

Medial Patellofemoral Ligament Reconstruction- State of the Art

Anshu Shekhar¹, Shantanu Patil², Sachin Tapasvi¹

Abstract

The management of recurrent patellar instability has undergone progressive changes over the past few decades with improved optimal and predictable outcomes for the patients. Open surgical realignment procedures with bony osteotomies either proximal or distal to the Patella, designed to correct the imbalance of the extensor mechanism such that the patella tracks smoothly over the trochlea were commonly advocated. These procedures aimed to restore normal chondral loading of the patellofemoral joint and modify or delay progression of arthritic changes at an early age. With enhanced knowledge on the biomechanics of the anatomical structures providing medial and lateral restraints around the knee, the role of the Medial Patello-Femoral Ligament has been shown to be a vital one. This has refined the surgical options available to minimally invasive arthroscopic approaches with satisfying calculable results. This review article outlines the evolution of the surgical management of patellar instability and the prominent role of the MPFL reconstruction in achieving it. The biomechanics, surgical principles, anatomic landmarks, types of grafts and fixation methods, along with the senior surgeon's preferred surgical technique are described in detail.

Keywords: recurrent patellar instability, Medial Patello-Femoral Ligament, reconstruction

Introduction

The role of medial patellofemoral ligament reconstruction in restoring the anatomical imbalance around the knee and treating recurrent patellar dislocations cannot be understated. With the refinement on the knowledge about the functions and structures on the medial side of the knee, the importance of repairing or reconstructing the medial restraints has gained widespread acceptance over the past decade. The treatment of patellar instability has undergone a remarkable evolution since the advent of arthroscopic minimally invasive surgeries. Invasive open surgeries with long drawn rehabilitation protocols and less than optimal results were commonplace until the advent and adoption of arthroscopic procedures as the standard of care [1, 2, 3, 4]. Distal realignment of the tibial tuberosity (TT) with or without a proximal soft tissue procedure to restore the balance of the

extensor mechanism such that the patella tracked reliably within the trochlear groove (TG) was the biomechanical goal of all such procedures [1, 5, 6]. This was expected to distribute the cartilage loads evenly, restore joint incongruity alleviate pain, thus affecting the natural progression of patellofemoral arthritis. Surgical release or lengthening of the lateral structures of the knee joint was also popular as a concomitant procedure either open or through minimal invasive approach [7, 8]. While the distal realignment procedures were effective, they were by no means optimal as reflected in the complications associated which included non-union of the osteotomies, tibial fractures, skin dehiscence, and worst of all unbalanced chondral loading on the medial facet leading to degenerative changes in the patellofemoral as well as the tibiofemoral articulations [9, 10, 11]. The attempts to quantitate the exact position and relocation

of the TT and the use of the TT-TG distances were important to avoid over-medialization [12]. The most common pathological feature among all patients with patellar instability is laxity of the medial periarticular structures, and medial plication and reefing have been shown to have satisfactory results in multiple reported series [13, 14, 15]. However, inadequate awareness of the medial retinacular anatomy would sometimes cause over-tightening and increased patellofemoral forces [15]. The presence of the medial patellofemoral ligament as a distinct ligamentous structure on the medial side of the knee was first described by Warren and Marshall [16]. However, this was perhaps largely forgotten till a more detailed description by Feller et al. several years later, and since then, there has been no looking back [17]. Further studies by Zaffagnini and Tanaka established the anatomic dimensions and the functions of the MPFL [18]. The wide acceptance and practice of MPFL reconstruction with various surgical techniques were also followed by a multitude of complications. One of the reasons for this was the variability in the anatomical locations of the attachments across the

¹The Orthopaedic Speciality Clinic, Wrangler Paranjpe Road, Pune

² Head, Translational Medicine & Research, SRM University, Kattankulathur, Tamil Nadu

Address of Correspondence

Dr. Sachin Ramchandra Tapasvi,
The Orthopaedic Speciality Clinic, Wrangler
Paranjpe Road, Pune
Email: stapasvi@gmail.com



Dr. Anshu Shekhar



Dr. Shantanu Patil



Dr. Sachin Tapasvi

© 2018 Shekhar et al | Asian Journal of Arthroscopy | Available on www.asianarthroscopy.com/ | doi:10.13107/aja.2456-1169.198

This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<http://creativecommons.org/licenses/by-nc/3.0/>) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

populations. The Schottle's point or Stephen's point derived to simplify the femoral attachment was useful in narrowing down the region of attachment [19, 20]. The Tanaka point, a broad area proximal to the articular surface of the medial patella is less sensitive to the effect of placement of patellar tunnels [21]. While the anatomical landmarks are vital in identifying the location for placing the bony tunnels, a thorough knowledge about the biomechanics of the medial structures is essential to ensure the success of the surgical procedures.

Biomechanics

The importance of MPFL as a crucial restraint to patella against lateral patellar dislocation is now firmly established. Conlan et al. published one of the earliest biomechanical studies to establish the importance of MPFL. In 25 fresh-frozen cadaveric knees they evaluated using a universal testing instrument, they found that MPFL alone contributed to about 53% of the total force against lateral dislocation [22]. Hautamaa et al. also had a similar conclusion in their cadaveric study and they also found that repair of this structure restored the biomechanics in cadaveric specimens [23]. The critical importance of MPFL was underscored by Sillanpää et al. in their analysis of the national registry in Finland. They discovered that this structure was always disrupted in patients with acute traumatic patellar dislocation, and hence, was a definite sign of this condition [24]. There are individual anatomic variations of the MPFL, but the biomechanical importance is not disputed. Amis et al. published their anatomic and biomechanical study, where they reported that the length of the MPFL is approximately 55 mm but the width ranges between 3 and 30 mm. They found that the maximum resistance by MPFL to lateral patellar dislocation was seen in the extended knee [25]. Mountney et al. reported the tensile strength of the MPFL to be about 208 N at 26 mm of displacement. Contrary to earlier belief they showed that repair of this ligament was using sutures or bone anchors were not good enough and only a reconstruction provided equivalent resistance to lateral displacement [26]. Hinckel et al. have

shown that the MPFL ruptures after an average deformation of 19.3 mm and was, hence, always ruptured after a lateral patellar dislocation, which requires about 50 mm of displacement [27].

Surgical Principles

There is a large body of scientific data to support conservative management for first-time dislocators, but surgical treatment is mandated for recurrent instability. The pathology of this condition is multifactorial with coronal and rotational limb malalignment, patella alta and trochlear dysplasia needing cognizance, MPFL is one structure which almost always needs to be reconstructed [28]. With more than 200 peer-reviewed publications since 2014, MPFL reconstruction is indeed a very hot topic in orthopedic sports literature [29]. Restoration of anatomy by precise graft placement and minimal graft tension are the keys to achieving successful outcome [28]. Nonanatomic reconstruction or an excess tension in the reconstruction have been described to cause non-physiologic loading conditions, increase medial patellofemoral pressure and its deleterious sequel [30,31]. There are several surgical techniques and variations described for MPFL reconstruction using all sorts of grafts and fixation devices, but adherence to these principles is crucial. Nonetheless, it is important to realize that MPFL reconstruction is not the panacea for all patellar instability. The presence of increased TT-TG distance and patella alta can significantly increase MPFL graft anisometricity leading to excessive graft tension and potential failure when performed in isolation [32].

Anatomic Landmarks

Feller et al. provided one of the earliest detailed descriptions of the MPFL as a distinct ligamentous structure within Layer II on the medial side. They also noted that the common insertion site on the superomedial patella with the vastus medialis obliquus (VMO) muscle might be responsible for the dynamic stabilizing function of this structure. The femoral insertion site was identified at 5 mm distal and 5 mm anterior to the adductor tubercle [17]. Tuxoe et al. also had similar

conclusions about the individual but not side to side variation about the MPFL in their cadaveric study. They measured the MPFL to be an average 1.9 cm wide and 5.3 cm long with a distinct insertion on the superomedial patella, medial to the VMO [33]. LaPrade et al. in their quantitative anatomic description of the medial side of knee placed the MPFL femoral insertion to be 10 mm proximal and 2 mm posterior to medial epicondyle in a saddle between the medial epicondyle and adductor tubercle. Alternatively, it is located about 2 mm anterior and 4 mm distal to the adductor tubercle, which is a more easily discernable bony landmark [34]. Philippot described in detail the femoral attachment site of the MPFL because accurate femoral attachment of the reconstructed ligament is important for restoring isometricity. This point was described as being 10 mm behind the medial epicondyle and 10 mm distal to the adductor tubercle using an orthonormal frame [35]. Baldwin et al. sought to provide greater clarity of this complex anatomy. They described two distinct femoral insertion points- one transverse 10.6 mm origin in a bony groove between the medial epicondyle and adductor tubercle and another oblique origin from the proximal 30 mm of the leading edge of the medial collateral ligament. The two heads fuse and insert onto the ventral edge of the patella over a span of about 28.2 mm [36]. Steensen described the isometric and anatomic relationship of the MPFL in cadavers. They found the ligament was nearly isometric from 0 to 90° of knee flexion in the portion between the inferior patellar attachment and superior femoral attachment. The superior femoral attachment was most important for restoring the isometricity of a reconstructed MPFL [37]. The anatomic landmarks, thus, described help execute an anatomic and isometric MPFL reconstruction. However, the femoral insertion, which is the most critical part, is difficult to be accurately and reproducibly identified without a complete open dissection medially as the medial epicondyle and adductor tubercle are not always easily palpable. Schöttle et al. described the radiograph landmark to accurately identify the anatomic and isometric femoral insertion intraoperatively on a true lateral view with posterior

condyles over-lapping. This point was 1.3 mm anterior to the posterior cortex extension line, 2.5 mm distal to the posterior origin of the medial femoral condyle, and proximal to the level of the posterior point of the Blumensaat line (Fig. 1) [19]. Stephen et al. described their technique of radiographic localization of the anatomic and isometric femoral insertion. Considering the anterior-posterior medial femoral condyle diameter as 100%, this was identified as a point 10% from the posterior, 50% from the distal, and 60% from the anterior border of the medial femoral condyle [20]. Another such radiographic description was provided by Barnett et al. using similar technique. The patellar attachment was described as being about 7.4 mm anterior to the posterior patellar cortical line and 5.4 mm distal to the perpendicular line intersecting the proximal margin of the patellar articular surface. The femoral attachment was described as 3.8 mm anterior to the posterior femoral cortical line and 0.9 mm distal to the perpendicular line intersecting the posterior aspect of Blumensaat's line. The authors underscored that the absolute necessity to obtain true lateral radiographs for accurate graft placement [38]. Balcarek and Walde also emphasized the need to obtain exact lateral radiographs intraoperatively as the femoral attachment site variation is extremely sensitive to any deviation. This could be responsible for the non-anatomic tunnel placements which have been reported to be as high as 64% [39]. Huston et al. have shown that the inter-observer variation and reproducibility in recognizing the Schöttle point was actually better for pediatric knees. However, they exercised caution to prevent any damage to the distal femoral physis [40]. Rather surprisingly, in the study by Hiemstra et al. of 155 MPFL reconstructions performed, all 8 failures were in patients who did not have malpositioned femoral tunnels as assessed by the Schöttle's point. Furthermore, femoral tunnel position did not correlate with the accuracy of femoral tunnel position [41]. Recently, there has been a criticism of the methods to accurately position femoral tunnels using radiographic landmarks. Sanchis-Alfonso et al. studied the accuracy of radiographic guided femoral tunnel

placement using 3D computed tomography scans. They found that the percentage of anatomic tunnel covered by creating 7 mm femoral tunnels using the Schöttle technique was $36.7 \pm 25.2\%$, whereas the Stephen technique covered $25.5 \pm 21.5\%$ of this area. Thus, both these techniques were approximations with wide variations and did not ensure precise placement of a femoral tunnel [42]. Further, Ziegler et al. advocated assessing anatomy intraoperatively for femoral tunnel placement rather than relying on radiographs. They found that even a 5° of axis deviation in performing lateral radiographs had a significant effect on tunnel localization leading to non-anatomic tunnel placement [43].

Graft and Fixation

The other bone of contention in MPFL surgery has been the choice of graft for an optimal reconstruction. There are several techniques described in literature using autografts, allografts and synthetic materials and a myriad of fixation techniques. The autograft options include gracilis tendon, semitendinosus tendon, and superficial quadriceps tendon. The direct comparison between each technique is not feasible, and most studies have small numbers and short follow-ups. McNeilan et al. have recently published a systematic review of MPFL reconstructions using the three graft options. They reported that the recurrence rates were generally low and there was no benefit in this regard when using an autograft, although there was a bias of reporting better than expected results in smaller studies. There was significant symptomatic relief post-reconstruction, regardless of the graft used. However, pediatric patients and those treated with adductor tendon autograft had higher rates of recurrent instability [29]. Weinberger et al. performed another systematic review and meta-analysis to assess graft choice and configuration on revision rates, and patient-reported outcomes after MPFL reconstruction. They found significantly higher improvements in Kujala scores when an autograft reconstruction was performed, but there was no difference compared to an allograft reconstruction for failures leading to recurrent instability.

Doubled limb reconstructions were associated with significantly better Kujala scores and lower failures compared to single limb reconstructions [44]. There has been a lot of interest in utilizing synthetic material for performing an MPFL in recent times. Lee et al. compared Fiber Tape® and gracilis autograft MPFL reconstruction in a small cohort of 50 patients over 40 months. All studied parameters and score significantly improved in both patient groups with no difference between the two grafts. The authors believed that adoption of a synthetic material MPFL reconstruction would avoid autograft related donor site morbidity and associated complications [45]. The pediatric patient with recurrent patellar instability has been a focus of attention. An open femoral physis is an issue when planning drilling or disruption for an anatomic tunnel placement. Sillanpää et al. have described two techniques to avoid this basic problem. They described a double-bundle adductor Magnus transfer and an adductor sling approach using a free gracilis tendon graft [46]. Lind et al. analyzed the outcome of MPFL reconstruction using this adductor sling technique involving soft tissue femoral side fixation of the graft. With a 20% redislocation rate in the 1st year post-surgery itself, they believed that method has high failure rates as it non-anatomic and a soft tissue fixation would provide insufficient dynamic biomechanical stability [47]. Nelitz et al. have described their technique of pedicled superficial quadriceps tendon MPFL reconstruction which did not require patellar hardware and spared the femoral physis. There was no redislocation in their cohort and significant improvement in Kujala score at minimum 2 years follow-up. The Tegner activity score improved but not significantly [48]. When considering graft options alone, Hohn and Pandya found that gracilis allograft reconstruction in children and adolescents resulted in a low incidence of recurrent instability, comparable to published results using autografts [49]. The methods utilized for graft fixation in published literature include suture fixation, interference screws, suture anchors, staples, and suspensory cortical fixation devices. A technique without any hardware and good clinical outcome with no hardware related complications has also



Figure 1: The Schöttle point [19] located with a microfracture awl intraoperatively using fluoroscopic guidance. The point lies 1.3 mm anterior to the posterior cortex extension line, 2.5 mm distal to the posterior origin of the medial femoral condyle, and proximal to the level of the posterior point of the blumensaatline. A true lateral view with posterior condyles over-lapping is absolutely essential.

been described [50]. Joyner et al. performed a cadaveric study to ascertain the strength of various graft fixation combinations at the femur and patella. They found that a construct having suture anchor fixation at patella and suspensory cortical fixation at femur needed significantly lesser force to fail than the native MPFL. Graft fixation by a suspensory cortical device at the femur and interference screw in patella was the strongest construct [51]. In the absence of standard defined practice guidelines or high-quality evidence, the performance of an MPFL reconstruction is currently guided by surgeon preference and skills and factors like allograft availability.

Surgical Technique



Figure 2: Arthroscopic visualization of patella tracking laterally in the trochlea groove as seen from a high superomedial portal.

There are numerous techniques described in literature for MPFL reconstruction using all sorts of graft and fixation devices. However, the one element which must not change is adherence to anatomy and isometricity. The technique described below using a doubled gracilis tendon autograft has been used by the senior author routinely for over 13 years with good clinical outcomes and very low complication rates. The critical steps in this technique are:

1. Arthroscopic confirmation of mal-tracking: A pre-operative work of the patient by clinical examination and imaging studies will reveal patella mal-tracking and MPFL deficiency. However, arthroscopic visualization of the lateral patellar tracking can be seen arthroscopically as well. An arthroscopy also reveals the status of patellar cartilage and any osteochondral lesion, besides other intra-articular pathology. This visualization of lateral patellar tracking is best seen from a high superomedial portal using a 30° arthroscope and the knee in full extension (Fig. 2). The knee is gradually



Figure 3: The gracilis tendon is harvested from a vertical incision placed medial to the tibial tuberosity.

flexed and extended to see and document how the patella mal-tracks is lower flexion angles but occupies the TG in deeper flexion.

2. Graft harvest and preparation: Our preferred graft is the gracilis tendon autograft. Every arthroscopy surgeon is familiar with the technique of harvesting this graft. A doubled gracilis graft provides adequate strength to the construct as to replace the MPFL. Using an autograft also eliminates allograft related complications. A 3 cm long vertical incision is placed 2 cm medial to the TT. Full-thickness flaps are raised to expose the pes tendons. After palpating the tendon, a transverse incision is made in the Sartorius fascia at the level of the upper border of the pes. The gracilis tendon is delivered out with a pair of Mixer forceps. The tendon must be freed of all vinculae bands. The tendon is harvested using an open or closed stripper (Fig. 3). The free graft is cleaned to remove all



Figure 4: (a) Two 2.8 mm titanium suture anchors are inserted in the superomedial patella after creating pilot holes with a 2.4 mm drill tip passing pin. (b) The distance between the anchors is about 1 cm.

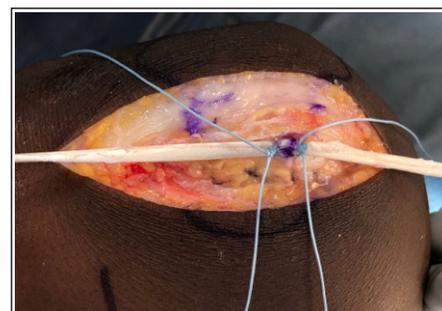


Figure 5: The central portion of the gracilis tendon is placed between the two sutures of each anchor and tied firmly. The Layer I fascia must be sutured over the tendon.



Figure 6: A 3 cm long longitudinal incision placed between the adductor tubercle and medial epicondyle to expose the sulcus between these two bony landmarks where the graft has to be inserted. Radiographic confirmation of this point is helpful to reduce tunnel mal-positioning.

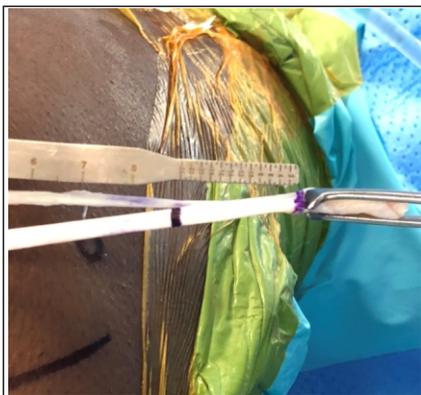


Figure 7: (a) The doubled gracilis tendon is measured up to the point of insertion and an extra 25 mm length of tendon is preserved. (b) This 25 mm length of tendon is sutured with a high strength suture material using baseball stitches and a loop made at the terminal end.

muscle and fat. The Sartorius fascia is repaired using Vicryl 0 suture.

3. Patellar fixation of graft: A 3 cm long vertical incision is taken along the superomedial border of the patella. Layer I is recognized and incised longitudinally to expose the patella. The implant of patellar fixation is two 2.8 mm Titanium suture anchors. The ventral border of patella where the transverse upper border curves to become vertical is marked. A 2.4 mm drill tip passing pin is used to drill two small holes about 1 cm apart. The two suture anchors are inserted into these pilot holes (Fig. 4a). The center of the gracilis tendon is marked and kept over the two anchors. The sutures from the anchors are used to tie the graft firmly (Fig. 4b). This gives us a double-bundle graft for reconstruction. A gentle tug of the tendon confirms the stability of the fixation. The fascia (Layer I) is sutured over the suture anchor and tendon. This method of patella fixation allows a wider area of graft attachment at the patella to mimic

a native MPFL and does not require any patella drilling or tunneling (Fig. 5).

4. Isolation of femoral graft attachment site: This is perhaps the single most important step which makes or breaks the reconstruction. A 3 cm longitudinal incision is made centered between the medial epicondyle and adductor tubercle. Layer I fascia is cut, and the sulcus between these two bony landmarks is located which is the anatomic and isometric point of MPFL insertion (Fig. 6). This is, however, not easy, especially in obese individuals. The use of intra-operative radiographic control to locate the Schottle's point on a true lateral view with both posterior condyles overlapping (Fig. 1) is a great aid as discussed previously.

5. Femoral fixation of graft: The preferred graft fixation method on the femoral side is a bioabsorbable interference screw. A 2.4 mm drill tip passing pin is drilled across the femur from the point isolated previously and confirmed on

image intensifier. This point has to be exact and not merely acceptable. A 4.5 mm drill bit is used to dilate the track over the passing pin across both cortices. The doubled gracilis graft is then brought up to this point and marked. An extra 25 mm length is taken, and the rest of the tendon is cut (Fig. 7a). This 25 mm length is what is intended to do into the femoral socket and is sutured with any high strength suture material using baseball stitches (Fig. 7b). This is important as the screw must sit on the suture and not the graft directly as this may lead to graft laceration and cut through. The doubled graft end is then sized, and this is usually 6 or 7 mm in diameter. A 6 or 7 mm endoscopic reamer is then drilled over the passing pin for a depth of 30 mm to create a socket. The graft is then passed from the patella to femoral site deep to Layer I fascia, as the native MPFL is a Layer II structure (Fig. 8). The guide wire for

chosen Bioscrew is inserted into the socket, and the graft end is then passed into the socket using a suture loop passed through the eyelet of the passing pin. The knee is brought to 300 flexions and traction applied to the graft by an assistant. A 6 or 7 mm diameter bio interference screw of 23 or 25 mm length is inserted to fix the graft (Fig. 9). While

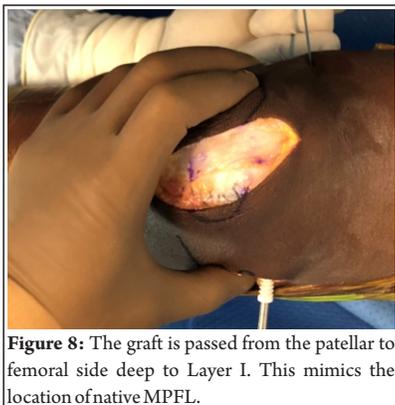


Figure 8: The graft is passed from the patella to femoral side deep to Layer I. This mimics the location of native MPFL.

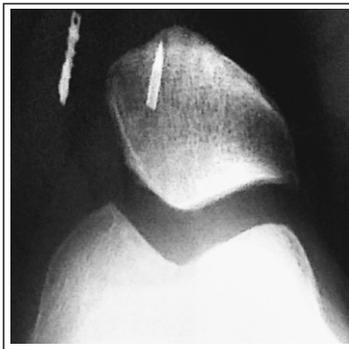


Figure 9: Fixation of the graft in the femur is done using a bioabsorbable interference screw in 300 knee flexion. The patella is held reduced in the center of trochlea to prevent over-tensioning of the graft.



Figure 10: A complication of this technique is back out of suture anchor from the patella.

doing this, over-tensioning must be avoided, and the patella is kept centered in the TG. Arthroscopic assistance to control this step is also worthwhile. Once the graft is fixed, proper tracking can be seen clinically or arthroscopically as previously described.

This technique is easily reproducible and has very low complication rates. Complications which have been encountered include infection, paresthesia at gracilis harvest site and anchor migration from patella (Fig. 10). Patella fracture risk is eliminated by this technique as there is no patella drilling or tunneling involved. Prevention of over tensioning will avoid loss of flexion in the early post-operative period, and medial side wears in longer follow-up.

References

- Fulkerson JP. Anteromedialization of the tibial tuberosity for patellofemoral malalignment. *ClinOrthopRelat Res* 1983;176:81.
- Roux C. The classic. Recurrent dislocation of the patella: Operative treatment. *ClinOrthopRelat Res* 1979;4:8.
- Hauser ED. Total tendon transplant for slipping patella: A new operation for recurrent dislocation of the patella 1938. *ClinOrthopRelat Res* 2006;452:7-16.
- Trillat A, Dejour H, Couette A. Diagnosis and treatment of recurrent dislocations of the patella. *Rev ChirOrthopReparatriceAppar Mot* 1964;50:813-24.
- Maquet P. Advancement of the tibial tuberosity. *ClinOrthopRelat Res* 1976;225:30.
- Marcacci M, Zaffagnini S, Iacono F, Visani A, Petitto A, Neri NP, et al. Results in the treatment of recurrent dislocation of the patella after 30 years' follow-up. *Knee Surg Sports TraumatolArthrosc* 1995;3:163-6.
- Hinckel BB, Arendt EA. Lateral retinaculum lengthening or release. *Oper Tech Sports Med* 2015;23:100-6.
- Chen SC, Ramanathan EB. The treatment of patellar instability by lateral release. *J Bone Joint Surg Br* 1984;66:344-8.
- Cosgarea AJ, Freedman JA, McFarland EG. Nonunion of the tibial tubercle shingle following fulkerson osteotomy. *Am J Knee Surg* 2001;14:51-4.
- Luhmann SJ, Fuhrhop S, O'Donnell JC, Gordon JE. Tibial fractures after tibial tubercle osteotomies for patellar instability: A comparison of three osteotomy configurations. *J Child Orthop* 2011;5:19-26.
- Payne J, Rimmke N, Schmitt LC, Flanigan DC, Magnussen RA. The incidence of complications of tibial tubercle osteotomy: A Systematic review. *Arthroscopy* 2015;31:1819-25.
- Dejour H, Walch G, Nove-Josserand L, Guier C. Factors of patellar instability: An anatomic radiographic study. *Knee Surg Sports TraumatolArthrosc* 1994;2:19-26.
- Cerciello S, Lustig S, Costanzo G, Neyret P. Medial retinaculum reefing for the treatment for patellar instability. *Knee Surg Sports TraumatolArthrosc* 2014;22:2505-12.
- Coons DA, Barber FA. Thermal medial retinaculum shrinkage and lateral release for the treatment of recurrent patellar instability. *Arthroscopy* 2006;22:166-71.
- Zhao J, Huangfu X, He Y. The role of medial retinaculum plication versus medial patellofemoral ligament reconstruction in combined procedures for recurrent patellar instability in adults. *Am J Sports Med* 2012;40:1355-64.
- Warren LF, Marshall JL. The supporting structures and layers on the medial side of the knee: An anatomical analysis. *J Bone Joint Surg Am* 1979;61:56-62.
- Feller JA, Feagin JA Jr, Garrett WE Jr. The medial patellofemoral ligament revisited: An anatomical study. *Knee Surg Sports TraumatolArthrosc* 1993;1:184-6.
- Zaffagnini S, Grassi A, MarcheggianiMuccioli GM, Luetzow WF, Vaccari V, Benzi A, et al. Medial patellofemoral ligament (MPFL) reconstruction for patellar instability. *Knee Surg Sports TraumatolArthrosc* 2014;22:2491-8.
- Schöttle PB, Schmeling A, Rosenstiel N, Weiler A. Radiographic landmarks for femoral tunnel placement in medial patellofemoral ligament reconstruction. *Am J Sports Med* 2007;35:801-4.
- Stephen JM, Lumpaopong P, Deehan DJ, Kader D, Amis AA. The medial patellofemoral ligament: Location of femoral attachment and length change patterns resulting from anatomic and nonanatomic attachments. *Am J Sports Med* 2012;40:1871-9.
- Tanaka MJ, Voss A, Fulkerson JP. The anatomic midpoint of the attachment of the medial patellofemoral complex. *J Bone Joint Surg Am* 2016;98:1199-205.
- Conlan T, Garth WP Jr, Lemons JE. Evaluation of the medial soft-tissue restraints of the extensor mechanism of the knee. *J Bone Joint Surg Am* 1993;75:682-93.
- Hautamaa PV, Fithian DC, Kaufman KR, Daniel DM, Pohlmeier AM. Medial soft tissue restraints in lateral patellar instability and repair. *ClinOrthopRelat Res* 1998;359:174-82.
- Sillanpää P, Mattila VM, Iivonen T, Visuri T, Pihlajamäki H. Incidence and risk factors of acute traumatic primary patellar dislocation. *Med Sci Sports Exerc* 2008;40:606-11.
- Amis AA, Firer P, Mountney J, Senavongse W, Thomas NP. Anatomy and biomechanics of the medial patellofemoral ligament. *Knee* 2003;10:215-20.
- Mountney J, Senavongse W, Amis AA, Thomas NP. Tensile strength of the medial patellofemoral ligament before and after repair or reconstruction. *J Bone Joint Surg Br* 2005;87:36-40.
- Hinckel BB, Gobbi RG, Demange MK, Pereira CAM, Pécora JR, Natalino RJM, et al. Medial patellofemoral ligament, medial patellofemoral ligament, and medial patellomeniscal ligament: Anatomic, histologic, radiographic, and biomechanical study. *Arthroscopy* 2017;33:1862-73.
- Weber AE, Nathani A, Dines JS, Allen AA, Shubin-Stein BE, Arendt EA, et al. An algorithmic approach to the management of recurrent lateral patellar dislocation. *J Bone Joint Surg Am* 2016;98:417-27.
- McNeilan RJ, Everhart JS, Mescher PK, Abouljoud M, Magnussen RA, Flanigan DC. Graft choice in isolated medial patellofemoral ligament reconstruction: a systematic review with meta-analysis of rates of recurrent instability and patient-reported outcomes for autograft, allograft, and synthetic options. *Arthroscopy* 2018;34:177-85.
- Elias JJ, Cosgarea AJ. Technical errors during medial patellofemoral ligament reconstruction could overload medial patellofemoral cartilage: A computational analysis. *Am J Sports Med* 2006;34:1478-85.
- Smirk C, Morris H. The anatomy and reconstruction of the medial patellofemoral ligament. *Knee* 2003;10:221-7.
- Redler LH, Meyers KN, Brady JM, Dennis ER, Nguyen JT, Stein BE. Anisometry of medial patellofemoral ligament reconstruction in the setting of increased tibial tubercle-trochlear groove distance and patella alta. *Arthroscopy* 2018;34:502-10.
- Tuxøe JI, Teir M, Winge S, Nielsen PL. The medial patellofemoral ligament: A dissection study. *Knee Surg Sports TraumatolArthrosc* 2002;10:138-40.
- LaPrade RF, Engebretsen AH, Ly TV, Johansen S, Wentorf FA, Engebretsen L, et al. The anatomy of the medial part of the knee. *J Bone Joint Surg Am* 2007;89:2000-10.
- Philippot R, Chouteau J, Wegrzyn J, Testa R, Fessy MH, Moyen B, et al. Medial patellofemoral ligament anatomy: Implications for its surgical reconstruction. *Knee Surg Sports TraumatolArthrosc* 2009;17:475-9.

Conclusions

There are multiple surgical techniques that have been described for reconstruction of the MPFL, and not all of them are devoid of any complications. As the surgeons' armamentarium to tackle this biomechanically challenging reconstructive procedure continues to expand along with the advancements in biomechanics and technology, there is an increased need to stay vigilant about the possible pitfalls and complications. Nevertheless, the reconstruction of the MPFL with or without skeletal realignment procedures has changed the management options for recurrent patellar instability with encouraging optimal outcomes for the patient.

36. Baldwin JL. The anatomy of the medial patellofemoral ligament. *Am J Sports Med* 2009;37:2355-61.
37. Steensen RN, Dopirak RM, McDonald WG. The anatomy and isometry of the medial patellofemoral ligament. *Am J Sports Med* 2004;32:1509-13.
38. Barnett AJ, Howells NR, Burston BJ, Ansari A, Clark D, Eldridge JD, et al. Radiographic landmarks for tunnel placement in reconstruction of the medial patellofemoral ligament. *Knee Surg Sports Traumatol Arthrosc* 2012;20:2380-4.
39. Balcarek P, Walde TA. Accuracy of femoral tunnel placement in medial patellofemoral ligament reconstruction: The effect of a nearly true-lateral fluoroscopic view. *Am J Sports Med* 2015;43:2228-32.
40. Huston KL, Okoroafor UC, Kaar SG, Wentt CL, Saluan P, Farrow LD. Evaluation of the schottle technique in the pediatric knee. *Orthop J Sports Med* 2017;5:2325967117740078.
41. Hiemstra LA, Kerslake S, Lafave M. Medial patellofemoral ligament reconstruction femoral tunnel accuracy: Relationship to disease-specific quality of life. *Orthop J Sports Med* 2017;5:2325967116687749.
42. Sanchis-Alfonso V, Ramirez-Fuentes C, Montesinos-Berry E, Aparisi-Rodriguez F, Marti-Bonmati L. Does radiographic location ensure precise anatomic location of the femoral fixation site in medial patellofemoral ligament surgery? *Knee Surg Sports Traumatol Arthrosc* 2016;24:2838-44.
43. Ziegler CG, Fulkerson JP, Edgar C. Radiographic reference points are inaccurate with and without a true lateral radiograph: The importance of anatomy in medial patellofemoral ligament reconstruction. *Am J Sports Med* 2016;44:133-42.
44. Weinberger JM, Fabricant PD, Taylor SA, Mei JY, Jones KJ. Influence of graft source and configuration on revision rate and patient-reported outcomes after MPFL reconstruction: A systematic review and meta-analysis. *Knee Surg Sports Traumatol Arthrosc* 2017;25:2511-9.
45. Lee PYF, Golding D, Rozewicz S, Chandratreya A. Modern synthetic material is a safe and effective alternative for medial patellofemoral ligament reconstruction. *Knee Surg Sports Traumatol Arthrosc* 2017;???:???
46. Sillanpää PJ, Mäenpää HM, Arendt EA. Treatment of lateral patella dislocation in the skeletally immature athlete. *Oper Tech Sports Med* 2010;18:83-92.
47. Lind M, Enderlein D, Nielsen T, Christiansen SE, Faunø P. Clinical outcome after reconstruction of the medial patellofemoral ligament in paediatric patients with recurrent patella instability. *Knee Surg Sports Traumatol Arthrosc* 2016;24:666-71.
48. Nelitz M, Dreyhaupt J, Williams SR. Anatomic reconstruction of the medial patellofemoral ligament in children and adolescents using a pedicled quadriceps tendon graft shows favourable results at a minimum of 2-year follow-up. *Knee Surg Sports Traumatol Arthrosc* 2017;???:???
49. Hohn E, Pandya NK. Does the utilization of allograft tissue in medial patellofemoral ligament reconstruction in pediatric and adolescent patients restore patellar stability? *Clin Orthop Related Res* 2016;475:1563-9.
50. vonEngelhardt LV, Fuchs T, Weskamp P, Jerosch J. Effective patellofemoral joint stabilization and low complication rates using a hardware-free MPFL reconstruction technique with an intra-operative adjustment of the graft tension. *Knee Surg Sports Traumatol Arthrosc* 2017;???:???
51. Joyner PW, Bruce J, Roth TS, Mills FB 4th, Winnier S, Hess R, et al. Biomechanical tensile strength analysis for medial patellofemoral ligament reconstruction. *Knee* 2017;24:965-76.

Conflict of Interest: NIL
Source of Support: NIL

How to Cite this Article

Shekhar A, Patil S, Tapasvi S. Medial Patellofemoral Ligament Reconstruction- State of the Art. *Asian Journal of Arthroscopy* Jan-April 2018;3(2):17-23..