

# Mini-invasive Quadriceps-plasty for Severe Flexion- Impeding Knee Stiffness



Jinzhong Zhao, M.D.

**Abstract:** Severe flexion-impeding knee stiffness is a common clinical condition that challenges orthopaedic surgeons. A mini-invasive and effective release technique to address this special condition is still being pursued. We describe a mini-invasive quadriceps-plasty that is performed through a small incision on the supralateral side of the knee and includes release of the retinaculum and patellofemoral joint, re-creation of the suprapatellar pouch and medial and lateral gutters, overlapping Z-plasty of the rectus femoris and vastus intermedius, and transfer of the vastus lateralis. Our clinical results indicate that this technique is safe and effective. We present a detailed description with video illustration of this technique that is beneficial for its application.

Severe flexion-impeding knee stiffness is challenging to orthopaedic surgeons because of severe adhesion, scar tissue formation, and knee extensor shortening. Both open and arthroscopic release techniques have been reported, among which an ideal surgical procedure that addresses all of these pathologies mini-invasively and effectively is still being sought.<sup>1-3</sup> We describe a quadriceps-plasty technique that we consider to meet the requirement of an ideal surgical release procedure: mini-invasive quadriceps-plasty (Table 1).<sup>4,5</sup> The indications for this technique are the same as those for large-incision release and can be applied to almost all types of flexion-impeding knee stiffness that have no surgical contraindications.

## Surgical Technique

### Incision

Starting from a site 2 cm proximal to the proximal-lateral pole of the patella, a 2- to 4-cm-long

longitudinal incision is made proximally, over the medial part of the vastus lateralis tendon. Through the skin incision, the fascia layers, the vastus lateralis, and the vastus intermedius are cut through to the femur (Fig 1, Video 1, Table 2).

### Step 1: Release of Vastus Lateralis and Lateral Retinaculum

With tissue scissors, a subcutaneous separation is performed from the incision distally to the lateral side of the tibial tubercle. Then, the vastus lateralis and the lateral retinaculum are released from the patella along the lateral margin of the patella and the patellar tendon from the level of the incision to that of the tibial tubercle (Fig 2).

### Step 2: Re-creation of Suprapatellar Pouch

Through the previously made skin and vastus lateralis incision, the fibrous connection between the quadriceps tendon and the distal femur is cut with scissors to re-create the suprapatellar pouch. If there is still adhesion between the quadriceps and the middle femur, release is continued proximally (Fig 3).

### Step 3: Release of Patellofemoral Joint

Along the newly established space between the quadriceps tendon and the femur, the scissors are extended into the patellofemoral joint to release the patellofemoral joint distally (Fig 4). When the patellofemoral joint is released, the scissors are bent backward and inserted through the patellofemoral joint to the posterior side of the patellar tendon to release the patellar tendon from the infrapatellar fat pad.

From the Department of Sports Medicine, Shanghai Sixth People's Hospital, Shanghai Jiao Tong University, Shanghai, China.

The author reports no conflicts of interest in the authorship and publication of this article. Full ICMJE author disclosure forms are available for this article online, as [supplementary material](#).

Received November 6, 2021; accepted December 14, 2021.

Address correspondence to Jinzhong Zhao, M.D., Department of Sports Medicine, Shanghai Sixth People's Hospital, Shanghai Jiao Tong University, 600 Yishan Road, Shanghai 200233, China. E-mail: [jzzhao@sjtu.edu.cn](mailto:jzzhao@sjtu.edu.cn)

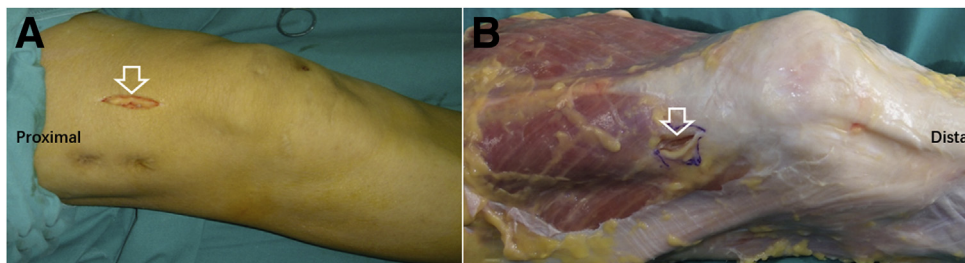
© 2022 THE AUTHORS. Published by Elsevier Inc. on behalf of the Arthroscopy Association of North America. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

2212-6287/211609

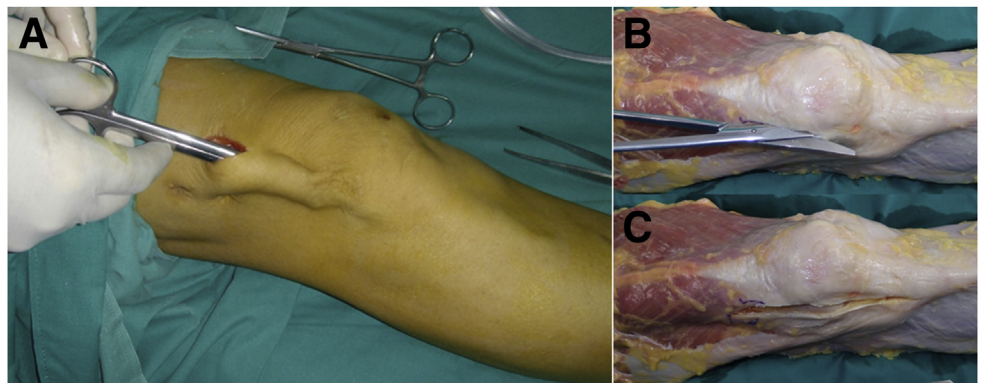
<https://doi.org/10.1016/j.eats.2021.12.021>

**Table 1.** Objectives of Mini-invasive Quadriceps-plasty

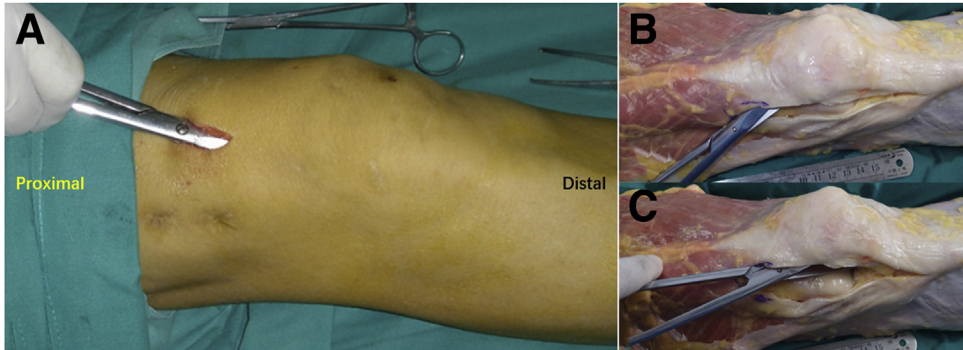
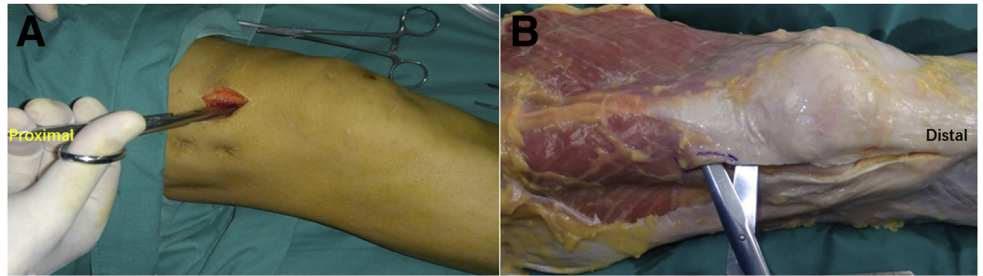
1. Release of medial and lateral retinaculum
2. Release of distal quadriceps from femur to re-create suprapatellar pouch
3. Release of patellofemoral joint
4. Release of infrapatellar fat pad and patellar tendon
5. Release of retinaculum from medial and lateral femoral condyles to re-create medial and lateral gutters
6. Sectioning of anterior part of medial and lateral capsular ligament
7. Dissociation of rectus femoris from patella
8. Proximal dissociation of vastus intermedius and overlapping Z-plasty of rectus femoris and vastus intermedius

**Fig 1.** Intraoperative view (A) and specimen illustration (B) of skin incision and incision through vastus lateralis (arrows; right knee).**Table 2.** Step-by-Step Mini-invasive Quadriceps-plasty Procedure

1. An incision is made at a site proximal to the proximal-lateral pole of the patella, and the vastus lateralis and vastus intermedius are cut through to the femur.
2. The vastus lateralis and the lateral retinaculum are released from the patella and the patellar tendon from the level of the initial skin and tendon incision to that of the tibial tubercle.
3. The fibrous connection between the quadriceps tendon and the distal femur is cut to re-create the suprapatellar pouch.
4. The patellofemoral joint is released, and the patellar tendon is released from the infrapatellar fat pad.
5. The medial retinaculum is released from the level of the adductor tubercle to the midpoint of the medial edge of the patellar tendon.
6. The medial capsule is released from the medial femoral condyle to re-create the medial gutter.
7. The lateral capsule is released from the lateral femoral condyle to re-create the lateral gutter.
8. A longitudinal incision is made along the junction of the rectus femoris and the vastus medialis.
9. Through the previously made incision, the lateral side of the rectus femoris is defined and the rectus femoris is separated from the vastus lateralis and intermedius.
10. The rectus femoris tendon is detached from the patella.
11. The tendon of the vastus intermedius is separated and cut as proximally as possible.
12. The anterolateral and anteromedial capsule-ligament is cut through additional anteromedial and anterolateral punches.
13. The rectus femoris tendon and the vastus intermedius tendon are pulled distally and proximally, respectively, and the knee is flexed at 90° to determine the length at which the tendons need to overlap.
14. The knee is extended, and the rectus femoris tendon and the vastus intermedius tendon are overlaid and sutured together.
15. The vastus lateralis is separated from the iliotibial band. All parts of the vastus lateralis detached from the patella are sutured to the vastus intermedius tendon.

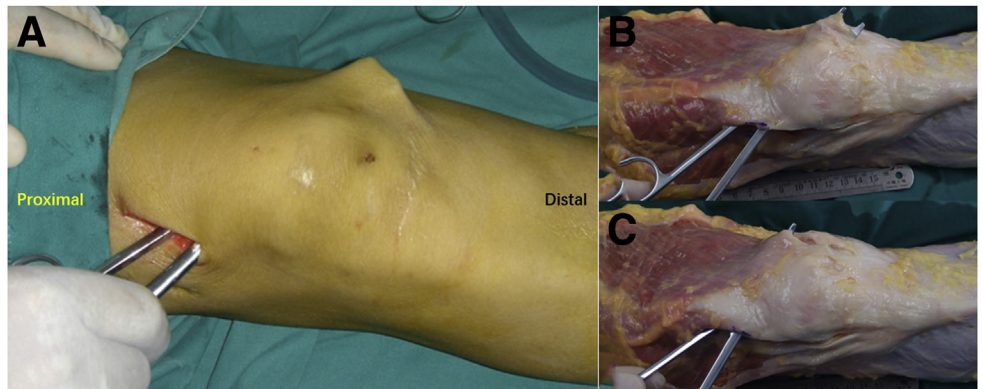
**Fig 2.** Release of vastus lateralis and lateral retinaculum (right knee). (A) Intraoperative view. (B) Specimen during release. (C) Specimen after release.

**Fig 3.** Re-creation of supra-patellar pouch. (A) Intra-operative view. (B) Specimen illustration.



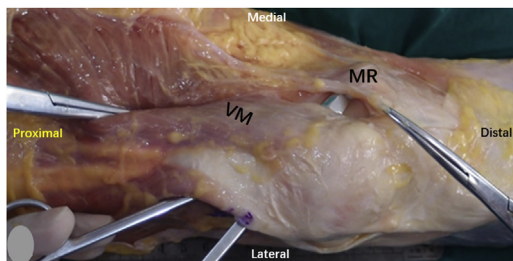
**Fig 4.** Release of patellofemoral joint, patellar tendon, and infrapatellar fat pad. (A) Intra-operative view. (B) Specimen view showing release of patellofemoral joint. (C) Specimen view showing release between patellar tendon and infrapatellar fat pad.

**Fig 5.** Release of the medial retinaculum. (A) Intraoperative view. (B) Specimen view showing release of medial retinaculum near patellar tendon. (C) Specimen view showing release of medial retinaculum near adductor tubercle.

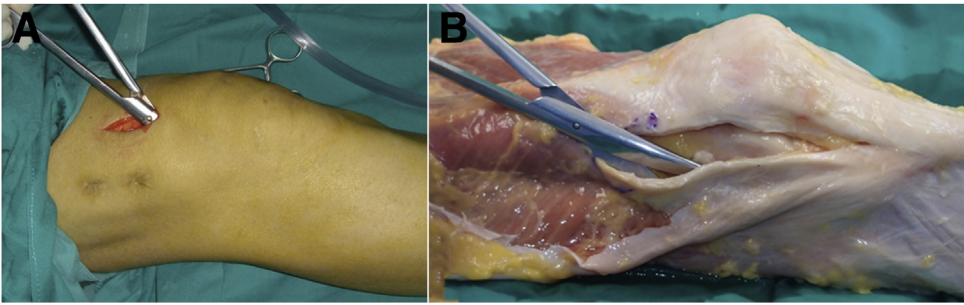


**Step 4: Release of Medial Retinaculum**

The scissors are curved upward and passed diagonally through the patellofemoral joint, touching the medial expansion of the vastus medialis and the medial retinaculum. Release is performed along a line from the adductor tubercle to the midpoint of the medial edge of the patellar tendon. All the fibrous tissue is cut from inside to outside to the subcutaneous layer. The patella is moved laterally. If lateral mobility of the patella is not restored, the medial side of the knee and the patellofemoral joint are further released (Fig 5).

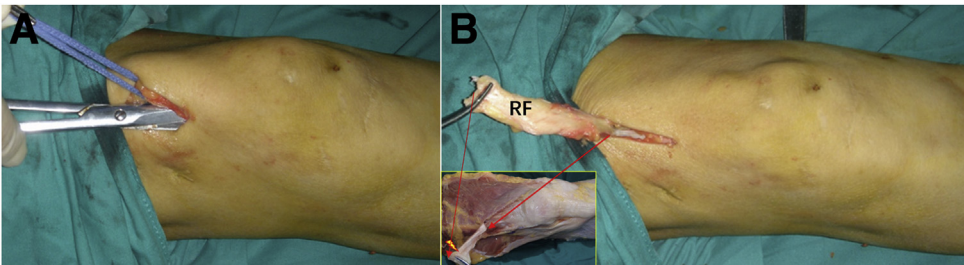
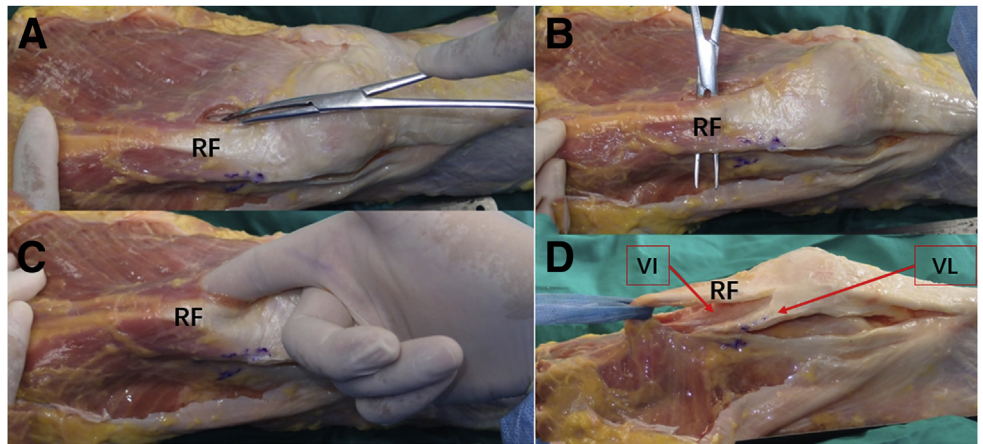


**Fig 6.** Specimen view showing re-creation of medial gutter. (MR, medial retinaculum; VM, vastus medialis.)



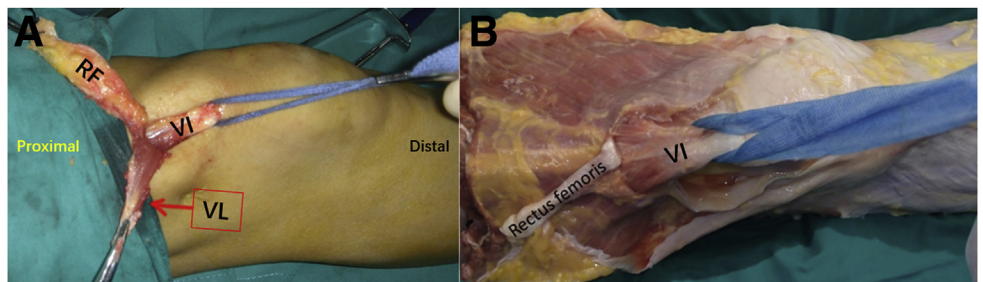
**Fig 7.** Re-creation of lateral gutter. (A) Intraoperative view. (B) Specimen view.

**Fig 8.** Distal separation of rectus femoris (RF) (specimen view of right knee). (A) An incision is made at the junction of the vastus medialis and the RF. (B) The lateral edge of the RF is defined by palpation at its underside. (C) The RF is separated from the vastus intermedius (VI) and the vastus lateralis (VL). (D) The separated RF is shown.

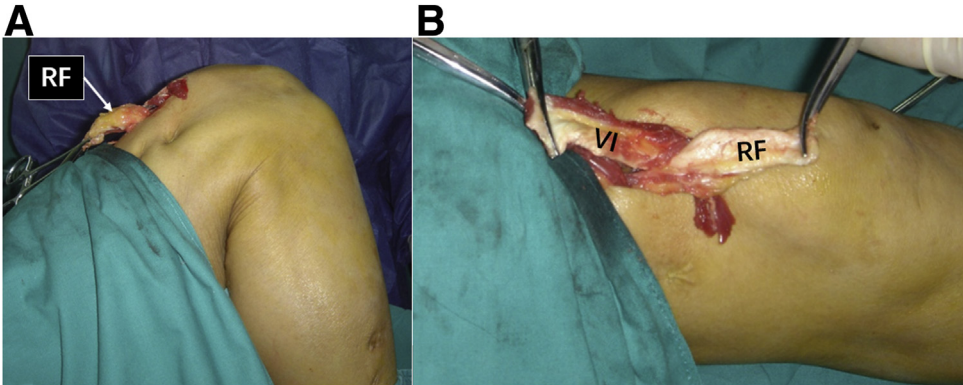
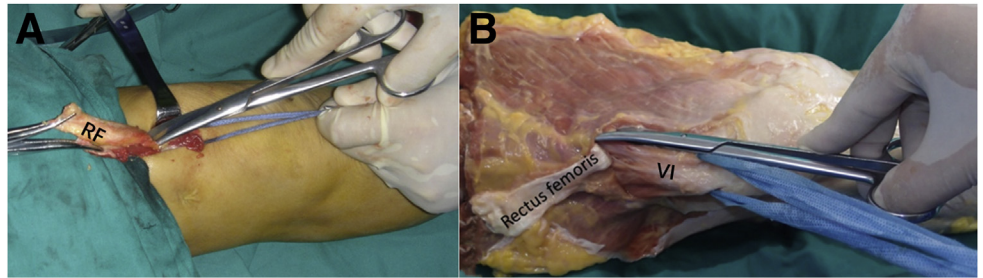


**Fig 9.** The rectus femoris (RF) is disassociated from the patella. (A) Intraoperative view during dissection of RF from patella. (B) Intraoperative view showing disassociation of RF from patella.

**Fig 10.** Separation of tendon of vastus intermedius (VI) (right knee). (A) Intraoperative view. (B) Specimen view.



**Fig 11.** Proximal dissociation of vastus intermedius (VI). (A) Intraoperative view. (B) Specimen view.



**Fig 12.** The knee is flexed to over 90° to evaluate the results of release (A), and the rectus femoris (RF) and vastus intermedius (VI) are pulled in opposite directions (B) (intraoperative view of right knee).

**Step 5: Re-creation of Medial and Lateral Gutters**

The scissors are curved backward and pushed along the surface of the medial femoral condyle to release the medial capsule from the medial femoral condyle and re-create the medial gutter (Fig 6). The scissors are then placed into the space between the lateral femoral condyle and the lateral capsule to release the lateral capsule from the lateral femoral condyle and re-create the lateral gutter (Fig 7).

For patients with no obvious contracture of the knee extensor, the aforementioned release can achieve the purpose. Then, other factors affecting knee flexion are

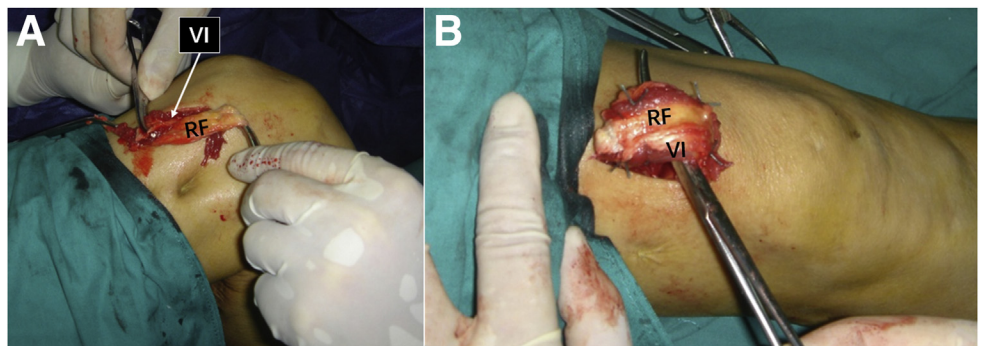
overcome by manual release.

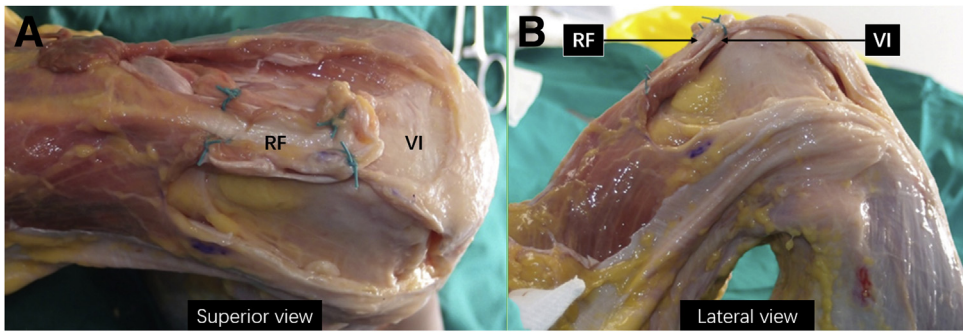
During the manipulation, the underside of the quadriceps tendon is touched to detect the tension of the quadriceps tendon. If knee flexion cannot reach 120°, which indicates that the tension of the quadriceps tendon is too high, the next step of release needs to be performed.

**Step 6: Dissociation of Rectus Femoris Tendon From Patella**

A sharp separation is performed on the surface of the quadriceps tendon to expose the junction between the

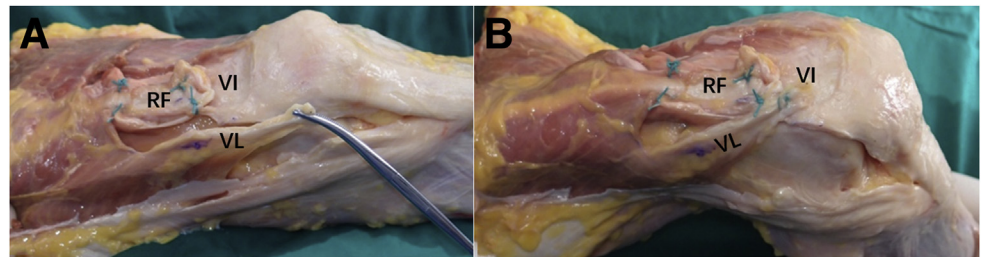
**Fig 13.** The knee is flexed at 90° to determine the length at which the tendons need to overlap (A), and the 2 tendons are overlaid and sutured according to the measured overlap length (B) (intraoperative view of right knee). (RF, rectus femoris; VI, vastus intermedius.)





**Fig 14.** Superior view (A) and lateral view (B) showing overlapping Z-plasty of rectus femoris (RF) and vastus intermedius (VI) in right knee specimen.

**Fig 15.** Specimen views showing reattachment of detached vastus lateralis (VL). (A) View during reattachment. (B) View after reattachment. (RF, rectus femoris; VI, vastus intermedius.)



rectus femoris and the vastus medialis, and a longitudinal incision is made along this junction (Fig 8). Through this incision, the inferior surface of the rectus femoris is palpated, the lateral edge of the rectus femoris is defined, and the rectus femoris is separated from the vastus lateralis and intermedius.

The rectus femoris tendon is pulled forward with a traction band, the scissors are inserted between the rectus femoris tendon and the vastus intermedius tendon, and the rectus femoris tendon is detached from the patella by sticking the scissors into the surface of the patella (Fig 9). The knee is then flexed, and the release is completed if the knee can be flexed beyond 120°. At 120° of flexion of the knee, the distal end of the rectus femoris tendon is sutured to the tendon of the vastus intermedius, through which the rectus femoris tendon

transmits power. During the aforementioned release steps, it is of utmost importance not to dissociate the vastus intermedius tendon from the patella; otherwise, this will cause difficulties for subsequent surgery.

### Step 7: Proximal Dissociation of Vastus Intermedius

If knee flexion cannot reach 120° after the rectus femoris tendon is detached and if the tendon of the vastus intermedius is obviously strained during the manual release, the tendon of the vastus intermedius needs to be disassociated. The vastus intermedius is around the femur from the anterior, medial, and lateral sides, with the tendinous part in the middle, which is longer and can proximally reach the middle part of the femur. The tendons of the vastus intermedius are cut longitudinally along both sides, and the

**Table 3.** Steps of Open Posterior Knee Release

1. In the knee flexion position, a longitudinal arc incision (i.e., a longitudinal incision in the knee extension position) is made on the posteromedial side of the knee with the joint line as the midpoint, with a length of about 6 cm. The posteromedial joint capsule and the medial head of the gastrocnemius are exposed by pulling the tendons of the pes anserinus and semimembranosus muscles backward.
2. A Hoffman retractor is placed posterior to the posterior capsule to protect the neurovascular structures on the posterior side of the knee. On the anterior side of the medial head of the gastrocnemius, the joint capsule is incised longitudinally to obtain entry into the posteromedial compartment. The posteromedial capsule, along with the medial head of the gastrocnemius, is detached from its femoral attachment site along the posterior side of the femur.
3. The triangular posterior septum is exposed and separated from the posterior capsule, and the posterior septum is removed to connect the posteromedial and posterolateral compartments of the knee.
4. The posterolateral capsule, along with the lateral head of the gastrocnemius, is detached from its femoral attachment site along with the posterior side of the femur.

**Table 4.** Pearls and Pitfalls in Addressing Postoperative Conditions After Mini-invasive Quadriceps-plasty

Condition	Pearls and Pitfalls
Avoiding wound healing problems	The main reasons for wound healing problems are the poor condition of the local soft tissues, poor extensibility, and excessive postoperative tension, which are the risks that must be borne when performing the release operation. If the original trauma has formed a large area of scar in the release area or if there are many surgical incision scars, the risk of wound healing or even local skin necrosis is greater; surgery should be performed with caution.
Addressing joint effusion	Although the release incision is small, the intra-articular release wound is large. The joint hemorrhage requires the placement of a drainage tube in the joint for a long time. The indications for extubation are either (1) a 24-h bloody drainage fluid volume < 50 mL or (2) drainage fluid changed from hemorrhage to serous status and a 24-h drainage volume < 100 mL. Joint exudation will directly affect wound healing, so the drainage volume and amount of wound healing should be taken into account when determining the timing of drainage tube removal. If the daily serous drainage volume has always exceeded 100 mL, it is recommended to remove the drainage after wound healing, which means 2 wk after surgery (the length of the drainage tube should be increased to prevent retrograde infection during drainage tube placement).
Addressing loss of releasing degrees	The final flexion angle of the joint after the rehabilitation period is less than that under anesthesia immediately after surgery, which is called "loss of releasing degrees." Generally, the loss of degrees in patients is 15°-30°, which means that if the knee can be flexed to 150° immediately after the operation, the final flexion angle may be only 120°-135° or even lower. The loss of releasing degrees is related mainly to re-adhesion postoperatively. Another main reason is patients' intolerance to pain. Patients with poor compliance and a fear of pain who do not cooperate with rehabilitation experience the highest loss of releasing degrees—or even complete failure—after this surgical treatment. In some patients, the loss of release is associated with joint infection or poor wound healing.
Avoiding poor knee extension	Early knee extension weakness after release may be related to failure to restore the function of the rectus femoris—vastus intermedius structure after the overlapping Z-plasty. Because the connection between the vastus medialis muscle and the patella is preserved in the described procedure, there is less possibility of complete functional defects in active knee extension. Patients eventually could still have knee extension weakness, generally related to the following factors: The first factor is the failure of the force chain of the vastus rectus—vastus intermedius owing to a force chain that is too slack. The second factor is vastus medialis muscle dysfunction, mainly caused by the rupture of the vastus medialis muscle or partial denervation of the vastus medialis. Because the vastus medialis has a small span, it is advantageous to avoid a tear if the flexion manipulation is carried out slowly. In addition, making full use of the vastus lateralis muscle is conducive to reducing weakness in knee extension. The vastus lateralis is dissociated from the patella during this release procedure. Thus, in the final step, the vastus lateralis is separated from the iliotibial band and then turned to the center to be sutured to the vastus intermedius tendon, which is conducive to increasing the overall muscle strength of knee extension.
Achieving pain relief	Patients undergoing surgery because of knee stiffness may experience pain after surgery, even if they had no pain or only mild pain before surgery. The trauma reaction of the release operation itself is one reason for this. However, the fundamental reason is that the position change between tissues is increased owing to the improvement in knee range of motion. It is necessary to adapt to the new functional state of the knee during daily activities.

**Table 5.** Pearls and Pitfalls of Mini-invasive Quadriceps-plasty

The release of the vastus lateralis and the lateral retinaculum from the patella results in partial dissociation of the force chain of the vastus lateralis. At the end of the whole process, the vastus lateralis is separated from the iliotibial band and the dissociated vastus lateralis is sutured to the medial femoral tendons to restore the force chain.
During release of the distal quadriceps and femur and re-creation of the suprapatellar pouch, sharp release in the proximal-medial direction should be performed carefully; it should be carried out close to the femur, and blunt instruments such as the periosteum dissection device should be used in a timely manner to avoid injury to the femoral artery. In addition, attention should be paid to perform release close to the anterior side of the femur to avoid injury to the tendon of the vastus intermedius.
The adhesion of the patellofemoral joint is mainly a peripheral adhesion. As a result of the sealing of adhesion tissue and the bump of the femoral condyle, it is sometimes not easy to accurately detect the gap of the patellofemoral joint. It is necessary to touch and define the junction of the patella and the femur. Blind shearing will injure the cartilage of the femoral trochlea or the patella.
The release of the medial retinaculum does not affect the integrity of the vastus medialis and its attachment to the patella, in which the function of the vastus medialis is preserved.
It is generally believed that the contracture of the vastus intermedius is more severe than the contracture of the rectus femoris during contracture of the knee extensor because the vastus intermedius is directly affected by stimulation of fracture, surgery, and internal fixation. However, we have found that in cases of severe contracture of the knee extensor, the contracture of the rectus femoris muscle is greater than that of the vastus intermedius and has a greater effect on knee flexion, possibly owing to the longer span of the rectus femoris. Therefore, we suggest that the rectus femoris tendon be disassociated at the attachment of the patella.
In patients who have undergone surgery on the distal femur, the rectus vastus tendon and the vastus intermedius tendon are not clearly hierarchical. Proximal and distal exploration is required to determine the separation plane between the vastus intermedius and the rectus vastus muscle. Generally, a finger is probed through the incision between the rectus vastus and the vastus medialis tendons. Proximally and anteriorly, the rectus femoris muscle abdomen can be clearly detected, and distally, the aponeurosis can be detected to the surface of the patella (the tendon of the vastus intermedius is attached to the upper pole of the patella).

**Table 6.** Advantages of Mini-invasive Quadriceps-plasty

---

The incision is small and in a non-tension concentration area.

Almost the entire operation, comprising release and quadriceps-plasty, can be performed through this incision.

Retaining the attachment of the vastus medialis muscle to the patella not only preserves its extensor muscle strength but also reduces the possibility of patellar ischemic necrosis.

Quadriceps muscle overlapping Z-plasty can effectively solve quadriceps muscle contracture.

---

tendons are wrapped with a traction band for distal traction (Fig 10). The scissors are placed proximally into the space between the rectus femoris and vastus intermedius (Fig 11). The vastus intermedius tendon is cut as proximally as possible. The part of the vastus lateralis medial to the initial lateral tendon incision needs to be detached from the attachment of the patella.

Then, a slow manipulation is performed to reach the maximum knee flexion angle (Fig 12A). In the process of manual release, the inferior side of the vastus medialis is palpated to detect residual fiber strips that impede flexion for the final release.

#### **Step 8: Cutting of Anterolateral and Anteromedial Ligaments**

When there is no fibrous strip on the anterior side of the knee but the knee cannot be flexed to 90°, the fibrotic or calcified anterolateral and anteromedial capsule-ligament is cut through additional anteromedial and anterolateral punches. Manipulation is then performed to flex the knee.

#### **Step 9: Overlapping Z-plasty of Rectus Femoris and Vastus Intermedius**

The rectus femoris tendon and the vastus intermedius tendon are pulled distally and proximally, respectively (Fig 12B). The knee is flexed at 90° to determine the length at which the tendons need to overlap (Fig 13A).

The knee is extended, and the 2 tendons are overlaid and sutured according to the measured overlap length (Figs 13B and 14). Generally, the tendon of the vastus intermedius is placed on the back side, and the adipose tissue and muscle tissue behind the tendon end of the vastus intermedius are not removed to reduce the chance of adhesion of the tendon to the femur.

#### **Step 10: Transfer of Vastus Lateralis**

The vastus lateralis is separated from the iliotibial band. After confirmation of appropriate overlapping at 90° of knee flexion, all parts of the vastus lateralis detached from the patella are sutured to the vastus intermedius tendon (Fig 15) to make full use of the vastus lateralis and reduce the incidence of post-operative knee extension weakness.

**Table 7.** Contraindications for Mini-invasive Quadriceps-plasty

---

Joint release is not recommended in the healing process of femoral and patellar fractures: It may lead to myositis ossificans and increase the degree of stiffness.

Joint release is inappropriate in patients with unhealed or poorly healed lower-limb fractures: The stress generated during postoperative rehabilitation may delay fracture healing or cause internal fixation failure.

If the quadriceps, especially the vastus medialis and rectus femoris muscles, is severely fibrotic or if the vastus medialis and rectus femoris muscles have few muscular components, the ability to generate sufficient knee extension power is not expected and release surgery is not recommended. Otherwise, the dysfunction would only be exacerbated.

Regarding knee ligament surgery patients, knee ligament surgery can cause joint fibrosis. The period of operation is determined according to the period of fibrotic reaction. Joint fibrosis can be divided into the pain stage, pain-stiffness stage, and stiffness stage. Release surgery is usually performed during the period of stiffness when pain is generally relieved. Premature release surgery is ineffective and may even aggravate fibrosis.

Release surgery is contraindicated in patients with ongoing myositis ossificans.

A large area of severe scar formation around the knee joint is not suitable for release in patients in whom the knee soft-tissue sleeve expansion is not expected to recover.

If there are severe anatomic abnormalities in the articular component bones, there is no basis for tibia-femur or patella-femur relative sliding, or there is osseous fusion of the tibiofemoral or patellofemoral joints, then joint release alone is not sufficient. Joint release plus joint replacement may be considered in these patients.

Patients with severe damage to the articular cartilage often have less pain when the knee joint is in the state of adhesion whereas the pain is more severe when the knee joint motion improves. The prognosis of these patients should be fully informed, and joint release surgery should be contraindicated in patients who cannot tolerate pain. Joint release plus replacement surgery may be considered in these patients.

In patients with lower-leg amputation and knee stiffness, the length of the stump and the ability to apply sufficient bending stress after the release of the knee determine whether surgery is appropriate. Patients with a leg stump that is too short should not undergo release.

In patients who have undergone previous operations involving the quadriceps, especially various release operations, we need to fully judge the integrity of the tendon of the rectus femoris and femoris intermedius and the feasibility of overlapping Z-plasty. If there is no possibility of overlapping Z-plasty, the release operation is generally not recommended. Because only V-Y-plasty of the quadriceps tendon can be performed at this time, the effect of elongation of the knee extension device is poor.

---



After anterior knee release, soft-tissue release on the posterior side of the knee can be performed arthroscopically through posteromedial and posterolateral portals. If the arthroscopic release technique is not mastered, open posterior release can be performed (Table 3).

### Postoperative Management and Rehabilitation

A suction drain is placed through a puncture on the lateral middle side of the thigh as far away from the joint line as possible. The incisions are closed.

Postoperatively, an elastic bandage is routinely used. Active flexion training is started immediately after surgery. Knee flexion should be more than 90° as early as possible after surgery in patients who do not undergo quadriceps-plasty. For those who undergo quadriceps-plasty, knee flexion should be more than 90° at 3 weeks after surgery and more than 120° at 6 weeks after surgery. At 6 weeks after the operation, knee extensor muscle training is started. Various post-operative conditions should be prevented and addressed (Table 4).

### Discussion

The described technique is designed mainly for surgeons who have not mastered the arthroscopic technique. However, arthroscopic debridement is suggested to remove all the scar tissue within the joint, as well as the fibrotic infrapatellar fat pad, to obtain better clinical results. In a clinical study, we found that compared with traditional release, the recovery effect of activity

and muscle strength using this mini-invasive quadriceps-plasty is much better; moreover, the incidence of complications is significantly lower.

The pearls and pitfalls of the current technique are listed in Table 5. The critical points of the current technique are that there is no disassociation of the vastus medialis from the patella, the correct amount of tension in the imbricated rectus femoris and vastus intermedius is preserved, and posterior release is performed once the anterior release is completed but flexion is still unsatisfactory (Table 6). The contraindications for mini-invasive quadriceps-plasty are listed in Table 7.

### References

1. Luo Y, Li H, Mei L, Mao X. Effects of Judet quadricepsplasty in the treatment of post-traumatic extension contracture of the knee. *Orthop Surg* 2021;13:1284-1289.
2. Kukreja M, Kang J, Curry EJ, Li X. Arthroscopic lysis of adhesions and anterior interval release with manipulation under anesthesia for severe post-traumatic knee stiffness: A simple and reproducible step-by-step guide. *Arthrosc Tech* 2019;8:e429-e435.
3. Pujol N, Boisrenoult P, Beaufils P. Post-traumatic knee stiffness: Surgical techniques. *Orthop Traumatol Surg Res* 2015;101:S179-S186 (suppl).
4. Wang JH, Zhao JZ, He YH. A new treatment strategy for severe arthrofibrosis of the knee. A review of twenty-two cases. *J Bone Joint Surg Am* 2006;88:1245-1250.
5. Wang JH, Zhao JZ, He YH. A new treatment strategy for severe arthrofibrosis of the knee. Surgical technique. *J Bone Joint Surg Am* 2007;89:93-102 (suppl 2, pt 1).