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The Docking Technique for Medial Patellofemoral Ligament Reconstruction

Surgical Technique and Clinical Outcome

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Background: Current techniques of medial patellofemoral ligament (MPFL) reconstruction vary with respect to methods of fixation on the femur and the patella. This article presents the outcomes of a surgical technique for reconstruction of the MPFL that uses a soft tissue graft with interference screw fixation on the femur and a docking technique for fixation on the patella.

Hypothesis: Patients with patellar instability who are treated with the docking technique for MPFL reconstruction will have improvements in knee symptoms and function, with a high percentage achieving good to excellent results at early follow-up.

Study Design: Case series; Level of evidence, 4.

Methods: Twenty consecutive patients with patellar instability underwent reconstruction of the MPFL. Patients were evaluated preoperatively and postoperatively by physical and radiographic examination and subjectively with the IKDC (International Knee Documentation Committee), Tegner, Kujala, and Lysholm questionnaires. Nineteen patients underwent magnetic resonance imaging preoperatively.

Results: The average follow-up was 31 months (range, 24-39). No recurrent episodes of dislocation or subluxation were reported. A firm endpoint to lateral patellar translation was noted in all patients at most recent follow-up. The IKDC subjective knee evaluation score improved from 42 preoperatively to 82 postoperatively ($P < .001$); Kujala, from 50 to 88 ($P < .001$); Lysholm, from 50 to 89 ($P < .001$); and Tegner, from 3.6 to 5.6 ($P < .001$).

Conclusion: The docking technique for MPFL reconstruction is an effective surgical procedure for the treatment of patellar instability.

Keywords: medial patellofemoral ligament; reconstruction; patella; instability

Recurrent patellar subluxation or dislocation is a disabling condition that occurs in young patients.[4] Although multiple factors influence patellar instability, in patients with normal osseous anatomy and lower extremity alignment, patellar instability is attributed to deficient and/or incompetent soft tissue stabilizers.[25] The soft tissue elements that contribute to patellofemoral stability include the medial patellofemoral ligament (MPFL), the medial patellotibial ligaments, and the vastus medialis obliquus (VMO). Biomechanical studies demonstrate that the MPFL accounts for 50% to 60% of the medial restraint resisting lateral patellar translation.[3,11,17,26,31,34] Several studies document that injury to the MPFL occurs with patellar dislocation.[2,15,25,32] Because of its critical role in stabilizing the patella, several techniques for MPFL reconstruction have been developed,[8-10,27,28,33,35] and studies have demonstrated encouraging results with early follow-up.

This study presents an MPFL reconstruction technique that (1) facilitates exact tunnel location to achieve native MPFL ligament isometry and simple graft tensioning and (2) incorporates the VMO into the reconstruction for combined patellar stabilization and enhanced VMO function. Fixation is achieved on the femur with an interference screw and on the patella with a docking technique. The

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hypothesis of this study is as follows: Patients with patellar instability who are treated with MPFL reconstruction will have improvements in knee symptoms and function, with a high percentage achieving good to excellent results at early follow-up.

MATERIALS AND METHODS

Patients who underwent MPFL reconstruction with the docking technique for patellar instability were retrospectively identified at 2 institutions. Patients who had concomitant distal realignment procedures or additional ligament reconstructions were excluded from the study. We obtained institutional review board approval. Indications for surgery included recurrent instability despite a trial of nonoperative treatment, including bracing and physical therapy. Two patients experienced recurrent subluxations, 2 dislocated once, 4 dislocated twice, and the remaining 12 experienced habitual dislocations (range, 3-10). All patients with dislocation also experienced recurrent subluxation after their initial dislocation. Patients who were considered to have recurrent subluxation were those who experienced frequent painful translation of their patella without a frank locking and who did not require manual manipulation or knee extension to have the patella move back into position. Patients with dislocation experienced a patellar translation with a frank locking of their knee that required either knee extension or manual manipulation to relocate the patella. Surgical reconstructions were performed by the 2 senior authors. In sum, 21 consecutive patients (6 male and 15 female) were identified who fit the inclusion criteria. One patient who underwent the procedure was unavailable for follow-up, thereby leaving 20 patients in the study (95% follow-up). The average age of the patients at the time of surgery was 23 years old (range, 11-43). The average follow-up was 31 months (range, 24-39). All patients were evaluated by physical examination and standard knee radiographs. Magnetic resonance imaging (MRI) scans were obtained preoperatively in 18 patients.

Preoperative and postoperative physical examination included evaluation for patellar apprehension, patellofemoral crepitus, pain with patellar compression, lateral patellar quadrant translation, firm versus soft endpoint to lateral patellar translation, Q angle, patellar tilt, medial and lateral patella facet tenderness, presence of quadriceps muscle atrophy, and generalized ligamentous laxity (defined as having elbow recurvatum, metacarpal hyperextension, and ability to place the thumb to the radius) (Table 1).

Plain radiographs, including Merchant views, were obtained preoperatively and postoperatively and were evaluated to determine the femoral sulcus angle, congruence angle, lateral patellofemoral tilt angle, lateral shift ratio, and absolute lateral patellar displacement. Lateral radiographic views at 30° of flexion were evaluated for the Insall-Salvati ratio,[19] Blackburne-Peel ratio,[5] and absolute trochlear depth (Table 2). The presence of osteochondral lesions, tears in the VMO and MPFL, and additional pathologic lesions were noted on preoperative MRI in 18 patients (Table 3).

TABLE 1
Preoperative Physical Examination Findings: Patients With Positive Findings[a]

Finding	n (%)
Generalized ligamentous laxity	6 (30)
Passive patellar tilt less than neutral	6 (30)
Patellar crepitus	8 (40)
Pain with patella compression	9 (45)
Medial facet tenderness to palpation	16 (80)
Lateral facet tenderness to palpation	12 (60)
Quadriceps muscle atrophy	11 (55)

[a]Out of 20 patients.

TABLE 2
Preoperative Radiographic Findings

Sulcus angle	137.3° (119° to 148°)
Congruence angle	11.6° lateral (26° lateral to 16° medial)
Tilt angle	12.3° lateral (20° lateral to 8° medial)
Lateral shift ratio	15.4 (0 to 30)
Lateral displacement	7.9 mm (1 to 18)
Insall-Salvati ratio	1.1 (0.7 to 1.5)
Blackburne-Peel ratio	1.0 (0.6 to 1.4)
Trochlear depth	8.0 mm (5 to 10)

TABLE 3
Preoperative Magnetic Resonance Imaging Findings[a]

Finding	n (%)
MPFL sprain or tear	11 (61)
Patella chondromalacia	
Isolated medial facet	2 (11)
Isolated lateral facet	2 (11)
Combined medial and lateral facets	1 (6)
Lateral trochlea chondromalacia	2 (11)
Lateral trochlea bone bruise	3 (17)
Medial patella facet bone bruise	2 (11)
Lateral trochlea hypoplasia	3 (17)
Medial collateral ligament strain	1 (6)

[a]Out of 18 patients. MPFL, medial patellofemoral ligament reconstruction.

The IKDC (International Knee Documentation Committee) subjective knee evaluation form,[18] Kujala questionnaire,[21] Lysholm questionnaire,[36] and Tegner scale[36] were completed and then used to compare preoperative and postoperative function (Table 4). Data analysis was performed with paired student *t* tests to evaluate differences in preoperative and postoperative subjective outcome scores.

SURGICAL TECHNIQUE

Examination under anesthesia was performed preoperatively to confirm the diagnosis of patellar instability and

TABLE 4
Subjective Knee Evaluation Questionnaires[a]

	Preoperative	Postoperative
IKDC	42.1	82.3
Kujala	49.9	88.2
Lysholm	49.5	88.7
Tegner	3.6	5.6

[a]All preoperative and postoperative differences significant, $P < .001$. IKDC, International Knee Documentation Committee.

to quantify the instability by lateral patella quadrant translation. The patella was visually divided into 4 vertical quadrants, and a lateral force was applied to the patella with the knee in full extension. The number of quadrants that the patella laterally translated was recorded; a patella that translates its full width has grade 4 translation. To assess if the patella was dislocatable under anesthesia, the knee was positioned in full extension and a manual lateral force was applied to the patella. The knee was then flexed while the lateral force on the patella was maintained; if the patella remained locked lateral to the trochlea after removal of the lateral force with the knee flexed to 60°, it was considered dislocatable under anesthesia. The lateral retinacular structures were evaluated by eversion of the patella. A lateral release was performed if the patella was unable to be everted to neutral.

An esmarch bandage was used to exsanguinate the leg, and a thigh tourniquet was inflated. Semitendinosus allograft was used in 2 patients and tibialis anterior allograft in 2 patients. Allograft was used in patients who wished to have minimal pain and/or required limited use of postoperative pain medication. If an autograft was used, the semitendinosus tendon was harvested. A vertical incision was made along the anteromedial proximal tibia, and the sartorial fascia was divided. The semitendinosus tendon was identified, released from its insertion, and controlled with a No. 2 suture, sewn to the tendon in whipstitch fashion. Soft tissue attachments to the medial head of the gastrocnemius muscle were released, and the semitendinosus tendon was released proximally with a tendon stripper. Muscle tissue was removed, and the proximal portion of the released tendon was sutured with a No. 2 suture, sewn in whipstitch fashion. The tendon was then folded over and whipstitched with a No. 2 suture for 1.5 cm at the folded portion. The diameter of the folded tendon was measured with a sizing guide.

Diagnostic arthroscopy was then performed. Intra-articular injuries were addressed with chondroplasty and/or removal of loose bodies, if needed. Chondroplasty was performed with a 3.5-mm shaver, and unstable loosely attached cartilage was removed to a stable rim of cartilage. A lateral release was performed in patients with tight lateral structures, as diagnosed on the examination under anesthesia. Patients with generalized ligamentous laxity do not typically exhibit a tight lateral retinaculum; thus, lateral release was avoided in these patients.

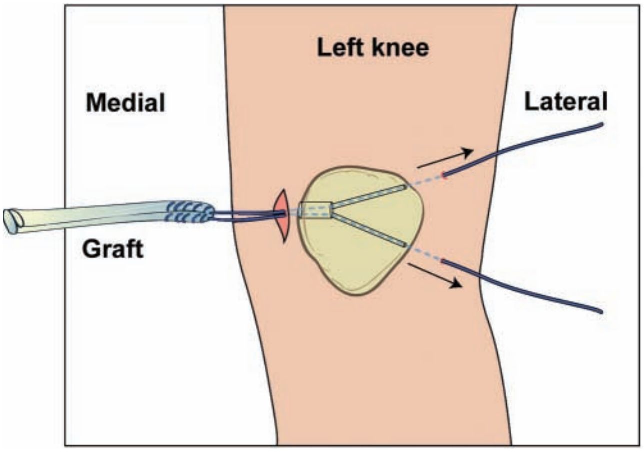

Figure 1. Suture attached to the graft traversing the patella. From "The Docking Technique for Medial Patellofemoral Ligament Reconstruction," Gabriel D. Brown, Christopher S. Ahmad, *Operative Techniques in Orthopaedics*. October 2007 (Vol. 17, Issue 4, Pages 216-222). Reprinted with permission from Elsevier.

A 3-cm longitudinal incision was made midway between the adductor tubercle and the medial border of the patella. A skin flap was raised, and dissection into the prepatellar bursa was carried out and extended to the lateral border of the patella. Placing the knee in full extension facilitated this exposure.

Exposure of the medial epicondyle was performed by placing the knee in 60° of flexion and incising the medial retinaculum horizontally, just distal to the VMO. This retinacular incision was extended from the adductor tubercle to the medial aspect of the patella at the junction of the proximal one third and distal two thirds corresponding to the native MPFL. A 2.4-mm guide pin was placed at this patellar insertion site to a depth of 20 mm. A reamer was used to drill the tunnel over the guide pin to a depth of 20 mm and a width equal to that of the folded-over semitendinosus tendon (usually 5 or 6 mm). A 2.4-mm pin with an eyelet (Arthrex, Naples, Florida) was used to drill divergent holes from the base of the docking tunnel, exiting the lateral aspect of the patella and piercing the skin. A minimum 1-cm bone bridge was created between the tunnels along the lateral aspect of the patella. Each pin was directed slightly anterior, to avoid penetrating the deep articular surface of the patella. The exit of the pins were palpated to ensure no penetration of the cartilage.

One free end of suture attached to the midportion of the folded graft was shuttled through each drill hole in the tunnel (Figure 1). The 2 suture ends exiting the lateral patella and skin were tensioned to dock the graft in the tunnel until the graft bottomed out in the tunnel. An arthroscopic probe was used to retrieve the sutures from the lateral aspect of the patella through the prepatellar bursal space that was created. With the patella positioned medially by manual translation, the suture limbs were hand-tied by placing the tying fingers into the mobile prepatellar bursa. The sutures were then cut just above the

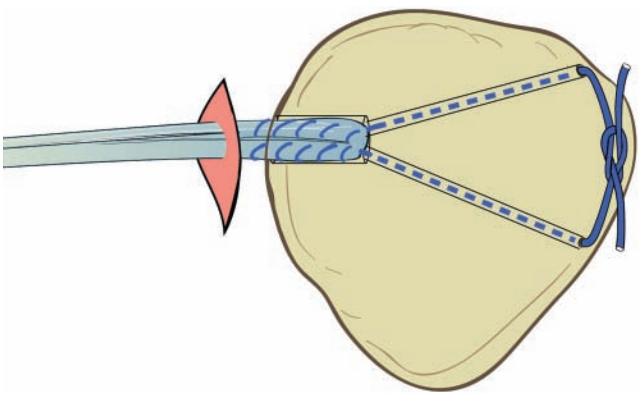

Figure 2. Suture tied over the lateral patella, securing the graft in the docking tunnel. From "The Docking Technique for Medial Patellofemoral Ligament Reconstruction," Gabriel D. Brown, Christopher S. Ahmad, *Operative Techniques in Orthopaedics*. October 2007 (Vol. 17, Issue 4, Pages 216-222). Reprinted with permission from Elsevier.

knot. The security of the fixation was checked by forcefully pulling on the graft in the direction exiting the tunnel (Figure 2).

The site of origin of the MPFL on the medial femoral epicondyle was identified adjacent and proximal to the origin of the superficial medial collateral ligament. A guide pin was placed at the site of origin and directed slightly anterior and superior to avoid penetration of the condyle posteriorly. The graft was wrapped over the guide pin, and isometry was evaluated by flexing and extending the knee while holding gentle tension on the graft draped over the guide pin. If the graft moved more than 3 mm relative to the guide pin, it was considered an anisometric position. The guide pin was repositioned in the medial femoral epicondyle as needed (usually to a more inferior and posterior position) until an isometric femoral fixation point was obtained. A 7-mm reamer was used to drill a tunnel over the guide pin to a depth of 25 mm. The patella was held reduced in the trochlea with the knee flexed to 60°. With the knee in 60° of flexion, the patella remains stable, in a reproducible position relative to the trochlea, owing to the trochlear geometry and the force on the patella from the passive tension of the quadriceps muscles. The medial-lateral patella position, when the graft is fixed, is thus not a subjective determination by the surgeon. The graft was positioned over the femoral tunnel and marked. The 2 graft strands were whipstitched with a No. 2 nonabsorbable suture for 20 mm from the site of entrance into the tunnel, as marked. A Bio-Tenodesis screw (Arthrex) was then used to fix the graft, with the knee in 60° of flexion.[22,23] With this system, the Bio-Tenodesis driver is used to tension the graft into the tunnel with a free looped suture that circles the graft and goes through the cannulation of the driver. The tip of the driver is positioned 20 to 25 mm distal on the graft, and the sutures are pulled tight at the far end of the driver to hold the graft fixed to the tip of the driver. The tip of the driver is then inserted into the tunnel with the graft, which tensions the graft into the tunnel. The

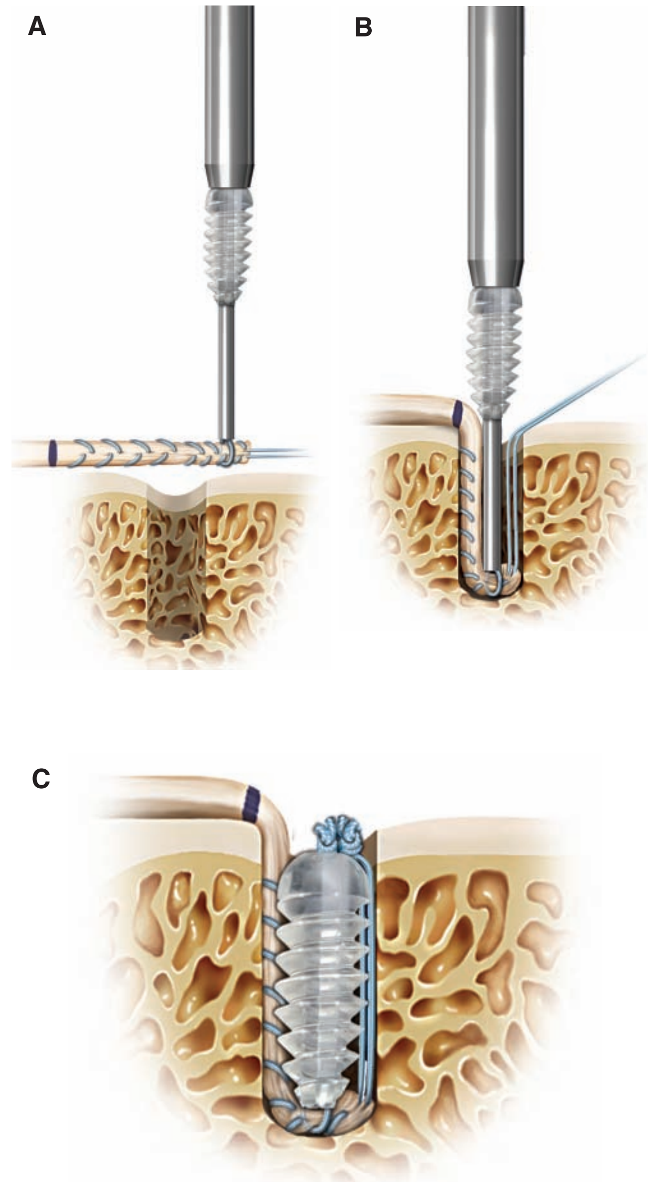

Figure 3. Bio-Tenodesis (Arthrex, Naples, Florida) screw fixation technique. A, A free looped suture circles the graft and goes through the cannulation of the driver. B, The suture at the far end of the driver is pulled tight to hold the graft fixed to the tip of the driver as the driver is advanced into the tunnel. C, The screw is then advanced over the tip of the driver. Reprinted with permission from Arthrex.

screw is then advanced over the tip of the driver by turning the handle while the tip of the diver keeps the graft positioned and tensioned in the tunnel (Figure 3). The sutures exiting the Bio-Tenodesis screw were tied over the screw to the sutures used to control the 2 free ends of the tendon, thereby creating a combined interference screw and suture anchor fixation construct (Figure 4).

Completion of the MPFL reconstruction was performed by imbrication and suturing of the VMO distally to the

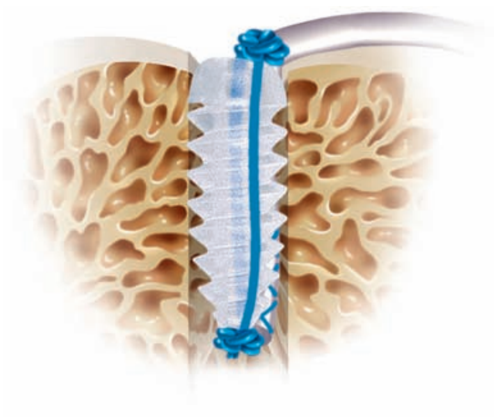

Figure 4. Combined interference fixation and suture fixation construct. Reprinted with permission from Arthrex.

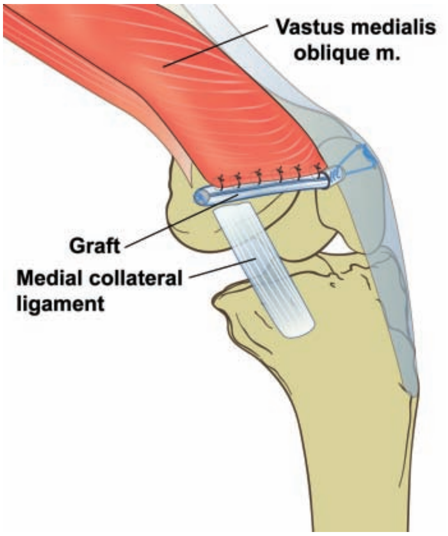

Figure 5. Completed medial patellofemoral ligament reconstruction with the graft sutured to the vastus medialis oblique muscle for dynamization. From "The Docking Technique for Medial Patellofemoral Ligament Reconstruction," Gabriel D. Brown, Christopher S. Ahmad, *Operative Techniques in Orthopaedics*. October 2007 (Vol. 17, Issue 4, Pages 216-222). Reprinted with permission from Elsevier.

inferior medial retinaculum and to the MPFL graft with multiple interrupted No. 0 nonabsorbable braided suture. The horizontal incision in the medial soft tissues facilitates an inferior advancement of the VMO, which potentially increases its function as a medial stabilizer. Furthermore, suturing the VMO to the MPFL graft will tension the graft when the VMO is activated, which can dynamize the MPFL and provide further medial soft tissue support to the patella (Figure 5). At this point, the knee is flexed from full extension to 110° of flexion to ensure that the reconstruction has not constrained knee motion and to confirm proper patella tracking. The incisions are closed, and the patient's knee is placed in a brace locked in full extension to permit ambulation with full weightbearing without quadriceps activity.

Patients were weightbearing, as tolerated, with the knee brace locked in full extension for 6 weeks postoperatively. Quadriceps muscle strengthening was immediately initiated. Per the direct supervision of a physical therapist, active and passive range of motion exercises were initiated 2 weeks postoperatively. Aggressive quadriceps, hamstring, and hip muscle strengthening were initiated after 6 weeks, and running and agility training were progressed after 12 weeks. Patients typically returned to full athletic participation 4 months postoperatively.

TABLE 5
Patients (n) With Patellofemoral Chondral Defects Noted Arthroscopically, by Outerbridge Classification

	Grade 1	Grade 2	Grade 3	Grade 4	Overall
Medial patella facet	1	2	6	2	11
Lateral patella facet	—	1	1	—	2
Medial trochlea	—	—	2	—	2
Lateral trochlea	—	—	3	2	5

RESULTS

Preoperative physical examination was positive for lateral patellar apprehension in all patients, whereas none remained apprehensive at most recent follow-up. There were no reported recurrent episodes of dislocation or subluxation postoperatively. The mean lateral quadrant translation was 3.5 preoperatively and 1.8 postoperatively ($P < .001$). The end point to lateral patellar translation was soft in all patients preoperatively and firm in all patients at the most recent follow-up examination. The average preoperative Q angle of patients who were treated was 18° (range, 12°-25°). Four patients had patella alta (as measured by Insall-Salvati ratios >1.2), and 6 had patella alta (as measured by Blackburne-Peel ratios >1.0), including the 4 patients with high Insall-Salvati ratios. Table 1 notes additional physical examination findings. The IKDC subjective knee evaluation, Lysholm, Kujala, and Tegner scores all statistically improved from preoperative values to most recent follow-up (Table 4). Knee stiffness developed postoperatively in 1 patient but resolved after 4 months of aggressive physical therapy. There was no preoperative extension lag or postoperative extension lag noted at final follow-up.

Table 2 presents preoperative radiographic parameters. Available MRI scans revealed tears or attenuation of the MPFL in 11 of 18 patients (61%). Table 3 lists additional MRI findings.

Intraoperatively, chondral defects of the patella or trochlea were noted in 16 patients (80%) and graded by the Outerbridge classification (Table 5).[29,30] The most common sites of chondral injury were the medial facet of the patella and the lateral trochlea. Additional intraoperative findings included hypoplasia of the lateral femoral condyle in 5 patients. Concomitant procedures included lateral release in 12 patients and chondroplasty in 7 patients.

DISCUSSION

Multiple surgical procedures described in the literature address patellar instability, and they have been characterized as proximal soft tissue, distal realignment, and combined procedures.[8-10,27,28,33,35] The presence of osseous abnormalities—including excessive femoral anteversion, hypoplasia of the lateral femoral condyle, a shallow femoral sulcus, external tibial torsion, and malalignment of the lower extremity—are indications for osseous distal realignment procedures.

In the absence of osseous abnormalities, the medial soft tissue restraints are responsible for lateral patellar stability.[7,11,17] These restraints include the MPFL, medial patellotibial ligaments, and VMO. Cadaver studies indicate that the MPFL is the primary soft tissue restraint against lateral patellar translation. Conlan et al[7] sectioned the MPFL, medial retinaculum, medial patellotibial, and patellomeniscal ligaments and found that the MPFL contributes 53% of the medial restraining force against lateral patellar translation. In a similar study, Hautamaa et al[17] reported that isolated release of the MPFL resulted in a 50% increase in lateral patellar translation and that repair of the ligament restored patellar stability. Similarly, Desio et al[11] found the MPFL to contribute 60% of the total medial restraining force to lateral patellar translation.

These biomechanical studies have led to the development of numerous surgical procedures that address patellar instability by reconstructing the MPFL. In 2003, Deie et al[10] reported on 4 patients who were treated with an MPFL reconstruction that harvested the semitendinosus tendon proximally and left the distal insertion intact. The tendon was routed through the superficial medial collateral ligament and fixed to the patella by passage through a bone tunnel in the adult patient or by suture to the anterior surface of the patella in skeletally immature patients. No recurrent patellar dislocations were reported. In 2004, Ellera Gomes et al[14] reported on 15 patients, using the semitendinosus tendon secured by suture to the lateral retinaculum and adductor magnus tendon after passage through bone tunnels in the patella and medial femoral condyle, respectively. Good to excellent results were reported in the majority of their patients. In 2005, Schottle et al[33] reported on 12 patients with suture anchor fixation of the semitendinosus tendon to the medial patella and interference screw fixation to the femur. At 47-month follow-up, there was a statistically significant improvement in mean Kujala score. In 2006, Nomura and Inoue[27] reported on 12 patients with semitendinosus graft fixation to the medial femoral condyle with a screw and washer and to the anterior patella with suture after passage through a patellar bone tunnel. At 4.2-year follow-up, they reported statistically significant improvement in mean Kujala score. In 2007, LeGrand et al[24] secured the semitendinosus tendon to the patella by shuttling the graft through bone tunnels in the patella and securing the 2 free graft ends to the femur with an interference screw. In 2008, Christiansen et al[6] reported on 44 patients with 12 to 32 months of follow-up. Reconstruction was performed with gracilis tendon autograft looped through 2 transverse 4.5-mm drill holes in the patella and fixed to the medial femoral condyle with an interference screw. Recurrent patellar dislocation was reported in 1 patient, subluxation in 3 patients, and chronic knee pain in 4 patients, all of whom had cartilage injury noted at surgery. The Kujala knee function score improved overall from 46 to 84 points.

Medial patellofemoral ligament isometry is important to the success of the reconstruction.[13,34] The junction of the superior one third and inferior two thirds of the patella were found to be the most isometric.[34] The optimal femoral placement was 10 mm distal and 5 mm posterior to the adductor tubercle. Elias and Cosgarea[13] evaluated graft placement in MPFL reconstruction and cautioned the surgeon to assess isometry and proper graft placement to avoid increasing patellofemoral contact pressures with an anisometric malpositioned graft. We fix the graft to the femur with the knee flexed to 60° because maximal graft length has been reported in this position.[34] This position therefore avoids overtightening the graft. In addition, at this knee flexion angle, the patella assumes its normal and reproducible position because of passive tension of the quadriceps and the patellofemoral articulation. Therefore, medial-lateral position of the patella is not a subjective determination by the surgeon. Our technique also allows assessment of graft isometry before commitment to tunnel location on the femur. This is the first study reporting results that facilitate the assessment of accurate graft isometry before tunnel placement.

Medial patellofemoral ligament reconstruction using the docking technique permits accurate isometric placement of the graft, with low risk of injury to the chondral surface of the patella. The small guide pins allow significant control when drilling across the patella, thus reducing the risk of iatrogenic injury to the articular surface of the patella intraoperatively. The small size of the pins also reduces the risk of patellar fracture intraoperatively and postoperatively. Fixation of the graft through the patella by the docking technique permits secure fixation using an established technique adapted from medial collateral ligament reconstruction of the elbow.[1,12] The graft is also permitted to heal in a bone tunnel, allowing for increased surface area for graft-to-bone healing. The femoral fixation of the graft is a strong combined interference screw and suture anchor fixation construct.[1,12]

The VMO is the essential dynamic stabilizer to lateral patellar translation.[16,20] Several studies demonstrate VMO injury with patellar dislocation, particularly with detachment of the MPFL off the femoral epicondyle.[8-10,27,28,33,35] Our technique is designed to improve the function of the VMO, in addition to the MPFL reconstruction, but we did not test and cannot prove in this study that suturing the VMO to the graft improves VMO or MPFL function.

Several limitations to this study must be considered. The postoperative evaluations were not blinded and there was no control group; however, our IKDC, Lysholm, Kujala, and Tegner results compare favorably with previous studies. All patients returned to preoperative levels of function and athletic participation after surgery. We did not encounter any intraoperative complications. Postoperative knee stiffness in 1 patient resolved by 4 months with aggressive physical therapy. We therefore conclude that MPFL reconstruction with the docking technique is safe (given that we observed no complications) and effective (because no postoperative subluxations or dislocations were observed in this case series). Patients reported high satisfaction with their outcomes and returned to preinjury function.

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