Cost-effective technique for medial meniscus posterior root tear repair

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Purpose
This study aimed at determining the effectiveness of medial meniscus posterior root repair by transosseous pull-out sutures, relying on readily available tools.
Patients and methods
Thirty-four patients, aged between 18 and 49 years old of both sexes, with isolated post-traumatic meniscal root tear, operated between September 2013 and September 2015, were prospectively evaluated clinically in terms of Lysholm and Tegner scoring systems. Successful repair was measured by improvement of gap sign, ghost sign, and meniscal extrusion.
Results
The study group had 18 females and 16 males, mean age was 40.8±6.9 years, mean BMI was 30.5±4.9 kg/m^2. The mean follow-up duration was 24.5 months. Lysholm and Tegner scores improved significantly (P=0.000). Complete healing occurred in 20 cases (P=0.000), and partial healing in 10 cases (P=0.000), failure occurred in four cases. Both absolute and relative meniscal extrusion decreased by −1.2±1.5 mm (P=0.01) and −0.12±0.15 (P=0.007), respectively.
Conclusions
Meniscal root repair by transosseous pull-out suture is a cost-effective and reproducible technique that yields good structural and functional results. This was objectively confirmed both functionally and radiologically in 88% of cases fixed by this technique.

Keywords:
medial meniscus, posterior root tear, transosseous repair

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Introduction

Meniscal root tear is the disruption that occurs within 1 cm of either the anterior or posterior horn attachments to the tibial plateau [1], a condition that simulates total menisectomy due to loss of meniscal biomechanical function [2].

Up to date, the body of this literature is still lacking solid evidence to create a consensus about the criteria of effective root tear repair.

Since the first case of medial meniscus posterior root tear (MMPRT) described by Pagnani *et al.* [3] in 1991, several studies were published to describe different methods of treatment for such an injury. Either open surgical fixation using transosseous sutures as described by Nha *et al.* [4] or arthroscopic repair using either pull-out suture technique as described by Shino *et al.* [5] or using anchor fixation as described by Engelsohn *et al.* [6].

So far, direct clues for effective MMPRT repair include root tear healing with disappearance of the ghost and the gap signs on sagittal and posterior coronal MRI cuts, respectively [7]. While indirect clues include functional knee scoring systems [8] and articular cartilage evaluation in terms of osteoarthritis development and progression, rated either radiographically (by Kellgren–Lawrence) [9] or MRI grading as recently described by Park *et al.* [10] Nevertheless, all the current assessment tools are either subjective methods or poorly controlled ones with high interobserver errors.

This study aimed at determining the effectiveness of medial meniscus posterior root repair by transosseous pull-out sutures, relying on comprehensive direct and indirect clues.

We hypothesized that with successful MMPRT repair, both the gap and ghost signs will disappear and the meniscal extrusion distance will be less than the upper-normal limit (i.e., 3 mm).

Patients and methods

The study was designed in the form of a prospective case series that included 34 patients who underwent arthroscopic MMPRT repair by transosseous pull-out suture technique [11], using the two simple suture configurations. The study was conducted between March 2013 and December 2015. This study was applied after obtaining the approval of the Research/ Ethics Committee.

The study inclusion criteria were:

(1) Age between 18 and 49 years of both sexes
(2) Isolated symptomatic post-traumatic meniscal root tear
(3) Grade II or less osteoarthritis according to Kellgren–Lawrence classification based on plain radiographs or Park and colleagues. Classification based on MRI

The exclusion criteria were:

(1) Patient's refusal
(2) Patient's BMI more than 35 kg/m^2
(3) Associated ligamentous injury
(4) Known rheumatoid arthritis patient
(5) Knee joint malalignment deformity
(6) Crushed meniscus unsuitable for repair

Surgical technique

Under general or regional anesthesia, using high above-knee tourniquet, the patients were positioned in a supine position, with the operated leg hanging to the table side. A side post was put in all cases to hinge upon it in order to achieve effective valgus moment that can open the medial knee compartment [12].

Standard 30°-angled, 4-mm scope was used. After prepping and draping, arthroscopy-set assembly was done followed by creation of the anterolateral and anteromedial portals [12].

A general knee exploration was first applied in all cases to inspect the articular cartilage status and to confirm the isolated MMPRT. Refreshing of the tear edge as well as scratching the undersurface of the posterior horn using shaver was done first [13].

A transosseous pull-out suture technique was employed in all cases to reimplant the torn root in situ; two simple sutures were passed through the torn root, using suture-passing lasso device (Quick pass suture Lasso, 45° curved tip right/left 1.8-mm tip with a thumb wheel, disposable lasso; Arthrex, 1370 Creekside Boulevard Naples, Florida, USA) selected according to the injured knee side. The lasso was passed in an upward-to-downward direction, loaded with nitinol wire or number-zero prolene (blue monofilament; Ethicon Co., USA), according to availability, acting like a shuttle to pass number 2 Fiber-Wire (38'/96.5-cm blue/white; Arthrex) through the meniscal root [14].

The marking hook of a low-profile tibial anterior crutiate ligament (ACL) guide (Arthrex) was applied through working portal to the tear site and the guide base with the bullet put in an inferolateral position (Gerdy's tubercle). An ACL guide wire (2.4 mm; Arthrex) was drilled through the aiming device until its tip appears at the desired reimplantation site. A size 7-mm cannulated drill bit was the preferred choice in all cases. Its orifice allows much of the meniscal root substance to be reimplanted again to the tibial plateau [15].

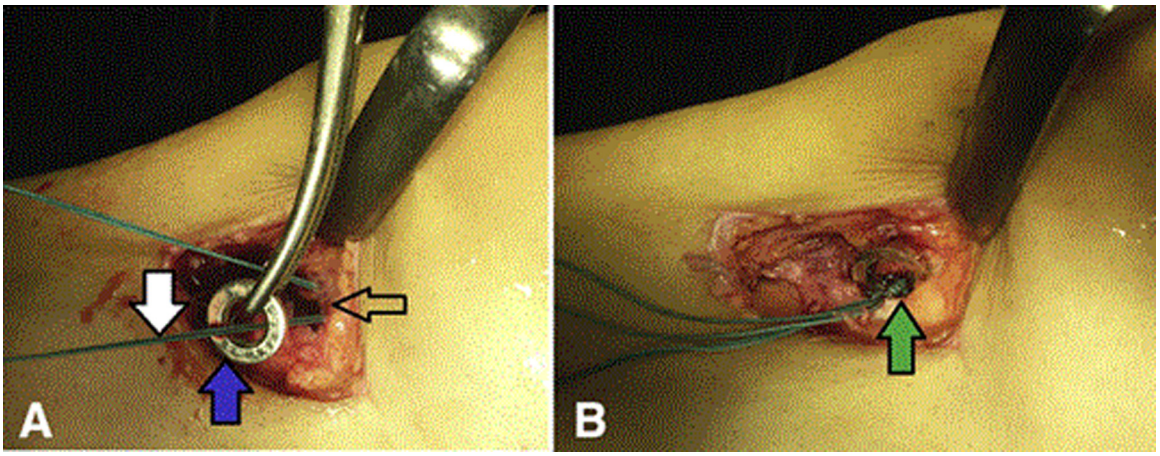
The four limbs of the two simple sutures were retrieved from inside the knee joint, through the tibial tunnel using a ring forceps. Tensioning of the four suture limbs over a 12-mm washer put at the tibial tunnel outer orifice (Fig. 1) was done under direct arthroscopic visualization of the meniscal root, in 15° of knee flexion [16].

Postoperative follow-up and rehabilitation program

After surgery, patients were mobilized nonweight bearing on crutches for 6 weeks. A hinged knee brace was applied for the first 2 weeks with the leg in a fully extended position. Patients were instructed to perform quadriceps muscle exercise, as well as straight-leg raise exercises several times daily starting immediately postoperatively. Patients were allowed increase in the active range of motion by 30° every 2 weeks up to 135°. Gradual weight bearing started at 6 weeks. Full flexion and squatting were allowed 3 months after the surgery. Patients returned to full activity 6 months postoperatively [17].

Clinical examinations as well as standing plain radiographies were done during follow-up visits at 3-, 6-, and 24-month visits to assess articular status based on Kellgren–Lawrence classification [9] (grade 0, no degenerative change; grade 1, questionable osteophytes and no joint space narrowing; grade 2, definite osteophytes with possible joint space narrowing; grade 3, definite joint space narrowing with moderate multiple osteophytes and some sclerosis; grade 4, severe joint space narrowing with cysts, osteophytes, and sclerosis). A 1.5-T MRI scan

Figure 1



(a) Two simple sutures: four limbs were passed through the tibial tunnel at the Gerdy tubercle (transparent arrow), and one limb from each suture (white arrow) was passed via a 12-mm washer (blue arrow). (b) The two suture limbs passing via the washer were knotted with the other two suture limbs to five-and-ahalf- hitch knots, and the final one in a locking mode (green arrow).

(OPTIMA MR 360; GE, USA) was performed postoperatively twice for each case, one at the sixth month postoperative point (baseline) and another one at 24 months. Assessment of articular cartilage status was done using both Park *et al*. [10] grading system for osteoarthritic knee joint changes (grade 0: no or minimal osteophyte (<5 mm) with no articular cartilage injury, grade 1: osteophyte >5 mm or bone marrow edema >10 mm or subchondral cyst >10 mm with articular cartilage signal change (increased T2), grade 2: as grade 1 but with articular cartilage partial-thickness defect <50%, grade 3: as grade 2 but with articular cartilage partial-thickness defect ≥50%, and grade 4: meniscal injury grade III with articular cartilage full-thickness defect). MRI was also studied to assess the success of MMPRT healing based on Lee *et al*. [18] criteria of root tear healing (complete healing was defined as confirmed continuity in sagittal, coronal, and axial views, partial healing was a loss of continuity in any one view, and nonhealing was defined as no continuity in all views).

Preoperative knee assessment studies were compared with the postoperative ones done at the sixth month and the 24 months visits, including

(1) Lysholm and Tegner knee scoring systems
(2) Absolute meniscal extrusion [19] (distance between the medial edge of the tibial plateau and the medial edge of the medial meniscus at the midcoronal plane on the MRI), 3 mm is the upper-normal limit for this distance
(3) Relative meniscal extrusion [20] (ratio between the absolute meniscal extrusion distance to the meniscal width on the midcoronal plane)
(4) Root tear healing as previously described [18].
(5) Ghost sign and the gap size (Fig. 2) [7]

Statistical analysis

Analysis of data was done by IBM computer using SPSS (Statistical Program for Social Science version 16) as follows:

(1) Description of quantitative variables as mean, SD, and range
(2) Paired *t*-test was used to compare Lysholm score, Tegner score, absolute meniscal extrusion, relative meniscal extrusion, and gap size in the same group before and after treatment
(3) χ^2 test was used to compare Kellgren–Lawrence grading, Park and colleagues grading and root tear healing, in the same group before and after treatment
(4) Mcnemar's test was used to compare ghost sign, in the same group before and after treatment

P value greater than 0.05 insignificant, *P* less than 0.05 significant, *P* less than 0.001 highly significant.

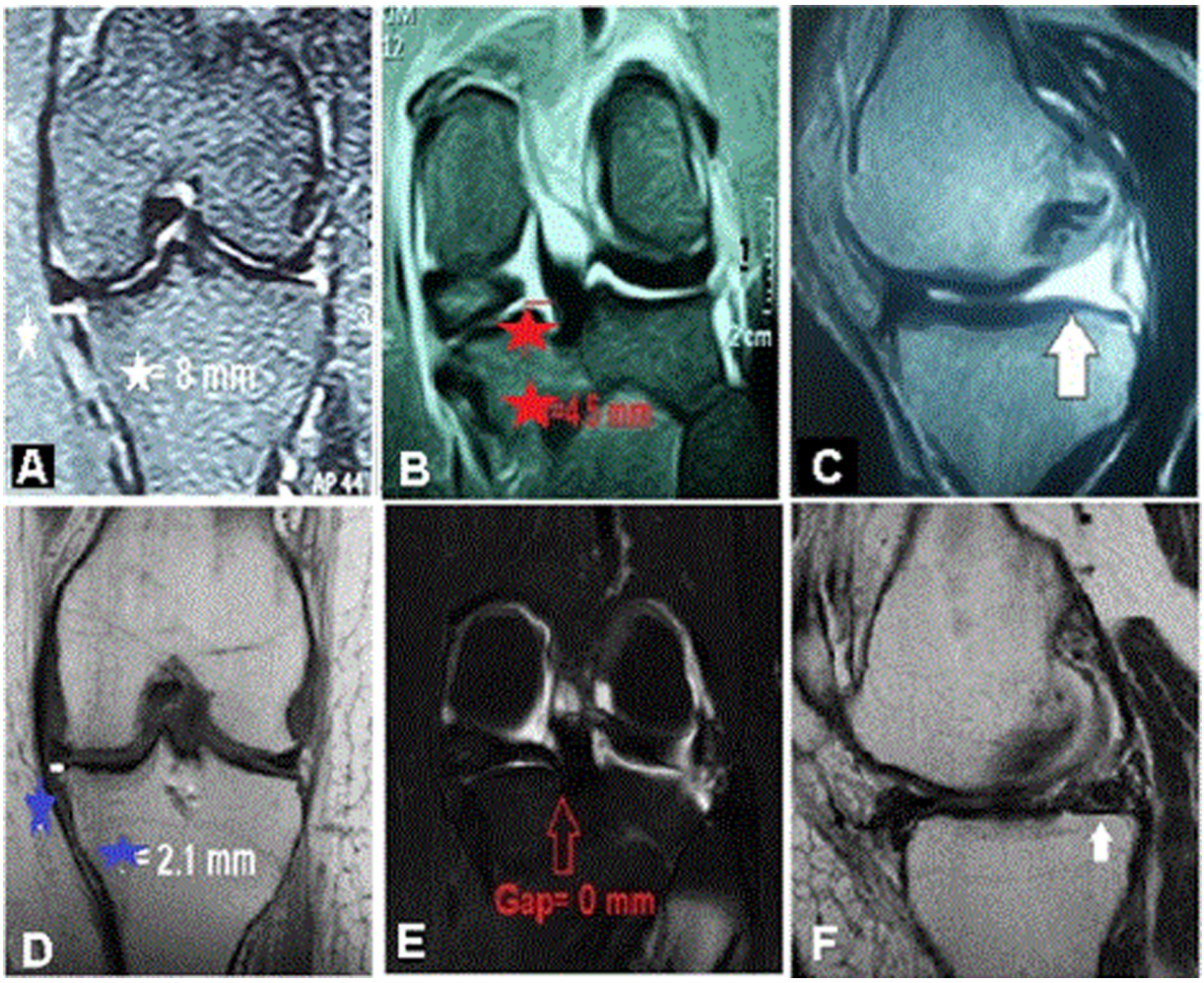
This study had a 94.28% power to detect a six -point difference in the measured variables with αvalue of 0.05.

Results

The patients' demographics of the studied group were homogeneous (Table 1). The mean follow-up duration was 24.5 months.

The studied group showed significant improvement in Lysholm score from 53.3±21 preoperatively to 88±8 at

Figure 2



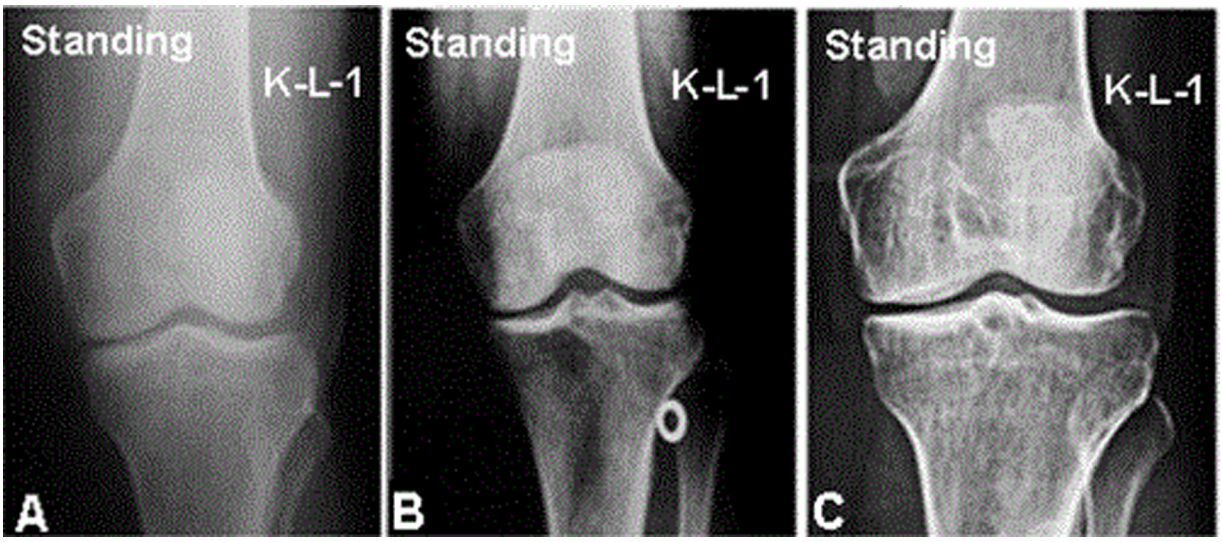
MRI comparison between preoperative status (a, b, c) and postmedial meniscus posterior root tear repair at 24 months (d, e, f). (a) Absolute medial meniscus extrusion on midcoronal MRI cuts=8 mm (marked by white star). (b) Gap size between posterior root and posterior cruciate ligament on posterior coronal MRI cuts=4.5 mm (marked by red star). (c) Ghost sign marked by the big white arrow reflecting medial meniscus posterior root tear on mid-sagittal MRI cuts. (d) Absolute meniscal extrusion decreased down to 2.1 mm (marked by blue star). (e) Gap size decresed down to 0. (f) Ghost sign disappeared (marked by small white arrow).

Table 1 Patients' demographics

Variables	Mean±SD	Range
Age	40.8±6.9	26–49
Weight	87.2±15	60–110
Height	1.68±0.10	1.55–190
BMI	30.5±4.9	23.4–35
Sex		
Male	16	47%
Female	18	53%

the latest follow-up [*P*=0.000 and 95% confidence interval (CI): −44 to −24]. Also, significant improvement was recorded in Tegner score from 2.65±1.6 preoperatively to 3.9±1.7 at the latest follow-up (*P*=0.000 and 95% CI: −1.7 to −7). The absolute meniscal extrusion significantly improved from 4.5±1.4 mm preoperatively to 3.3±1.5 mm at the latest follow-up (*P*=0.01, 95% CI: 0.31–1.9). Also, the relative meniscal extrusion significantly improved from 0.45±0.18 preoperatively to 0.33 ±0.15 at the latest follow-up (*P*=0.007 and 95% CI: 0.03–0.20). Of the 34 patients, 20 (55.5%) showed complete healing and 10 (33.5%) showed partial healing while four (11%) showing failure of healing (*P*=0.000). The ghost sign disappeared in 25 cases at the latest follow-up (*P*=0.004). The gap size significantly decreased from 3.9±1.7 mm preoperatively to 1.02±1.9 mm at the latest follow-up (*P*=0.000). A single case showed deterioration in the articular cartilage status with progression from grade 1 K–L classification to grade 2, this was not significant, while the rest of cases remained stationary (Fig. 3). As regards articular cartilage grading in terms of Park and colleagues system, one case deteriorated from grade 0 to grade 1, while another case improved from grade 2 to grade 1 comparing preoperative with the latest follow-up status (*P*=0.004) (Table 2).

Figure 3



Radiography follow-up. (a) Preoperative plain radiography anterioposterior view, Kellgren–Lawerence grade 1. (b) Six-month postoperative radiographies with a stationary course as well as in (c) 24 months postoperatively.

Table 2 Comparison between preoperative and the latest postoperative results

Variables	Preoperative	Latest postoperative	*P* value	95% CI for the difference
Lysholm score	53.3±21	88±8	0.000*	−44 to −24
Tegner score	2.65±1.6	3.9±1.7	0.000*	−1.7 to −7
Kellgren–Lawrence grade [*n* (%)]				
0	7 (20)	7 (20)		
1	22 (65)	21 (60)	0.000*	
2	5 (15)	6 (20)		
Absolute meniscal extrusion (mm)	4.5±1.4	3.3±1.5	0.01*	0.31–1.9
Relative meniscal extrusion (%)	0.45±0.18	0.33±0.15	0.007*	0.03–0.20
Healing status (complete–partial–failed)	0–0–34	20–10–4	0.000*	
Ghost sign				
Negative	4	29	0.004*	
Positive	30	5		
Gap size (mm)	3.9±1.7	1.02±1.9	0.000*	1.8-4
Park *et al*. articular cartilage MRI grade [*n* (%)]				
0	9 (26)	8 (24)		
1	22 (64)	24 (70)	0.004*	
2	3 (10)	2 (6)		

*Statistically significantly improved ($P<0.05$).

Discussion

Despite the witnessed increase in MMPRT repair in the past decade, few case series have been reported in the literature. The majority of the current literature stated that MMPRT repair resulted in significant improvements in the clinical subjective scores. Yet, it did not prevent either the meniscus extrusion or arthritis progression both radiographic and on MRI [21].

In the current study, the arthroscopic trans-tibial pull-out suture technique (TPS) using two simple sutures, was tested as regards its cost-effectiveness and successfulness in restoring the meniscal root back to near-normal anatomical attachment site and protecting the articular cartilage status from further deterioration. Hopefully reversing any deleterious effects caused during the time lapse between root tear occurrence and its repair might become the ultimate goal for treatment.

Both Lysholm and Tegner scores improved on comparing pre- with postoperative results. Recently, Jung and colleagues reported improvement in Lysholm score from 69.1 to 90.3 ($P<0.001$) and in Tegner score from 1.9 to 3.9 ($P<0.001$), in 13 MMPRT cases

repaired with all inside anchors. Although the repair technique was different from the current study, yet, the results were similar [22]. Lee and colleagues in their comparative study similarly adopting the transosseous pull-out suture (TPS) technique using two simple suture configuration in group A and modified Masson–Allen sutures in group B, with 25 patients in each group, showed improvement in both groups with Lysholm score in group A that improved from 56.1±8.3 to 85.4±3.6 ($P<0.001$), and Tegner score in the same group that improved from 4.3±1 to 4.7±1.4 ($P<0.05$) [18].

Significant improvement in both absolute and relative meniscal extrusion was recorded in the current study. Similarly, Kim and colleagues. applied TPS to 22 MMPRT cases. They reported decline in the meniscal extrusion from 4.3±0.9 to 2.1±1.0 mm ($P=0.42$) [23]. In contrast to this study, Moon and colleagues reported an increase in the absolute meniscal extrusion distance from 3.6±1.2 to 5.0±1.7 mm ($P<0.001$). This could be attributed to the technical differences in the used technique where they applied TPS using prolene 2–0 simple sutures, which is notorious for cutting through. Also, they passed the limbs of the sutures through two tunnels (one limb in a separate tunnel) done by guide pins 2.7 mm, which might have prevented proper tensioning of the sutures. Moreover, they allowed partial weight bearing during the first 6 weeks postoperatively in contrast to nonweight bearing protocol during that period in the current study [24].

Both the ghost sign and the gap size significantly improved in this study. Similarly, Kim *et al.* [23] reported significant decline in the mean gap size from 3.2±1.1 to 0.5±0.2 mm.

In the latest follow-up of our study, 89% of the cases showed meniscal healing either complete or partial as shown by their MRI study. Also, Kim *et al.* [25] reported that 93.3% had complete or partial healing of the repaired root tear, and 6.7% had repeated tears. A systematic review published by Feucht and colleagues showed that arthroscopic TPS repair for MMPRT improves functional outcome scores and prevents the progression of osteoarthritis in most patients, during a short-term follow-up. The Lysholm score increased from 52.4 to 85.9. As regards Kellgren–Lawrence grading, 64 of 76 patients (84%) showed no progression. No progression of cartilage degeneration in 84 of 103 patients (82%) on magnetic resonance imaging and medial meniscal extrusion reduction in 34 of 61 patients (56%). Based on second-look arthroscopy, healing status was reported as complete in 62%, partial in 34%, and failed in 3%. This study compares favorably with its results, particularly meniscal extrusion rate, which was 80% in the current study in contrast to 56% in their study [26].

The current study showed progression in the articular cartilage osteoarthritis in only one case on both radiographic and MRI grading systems using K–L and Park and colleagues systems, respectively. Similarly, Lee *et al.* [17] applied TPS for 21 cases and they reported progression of arthritis in one case (grade 2–3) based on K–L classification with mean follow-up of 31.8 months. Seo *et al.* [27] applied TPS for 18 cases using modified Masson–Allen technique secured by a knotless anchor, there was no clinically significant worsening in the K–L grade. In contrast to this study, in 2014, Lee and colleagues reported statistically significant worsening of the articular cartilage status base on K–L grading system where out of 25 cases repaired by TPS, six cases progressed from grade 1 to 2 ($P=0.008$).

Therefore, it could be assumed that preservation of the meniscal tissue (by MMPRT repair) and restoration of the meniscal root attachment to anatomical or near-anatomical position can yield favorable results with a cost-effective technique using readily available tools.

Some limitations were encountered during the deployment of this study; first, only a limited number of level III and IV publications were found to match the current study criteria. Also, second-look arthroscopic evaluation was not feasible in the current study. Increasing the number of the cases available for the second-look arthroscopy will give better result validation. Finally, the follow-up period was for the short term, the same case as in the majority of the currently available literatures, longer-term results are still needed [28].

Conclusion

Meniscal root repair by transosseous pull-out suture is a cost-effective and reproducible technique that yields good structural and functional results. This was objectively confirmed both functionally and radiologically in 88% of cases fixed by this technique.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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