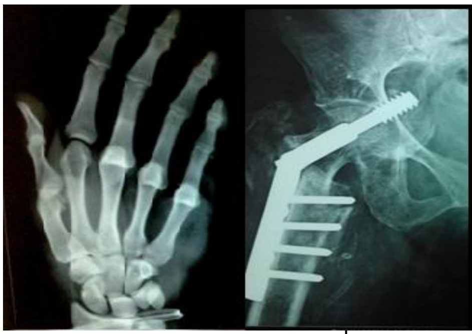

International Journal of Orthopaedics Sciences

E-ISSN: 2395-1958
P-ISSN: 2706-6630
Impact Factor (RJIF): 6.72
IJOS 2026; 12(1): 04-11

www.orthopaper.com
Received: 14-11-2025
Accepted: 13-12-2025

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Results of meniscal root repair by transtibial pullout technique without fixation implants

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DOI: https://www.doi.org/10.22271/ortho.2026.v12.i1a.3880

Abstract
Background: A meniscus root tear is described as a radial tear or avulsion at the posterior horn attachment to bone for medial or lateral meniscus. The aim of this work was evaluation of effectiveness of arthroscopic repair of posterior root tear of medial meniscus without fixation implants in restoring meniscal structural integrity and functions in 20 patients after one year follow up.
Methods: This prospective study included 20 adult patients diagnosed as medical meniscus root tears. All patients were followed up fort one year and assessed using Lysholm activity scale. McMurray test was used to assess medial meniscal tear.
Results: The postoperative extension lag was significantly lower compared to preoperative extension ($p<0.001$). The postoperative flexion was significantly higher compared to preoperative flexion ($p<0.001$). Visual analogue scale (VAS) was significantly lower at 3, 6 and 12 months compared to preoperative VAS ($p<0.05$) and none of the studied patients showed pain at 12 months. The postoperative Lysholm score was significantly improved (higher) compared to preoperative score ($p<0.001$, <0.001).
Conclusions: Arthroscopic pull-out repair of meniscal root tears without fixation implants significantly reduced pain VAS, improved range of motion, and enhanced Lysholm knee scores compared to preoperative values.

Keywords: Meniscal root repair, transtibial pullout, lysholm activity scale, range of motion, visual analogue scale

Introduction
The knee joint contains two menisci, the main function of which is to provide lubrication between femur and tibia as well as support. Terminal portions of both anterior and posterior horns of both menisci are anchored to meniscal enthuses or meniscal roots. Meniscal roots must be attached to the tibia firmly so that the meniscus can perform its hoop stress's function transferring loads across the knee joint in physiological values that will not harm the knee joint articular cartilage [1].
Magnetic resonance imaging (MRI) signs indicative of meniscal root tear include a radial tear of the meniscal root (on axial imaging), a vertical linear defect in the meniscal root (truncation sign on coronal imaging), meniscal extrusion 3 mm outside the peripheral margin of the joint (on coronal imaging), and increased signal within the meniscal root (ghost sign on sagittal sequences) [2].
The primary goal of meniscus root tear repair is maintaining longevity of the patient's native knee functions to maximize utility, quality of life and patient satisfaction, in addition to, minimizing pain, instability, and mechanical symptoms [3].
Two main repair techniques have been described: suture anchor (direct fixation) and transtibial pullout (indirect fixation). The most common repair technique is transtibial technique. In this technique, sutures are placed into the torn meniscal root and then shuttled down through the tunnel in the tibia to tie the repair distally [4].
Another option is adopted to fix the meniscal root distally by wrapping threads of fiber tape around the Tibial Tubercle (TT) through a transverse tunnel posterior to the tibial tubercle with buried knots inside the transverse tunnel without the use of metal buttons or anchors.

This technique provides secure tension for repair without loosening of knots and tension that occur when using metal buttons and avoiding irritation caused by metal buttons and knots in patients [5]. The aim of this work was evaluation of effectiveness of arthroscopic repair of posterior root tear of medial meniscus without fixation implants in restoring meniscal structural integrity and functions.

Patients and Methods

This prospective study included 20 adult patients diagnosed as medical meniscus root tears. An informed written consent was obtained from the patient or relatives of the patients. The study was done after approval from the Ethical Committee Benha University.

Inclusion criteria included adult patients of both sexes, aged 18 to 40 years, with no contraindications for anesthesia, presenting with traumatic or sport-related meniscal root tears, specifically isolated medial meniscus root tears. Exclusion criteria included patients younger than 18 or older than 40 years, those with known rheumatoid arthritis or inflammatory arthropathy, with contraindications for surgery, with meniscal tears other than root tears, with limb malalignment or associated ligamentous injuries, or with a BMI greater than 35 kg/m².

All patients were subjected to full history taking, complete general examination including McMurray test for assessment of medial meniscal tear, laboratory investigations and radiological investigations including knee X-ray standing (anteroposterior, lateral views) and MRI.

All patients were positioned supine with the end of the table dropped. After induction of anesthesia, a well-padded high-thigh tourniquet was placed on the operative leg. Standard anterolateral and anteromedial arthroscopic portals were made adjacent to the patellar tendon. The joint was inflated with normal saline solution and visualized with a 30° arthroscopic camera. The damaged meniscal root was probed to assess the tear pattern and to perform an anatomic repair. An arthroscopic shaver was inserted into the knee, and any notable adhesions were removed (Figure 1).

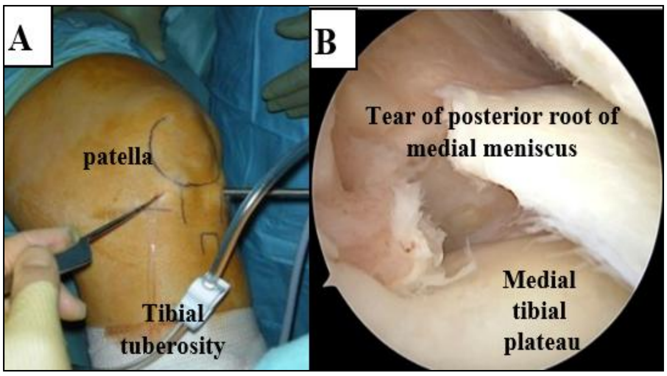


Fig 1: (A) Standard anterolateral and anteromedial portals of left knee arthroscopy (B) Root tear of posterior horn medial meniscus as visualized with arthroscopy

Tibial tunnel creation

The footprint of the planned medial meniscal root repair on the tibial plateau was be decorticated using a curved curette through anteromedial portal. A grasper was used to position the torn meniscal root into the footprint on the tibial plateau to perform repair. An initial vertical incision for the transtibial tunnel was made just medial to the tibial tubercle. To best restore the footprint of the meniscus and increase the chance of biological healing, the transtibial tunnel was created at the location of the root attachment. An aiming device with a cannulated sleeve was used to position a drill pin. A tibial tunnel guide was then used to ream the tunnel. The tunnel was visualized arthroscopically to verify correct tunnel placement, and the drill pin was removed, leaving the cannula in place for passage of sutures (Figure 2).

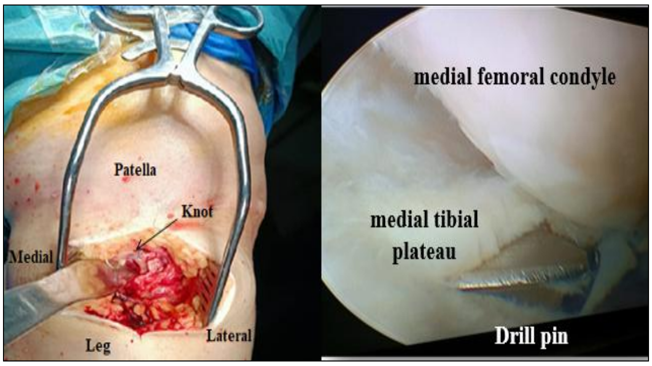


Fig 2: (A) Showing incision for the transtibial tunnel just medial to the tibial tubercle (B) Showing a drill pin passing through the tibia aiming the footprint of the repair

A knee scorpion suture passer was used to pass a simple suture of fiber wire through the far-posterior portion of the detached meniscal root, approximately 5 mm medial to its lateral edge for the medial meniscus (Figure 3).

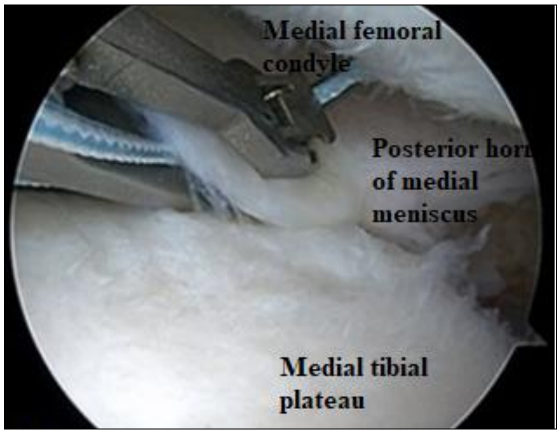


Fig 3: Showing a knee scorpion suture passer used to pass a simple suture through the detached root of posterior horn of medial meniscus

Before passing the second suture of fiber wire through the meniscus, the first suture was shuttled down through the tibial tunnel to avoid intra-articular suture interlacing. To accomplish this, a looped passing wire was placed up the tunnel cannula and the suture was shuttled down the tunnel. The steps were repeated with the second suture positioned through the midportion of the meniscal root, anterior to the first suture placed into the meniscus. The second suture is then pulled down through the tibial cannula (Figure 4).

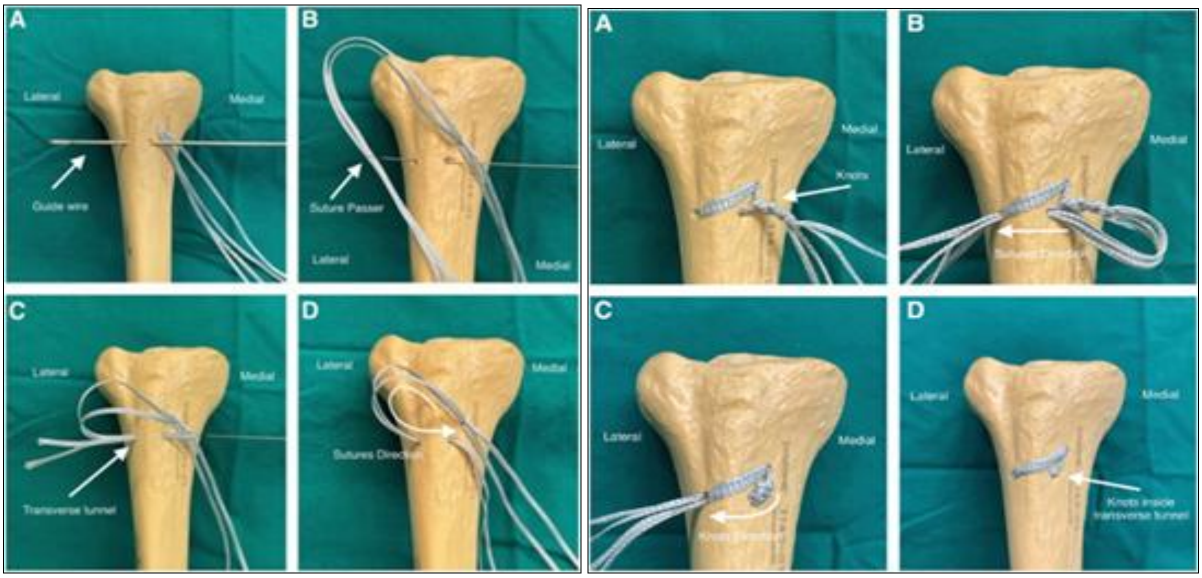


Fig 4: Tibial fixation of meniscal root sutures (steps A-D)

The free ends of the sutures shuttled down through the tibial tunnel are separated into two limbs, which include one end from each suture. One limb was wrapped around the tibial tubercle anteriorly and passed through the drilled transverse tunnel posterior to the tibial tubercle from the other side via a looped passing wire. Then the limb passed through the transverse tunnel was tied with second limb of the suture shuttled down through the tibial tunnel, the knots created were passed in the transverse tunnel laterally by a looped passing wire inside the transverse tunnel. The arthroscope and probe were reinserted into the knee to confirm that anatomic stable fixation has been obtained (Figure 5).

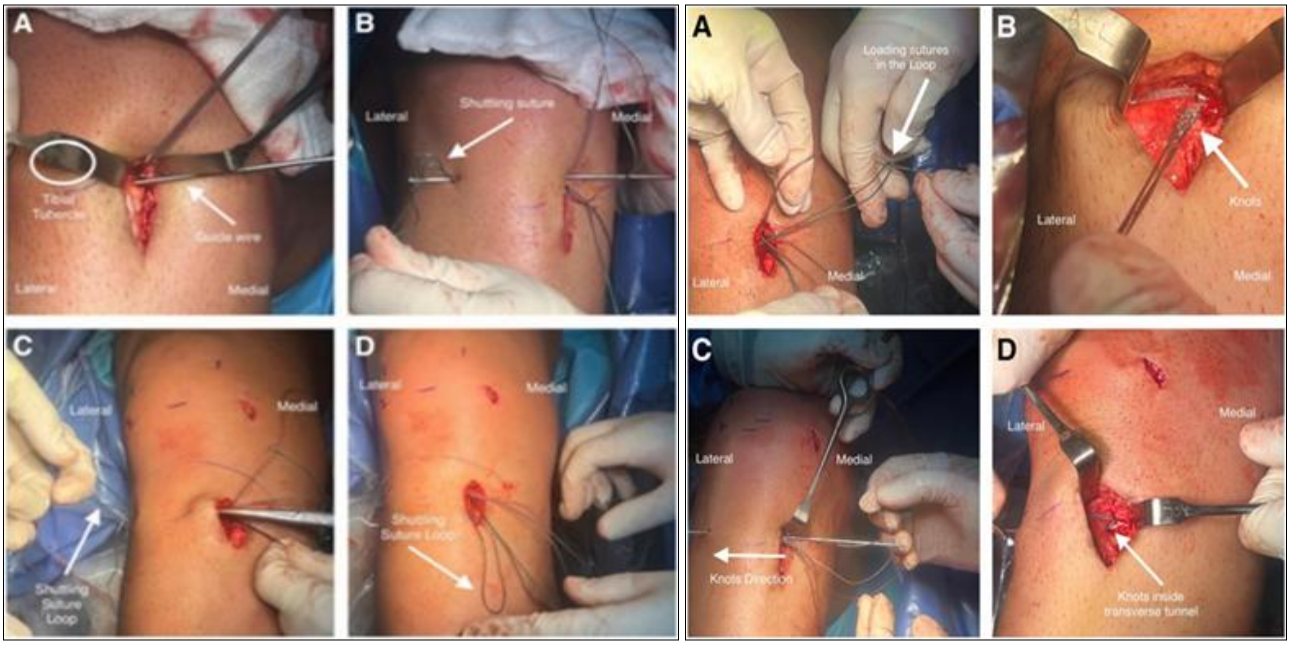


Fig 5: Intraoperative steps of tibial fixation of meniscal root sutures (steps A-D)

The follow up period was one year. Results were evaluated using Lysholm activity scale.

Lysholm activity scale

It is an overall score of 0 to 100 calculated and graded based on 8 domains: limp, locking, pain, stair climbing, using support, instability, swelling, and squatting ability. A score of 95 to 100 is considered excellent, 84 to 94 is good, 65 to 83 is fair, and < 65 is poor [6].

Statistical analysis

Statistical analysis was done by SPSS v28 (IBM Inc., Armonk, NY, USA). Quantitative variables were presented as mean and standard deviation (SD). Qualitative variables were presented as frequency and percentage (%). A two tailed p-value < 0.05 was considered statistically significant.

Results

Table 1 shows demographic and clinical characteristics including age, sex, weight, BMI, mode of injury, and time interval since injury of study participants.

The follow up duration ranged from 12 to 16 months with mean of 12.45±0.51 months. The postoperative extension lag was significantly lower compared to preoperative extension (p<0.001). The postoperative flexion was significantly higher compared to preoperative flexion (p<0.001). Preoperative extension lag ranged from 5º to 10º with mean of 7.5±1.79º. Postoperative extension lag was 0º. Preoperative flexion ranged from 32 to 59 ° with mean of 46.75±8.47°. Postoperative flexion ranged from 101 to 120 ° with mean of 111.75±5.7°. VAS was significantly lower at 3, 6 and 12 months compared to preoperative VAS ($p<0.05$) and none of the studied patients showed pain at 12 months. The postoperative Lysholm score was significantly improved (higher) compared to preoperative score ($p<0.001$, <0.001) (Table 2).

Table 1: Demographic data, mode of injury and time interval from injury to surgery of the studied patients

	Total (N=20)
Age (years)	29.65±7.01
Sex	
Male	13 (65%)
Female	7 (35%)
Weight (Kg)	71.65±10.25
BMI (Kg/m²)	26.07±3.34
Mode of injury	
RTA	2 (10%)
Knee twisting	3 (15%)
Sporting	15 (75%)
Time interval (months)	3.35±0.81

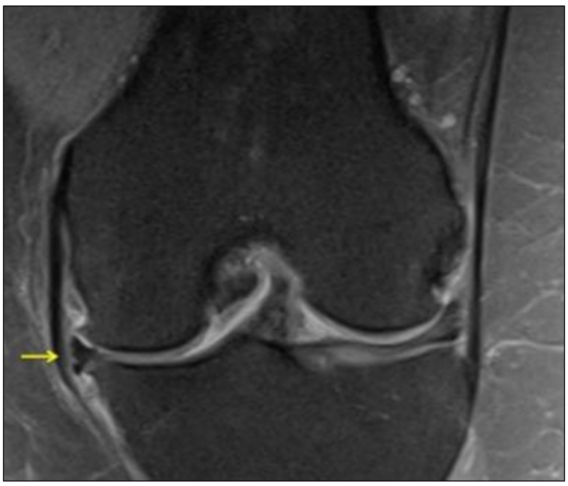
Data are presented as mean ±SD or frequency (%). BMI: Body mass index, RTA: road traffic accident.

Table 2: Follow up of the studied patients

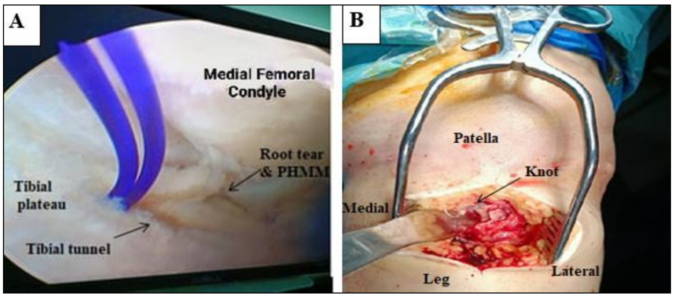
	Preoperative	**Postoperative**			**P-Value**
Extension lag	7.5±1.79	0±0			<0.001*
Flexion	46.75±8.47	111.75±5.7			<0.001*
	Preoperative	**3 months**	**6 months**	**12 months**	
VAS	6.95±0.76	5.4±0.88	1.7±0.57	0±0	<0.001*
P1=0.002*, P2<0.001*, P3<0.001*					
	Preoperative	**Postoperative**			
Mean ±SD	59.3±8.93	96.4±5.41			<0.001*
Excellent (95-100)	0 (0%)	16 (80%)			<0.001*
Good (84-94)	0 (0%)	3 (15%)			
Fair (65-83)	7 (35%)	1 (5%)			
Poor (<65)	13 (65%)	0 (0%)			

VAS: Visual Analogue Scale, *: statistically significant different, P1: p value between preoperative and 3 months, P2: p value between preoperative and 6 months, P3: p value between preoperative and 12 months.

Postoperative complications included superficial wound infection occurred only in 1 (5%) patient (which is followed up and managed with appropriate antibiotic), whereas 19 (95%) patients had no complications.



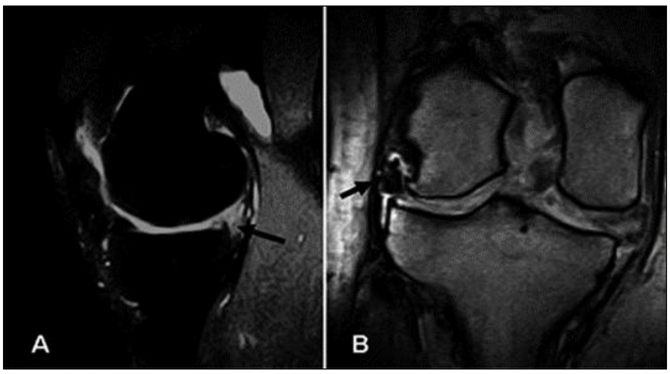
MRI of left knee (coronal cuts) showing medial meniscal posterior root extrusion (yellow arrow)



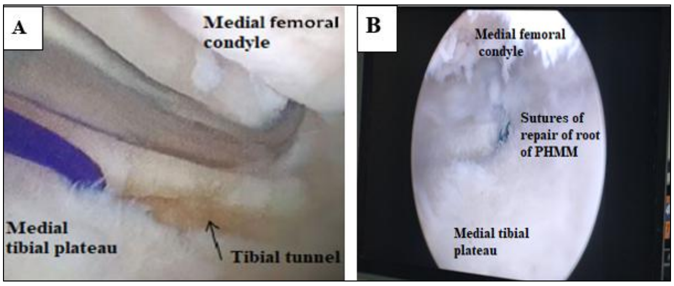
(A) Showing tibial tunnel on footprint, (B) Showing knot on tibial tunnel after repair of medial meniscal root tear

Showing postoperative photos (A) squatting position (B) left knee full flexion (C) left knee full extension

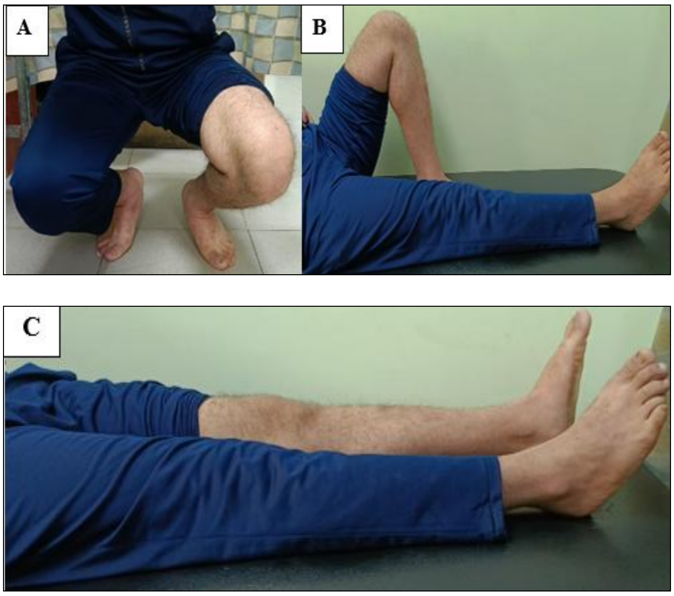
Fig 6: A 37-year-old nurse presented two months after a left knee twisting injury, complaining of intermittent medial knee pain with joint effusion, worsened by squatting and relieved by rest. On examination, medial joint line tenderness, mild effusion, and a positive McMurray test for the medial meniscus were noted. Her body mass index was 25 kg/m². Preoperative Lysholm score was 66/100 (fair). Radiographs appeared normal, while MRI revealed a medial meniscal root tear with posterior root extrusion. Intraoperatively, a posterior horn medial meniscus root tear was confirmed, and an arthroscopic transosseous pull-out suture technique was performed without fixation implant. The patient completed a 12-month postoperative follow-up, achieving a Lysholm score of 99/100 (excellent).



MRI of left knee (A) Sagittal cut showing positive ghost sign (B) Coronal cut showing medial meniscus extrusion (Arrow)

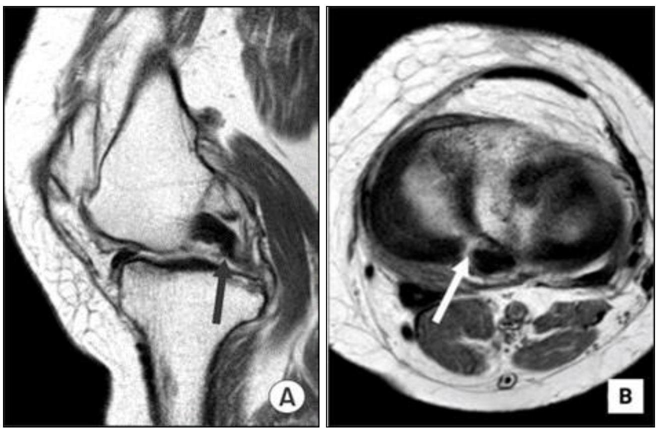


(A) Showing tibial tunnel aiming the footprint of root of posterior horn of medial meniscus of left knee (B) showing sutures of repair of root of posterior horn of medial meniscus

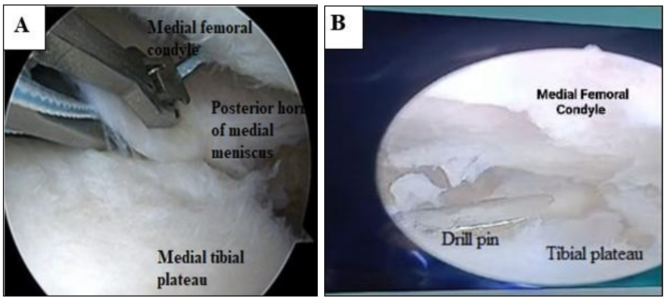


Showing postoperative follow up photos (A) squatting position (B) left knee full flexion (C) left knee full extension

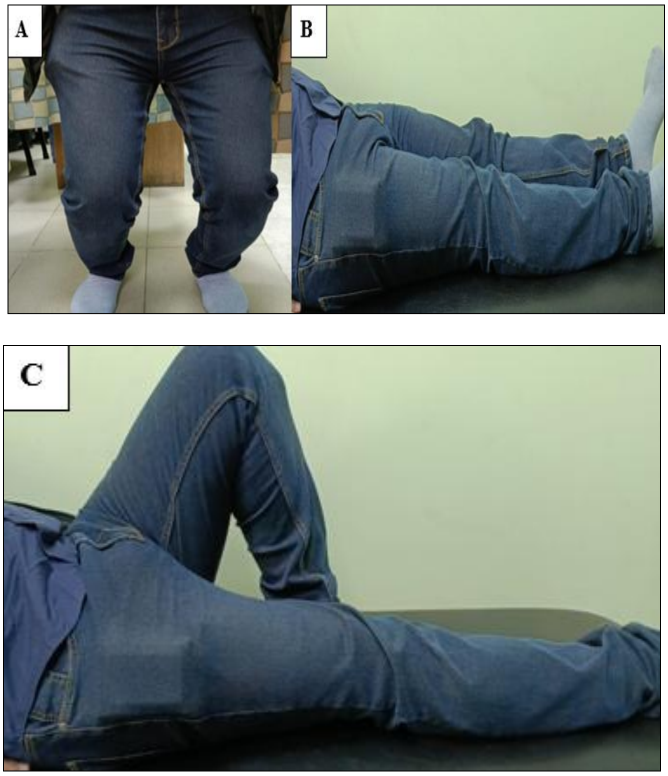
Fig 7: 39-year-old male worker, medically free, presented one month after a hyperflexion injury to his left knee from a fall downstairs, reporting persistent pain and effusion unresponsive to medical treatment or physiotherapy. Examination revealed medial joint line tenderness and a positive McMurray test for medial meniscus tear. Preoperative Lysholm score was 79/100 (fair). Radiographs appeared normal, while MRI showed medial meniscus posterior root extrusion and a positive ghost sign. Intraoperatively, a posterior horn medial meniscus root tear was confirmed, and an arthroscopic transosseous pull-out suture technique was performed without fixation implant. Early postoperative follow-up was complicated by a superficial wound infection, treated successfully with two weeks of broad-spectrum parenteral antibiotics, resulting in normalization of laboratory values and resolution of fever. The patient completed a 12-month follow-up, achieving a postoperative Lysholm score of 96/100.



MRI of left knee (A) sagittal cut showing positive ghost sign (B) axial cut showing root tear of posterior horn medial meniscus

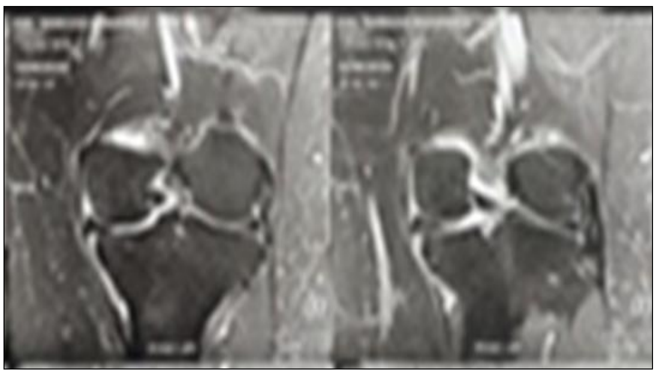


(A) Showing a knee scorpion suture passer, (B) Showing a drill pin making the tibial tunnel

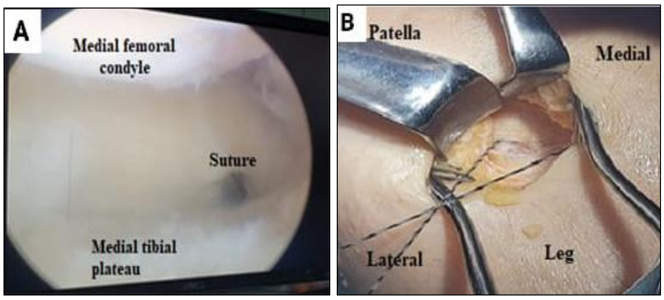


Showing postoperative follow up photos, (A) squatting position, (B) left knee full extension, (C) left knee full flexion

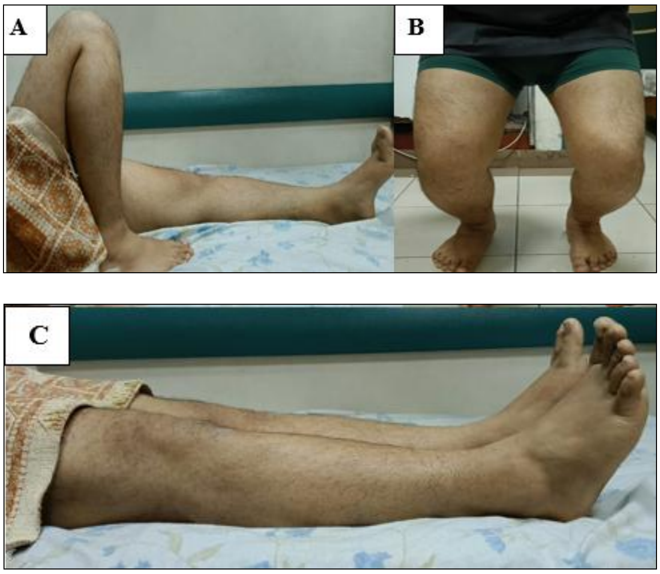
Fig 8: A 35-year-old male driver presented two months after direct trauma to his left knee, complaining of continuous pain and effusion unresponsive to medical treatment. On examination, medial joint line tenderness, moderate effusion, and a positive McMurray test for medial meniscus tear were noted. Preoperative Lysholm score was 31/100 (poor). Radiographs were normal, while MRI revealed medial meniscus posterior root extrusion and a positive ghost sign. Intraoperatively, a posterior horn medial meniscus root tear was confirmed, and an arthroscopic transosseous pull-out suture technique was performed without fixation implant. Postoperatively, the patient completed follow-up and achieved a Lysholm score of 96/100 (excellent)



MRI of right knee (coronal cuts) showing medial meniscus posterior root extrusion



(A) Showing suture of repair of root tear of posterior horn medial meniscus of right knee, (B) showing fiber wire passing through tibial tunnel of right knee



Showing postoperative photos of case 4, (A) right knee full flexion, (B) squatting position, (C) right knee full extension

Fig 9: A 38-year-old male engineer presented one month after sustaining a twisting injury to his right knee at work, reporting continuous pain that interfered with daily activities and persistent effusion unresponsive to medical treatment or physiotherapy. Clinical examination revealed medial joint line tenderness and a positive McMurray test for medial meniscus tear. The preoperative Lysholm score was 35/100 (poor). Radiographs appeared normal, while MRI demonstrated medial meniscus posterior root extrusion. Intraoperatively, a posterior horn medial meniscus root tear was confirmed, and an arthroscopic transosseous pull-out suture technique was performed without fixation implant. The patient completed a 12-month postoperative follow-up, achieving a Lysholm score of 95/100 (excellent)

Discussion

Meniscus root tears are defined as any meniscus tear that occurs within one cm of the root attachment to the tibia. Such tears have been encountered or diagnosed in 4.3% of all arthroscopic surgeries, and medial meniscus root tears account for 52% of all meniscal root tears. The absence of the normal meniscus signal at the root attachment on sagittal views of T_2-weighted magnetic resonance imaging (MRI) is pathognomonic for a root tear; this is commonly known as a ghost sign [7].

Regarding baseline characteristics of the studied patients, the age ranged from 20 to 40 years with mean of 29.65±7.01 years. 13 (65%) males and 7 (35%) females were included. The weight ranged from 60 to 90 kg with mean of 71.65±10.25 kg. The BMI ranged from 21.51 to 33.06 Kg/m2 with mean of 26.07±3.34 Kg/m2.

Our results are in agreement with Ford *et al.* [8]., who notified that medial meniscus tears are more common in obese individuals because excess body weight places increased stress, strain, and torque on the knee joint, leading to gradual wear and tear, also known as degenerative changes.

On explanation of our findings, medial meniscus tears are more common in males, this increased risk is often linked to differences in physical activity levels, participation in contact sports, and potentially anatomical factors [9]. According to mode of injury, 2 (10%) patients had RTA, 3 (15%) patients suffered from knee twisting and 15 (75%) patients had injury due to sporting trauma.

As well, Popper *et al.* [10]., stated that most isolated meniscus injuries occur as a result of rotational or shearing forces placed across the knee joint during an increased axial load, namely the “load-and-shear” mechanism. These commonly occur during twisting or pivoting moments to the knee with the ipsilateral foot planted on the ground. They may also occur during an increased degree of knee flexion, during kneeling or squatting, while rapidly accelerating or decelerating, or while jumping, as well as through traumatic events such as motor vehicle accidents, falling from a height, or a trampoline injury.

The time interval from injury to surgery ranged from 2 to 4 months with mean of 3.35±0.81 months. The follow up duration ranged from 12 to 13 months with mean of 12.45±0.51 months.

Similarly, Javid *et al.*, [11] reported, the average time to surgery was 3.12 months (range: 3 weeks-one year). This is attributed that the interval between trauma and arthroscopic meniscal repair has no influence on the failure rate. Differences in survival rate of meniscal repair are more dependent on location of the lesion and ACL status, rather than chronicity of injury. [12]

In our study, the postoperative extension lag was significantly lower compared to preoperative extension (p<0.001). The postoperative flexion was significantly higher compared to preoperative flexion (p<0.001). Preoperative extension ranged from 5o to 10 o with mean of 7.5±1.79o. Postoperative extension was 0 o. Preoperative flexion ranged from 32 to 59 o with mean of 46.75±8.47o. Postoperative flexion ranged from 101 to 120 o with mean of 111.75±5.7o.

These findings are similar to Kim *et al.* [13], compared radiologic and clinical outcomes between patients who underwent medial meniscus posterior root tear repair. ROM was performed 3 weeks postoperatively. At 6 weeks, 0° to 90° flexion was allowed. At 12 weeks, 0° to 120° flexion was allowed.

Added to that, Lind *et al.* [14], followed 32 (53%) of 60 patients who underwent arthroscopic meniscus repair without applying ROM restriction in the postoperative period, and 28 (47%) by restricting ROM in full extension for 6 weeks. On explanation of lower postoperative extension, a knee brace locked in extension was required for 10 days postoperatively. The motion allowed within the brace was progressively increased starting after that [15].

Regarding the results, VAS was significantly lower at 3, 6 and 12 months compared to preoperative VAS (p<0.05) and none of the studied patients showed pain at 12 months.

These findings were in accordance with Pathak *et al.*, [16] who presents a case series of 34 patients who underwent repair of meniscal tears along with ACL reconstruction from 2014 to 2016. Cases of discoid meniscal lesions and combined or ligament injuries other than ACL injuries were excluded. Patients were followed up periodically, at 3, 6, 9, 12, and 24 months. The mean visual analog scale score decreased from 7.3 preoperatively to 2 postoperatively. In parallel with our results, Hiranaka *et al.*, [17] investigate the clinical outcomes of the transtibial pull-out repair for medial meniscus posterior root tear, including the meniscal healing status and osteoarthritic change. They reported that the postoperative pain score (VAS) was significantly decreased compared to preoperative one (p<0.05).

Furthermore, Ventura *et al.* [18], the patients were divided into two groups: Group 1-partial meniscectomy (PM) and Group 2-meniscal repair (MR). In both groups, we found an improvement in pain 2 years after the surgery, with a decrease in the VAS value between the pre- and post-surgery. On average, the VAS score decreased from 7.9 to 4.5 in the group subjected to partial meniscectomy, and from 7.5 to 3.2 in the meniscal repair.

Concerning the results, the postoperative Lysholm score was significantly improved (higher) compared to preoperative score (p<0.001, < 0.001).

In the same line, Yoon *et al.*, [19] demonstrated that the transtibial pull-out repair group improved significantly. Improvement in the mean Lysholm score at the 2-year follow-up.

Additionally, Bozduman *et al.*, [20] reported in 48 patients diagnosed with meniscus tear by physical examination and Magnetic Resonance Imaging (MRI) examination and underwent arthroscopic repair were evaluated retrospectively. It was determined that the mean Lysholm score was increased by 22.3 points to 89.5.

Added to that, between January 2019 and August 2019, Seifeldin & Abdelrazek al. [21], operated on 16 patients who met our inclusion criteria, having root tears of the medial meniscus. All patients underwent arthroscopic evaluation and re-insertion of the root tear medial meniscus using heavy braided suture material shuttled through a tibial tunnel and tied over a bone button. An accessory supra-meniscal portal was used to facilitate instrumentation and suture management. All patients were followed up for 2 years, and the Lysholm knee score was used for assessment at the final follow-up. A total of 16 patients were operated upon and followed up for a mean of 24 months. The mean Lysholm score improved from 73.5±12.61 preoperatively to 93.75±6.90 postoperatively, with a value of 0.001. The mean preoperative and postoperative Lysholm scores were higher for the traumatic tears as compared with degenerative tears.

Regarding the postoperative complications, wound infection occurred only in 1 (5%) patient (which is followed up and managed with appropriate antibiotic), whereas 19 (95%) patients had no complications.

Similarly, Murphy *et al.* [22] reported a single, superficial infection occurred in the non-PFC group and was successfully treated with oral antibiotics.

Furtherly, Blevins *et al.* [23], showed that the reported incidence of septic arthritis following knee arthroscopy varies from 0.04% to 3.4%.

Moreover, Lai *et al.* [24], demonstrated that arthroscopic meniscus repair is low-risk procedure with 30-day complication rates < 1% overall and < 1.3% among patients aged > 40 years. These findings support meniscus repair whenever feasible in the setting of preserved articular cartilage. On the other hand, Mlv *et al.*, [25] explored of all the arthroscopic procedures, arthroscopic knee surgeries are the commonest. Post arthroscopic procedures infection is rare with incidence ranging from 0.3% to 1.70% and mostly due to bacteria. The difference to ours are related to our small sample size.

For optimization of the outcome results, evaluation of the patients should include knee MRI and second look arthroscopy, but we couldn't do this for cost benefit and we relied on clinical functional evaluation by lysholmscore.

Limitations

The small sample size inevitably reduced the statistical power of the analysis, and being a single-center study limits the generalizability of the findings. Absence of a control group and comparison with other treatment methods restricts the ability to draw definitive conclusions regarding relative efficacy. Finally, the follow-up duration was relatively short, limited to one year, which may not fully capture long-term outcomes.

Conclusions

Compared to preoperative, arthroscopic pullout repair of meniscus root tears without fixation implants resulted in significantly less pain (measured by VAS) and improved range of motion. There was a notable improvement in the Lysholm knee score.

Financial support and sponsorship: Nil

Conflict of Interest

Not available

Financial Support

Not available

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How to Cite This Article
Khalek MKA, Hussein ES, Khamis ARA, Elbegawy HEA. Results of meniscal root repair by transtibial pullout technique without fixation implants. International Journal of Orthopaedics Sciences. 2026;12(1):04-11.