Basket-Weave Technique for Medial Patellofemoral Ligament Reconstruction
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Abstract: The anatomy of the medial patellofemoral ligament (MPFL) has been well defined, with parts of its uppermost fibers having a soft-tissue insertion onto the vastus intermedius. Bone tunnels and implants on the patellar side therefore cannot replicate this anatomic construct precisely. Because of implants and tunnels, complications have been reported with bone tunnel fracture. Similarly, on the femoral side, rigid fixation with implants can result in over-constraint with compromised results. Moreover, bone tunnels cannot be used in skeletally immature cases. To overcome issues related to bone tunneling and implants, as well as to reconstruct the MPFL in a precise anatomic manner, an all—soft-tissue fixation technique was devised. Bony landmarks were used as reference points instead of radiologic markers to achieve a more precise construct and to eliminate intraoperative radiography. Hamstring graft was used to reconstruct the MPFL. Special suturing techniques were used to achieve optimal graft fixation with minimal suture knots. A special tissue elevator—suture passer device was designed to facilitate graft passage and ease in performing the procedure. This technique permits differential tensioning, and therefore one achieves stability throughout the range of motion.

Various medial patellofemoral ligament (MPFL) reconstruction techniques have been described in the literature. Most of the techniques require implants or bone tunnels in the patella and femur for fixation of the reconstruction. Bone tunnels and implants are known to cause complications such as patellar fracture through the bone tunnels or implant-related complications. The site of anatomic insertion of the MPFL on the medial femoral condyle is close to the distal femoral physis. Bone tunnels are therefore not advisable in young individuals with open physes. Soft-tissue fixation techniques described earlier in the literature use the adductor magnus1,2 or medial collateral ligament insertion3–5 as a sling for the hamstring graft. However, these points on the femur are nonanatomic points of insertion on the femur. Similarly, the adductor magnus transfer6,7 would also be nonanatomic. The normal MPFL on its femoral side inserts 1.9 mm anterior to the region between the adductor tubercle and medial epicondyle.8 These constructs would therefore be nonanatomic and consequently cannot restore normal physiological properties, mobility, stability, and function of the patellofemoral joint.

The superior fibers of the MPFL interdigitate with the vastus intermedius.9 They therefore have a soft-tissue attachment above the superior pole of the patella. This soft-tissue insertion cannot be anatomically replicated by constructs fixed with bone tunnels or implants in the patella.

The “basket-weave technique” was developed to overcome drawbacks of previously described techniques. It also precisely replicates the vastus intermedius, patellar, and femoral insertion point anatomy, in addition to its other advantages. This technique relies more on anatomic landmarks, rather than radiographic markers,10 to further reduce errors in the femoral insertion point. Special suturing techniques are used to provide a firm fixation and avoid bone tunneling and rigid implant fixation that may cause over-constraint.11

The procedure is reliable and reproducible. In our case series it has been effective in giving good results with a very low risk of intraoperative and postoperative complications.

Basket-Weave Technique
The graft of choice is the ipsilateral gracilis tendon with a minimum length of 210 mm (Video 1). The semitendinosus tendon is used in nonathletic female
patients or if the gracilis length is insufficient. The graft is acquired using the standard anteromedial incision or through the posterior mini-incision technique to yield a better cosmetic result.\textsuperscript{12,13} The graft is held with No. 2 Ethibond cinch knots (Ethicon, Somerville, NJ) on either end and is pre-tensioned over a graft preparation board before the reconstruction.

A 2-cm-long medial patellar skin incision is taken (Fig 1). The medial retinaculum is identified and incised along the medial patellar border to expose the second layer of the retinaculum (Fig 2). If the MPFL can be identified, its lower margin is defined to confirm its extent of insertion. A plane is achieved between the first layer 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 (all rights reserved to author) designed by the author (Fig 3). Performing the reconstruction in this plane avoids detachment of the original MPFL, which otherwise is incised if the reconstruction is to be carried out deeper to this second layer.

A 1-cm skin incision is made in the region overlying the medial epicondyle and adductor tubercle (Fig 1).

These bony landmarks are well palpable while keeping the knee in 90° of flexion. Palpation commences from the adductor magnus to the first bony bump of the adductor tubercle, followed by the second bony prominence of the medial epicondyle (Table 1). On exposure of the medial anatomy in this region, a sharp 1-cm-long incision is taken 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 2 bony prominences is covered by a ligamento-periosteal tissue formed by the confluence of insertion of the medial collateral ligament

Fig 1. Medial patellar incision and second incision over region between adductor tubercle and medial epicondyle, shown in a left knee.

Fig 2. First layer of medial retinaculum lifted with forceps from second layer of medial retinaculum, shown in a left knee. This is just medial to the medial border of the patella. The tip of the scissors can be seen placed between the 2 layers.

Fig 3. Tissue Elevator—Suture Passer prototype (all rights reserved to author). This instrument allows easy passage and shuttling of sutures and graft between the layers of the retinaculum and underneath the extensor sleeves. The slot in the elevator portion provides for feeding of the sutures holding the graft to pull it across.
and medial retinaculum with the MPFL and adductor magnus. A 1-cm-wide strong sleeve of this ligamento-periosteal tissue is elevated from the saddle-shaped groove (Fig 4).

The graft is looped up to its center underneath this ligamento-periosteal sleeve. A Mixter forceps is hooked underneath the ligamento-periosteal sleeve to facilitate looping the graft underneath it (Fig 5). The 2 limbs of

Table 1. Tips and Pearls
1. Perform an arthroscopy before the MPFL reconstruction. Loose bodies can be removed and chondral injuries or other associated injuries can be assessed and treated if necessary.
2. Palpate the adductor tubercle starting from the adductor magnus tendon. The medial epicondyline is at the downslope of the bony prominence distal to the adductor tubercle. The medial incision spans between these 2 bony prominences.
3. For the parapatellar dissection, incise the first layer of the medial retinaculum carefully to avoid entering the second and third layers into the joint.
4. Avoid a location that is too posterior while elevating the ligamento-periosteal sleeve over the femur.
5. Use sharp No. 15 blades to elevate the extensor sleeves from the anterior aspect of the patella. Keep the blade flush and parallel to the anterior surface of the patella.
6. Use the Tissue Elevator—Suture Passer to shuttle the graft from the femoral incision to the patellar incision and to perform passage of the graft underneath the extensor retinaculum sleeves.
7. Use the pretzel stitch to fix the graft to the sleeves at every level, with approximately 3 stitches for the superior limb and 4 stitches for the inferior limb.
8. Fix the 2 limbs of the graft differentially, with the superior limb at 30° of flexion and the inferior limb at 90° of flexion.
9. Centralize, but do not medialize the patella while fixing the graft to the patella.

MPFL, medial patellofemoral ligament.

Fig 4. Graphic representation of medial aspect of a left knee. The green areas show the native medial patellofemoral ligament (MPFL). The blue areas show the capsule. The first layer is not shown. The yellow areas show the ligamento-periosteal sleeve (asterisks). This is a 1-cm-thick tissue sleeve elevated between the adductor tubercle and medial epicondyle. (AM, adductor magnus; MCL, medial collateral ligament.)

Fig 5. (A) A right-angle (Mixter) forceps is hooked underneath the ligamento-periosteal sleeve elevated from the region between the medial epicondyle and adductor tubercle, as shown in the medial aspect of a left knee. (B) The hamstring graft is looped underneath the ligamento-periosteal sleeve to its halfway mark.

Fig 5. (A) A right-angle (Mixter) forceps is hooked underneath the ligamento-periosteal sleeve elevated from the region between the medial epicondyle and adductor tubercle, as shown in the medial aspect of a left knee. (B) The hamstring graft is looped underneath the ligamento-periosteal sleeve to its halfway mark.
of the patella are elevated. For this, sharp vertical incisions up to the bone are taken at 1-cm intervals. Alternate strips of the retinaculum are elevated using a No. 15 knife passed flush and parallel to the anterior bony surface of the patella and then elevated using the Tissue Elevator—Suture Passer (Fig 7). Thus the graft is passed alternately below and above the extensor retinaculum sleeves on the anterior aspect of the patella. The sleeves elevated for the proximal and distal limbs of the graft are also elevated alternately so that they do not coalesce. This method of passage of the proximal and distal limbs of the graft through the extensor retinaculum resembles a basket-weave pattern (Fig 8).

The proximal limb of the graft is sutured to the sleeves of the retinaculum, with the graft kept taut, the patella centered, and the knee in 30° of flexion. In the

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Fig 6. (A) The Tissue Elevator—Suture Passer (all rights reserved to author) is passed from the medial patellar incision between the first and second layers across and emerges from the medial incision over the medial epicondyle, as shown in the medial aspect of a left knee. (B) Sutures of proximal limb of graft fed into Tissue Elevator—Suture Passer. (C) Superior limb of graft pulled across to be delivered through medial patellar incision. (D) Superior and inferior limbs of graft delivered through medial patellar incision looped over ligamento-periosteal sleeve. The graft is fixed to the ligamento-periosteal sleeve by a pretzel stitch, and the first layer of the medial retinaculum is sutured back over it in this medial epicondylar region.

Fig 7. Extensor retinaculum sleeve elevated over anterior aspect of patella. The first upper medial sleeve for the first passage of the superior limb of the graft is shown. The Tissue Elevator—Suture Passer (all rights reserved to author) is passed underneath the sleeve for passage of the graft. The first pass for both the superior and inferior limbs of the graft is underneath the medial-most sleeve.

Fig 8. Incision retracted open to show basket-weave pattern of graft fixation on patella, shown from the top view of a left knee. The graft alternates above and below the extensor retinacular sleeves and the proximal and distal limbs to give a basket-weave pattern. One should note that the first medial pass for both the superior and inferior limbs of the graft is underneath the sleeve.
presence of trochlear dysplasia, the bony stability of the patella beyond 30° of flexion is compromised; therefore the distal limb is fixed by suturing it with the knee in 90° of flexion. This ensures stability and normal mobility of the patella throughout the range of motion.

Simple suturing of the graft to the sleeves may not be adequate because the sutures may cut through or may result in too many knots on the anterior surface. To avoid this issue, a special “pretzel stitch” (Fig 9) was designed for fixation of the graft to each of the sleeves. No. 1 Vicryl sutures (Ethicon) are used for suturing. The pretzel stitch cinches the sleeve around the graft and simultaneously transfixes the graft to the sleeve, thus giving a firm fixation. The pretzel stitches are made at each sleeve level, where the graft passes above or below them. Each level of suturing beyond the first suture provides backup fixation for the previous suture, thus reinforcing the fixation. The application of a total of 3 or 4 fixation sutures is ensured for each limb of the graft (Fig 10).

The first incised layer of the retinaculum is sutured back to the medial margin of the patella on its anterior aspect to eliminate the slack in the retinaculum. The graft construct lies in between the first and second layers of the retinaculum (Fig 11). This suturing is performed while keeping the knee in 30° of flexion, thus completing the procedure. Postoperative arthroscopic views show that the reconstruction and fixation are extracapsular and anatomic, extending from the region between the medial epicondyle and adductor tubercle to the upper half of the medial margin of the patella (Fig 12).

**Postoperative Rehabilitation**

The knee is immobilized in 30° of flexion in a rigid long knee brace for 2 weeks. Toe-touch weight bearing is permitted immediate postoperatively. Full weight bearing in extension, active-assisted and active range-of-motion exercises, and quadriceps-toning exercises are started after suture removal (10 to 14 days). The
brace is discarded after 4 to 6 weeks or once the patient regains strength and good quadriceps control. The patient is expected to regain full range of motion by 2 to 3 months postoperatively. Thereafter foot, ankle, hip, and core stabilization exercises are initiated. Balance and proprioceptive training can be followed by resumption of sports at 4 months.

**Discussion**

With the MPFL’s patellar insertion extending high near the superior pole of the patella and with the soft-tissue insertion on the vastus intermedius, none of the previously described techniques with bone tunnels can precisely replicate the anatomic insertion points of the reconstruction. This is because the vastus intermedius insertion of the MPFL extends proximal to the superior pole of the patella.\(^9\)

Radiologic landmarks for the insertion point of the MPFL on the femur have been described by Schöttle et al.\(^3\) However, 1 of the 8 MPFL insertions described was in fact found to be posterior to the posterior line of Schöttle’s area in this study. So the insertion point would be incorrect in 12.5% cases if these landmarks are followed for surgical reconstructions. The point suggested by Schöttle et al. is just an average of all the points in the 8 cadaveric knees studied. Schöttle’s point therefore does not give us the precise radiologic point of insertion of the MPFL on the femur for all cases. Moreover, in skeletally immature knees, this radiographic marking cannot be followed because it has been shown to be incorrect for such knees. Using this radiologic point to guide one’s surgical reconstruction
may often result in an erroneous nonanatomic reconstruction with compromised results. The use of a radiologic marker for our MPFL reconstructions was eliminated in the described technique, and we preferred to use a more reliable method to describe the anatomic bony landmarks. Similar to any other ligament attachments, the MPFL shows a consistent attachment in relation to the 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. These palpable bony prominences were used as landmarks for precise anatomic reconstruction and avoidance of the errors of using an imprecise radiologic marker. Because the femoral attachment is crucial for the anatomic reconstruction, this more reliable method in which the medial epicondyle and adductor tubercle are used as guides for reconstruction reduces errors and avoids unnecessary fluoroscopy. This possibly gives more effective, reliable, and reproducible results.

Unlike rigid fixation methods using screws or anchors, this soft-tissue fixation technique is more forgiving and does not result in over-constraint of the patellofemoral joint or limitation of flexion. The basket-weave technique for MPFL reconstruction has a number of advantages over other techniques:

1. No implants are used in the operation. The entire procedure is carried out using only special suturing techniques. Basket weaving of the graft avoids coalescing of the proximal and distal sleeves on the anterior aspect of the patella. It provides for graft-on-bone contact for a firm union and simultaneously provides for a soft-tissue fixation. The proximal limb of the construct can be fixed appropriately to the vastus intermedius to replicate the natural anatomy and proximal extent of the MPFL. The pretzel stitch provides for simultaneous transfixation and cinching of the graft to the soft tissue with a single stitch. This avoids excessive knotting for a firm fixation. No bone tunnels are made either in the femur or in the patella. The technique therefore avoids bone tunnels, implant-related complications, and physeal disruption in skeletally immature patients.

2. The technique avoids use of intraoperative fluoroscopy and radiation. Radiologic markers (Schottle’s point) can be imprecise because they represent only an average of precise insertion points in different individuals. Bony landmarks for fixation points are more individualized, precise, and reliable for determining the insertion point on the femur. Their use therefore gives a precise anatomic reconstruction, lessening the room for error.

3. The technique does not disrupt remnants of the original MPFL or its insertions with drill holes.

Bone drilling at points of anatomic insertion of the original ligament can lead to erasure of its insertion. The residual function and scaffold provided by the MPFL remnant would therefore be compromised. This technique avoids the loss of function of the native MPFL remnants.

4. The technique does not disrupt the capsule or any other structure around the joint and, therefore, is a more biological, tissue-preserving, minimally invasive, and less traumatic procedure. An arthroscopically performed MPFL reconstruction requires removal of the medial capsule for its reconstruction. This technique does not cause any surgical injury to the original MPFL or its insertion points. There is no added bone or soft-tissue trauma to important stabilizing structures. The technique is less traumatic because of minimal dissections required and minimal tissue trauma, thus providing for better patient compliance and rapid recovery with rehabilitation.

5. The soft-tissue fixation is a firm but less rigid construct than a tunnel fixation or fixation with implants. It therefore prevents erroneous medial over-constraint even in case of minor surgical errors in tensioning or positioning during fixation. This makes the procedure more forgiving, with some inherent pliability in the construct. The postoperative examination therefore shows normal mediolateral mobility with a normal soft endpoint, with high patient satisfaction scores at follow-up.

6. The proximal and distal limbs of the graft can be tensioned in varying degrees of knee flexion. This provides for stability throughout the range of motion, even in the presence of a dysplastic trochlea. Techniques using a single-stranded construct or techniques requiring the patellar fixation to be performed first cannot reproduce this differential tensioning in 2 different positions of flexion.

7. The soft-tissue fixation possibly gives better proprioceptive feedback, thus triggering a better active reflex response to avoid patellar dislocation. It is noted that varying tension in ligaments at different joint positions stimulates the proprioceptors located at the insertion points of the ligaments. Direct bony fixation with implants cannot result in stimulation of these proprioceptors. A soft-tissue fixation using the described technique can stimulate these proprioceptors in the soft tissues, giving better proprioceptive feedback. This can hypothetically result in better reflex stimulation of the vastus medialis obliquus if initiated and possibly reduces the failure and recurrence rates after this reconstruction technique.

8. The procedure can be used for skeletally immature patients, for patients with hypoplastic patellae, or even for patients with patellar arthroplasty because
it does not rely on the bone structure of the femur or patella. No abnormalities have been noted in distal femoral physeal growth after this procedure in our 4 years of follow-up.

9. Because there are no bone tunnels, a revision surgical procedure—if ever necessary—would not be complicated as a result of this primary procedure because it relies only on soft-tissue fixation.

10. The procedure is economical because it avoids the use of expensive implants.

References


