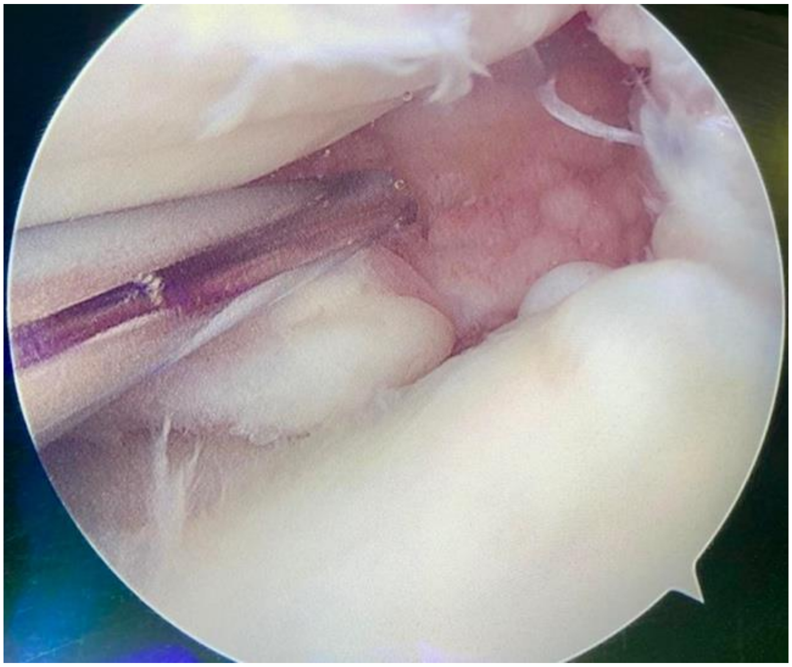


Fig 31: Probing the posterior horn of meniscus, if the root dislodges from its attachment confirms the diagnosis.

Tibial Tunnel preparation:[107]

The transtibial tunnel incision of 2-3cm is made antero-laterally, just distal to the medial portion of Gerdy's tubercle, for lateral meniscus posterior horn root tears, and just medial to the tibial tubercle and proximal to pes anserinus, for medial meniscus posterior horn root tears.

A tibial aiming jig is placed with a cannulated sleeve. A drill guide is used to ream and position is confirmed. Using a 4.5mm and 8mm reamer, guide wire is over drilled.

Suturing the torn menisci:

A non-absorbable braided suture (Fibre Wire No.2/No.0) is loaded to a suture-passing device (Scorpion, First Pass). Through the antero-medial portal, this device is inserted and suture is passed 3-5mm away from the torn end. Another suture is passed next to it for better stability and fixation. Pull the fibre wire ends out and make a loop and create a Mickey's ear stitch outside the portal. Using a knot pusher, tighten the stitch.

A nitinol passing wire/ Ethibond is passed through the tibial tunnel into the joint as a loop. With a probe or a grasper, the fibre wire is passed into the loop. Now the ethibond is pulled back out through the tibial tunnel.

By doing this, the meniscus root is reduced into the tibial socket by tensioning the free ends of the sutures. Tibial fixation is done by tying it to a suture button (e.g. Endo button/ Suture disc/ MR-Fix) or with a suture anchor.

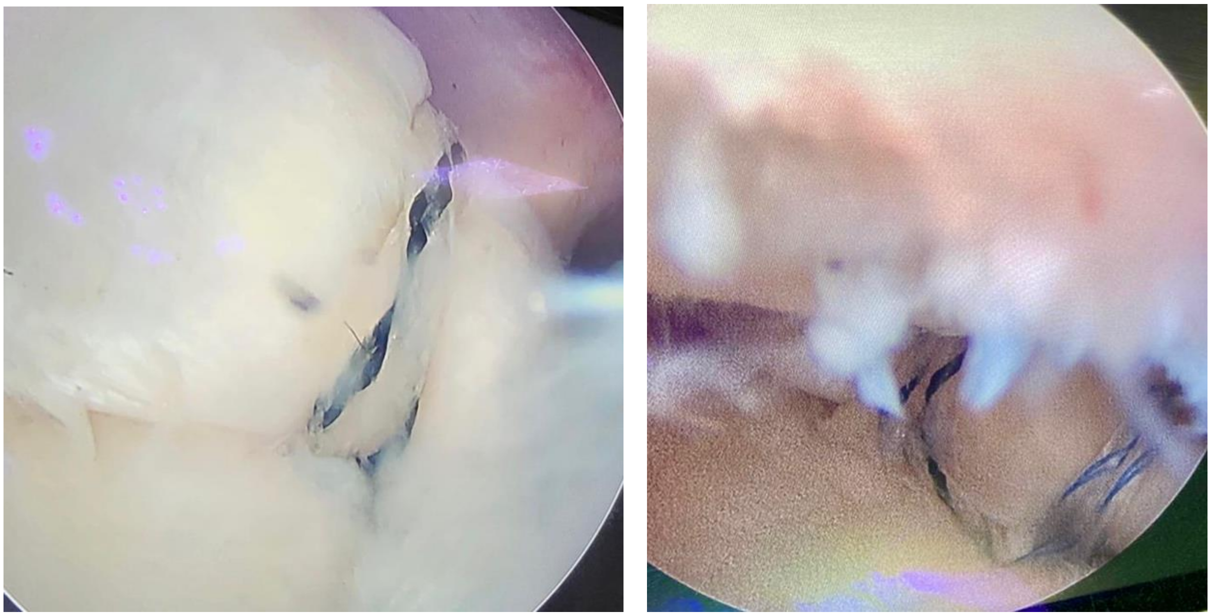


Fig 32: Showing suturing of torn root of posterior horn meniscus using Fibre wires No 2 .

Fig 33 : Transtibial tunnel, through which the fibre wire is retrieved .

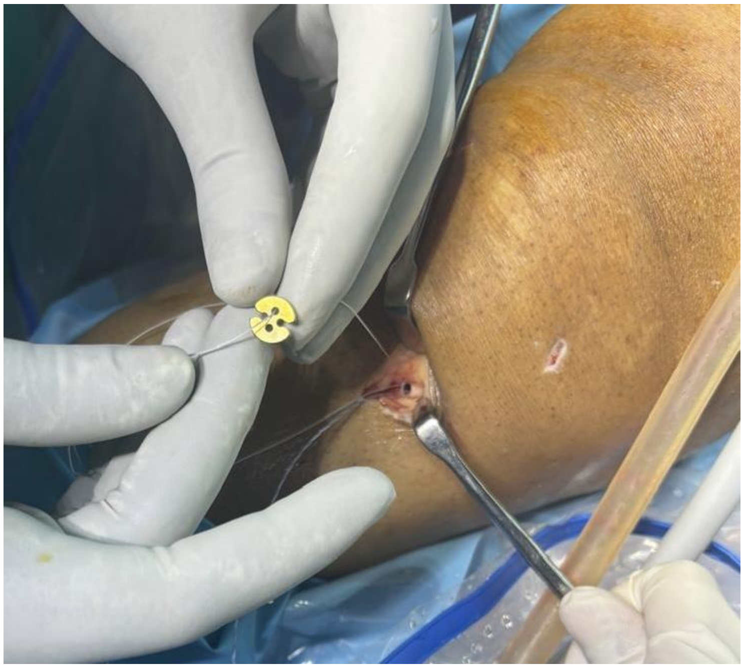


Fig 34: Showing use of MR-Fix to fix the fibre wire to the tibia.

POST- OPERATIVE MANAGEMENT AND REHABILITATION:

Leg elevation and immobilisation in a knee brace were practised in the initial days after surgery. After surgery, intravenous antibiotics were given for three days. The wound was checked on the second and fifth post-operative days. The sutures removed on the twelfth day following the procedure. The process of rehabilitation began immediately.

TIME PERIOD	**REHABILITATION PROTOCOL**
0-2weeks	- Strict non-weight bearing walker mobilization for 4 weeks - Use of Long knee brace/ Extension brace. - Quadriceps strengthening started from first day (static), dynamic and Straight and side leg raise as per tolerated with brace. - Electric stimulation if poor strength of quadriceps. - Mobilisation of Patella (superior-inferior and Medio-lateral direction) - Ankle pumps - Passive range of motion exercises from 0º to 90º flexion started on Day 1 of surgery.
2-4 weeks	- Knee flexion can be increased as tolerated. - Continue Quadriceps strengthening (static & dynamic) and Straight and side leg raise as per tolerated with brace with ankle pumps.
4-6 weeks	- Partial/ Toe-touch weight bearing started. - Dynamic Quadriceps strengthening and Straight and side leg raise
>6 weeks	- Full weight-bearing begins progressively. - Partial/ half squats.
>4 months	Deep leg presses and squats exceeding 70º of knee flexion.
>6 months	Running, Jogging, Swimming.

EVALUATION:

All patients had post-operative anteroposterior and lateral radiographs. Functional results were evaluated at 3 months, 6 months, and one-year intervals for the patients.

Patients were evaluated by VAS and WOMAC scoring systems.

CASE ILLUSTRATIONS

CASE 1: A 41 year old female diagnosed with left knee medial meniscus posterior horn root tear and underwent arthroscopic medial meniscus repair using transtibial pull-out technique and fixation was done using MR-Fix.

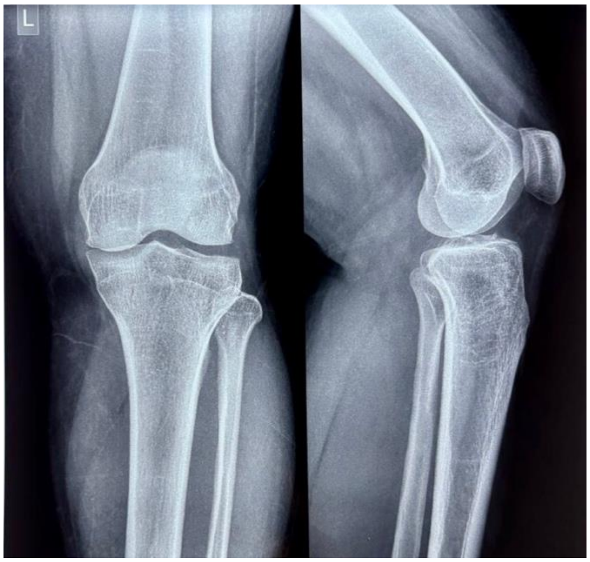


Fig 35A: Pre-operative x-ray

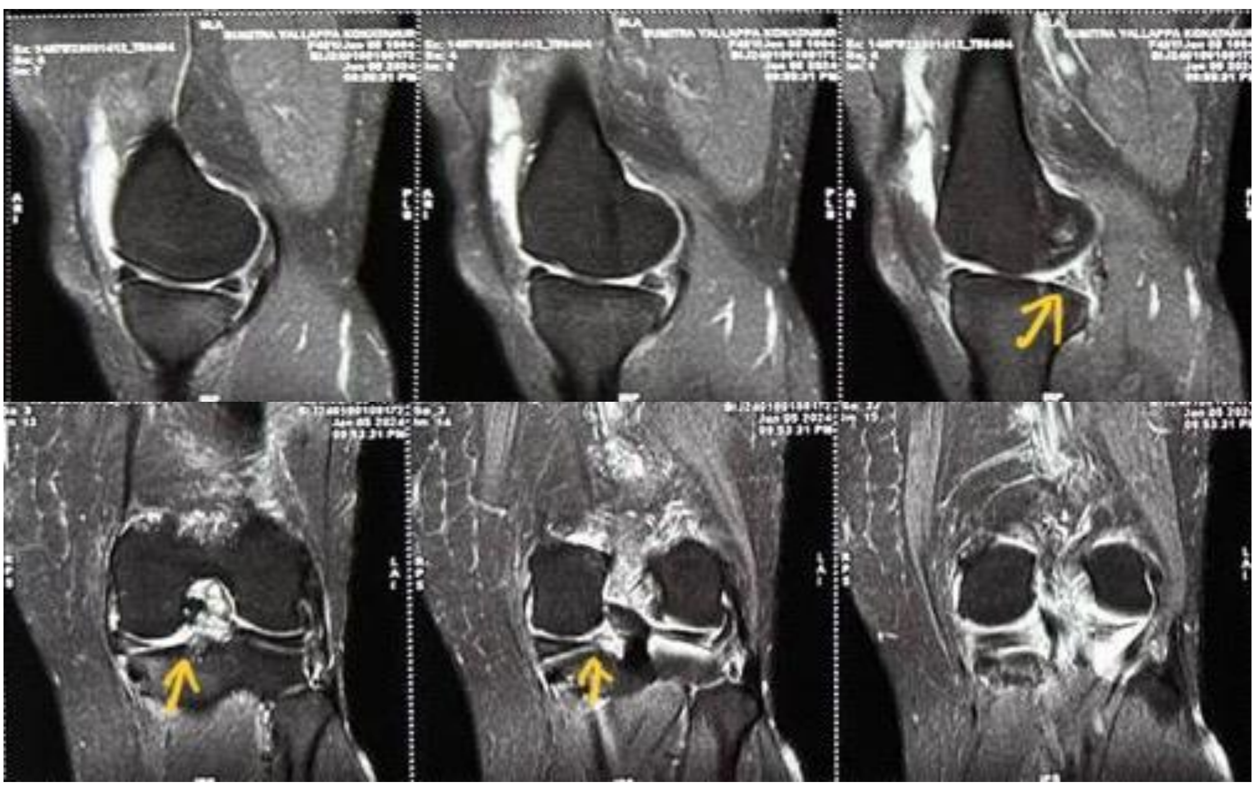


Fig 35B: MRI showing Medial meniscus posterior horn tear (Ghost Sign)

Fig 35C: Clinical pictures of post-op patient.

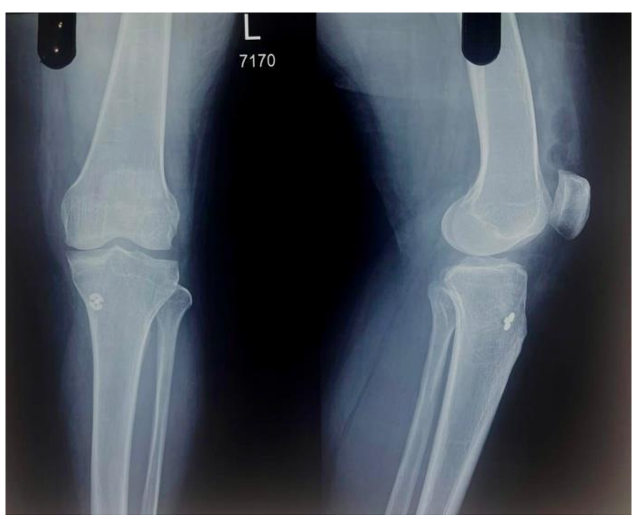


Fig 35D: Post-operative meniscus root repair using transtibial pull-out technique with MR-Fix

CASE 2: A 46 year old male, diagnosed with left knee medial meniscus posterior horn root tear and underwent arthroscopic medial meniscus repair using transtibial pull-out technique and fixation was done using suture MR-Fix.

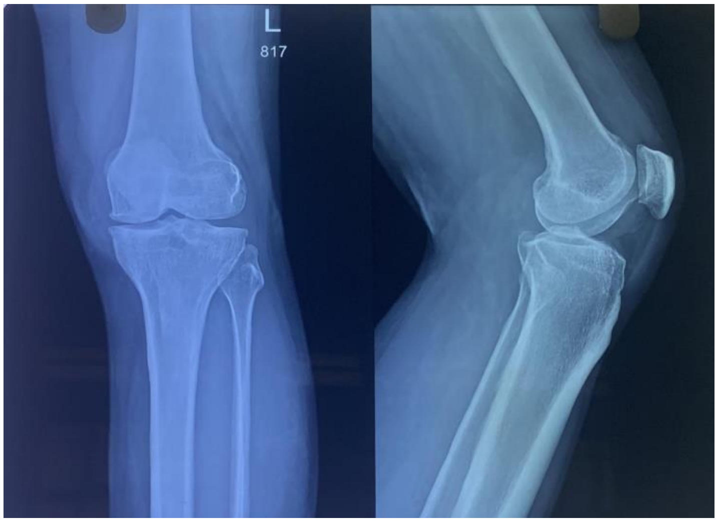


Fig 36A : Pre-operative x-ray

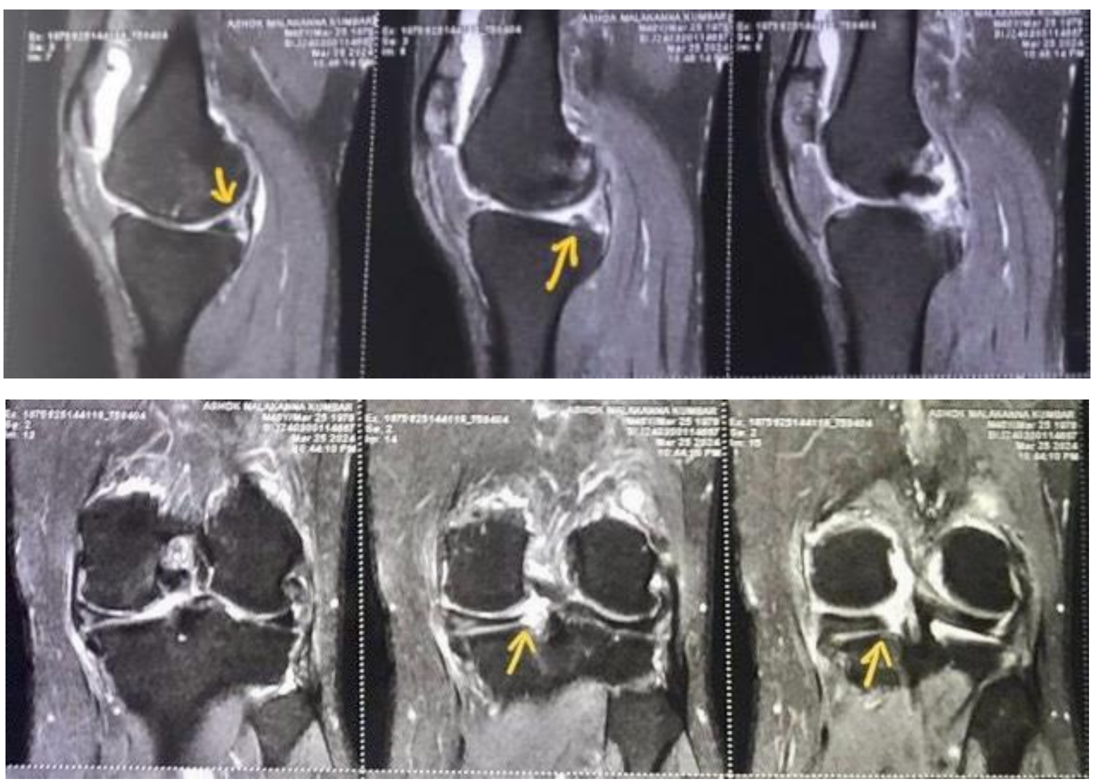


Fig 36B: Above MRI findings depict the medial meniscus posterior horn signal intensity, suggesting tear.

Fig 36C: Clinical photos of post-op patient.

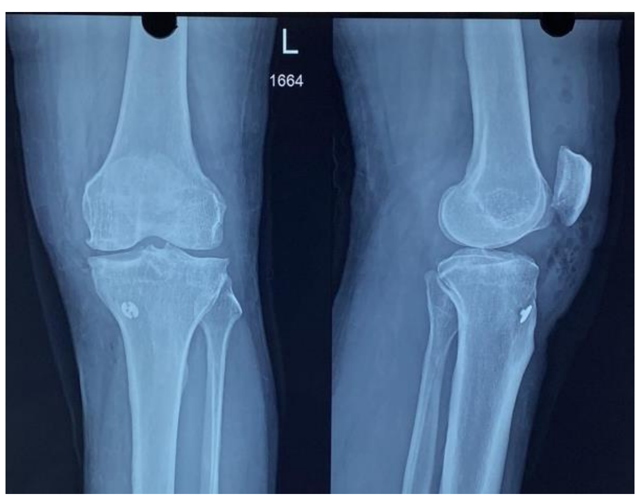


Fig 36D: Post-operative meniscus root repair using transtibial pull-out technique with MR-Fix

RESULTS

35 cases of arthroscopic meniscus posterior horn root repair were randomized and were followed up regularly for a period of 12 months minimum and 17 months maximum in BLDE (DEEMED TO BE UNIVERSITY) Shri B. M. Patil Medical College, Hospital & Research Centre, Vijayapura (August 2022 to January 2024).

AGE DISTRIBUTION:

Age	No. of patients	Percentage
< 45	15	42.9
45 - 49	13	37.1
50+	7	20.0
Total	35	100.0

Table 1: Age distribution

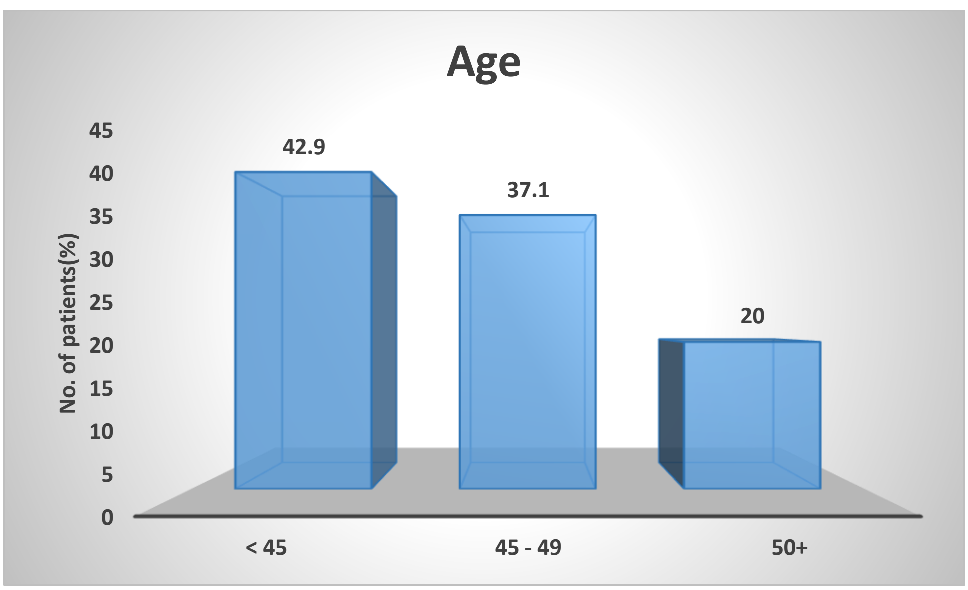


Fig 37: Age distribution

All patients taken for the study were in between 40 to 55 years of age, out of which 15 (42%) patients were below 45 years, 13 (37%) were between 45-49 years, 7 (20%) were over 50 years.

SEX DISTRIBUTION:

Gender	No. of patients	Percentage
Female	27	77.1
Male	8	22.9
Total	35	100.0

Table 2: Sex distribution.

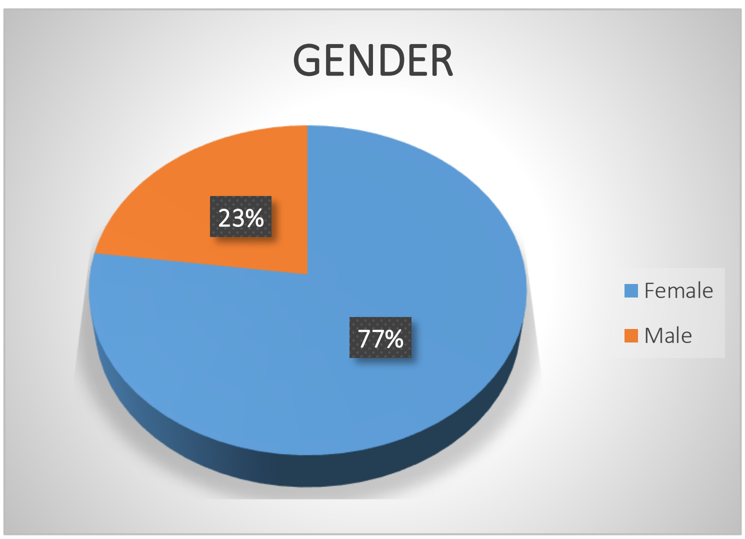


Fig 38: Gender distribution

Out of 35 cases, females were 27 (77%) and males were 8(23%).

LIMB INVOLVED:

Affected Limb	No. of patients	Percentage
LEFT	14	40.0
RIGHT	21	60.0
Total	35	100.0

Table 3: Limb involved

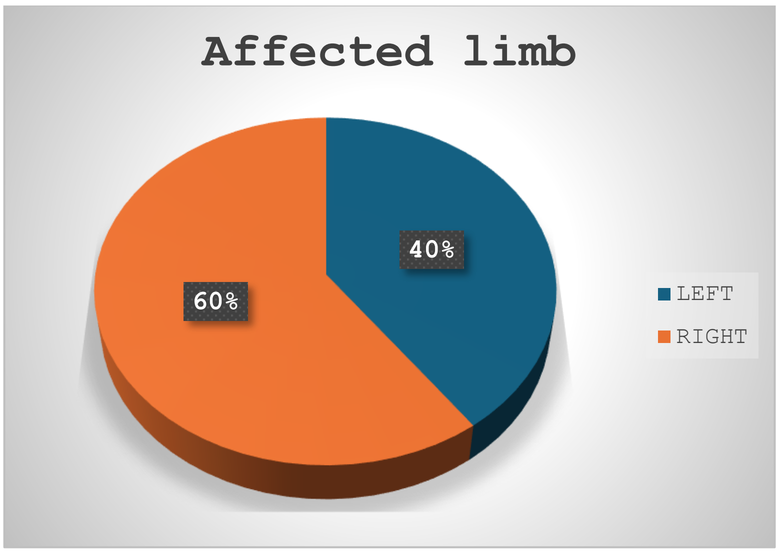


Fig 39: Affected limb

Limb involvement on the right side accounted to be 21 (60%) and left was 14 (40%).

INJURY:

Injury	No. of patients	Percentage
-	20	57.1
+	15	42.9
Total	35	100.0

Table 4: Sustained injury or not.

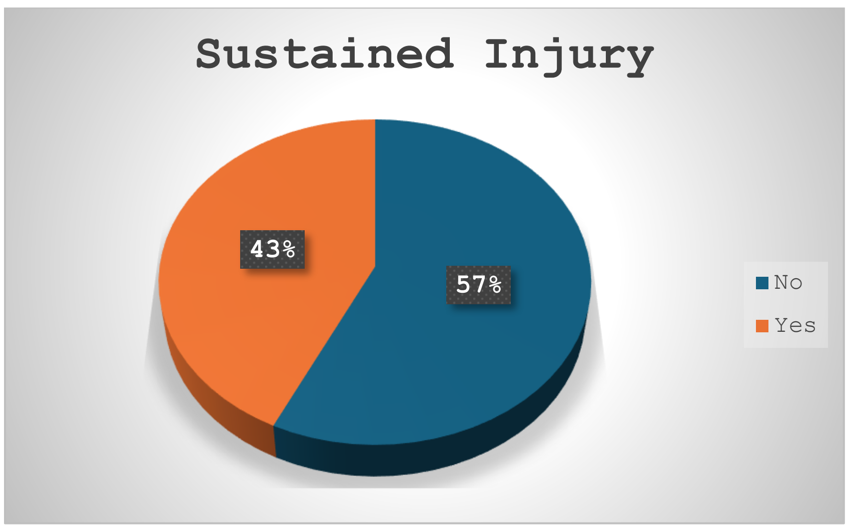


Fig 40: Sustained Injury

In our study, total number of patients who gave history of trauma such as fall or twisting injury were 15 (43%) and those without any mode of injury were 20 (57%).

TYPE OF ROOT TEARS:

Intra-operative finding: Type of tear	No. of patients	Percentage (%)
2	17	48.6
4	3	8.6
5	15	42.9
Total	35	100.0

Table 5: Intra-operative confirmation of type of root tear

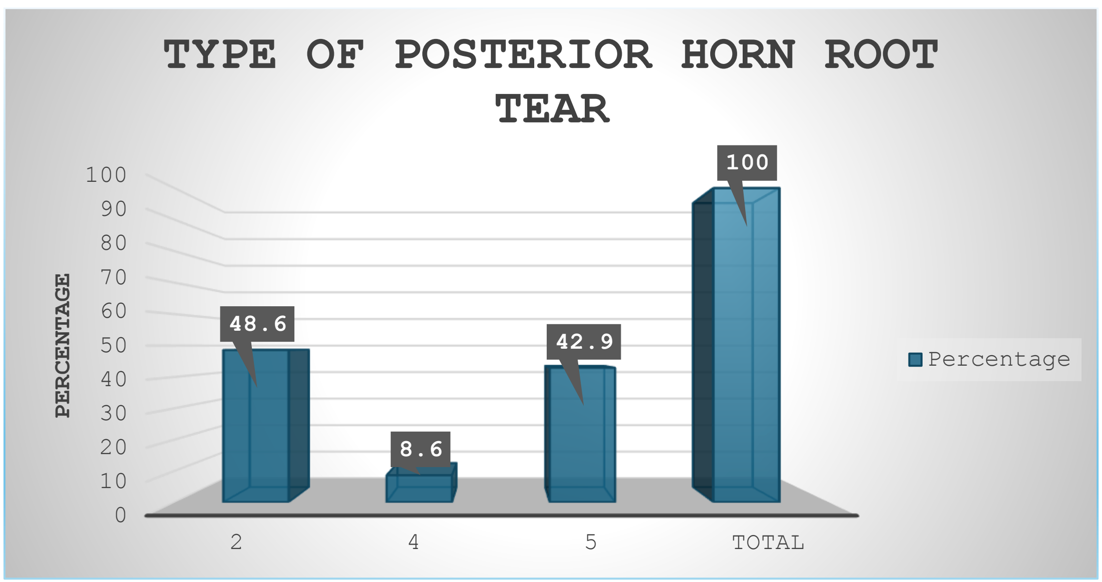


Fig 41: Types of posterior horn root tears

Intra-operatively, we found that 17 (49%) of the cases belonged to type 2, 3 (9%) to type 4 and 15 (43%) belonged to type 5.

VAS SCORE:

VAS SCORE	Mean	Std. Deviation	25th	50th (Median)	75th	Friedman Test	P-Value
PRE-OP	7.26	.701	7.00	7.00	8.00	103.696	.0001
3 MONTHS	5.31	.718	5.00	5.00	6.00		
6 MONTHS	4.37	.731	4.00	4.00	5.00		
12 MONTHS	2.11	1.105	2.00	2.00	3.00		

Table 6: VAS scoring system interpretation.

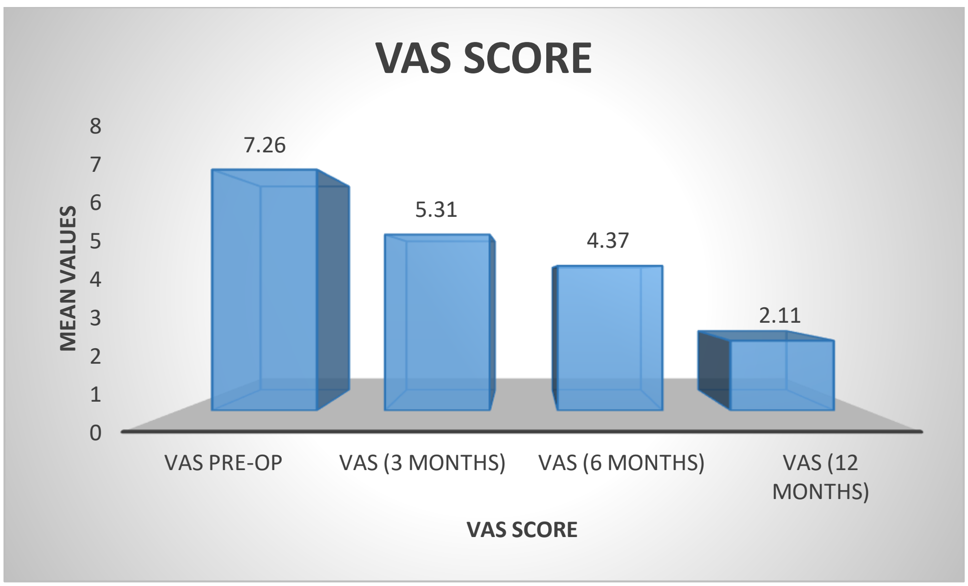


Fig 42: VAS Score

After interpreting the VAS score pre-op and post-op at 3,6 and 12 months period, we can see that there is a significant decrease in the VAS score suggesting and the comparison has given us a P-value of 0.001 which is significant.

WOMAC SCORE:

WOMAC SCORE	Mean	Std. Deviation	25th	50th (Median)	75th	Friedman Test	P-Value
PRE-OP	45.54	2.873	44.00	46.00	48.00	105.000	.0001
3 MONTHS	35.37	3.020	32.00	36.00	38.00		
6 MONTHS	20.57	2.973	20.00	20.00	22.00		
12 MONTHS	4.80	2.286	2.00	4.00	6.00		

Table 7: WOMAC scoring system interpretation.

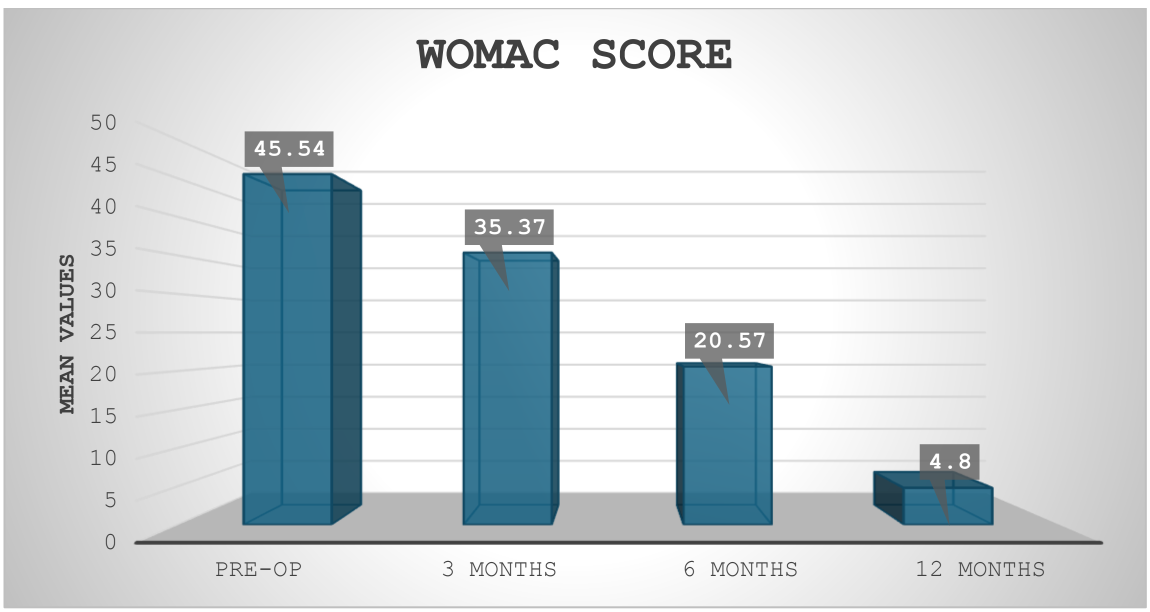


Fig 43: WOMAC Score

After interpreting the WOMAC score pre-op and post-op at 3,6 and 12 months period, we can see that there is a significant decrease in the WOMAC score suggesting and the comparison has given us a P-value of 0.001 which is significant.

MRI :

MRI Findings	No. of patients	Percentage
LATERAL MENISCUS POSTERIOR HORN ROOT TEAR	7	20.0
MEDIAL MENISCUS POSTERIOR HORN ROOT TEAR	28	80.0
Total	35	100.0

Table 8: MRI impression.

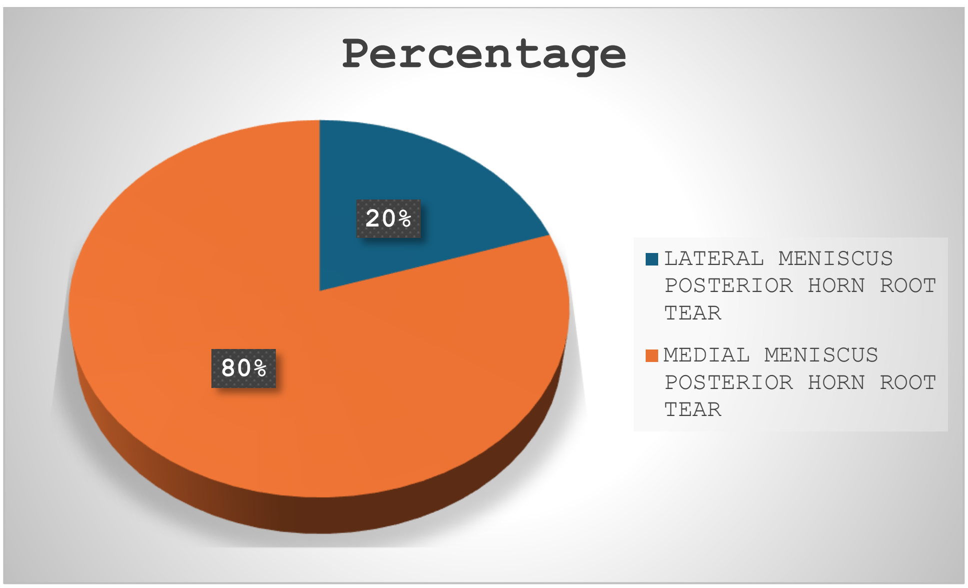


Fig 44: MRI Impression

No of cases involving the lateral and medial meniscus were 7(20%) and 28(80%) respectively.

COMPLICATIONS

2 patients were noted to have superficial infection in our study they were treated with IV Antibiotics and improved.

3 patients complained of restricted range of movement due to poor compliance to post operative rehabilitation and pain intolerance. These patients were given aggressive physiotherapy along with adequate analgesics coverage and range of movements was achieved.

DISCUSSION

The exploration of functional outcomes following posterior meniscal root repairs employing the trans-tibial pullout technique provides valuable insights, particularly when comparing findings across diverse studies. Our research conducted at BLDE (Deemed to be University) Shri B. M. Patil Medical College, Hospital & Research Centre, Vijayapura, between August 2022 and January 2024, involved 35 participants undergoing this surgical procedure. This analysis emphasizes the demographic characteristics, clinical outcomes, and intra-operative findings, fostering a comprehensive understanding of the technique's efficacy across different patient settings.

Our study predominantly comprised middle-aged females (77%), mirroring the demographic profile observed in the study by Feucht et al., where 83% of the participants were female. This demographic trend underscores potential gender-specific considerations in postoperative care and rehabilitation strategies due to the higher susceptibility of females to meniscal injuries[107]. Unlike the study done by Aaron J. Krych et al.,[42] which did not detail gender distribution but noted significant clinical improvements regardless of demographic variables such as age and BMI, our findings also indicated that these factors were non-influential.[40]

The age profile in our study, spanning from 40 to 55 years, closely aligns with the mean patient age of 55 years reported by Feucht et al., suggesting the trans-tibial pullout technique's consistent effectiveness across a similar demographic. This is particularly pertinent given the rising incidence of degenerative meniscal lesions in this age group.[107]

Regarding trauma history, 43% of our patients reported incidents such as falls or twisting injuries, highlighting the role of acute injuries in meniscal tears. This aspect of patient history could potentially affect the preoperative meniscal condition and subsequently influence post-repair prognosis.

Intraoperatively, the majority of the meniscal tears we addressed were type 2 (49%), followed by type 5 (43%). This indicates the complexity of the cases handled and may impact the surgical approach and expected recovery outcomes. In the studies done by Feucht et al. and Aaron J. Krych et al., however, did not provide detailed breakdowns of tear types, focusing more broadly on the overall efficacy of the repair technique in enhancing clinical scores and halting osteoarthritic progression.[40,107]

Our results demonstrated significant improvements in VAS and WOMAC scores postoperatively, corroborating the findings from the multicenter study done by Aaron J. Krych et al.,[42] which also documented substantial clinical improvements at 2 years. This consistency across studies highlights the trans-tibial pullout method's capacity to facilitate significant functional recovery.[40] The systematic review by Feucht et al. further supports this, with additional evidence showing the procedure's capability to arrest osteoarthritic progression, although they noted that complete healing and reduction of meniscal extrusion were less predictable, occurring in about 60% of cases.[107]

Surgeons are still debating whether older patients should have meniscectomy or root repair. In a different comparative cohort study, Chung K S et al., found that patients with an average age of 55 who had posterior medial root meniscectomy as opposed to root repair fared better than expected. The repair cohort's scores improved by 32 points from preoperative to postoperative status, while the meniscectomy cohort's improvement was only 12 points.[43]

Despite our study and the multicenter research by Aaron J. Krych et al., not finding a direct correlation between meniscal extrusion and poorer functional outcomes, literature from Feucht et al., suggests that progressive extrusion is associated with worse clinical outcomes and more severe osteoarthritic changes over time. This discrepancy may be due to differences in the follow-up durations and methods employed in assessing extrusion and its clinical impacts.[40,107]

SUMMARY

This study at BLDE (Deemed to be University) Shri B. M. Patil Medical College analysed 35 patients undergoing posterior meniscal root repairs with the trans-tibial pullout technique from August 2022 to January 2024. The demographic profile showed a predominance of middle-aged females (77%), aligning with similar studies, suggesting gender-specific postoperative care considerations. The age range of 40-55 years was consistent with other findings, indicating the technique's efficacy in this demographic. Our results indicated significant improvements in VAS and WOMAC scores postoperatively, supporting the technique's effectiveness. This was in line with findings from Aaron J. Krych et al. and Feucht et al., who also reported substantial clinical improvements and osteoarthritic progression arrest, albeit with some variations in meniscal extrusion impacts.[42,107] The debate on whether older patients should undergo meniscectomy or root repair continues, with some studies indicating better outcomes with repair. Overall, the trans-tibial pullout method shows promise in facilitating significant functional recovery across different patient settings.

CONCLUSION

As demonstrated by the VAS and WOMAC scores, the transtibial pull-out approach for the treatment of meniscal posterior horn root injuries substantially improves pain and functional outcomes. For patients with meniscal injuries, this procedure provides a dependable option that can significantly improve joint functionality and reduce pain. It is especially beneficial for female patients under 50 years of age. Variations in outcomes are likely influenced by patient-specific factors such as age and the extent of meniscal extrusion. This approach has to be further investigated and improved in the future in order to maximise its application and optimise recovery protocols for a variety of patient demographics. In conclusion, the comparative analysis of these studies affirmatively supports the effectiveness of the trans-tibial pullout technique in managing posterior meniscal root tears.

LIMITATIONS

1. Limited Sample Size: With only 35 participants, findings may not be broadly applicable to other demographic groups, reducing the study's generalizability.

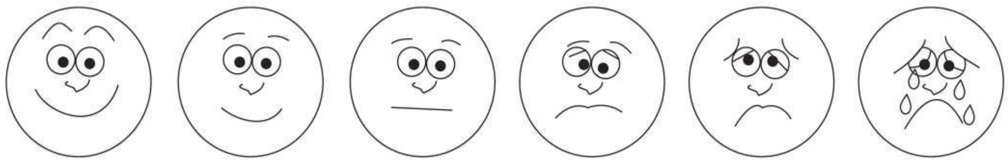
2. Short Follow-up Period: A 12-month follow-up restricts the ability to evaluate long-term surgical outcomes and the progression of osteoarthritis.

3. Lack of Control Group: The absence of a control group prevents definitive conclusions about the efficacy of the transtibial pull-out technique compared to other treatments.

4. Subjective Outcome Measures: Dependence on subjective measures like VAS and WOMAC scores introduces variability affected by individual patient perceptions.

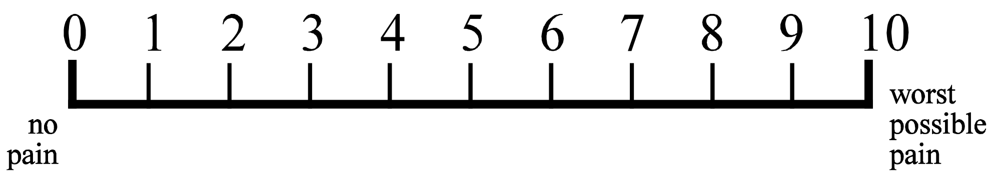
VAS SCALE

Faces Pain Scale



0	2	4	6	8	10
Very happy, no hurt	Hurts just a little bit	Hurts a little more	Hurts even more	Hurts a whole lot	Hurts as much as you can imagine (don't have to be crying to feel this much pain)

Visual Analog Scale (VAS)



WOMAC SCALE

The Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC)

Name:____ Date:________________

Instructions: Please rate the activities in each category according to the following scale of difficulty: 0 = None, 1 = Slight, 2 = Moderate, 3 = Very, 4 = Extremely

Circle **one number** for each activity

Pain	1. Walking	0	1	2	3	4
	2. Stair Climbing	0	1	2	3	4
	3. Nocturnal	0	1	2	3	4
	4. Rest	0	1	2	3	4
	5. Weight bearing	0	1	2	3	4
Stiffness	1. Morning stiffness	0	1	2	3	4
	2. Stiffness occurring later in the day	0	1	2	3	4
Physical Function	1. Descending stairs	0	1	2	3	4
	2. Ascending stairs	0	1	2	3	4
	3. Rising from sitting	0	1	2	3	4
	4. Standing	0	1	2	3	4
	5. Bending to floor	0	1	2	3	4
	6. Walking on flat surface	0	1	2	3	4
	7. Getting in / out of car	0	1	2	3	4
	8. Going shopping	0	1	2	3	4
	9. Putting on socks	0	1	2	3	4
	10. Lying in bed	0	1	2	3	4
	11. Taking off socks	0	1	2	3	4
	12. Rising from bed	0	1	2	3	4
	13. Getting in/out of bath	0	1	2	3	4
	14. Sitting	0	1	2	3	4
	15. Getting on/off toilet	0	1	2	3	4
	16. Heavy domestic duties	0	1	2	3	4
	17. Light domestic duties	0	1	2	3	4

Total Score: ______ / 96 = _______%

Comments / Interpretation (to be completed by therapist only):

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ANNEXURE I

INFORMED CONSENT FORM FOR PARTICIPATION IN DISSERTATION / RESEARCH

I, the undersigned, _______________, S/O D/O W/O ________________, aged ____years, ordinarily resident of ____________ do hereby state/declare that **Dr. ANUSHA BALAJI** of Shri. B. M. Patil Medical College Hospital & Research Centre has examined me thoroughly on ______________ at ______________ (place) and it has been explained to me in my own language that I am suffering from ________________ disease (condition) and this disease/condition mimic following diseases. Further **Dr. ANUSHA BALAJI** informed me that he/she is conducting dissertation/research titled "**TO STUDY THE FUNCTIONAL OUTCOME OF "TRANSTIBIAL PULL OUT TECHNIQUE FOR POSTERIOR MENISCAL ROOT TEAR IN EARLY OSTEOARTHRITIS**" under the guidance of **Dr. S.S NANDI** requesting my participation in the study. Apart from routine treatment procedure, the pre-operative, operative, post-operative and follow-up observations will be utilised for the study as reference data.

The doctor has also informed me that during the conduct of this procedure, adverse results might encounter. Most of them are treatable but are not anticipated; hence there is a chance of aggravation of my condition. In rare circumstances, it may prove fatal despite the expected diagnosis and best treatment made available. Further Doctor has informed me that my participation in this study help in the evaluation of the results of the study, which is a useful reference to the treatment of other similar cases in future and also, I may be benefited from getting relieved from suffering or a cure of the disease I am suffering.

The Doctor has also informed me that information given by me, observations made/ photographs/ video graphs taken upon me by the investigator will be kept secret and not assessed by the person other than my legal hirer or me except for academic purposes.

The Doctor did inform me that though my participation is purely voluntary, based on the information given by me, I can ask for any clarification during treatment/study related to diagnosis, the procedure of treatment, the result of treatment, or prognosis. I've been informed that I can withdraw from my participation in this study at any time if I want, or the investigator can terminate me from the study at any time from the study but not the procedure of treatment and follow-up unless I request to be discharged.

After understanding the nature of dissertation or research, diagnosis made, mode of treatment, I the undersigned Shri/Smt ____ under my full conscious state of mind agree to participate in the said research/dissertation.

Signature of the patient:

Signature of doctor:

Witness: 1.

2.

Date:

Place:

ANNEXURE II

SCHEME OF CASE TAKING

CASE NO:

FOLLOW UP NO:

NAME:

AGE/SEX:

I P NO:

DATE OF ADMISSION:

DATE OF SURGERY:

DATE OF DISCHARGE:

OCCUPATION:

RESIDENCE:

Presenting complaints with duration:

History of presenting complaints:

Family History:

Personal History:

Past History:

Vitals:

PR: RR:

BP: TEMP:

Systemic Examination:

Respiratory system-

Cardiovascular system-

Per abdomen-

Central nervous system-

Local examination:

Right/ Left Leg

Gait:

Inspection:

- Attitude
- Abnormal swelling
- Shortening
- Skin condition
- Compound injury, if any

Palpation:

- Swelling
- Local tenderness
- Bony irregularity
- Abnormal movement
- Crepitus/ grating of fragments
- Absence of transmitted movements
- Wound

Movements:	Active	Passive
Flexion		
Extension		

Intra Operative details:

Post Operative:

- Rehabilitation protocol as per the guidelines
- Functional outcome evaluation with:
- VAS Score
- WOMAC Score.

Azadi Ka Amrit Mahotsav

BLDE
(DEEMED TO BE UNIVERSITY)
Declared as Deemed to be University u/s 3 of UGC Act, 1956
Accredited with 'A' Grade by NAAC (Cycle-2)
The Constituent College
SHRI B. M. PATIL MEDICAL COLLEGE, HOSPITAL & RESEARCH CENTRE, VIJAYAPURA

BLDE (DU)/IEC/ 723/2022-23

30/8/2022

INSTITUTIONAL ETHICAL CLEARANCE CERTIFICATE

The Ethical Committee of this University met on **Friday, 26th August, 2022 at 3.30 p.m. in the Department of Pharmacology** scrutinizes the Synopsis of Post Graduate Student of BLDE (DU)'s Shri B.M.Patil Medical College Hospital & Research Centre from ethical clearance point of view. After scrutiny, the following original/ corrected and revised version synopsis of the thesis/ research projects has been accorded ethical clearance.

TITLE: "To study the functional outcome of transtibial pull out technique for posterior meniscal root tear in early osteoarthritis".

NAME OF THE STUDENT/PRINCIPAL INVESTIGATOR: DR ANUSHA BALAJI

NAME OF THE GUIDE: Dr.S.S.Nandi, Professor, Dept. of Orthopedics. .

Dr. Santoshkumar Jeevangi
Chairperson
IEC, BLDE (DU),
VIJAYAPURA

Chairman,
Institutional Ethical Committee,
BLDE (Deemed to be University)
Vijayapura

Dr.Akram A. Naikwadi
Member Secretary
IEC, BLDE (DU),
VIJAYAPURA

MEMBER SECRETARY
Institutional Ethics Committee
BLDE (Deemed to be University)
Vijayapura-586103. Karnataka

Following documents were placed before Ethical Committee for Scrutinization.

- Copy of Synopsis/Research Projects
- Copy of inform consent form
- Any other relevant document

Smt. Bangaramma Sajjan Campus, B. M. Patil Road (Sholapur Road), Vijayapura - 586103, Karnataka, India.
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MASTERCHART

SL.NO	NAME	AGE(YEARS)	SEX	PATIENT ID	AFFECTED LIMB	INJURY (+/-)	DURATION OF SYMPTOMS (Months)	MCMURRAYS TEST	MRI FINDINGS	INTRAOPERATIVE FINDINGS (TYPE)	VAS PRE-OP	VAS (3 MONTHS)	VAS (6 MONTHS)	VAS (12 MONTHS)	WOMAC PRE-OP	WOMAC (3 MONTHS)	WOMAC (6 MONTHS)	WOMAC (12 MONTHS)
1	SUNANDA	52	F	100841	RIGHT	-	6	POSITIVE	MEDIAL MENISCUS POSTERIOR HORN ROOT TEAR	2	8	6	5	3	46	36	18	2
2	MADEVI	45	F	129961	RIGHT	-	4	POSITIVE	MEDIAL MENISCUS POSTERIOR HORN ROOT TEAR	5	7	5	4	2	40	38	20	6
3	KASHIBAI	45	F	176695	LEFT	-	5	POSITIVE	MEDIAL MENISCUS POSTERIOR HORN ROOT TEAR	2	8	6	5	4	48	38	20	4
4	GANGABAI	55	F	186120	LEFT	+	3	POSITIVE	LATERAL MENISCUS POSTERIOR HORN ROOT TEAR	4	7	5	4	2	48	40	24	2
5	SUJATA	44	F	122996	RIGHT	-	7	POSITIVE	MEDIAL MENISCUS POSTERIOR HORN ROOT TEAR	2	7	5	3	0	42	38	14	6
6	SIDDAMMA	46	F	309823	LEFT	-	8	POSITIVE	MEDIAL MENISCUS POSTERIOR HORN ROOT TEAR	5	8	6	5	3	50	40	20	8
7	SUREKHA	48	F	311297	LEFT	+	6	POSITIVE	MEDIAL MENISCUS POSTERIOR HORN ROOT TEAR	5	8	6	5	2	50	40	20	4
8	VEENA VIBHUTI	43	F	366247	RIGHT	+	5	POSITIVE	MEDIAL MENISCUS POSTERIOR HORN ROOT TEAR	2	7	5	4	2	42	36	22	4
9	BEERAPPA	43	M	360310	RIGHT	+	4	POSITIVE	LATERAL MENISCUS POSTERIOR HORN ROOT TEAR	2	7	5	5	2	46	32	18	2
10	KASHIBAI	46	F	123620	RIGHT	-	3	POSITIVE	MEDIAL MENISCUS POSTERIOR HORN ROOT TEAR	2	6	4	3	1	50	38	16	8
11	SUSHILABAI	50	F	100755	RIGHT	-	12	POSITIVE	MEDIAL MENISCUS POSTERIOR HORN ROOT TEAR	2	6	4	3	2	48	32	20	2
12	SANGEETA	40	F	144819	RIGHT	-	7	POSITIVE	MEDIAL MENISCUS POSTERIOR HORN ROOT TEAR	2	8	6	5	5	46	36	26	10
13	SAMABAI	41	F	158556	LEFT	-	8	POSITIVE	MEDIAL MENISCUS POSTERIOR HORN ROOT TEAR	5	7	5	4	2	44	34	24	8
14	SHIVALINGAVVA	44	F	276505	LEFT	-	14	POSITIVE	MEDIAL MENISCUS POSTERIOR HORN ROOT TEAR	5	7	5	4	2	44	34	22	4
15	MANJULA	49	F	379910	RIGHT	+	4	POSITIVE	MEDIAL MENISCUS POSTERIOR HORN ROOT TEAR	5	8	6	5	3	46	34	20	6
16	SHEKUBAI	41	F	126302	RIGHT	-	8	POSITIVE	MEDIAL MENISCUS POSTERIOR HORN ROOT TEAR	4	8	6	5	3	48	34	20	2
17	SUMITRA	41	F	138201	LEFT	+	3	POSITIVE	LATERAL MENISCUS POSTERIOR HORN ROOT TEAR	5	6	4	3	1	50	38	18	4
18	JAYASHREE	42	F	188648	RIGHT	+	4	POSITIVE	LATERAL MENISCUS POSTERIOR HORN ROOT TEAR	5	7	5	5	2	46	36	24	8
19	ASHOK	46	M	136234	LEFT	+	5	POSITIVE	MEDIAL MENISCUS POSTERIOR HORN ROOT TEAR	2	7	5	4	0	42	40	20	6
20	SUBHARAO	47	M	154867	RIGHT	-	10	POSITIVE	MEDIAL MENISCUS POSTERIOR HORN ROOT TEAR	5	7	5	4	2	44	32	24	2
21	APPASAHEB	40	M	148392	RIGHT	+	7	POSITIVE	MEDIAL MENISCUS POSTERIOR HORN ROOT TEAR	5	8	6	5	3	48	34	22	2
22	SHIVANAND	47	M	271803	LEFT	-	8	POSITIVE	MEDIAL MENISCUS POSTERIOR HORN ROOT TEAR	2	8	6	6	2	48	32	20	2
23	SIDDAPPA	51	M	313299	RIGHT	+	5	POSITIVE	MEDIAL MENISCUS POSTERIOR HORN ROOT TEAR	2	8	6	5	2	46	40	24	4
24	GANGADHAR	42	F	313294	RIGHT	-	12	POSITIVE	MEDIAL MENISCUS POSTERIOR HORN ROOT TEAR	4	7	6	5	3	46	40	18	8
25	SHABANA	51	F	139258	LEFT	+	6	POSITIVE	MEDIAL MENISCUS POSTERIOR HORN ROOT TEAR	5	8	5	4	2	40	32	16	8
26	MANJULA	49	F	379910	RIGHT	+	4	POSITIVE	LATERAL MENISCUS POSTERIOR HORN ROOT TEAR	2	7	6	5	4	40	32	20	6
27	PRAVEEN	41	M	334479	LEFT	-	5	POSITIVE	MEDIAL MENISCUS POSTERIOR HORN ROOT TEAR	2	7	5	4	2	48	36	22	4
28	SHEKUBAI	45	F	271384	RIGHT	-	10	POSITIVE	MEDIAL MENISCUS POSTERIOR HORN ROOT TEAR	2	8	6	4	1	46	34	26	6
29	KANTABAI	40	F	146384	LEFT	-	7	POSITIVE	MEDIAL MENISCUS POSTERIOR HORN ROOT TEAR	2	8	6	5	3	44	32	24	4
30	VINOD	41	M	137216	RIGHT	-	8	POSITIVE	MEDIAL MENISCUS POSTERIOR HORN ROOT TEAR	2	7	6	4	0	46	34	22	6
31	BHARATI	44	F	130835	RIGHT	+	6	POSITIVE	LATERAL MENISCUS POSTERIOR HORN ROOT TEAR	5	7	5	4	2	44	30	22	4
32	MANJAMMA	45	F	132432	LEFT	+	5	POSITIVE	MEDIAL MENISCUS POSTERIOR HORN ROOT TEAR	5	6	5	4	2	44	32	20	6
33	PARVATHAMMA	47	F	236543	RIGHT	-	11	POSITIVE	MEDIAL MENISCUS POSTERIOR HORN ROOT TEAR	5	6	4	4	0	46	36	20	4
34	GIRIJA	53	F	265783	RIGHT	-	9	POSITIVE	MEDIAL MENISCUS POSTERIOR HORN ROOT TEAR	5	8	4	4	2	42	36	14	4
35	LAKSHMAMMA	52	F	178767	LEFT	+	3	POSITIVE	LATERAL MENISCUS POSTERIOR HORN ROOT TEAR	2	7	6	5	4	46	32	20	2

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