DIAGNOSIS AND SURGICAL CORRECTION OF MEDIAL PATELLAR SUBLUXATION

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This article reviews the clinical entity of medial patellar subluxation, including relevant anatomic and biomechanical factors. Most cases of medial patellar subluxation occur as a late complication of lateral retinacular release. Symptoms include pain, disability, crepitus, and intermittent swelling. Clinical signs include subluxation of the patella with manual medial glide, an observable defect in the vastus lateralis tendon, and positive apprehension with medial patellar glide. The application of various imaging methods is also presented. Finally, the authors review several surgical procedures for correction of medial patellar subluxation.
KEY WORDS: patella, knee, instability, reconstruction

Medial subluxation of the patella occurs as the apex of the articular surface of the patella translates medially in the femoral trochlea toward the medial femoral condyle. Abnormal medial excursion of the patella is normally prevented by several lateral static and dynamic stabilizing structures, including the lateral retinaculum, the lateral patellotibial ligament, the lateral epicondopatellar ligament, the vastus lateralis, and the vastus lateralis obliquus.[1,2] Medial subluxation of the patella is most often seen as a late complication of lateral retinacular release surgery (LRR), in which these lateral structures are sectioned.[3,4]

Hughston and Deese[3] first recognized and reported this condition. Among 54 patients (60 knees) referred to the investigators for failed LRR, 30 (50%) were diagnosed with medial subluxation of the patella. Of the 125 reported cases of clinically evident medial patellar subluxation the authors found in the literature, 117 (94%) reported undergoing a previous LRR procedure that was followed by an increase in pain, crepitus, or instability.[4-13] The incidence of medial patellar subluxation after LRR, however, has not been formally studied.

Betz et al[5] reported a single case of medial patellar subluxation as a late complication of LRR surgery among a review of 34 patients. In 2 widely cited articles describing arthroscopic LRR procedures, none of the 121 patients (138 knees) had a complication of medial subluxation at 12 to 58 months of follow-up.[14,15] Both articles described LRR procedures that included completely releasing the lateral synovium, the lateral retinaculum, and the entire vastus lateralis tendon.[14,15] Similarly, Sherman et al[16] reported no cases of medial subluxation at 24 to 32 months of follow-up in 40 patients (47 knees) undergoing LRR. However, in a follow-up report of 117 patients (141 knees) who had undergone LRR, Kolowich et al[7] found that 16 patients (14%) "required vastus lateralis repair for over-release of the lateral structures."[7] Most of these 16 patients had "demonstrated medial subluxation."

Hughston and Deese[3] attributed medial patellar subluxation after LRR to several factors, including the lack of a definitive preoperative diagnosis, poorly identified surgical indications, lack of conservative care before performing LRR, multiple prior knee surgeries, and a complete detachment of the tendinous insertion of the vastus lateralis and the lateral patellotibial ligament.[3] In particular, detaching the vastus lateralis has been proposed as a significant contributor to medial patellar subluxation.[1,17]

Typical LRR procedures resect the superficial and deep retinaculum from the lateral patellar border, including the lateral epicondopatellar and patellotibial ligaments.[1] In addition, the fibers of the vastus lateralis obliquus may be resected to reduce lateral force vectors acting on the patella.[14-18] Some surgeons have recommended extending the release proximally to include the entire vastus lateralis portion of the quadriceps tendon to its distal musculotendinous junction with the rectus femoris.[14,15] Others have stated that releasing the vastus lateralis tendon may produce complications, including medial patellar subluxation.

ANATOMY AND BIOMECHANICS

The patella is stabilized in the femoral trochlea through bony, static, and dynamic soft-tissue mechanisms.[6] The femoral condyles, which form the trochlea, provide a bony barrier to horizontal movement of the patella. The contribution of this bony barrier to patellar stability increases with increased flexion of the knee as the patella engages the trochlea.

Static soft-tissue restraints include the lateral patellotibial ligament, attaching the patella to the lateral meniscus and the tibia, and the epicondopatellar ligament, attaching the patella to the lateral femoral epicondyle and

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lateral intermuscular septum.[2,6,19] These structures are tendinous expansions of the distal and proximal lateral patellar retinaculum, respectively.[2,19]

The lateral retinaculum attaches the lateral patella to the tibia and the surrounding soft tissues.[6,19] The lateral retinaculum consists of a deep transverse portion, which attaches to the lateral patella, and a superficial oblique portion, which inserts on the lateral quadriceps tendon, the lateral patella, and the lateral patellar tendon.[2,19] The origin of the lateral retinaculum allows dynamic input to the patella.[6,19,20]

The primary muscular stabilizer of the patella is the quadriceps, which inserts at vertical and oblique angles on the superior patella.[20,21] The vastus lateralis contribution to patellar stability is somewhat complex. The majority of the vastus lateralis contribution to the quadriceps tendon inserts nearly vertically on the superior-lateral patella. Vastus lateralis oblique fibers, however, originate on the femur and the lateral intermuscular septum, with tendinous insertions at an oblique angle on either the lateral portion of the quadriceps tendon or on the superficial lateral retinaculum near the lateral patellar border.[20] In addition, the vastus lateralis portion of the quadriceps tendon does not always completely traverse the patella to join the patellar tendon. This lack of distal continuity alters the patellofemoral and knee extension force vectors that are produced by vastus lateralis oblique activity.[20] The entire lateral complex controls patellar glide during flexion and extension of the knee and minimizes horizontal translation.

Using cross-sectional kinematic magnetic resonance imaging at 5°, 10°, 15°, 20°, 25°, and 30° of knee flexion with the patient's quadriceps relaxed, Shellock et al[22] have described several types of patellar instability. Lateral subluxation occurs when the apex of the patella shifts laterally with respect to the femoral trochlea at any point in the range of motion. Excessive lateral pressure syndrome is a consistent lateral tilting of the patella without subluxation. Dislocation occurs with complete lateral displacement of the patella from the femoral trochlea. Medial subluxation occurs when the apex of the patella shifts medially with respect to the trochlea at any point in the range of motion. Shellock et al[22] also described a lateral-to-medial subluxation syndrome, in which the patella is laterally displaced on knee extension but becomes medially displaced with increasing knee flexion. A similar clinical phenomena was noted in several patients by Hughston and Deese.[3]

In 130 patients (235 symptomatic knees), only 23 of whom had undergone previous surgery, Shellock et al[22] found 106 knees (41%) with medial subluxation and 19 knees (7%) with lateral-to-medial subluxation. According to the technical criteria described by Shellock et al,[22] medial subluxation may be a far more common clinical entity than previously described. Of the 14 knees in the study that had undergone LRR, 13 (93%) had medial patellar subluxation according to the kinematic magnetic resonance imaging criteria.[22]

Shellock et al[22] also found that several of the patients in their study had a lateral patellar subluxation in the early stages of knee flexion despite relaxed quadriceps and redundancy of the lateral retinaculum evident on the magnetic resonance image.[22] This suggests that the lateral retinaculum and vastus lateralis are not the only factors contributing to lateral patellar subluxation. Lateral subluxation in these subjects may have been a result of an incompetent medial retinaculum or an insufficient vastus medialis.[22] The relatively high proportion of patients with medial or lateral-to-medial patellar subluxation led Shellock et al[22] to propose that performing LRR in patients with these conditions predisposed them to medial patellar subluxation. The investigators also noted that the clinical presentation (ie, joint pain, "joint laxity," positive apprehension) of patients with medial patellar subluxation did not differ from patients with lateral patellar subluxation.[22] However, Shellock et al[22] did not report whether their subjects had abnormal motion with the manual or gravity patellar glide tests that have been described by other investigators to diagnose medial patellar subluxation.[3,4,10] Shellock et al[22] proposed that symptomatic medial patellar subluxation (although often unrecognized) may not exist strictly as a complication of LRR but may be a unique clinical phenomenon.

Indications and procedures for performing LRR have been described elsewhere and will not be extensively reviewed in this article.[1,5,6,14,15] Relative to medial patellar subluxation as a complication, however, several points are warranted. Universally, the procedure involves sectioning the synovium, lateral superficial and deep retinaculum, lateral patellotibial ligament, and lateral epicondopatellar ligament.[5-7,14-16] Some techniques also release the entire vastus lateralis tendon from the superior patella.[14,15] The release of the vastus lateralis tendon has been proposed to contribute significantly to development of medial patellar subluxation after LRR.[3,7,10]

Recent biomechanical studies have shown the patella moves vertically, then medially during walking in healthy subjects.[23] This pattern is consistent with the observed pattern of electromyographic quadriceps activity. In a study of 2 patients with medial patellar subluxation, however, the patella deviated medially during the unloading phase of gait, whereas the quadriceps were inactive.[8] This suggests that medial patellar subluxation may be an effect of insufficient lateral retinaculum and the released lateral patellotibial and epicondopatellar ligaments rather than a failure of the vastus lateralis to control patellar motion.[8] In a series of 58 patients undergoing LRR of the retinaculum only (ie, not including the vastus lateralis tendon), Simpson and Barrett[24] reported no cases of medial subluxation as a complication, but considered failure to release the patellotibial ligament as a contributing factor to poor outcomes in 3 cases. Reconstruction of the lateral retinaculum and lateral patellofemoral ligament would be likely to reduce medial patellar subluxation. Repositioning the retracted vastus lateralis tendon alone may not restore patellar stability.

DIAGNOSIS

History

The association of medial patellar subluxation with a history of a failed LRR is very strong. The history almost invariably includes surgery involving the extensor mech-

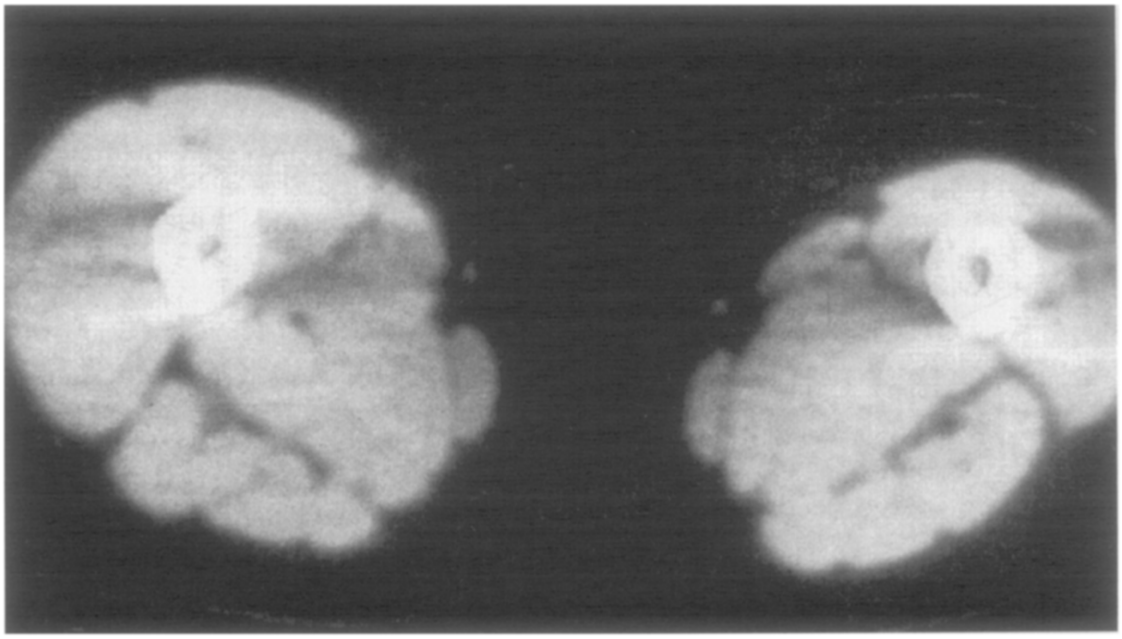

Fig 1. Bilateral computed axial tomography scan at midthigh showing atrophy and retraction of the vastus lateralis in the operative limb compared with the normal extremity. (Reprinted with permission.[3])

anism of the involved knee. Hughston and Deese[3] have noted that most patients in their series reported an apparently paradoxical increase in symptoms and decrease in functional ability after an LRR. Symptoms may include anterior knee pain, instability with activity, difficulty using stairs, popping or cracking, and intermittent swelling.[3,10] Patients have often been labeled as psychotic or malingering, or are receiving professional care for depression or anxiety related to their disability.[4]

Physical Examination

Several clinical signs have been described for identifying medial patellar subluxation. The definitive clinical sign is demonstrable medial patellar laxity relative to the contralateral knee or palpable medial patellar subluxation upon applying manual pressure to the lateral patella.[3,4,10] Additionally, Nonweiler and DeLee[10] have described a "gravity subluxation test." The patient lies in the lateral decubitus position with the involved leg superior and the knee in full extension. With the patient completely relaxed, the examiner abducts the leg and observes the patella. In patients with lateral retinacular laxity, the patella shifts medially and may visibly subluxate. On active quadriceps contraction by the patient, the patella remains medially displaced. This suggests complete dissociation of the vastus lateralis from the patella.[10] In patients with an intact vastus lateralis, the patella will reduce from the medially subluxated position with quadriceps contraction.[10]

Other signs may include notable atrophy of the vastus lateralis in comparison with the contralateral leg, and a "palpable and visible void" at the patellar insertion of the vastus lateralis tendon.[3] A positive patellar apprehension test, although often present, is not necessarily a definitive sign of patellar subluxation.[3] There may also be minimal-to-moderate knee joint effusion or painful patellofemoral crepitus.[3,10]

Imaging

"Skyline" or axial radiographic views of the patella and the trochlea at 30° of knee flexion have been advocated as an objective measure of medial (or lateral) patellar subluxation.[25] On these axial views, the "congruence angle" of the femoral trochlea, from the nadir of the trochlea to the apex of each femoral condyle, is bisected. A line is then drawn from the nadir of the trochlea to the most posterior point of the articular surface of the patella. If this patellar line lies medial to the bisection line, the patella is in a position of medial subluxation.[25] Beaconsfield et al[25] have stated that this patellar position could be caused by excessive lateral tilt due to overly tight lateral structures, although this would be unlikely in a patient with a history of LRR.

Imaging studies can also include gravity radiographs (identical to the clinical test previously described) to evaluate patellar position during passive and active quadriceps contraction.[10] Computed axial tomography scans can reveal the status of the vastus lateralis muscle and tendon at the patellar insertion (Fig 1), but are not routinely necessary.[3,18]

Kinematic magnetic resonance imaging (MRI) of the patella in various degrees of flexion has also been proposed.[12,22] Although kinematic MRI appears to have high specificity (ie, patients with anterior knee pain nearly always have abnormal results), sensitivity of the test (ie, proportion of subjects with abnormal results that have symptoms) has not been well established. Patellar position and motion may vary between patients for reasons other than pathology, such as positioning during imaging.[12] Results of imaging studies should augment the history and clinical examination findings when making a diagnosis.[7,12,25]

SURGICAL PROCEDURES

Indications

The indication for operative repair or reconstruction is demonstrable medial patellar subluxation after LRR that causes incapacitating pain and disability. Failure of conservative treatment, including supervised rehabilitation

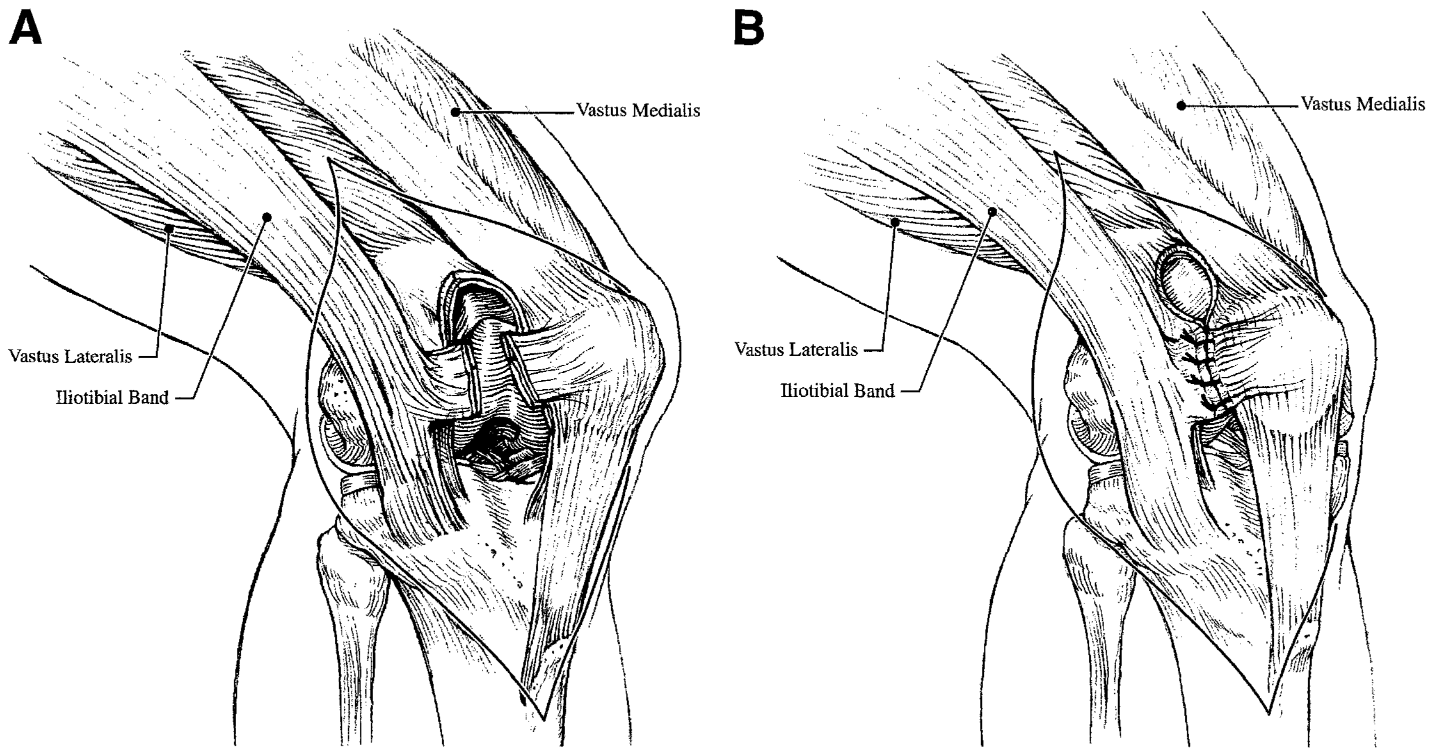

Fig 2. Direct retinacular repair using the side-to-side anastomosis technique. (A) Illustration before repair, (B) illustration of direct repair.

for several months, to improve symptoms or function, requires surgery.

Rationale

Hughston et al[4] have described 4 procedures to correct medial patellar subluxation after lateral retinacular release. These procedures repair or reconstruct the lateral patellar stabilizers and attempt to mobilize the retracted vastus lateralis tendon distally. For each procedure, the patient is placed under general anesthesia and the knee is positioned in 60° of flexion to place tension on the patellar tendon. The extensor mechanism is approached through a lateral parapatellar skin incision with dissection carried through the plane of the prepatellar bursa to create a medially based flap exposing the entire anterior aspect of the knee. With the extensor mechanism exposed, the knee is taken through an arc of motion to determine patellar tracking. Provocation tracking is observed by placing mild pressure on the inferior medial, then inferior lateral poles of the patella to determine whether the patella subluxates during tracking maneuvers. The degree of previous surgical retinacular release is noted as well as the degree of disruption of the lateral patellotibial and epicondopatellar ligaments. The degree of vastus lateralis retraction and atrophy is also noted. Choice of procedure depends on these findings.[4]

With each of the reconstruction procedures, it is essential to balance the tension of the reconstructed lateral patellotibial ligament so that the patella cannot be displaced medially while flexing and extending the knee. In addition, the relative tension between the reconstructed lateral patellotibial ligament and the patellar tendon should ensure that the reconstructed ligament will not assume the load of the patellar tendon in the process of extension or deceleration forces.

Direct Ligament Repair

Figures 2A and 2B show direct repair of the lateral retinacular fascia.[4] This procedure requires sufficient lateral retinacular tissue remaining for mobilization and suturing. Approximation and reanastomosis of the fascial layers is performed in a side-to-side manner. If the vastus lateralis tendon has previously been released and has retracted proximally, the surgeon tries to release the vastus lateralis tendon from its retracted position, mobilize it as far distally as possible, and centralize it on the quadriceps tendon for reattachment. A severely atrophied tendon often cannot be fully mobilized back to its original insertion on the patella.[4] A similar procedure involving imbrication of the lateral retinaculum has been described by Richman and Scheller.[11] Nonweiler and DeLee[10] also described imbrication of the lateral retinaculum with distal mobilization of the retracted vastus lateralis tendon, performing this procedure under sensory epidural anesthesia to evaluate the effect of active quadriceps contraction on sutures and patellar tracking.

These "direct repair" procedures repair the lateral retinaculum and lateral patellotibial ligament. It is important to carefully evaluate the quality of the lateral tissues. If tissue quality is poor, patellotibial ligament reconstruction using 1 of the procedures described in the following sections is required.

Reconstruction Using the Iliotibial Band

When there is insufficient fascia remaining laterally, reconstruction of the lateral patellotibial ligament is neces-

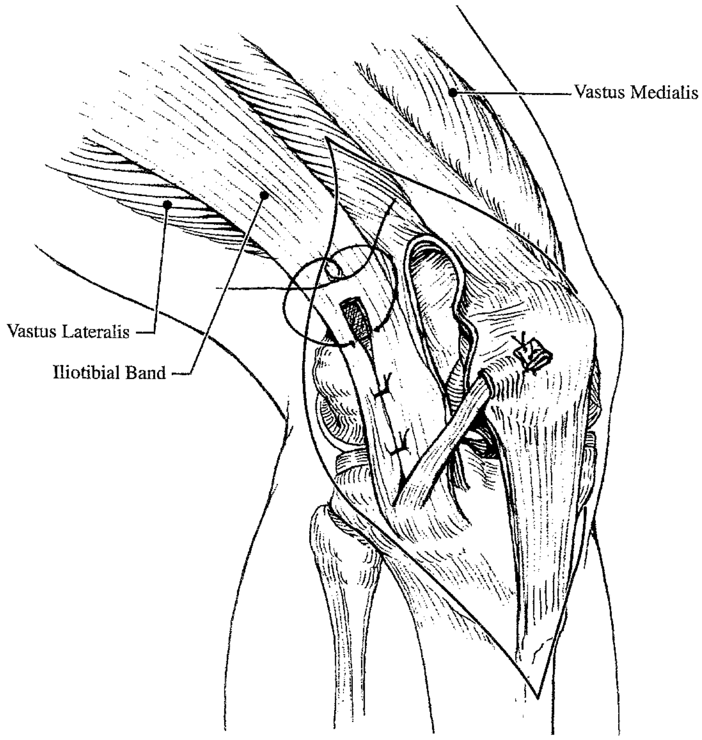

Fig 3. Reconstruction of the lateral patellotibial ligament using a strip of the iliotibial band. The surgeon sutures the strip to the periosteum or through a bony tunnel at the inferolateral pole of the patella.

sary[4] (Fig 3). Leaving the posterior section of the iliotibial band undisturbed, the surgeon can dissect a 1-cm strip approximately 3 to 4 cm in length, leaving the distal base attached to the lateral tibial tubercle (Gerdy's tubercle). The surgeon attaches this strip anteriorly to the lateral patella close to the lateral border of the patellar tendon. The transfer reproduces the anatomic location of the patellotibial ligament. The end of the iliotibial band strip is attached to the patella by tunneling through either the soft tissues overlying the patella or through the patella itself. The surgeon passes the strip through the tunnel, rolled back, and sutured on itself. If the vastus lateralis tendon has previously been released and has retracted proximally, the surgeon tries to mobilize it distally for centralized reattachment on the quadriceps tendon. With the knee at 60° flexion, any lateral retinaculum that falls into apposition is closed, but if a large gap in the retinaculum remains, it is not closed,[4] as closing a large gap would cause excessive lateral tension.

Reconstruction Using the Patellar Tendon

If there is insufficient tissue of both the lateral retinaculum and iliotibial band, the lateral one fourth of the patellar tendon can be detached from the tibial tubercle with or without a small bone block, leaving the proximal patellar attachment intact.[4] The surgeon attaches the distal end of the patellar tendon strip to the lateral tibial tubercle using direct suture to the soft tissues, by passing the strip through a bony tunnel at the lateral tibial tubercle, or sutures brought through the strip and anchored in the lateral tibial tubercle with a bone anchor (Fig 4). The vastus lateralis tendon, if retracted, is mobilized distally and reattached centrally on the quadriceps tendon. As mentioned, with the knee in 60° flexion, any lateral retinaculum falling into adequate apposition is closed.

Reconstruction Using the Iliotibial Band and Patellar Tendon

Hughston et al[4] also described a "combined" technique, shown in Figure 5, that rotates a strip of the patellar tendon toward the lateral tibial tubercle and rotates a strip of the iliotibial band toward the patella. Both tendon strips are routed beneath the iliopatellar band. They are tensioned and joined in a side-to-side anastomosis and sutured to the iliopatellar band, allowing dynamic input to the reconstructed patellotibial ligament. Again, the remaining retracted vastus lateralis tendon is mobilized distally to the quadriceps tendon and reattached, and any retinaculum falling into apposition is closed. This technique avoids the problems of tendon-to-bone healing and eases certain technical aspects of the procedure (ie, no bone tunnels).[4]

POSTOPERATIVE CARE AND REHABILITATION

Postoperatively, patients ambulate touch-down weightbearing with bilateral crutches and a knee immobilizer for 1 month. Quadriceps setting exercises are initiated on postoperative day 1, but no active extension or straight leg raising exercises are performed.[4] Active assisted or gentle passive flexion to 90° is performed. Flexion is not forced, and the motion returning into extension is strictly passive. Most patients should achieve 90° of knee flexion within 5

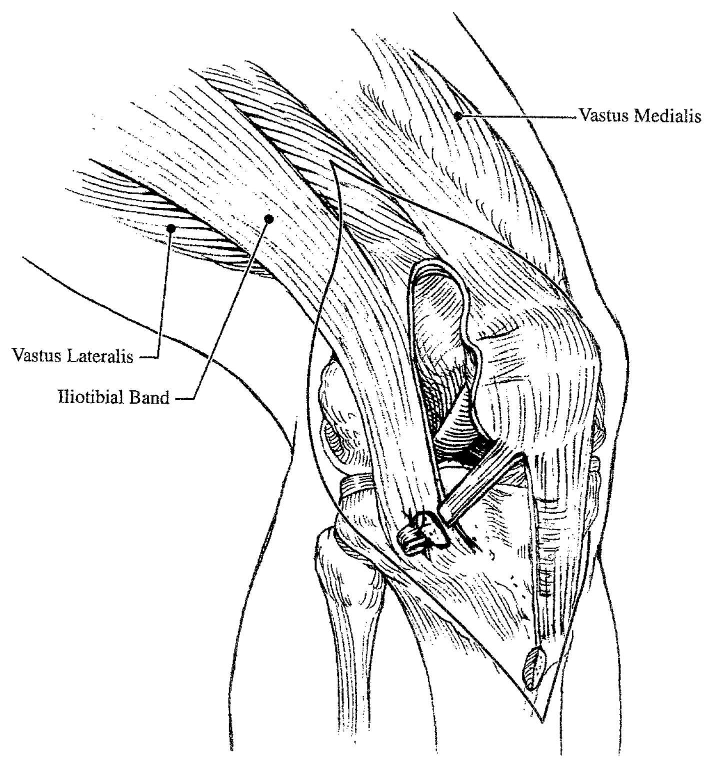

Fig 4. Reconstruction of the lateral patellotibial ligament using the lateral fourth of the patellar tendon. The surgeon sutures the strip to the periosteum or brings it through a bony tunnel at the lateral tibial tubercle.

days of surgery. Coincident with soft-tissue healing, straight leg raises are started at 4 to 6 weeks after surgery, with the goal to avoid an extensor lag. A progressive, functional rehabilitation program for the extensor mechanism begins after the patient regains approximately 80% of his or her normal motion and strength.[4]

OUTCOMES OF SURGICAL RECONSTRUCTION

Medial patellar subluxation is very disabling. In the series reported by Hughston et al,[4] 85% of the subjects with medial patellar subluxation could not perform light recreational activities (ie, activities not requiring lower extremity agility), and 78% reported they either required crutches or could walk only on even ground, could not climb stairs, and could perform only "sedentary" activities at work and home before undergoing reconstruction. Only 5 of 65 patients reported being able to participate in competitive sports. In addition, 69% of the patients reported having "severe" or "disabling" knee pain.

An average of 54 months (range, 24 to 99) after undergoing repair or reconstruction of the lateral patellar structures, 68% of the patients in the study by Hughston et al[4] had an improved functional ability level and only 14% still had severe or disabling pain. Regarding general subjective outcome, 49 of 65 (75%) knees improved, 5 (8%) were unchanged, and 5 (8%) were worse. Table 1 summarizes the results reported by Hughston et al.[4] The investigators noted that successful outcomes were obtained in only 22 of the first 33 procedures compared with 30 of the last 32 reported in the study, suggesting there is a learning curve for performing these reconstructive procedures.[4]

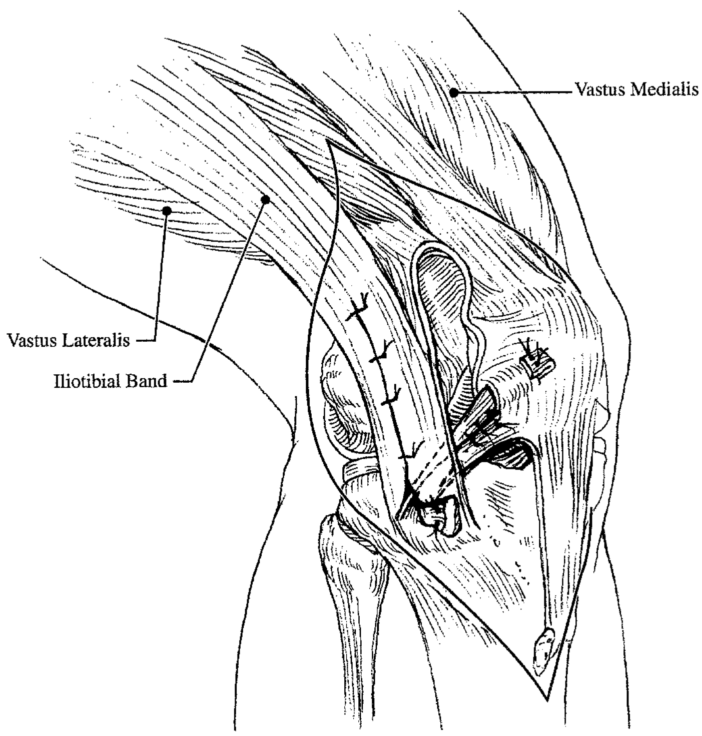

Fig 5. Reconstruction of the lateral patellotibial ligament using a strip of iliotibial band and the lateral fourth of the patellar tendon. Both strips are rotated toward one another, routed under the iliopatellar band, joined by side-to-side anastomosis, and sutured to the iliopatellar band. Tension in the reconstructed patellotibial ligament is adjusted by the relative apposition of the 2 strips of ligament before they are sutured together.

TABLE 1. Functional Level and Pain Reported by Patients Undergoing Lateral Retinacular Reconstruction for Medial Subluxation of the Patella*

	Preoperative		Follow-Up†	
	N	(%)	N	(%)
Functional level				
External support required, or sedentary activities of daily living only	51	(79)	13	(20)
Light or moderate recreational activity	11	(17)	23	(35)
Vigorous or competitive activity	3	(5)	23	(35)
Pain				
Severe or totally disabling pain	45	(69)	9	(14)
Moderate pain	16	(25)	11	(17)
None or mild pain	4	(6)	39	(60)

*N = 65.
†Six knees required surgical revisions and were classified as surgical failures.
Data from Hughston.[4]

After undergoing surgical correction of medial patellar subluxation, 6 of the 65 subjects (9%) required a surgical revision for failure to improve or reinjury.[4] Revision surgery occurred an average of 21 months (range, 11 to 52) after the lateral retinacular reconstruction procedure. Failures were attributed to technical errors (2 knees), reinjury (1 knee), and failure to appreciate the poor tissue quality of the lateral retinaculum at the time of reconstruction (3 knees).[4]

The surgical revisions, complications, and additional surgical procedures in the study by Hughston et al[4] can be explained by 2 factors. First, 46 (71%) of the subjects had undergone 2 or more unsuccessful previous surgeries before undergoing lateral retinacular reconstruction. The disability resulting from chronic injury and multiple failed surgical procedures tempered the results. The surgical procedures described are considered salvage procedures to attempt to correct the effects of prior failed surgery[4]; relatively higher complication rates and poorer outcomes can be expected. Second, Hughston et al[4] have acknowledged that the technical demands of the procedure are associated with a learning curve and that a relatively high number of the initial procedures were not successful. The success rate improved as experience with the procedure developed.

SUMMARY

Medial patellar subluxation often occurs as a complication of LRR, particularly after complete release of the vastus lateralis, but may also exist as an independent clinical entity. The diagnosis of medial patellar subluxation relies primarily on a history of increasing pain and disability after LRR, demonstrable manual subluxation of the patella medially, and an observable deficit in the vastus lateralis tendon at its normal insertion point on the superolateral pole of the patella. Imaging studies such as axial radiographs, computed axial tomography scans, or kinematic magnetic resonance may augment clinical findings. Indications for surgery include demonstrable medial patellar subluxation after LRR and failure of conservative care. Surgical procedures include direct repair of the lateral retinaculum or reconstruction of the lateral patellotibial ligament using an iliotibial band strip, a patellar tendon strip, or both. Concomitantly mobilizing the retracted vastus lateralis tendon and reattaching it to the quadriceps tendon restores dynamic stabilization.

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