Original Article

"Basket weave technique" for medial patellofemoral ligament reconstruction

Clinical outcome of a prospective study

Pranjal S Kodkani[1,2]

Abstract

Background: Bone tunneling and implants with rigid fixations for medial patellofemoral ligament (MPFL) reconstruction are known to compromise results and are avoidable, especially in skeletally immature subjects. This study was to assess if these deficiencies were overcome with the technique devised by the author which avoids implants and bone tunnels. Results were assessed for complication rate and outcome.

Materials and Methods: Fifty six knees of recurrent lateral patellar dislocation were treated in the past 49 months by MPFL reconstruction. Thirty nine were female and 17 male knees. The mean age was 20.6 years (range 9-48 years). Mean followup was 26 months. Five knees had previously failed stabilization procedures. Thirty one cases had Dejours Type A or B and 12 had Type C trochlear dysplasia. Arthroscopy was performed for associated injuries and loose bodies. Seven knees required loose body removal. Five knees underwent lateral retinacular release. Four knees had tibial tuberosity transfer. One knee had an associated anterior cruciate ligament reconstruction. An anatomical MPFL reconstruction was performed using hamstring autograft without the need for intraoperative fluoroscopy. Only soft tissue fixation was necessary with this newly devised technique and suturing. A rapid rehabilitation protocol was implemented with monthly followup until normalcy and 6 monthly thereafter.

Results: All achieved full range of motion and normal mediolateral stability. There was no recurrence of dislocation. No major surgery related complications. One patella fracture at 8 months was due to a fall developed terminal restriction of flexion. Those in sports could return to their sporting activities (Tegner 1–9). Cases with osteochondral fractures had occasional pain that subsided in 1 year. Mean Kujala score improved from 64.3 to 99.69 with KOOS score near normal in all.

Conclusion: This new method of MPFL reconstruction gives excellent results. It avoids complications related to bone tunneling and implants. It is a safe, effective, reliable and reproducible technique.

Key words: Basket weave technique, ligament reconstruction, medial patellofemoral ligament, MPFL, patellar dislocation, patellar instability

MeSH terms: Patella, Patellar dislocation, ligaments, instability, joint

Introduction

Medial patellofemoral ligament (MPFL) reconstruction has been one of the procedures indicated for management of recurrent lateral dislocation of the patella. A number of methods of reconstruction have evolved over a short period.[1-25] A majority of described techniques use either implants or bone tunnels for fixation of the MPFL graft. It has now been widely accepted that the reconstruction needs to be anatomical, both at the femoral and patellar insertion sites.

A number of studies have confirmed the anatomy of MPFL and its relation to the bony landmarks of the femur

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Access this article online	
Quick Response Code:	Website: www.ijoonline.com
	DOI: 10.4103/0019-5413.173520

How to cite this article: Kodkani PS. "Basket weave technique" for medial patellofemoral ligament reconstruction: Clinical outcome of a prospective study. Indian J Orthop 2016;50:34-42.

and patella. The MPFL has a soft tissue attachment on the femoral condyle on an average 1.9 mm anterior and 3.8 mm distal to adductor tubercle, anterior to the region in between the medial epicondyle and adductor tubercle.[26] On the patellar side, it has a broad attachment extending right from the superior pole of the patella extending inferiorly to almost 50–60% of its medial border. The ligament therefore runs underneath the lower margin of the vastus medialis obliquus in the second layer of medial retinaculum with the superior fibers fanned out to have a soft tissue attachment onto the vastus intermedius.[27] This anatomy cannot be reconstructed using patellar bone tunnels.

With the patellar insertion extending high near the superior pole of the patella (soft tissue insertion of the MPFL into the vastus intermedius and not a bony insertion), none of the techniques described with bone tunnels would precisely replicate the anatomical insertion points with a reconstruction. Bone tunnels can cause further tissue trauma and increase the risk of patella fracture.[28-32] These cannot be implemented in the skeletally immature, hypoplastic patellae or cases where a patella arthroplasty has been performed. Implant related complications add to the morbidity. Implant fixation also forms a very rigid construct increasing medial patellar compression forces.[33] These have been known to result in early patellofemoral arthrosis due to increased contact pressure. Rare cases of over constraint or mal positioning of rigid fixation points have even resulted in medial instability[34] of the patella since the rigid fixations are less forgiving. A soft tissue fixation to the extensor retinaculum over the patella can be more forgiving. Other complications such as limitation of range of motion,[35] arthrofibrosis,[36] graft loosening,[37] early hemarthrosis,[38,39] and painful and prominent implants[5] have been reported.

On the femoral insertion point, similar methods have been devised to make a bone tunnel at the anatomical site and use screw fixation. These bone tunnels however are not advisable in skeletally immature patients as it is close to the physis. Also, bone tunnels cause additional tissue injury by avulsing remnants of the MPFL at its insertion and bone trauma. Implant related complications are also known to occur,[5] and the fixation is nonforgiving and rigid, leading to overloading of the medial patellofemoral joint even due to minor errors.[33] These have given compromised results, either due to the limitation of motion,[35] failure to achieve normal patellofemoral mobility or even pain. Soft tissue fixations on the femoral side using the adductor magnus[39,40] or the medial collateral ligament[18] for the sling are nonanatomical. Similarly, using the adductor magnus itself is also a nonanatomical construct.[41,42] These nonanatomical constructs cannot reproduce normal patellofemoral mobility and stability, thus compromising results with a lower score.

In order to overcome these pitfalls of the current techniques, a new "Basket weave"[43] reconstruction technique was developed. This method utilizes a soft tissue method of fixation on the femoral side using bony landmarks, thus avoiding complications related to bone tunneling and implants. Also, it results in a more normal pliable construct compared to a rigid construct with implants which is important for normal patellar mobility.

Thus by avoiding implants and bone tunnels, we aimed to have lesser complications. By being more precise in the anatomical reconstruction, we aimed to achieve optimal results with a high patient satisfaction. The study was conducted to confirm if comparable or even better results than those documented in literature could be achieved implementing this implantless and bone tunnel-free technique with a low complication rate.

Materials and Methods

Fifty-six knees (50 patients) were treated with MPFL reconstruction using "Basket weave" technique in the past 49 months. There were thirty nine female and 17 male knees. Eleven cases had bilateral patellar dislocations, of which 6 patients (2 males, 4 females) underwent MPFL reconstruction for both knees. Five knees were revision cases with previously performed medial retinacular reefing with or without lateral release. The mean preoperative Kujala score was 64.3. Preoperative and postoperative KOOS scoring was done for all patients. The inclusion and exclusion criteria were laid before the study. A private ethics committee approval and written informed consent of all patients were obtained for the study. The cases included were those with lateral patellar instability having recurrent lateral patellar dislocation or first time dislocators with associated nonrepairable osteochondral fracture fragment with a clinically dislocatable patella. The nonrepairable fragments were excised arthroscopically. Those with a repairable osteochondral fragment from the patella underwent a medial arthrotomy with fixation of the fragment followed by repair of the medial arthrotomy by a medial retinacular advancement without MPFL reconstruction. The mediolateral stability was confirmed postoperatively. These cases were therefore excluded from the study. All patients selected for MPFL reconstruction had an apprehension test positive for lateral instability. MPFL reconstruction was undertaken only after all knees achieved a full normal range of motion with an adequate period of appropriate preoperative rehabilitation. The meantime interval for MPFL reconstruction from the first dislocation was 1 year (range 2 weeks - 3 years) knees that were asymptomatic following rehabilitation did not undergo MPFL reconstruction. Only those presenting

with symptomatic patellar instability (dislocatable or subluxating) were subjected to MPFL reconstruction. Cases with a failed previous stabilization procedure were also included. Exclusion criteria included cases of habitual patellar dislocation, chronic irreducible patella dislocation and severe patellofemoral arthrosis. Those undergoing trochleoplasty were not subjected to MPFL reconstruction at the same stage.

Investigations included plain radiography of the knee including anteroposterior and lateral views of both knees in standing. Those with valgus alignment of knee beyond normal were subjected to an alignment view X-ray of full lower limb in standing. Nineteen knees had a mean mechanical axis valgus of 5° (range 3°-7°). MRI was done in all cases to assess integrity of MPFL, presence of osteochondral fragments, trochlear dysplasia, patellofemoral articulation and associated injuries if any. Superimposition computed tomography (CT) scan was done in cases where clinical assessment suggested torsion malalignment of the femur or tibia and those having an abnormal "Q" angle (for TT-TG distance). Those with suspected Dejours[44] Type C and D trochlea had a three-dimensional CT reconstruction of the lower end femur to assess the trochlear geometry.

Based on the clinical and radiological correlation, these cases were subjected to either isolated MPFL reconstruction or performed along with an adjunctive procedure considered necessary for the management of the instability. Among the adjunctive procedures performed were loose body removals, limited lateral retinacular release (release of lateral patellofemoral ligament without release of patellomeniscal ligament), tibial tuberosity transfer and anterior cruciate ligament (ACL) reconstruction.

All loose bodies that were long standing with rounded edges or those partially resorbed with the patellar defect showing a healed lesion were excised arthroscopically. Also, fresh fragments having a size of 1 cm^2 or smaller were excised. Only knees with a tight lateral retinaculum with less than quarter patellar breadth medial mobility and a negative lateral lift off underwent a limited lateral retinacular release of the lateral patellofemoral ligament. Four knees with TT-TG distance more than 20 mm were subjected to a tibial tuberosity medialization prior to MPFL reconstruction during the surgery. One knee having a concomitant ACL injury underwent an ACL reconstruction [Table 1]. Rest of knees underwent an isolated MPFL reconstruction.

Surgery was performed either under general anesthesia with a postoperative femoral block or under spinal anesthesia. All knees were subjected to an arthroscopic assessment prior to the reconstruction.

Table 1: Associated pathologies and procedures along with MPFL reconstruction

Associated pathology	Associated procedure	Number of knees
Osteochondral fragments/ chondromalacia	Loose body removal/ chondroplasty	18
Trochlear dysplasia (type A/B/C)	Not addressed	12
Tight lateral retinaculum	Lateral retinacular release	5
Increased TT-TG distance (>20 mm)	Tibial tuberosity transfer (medialization)	4
ACL tear	ACL reconstruction	1

MPFL=Medial patellofemoral ligament, ACL=Anterior cruciate ligament

The "Basket weave" technique

The graft of choice is the ipsilateral gracilis with a minimum length of 210 mm. The semitendinosus was used in the nonathletic, female population or if gracilis length was insufficient. The graft is held with No. 2 Ethibond (Ethicon, Johnson and Johnson) cinch knots on either end and is pretensioned over a graft preparation board prior to the reconstruction.

A 2 cm long medial patellar skin incision was taken. The medial retinaculum was identified and incised along the medial patellar border to expose the second layer of the retinaculum [Figure 1]. If the MPFL could be identified, its lower margin was defined to confirm its extent of insertion. A plane was achieved between the first and this second layer of the retinaculum from the medial patellar border to the femoral insertion point using scissors and a "tissue elevator-suture passer" © designed by the author [Figure 2]. Performing the reconstruction in this plane avoids detachment of the original MPFL that otherwise requires to be incised if the reconstruction is to be carried out deeper to this second layer.

A 1 cm skin incision was made in the region overlying the medial epicondyle and adductor tubercle. These bony landmarks were well palpable keeping the knee in 90° flexion. Palpation commenced from the adductor magnus to the first bony bump of adductor tubercle followed by the second bony prominence of the medial epicondyle. On exposure of the medial retinaculum in this region, a sharp 1 cm long incision was made up to the bone extending from the anterior margin of the medial epicondyle to the anterior margin of the adductor tubercle. The saddle shaped groove between the two bony prominences were covered by a ligamento-periosteal tissue formed by the confluence of insertion of the medial collateral ligament, medial retinaculum with the MPFL and the adductor magnus. A centimeter broad, strong sleeve of this ligamento-periosteal tissue was elevated from this saddle groove [Figure 3].

The graft is looped up to its center underneath this ligamento-periosteal sleeve. The two limbs of the graft were

then shuttled through the plane between the first and second layer of the retinaculum to be delivered through the medial parapatellar incision. The graft was sutured to this sleeve to achieve the femoral fixation. The retinacular incision at the site was sutured back over it.

The two limbs of the graft were then planned for fixation such that the proximal limb was at the superior pole. This proximal limb was fixed to the extensor retinaculum at the level of proximal extent of the native MPFL. These were the MPFL fibers that insert into the vastus intermedius at the superior pole of patella (this is a soft tissue insertion and not a bony insertion on the patella). The distal limb was fixed at the level of lower extent of the original MPFL. If this extent was not clear, then it was attached at the middle level of the medial patellar margin.

To achieve a robust soft tissue fixation on the patella, sleeves of extensor retinaculum on the anterior aspect of the patella were elevated. For this, sharp vertical incisions up to the bone were made at one centimeter intervals. Alternate strips of the retinaculum are elevated using a 15 number knife passed flush parallel to the anterior bony surface of the patella and then elevated using the "tissue elevator-suture passer"©. Thus, the graft was passed alternately below and above the extensor retinaculum sleeves on the anterior aspect of the patella. The sleeves elevated for the proximal and distal limb of the graft were also elevated alternately so that they did not coalesce together. This method of passage of proximal and distal limb of the graft through the extensor retinaculum is in a "Basket weave" pattern [Figure 4].

Simple suturing of the graft to the sleeves might not be adequate, as it might cut through or might result in too many knots on the anterior surface. To avoid this issue, a special "pretzel stitch" [Figure 5a-d] was designed for fixing the graft to each of the sleeves. This stitch cinched the sleeve around the graft and simultaneously transfixes the graft to the sleeve thus giving a firm fixation to the sleeves. These "pretzel stitches" are taken at each sleeve level where the graft passes above or below them. Each level of suturing beyond the first suture provides a backup fixation for the previous thus reinforcing the fixation. A total of three or four fixation sutures were ensured for each limb of the graft [Figure 6].

Figure 1: Peroperative photograph showing first layer of medial retinaculum lifted from second layer

Figure 2: Photograph of tissue elevator-suture passer

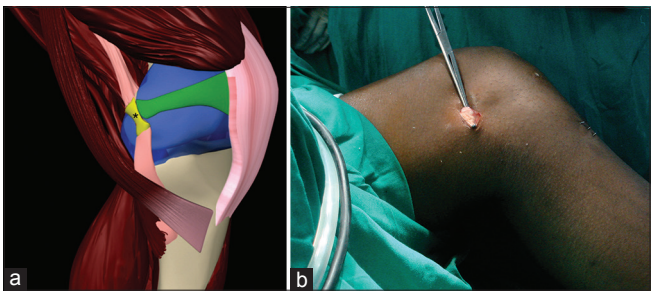


Figure 3: Schematic diagram and (b) clinical photograph of knee showing Ligamento-periosteal sleeve (*) in yellow

Figure 4: Clinical photograph showing "Basket weave" pattern of graft fixation on patella

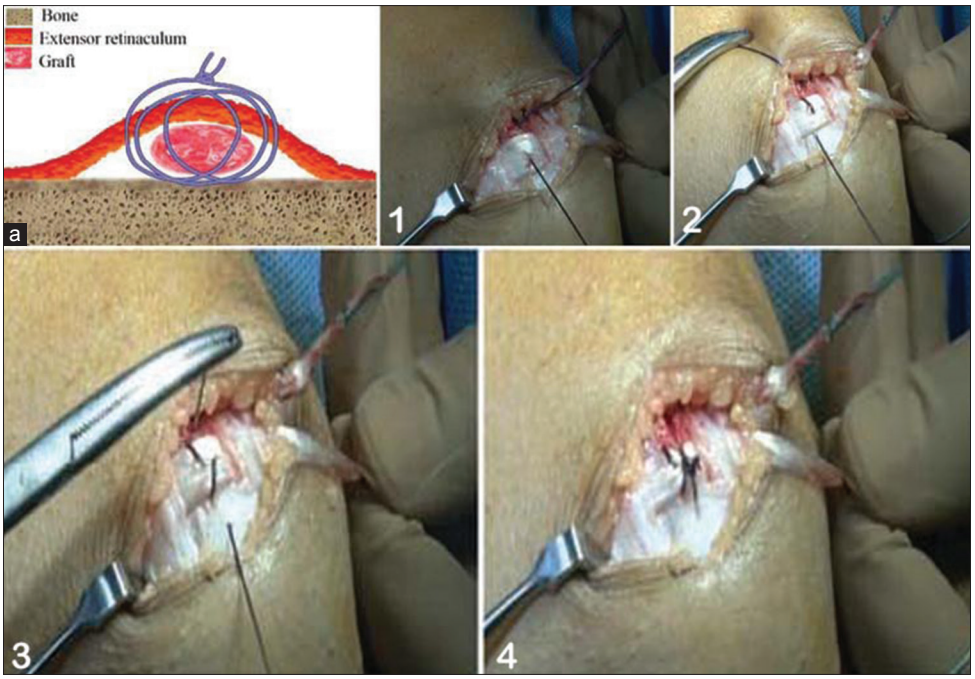


Figure 5: (a) "Pretzel stitch" (diagrammatic) in cross section. Peroperative photographs (1-4) showing steps of technique

The proximal limb of the graft was sutured to these sleeves of the retinaculum keeping the graft taut, patella centered and the knee in 30° flexion. A large majority of the patients had an associated trochlear dysplasia. Thirty-one knees had Dejours Type A or B and 12 had Type C trochlea. In presence of trochlear dysplasia, the bony stability to the patella beyond 30° flexion is compromised therefore the distal limb is fixed by suturing it with the knee in 90° flexion. This differential fixation ensures stability and normal mobility of the patella throughout the range of motion. All knees irrespective of the status of trochlear dysplasia underwent this differential method of graft fixation.

The first incised layer of retinaculum was then sutured back to the medial margin of the patella on its anterior aspect to eliminate the slack in the retinaculum. This suturing was done keeping the knee in 30° of flexion thus completing the procedure. Postoperative arthroscopic view shows that the reconstruction and fixation are extracapsular and anatomical extending from the region between the medial epicondyle and adductor tubercle to the upper half of the medial margin of patella [Figure 7].

Postoperative rehabilitation

The knee was immobilized in 30° flexion in a rigid long knee brace for 2 weeks with the limb with toe touch weight bearing. Active range of motion and quadriceps toning exercises are started following suture removal (10–14 days). The brace was discarded after 6 weeks or once the patient regains strength and good quadriceps control. One expects

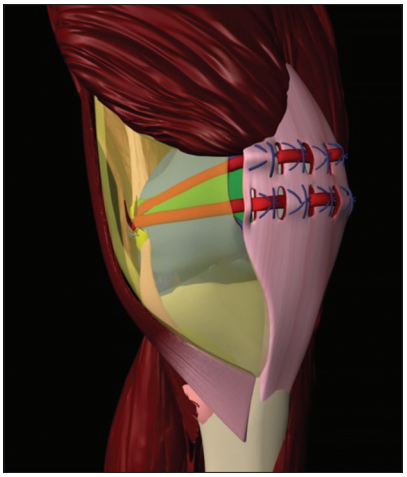


Figure 6: Schematic diagram showing final medial patellofemoral ligament construct

to regain full range of motion by 2–3 months postoperatively. Following this foot, ankle, hip and core stabilization exercises were initiated. Balance and proprioception training could be followed by resumption of sports at 4 months.

Results

The mean followup was of 26 months (range 7 months - 4 years). Mean age was 20.6 years (range 9–48 years). Cases were assessed at 1 month intervals until one achieved full range of motion, followed by 3 monthly assessments until they achieved normal function of the knee. Eleven cases had bilateral patellar instability of which 6 required bilateral MPFL reconstruction. Remainder 5 did

not fit our inclusion criteria for MPFL reconstruction for the second knee as they recovered well with appropriate rehabilitation. Those who underwent bilateral MPFL reconstruction had the full normal function of the first knee followed by surgery for second knee.

Two knees with patellar osteochondral fragments had minimal anterior knee pain following running, jumping and squatting for an average of 1 year following which the pain resolved, and they could get back to full normal sporting activities. Sixteen knees had Grade 2 or 3 chondral changes on the medial patellar facet or lateral trochlea. They recovered well without any residual pain.

Three female patients from the study group were found to be apprehensive to pain with the rehabilitation protocol and regained full flexion with normal function at 5–6 months postoperatively as compared to 3 months on an average for remainder cases. Those operated bilaterally showed a more rapid recovery in the second knee with respect to the range of motion and resumption of activities as compared to the first knee. Four knees had vastus medialis wasting as compared to the contralateral normal knee at their final followup. These had a reduced average Kujala score of 98.

Knees having associated trochlear dysplasia also recovered well without symptoms of instability. Five knees had a failed previous procedure of lateral release and medial plication. These had failed on an average of 4 years postoperatively. Their mean KOOS score was near normal following the MPFL reconstruction with return to all normal activities without any recurrence of instability.

One case had a fall from stairs, 8 months following the MPFL reconstruction. She suffered a transverse fracture of the patella. This was fixed with Kirschner wires and tension band wiring. Intraoperatively, the MPFL reconstruction construct was found intact despite the patella fracture [Figure 8]. It was evident from this example that this MPFL reconstruction was a sturdy and reliable construct. One could perform the fracture fixation without any impedance from the previously performed surgery. She however had restriction of motion up to 110° at the last followup 1 year after the fracture fixation. However, there was no difficulty in running or jumping activity. There was thigh atrophy with only occasional pain on exertion. Her Kujala score was 91 at last followup of 1 year.

The remainder cases had normal, symptom free, painless function with near 100 points (KOOS) at their final followup in all parameters [Figure 9]. Those into sporting activity, without any quadriceps wasting could resume back to preinjury level of sports in 4–5 months. They could return to all activities of daily living with normal quality of life. Cases with unilateral dislocations could get a sense of normalcy as compared to the contralateral knee and expressed a subjective feeling of the knee being as good as the opposite normal knee. There was no case with recurrence of dislocation following MPFL reconstruction.

The mean Kujala score for these 56 knees improved to 99.69 from a preoperative value of 64.3. The mean KOOS

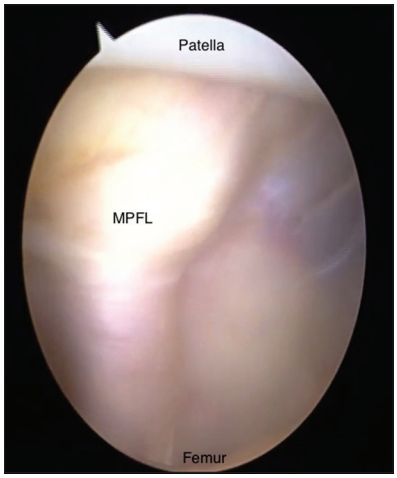
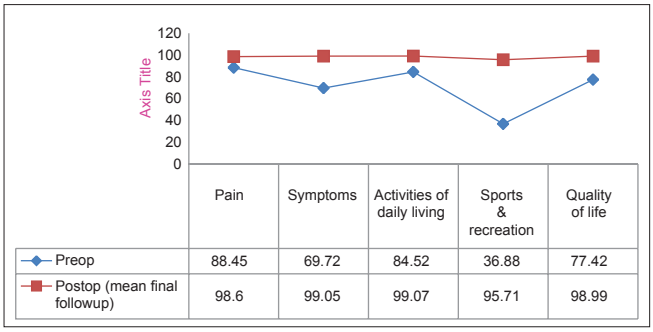


Figure 7: Arthroscopic view showing medial patellofemoral ligament – Extracapsular and anatomic

Figure 8: Intraoperative photograph of 8 months postoperative fracture patella showing good incorporation of graft and the intact medial patellofemoral ligament graft construct



	Pain	Symptoms	Activities of daily living	Sports & recreation	Quality of life
Preop	88.45	69.72	84.52	36.88	77.42
Postop (mean final followup)	98.6	99.05	99.07	95.71	98.99

Figure 9: A chart cum table showing KOOS score

scoring was near normal (near 100 in all parameters) for all except the case with patella fracture.

No complications were found with regards to growth plate disturbance or loss of stability or motion in the 21 skeletally immature patients (age range 9–19 years). Since there are no implants or bone tunnels in this technique, their related complications were completely averted.

Discussion

This technique with soft tissue fixation on the patellar and femoral site has given good results. It is more forgiving and does not result in an over constraint of the patellofemoral joint or limitation of flexion unlike rigid fixation methods. It also avoids complications related to bone tunnels and implants. Rigid fixation methods on the patellar side are nonanatomical and therefore may not restore normal physiometricity and biomechanics of the patellofemoral joint.

A radiological landmark for insertion point of MPFL on femur has been described by Schöttle *et al*.[45] However, it is important to go into the details of this article and to note that one of the eight MPFL insertions studied was in fact found to be posterior to the posterior line of Schottles "area." The point suggested by the author is just an average of all the points in the 8 cadaveric knees studied. The "Schottle point" therefore does not give us the precise radiological point of insertion of MPFL on the femur for all cases. Moreover in the skeletally immature knee, this radiographic marking cannot be followed as it has been shown to be incorrect for these knees. Following this radiological point to guide ones, surgical reconstruction may often result in an erroneous nonanatomical reconstruction with compromised results.

We therefore decided to eliminate the use of this radiological marker for our MPFL reconstructions and preferred to use the more reliable method of anatomic landmarks. The MPFL just as any other ligament attachments shows consistent attachment in relation to bony prominences. It is well documented that the MPFL attaches on the femur just anterior to the region between the adductor tubercle and the medial epicondyle.[26] These palpable bony prominences were used as landmarks for precise anatomic surgical reconstruction and to avoid the errors of using an imprecise radiological marker. Since the femoral attachment is crucial for the anatomical reconstruction, this more reliable method of using the medial epicondyle and adductor tubercle as the guide for reconstruction reduced errors and avoided unnecessary fluoroscopy. This possibly resulted in more effective, reliable and reproducible results.

Careful palpation of bony landmarks and elevation of ligamento-periosteal sleeves, extensor sleeves over the patella can avoid intraoperative errors. Graft fixation with "pretzel stitches" gives a good fixation. With adequate precautions and precisely following all the steps of the procedure, one can ensure optimal results.

No technique related complications were encountered in cases operated with this method of reconstruction. This "Basket weave technique" of MPFL reconstruction has a number of advantages over other techniques. (a) No implants are used in the surgery. The entire procedure is carried out using only suturing techniques. No bone tunnels are made either in the femur or in the patella. It therefore avoids bone tunnels and implant related complications and physeal disruption (b) The technique avoids the use of intraoperative fluoroscopy and relies on bony landmarks for fixation points. It therefore gives a precise anatomical reconstruction, being a more precise anatomical construct it possibly gives more reliable results (c) It does not disrupt the capsule or any other structures around the joint as in the all arthroscopic techniques described. It is therefore more biological, tissue preserving, minimally invasive and less traumatic procedure (d) The soft tissue fixation is a firm but less rigid construct than tunnel fixations and therefore prevents erroneous over constraint of the medial patellar forces. The postoperative examination therefore demonstrates a normal mediolateral mobility with a normal soft endpoint with a high patient satisfaction scores in their followup. (e) It avoids the risk of patellar fracture following bone tunneling. (f) The procedure can be utilized for the skeletally immature cases, those with hypoplastic patellae or even for cases with patellar arthroplasty. (g) Since there are no bone tunnels, a revision surgery if ever necessary would not be complicated as a result of this primary procedure. (h) The procedure is also economical since it avoids the use of expensive implants.

The limitations of this study were that it was not a randomized, comparative or blinded study, a small sample size, and a single operating surgeon. However, the aim

Table 2: Comparative results of MPFL reconstructions in literature

Author	Number of knees	Mean followup	Kujala score
Christiansen *et al*.[30]	44	22 months	88
Thaunat and Erasmus[35]	20	27.6 months	93
Steiner *et al*.[37]	34	66.5 months	90.7
Sillanpää *et al*.[41]	15	10.1 year	88
Ronga *et al*.[46]	28	3.1 year	94.3
Ahmad *et al*.[47]	20	31 months	88
Goyal[25]	32	38 months	91.25
Schöttle *et al*.[45]	12	47 months	85.7
Nomura and Inoue[50]	12	4.2 years	96

MPFL=Medial patellofemoral ligament

of the study was to assess the efficacy of this technique of MPFL reconstruction for its rate of complications and compare the results to other series currently reported in literature. A majority of the procedures described for MPFL reconstruction have shown good results with Kujala scores ranging from 83 to 96. This study has shown a higher postoperative Kujala score of 99.69. If the case with patellar fracture is excluded from the study, the average Kujala score would be 99.85 which is higher than any of the other reported series[25,30,35,37,40,41,46-51] [Table 2]. This technique has a number of advantages over the other currently described techniques in literature. It also has a broader applicability since there are no limitations due to patient age, bone structure or arthroplasty.

We conclude that an implantless, tunnel-free MPFL reconstruction using this technique could reduce complications, simplify the procedure and give optimal outcomes. Therefore, this is possibly a well suited option for an MPFL reconstruction where indicated.

Acknowledgment

Majority of the cases in this series were referrals from Dr. Anant Joshi. I am thankful to him.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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