Technical Note

Combined Autologous Adductor Magnus and Partial Quadriceps Tendon Technique for Medial Patellofemoral Ligament Reconstruction and Cellularized Scaffold Implantation of the Patella

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Abstract: There are many studies in the literature on the use of adductor magnus and quadriceps tendons in primary or revision surgery of patellofemoral instability in skeletally immature patients. In this Technical Note, the combination of both tendons is presented with cellularized scaffold implantation cartilage surgery in the patella.

Introduction

Traumatic patellofemoral instability is common in childhood and adolescence. First-time patellofemoral dislocation is often treated with a conservative approach. Recurrent dislocations, however, require surgical treatment. Prior to planning surgical treatment, anatomical and morphological features, lower extremity alignment, patellofemoral alignment, and ligamentous stability must be evaluated and taken into account. Planning is crucial in the surgical treatment of skeletally immature patients. A consensus is yet to be reached on the optimal surgical technique, graft, and fixation materials among the many described in the literature.[1-3]

Both the lack of sufficient bone stock in the patella and the challenges in achieving isometric fixation in skeletally immature patients can lead to treatment failure. For these reasons, revision surgeries can often pose a significant challenge to surgeons. Proper graft selection and the choice of patellar and femoral fixation points are particularly important in the setting of revision surgery.[4,5] In the technique presented here, we combine two different grafts, which have been individually described in the literature, to address patellofemoral instability and a full-thickness cartilage lesion of the patella in order to simultaneously benefit from the different advantages of the two methods.

Patient Evaluation

In the physical examination of the patient, joint range of motion, joint laxity, and malalignment are initially evaluated. In addition, soft tissue laxity in the anatomical region of medial patellofemoral ligament (MPFL), tenderness on palpation, patellar apprehension, and the presence of J sign in early flexion should be evaluated.

Indications

In all cases of lateral patellar instability, soft tissue retensioning and augmentation can be performed by MPFL reconstruction and LRL virtually. The principal decision to be made is whether to perform it in isolation or in conjunction with another procedure. As most surgical patellar instability is the result of some form of pathoanatomy, it will be necessary to determine whether the underlying pathoanatomy needs to be corrected. An isolated MPFL reconstruction and LRL can be carried out in cases where the underlying pathoanatomy is mild to moderate. This soft tissue rebalancing is done in addition to corrective procedures when the underlying condition is more serious. To be clear, a weak MPFL is not the main cause of patellar

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instability in almost all cases. Therefore, MPFL reconstruction should be seen as a compensatory operation that strengthens the native MPFL in order to resist the underlying pathology that has caused the instability. The selection of graft is the most crucial factor that should be considered in MPFL reconstruction. Regarding graft strength and isometry for the femur and patella, combined grafting from the quadriceps and adductor magnus is an exceptional choice.

Imaging

The evaluation of patients with patellar instability should include standing long-leg weight-bearing films for mechanical alignment and either computed tomography or magnetic resonance imaging to determine the tibial tuberosity-tibial groove distance for rotational alignment along with a standard knee radiographic series. These measures help the surgeon decide if a bone realignment operation, such as a tibial tubercle osteotomy, is required in order to prevent recurring instability, in addition to MPFL restoration.

Surgical Technique

A detailed anatomic dissection of quadriceps tendon and adductor magnus tendon harvesting and summary of the decribed surgical technique are presented in Video 1.

A standard knee arthroscopy is first performed for preoperative assessment. The tourniquet is initially released for dynamic examination of the patellofemoral joint. The patella is subluxated laterally. A large chondral lesion is recorded involving the lateral and medial facets of the patella, and patellofemoral dynamic examination revealed that the patella is positioned over the femoral condyle lateral to the trochlear groove. All other anatomical structures are evaluated.

Subsequently, the pneumatic tourniquet is inflated and a straight longitudinal incision is made on the medial side of the knee. After incision of the skin and subcutaneous tissue, the quadriceps tendon is exposed. Then the adductor tubercle is palpated on the medial femoral condyle, and the adductor magnus tendon is first palpated and proximally dissected and exposed. The patella is reduced in the groove, and isometric flexion and extension are evaluated by dynamic examination. The distance between the adductor tubercle and the superior quadrant of the patella is measured and noted. Accordingly, an 8-mm-wide and 65-mm-long graft is harvested from the medial one-third of the quadriceps tendon (Fig 1). The adductor magnus tendon is then mobilized proximally, and a 55-mm graft is harvested and prepared (Fig 2). Subsequently, the joint is opened with a medial parapatellar mid-vastus incision. The patellofemoral joint surface is observed. The full-thickness cartilage lesion involving both the lateral and medial patellar facets is debrided with a curette, and a microfracture is performed. The size and shape of the cartilage lesion were determined, and a template is designed. Accordingly, a scaffold is prepared (Novocard Basic, Tetec AG, Germany). The prepared scaffold is sutured to the site of the lesion. The prepared bone marrow aspirate concentration is then injected under the scaffold (Fig 3A), and the final fixation of the scaffold is achieved with fibrin glue (Fig 3B). After allowing 5 minutes for fixation, the stability of the scaffold is tested by patellofemoral joint movement. The quadriceps graft is then positioned over the superior quadrant of the patella. Subsequently, a soft-tissue anchor is placed on the superior quadrant of the patella, and the quadriceps tendon is placed along the medial border of the patella up to this point; with this soft-tissue anchor, an insertion point is created on the superior border of the patella (Fig 4, A-C). Next, the quadriceps tendon is inserted into the femoral condyle immediately superior and distal to the adductor tubercle. The adductor magnus is fixed to the superior quadrant of the patella with a soft tissue anchor just distal to the tunnel where the quadriceps tendon is inserted (Fig 5). Subsequently, both tendons are sutured together, and the reconstruction is concluded (Fig 6). Dynamic examination is performed, and then the surgical site is closed in anatomical layers.

Critical points in surgical technique are presented in Table 1.

Rehabilitation

Passive range of motion (PROM) of the knee is advised at the earliest stage of postoperative rehabilitation. In the first 2 weeks following surgery, PROM has a restricted flexibility of 0° and 90°. Full PROM is allowed following this period. Range-of-motion

Fig 1. An anterior midline incision of around 5 to 6 cm is extended over the upper pole of the patella. Graft harvester is used at the medial third of the quadriceps tendon, and then scissors are used to gain access between the superficial and middle laminas. A retractor is inserted between the 2 surgically separable laminas, and the superficial lamina is lifted. (Right Knee, Supine position)

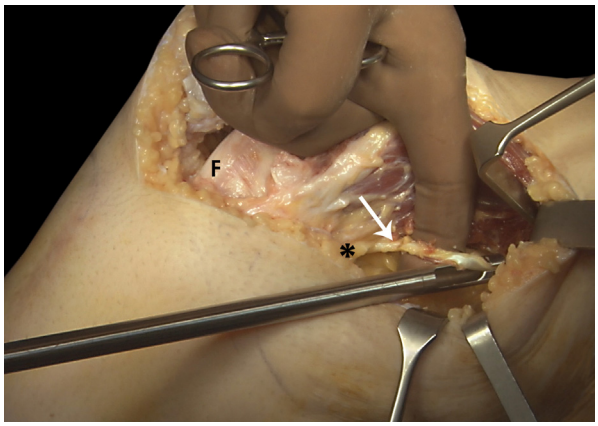

Fig 2. At the medial side of the distal femur, exposure was expanded, and the distal segment of the adductor magnus was exposed. F, femur. White arrow denotes adductor tendon, and black asterisk denotes adductor tubercle. (Right Knee, Supine position)

exercises, patella and patellar tendon mobilization exercises, extension mobilization, quadriceps series, and ankle pumps are among the rehabilitation exercises performed from the 1st to the 8th week. The patient is permitted to begin riding and/or rowing during this time using the unoperated limb. After 6 weeks, both limbs may participate in bicycle activities with no resistance until week 8. Toe-heel raises, balancing series, and hamstring sets begin in week 6. Leg presses and balancing squats may start in week 10.

Step by Step Surgical Technique

1. A standard knee arthroscopy is first performed for preoperative assessment.
2. If there are combined injuries with patellofemoral instability, medial parapatellar incision can be used. If isolated MPFL surgery is to be performed, two separate incisions can be made. The first incision is made between the adductor tubercle and the medial femoral epicondyle along the adductor magnus muscle. The second incision is made from the superomedial of the patella to the proximal along the quadriceps tendon.
3. The adductor tubercle is palpated on the medial femoral condyle, and the adductor magnus tendon is first palpated and then proximally dissected without damaging the saphenous nerve and infrapatellar branch and exposed.
4. The adductor magnus tendon is then mobilized proximally, and a graft is harvested and prepared.
5. An anterior midline incision of around 5 to 6 cm is extended over the upper pole of the patella. Graft harvester is used at the medial third of the quadriceps tendon, then scissors are used to gain access between the superficial and middle laminas. A retractor is inserted between the 2 surgically separable laminas, and the superficial lamina is lifted.
6. An 8-mm-wide and 65-mm-long graft is harvested from the medial one-third of the quadriceps tendon.
7. The quadriceps graft is then positioned over the superior quadrant of the patella. Subsequently, a soft-tissue anchor is placed on the superior quadrant of the patella, and the quadriceps tendon is placed along the medial border of the patella up to this point; with this soft-tissue anchor, an insertion point is created on the superior border of the patella.
8. The quadriceps tendon is inserted into the femoral condyle immediately superior and distal to the adductor tubercle.
9. The adductor magnus is fixed to the superior quadrant of the patella with a soft tissue anchor just distal to the tunnel where the quadriceps tendon is inserted.
10. Subsequently, both tendons are sutured together and the reconstruction is concluded.

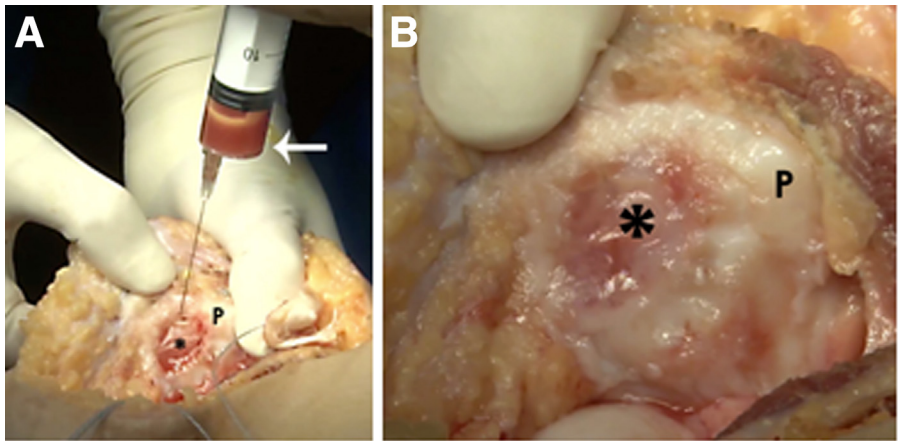

Fig 3. (A) After debridement and microfracture of the chondral lesion of the patella, bone marrow aspirate concentration is injected under the scaffold. (P: Patella, white arrow: BMAC, black asterisk: scaffold). (B) Final appearance of scaffold after suturing and then fixation with fibrin glue to the chondral lesion site. P: Patella, black asterisk: scaffold. (Right Knee, Supine position)

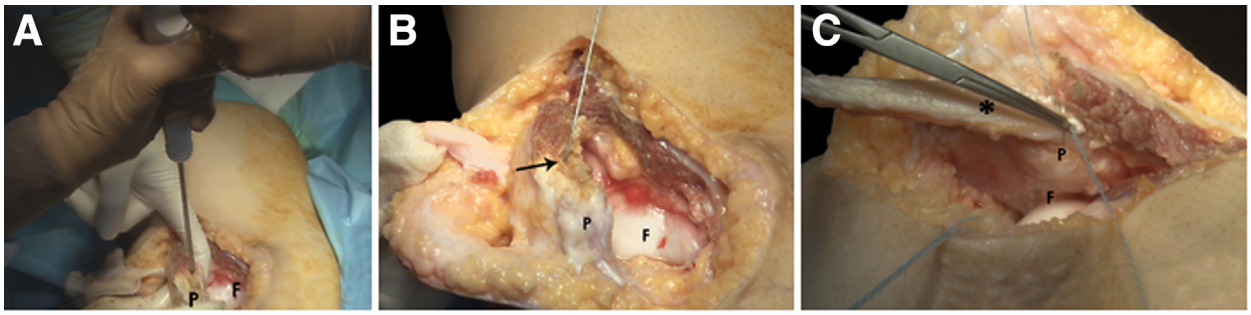

Fig 4. (A-C) The quadriceps tendon strip is subperiostally elevated from the surface of the patella. The proximal 1.5 cm of the medial patellar bony border is exposed, and then the bony border is shaved, and bony canale is reshaped to fix the tendon on the medial superior edge of the patella. The quadriceps tendon strip is pulled under the vastus medialis toward the medial border of the patella. Then the graft is brought back upon itself and sutured to the created canal with a Q-Fix anchor (Smith & Nephew) to prevent it from rolling onto itself. Next, the graft was then secured to the retinaculum tissue on the medial patellar edge by 2.0 resorbable sutures. F, femur; P, patella. Black arrow denotes anchor insertion on the patella, and the black asterisk denotes quadriceps tendon graft. (Right Knee, Supine position)

Discussion

MPFL reconstruction is one of the most popular options for the treatment of recurrent patellar dislocation in skeletally immature patients. The most important surgical consideration in this patient population is growth plate injuries. Accordingly, many different technical approaches and grafts have been proposed for MPFL reconstruction in this population. In recent years, together with gracilis and semitendinosus grafts, the use of quadriceps and adductor magnus tendon grafts has become increasingly common. The literature presents numerous clinical data on surgical techniques designed to preserve the growth plate.[6-12]

Other than preserving the physis, different techniques have been described for cases in which the quadriceps or adductor magnus tendons could not be used with sufficient safety or patients with insufficient bone stock.[4-7,9,12]

The quadriceps tendon autograft is a safe choice due to its physiological relationship to the patella. However, improper graft harvesting can cause patellar avulsion fractures. In addition, it may not be possible to obtain a graft of sufficient length from the quadriceps tendon, which requires diligent surgical planning. On the other hand, femoral fixation may also be associated with physeal injury.[4,6,7,12]

In contrast, the adductor magnus, another autologous option for MPFL reconstruction, requires secure fixation to the patella. Although there are numerous clinical studies on patellofemoral ligament reconstruction using an adductor magnus tendon graft, there are also

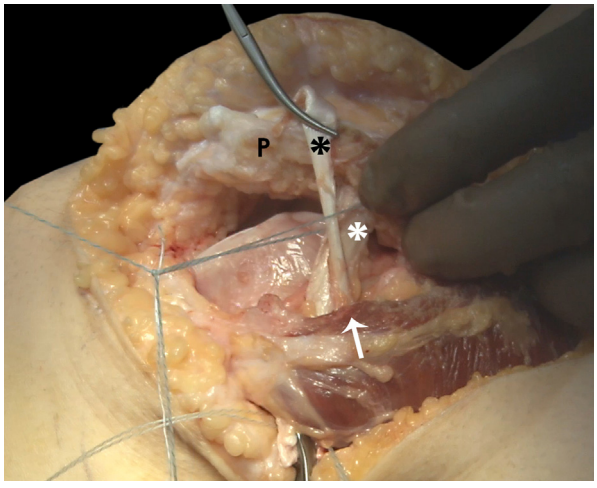

Fig 5. The harvested adductor magnus tendon was shuttled to the medial border of the patella, and a suture anchor was placed. Afterward, the free end of the tendon was fixed to the medial facette of the patella at 30° of knee flexion. F, femur; P, patella. Black asterisk denotes adductor tendon, white asterisk denotes quadriceps graft, and white arrow denotes anchor fixation on the femur.

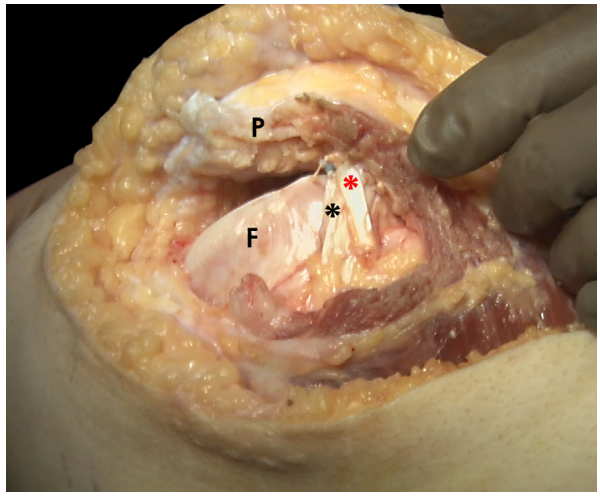

Fig 6. Both quadriceps tendon strip and adductor magnus tendons are sutured together by 2.0 resorbable sutures. F, femur; P, patella. Black asterisk denotes adductor tendon, black asterisk denotes quadriceps tendon graft, and red asterisk denotes adductor tendon graft.

Table 1. Pearls and Pitfalls

Pearls
The quadriceps tendon graft is a similar structure shape to the native medial patellofemoral ligament (MPFL), and the technique provides similar projection to the the native MPFL. In addition to the anatomical similarities, biomechanics of the graft is similar to the native MPFL.
The technique spares the hamstring tendons for primary cases. In addition, it provides reliable and anatomical fixation in revision cases where hamstring tendons were used.
Demonstration of the adductor tubercle in this technique eliminates the need for fluoroscopy in femoral fixation of the quadriceps tendon.
Femoral fixation is fully anatomic
The adductor magnus tendon and the quadriceps tendon provide a complete anatomic reconstruction of the patellar and femoral sites.
Both tendons provide double-row fixation on the patella.
Pitfalls
In the case of open physis, care should be taken in the femoral fixation of the quadriceps tendon.
The quadriceps tendon and the adductor magnus tendon may not be of sufficient length in some people. In this case, instead of creating too much tension, both grafts should be stitched together to form a single construct.
In this technique, care should be taken that it is not overconstrained, especially in the final construct.
There is a risk of avulsion for both tendons. In particular, the creation of a new insertion point by refixing the quadriceps tendon in the patella is important for both anatomical placement and secure fixation.

many reported disadvantages and a higher recurrence rate.[13] The femoral vessels, which pass through the adductor hiatus between the two parts of the muscle, pass into the fossa popliteal and extend as the popliteal vessels. The saphenous nerve, which enters the adductor canal with the femoral vessels, penetrates the vastoadductor intermuscular septum between the vastus medialis and the adductor tendon and goes below the sartorius. It crosses the adductor magnus tendon during its subsartorial course. Then, passing between the sartorius and gracilis tendon, it becomes superficial and joins the greater saphenous vein in the medial of the knee.

Nevertheless, the cadaver study conducted by Milinkovic et al.[9] showed that the adductor tendon is a good option due to presenting a graft of significant volume, specific topographic anatomy, and sufficient tensile strength. Although the same study reported that the proximal localization of neurovascular structures reduced the risk of neurovascular damage, it should be noted that the proximity of the graft insertion site to the adductor tubercle is critical when harvesting a graft of sufficient length and that, in some cases, the graft may need to be obtained from structures closer to the neurovasculature in order to achieve sufficient graft size. However, it is clear that patellar fixation is safe in terms of patellar bone stock.

In the technical approach that we have described, the quadriceps and adductor tendons are used together in the treatment of challenging cases or revision surgeries. This technique combines the advantages of both methods and makes it possible to achieve a more durable and anatomically correct reconstruction. Moreover, in the event of simultaneous cartilage treatment and a compromised patellar bone structure, as was the case for our patient, low-profile fixation without requiring large tunnels provides significant convenience. Constructing the quadriceps tendon to create an insertion point on the patella allowed the achievement of a reconstruction anatomically similar to the MPFL. In addition, the attachment of the AT immediately distal to the QT fixation point is important in terms of creating a large insertion point. Establishing stable and strong fixation on both sides is important for a durable and secure reconstruction.

To conclude, the method described here is promising for the treatment of challenging cases and revision surgeries.

References

1. Chatterton A, Nielsen TG, Sørensen OG, Lind M. Clinical outcomes after revision surgery for medial patellofemoral ligament reconstruction. *Knee Surg Sports Traumatol Arthrosc* 2018;26:739-745.
2. Ferrari MB, Sanchez G, Chang A, Ferdousian S, Provencher MT. Medial patellofemoral ligament reconstruction in revision setting: Anchor and interference screw fixation. *Arthrosc Tech* 2017;64:e927-e932.
3. Sanchis-Alfonso V, Montesinos-Berry E, Ramirez-Fuentes C, Leal-Blanquet J, Gelber PE, Monllau JC. Failed medial patellofemoral ligament reconstruction: Causes and surgical strategies. *World J Orthop* 2017;8:115-129.
4. Nelitz M, Dreyhaupt J, Williams SRM. 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* 2018;26:1210-1215.
5. Alm L, Krause M, Mull C, Frosch KH, Akoto R. Modified adductor sling technique: A surgical therapy for patellar instability in skeletally immature patients. *Knee* 2017;24:1282-1288.
6. Peter G, Hoser C, Runer A, Abermann E, Wierer G, Fink C. Medial patellofemoral ligament (MPFL) reconstruction using quadriceps tendon autograft provides good clinical, functional and patient-reported outcome measurements (PROM): A 2-year prospective study. *Knee Surg Sports Traumatol Arthrosc* 2019;27:2426-2432.
7. Fink C, Veselko M, Herbort M, Hoser C. Minimally invasive reconstruction of the medial patellofemoral ligament using quadriceps tendon. *Arthrosc Tech* 2014;12(3):e325-e329.
8. Fulkerson JP, Edgar C. Medial quadriceps tendon-femoral ligament: Surgical anatomy and reconstruction technique to prevent patella instability. *Arthrosc Tech* 2013;2:e125-e128.

9. Milinkovic DD, Fink C, Kittl C, et al. Anatomic and biomechanical properties of flat medial patellofemoral ligament reconstruction using an adductor magnus tendon graft: A human cadaveric study. *Am J Sports Med* 2021;49:1827-1838.
10. Prieto DP, Capurro B, Gelber PE, et al. The anatomy and isometry of a quasi-anatomical reconstruction of the medial patellofemoral ligament. *Knee Surg Sports Traum Arthrosc* 2017;25:2420-2423.
11. Tanaka MJ. Femoral origin anatomy of the medial patellofemoral complex: Implications for reconstruction. *Arthroscopy* 2020;36:3010-3015.
12. Xu J, Ye Z, Qiao Y, et al. Medial patellofemoral ligament reconstruction using adductor-transfer and adductor-sling at nonanatomic femoral attachment sites leads to unfavorable graft-length change patterns: A descriptive biomechanical study. *Arthroscopy* 2022;38:1557-1567.
13. 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;34:1340-1354.