When to Add Lateral Soft Tissue Balancing?

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Abstract: Lateral patellofemoral (PF) soft tissue abnormalities range from excessive lateral PF tightness (lateral patellar compression syndrome, lateral patellar instability and arthritis), to excessive laxity (iatrogenic lateral PF soft tissue insufficiency postlateral release). The lateral soft tissue complex is composed of the iliotibial band extension to the patella, the vastus lateralis tendon, the lateral PF ligament, lateral patellotibial ligament, and lateral patellomeniscal ligament, with intimate connections between those structures. To identify lateral retinaculum tightness or insufficiency the most important tests are the patellar glide test and patellar tilt test. Imaging aids in that evaluation relying mostly on the patella position assessed by radiographs, computed tomography, and magnetic resonance imaging with referencing to the posterior femoral condyles. Lateral retinaculum lengthening (preferred) or release may be added when there is excessive lateral retinaculum tightness. A lengthening may be performed using a minimally invasive approach without compromising the lateral patella restraint. Lateral retinaculum repair or reconstruction is indicated when there is lateral retinaculum insufficiency. Lateral retinaculum surgery to balance the medial/lateral soft tissue restraints, improves patellar positioning and clinical results.

Key Words: lateral retinaculum release, lateral retinaculum lengthening, patellar instability, patella dislocation

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Lateral patellofemoral (PF) soft tissue abnormalities include from excessive lateral PF tightness (lateral patellar compression syndrome), lateral patellar instability, PF arthritis and to excessive laxity (iatrogenic lateral PF soft tissue insufficiency postlateral release). In the setting of lateral patellar instability, it is often associated with medial ligamentous deficiency and can independently contribute to the axial imbalance of the PF joint.[1–3] This imbalance can be corrected by decreasing lateral tightness [lateral retinaculum release (LRR) or lengthening (LRL)] or by repair or reconstruction of the lateral retinaculum. However, after the medial restraints are lost, the next restraint to lateral displacement is the lateral retinaculum and thus the contra-indication of isolated lateral release to treat lateral patellar instability.

PERTINENT ANATOMY AND BIOMECHANICS

The lateral soft tissue complex is composed of the iliotibial band extension to the patella (ITB-patella), the vastus lateralis tendon, the lateral patellofemoral ligament (LPFL), lateral patellotibial ligament (LPTL), and lateral patellomeniscal ligament, with intimate connections between those structures.[4–8] The complex has superficial longitudinal fibers (superficial fibers of the ITB-patella) and deep transverse fibers (deep fibers of the ITB-patella, vastus lateralis, LPFL, LPTL, and lateral meniscal ligament).[4–8] The LPFL femoral insertion was found to be 19.7 mm anterior to the posterior end of lateral condyle and 16.5 mm proximal to the distal end of the lateral condyle;[9] and more frequently in the middle thirds in both the anteroposterior (75%) and proximo-distal axis (53.1%). The ITB-patellar band is the strongest, (load to failure 582 N), and stiffest (97 N/mm). The LPFL load to failure is 172 N, and stiffness 16 N/mm; the lateral patellomeniscal ligament load to failure is 85 N, with 13 N/mm stiffness.[6] These structural properties suggest that most of the load in vivo is transmitted to the patella by the iliotibial band extension to the patella.

EVALUATION OF LATERAL RETINACULUM TIGHTNESS

Diagnosis is based on the combined evaluation of the physical examination and imaging findings.

Increased lateral tilt can be suggestive of lateral retinaculum tightness. However, in patients with PF instability, lateral tilt is associated with several factors. Those are lateral retinaculum tightness, medial restraint insufficiency,[10] trochlea dysplasia,[1,2] and/or lateral quadriceps vector.[2] Hence, all of those factors should be evaluated before making a surgical decision.

To identify lateral retinaculum tightness or insufficiency the most important tests are the patellar glide test and patellar tilt test.

- Patellar glide test (Sage test): the patient is positioned supine with knee at full extension. For this test, one can divide the patella into 4 vertical quadrants and manually translate it medially and laterally. Medial displacement of <1 quadrant suggests lateral tightness, while > 3 suggests lateral excessive soft tissue laxity.[11]
- (Medial) patellar tilt test: the patient is positioned supine and the knee is relaxed in full extension. Examiner holds the patella between their thumb and forefinger, and pushes the medial patella border down in an attempt to tilt the lateral edge of the patella upwards (reversing tilt). Elevation of the lateral patella from 0 to 20 degrees is normal while <0 suggests lateral tightening and > 20 degrees suggests lateral soft tissue laxity.[11] In previously operated cases the patella may tilt up to 90 degrees in which case a complete lateral retinaculum insufficiency is assumed. In cases in which the patella is subluxated, it needs to be reduced in the groove before performing the medial tilt test. Should a relocation not be possible it indicates a chronically shortened lateral retinaculum.

The medial insufficiency contribution can also be better evaluated with the contralateral unaffected knee examination. When the tilt is similar in the contralateral (unaffected) knee, it suggests the medial deficiency is not an isolated reason for the

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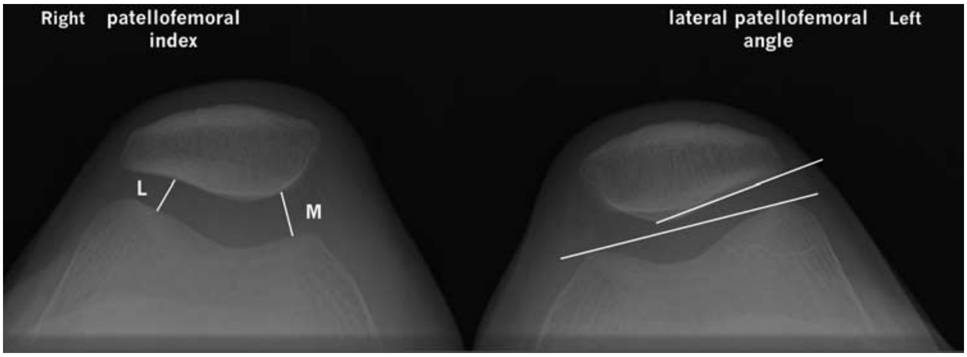

FIGURE 1. Merchant radiograph view of the right and left knee. Right knee; patellofemoral index is the ratio between the medial (M) and lateral (L) joint spaces M/L. Left knee; lateral patellofemoral angle is formed by the line tangent to the anterior points of the medial and lateral trochlear facets and the line tangent to the lateral patellar facet. © Copyright by B.B.H. and C.L.

angle of the lateral tilt, and lateral tightness may have a major role in that deformity and therefore should be corrected.[12]

Imaging evaluation relies mostly on the patella position assessed by axial radiographs, computed tomography (CT), and magnetic resonance imaging (MRI).

Axial radiograph Laurin view (20 to 30 degrees of flexion): the lateral PF angle and PF index can be evaluated. Lateral PF angle is formed by the line tangent to the anterior points of the medial and lateral trochlear facets and the line tangent to the lateral patellar facet (Fig. 1, left knee). In normal knees this angle opens laterally.[13] Images with progressive flexion can be very useful to verify the reduction of patellar tilt. The lack of reduction during early flexion suggests lateral tightness.[12] The PF index is the ratio between the medial (M) and lateral (L) joint spaces M/L (Fig. 1, right knee). Normal is <1.6.[14] This measure becomes difficult to evaluate in patients with arthritis of the PF joint as significant lateral joint space narrowing may affect this index.

CT and MRI: the patellar tilt angle formed by the transverse axis through the middle of the patella and a line tangent the posterior femoral condyles (Fig. 2). Tilt >20 degrees is increased and abnormal.[3] When the patellar height is normal both lines can be seen in the same axial cut. However, when there is patella alta they will be in different cuts. In that case, the posterior condylar line should be transferred to the image on which the transverse axis of the patella is obtained in order to perform the measurement. The lateral retinaculum itself can also be evaluated on the MRI. The normal retinaculum is not redundant with the patella reduced (Fig. 3). When there is increased tilt but the retinaculum is redundant (Fig. 4), the lateral soft by definition is not be the cause of the tilt, especially when other causes of tilt are present, trochlea dysplasia or increased quadriceps vector. On the other hand, if the retinaculum is "straight" or not redundant (Fig. 5) with subluxation present, it is more likely that it will be tight and restrict the patellar motion. In cases of previous retinaculum release, it is also possible to identify the defect on the soft tissue (Fig. 6).

FIGURE 2. Axial cut on computed tomography. Patellar tilt angle formed by the transverse axis through the middle of the patella and a line tangent the posterior femoral condyles. © Copyright by B.B.H. and C.L.

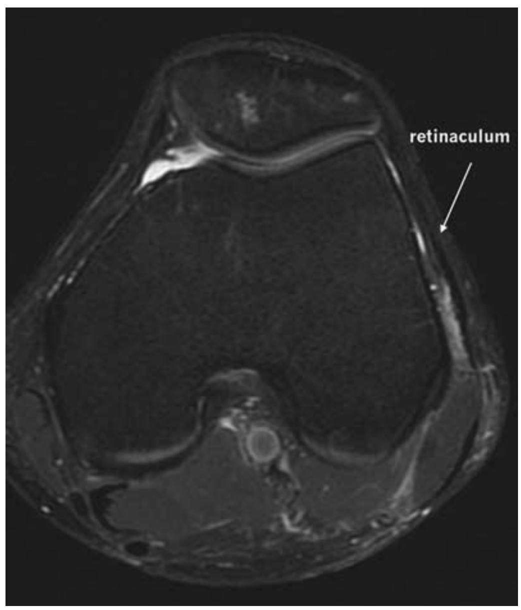

FIGURE 3. Axial cut on magnetic resonance imaging. Normal lateral retinaculum, it is not redundant with the patella reduced. © Copyright by B.B.H. and C.L.

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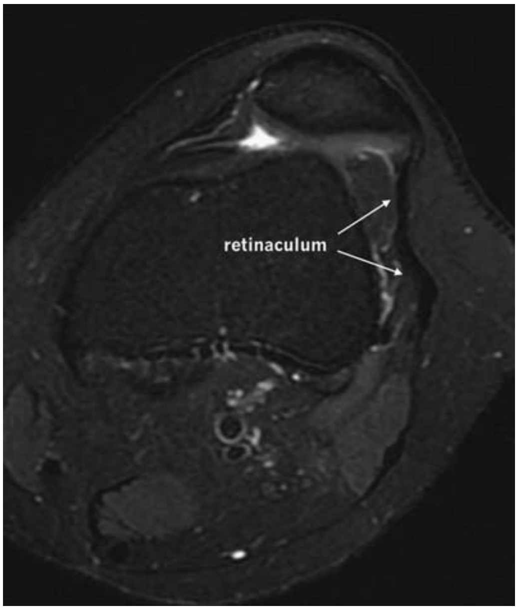

FIGURE 4. Axial cut on magnetic resonance imaging. Redundant lateral retinaculum. © Copyright by B.B.H. and C.L.

Trochlear dysplasia and large quadriceps vector are often associated with a pathologic lateral tilt. They may contribute to the tilt. When there is trochlea dysplasia the patellar position may be determined by the bony anatomy, as there is not a deep enough groove to permit reduction of the tilt. In that situation, performing a LRR/LRL without addressing the trochlea dysplasia is contra-indicated as more lateral laxity will not improve the patellar positioning or contact forces. Similarly, when there is an increased lateral quadriceps vector, as measured by increased quadriceps-angle (Q-angle), increased tibial tuberosity-trochlear groove distance (TT-TG) or increased TT-TG angle, the lateral tilt should not be corrected without addressing the underlying malalignment.

FIGURE 5. Axial cut on magnetic resonance imaging. Straight "tight" lateral retinaculum with patellar subluxation. © Copyright by B.B.H. and C.L.

FIGURE 6. Axial cut on magnetic resonance imaging. The lateral retinaculum is visualized, as well as a defect due to prior lateral retinaculum release. © Copyright by B.B.H. and C.L.

Thus, physical examination and imaging provide complementary information when making surgical decisions. While excessive lateral patellar tilt can easily be identified on imaging examinations, the contribution of lateral tightness must be verified by the physical examination. Isolated radiographic findings with a lack of clinical findings should not lead to a surgical procedure. That is, many patients with excessive lateral retinaculum tightness by clinical examination and imaging are not symptomatic. In the symptomatic patients with both positive radiographic findings and positive clinical findings, a surgical approach may be considered.

EVALUATION OF LATERAL RETINACULUM INSUFFICIENCY AND/OR MEDIAL PF INSTABILITY

Lateral retinaculum insufficiency is considered to be an iatrogenic condition (when excluding collagen diseases with pathalaxity) resulting from excessive lateral release, with no reports of medial instability after lateral lengthening to date.[15–20] The true incidence of iatrogenic medial instabilities is unknown because the reports in the literature are only case reports or small case series.[15–20] The most common symptoms are pain, swelling, and giving way that can be exacerbated by twisting/pivoting.[15,16,19,20] Commonly patients with medial instability will not be fully aware of the direction of displacement. Therefore, a thorough surgical history should be obtained to determine if this is a risk factor in these patients. Understandably, typical medial displacement patellar stabilization braces may aggravate the condition, whereas braces that apply lateral displacement forces to the patella may improve their symptoms. The diagnosis is obtained by clinical examination. Atrophy of the vastus lateralis muscle can be present.[16] Patients are often painful both at the medial and lateral PF joint or during palpation of the iatrogenic lateral release gap. The medial glide test is usually positive and typically the medial apprehension test is positive.[15,16,19,20] The positive gravity subluxation test can be helpful, specifically in patients with generalized laxity.[19] This test is performed with the patient in contralateral decubitus. The hip is abducted and the quadriceps relaxed by extending the knee. In this position, the patella subluxes medially. The patella can be passively pushed back into the groove but it does not reduce with quadriceps contraction.[19] Imaging examinations can be helpful. The medial subluxation can be visible in extension in cases with isolated medial instability; or in cases with medial and lateral instability (patients with lateral patellar instability that are treated with isolated lateral release) there can be lateral subluxation in extension with medial subluxation with progressive flexion.[17,20]

INDICATIONS FOR ADDRESSING LATERAL RETINACULUM TIGHTNESS

LRL or release should only be done as an adjunct procedure in patients with PF instability and should be added when there is lateral retinaculum tightness (as diagnosed above). Done in isolation for PF instability, it will not address the medial patellar restraints insufficiency and will remove the next restraint to lateral displacement potentially increasing the lateral instability. Thus, medial patellofemoral ligament reconstruction (MPFL) is the "common denominator" for the treatment of lateral PF instability. Most commonly, LRR/LRL are needed in the subset of PF instability patients that have concomitant maltracking, therefore, it is, more often than not, performed in association with bony realignment procedures (eg, tibial tuberosity osteotomy—TTO, and trochleoplasty). If the underlying bony deformities are not addressed, isolate LRR/LRL will not correct patellar positioning.

LRR Versus Lengthening

LRR was first described in 1891 for the treatment of patellar instability and subsequently used for the treatment of lateral patellar hypercompression syndrome associated with a tight lateral retinaculum (often associated with lateral patellar tracking, joint overload, degeneration, and anterior knee pain). Metcalf further popularized the procedure by describing an arthroscopic technique as a less invasive procedure. Despite superficially appearing to be "minimally invasive," the arthroscopic technique can be more extensive (or "invasive") than an open approach. As proximal and distal releases are performed from "inside out," greater disruption of the capsule and muscle are required to reach the release of the more superficial layers. A complete LRR decreases by almost 20% the force needed to displace the patella 10 mm laterally in early flexion.[21]

Z-plasty type of lengthening of the lateral retinaculum was described as an alternative procedure to maintain lateral patellar soft tissue integrity while decreasing the tension of the lateral tissue restraints.[22]

In many cases, the maintenance of lateral soft tissue control with LRL is preferable to an arthroscopic or open release with very few exceptions. It is straightforward and can be performed with a minimally invasive technique without compromising the lateral patella restraint.

LRR TECHNIQUE

LRR can be performed open, via a small 2 to 3 cm lateral parapatellar incision (if done in isolation), through a traditional midline incision or arthroscopically. For the open technique, the lateral retinaculum can be reached by an anterior skin incision that gives access to both medial (for the MPFL reconstruction) and lateral patellar side. Alternatively, the lateral retinaculum may be approached through a separate skin incision approximately the length of the patella and just in the lateral boarder of the patella and can be utilized. The lateral soft tissue complex is just deep to the subcutaneous tissue. Incise the superficial layer ~1 cm lateral to the patella starting at the distal end of vastus lateralis and extending (at times distally to the tibial tuberosity). Hemostasis of the superior and inferior lateral genicular arteries close to the superior and inferior patellar borders should be performed to prevent significant bleeding and hemarthrosis.[23] Open techniques have the advantage allowing maintenance of joint capsule. All-arthroscopic techniques involve cutting through the capsule to access the lateral retinaculum using electrocautery.

LRL TECHNIQUE

There are 2 distinct layers of the lateral patellar retinaculum, readily identified during surgery. They are, the superficial oblique fibers from the anterior iliotibial band and the deep transverse fibers from the femur, attaching on the superior lateral patella is essential in this technique of LRL. First, the fascia lata should be detached from the vastus lateralis. This releases some lateral tension and also helps the identification of the superficial and deep layer. The proximal lateral soft tissues of the patella are exposed and the outer oblique layer of the lateral retinaculum is incised close to the lateral border of the patella. With a scalpel, the superficial oblique fibers of the retinaculum are sharply dissected from the deep transverse fibers and elevated as dissection is carried posteriorly to the posterior most extent of the retinaculum envelope (usually for ~1 to 2 cm) (Figs. 7, 8). The deep transverse fibers are incised longitudinally at the posterior margin (Fig. 9). If needed to gain mobilization, the capsule can be incised along with the deep transverse fibers. The knee is then positioned at the position that sets the lateral retinaculum to length (where the 2 layers are further apart). This will be somewhere between 30 and 60 degrees of flexion. The cut edges of the superficial oblique and deep transverse fibers are then sutured together using absorbable suture with the appropriate amount of lengthening to remove excess tension in lateral structures while keeping lateral soft tissue integrity (Fig. 10). Figure 11 is an illustration of the steps of the procedure. It is important to note that neither the MPFL nor the LR are "tensioned" but rather "adjusted" in their length as they simply act as a

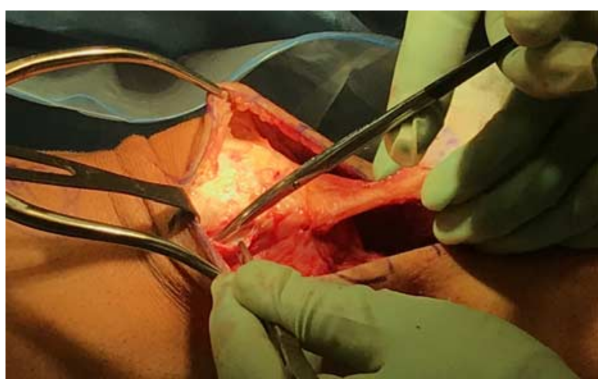

FIGURE 7. Lateral retinaculum lengthening in the right knee. Dissection being performed between the superficial and deep layers of the lateral retinaculum. © Copyright by B.B.H. and C.L.

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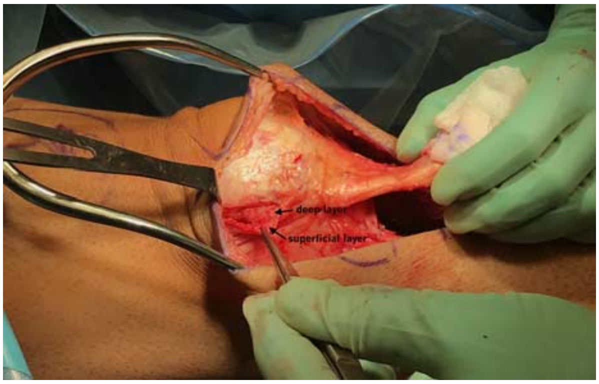

FIGURE 8. Lateral retinaculum lengthening in the right knee. The superficial and deep layers of the lateral retinaculum can be observed. Superficial layer being retracted. © Copyright by B.B.H. and C.L.

checkrein to guide the patella. If this procedure is done in conjunction with a tibial tubercle transfer (medial and/or distal) or an MPFL reconstruction, the tubercle fixation is performed first followed by a preliminary setting of the medial restraint (MPFL).

LATERAL RETINACULUM PLASTY (LRP)

Liu et al[25] and Niu et al[26] have described this procedure as an alternative to LRL or LRL to be performed in the setting of primary surgery. This technique may be more suited in the case of thin lateral soft tissue which precludes standard LRL technique or in the revision setting after LRR. A section in the lateral patellar retinaculum 1 to 2 cm wide along the line from the lateral upper margin of the patella to the lateral femoral condyle is grafted to the junction of the lateral patellar retinaculum and the tensor fasciae lata. The free end of the lateral patellar retinaculum is pulled to the center of the patellar lateral edge and fixed on the lateral edge of the patella with absorbable suture with transposition of part of the posterior lateral retinaculum to the patella, adding a restraint to medial translation.

TREATING THE LATERAL RETINACULUM INSUFFICIENCY

Indicated when there is lateral retinaculum insufficiency as described above. Contrary to lateral patellofemoral instability

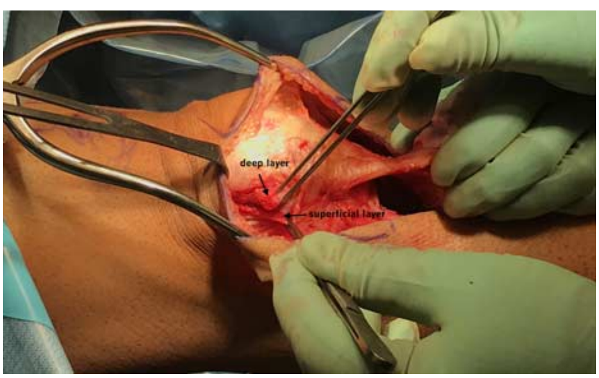

FIGURE 9. Lateral retinaculum lengthening in the right knee. The deep transverse fibers are incised longitudinally at the posterior margin, and that margin is free. © Copyright by B.B.H. and C.L.

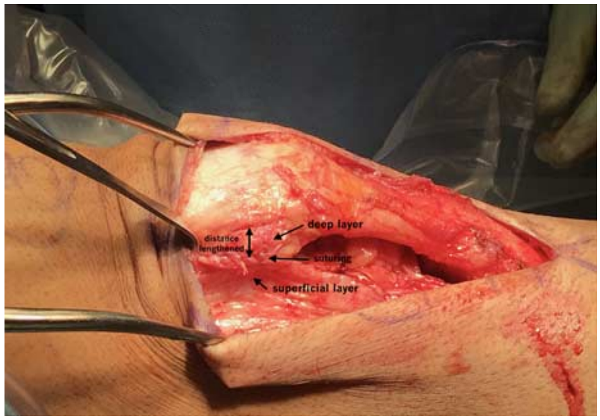

FIGURE 10. Lateral retinaculum lengthening in the right knee. The cut edges of the superficial oblique and deep transverse fibers are sutured together using absorbable suture with the appropriate amount of lengthening to remove excess tension in lateral structures while keeping lateral soft tissue integrity. © Copyright by B.B.H. and C.L.

in which soft tissue insufficiency might be associated with other anatomic risk factors, for iatrogenic medial instability PF alignment is usually favorable. Therefore, restoring the integrity of the lateral soft tissue is the main goal and should be sufficient to restore stability and improve symptoms. Open lateral retinaculum closure provides successful outcomes and should be attempted first.[15,17,19] When lateral retinaculum closure is not possible due to inadequate lateral soft tissue quality or length, or when primary closure will lead to lateral subluxation lateral, retinaculum reconstruction can be performed, in form of a lateral retinaculum augmentation of lateral tissue with either a collagen patch spanning the defect or a LPFL reconstruction or LPTL reconstruction.[16,27,28]

Augmentation of the lateral soft tissue can be performed with collagen "sheet" type of tissue, such as iliotibial band allograft, collagen type1/3 allograft membranes or dermal allograft. After the closure of the remaining viable tissue, the patch can be sutured over the repair and eventual remaining gap. The LPTL and LPFL can be performed as a "mirror" of the MPFL and MPTL reconstructions.[26,29–34] The anatomy, metric behavior, and biomechanics of both the LPTL and LPFL are not well understood so there is no clear evidence, other than surgeons' opinion, on how to best perform those surgeries. For that reason, at this current time tissue augmentation should be the method of choice and LPTL or LPFL reconstructions should be considered procedures only when augmentation fails to adequately address the deficiency.

OUTCOMES AND COMPLICATIONS

Outcomes of isolated LRR in patients with patellar instability are poor, with satisfactory results reported by only 50% to 70% of patients and recurrence rates of up to 35%.[35–40] Isolated reconstruction of the MPFL can provide good clinical outcomes and low recurrence rate of <10%, in primary or revision surgeries.[30–34,41] Therefore, isolated MPFL reconstruction has better outcomes than isolated LRL for lateral patellar instability and, as previously mentioned, LRR/LRL should not be performed in isolation to treat patellar instability.

Two prospective randomized studies found, in patients with pain, that functional knee outcomes and return to athletic activities increased more after LRL than LRR.[42,43] These

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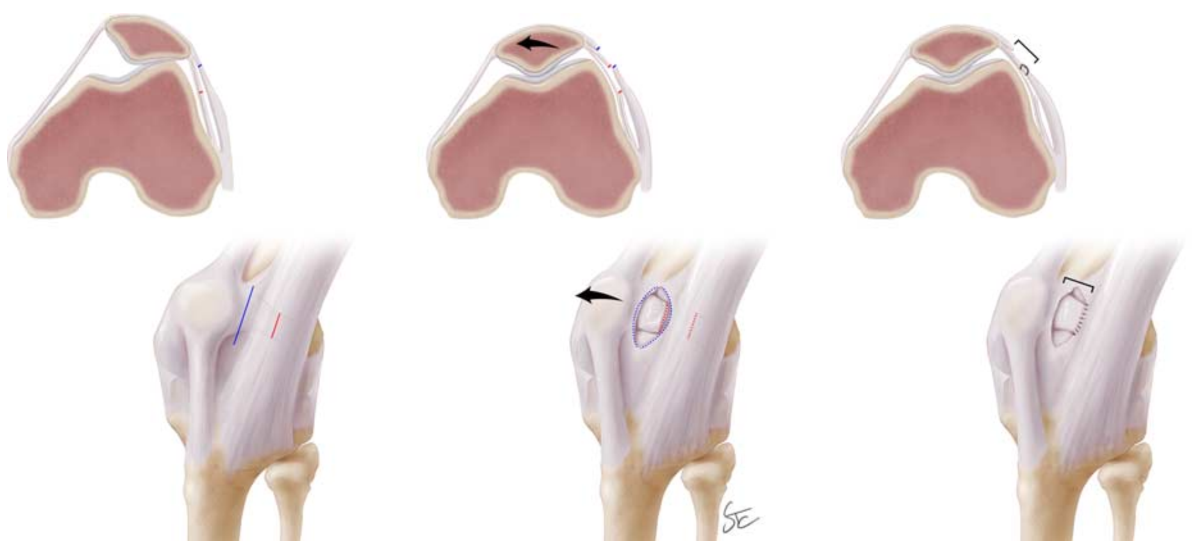

FIGURE 11. Image being reprinted from Unal et al.[24] Illustration of lateral retinaculum lengthening technique. Images on the left demonstrate a laterally subluxed patella with tight lateral retinaculum. There are 2 distinct layers of the lateral retinaculum, the superficial layer (blue) and deep layer (red), inserting on the superior lateral patella. In the center images, the 2 retinaculum layers are dissected sharply and longitudinally cut at different levels to allow patella to reduce medially and center in the trochlea. The arrows demonstrate the reduction of the patella. Images on the right demonstrate, reapproximating the 2 layers of the lateral retinaculum edge to edge at the appropriate tension. © Copyright 2019 by The Curators of the University of Missouri, a public corporation.

procedures had similar rates of postoperative knee stiffness, decreased muscle mass, and decreased strength.[42,43] Of note, both used a very extensive LRR, until the patella was perpendicular to the trochlea, which may have affected outcomes. Thus, results of LRR to normalize the patella mobility in patients with patellar instability cannot be assumed to lead to equivalent results. A more recent study compared patients with patellar instability and MPFL reconstruction with a LRR, just enough to normalize patellar tracking, to MPFL reconstruction with LRP.[25] The LRP resulted in better Kujala score and less medial patellar excursion compared with LRR.

One study compared MPFL reconstruction alone to MPFL reconstruction with LRP in patients with patellar instability.[26] They excluded patients with anatomic risk factors and an inability to return the patella to a central position in the trochlear groove at 30 degrees of knee flexion after isolated MPFL reconstruction. The authors found no difference between the groups in regards to patellar tilt, patellar shift, and patient-reported outcomes. This is not surprising as they excluded the patellofemoral instability patients in which LRL would normally be indicated. This finding corroborates the importance of good diagnostic workup before patellofemoral surgery. One can, however, deduct from this study that even if a LRL procedure is added, it does not result in increased PF instability in contrast to adding a LRR.

Complications of performing LRR/LRL to change the lateral restraint include iatrogenic medial patellar instability, increased lateral pain, repair failure, recurrent lateral instability, quadriceps weakness and atrophy, postoperative hemarthrosis, knee stiffness, wound complications, and thermal skin injury.[39] These complications often result from poor surgical technique and too aggressive release. Medial instability is the most devastating of those complications.

CONCLUSIONS

Lateral PF soft tissues abnormalities range from excessive lateral patellofemoral tightness (lateral patellar compression syndrome, lateral patellar instability, and arthritis), to excessive laxity (iatrogenic lateral patellofemoral soft tissue insufficiency postlateral release). When well indicated, and performed with good technique, the LRL balances medial/lateral soft tissue and improve patellar positioning and clinical results, without increasing unwanted complications such medial patellar instability. Finally, lateral retinaculum repair or reconstruction is performed for lateral retinaculum insufficiency (eg, medial subluxation).

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