Evaluation of the results of double-bundle transpatellar medial patellofemoral ligament reconstruction using semitendinosus autograft

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Background
The medial patellofemoral ligament (MPFL) is the main static patellar stabilizer beyond 30° of knee flexion. Nowadays, MPFL reconstruction is the gold standard operation for recurrent patellar dislocation.
Aim
To assess the results of double-bundle transpatellar MPFL reconstruction using semitendinosus graft. A case series study held at Alexandria University Hospitals.
Patients and methods
Between May 2011 through October 2013, 58 patients with recurrent patellar dislocation were treated by MPFL reconstruction using semitendinosus tendon autograft. Their mean age was 20.05 years. There were 13 men and 45 women. All patients were followed up for at least 24 months. Patients were assessed using the Kujala score.
Results
The overall results were considered good to excellent. No case reported postoperative redislocation. All patients had negative apprehension test postoperatively. The mean Kujala score improved from preoperative 49 (range: 35–64) points to postoperative 93.9 ($P<0.01$).
Conclusion
The use of transpatellar technique for MPFL reconstruction has very low complication rate of more than 24 months follow-up. There were no reported cases of patellar fractures or loss of knee flexion.

Keywords:
medial patellofemoral ligament reconstruction, patellar instability, semitendinosus autograft

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Introduction

The medial patellofemoral ligament (MPFL) is the main medial patellar stabilizer against lateral patellar dislocation [1,2]. In most of the individuals, MPFL was flat and fan shaped, being larger at its patellar attachment than its femoral attachment. The ligament length average is 58.3 mm with a range of 47.2–70.0 mm. The MPFL is most commonly attached to the posterior part of the medial epicondyle, ~1 cm distal to the adductor tubercle [3,4].

The causes of patellar instability include: MPFL insufficiency, trochlear dysplasia (short shallow trochlear groove), excessive femoral anteversion, excessive external tibial rotation, weak vastus medialis obliques (VMO), hypoplastic flat lateral femoral condyle, hypoplastic or high patella, axial (genu valgum) and sagittal (genu recurvatum) deviations, lateral offset of the tibial tuberosity, generalized ligamentous laxity, and contracture dysfunction of vastus lateralis [5–7]. These combined anatomic and constitutional factors predispose the patella to lateral dislocation, especially in early flexion [8,9].

The MPFL is particularly important in the first 30° of knee flexion, as the patella is most vulnerable to lateral dislocation in this position, due to lack of bony protection afforded by the lateral femoral condyle [3].

The indications for MPFL reconstruction are recurrent dislocation or persistent instability, failure of conservative treatment, and a positive apprehension test. MPFL reconstruction offers superior functional results when compared with older realignment, stabilization procedures with a lesser degree of perioperative morbidity, and long-term complications [10].

This study was held to assess the clinical and functional results of double-bundle transpatellar MPFL reconstructions in patients with recurrent patellar dislocation over a 2-year follow-up.

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Patients and methods

Between May 2011 and October 2013, 58 patients with recurrent patellar dislocation were treated by MPFL reconstruction using semitendinosus tendon autograft from the ipsilateral knee. The mean age at the time of operation was 20.05 years (range: 19–24 years). There were 13 men and 45 women. All patients were followed up for at least 24 months. All the patients reported recurrent dislocation more than one time. The period lapsed between first dislocation and operation ranged from 3 to 6 months. Table 1 shows the anthropometric data of the participants.

Patients with sulcus angle greater than 150, tibial tuberosity-trochlear groove (TT-TG) distance greater than 20 mm, patella alta (Insall–Salvati index [11]>1.2), patellar dysplasia grade IV and V (Wiberg classification) [12], concomitant knee cruciate ligament or collateral ligament injury, rheumatoid arthritis, osteonecrosis with cartilage damage greater than grade II according to Outerbridge classification [13], previous surgery to the injured knee and *Q* angle more than 20 in women or more than 17 in men were excluded from the study.

Table 1 Anthropometric data of the participants

Age (years)	
Mean	20.05
Range	19–24
Sex [*n* (%)]	
Male	13 (22.5)
Female	45 (77.5)
Follow-up (mean) (months)	24
Sport participation [*n* (%)]	29 (50)
Period lapse between injury and operation (months)	3–6
Preoperative Kujala score (points)	
Mean	49
Range	35–64
Sulcus angle (deg.)	
Mean	138.25
Range	129–149
Patellar dysplasia [*n* (%)]	4 (6)
Trochlear dysplasia [*n* (%)]	
Grade A	7 (12)
>Grade A	None
Insall–Salvati index	
Mean	1.068
Range	0.9–1.28
Congruence angle (deg.)	
Mean	13.2
Range	11.4–14.6
Tibial tuberosity-trochlear groove distance (mm)	
Mean	11.95
Range	10.3–17.4
Patellar tilt angle (deg.)	
Mean	11.4
Range	6.4–15.8
Lateral patellar shift (mm)	
Mean	11.5
Range	10–15
Q angle (deg.)	
Mean	17.5
Range	14–22
Associated chondral lesions [*n* (%)]	6 (10.3)
Tight lateral retinaculum [*n* (%)]	3 (5)
Hypermobility [*n* (%)]	15 (26)

The inclusion criteria include

(1) Patellar dislocation occurred at least two times, or the patient had a history of patellar dislocation, and patellar instability symptoms (pain, subluxation, or both) that existed for more than 3 months after the first dislocation.
(2) Positive patellar apprehension test.
(3) Failure of conservative treatment.

All patients were evaluated clinically and radiologically before the operation. History of knee giving way or pop out of place during a twisting activity. The patient may give a history of previous subluxation episodes or a history of dislocation of the opposite knee. Patients were examined for limb alignment, hypermobility syndrome (Carter–Wilkinson criteria) [14], apprehension test, *Q* angle, and lateral retinacular tightness.

All patients were evaluated using an anteroposterior, a lateral, and a 45° tangential views of the patella (Merchant view). Radiographs were examined for trochlear dysplasia according to Dejour *et al.* [15], Patellar height according to Insall and Salvati index [11,16], the congruence angle, the patellar tilt angle, the lateral patellar shift, and the sulcus angle.

The computed tomography scan with superimposed images of distal femur and proximal tibia was done. It was used for the evaluation of the TT-TG distance and lateral patellar tilt angle.

Magnetic resonance imaging was used to assess chondromalacia in the patella and trochlea associated with instability or to pick up chondral fractures and loose bodies and also to detect torn medial structures and to localize the site of rupture. Patients were assessed during follow-up using the Kujala score [17].

All the procedures described in this investigation were approved by the local ethics committee of the Alexandria University and a written consent was taken from all patients included in the study.

The surgical technique

A diagnostic arthroscopy was performed using standard parapatellar anteromedial and anterolateral portals. Patellofemoral joint was inspected for any osteo chondritis deissecans (OCD) or chondral lesions. Arthroscopic chondroplasty was done before any reconstruction. A shaver was used to remove any unstable cartilage flaps. All loose bodies were removed. Only patients with tight lateral retinaculum had arthroscopic lateral release using radiofrequency.

A semitendinosus tendon autograft was harvested from the pes anserinus in the standard manner. A 2-cm-long oblique incision is performed at the pes anserinus. After incising the sartorius aponeurosis, the semitendinosus tendon was harvested and used as an autograft. After harvesting the tendon with a tendon stripper and removing the muscle tissue, the doubled tendon diameter was determined (usually 5–6 mm) and both ends were whipstitched with an absorbable braided suture over a length of 15 mm. The hamstring tendon graft was prepared to ~22–24 cm (≥18 cm). The two ends of the tendon graft were each sutured with no. 2 nonresorbable sutures using the whipstitch technique up to ~1.5 cm from each end. Markings were then placed 2 cm from each end.

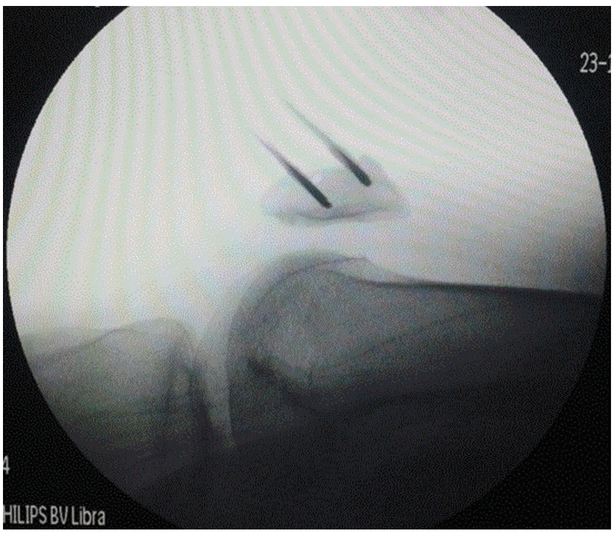
As it is known that the patellar MPFL insertion extends approximately from the superomedial corner of the patella to the midpoint of the medial margin of the patella, a 3 cm skin incision is performed directly over this insertion area. The bony insertion area of the MPFL was prepared. Then, the second and the third layers of the medial patellofemoral complex, where the MPFL is anatomically situated, were separated from each other down to the femoral insertion side, while care had been taken to leave the capsule intact so that the joint remained uninjured.

At 30° knee flexion, a 3 cm longitudinal skin incision was performed in the area between the medial epicondyle and the adductor tubercle. Using a 2.5 mm drill bit, two transverse tunnels were created from the medial to the lateral surface of the patella. The superior tunnel is located at the junction of superior one-third and inferior two-third of the patella. The inferior tunnel is located at the junction of the upper and lower half of the patella. Usually, there was 10–12 mm between the two tunnels. Two passing pins were inserted through these tunnels with passing sutures through their eyelets in a revered manner to retrieve the graft (Fig. 1).

To avoid nonphysiological patellofemoral forces, the femoral MPFL insertion had to be very accurate. Therefore, a guide wire with an eyelet was placed slightly posterior to the midpoint of the medial epicondyle and the adductor tubercle and the entering point into the bone was controlled by a dead lateral fluoroscopy to obtain the correct anatomical femoral insertion. The Schottle point [18,19] was used as standardized radiographic landmark of the anatomical femoral MPFL insertion which had been shown to be located slightly anterior to an elongation of the posterior femoral cortex in between the proximal origin of the medial condyle and the most posterior point of Blumensaat's line (Fig. 2).

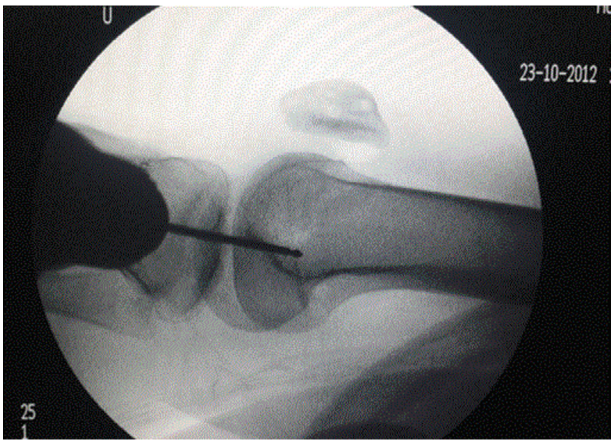
The guide pin was drilled to the opposite cortex. Then the femoral tunnel was created using a cannulated drill

Figure 1



Two parallel patellar tunnels at the anatomical insertion points of medial patellofemoral ligament on the medial side of the patella.

Figure 2



Determination of femoral tunnel at Shottle point using image intensifier.

Figure 3

Passing the graft from medial patellar incision to the femoral insertion point.

Figure 4

Fixing the graft at femoral insertion points with knee flexed 30°–45°.

with a diameter greater than the graft diameter by 1 mm. (usually we used a 6–7 mm drill bit). Tunnels were drilled to a diameter of 30 mm. A passing suture loop was used to retrieve the graft into the femoral tunnel.

The prepared free graft ends were then retrieved through patellar tunnels and then a clamp was used to pass the graft between layer 2 and 3. Then graft ends were retrieved through a suture loop of the femoral guide pin. Tension was applied before graft fixation by bringing the knee through flexion and extension while applying traction to the graft exiting the lateral femoral cortex (Fig. 3).

Central patellar tracking was checked arthroscopically. After confirming anatomical graft reconstruction and perfect patellar tracking, femoral fixation was done by a 25 mm biointerference screw (Biocryl; Smith and Nephew, Watford, England, UK) guided by an interference screw guide pin. All cases were fixed at 30°–45° (Fig. 4).

After finishing the reconstruction, the VMO was imbricated to the superior bundle of the graft for dynamic tensioning of the graft. Retinacular structures, VMO, and fascia were closed anatomically with absorbable sutures. A small suction drain was left in place under the deep fascia for 24 h.

Postoperative measures and follow-up

Postoperative clinical symptoms were evaluated comparing the preoperative and postoperative Kujala score [17]. All patients were instructed to wear a knee brace locked in full extension for the first 2 weeks while allowing immediate quadriceps exercises. After 2 weeks passive and active knee range of motion (ROM) was encouraged under physiotherapist supervision. Also partial assisted weight bearing (20 kg) was encouraged using crutches. In the next 4 weeks, full weight bearing was allowed with intensive quadriceps and hamstring exercises up to 3 month postoperatively. Patients can return to sport after 6 months. All patients were followed up for at least 24 months.

Results

The overall results were considered good to excellent. No case reported postoperative redislocation. All patients had negative apprehension test postoperatively.

Fifteen patients had hypermobility joint syndrome. They were all women. Eleven patients had positive apprehension test while sublaxating patella more than 1.5 cm while the others had positive test when less than 1.5 cm lateral displacement. The mean *Q* angle was 17.5° (range: 14°–22°). Seven patients had mild trochlear dysplasia (Dejour A). Only four patients had mild patellar dysplasia with lateral facet slightly larger than the medial one.

None of the patients had patella alta as evident by Insall and Salvati ratio (the mean ratio was 1.068 with a range from 0.9 to 1.28). The mean sulcus angle was 138.25 (range: 129–150). There were significant differences between the mean preoperative congruence angle and the postoperative scores after MPFL reconstruction ($P<0.01$). The mean congruence angle was 13.2° preoperatively and reverted to the normal range postoperatively (2.1°±3°). There were also significant differences between the mean preoperative and postoperative lateral patellar tilt angle ($P<0.05$; Table 2).

The mean lateral patellar tilt decreased significantly from 11.4° preoperatively to 5.6° postoperatively. The mean patellar lateral shift preoperatively was 11.5 mm (range: 4°–15°). It was significantly improved after surgery to a mean of 5.3 mm. The mean TT-TG distance was 11.95 mm (range: 9–17 mm) (Table 2).

Six patients had chondral lesions but of mild degrees (I, II) and was treated by arthroscopic chondroplasty. Three patients required lateral retinaculum release due to tight lateral retinaculum. In those three patients the operation was done after 6 months of the first dislocation (Table 1).

The mean preoperative Kujala score was 49 (range: 35–64). There was significant improvement postoperatively as the mean Kujala score elevated to 93.9 (range: 86–99) (Table 2).

Regarding complications seven patients reported anterior knee pain that persists for 1 month postoperatively. Ten patients had quadriceps weakness for 1 month that improved on physiotherapy. Three of them had persistent extensor lag of 5°–10° that persist for 2 months postoperatively. None of the cases reported patellar cortex violation or loss of knee flexion.

Discussion

Patellar dislocation is a disabling condition that often results in disruption of the MPFL. Recurrence of the dislocation occurs in up to 44% of conservatively treated patients, and appears to be more common in women and patients with predisposing factors. Patient selection, tunnel positioning, graft fixation, and tensioning were considered as the key pillars for successful MPFL reconstructive procedures [20].

Upon careful observation of the anatomical shape of the original MPFL, it is apparent that the patellar insertion is much wider than the femoral one. Respecting this anatomic condition, a double-bundle reconstruction at the patellar side is reasonable to restore native ligamentous morphologic and biomechanical properties. Kang *et al.* [21] pointed out the functional bundles' concept, forming the ascending superior-oblique bundle and horizontal inferior-straight bundle. The superior-oblique bundle together with the vastus medialis obliquus maintained the dynamic stability of the patellar, while the inferior-straight bundle provided the static strength of inhibition. Respecting this concept during reconstruction is very crucial for successful MPFL reconstruction.

Table 2 Comparison between preoperative and postoperative data

	Preoperative value	Postoperative value	Significance (*P* value)
Congruence angle (deg.)	13.2	2.1	<0.05
Patellar tilt angle (deg.)	11.4	5.6	<0.05
Lateral patellar shift (mm)	11.5	5.3	<0.05
Kujala score (points)	49	93	<0.05

There is a variety of patellar fixation methods such as complete or incomplete transpatellar tunneling and use of a patellar interference screw, partial tunneling, and refixation onto the graft itself, periosteal plication and suturing the graft onto the patella or use of suture anchors to fixate the graft at the patellar side. Complications such as loss of fixation, violation of the anterior cortex or patellar fracture (with complete transpatellar tunnels) have been described. More recently, suture anchor, interference screw fixation of the graft, and the docking technique have been used to avoid the tunnels through the patella. These aperture fixation techniques seem to be less morbid than the techniques utilizing transverse tunnels needing longer tendon graft for reconstruction. In this study, only patellar tunnels were used for MPFL reconstruction

Shah *et al.* [22] performed a systematic review about complications and pitfalls in MPFL reconstruction. They found that a total of 164 complications occurred in 629 (26.1%) knees. These adverse events were common with cases of patellar tunnels more than aperture anchor fixation. The most two common complications were patellar fractures and loss of knee flexion. In this study, there were no reported cases of patellar fractures or loss of knee flexion due to overtight grafts. This may be explained by the technique used, as the knee was fixed at 30°–45°. This is the angle of engagement of MPLF and respecting this angle of fixation, complications due to overtensioning can be avoided.

Matthews *et al.* (2010) [23] used semitendinosus autograft for MPFL reconstruction in 25 knees. The cases were followed up for 31 months. The mean Kujala score improved to 87 points and the Tegner score improved significantly from 3 to 4.4 points. They reported no cases of redislocation or positive apprehension after the final follow-up. Christiansen *et al.* [25] used the gracilis autograft through two transverse patellar tunnels. They reported one case of redislocation among 44 patients followed up to 3 years. Also, four patients had chronic knee pain and three of them had recurrent subluxation. LeGrand and colleagues used semitendinosus autograft through two transverse patellar tunnels. They had no patellar dislocation nor patellar fractures after final follow-up. In this study, semitendinosus autograft was used for MPFL reconstruction in 58 knees. Cases were followed up for 24 months. Only seven patients reported anterior knee pain that persists for 1 month postoperatively. The mean Kujala score improved from a mean preoperative value of 49–93 points postoperatively.

Some authors reported painful hardware irritation of the femoral fixation over the medial side of the knee [24]. Christiansen *et al.* [25] reported that three of the 14 patients in their series underwent screw removal 6–12 months after surgery for painful prominence at the site of the femoral interference screw. Steiner *et al.* [26] found that three of the 34 patients required removal of painful implants at the femoral fixation site. Nomura *et al.* [27] reported pain at the fixation site in 57% of patients treated with staples and in 23% of patients treated with an integrated double-staple system. In this study, there was no cases of painful hardware with the use of the interference screw. Tunnel drilling was done to 30 and 25 mm interference screw was used for the fixation of the graft at the femoral tunnel.

Postoperative widening of the femoral tunnel is a phenomenon that is still poorly understood. It is defined by doubling of the tunnel diameter in a lateral plain radiograph of the distal femur. A retrospective study by Berard *et al.* [28] showed an incidence of 41.8% after a 1-year follow-up. They reported that the main cause of tunnel widening was malpositioning of the graft. In this study, there was no reported cases of tunnel widening of graft loosening for the whole period of the follow-up (24 months). This may be explained by the anatomical reconstruction of the graft with accurate patellar and femoral insertion points using an image intensifier.

Hopper *et al.* [29] reported an incidence of 5.6% for postoperative anterior patella stress fractures after transpatellar tunnel drilling. Thaunat and Erasmus [30] described two patients with an avulsion fracture of the patella at the fixation site. Christiansen *et al.* [25], Gomes *et al.* [31], Lippacher *et al.* [32], and Parikh and Wall [33] described iatrogenic patellar fractures after surgery. These fractures occurred because of violation of the anterior patellar cortex that had occurred intraoperatively during drilling of the patellar tunnel. Also, recent literature showed cases of patella fractures after fixation with suture anchors and tunnels that did not fully transverse the patella [34]. In this study, although transpatellar tunnels were used, there was no reported cases of patellar cortex violation. This may be explained by keeping at least 10 mm between two tunnels, keeping the tunnels at the subchondral level and before all, the anatomical reconstruction of the graft to avoid overtension of the graft which is usually the main cause of this problem.

The most common complication of graft overtensioning is a postoperative flexion limitation partly accompanied by severe pain in the patellofemoral joint or over the medial retinaculum. The incidence of this problem was estimated to be around 30% [35,36]. In this study, there was no reported cases of flexion limitation. This may be also explained by correct tunnel placement and proper angle of fixation during MPFL reconstruction. Also, mild tension was applied during the reconstruction as the native MPFL only acts as just checkrein to prevent lateral patellar subluxation at 30° of knee flexion [37,38]. Malposition of the femoral tunnel around 5 mm proximal of its correct position leads to a significant redistribution of forces [38]. Deviations of 10.5 mm from the correct femoral insertion point in any direction have been identified as a risk factor for medial pain together with a decline in WOMAC and KOOS scores [39].

As with any procedure involving the knee, arthrofibrosis can occur after MPFL reconstruction. Drez *et al.* [40] reported the incidence of this complication to be 5%. There was no reported cases of knee stiffness in this study. This may be due to keeping the reconstruction extra-articular between layer 2 and 3 of medial knee restructures. The knee capsule should never be opened during this procedure.

This study is limited by investigating a small number of patients (58 patients) with mid-term clinical results after MPFL reconstruction. However, the results of this study using the semitendinosus tendon autograft with two transverse patellar tunnels showed a zero redislocation rate and subjective patient outcome scores compatible with other reported techniques. Patient selection remains vitally important to ensure optimal surgical outcomes. Another limitation of this study is the design of the study as a case series study with no control group.

Conclusion

This study showed that the use of transpatellar tunnels had a very low complication rate over a 24 month follow-up. There were no reported cases of patellar fractures or loss of knee flexion. The incidence of anterior knee pain was very low. It has less cost than implant-dependent fixation methods at the patellar side with the same clinical outcome.

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Conflicts of interest

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