Evaluation of combined arthroscopic lateral release and medial patellofemoral ligament reconstruction for the treatment of recurrent lateral patellar instability

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Background

Different methods were used for the treatment of recurrent lateral patellar instability (LPI) of the knee and the combined arthroscopic lateral release and medial patellofemoral ligament (MPFL) reconstruction is an effective method of treatment.

Aim

This study aimed to evaluate the functional and radiological outcomes of treatment of recurrent LPI using combined arthroscopic lateral release and MPFL reconstruction.

Patients and methods

This prospective study was conducted on 12 patients, two male and 10 female, attending Saudi German Hospital in Saudi Arabia between March 2013 and October 2014, and the mean age was 26 years (range: 20–34) at the time of surgery. Patients with recurrent LPI confirmed by means of history, physical examination, and radiographic examinations were included in the study. Follow-up evaluation of the results after 1 year of surgery was carried out using Kujala score, Lysholm score, Tegner activity score, and the criteria of Crosby and Insall, and the rate of satisfaction was evaluated according to Nelitz.

Results

The congruence angle improved from 18.3±5.4° preoperatively to –5.0±0.4° at 1-year follow-up. The lateral patellar angle significantly improved from –7.5±4.2° preoperatively to 6.2±3.1° at 1-year follow-up. Moreover, the patellar tilt angle improved from 28.5±6.5° preoperatively to 8.2±0.7° at 1-year follow-up. The mean Kujala score increased significantly from 44.6±2.5 preoperatively to 92.4±3.6 points postoperatively ($P<0.05$). The mean Lysholm score increased significantly from 42.8±6.4 points preoperatively to 94.4±4.2 points postoperatively ($P<0.05$). In addition, the Tegner score improved from 2.6±0.8 points preoperatively to 6.6±0.4 points at 1-year follow-up. Evaluation using Crosby–Insall criteria after 1-year follow-up showed that 10 (83%) patients had excellent results and two (17%) patients had good results. According to Nelitz criteria, eight (67%) patients were very satisfied with surgery, three (25%) patients were satisfied, and one (8%) patient partially satisfied. No postoperative vascular or neurological complications were found and no patient had patellar redislocation. One patient had superficial infection that improved with frequent dressing.

Conclusion

The double bundle graft technique used in this study for the reconstruction of MPFL provides proper anatomical position of the femoral fixation of the graft and gives stable tendon-to-bone fixation with early healing and offers a successful outcome that allows an early rehabilitation and return to full activity.

Keywords:
arthroscopy, instability, medial patellofemoral ligament, patella, reconstruction

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Introduction

The normal patellofemoral joint has two types of stabilizers: the first is active stabilizers (extensor muscles) and the second is passive stabilizers (bones and ligaments). The main bone stabilizers are the high lateral trochlea and the deep femoral sulcus, and the main ligament stabilizers are the medial patellofemoral retinaculum and the medial patellofemoral ligament (MPFL) [1].

The patella is primarily stabilized using the MPFL from full extension as it tightens to ~20° of flexion as it becomes lax and the patella should engage into the trochlear groove at this degree. The trochlea provides stability up to 60–70° of flexion, where the patella begins engaging into the notch, and, in cases of trochlear dysplasia, the patella cannot be guided properly and dislocation of the patella can occur. In cases of a valgus deformity or internal rotation of the distal femur, the patella does not engage the notch in greater than 70° of flexion, and instability occurs [2]. In addition, many authors reported in biomechanical studies that the MPFL accounts for ~50–60% of the total lateral restraint, and being the primary medial stabilizer of the patella at 0–30° of flexion and additional stresses and tension on the medial soft-tissue from maltracking leads to insufficient MPFL and subsequent recurrent instability [1,3].

Favaro *et al.* [4] reported with the measurement of the Merchant congruence angle and the Laurin lateral patellofemoral angle that the MPFL has an important role in knee stability with the knee flexed at 45°. Many other studies also confirmed that rupture of the MPFL is the main pathological consequence of patellar dislocation [5–10]. Another study reported that the principle resistance to lateral patellar displacement is the height and the slope of the lateral femoral condyle [11].

The anatomic causes for instability of the patellofemoral joint include trochlear dysplasia, dysplastic patella, patella alta, abnormal *Q* angle, and lateralization of the tibial tuberosity. Other common etiological factors, such as genu valgum, external tibial torsion, patellar hypermobility (PH), and post-traumatic patellar dislocation, exhibit important factors for patellar instability [12]. During hypermobility, the patella sits in its groove very superficially and loose and exhibits marked side to side movement; patients with hypermobility complain that the patella pops out and the knee gives way. Other clinical signs are positive apprehension test and tenderness of the medial retinaculum. In addition, the *Q* angle normally measures 0–14° and a *Q* angle greater than 15° is a sign of lateral patellar instability (LPI) [13].

Trochlear dysplasia is characterized by abnormal trochlear morphology and a shallow groove and is associated with recurrent patellar instability. Bollier and Fulkerson [14] reported that MPFL reconstruction in these patients is recommended in the absence of patella alta or increased tibial-tubercle groove distance. In the study by Feller *et al.* [5], trochleoplasty was indicated in severe trochlear dysplasia with hypoplasia of the medial facet of the trochlea as MPFL reconstruction alone has high failure rate in these patients.

According to Aglietti *et al.* [15], recurrent LPI is characterized by patellar instability in patients who suffer repeated subluxation of the patella without complete dislocation or experienced repeated episodes (two or more) of complete dislocation of the patella.

Plain radiographic examination was carried out for the diagnosis of LPI in the tangential patellar view as described by Merchant *et al.* [16] and Laurin *et al.* [17], to measure the patellar tilt angle, which is defined as the angle subtended by a line joining the medial and lateral edges of the patella and the horizontal. The mean tilt angle in patients who had patellofemoral malalignment was 12±6° as the normal tilt is up to 5° [18]. Another angle in the evaluation of the patellar malalignment and lateral instability is the congruence angle. It is the angle formed by dissecting the sulcus angle and central patellar ridge, and the congruence angle should be normally less than and equal to 0° and patellar subluxation greater than and equal to 0° [4]. Computed tomography (CT) scan is useful in the diagnosis of LPI as described by Schutzer *et al.* [19] and Fulkerson *et al.* [20], as CT slice through the midpatella taken at 20° of knee flexion will indicate abnormal tilting of the patella. In addition, MRI is helpful in the evaluation of trochlear dysplasia and tibial-tubercle–trochlear groove (TT–TG) distance.

In the study by Fithian *et al.* [21], surgical management for recurrent patellar instability is indicated if conservative measures fail. A variety of surgical techniques have been reported for the treatment of recurrent LPI. Two main basic techniques were used, one is medial soft-tissue realignment and the second is distal bony realignment of the tibial-tubercle. Medial soft-tissue realignment includes a standard lateral retinacular release (LRR) as well as plication of the medial structures as medial reefing of the medial soft tissues, medial release with lateral and distal advancement of the vastus medialis insertion, medial soft-tissue flap, and medial patellofemoral reconstruction [13,22–24].

LRR relieves the excessive retinacular strain and restores a laterally tilted patella to the normal alignment. In addition, it has the advantage of minimal morbidity and fast recovery, but many surgeons believed that it is an insufficient procedure for the treatment of chronic dislocation or subluxation of the patella [25]. The indications for LRR vary excessively, although it is one of the most commonly used surgical procedures in the USA [21]. In the study by Clifton *et al.* [26], the main indications for LRR were patellar tilt and an excessively tight lateral retinaculum. In another study by Schock and Burks [27], LRR was not indicated in patients who had insufficient trochlear groove restraint, inadequate medial retinacular tissue, patellar tendon length abnormalities, and limb alignment torsional abnormalities. Dandy and Desai [28] concluded that arthroscopic lateral release is the procedure of choice for patients suffering from recurrent complete dislocation of the patella with exclusion of patients with abnormal ligamentous laxity or subluxation on extension.

Open surgical techniques used initially were miniopen and percutaneous techniques [29] and were followed by arthroscopic techniques using thermal devices [30]. More recently, arthroscopic bipolar radiofrequency has been used for lateral release [31].

Many anatomical and biomechanical studies had shown that the primary ligamentous restraint to lateral patellar displacement is the MPFL [12,21]. Reconstruction of the MPFL is indicated for patellar instability that occurs in extension or slight flexion, and many techniques for reconstruction had been described. In addition, MPFL attachment is of clinical importance for reconstruction as the fibers spread out in the region of the epicondyle and the adductor tubercle [5]. Multiple studies evaluate the femoral insertion of the MPFL that depends on anatomic, biomechanical, and radiological findings to avoid the complications of increased patellofemoral pressure that is associated with nonanatomic fixation of the graft [2,32,33]. In a detailed anatomic study, Baldwin [34] showed that the adductor tubercle provides attachment of the adductor magnus tendon and that the medial epicondyle provides attachment for the Medial collateral ligament (MCL), whereas the insertion of the MPFL is found in a groove between these two landmarks.

The aim of this study was to evaluate the results of combined arthroscopic lateral release of the patella and MPFL reconstruction for the treatment of recurrent LPI and the hypothesis that it is an effective and safe technique in improving patellofemoral function by relieving pain and for patellar stability.

Patients and methods

This prospective study was conducted on 12 patients, two male and 10 female, attending Saudi German Hospital in Saudi Arabia between March 2013 and October 2014, and the mean age was 26 years (range: 20–34) at the time of surgery. This study approved by the Ethical committee of Saudi German Hospital in Saudi Arabia, KSA and Suez Canal University, Ismailia, Egypt.

Patients with recurrent LPI that resulted from minor indirect trauma or during daily activities confirmed by means of history, physical examination, and radiographic examinations and patients with lateral subluxation with knee cap shifts to the side or patients with a history of two or more episodes of lateral dislocation were included in the study. In addition, patients with PH were also included in the study and diagnosed when the patella easily moved from side to side and subluxed out of the groove to the point of near dislocation.

Exclusion criteria for this operation were as follows: age younger than 18 years, significant patellofemoral articular cartilage degeneration according to the outer bridge [35] classification (Table 1) (grades III–IV) confirmed through arthroscopic evaluation; severe trochlear dysplasia (types C and D) according to Dejour *et al.* [36] classification (Table 2); presence of patella alta; a history of previous knee surgery or surgical treatment of an initial patellar instability; multiple ligament injury; *Q* angle greater than 20°; and significant patellar malalignment, wherein the TT–TG distance is greater than 20 mm. In addition, patients with LPI due to marked genu valgus and severe tibial torsion were excluded from the study.

Preoperative evaluation was carried out, including history of recurrent patellar instability, physical examination, plain radiography including merchant view to assess patellar tilt and the congruence angle, and CT scan to accurately document patellar malalignment and instability. In addition, MRI was used to evaluate trochlear dysplasia and TT–TG distance.

Evaluation was carried out preoperatively and postoperatively after 1 year of surgery for Kujala

Table 1 Outer bridge classification of chondral lesions

Grade 0	Normal cartilage
Grade I	Cartilage with softening and swelling
Grade II	A partial-thickness defect with fissures on the surface that do not reach subchondral bone or exceed 1.5 cm in diameter
Grade III	Fissuring to the level of subchondral bone in an area with a diameter more than 1.5 cm
Grade IV	Exposed subchondral bone

Table 2 Classification of trochlear dysplasia

Type A	Normal shape of the trochlea, but shallow trochlear groove
Type B	Markedly flattened
Type C	Trochlear facet asymmetry, with too high lateral facet and hypoplastic medial facet
Type D	Type C and vertical link between facets (cliff pattern)

Table 3 Kujala score

Items	Scores
Limp	
None	5
Slight or periodical	3
Constant	0
Support	
Full support without pain	5
Painful	3
Weight-bearing impossible	0
Walking	
Unlimited	5
More than 2 km	3
1–2 km	2
Unable	0
Stairs	
No difficulty	10
Slight pain when descending	8
Pain both when descending and ascending	5
Unable	0
Squatting	
No difficulty	5
Repeated squatting painful	4
Painful each time	3
Possible with partial weight–bearing	2
Unable	0
Running	
No difficulty	10
Pain after more than 2 km	8
Slight pain after start	6
Severe pain	3
Unable	0
Jumping	
No difficulty	10
Slight difficulty	8
Constant pain	2
Unable	0
Prolonged sitting with the knee flexed	
No difficulty	10
Pain after exercise	8
Constant pain	6
Pain forces to extend knees temporarily	4
Unable	0
Swelling	
None	10
After severe exertion	8
After daily activities	6
Every evening	4
Constant	0
Pain	
None	10
Slight and occasional	8
Interferes with sleep	6
Occasionally severe	3
Constant and severe	0
Abnormal painful knee cap movements	
None	10
Occasionally in sports activities	6
Occasionally in daily activities	4
At least one documented dislocation	2
More than two dislocations	0
Atrophy of the thigh	
None	5
Slight	3
Severe	0
Flexion deficiency	
None	5
Slight	3
Severe	0

Table 4 Lysholm knee score

Items	Scores
Limp	
None	5
Slight or periodical	3
Severe and constant	0
Support	
None	5
Stick or crutch	2
Weight-bearing impossible	0
Pain	
None	25
Inconstant and slight during severe exertion	20
Marked during severe exertion	15
Marked on or after walking more than 2 km	10
Marked on or after walking less than 2 km	5
Constant	0
Instability	
Never giving way	25
Rarely during athletics or other severe exertions	20
Frequently during athletics or other severe exertions	15
Occasionally during daily activities	10
Often during daily activities	5
Every step	0
Locking	
No locking and no catching sensation	15
Catching sensation but no locking	10
Locking occasionally	6
Frequently	2
Locked joint on examination	0
Swelling	
None	10
On severe exertion	6
On ordinary exertion	2
Constant	0
Stairs – climbing	
No problems	10
Slightly impaired	6
One step at a time	2
Impossible	0
Squatting	
No problems	5
Slightly impaired	4
Not beyond 90°	1
Impossible	0

Excellent: ?90. Good: 84–90. Fair: 65–83. Poor: <65.

Table 5 The criteria of Crosby and Insall

Excellent	No pain; normal activities including all sports; full range of movements; knee subjectively normal
Good	Occasional discomfort; feeling of stiffness or instability; no participation in contact sports; slight loss of flexion; knee considered improved by the patient
Fair/poor	Pain most of the times; symptoms altered but include recurrent subluxation or a significant loss of flexion; further surgical treatment required in some instances
Worse	Pain increased; displacement more frequent

score [37] (Table 3), Lysholm score [38] (Table 4), Tegner activity score [39], and the criteria of Crosby and Insall [40] (Table 5). The rate of satisfaction was evaluated according to Nelitz *et al.* [41], and outcome was rated as very satisfied (knee function much better than their preoperative status), satisfied (knee function improved with no subluxation), partially satisfied (knee function improved but still apprehensive), or not satisfied (knee function same as preoperative status with one or more episodes of patellar subluxation).

Surgical technique

Examination under anesthesia was performed on both knees for the assessment of tight lateral retinaculum and increased lateral translation of the patella. After tourniquet was applied, arthroscopy assessment of the tracking of the patella through range of flexion, the trochlear shape, and the cartilaginous condition for degenerative changes were evaluated. Anterolateral, superolateral, and anteromedial portals were used, and retinacular r was performed arthroscopically by applying the arthroscope through the anteromedial portal and placing the 45° angled bipolar radiofrequency through the superolateral portals with minimal inflow pressure. Release was started from the intersection point of the superior patellar pole and 1.5 cm lateral from the patella and continued to the anterolateral portal distally. Synovium and lateral retinaculum were divided in layers until approaching the subcutaneous tissue. The sufficiency of the release was assessed by pressing the medial edge of the patella toward the medial condyle; if the lateral edge of the patella was moving 1 cm or more away from lateral condyle anteriorly, the release is sufficient, and, if not, the release was extended a further 2 cm proximally.

For MPFL reconstruction, the gracilis autograft was used as the size and strength has been shown to be sufficient for MPFL reconstruction, with ~4 mm in diameter and a graft length of 18 cm, and stitches were tied at both ends. Skin incision for 2 cm was made from the superior medial corner of the patella and extending to the center of the medial edge of the patella. Thereafter, the medial edge of the patella was exposed, and then using C-arm control a hole of 2.4 mm guide pin was drilled in a transverse direction across the patella to a minimum depth of 25 mm at a point 3 mm distal to the proximal corner of the patella at the medial side. Another 2.4 mm guide pin 15–20 mm distal and parallel to the first one was inserted. Overdrilling of the two guide pins with a 4.5 mm cannulated reamer was performed to a depth of 25 mm and then the two guide pins were removed. The stitches at one end of the graft were passed through the eyelet of the first 4.75 mm Swive Lock and the graft/anchor was pushed into the proximal drill hole until the eyelet was fully seated. While maintaining tension on the suture, the Swive Lock Anchor was screwed into the patella, and after removal of the driver the stitch was cut and the same technique was used for fixation of the second graft end.

For femoral insertion, MPFL template was used to establish the position of the guide pin. The insertion point was ~1 mm anterior to the posterior cortex extension line, 2.5 mm distal to the posterior articular border of the medial femoral condyle, and proximal to the level of the posterior point of Blumensaat's line. The template was placed on the area of the medial epicondyle on the distal femur, and, under fluoroscopic guidance, a 2.4 mm guide pin was drilled across the femur and out through the lateral epicondyle. The femur was drilled with a 6 mm reamer, as the diameter of the doubled gracilis graft was between 4 and 5 mm and drilled to the far cortex by keeping the 2.4 mm guide pin to pass the graft into the femur. A blunt dissection was made with scissors through the space between the vastus medialis and the capsule and toward the femoral insertion by keeping the capsule intact. A right angle clamp was inserted toward the medial epicondyle and the tip of the clamp was turned toward the skin and a loop passed back to the patellar insertion area and the graft was fixed to the loop and passed back to the insertion point at the medial femoral epicondyle by maintaining equal tension on both graft bundles. A 1.1 mm guide wire was inserted in the drill hole with guide wire with graft sutures passed in the eyelet of the wire, and the graft was pulled out of the lateral femur by maintaining tension on both graft bundles. Proper isometric MPFL was maintained by manually holding the lateral patellar facet in level with lateral femoral condyle at 30° flexion of the knee, and, by keeping tension on the graft, a 6 mm×23 mm screw was fixed into the femur. Thereafter, evaluation of the patellar tracking was carried out with full knee range of motion. Thereafter, suction drain was applied and patients were allowed for immediate active quadriceps exercises between 0 and 90° and knee brace was applied for 6 weeks. Partial weight-bearing was allowed until wound healing was complete and increased gradually as pain was tolerated by the patient and full Range of Motion (ROM) was allowed after 6 weeks postoperatively.

Statistical analysis

Statistical analysis was performed with SPSS software (version 11.0; SPSS, Chicago, Illinois, USA). Preoperative and postoperative indices for this study were compared using the paired t test. *P* less than 0.05 was defined as a significant difference.

Results

After 1 year postoperatively, a significant improvement was found in all patients and the measurements of angles improved in comparison with preoperative results. The congruence angle improved from 18.3 ±5.4° preoperatively to −5.0±0.4° at 1-year follow-up. The lateral patellar angle significantly improved from −7.5±4.2° preoperatively to 6.2±3.1° at 1-year follow-up. Moreover, the patellar tilt angle improved from 28.5±6.5° preoperatively to 8.2±0.7° at 1-year follow-up. The mean Kujala score increased significantly from 44.6±2.5 preoperatively to 92.4 ±3.6 points postoperatively ($P<0.05$). The mean Lysholm score increased significantly from 42.8±6.4 points preoperatively to 94.4±4.2 points postoperatively ($P<0.05$). In addition, the Tegner score improved from 2.6±0.8 points preoperatively to 6.6±0.4 points at 1-year follow-up (Tables 6 and 7).

Subjective evaluation using Crosby–Insall criteria after 1-year follow-up showed that 10 (83%) patients had excellent results and two (17%) patients had good results. The rate of satisfaction was also evaluated after 1 year of follow-up, and according to Nelitz criteria eight (67%) patients were very satisfied with surgery, three (25%) patients were satisfied, and one (8%) patient partially satisfied as he suffered from positive apprehension sign and mild anterior knee pain on activity. No postoperative vascular or neurological complications were found and no patient had patellar redislocation. One patient had

Table 6 Computed tomography measurements of patellofemoral angles

Angles	Preoperative	Postoperative
Congruence angle	18.3±5.4°	−5.0±0.4°
Lateral patellar angle	−7.5±4.2°	6.2±3.1°
Patellar tilt angle	28.5±6.5°	8.2±0.7°

P=0.000.

Table 7 Functional score outcomes

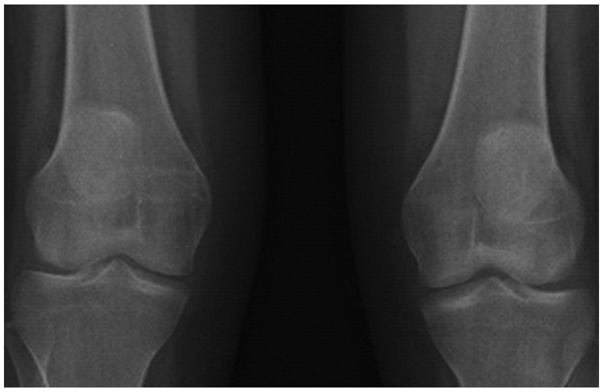
	Preoperative	Postoperative
Kujala score	44.6±2.5	92.4±3.6
Lysholm score	42.8±6.4	94.4±4.2
Tegner activity score	2.6±0.8	6.6±0.4

P=0.000.

Figure 1

Postoperative right knee with no patellar tilt or subluxation

Figure 2

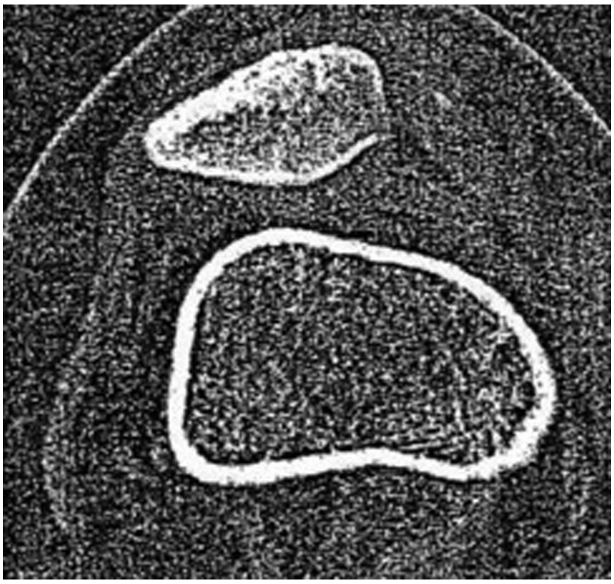


Postoperative plain radiography in anteroposterior view

Figure 3

Postoperative radiography of the distal femur lucent tunnel is noted

Figure 4



Postoperative computed tomography with minimal patellar tilt

superficial infection that improved with frequent dressing.

Figures 1 and 2 show the postoperative plain radiography anteroposterior and tangential view of the right knee of a 21-year-old female with no patellar tilt or subluxation. Figures 3 and 4show the postoperative lateral view of the distal femur and lucent tunnel is noted, and postoperative CT scan showing minimal lateral patellar tilt.

Discussion

Many surgical techniques were described for the treatment of LPI and classified as proximal realignment, distal realignment, proximal and distal realignment, medial retinacular reconstruction, and LRR [42]. Surgical procedures such as quadriceps extensor and retaining procedures such as Campbell operation and distal realignment procedures require large incisions and extensive musculofascial-tendinous dissection with the disadvantages of painful scars and extended postoperative immobilization and rehabilitation [43].

According to Bray *et al.* [44] and Aglietti *et al.* [15], isolated LRR is a good procedure for the treatment of lateral patellar migration but not a good choice for the treatment of patellar instability due to PH. In another study, Gerbino [45] also confirmed that lateral release alone in patients suffering from patellar dislocations due to hyperlaxity, has not been useful, but it can be combined with MPFL reconstruction. In addition, Ricchetti *et al.* [46] confirmed that isolated LRR had inferior results postoperatively with respect to recurrent LPI when compared with LRR with medial reconstruction (MR) and advised it as an effective and minimally invasive technique for the treatment of recurrent patellar instability. In another study, LRR has been found to decrease lateral patellar tilt due to tight lateral retinaculum, but it has been found to also increase both passive medial and lateral displacement of the patella and thus patellar instability. These findings suggest that isolated LRR may actually worsen cases of recurrent patellar instability and should not be performed for this indication [47]. However, Small *et al.* [48] reported that the medial patellar retinacular reefing technique has the disadvantage of suture loosening.

In the study by Paul [13], combined lateral release and medial tethering was indicated in patients with PH and LPI as LPI alone needs only lateral release and PH alone may be asymptomatic and quadriceps strengthening exercises are enough.

Many studies confirmed that combined lateral release and MR has superior results to lateral release alone. In the study by Panni *et al.* [49] and Woods *et al.* [50], the mean success rate of postoperative knee stability after 1 year of LRR technique was 77.3%. In another study, the mean success rate after combined LRR and medial soft-tissue realignment (MR) was 93.6% [51,52]. Nomura *et al.* [53] found that the average success rate of LRR in correcting patellofemoral instability is only 65%, which is inferior to the rate obtained with medial patellofemoral reconstruction.

Nelitz *et al.* [41] also found that the anatomic reconstruction of the MPFL was a safe and effective procedure for the treatment of recurrent patellofemoral dislocation in adolescents and young adults. In another study, Camp *et al.* [54] also found that failure to restore the anatomic femoral insertion was the main risk factor for failure of MPFL reconstruction. More recently, Jia *et al.* [55] confirmed in their study that MPFL reconstruction is the preferred operative treatment for recurrent patellar dislocation. Many surgical techniques were described for MPFL reconstruction. For the fixation of patellar graft, the direction of the bone tunnel varied from parallel to oblique. Carmont and Maffulli [56] described a technique of drilling the bone tunnels that traverse the entire patella. In another study, Papp and Cosgarea [57] described the blind patellar tunnel, which was drilled from the medial to the lateral at the midpoint of the MPFL insertion. However, many authors reported in their studies the complications of drilling the entire patella. Gomes [58] reported that creating a patellar bone tunnel can lead to cartilage damage. In another study, Dobbs *et al.* [59] reported that drilling transverse tunnels through the patella can lead to bone stress and fracture. More recently, Schottle *et al.* [60] described in their study a technique of fixation of the graft to the medial part of the patella using two suture anchors and to the femur with a biodegradable interference screw. In another recent study by Jia *et al.* [55], they used the fixation of the graft at the patellar side using the bone-fascia tunnel technique that permits secure fixation with direct pull on the patella with mechanical power similar to those of the bone tunnel technique.

Parker *et al.* [61] evaluated and compared the patellofemoral kinematics of a single-stranded isometric MPFL reconstruction technique with that of a double stranded anatomic technique, and they emphasized that the double strand graft more closely recreates the normal anatomy of the MPFL. Amis *et al.* [2] also reported that the double bundle techniques provide a higher stability during flexion and decreases patellar rotation. Gomes *et al.* [62] suggested that the choice of graft among semitendinosus tendon, gracilis tendon, or even artificial ligament is essentially a matter of personal preference that does not conflict with main aim.

More recently, Schoettle *et al.* [63] confirmed in their study that the anatomic double bundle MPFL reconstruction technique has several advantages: it gives the native shape of the MPFL, provides the best possible stability in both flexion and extension, and limits rotation throughout the ROM by minimizing postoperative instability. In addition, the gracilis autograft was used as the size and strength has been shown to be sufficient for MPFL reconstruction, with ∼4 mm in diameter and a graft length of 18 cm.

In the study by Jia *et al.* [55], the congruence angle showed significant improvement from 19.2±6.3° before surgery to −6.0±0.5° at the last follow-up. The lateral patellar angle showed a significant improvement from −6.9±3.5° before surgery to 5.1±2.4° at the last follow-up. The patellar tilt angle showed a significant improvement from 24.5±5.2° before surgery to 12.3±1.9° at the last follow-up. The Kujala score was significantly increased from 52.9±3.2 points preoperatively to 90.1±5.8 points postoperatively ($P<0.05$). The mean Lysholm score was significantly increased from 47.2±5.2 preoperatively to 92.5±6.2 points postoperatively ($P<0.05$). The Tegner activity score improved overall from 3.1±0.6 points to 5.8±0.9 points at follow-up.

In the study by Nelitz *et al.* [41], the average Kujala score improved from 72.9 (range: 37–87) preoperatively to 92.8 (range: 74–100) at follow-up after 2 years. The Tegner activity score decreased from 6.0 (range: 3–9) preoperatively to 5.8 (range: 3–9) postoperatively. Tegner activity score improved postoperatively in three (6.4%) patients, in four (19%) patients it decreased, and in 14 (66.6%) patients there was no change in the Tegner activity score. In addition, three (6.4%) patients returned to usual activity and sports at a higher level than that preoperatively, 14 (66.6%) patients returned to the same level of activity as preoperative level, and four (19%) patients had lower activity level.

In the current study, the congruence angle improved from 18.3±5.4° preoperatively to −5.0±0.4° at 1-year follow-up. The lateral patellar angle significantly improved from −7.5±4.2° preoperatively to 6.2±3.1° at 1-year follow-up. Moreover, the patellar tilt angle improved from 28.5±6.5° preoperative to 8.2±0.7° at 1-year follow-up. The mean Kujala score increased significantly from 44.6±2.5 preoperatively to 92.4±3.6 points postoperatively ($P<0.05$). The mean Lysholm score increased significantly from 42.8±6.4 points preoperatively to 94.4±4.2 points postoperatively ($P<0.05$). In addition, the Tegner score improved from 2.6±0.8 points preoperatively to 6.6±0.4 points at 1-year follow-up. These results are comparable to the results of the study by Jia *et al.* [55], as they used the double strand graft technique for reconstruction of the MPFL similar to the technique used in the current study.

In the study by Nelitz *et al.* [41], 14 (66.6%) patients were very satisfied with the surgical procedure, four (19%) patients were satisfied, and three (6.4%) patients were partially satisfied and they suffered from positive apprehension sign, and no patients had redislocation of the patella.

In the study by Gomes *et al.* [62], 13 (87%) patients were satisfied with the outcome of surgery and two (13%) patients were not satisfied. According to the subjective evaluation using Crosby–Insall criteria, 11 (73%) patients had excellent results, three (20%) patients had good results, and one (7%) patient had poor result, giving a median score 4 [3,4]. Patellofemoral pain was absent and the apprehension test was negative in 14 (93%) patients. Eight (53%) patients continued physical activity as before surgery and seven (47%) patients stopped any physical activity after surgery.

In the current study, subjective evaluation using Crosby–Insall criteria after 1-year follow-up showed that 10 (83%) patients had excellent results and two

(17%) patients had good results and these results are comparable to the results of the study by Gomes *et al.* [62]. In addition, the rate of satisfaction in the current study was also evaluated after 1 year of follow-up, and according to Nelitz criteria eight (67%) patients were very satisfied with surgery, three (25%) patients were satisfied, and one (8%) patient partially satisfied as he suffered from positive apprehension sign and mild anterior knee pain on activity. These results are closely similar to the results of the study of Nelitz *et al* [41].

No postoperative vascular or neurological complications were found in the current study and no patient had patellar redislocation. One patient had superficial infection that improved with frequent dressing.

Finally, the advantages of the technique used in the current study are as follows: better healing of the graft in the bone tunnel due to increased surface area for graft-to-bone healing, and this technique eliminates the risk for violation of the patellar articular surface. Moreover, the double bundle graft used in this study gives the above-mentioned advantages of graft stability in contrast to the single bundle technique. In addition, accurate positioning of the femoral insertion of the MPFL is very important to maintain proper biomechanics of the patellofemoral joint through the entire range of motion.

Conclusion

The double bundle graft technique used in this study for the reconstruction of the MPFL provides proper anatomical position of the femoral fixation of the graft and gives stable tendon-to-bone fixation with early healing and offers a successful outcome that allows an early rehabilitation and return to full activity.

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Conflicts of interest

There are no conflicts of interest.

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