

Quadriceps Tendon Lengthening for Obligatory (Habitual) Patellar Dislocation in Flexion



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Abstract: Obligatory patella dislocation in flexion is an uncommon form of patellar instability, where the patella is located in extension and dislocates with every episode of knee flexion. This results in dramatically altered patellofemoral kinematics and can be extremely debilitating due to extensor strength deficits and lack of knee confidence in flexion. Concomitant pathology, which is often seen, includes a tight lateral retinaculum and a shortened extensor mechanism. Lengthening the extensor mechanism is a critical part of successful patellar stabilization, and has not been well-reported. Herein, we present a technique of quadriceps lengthening for the treatment of obligatory patellar dislocation.

Obligatory patellar dislocation in flexion is a childhood condition in which the patella dislocates on every occasion the knee is flexed and reduces with knee extension.¹ It can be reasonably well-tolerated in children without pain or apprehension, especially in younger children; however, it usually causes pain,

dysfunction, and instability, and symptoms worsen as patients grow older.^{2,3} Obligatory patellar dislocation is a rare form of dislocation and as such should have a different treatment than the more common recurrent lateral patellar dislocation. As such, the treatment of obligatory patellar dislocation is also not as well understood or reported.

Various factors have been described in the pathogenesis of obligatory patellar dislocation; the most important pathologic factors are medial soft-tissue insufficiency and contracture of the lateral soft tissues and in some cases the quadriceps.²⁻⁸ In obligatory patellar dislocation, the extensor mechanism does not have enough length and excursion to allow for full knee flexion with the patella centered, mostly due to quadriceps contracture; as a result, the patella is pulled laterally on a shorter path for the extensor mechanism, allowing knee flexion only when the patella is laterally displaced.³

The treatment of obligatory patellar dislocation includes procedures that are commonly performed and well described for the treatment of recurrent lateral patellar dislocation, including medial patellofemoral ligament (MPFL) repair/reconstruction. However, the most crucial procedure is the release/lengthening of the lateral contracted structures (lateral retinaculum and vastus lateralis) and the quadriceps tendon lengthening that has not been well reported. Herein, we present a step-wise approach to address the contracted lateral soft tissue and quadriceps, including a technique of quadriceps tendon lengthening for the treatment of obligatory patellar dislocation.

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Indications (With Video Illustration)

This technique is indicated for the treatment of obligatory patellar dislocation with associated quadriceps shortening (Video 1) evaluated by the stepwise approach described to follow.

Pearls and pitfalls (Table 1) and advantages/disadvantages of this procedure (Table 2) are discussed in their associated tables.

Pertinent Anatomy, Physiology, and Biomechanics

The average quadriceps tendon length is reported as 6.87 ± 1.49 cm in pediatric populations⁹ and 88.3 ± 8.4 mm (range, 78.3-99.7 mm) in adults.¹⁰ The thickness is reported as 3.7 ± 1.2 mm in pediatric populations⁹ and 4.94 mm (0.7-9.78 mm) in adults.¹¹

There are 3 layers of the quadriceps tendon that can be identified. They are the superficial layer, composed by the tendon of rectus femoris; the intermediate layer, composed by the tendons of the vastus lateralis (VL) and vastus medialis (VM) with contributions of the antero-medial portion the vastus intermedius (VI); and the deep layer, composed by the tendon of the VI, mainly its lateral portion.^{12,13} The superficial portion of the VI is attached to the VM and rectus femoris medially, while its deep portion fuses to the VL.¹² In patients with patellar instability, the VM more frequently inserts in the retinaculum instead of directly in the patella. In addition, the VM has a more proximal insertion and a decreased patellar insertion relative to patients without patellar instability.¹⁴

The muscle belly of the VM occupies a greater proportion of the quadriceps cross-sectional area distally, whereas the VL occupies a greater proportion proximally.¹⁵ In patients with obligatory patella dislocation,

Table 1. Pearls and Pitfalls

| Pearls | Pitfalls |
|---|--|
| <ul style="list-style-type: none"> • Perform one step at a time and re-evaluate patellar tracking. • Identify the 3 layers of the quadriceps tendon (easier to identify proximally). • Set the quadriceps tendon lengthening by opposing the layers with the knee in 70 to 90° of flexion to avoid over/under-tensioning. • Reattach the “lateral sleeve” where it reaches the remaining extensor mechanism without over/under tension. • Perform hemostasis at the end of the procedure to avoid hematoma, look carefully for the lateral superior and inferior genicular arteries. | <ul style="list-style-type: none"> • Failure to identify the 3 layers of the quadriceps tendon prevents one from adequately performing the procedure. • Overtensioning of the quadriceps tendon lengthening and/or “lateral sleeve” reattachment will increase chances of failure. • Undertensioning of the quadriceps tendon lengthening will result in extension lag. |

Table 2. Advantages and Disadvantages

| Advantages | Disadvantages |
|---|---|
| <ul style="list-style-type: none"> • Specifically developed to treat habitual patellar instability. • Provides a standardized stepwise approach for evaluation and treatment. • Respects the planes of dissection and innervation; and preserves tendon continuity with tendon reattachment and/or tendon–tendon suturing. • Offers an excellent balance between the medial and lateral soft tissue by lengthening only the short components of the quadriceps while keeping the VM attached to the medial patella, or independently shortening it if needed. | <ul style="list-style-type: none"> • Risk of failure with recurrent instability if the quadriceps tendon lengthening is overtensioned • Risk of extension lag if under quadriceps tendon lengthening is undertensioned. |
| VM, vastus medialis. | |

the vastus lateralis muscle shows signs of fibrosis and degeneration that can decrease the muscle excursion.⁴ In addition, it may be hypotrophic compared with that of the normal side.⁴ In many patients, the subcutaneous fat and the vastus intermedius muscle adjacent to the vastus lateralis may also be thinner and can contain fibrotic bands.⁴

The VM and medial portion of the VI are innervated by the medial division of the femoral nerve, which then branches off from the saphenous nerve, arriving medially to those muscles.^{12,16,17} The VL and the lateral portion of the VI are innervated by the lateral division of the femoral nerve, arriving laterally to those muscles.¹²

A complex vascular anastomotic ring lies in the thin layer of loose connective tissue that covers the dense fibrous rectus expansion surrounding the patella.¹⁸ Blood supply comes from arteries in the medial and lateral retinacula and proximally from the quadriceps, and then distributes through the patella via intraosseous systems.¹⁹

Biomechanical in vivo and laboratory studies have shown delay in the activation of the VM and decrease on the magnitude of the VM activation relatively to the VL is associated with and increase patellar tilt²⁰; and that decrease in loading forces from the VM increased lateral patellar shift.²¹

Surgical Technique

The goal of this technique is to correct for soft-tissue imbalances. Lateral retinaculum and quadriceps contractures need to be released or lengthened, and the medial patellar restraints need to be restored.

A direct anterior approach is performed. A skin incision of about 10 to 15 cm is performed anterior to

the knee. This provides proper access to the extensor mechanism and the medial and lateral parapatellar soft tissue; allowing all procedures to be performed through one approach.

A stepwise approach is carried out with evaluation of patellar tracking after each step. The goal is to maintain the patella in the trochlear groove during flexion with minimal manual lateral restraint. One can perform this evaluation by having one's thumb on the lateral patella applying minimal force to resist lateral displacement (thumb test).

First Step: Lateral Retinaculum Release or Lengthening

Perform a standard lateral retinaculum release or lengthening and release.²² In addition, release all adhesences of the vastus lateralis to the iliotibial tract and the lateral intermuscular septum, reaching as proximal as possible. Lateral retinaculum lengthening may not be possible if the lateral soft-tissue shortening is greater than 2 cm. If the thumb test is still positive and the patella is laterally displaced in deep flexion, the quadriceps contracture needs to be addressed.

Second Step: Vastus Lateralis Tendon Release

Release the VL tendon by sectioning it close to the patella. If the VL has a major role in the contracture then the rectus femoris, the VL release may be enough to prevent the patella from dislocating. If the thumb test is still positive, a quadriceps tendon lengthening is required.

Third Step: Quadriceps Tendon Lengthening Technique

A full-thickness incision is performed in the lateral portion of the quadriceps tendon, about 2 mm medial from the muscle portion, just enough to allow suturing

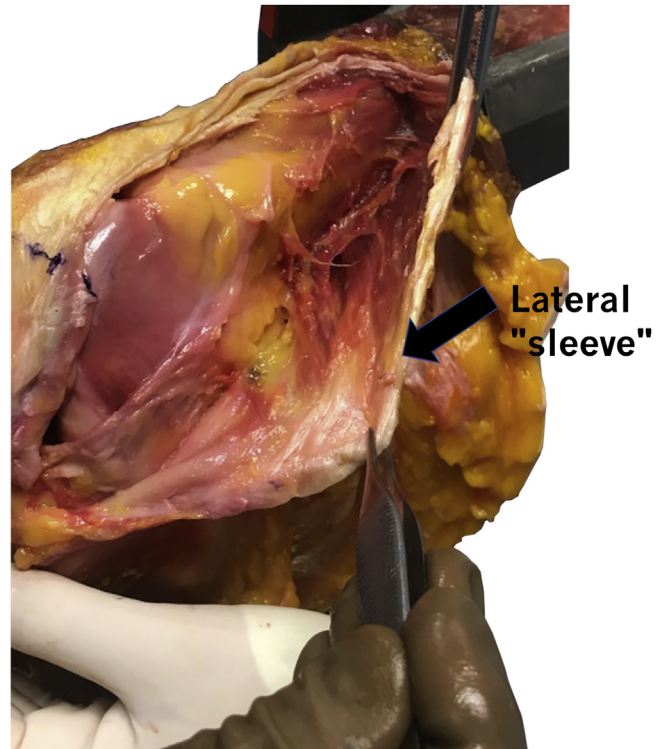


Fig 2. Oblique lateral view. The full-thickness incision is performed in the lateral portion of the quadriceps tendon, seen in **Figure 1**, resulting in a lateral "sleeve" that contains the vastus lateralis and the lateral portions of the rectus femoris.

of the lateral "sleeve" to the remaining portion of the quadriceps at the end of the procedure. This incision should be continuous with the previous VL tendon release (**Fig 1A** and **B**). This will result in a lateral "sleeve" that contains the VL and the lateral portions of the remaining tendon (**Fig 1B** and **Fig 2**).

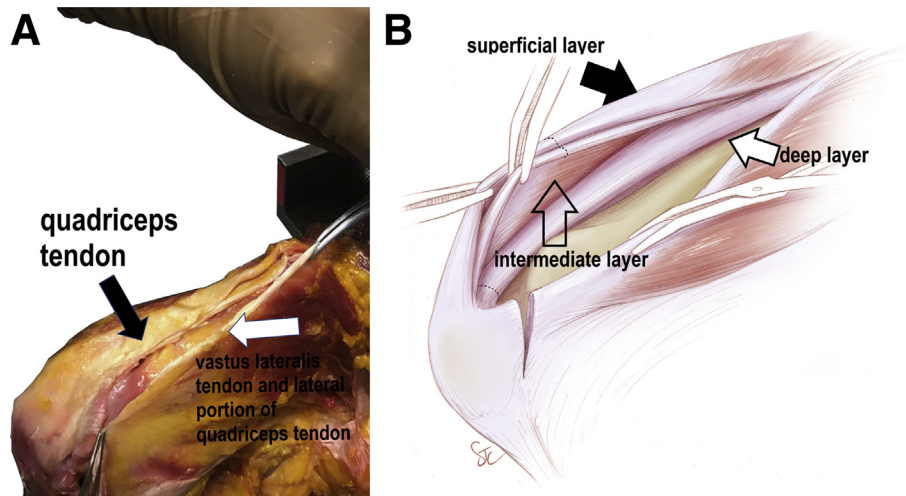


Fig 1. Oblique lateral view. (A) Full-thickness incision performed in the vastus lateralis tendon and lateral part of the quadriceps tendon. This incision is about 2 mm medial from the muscle portion, just enough to allow suturing of the lateral "sleeve" to the remaining portion of the quadriceps at the end of the procedure. (B) The quadriceps superficial, intermediate, and deep layers can be seen.

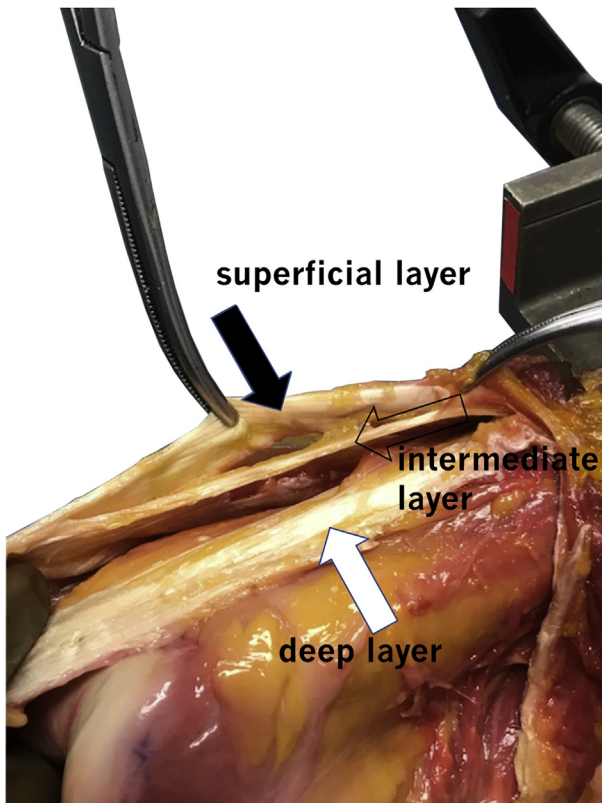


Fig 3. Oblique lateral view. The 3 layers of the quadriceps tendon. The superficial layer, composed by the tendon of rectus femoris (RF); the intermediate layer, composed by the tendons of the vastus lateralis (VL), vastus medialis (VM) with contributions of the anteromedial portion the vastus intermedius (VI); and the deep layer, composed by the tendon of the VI, mainly its lateral portion.

The three layers of the quadriceps should be identified (Fig 1B and Fig 3). This is more easily performed proximally, as distally the layers tend to fuse.

Once the layers are identified, the superficial and intermediate layers should be sectioned as proximally as possible and the deep layer as distal as possible (close to the patella) (Figs 4, 5, and Fig 6). The knee is flexed to 70 to 90° with the patella reduced in the trochlear groove. The superficial and intermediate layers will slide distally, lengthening the quadriceps tendon (Fig 7). The amount of lengthening can be measured by the distance between the distal and proximal borders of the deep layer (Fig 5). With the knee still at 70 to 90° of flexion, the layers should be positioned in a way so that the quadriceps and patellar tendon are straight with mild tension, mimicking the normal quadriceps tension. If the knee is not flexed enough, there is a risk the patient won't regain full flexion postoperatively, conversely, if the knee is too flexed there is a chance the patient will have an extension lag. The layers are sutured in this position with running sutures (Fig 8A and B). A combination of absorbable and

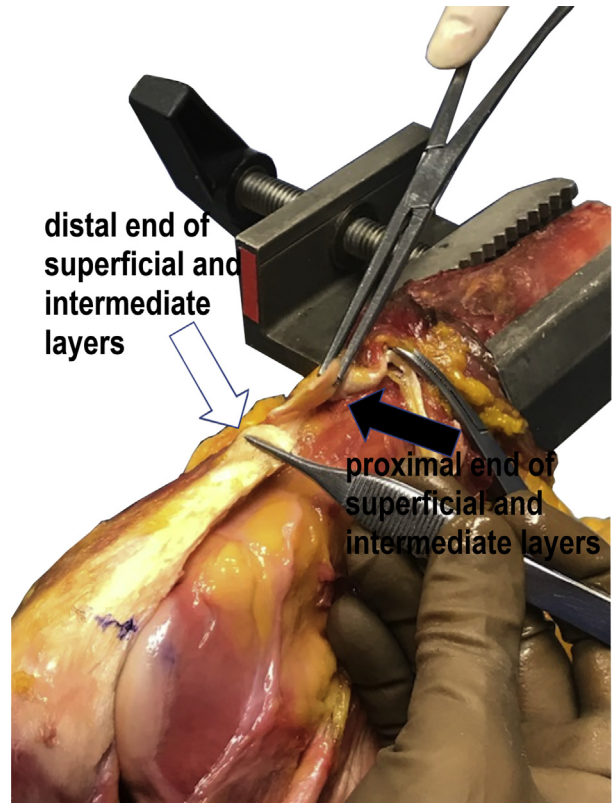


Fig 4. Oblique lateral view. Layers of the quadriceps are identified; the superficial and intermediate layers should be sectioned as proximally as possible.

nonabsorbable sutures can be used; the use of only nonabsorbable sutures is not recommended. Since the quadriceps tendon length is roughly 7 to 9 cm, enough lengthening can be performed while maintaining adequate overlap and suture between the layers. The lateral "sleeve" is positioned in the quadriceps-patellar unit in location that it reaches without provoking any excessive lateral pull to the patella. Since the lateral structures are shortened, this will likely be proximal to the original insertion (Fig 9).

The knee is put under range of motion (ROM), and stability of the patella is verified once again with the thumb test.

Once the patella tracks centrally thru passive knee flexion, attention is turned to the medial soft-tissue structures to maintain this balance. One should address the medial insufficiency with a MPFL reconstruction. An additional reconstruction of the medial patellotibial ligament can be considered to provide further stability, since the medial patellotibial ligament increases its contribution against lateral patellar translation in deeper flexion.²³ The medial ligamentous reconstruction should never be used to "pull" the patella into the groove in flexion, as over time this will stretch out and fail. An imbrication of the medial soft tissue (including the attenuated medial patellar

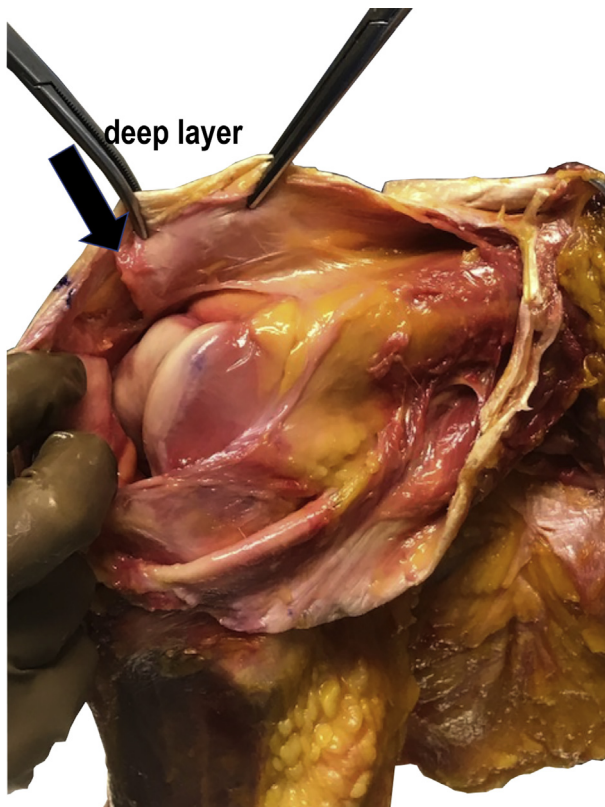


Fig 5. Oblique lateral view. Layers of the quadriceps are identified; the deep layer should be sectioned as distal as possible, close to the patellar attachment.

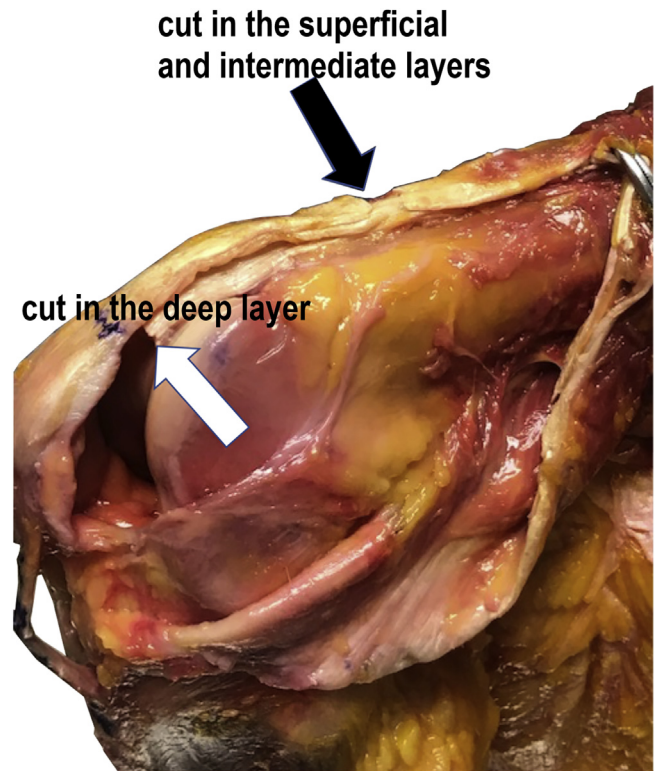


Fig 7. Lateral view. The knee is flexed to 90° with the patella reduced in the trochlear groove. The superficial and intermediate layers will slide distally and the deep layer will slide proximally, lengthening the quadriceps tendon.

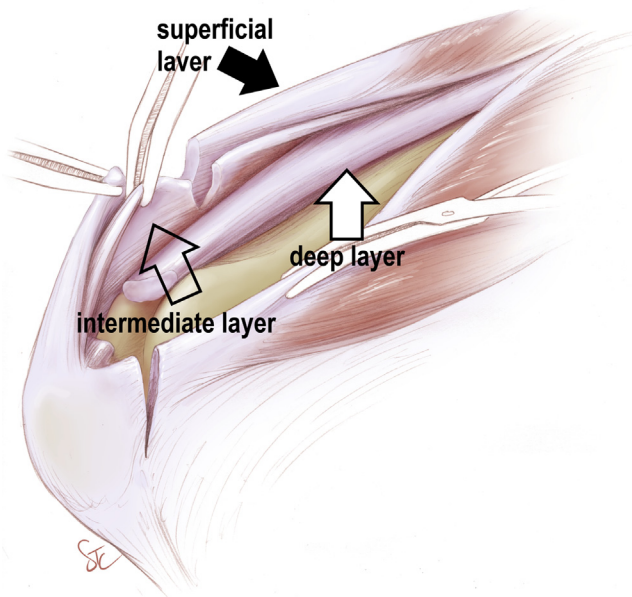


Fig 6. Oblique lateral view. The amount of lengthening can be seen proximally and distally in the quadriceps tendon. Layers of the quadriceps are identified; the superficial and intermediate were sectioned as proximally as possible, and the deep layer was sectioned as distal as possible, close to the patellar attachment.

stabilizers and the VM tendon) can be performed if it remains excessively redundant and loose; otherwise, the medial soft tissue will restore an appropriate resting length over time.

Postoperative Protocol

If only a lateral retinaculum lengthening and vastus lateralis release were performed, the standard post-operative MPFL reconstruction protocol is followed. If a quadriceps tendon lengthening was performed, patients are discharged home with crutches and are toe-touch weight-bearing with a brace locked in extension for 6 weeks. Patellar mobilization, heel slides, and quadriceps sets can be initiated on postoperative day 1, and they should be performed 3 to 4 times a day. At 6 weeks, patients may start active ROM and strengthening programs; progression to full weight-bearing, unlocking, and eventual discontinuation of the brace when adequate quadriceps control is achieved. Low-impact activities are initiated within the first 3 months. Jogging and sport-specific drills may be initiated between 4 and 6 months. Patients may use criteria-based progression with return-to-play by 6 to 12 months.

The described quadriceps tendon lengthening was performed in 1 patient with preoperative obligatory patellar dislocation. Associated procedures were MPFL

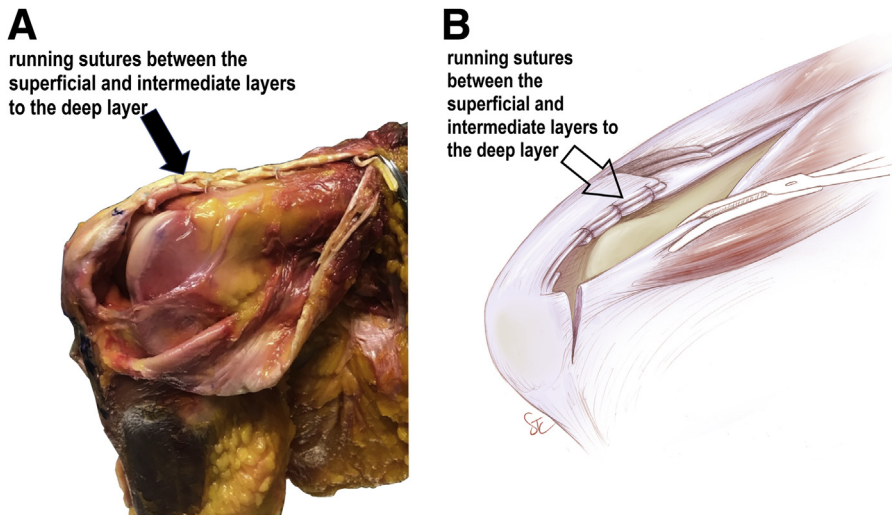


Fig 8. (A) and (B) Lateral view. The layers are sutured with running sutures in the overlap between the superficial and intermediate layers to the deep layer. The final lengthening can be seen.

reconstruction, MTPL reconstruction, and lateral retinaculum release. She maintained full ROM without extension lag and no recurrence of dislocation after 4 years.

Discussion

In this Technical Note, we present a stepwise quadriceps tendon-lengthening technique. Sequential targeted sectioning and lengthening of portions of the

lateral retinaculum and quadriceps tendon provides adequate lengthening with a lesser risk of iatrogenic excessive lengthening that can cause extension lag. This technique should be used with the goal of restoring patellofemoral congruity (centering the patella in the trochlear groove) and extensor mechanism alignment primarily in patients with obligatory flexion patellar dislocation.

Obligatory patellar dislocation in flexion can be treated by proximal and distal realignment without the quadriceps lengthening.^{2,3,24} Nonetheless, this is achieved by great changes that distort the normal anatomy to pull the patella medially, instead of addressing the abnormalities in the quadriceps and lateral side. The importance of the quadriceps tendon shortening when treating patients with obligatory patellar dislocation in flexion has been previously emphasized. Bergman and Williams⁶ reported that 37% of patients required a quadriceps tendon lengthening after the release of vastus lateralis, and Gao et al.⁵ reported it was needed in some cases.

The advantages of the approach described here are: it was specifically developed to treat habitual patellar instability, it provides a standardized stepwise approach for evaluation and treatment, it respects the planes of dissection and innervation, preserves tendon continuity with tendon reattachment and/or tendon-tendon suturing (no tendon is left completely released), and it offers an excellent balance between the medial and lateral soft tissue by lengthening only the short components of the quadriceps (rectus, intermedius, and lateralis), decreasing the pull of the lateral quadriceps, while keeping the VM attached to the medial patella, or independently shortening it if needed, keeping the medial quadriceps pull intact. Those are important advantages compared with other described procedures. Bergman and Williams⁶ described extending the medial release proximally (which weakens the medial pull

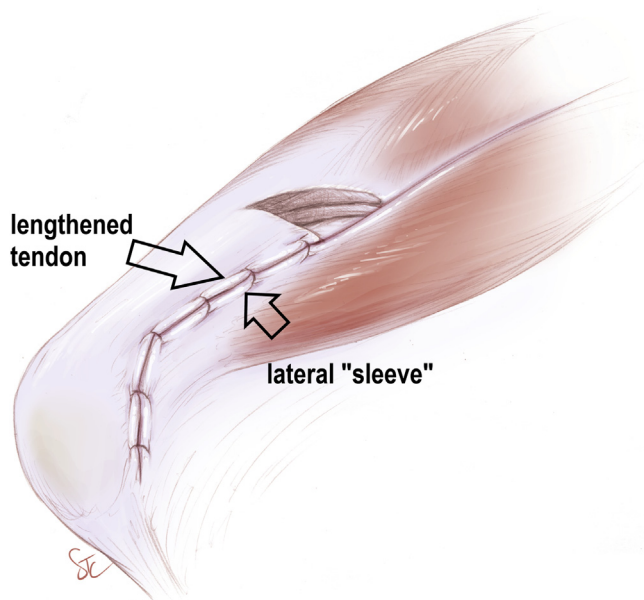


Fig 9. Oblique lateral view. The lateral “sleeve” is positioned in the location that it reached without provoking any excessive lateral pull to the patella, likely proximal to the original insertion. Since the quadriceps tendon length is roughly 7 to 9 cm, a sufficient amount of lengthening can be performed while maintaining adequate overlap and suture between the layers.

action of the vastus medialis) and dividing the rectus femoris at its musculotendinous junction (which weakens knee extension) with subsequent vastus lateralis and vastus medialis and rectus femoris tendon suturing in its lengthened position. Gao et al.⁵ reported the detachment of the vastus lateralis, sectioning of the vastus intermedius, without reattachment (which weakens knee extension), and lengthening of the rectus femoris. The most frequently described procedure to address quadriceps contractures, is the so-called quadricepsplasty (Judet and Thompson technique). However, it is an aggressive procedure that can be complicated by skin necrosis and extensor lag.²⁵ Furthermore, they have been reportedly indicated for post traumatic knee stiffness and not for obligatory patellar dislocation.

Conclusions

Obligatory patellar dislocation of the patella in flexion is rare. The most important pathologic factor is contracture and short length of the quadriceps and lateral soft tissues. Thus, we propose a stepwise approach with evaluation of the patellar tracking after each step. Sequential targeted sectioning and lengthening of portions of the lateral retinaculum and quadriceps provides adequate lengthening with a lesser risk of iatrogenic excessive lengthening that can cause extension lag. In addition, this technique respects the planes of dissection and innervation and leads to a better balance between the medial and lateral soft tissues.

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