Technical Note

Arthroscopic Release of Severe Flexion- and Extension-Impeding Knee Stiffness With Inaccessible Joint

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Abstract: Knee stiffness with severe flexion and extension impediment is a common clinical condition that challenges orthopaedic surgeons. Arthroscopic release techniques have been reported, mostly for slight extension or flexion deficits. However, for severe flexion- and extension-impeding knee stiffness, especially when there is no intra-articular space in which to place the arthroscope, effective arthroscopic release techniques are still being pursued. We introduce a systemic arthroscopic release technique to address this special condition, in which a trans—infrapatellar fat pad release technique is developed to obtain access to the joint and to perform intra-articular and periarticular release, as well as scar tissue removal. One critical point of this technique is to create the posteromedial and posterolateral portals to re-establish the posterior compartments, remove the fibrotic posterior septum, and release the posterior capsule. This technique combines almost all related arthroscopic techniques in the treatment of knee stiffness. We consider that the introduction of this technique will provide a useful guide when surgical release is selected for this special condition.

Knee stiffness with both extension and flexion impediment is the most common type of post-traumatic condition clinically. For slight end-stage range-of-motion limitation, in which condition the joint is accessible by an arthroscope, arthroscopic release is easy to perform and effective.[1-8] However, for knee stiffness with concomitant severe extension and flexion limitation, there is no intra-articular space in which to place the arthroscope because of scar tissue filling (Fig 1) and structural obstruction. In this case, the classic mini-invasive quadriceps-plasty is difficult to perform because it is difficult to release the anteromedial (AM) side of the knee across the patellofemoral joint through the small proximal anterolateral (AL) incision without full extension of the knee.[9] For this kind of knee stiffness condition, we have developed a set of arthroscopic release techniques, through which we can obtain access to the anterior

Fig 1. Preoperative magnetic resonance image indicating scar tissue filling in suprapatellar pouch (arrow) and fibrosis of infrapatellar fat pad (arrow) and posterior septum (dotted area).

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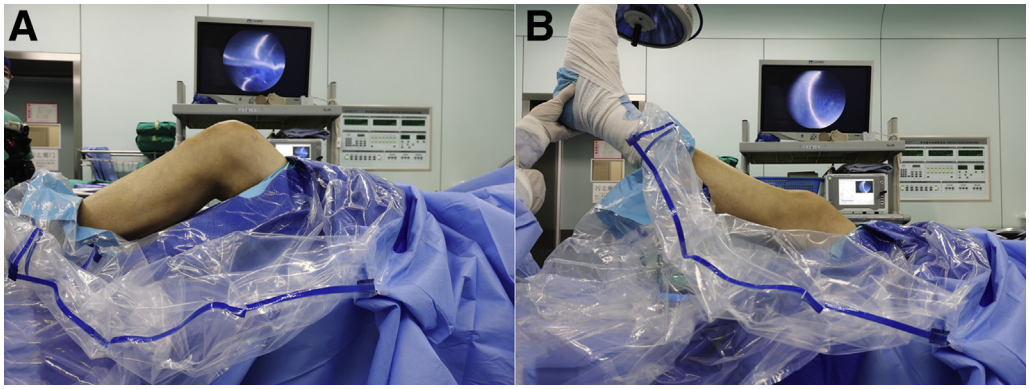

Fig 2. Preoperative degree of knee flexion (A) and extension (B).

compartment, suprapatellar pouch, and posterior compartments and complete the required release and scar tissue removal. The indications for this technique are knee stiffness with an extension limitation greater than 10°, less than 70° of knee flexion, and a joint that is inaccessible to the arthroscope (Fig 2).

Surgical Technique

Preoperatively, radiography, computed tomography, and magnetic resonance imaging examinations are performed to evaluate the integrity of the soft-tissue structures, structural fibrosis or calcification, and scar formation and adhesion (Fig 3). The elongation potential of the quadriceps is evaluated according to the disease history.

The patient is placed in the supine position. A tourniquet is placed on the proximal thigh. A lateral post is placed on the lateral side of the thigh for lateral leaning of the thigh at knee flexion. The medial edge of the vastus medialis and the lateral edge of the vastus lateralis are marked.

Creation of Working Space in Infrapatellar Fat Pad

The AL and AM portals are created at the medial and lateral edges of the patellar tendon at the level of the distal pole of the patella (Table 1, Video 1). Through the AL and AM portals, a working space is bluntly created in the infrapatellar fat pad. The scope is placed through the AL portal, and the instrument is placed through the AM portal. The working space is enlarged by partial removal of the infrapatellar fat pad (Fig 4).

Medial Retinacular Release

A medial subcutaneous soft-tissue tunnel is made with an obturator from the AM portal to the medial edge of the vastus medialis at the adductor tubercle (Fig 5A). Along this medial soft-tissue tunnel, the

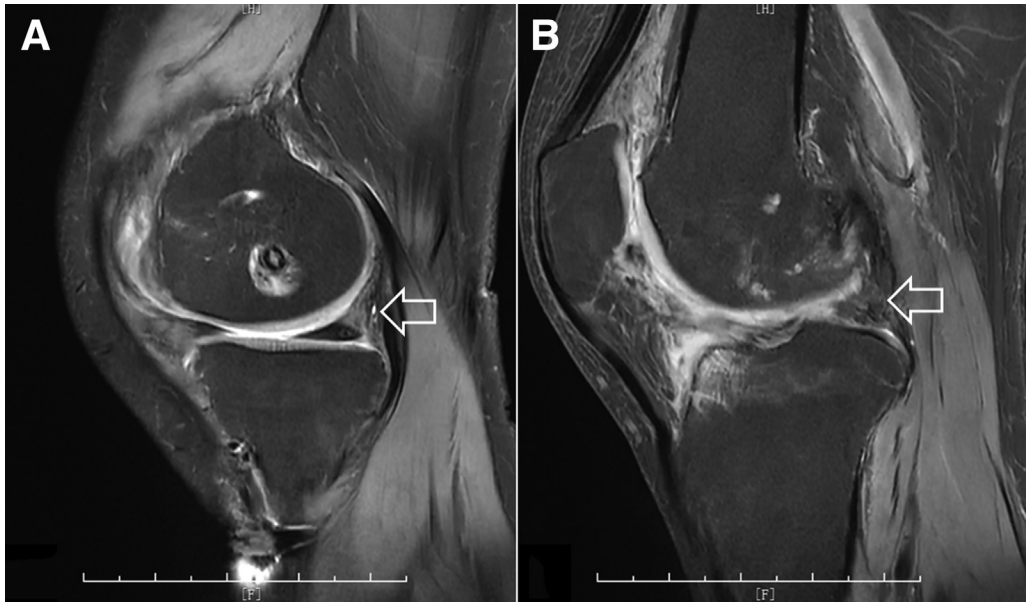

Fig 3. Preoperative magnetic resonance images indicating fibrosis of posterior capsule of posteromedial (A) and posterolateral (B) compartments (arrows).

Table 1. Step-by-Step Procedures for Arthroscopic Release of Severe Flexion- and Extension-Impeding Knee Stiffness With Inaccessible Joint

1.	The anterolateral and anteromedial portals are created. A working space is created in the infrapatellar fat pad and enlarged by its partial removal.
2.	A medial subcutaneous soft-tissue tunnel is made from the anteromedial portal to the medial edge of the vastus medialis at the adductor tubercle. Along this medial soft-tissue tunnel, the medial retinaculum, along with the inner capsule layer, is released to expose the medial femoral condyle.
3.	A lateral subcutaneous soft-tissue tunnel is made from the anterolateral portal to the lateral edge of the vastus lateralis at the junction of the vastus lateralis and the iliotibial band. Along this lateral soft-tissue tunnel, the lateral retinaculum, along with the inner capsule layer, is released to expose the lateral femoral condyle.
4.	The vastus lateralis is detached from the lateral femoral condyle. The fibrotic capsule layer is removed from the underside of the vastus lateralis.
5.	The infrapatellar fat pad is detached from the distal pole of the patella.
6.	The suprapatellar pouch is re-established through release along the anterior side of the distal femur.
7.	A supralateral patellar portal is created. All the scar tissue in the suprapatellar pouch, especially that sticking to the inferior side of the quadriceps, is removed.
8.	The fibrotic infrapatellar fat pad is fully removed.
9.	The medial gutter is re-established by removing the scar tissue between the medial capsular ligament layer and the medial femoral condyle.
10.	The lateral gutter is re-established by removing the scar tissue and the capsule layer between iliotibial band and the lateral femoral condyle.
11.	Vastus intermedius–based quadriceps-plasty is performed when indicated.
12.	The scar tissue on the distal-anterior side of the ACL tibial insertion and that within the femoral notch are removed. Femoral notch–plasty is performed. The scar tissue over the anterior horns of the medial and lateral menisci is removed to expose the medial and lateral tibial eminences near extension.
13.	The elevated medial tibial eminence is removed. The arthroscope is placed into the posteromedial compartment. The posteromedial portal is fabricated.
14.	The scope is placed into the posteromedial compartment and passed through the posterior septum to the site of the posterolateral compartment. The posterolateral portal is created.
15.	The posterolateral compartment is re-established by releasing the scar tissue from the posterior side of the lateral femoral condyle. The inner-layer scar tissue is removed from the lateral head of the gastrocnemius to expose it. Part of the posterior septum is removed.
16.	The posteromedial compartment is re-established by releasing the scar tissue from the posterior side of the medial femoral condyle. The inner-layer scar tissue is removed from the medial head of the gastrocnemius to expose it. The posterior septum is totally removed.
17.	The posterior capsule, along with the fibrotic layer of the medial and lateral heads of the gastrocnemius, is released from the posterior side of the distal femur.
18.	The posterior capsule is release from its tibial attachment.

ACL, anterior cruciate ligament.

medial retinaculum, along with the inferior capsule layer, is released to expose the medial femoral condyle (Fig 5B).

Lateral Retinacular Release

The arthroscope is placed into the infrapatellar fat pad through the AM portal; the instruments are placed through the AL portal. A lateral subcutaneous soft-tissue tunnel is made with an obturator from the AL portal to the lateral edge of the vastus lateralis at the junction of the vastus lateralis and the iliotibial band (ITB) (Fig 6A). Along this lateral soft-tissue tunnel, the lateral retinaculum, along with the inferior capsule layer, is released to expose the lateral femoral condyle (Fig 6B).

Detachment of Lateral Extensor From Femoral Condyle

Along the anterior-lateral side of the lateral femoral condyle, the vastus lateralis is detached from the lateral femoral condyle to expose the lateral side of the patellofemoral joint (Fig 7). The fibrotic capsule layer is removed from the underside of the vastus lateralis.

Detachment of Infrapatellar Fat Pad From Patella

The infrapatellar fat pad is detached from the distal pole of the patella to obtain access to the patellofemoral

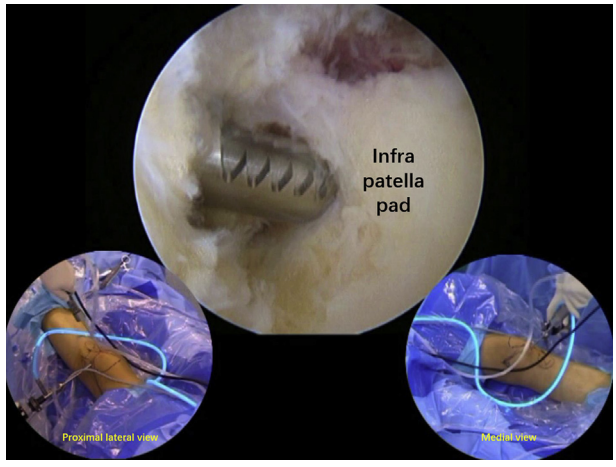

Fig 4. Arthroscopic view of retropatellar tendon space in left knee through anterolateral portal showing creation of working space within fibrotic infrapatellar fat pad.

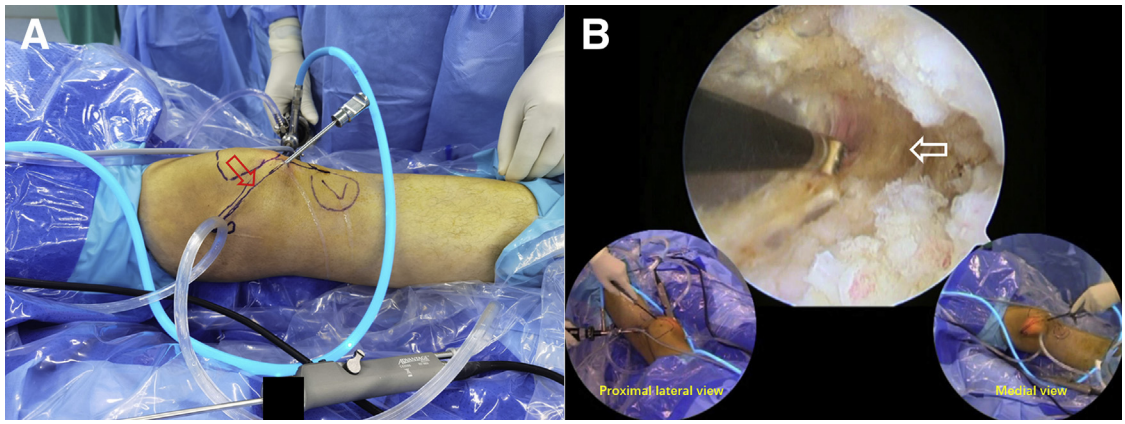

Fig 5. (A) Medial view of left knee showing creation of medial subcutaneous soft-tissue tunnel (arrow) from anteromedial portal to medial edge of vastus medialis. (B) Arthroscopic view of left knee through anterolateral portal showing release (arrow) of medial retinaculum and capsule along medial soft-tissue tunnel.

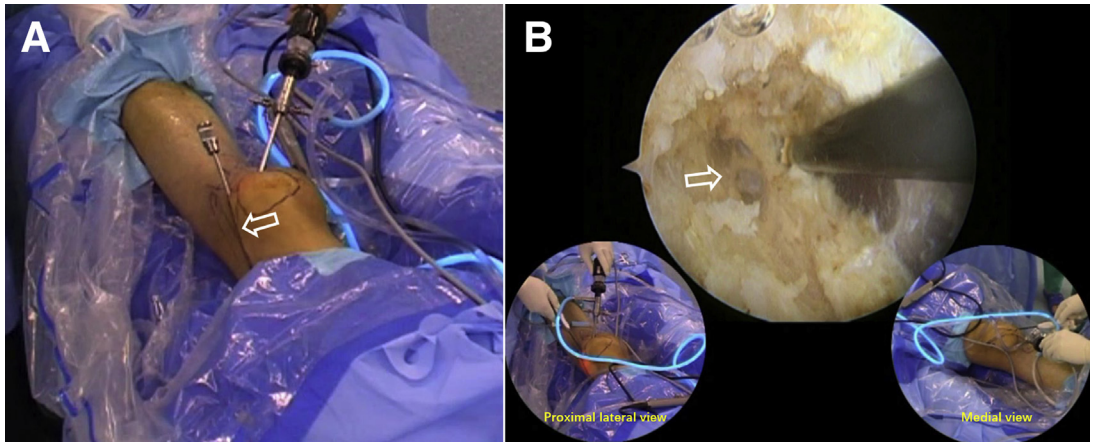

Fig 6. (A) Proximal lateral view of left knee showing creation of lateral subcutaneous soft-tissue tunnel (arrow) from anterolateral portal to junction of vastus lateralis and iliotibial band. (B) Arthroscopic view of left knee through anteromedial portal showing release (arrow) of lateral retinaculum and capsule along lateral soft-tissue tunnel.

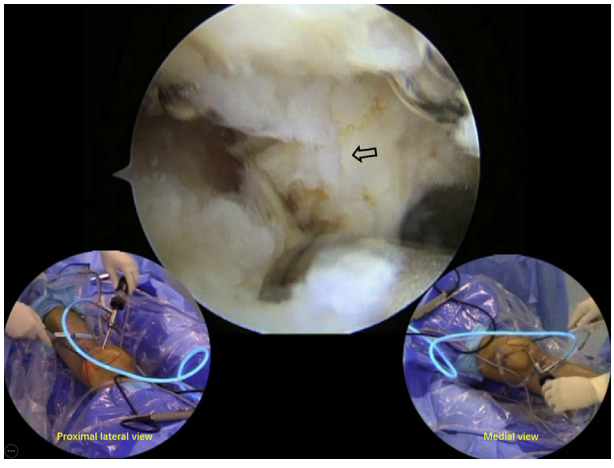

Fig 7. Arthroscopic view of left knee through anteromedial portal showing release of scar tissue (arrow) between vastus lateralis and lateral femoral condyle.

joint through the AM and AL portals and the suprapatellar pouch through the patellofemoral joint (Fig 8).

Re-establishment of Suprapatellar Pouch

The suprapatellar pouch is re-established through a release along the distal femur proximally until beyond the scar tissue connection between the quadriceps tendon and the distal femur (Fig 9). A supralateral patellar portal is created. All the scar tissue in the suprapatellar pouch, especially that sticking to the inferior side of the quadriceps, is removed (Fig 10).

Re-establishment of Medial Gutter

The fibrotic infrapatellar fat pad is fully removed (Fig 11). The medial gutter is re-established by removing the scar tissue between the medial capsular ligament layer and the medial femoral condyle (Fig 12). The calcified tissue within the medial collateral ligament is

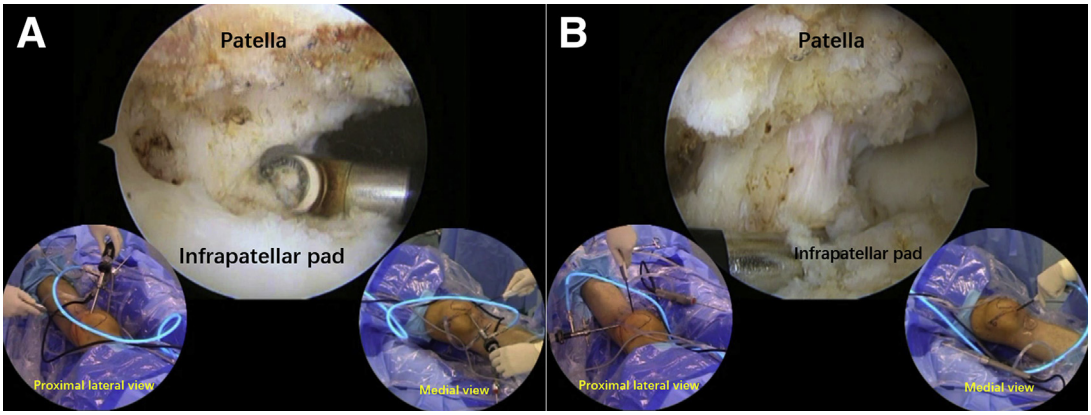

Fig 8. (A, B) Arthroscopic view of left knee through anterolateral portal showing detachment of fibrotic infrapatellar fat pad from patella.

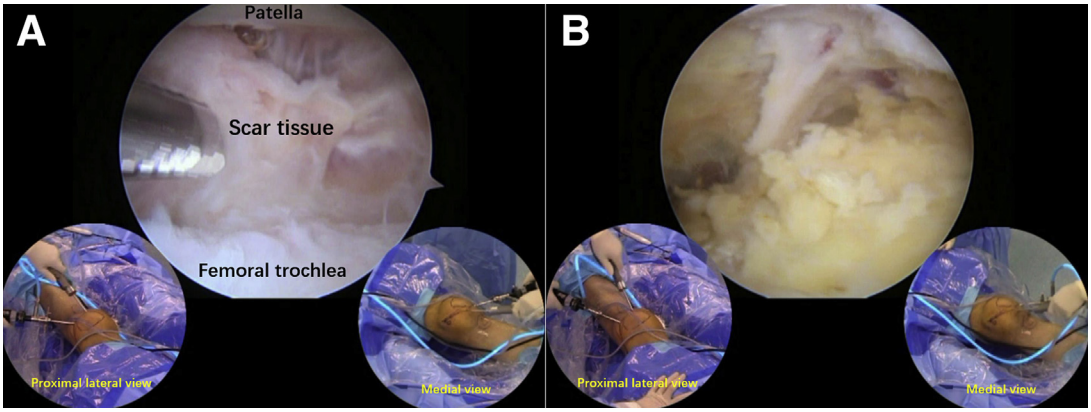

Fig 9. Arthroscopic view of left knee through anterolateral portal showing scar tissue filling suprapatellar pouch (A) and after removal (B).

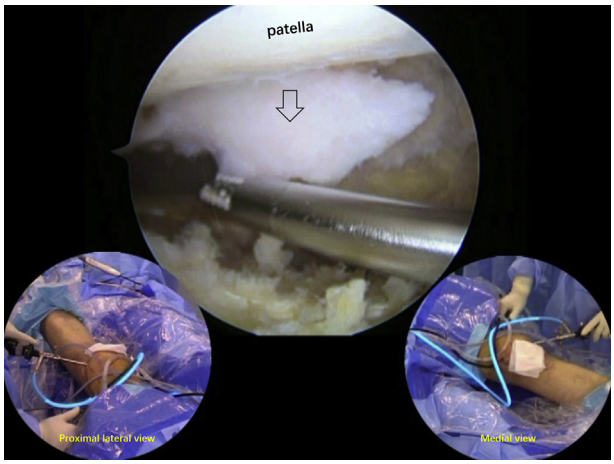

Fig 10. Arthroscopic view of left knee through anterolateral portal showing removal of scar tissue (arrow) under quadriceps tendon.

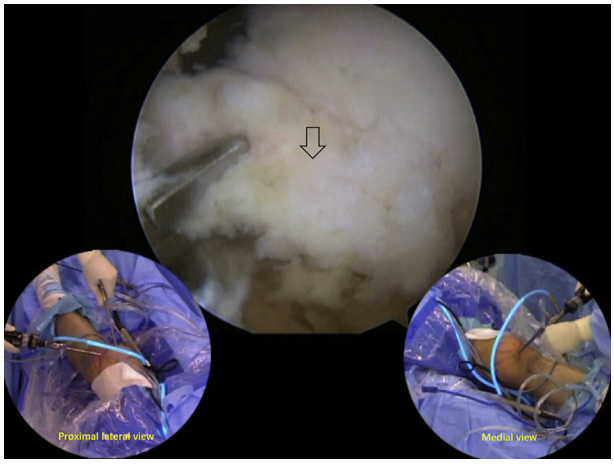

Fig 11. Arthroscopic view of left knee through anterolateral portal showing removal of fibrotic infrapatellar fat pad (arrow).

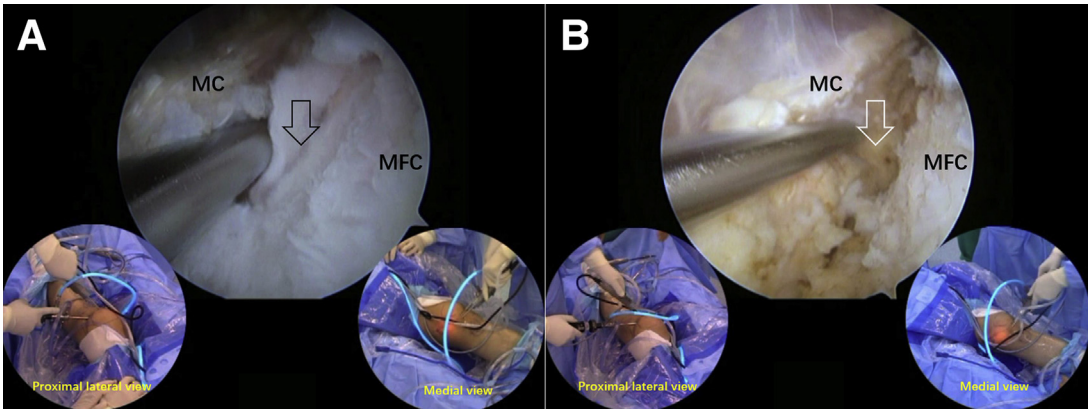

Fig 12. Arthroscopic view of left knee through anterolateral portal showing removal of scar tissue between medial capsular ligament (MC) and medial femoral condyle (MFC) (arrow) (A) and re-creation of medial gutter (arrow) (B).

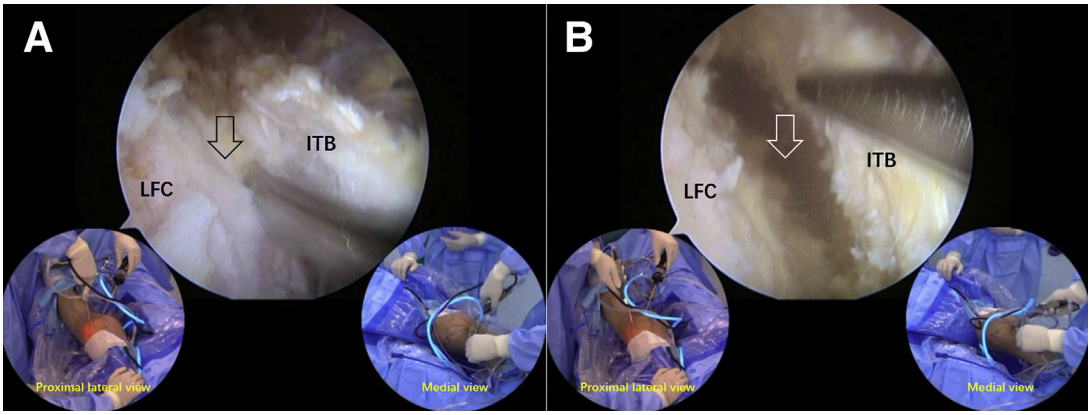

Fig 13. Arthroscopic view of left knee through anteromedial portal showing removal of scar tissue between iliotibial band (ITB) and lateral femoral condyle (LFC) (arrow) (A) and re-creation of lateral gutter (arrow) (B).

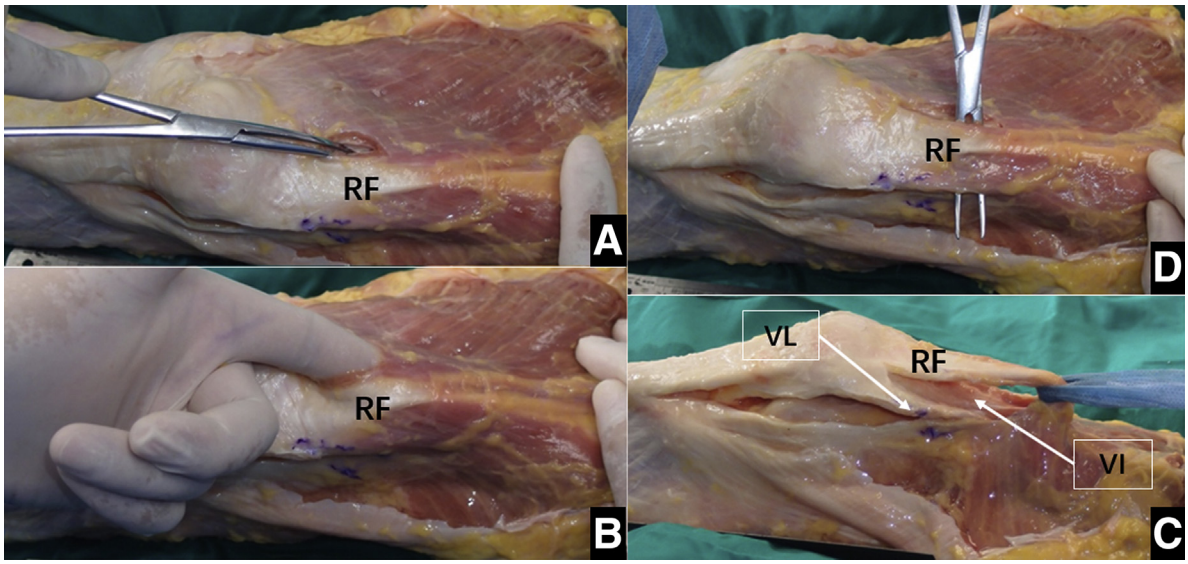

Fig 14. Specimen view of left knee showing distal separation of rectus femoris (RF). (A) An incision is made at the conjunction of the vastus medialis and the RF. (B) The lateral edge of the RF is defined by palpation at its underside. (C) The RF is separated from the vastus intermedius (VI) and the vastus lateralis (VL). (D) Separated RF.

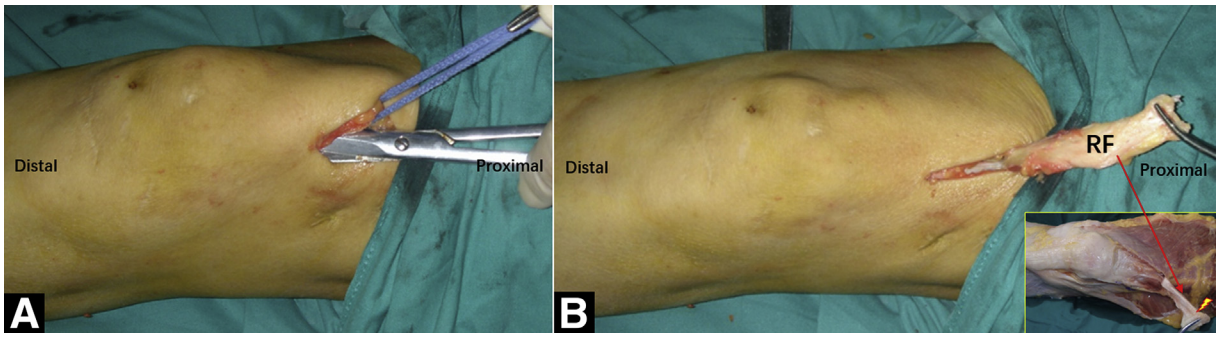

Fig 15. The rectus femoris (RF) is disassociated from the patella. (A) Intraoperative view during dissociation of RF from patella. (B) Intraoperative view showing dissociation of RF from patella.

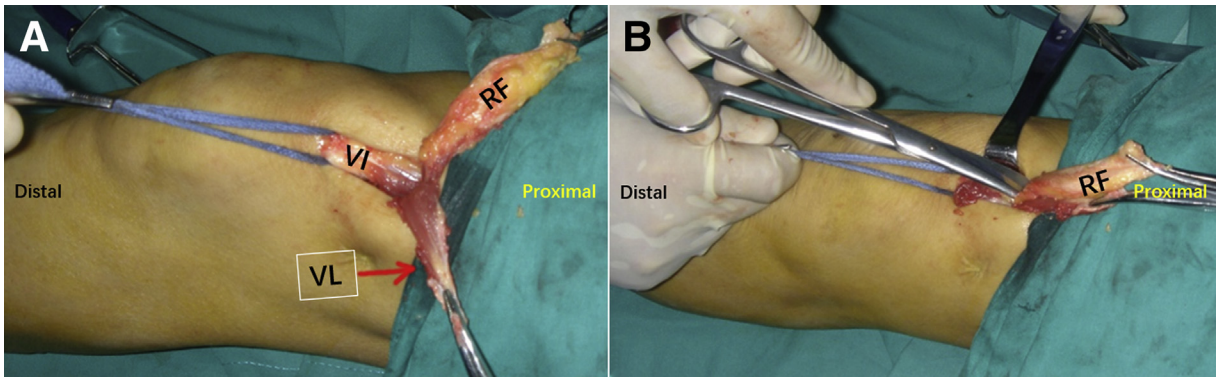

Fig 16. Intraoperative view of left knee showing separation (A) and proximal dissociation (B) of vastus intermedius (VI). (RF, rectus femoris; VL, vastus lateralis.)

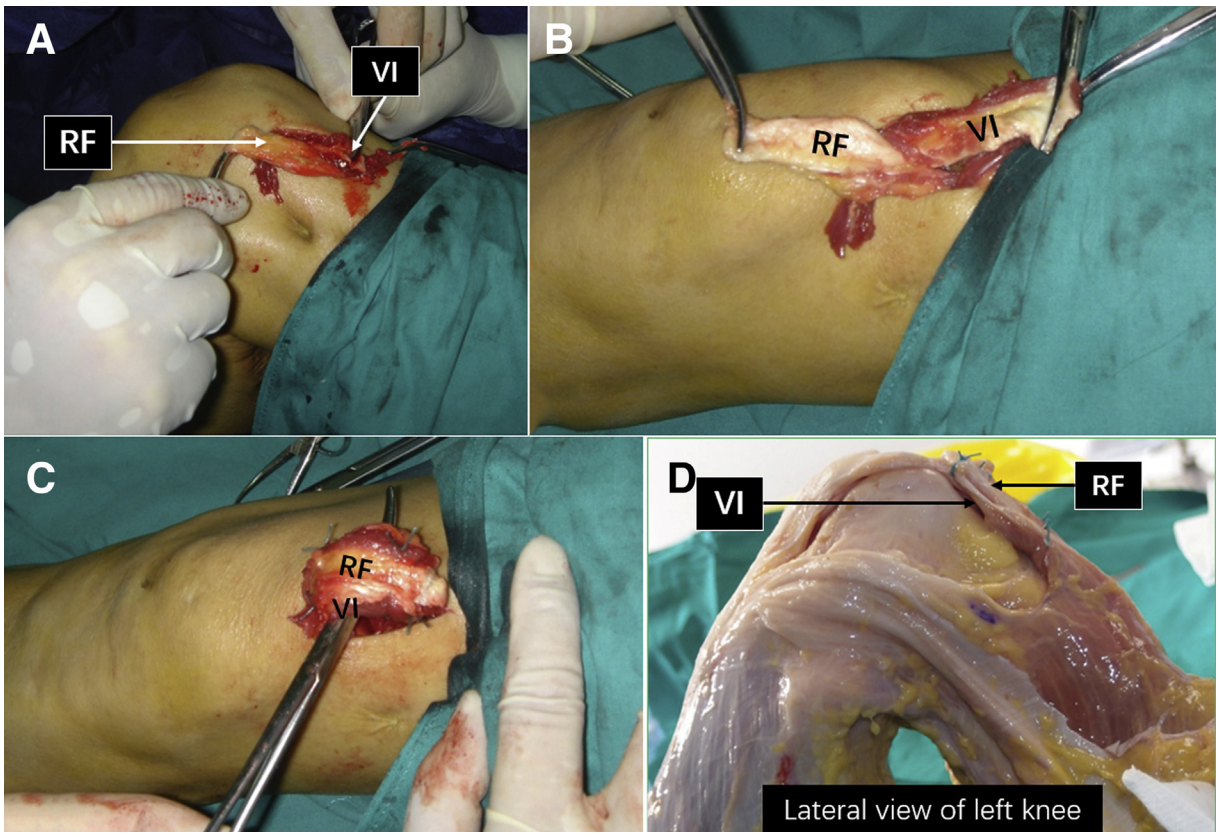

Fig 17. Overlapping Z-plasty of rectus femoris (RF) and vastus intermedius (VI). (A) The knee is flexed to over 90° to evaluate the results of release and to determine the length to which the tendons need to overlap. (B) The RF and vastus medialis are pulled in opposite directions. (C) The 2 tendons are overlaid and sutured according to the measured overlap length. (D) Lateral view showing overlapping Z-plasty of RF and VI in left knee specimen.

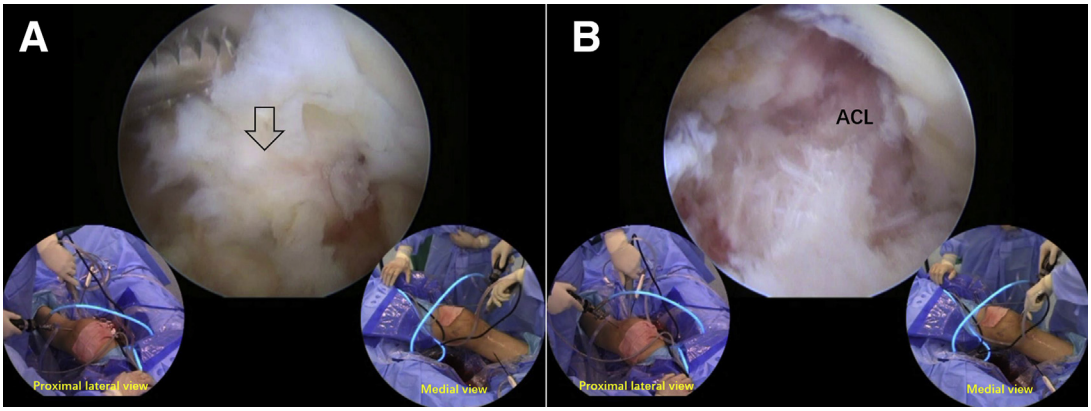

Fig 18. Arthroscopic view of left knee through anteromedial portal showing removal of scar tissue on anterior side of tibial insertion of anterior cruciate ligament (ACL) (arrow) (A) and exposure of ACL (B).

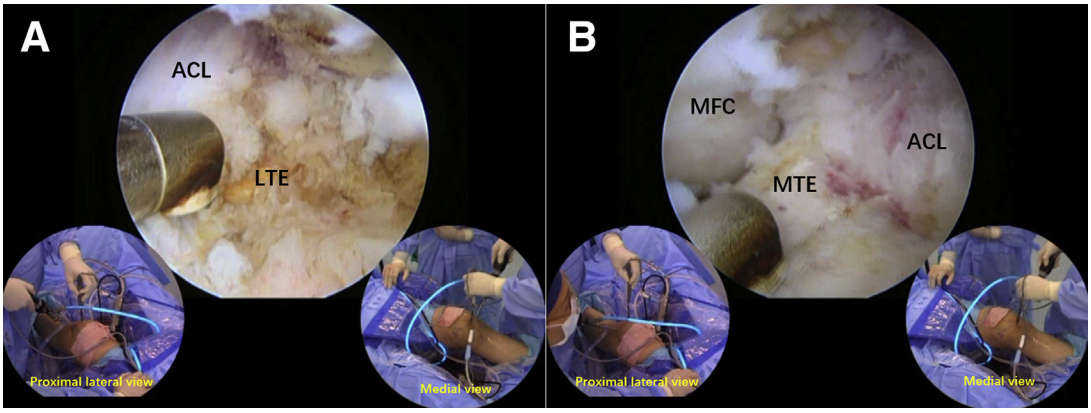

Fig 19. Arthroscopic view of left knee through anteromedial portal showing removal of scar tissue at insertions of anterior horn of medial (A) and lateral (B) menisci and exposure of tibial eminences. (ACL, anterior cruciate ligament; LTE, lateral tibial eminence; MFC, medial femoral condyle; MTE, medial tibial eminence.)

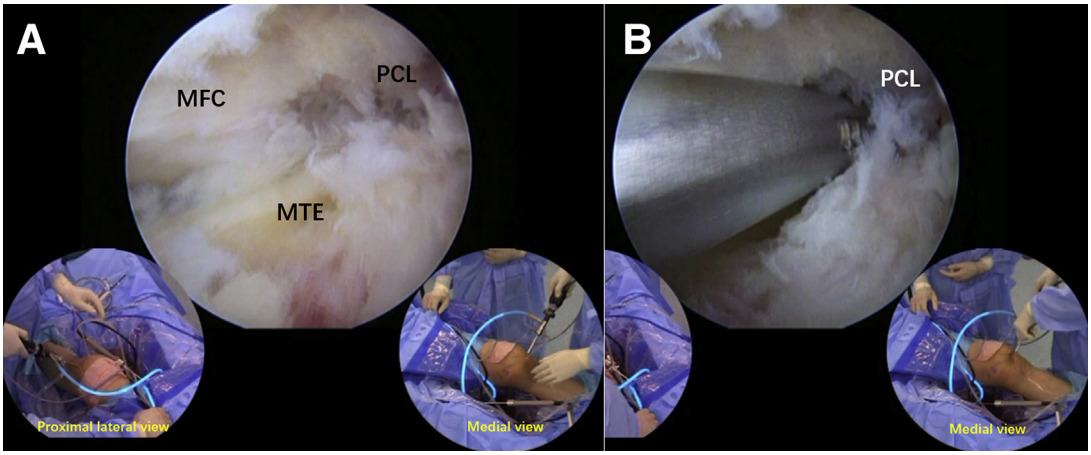

Fig 20. Arthroscopic view of left knee through anterolateral portal. The elevated medial tibial eminence (MTE) is removed (A), and the passage to the posteromedial compartment through the femoral notch is cleared (B). (MFC, medial femoral condyle; PCL, posterior cruciate ligament.)

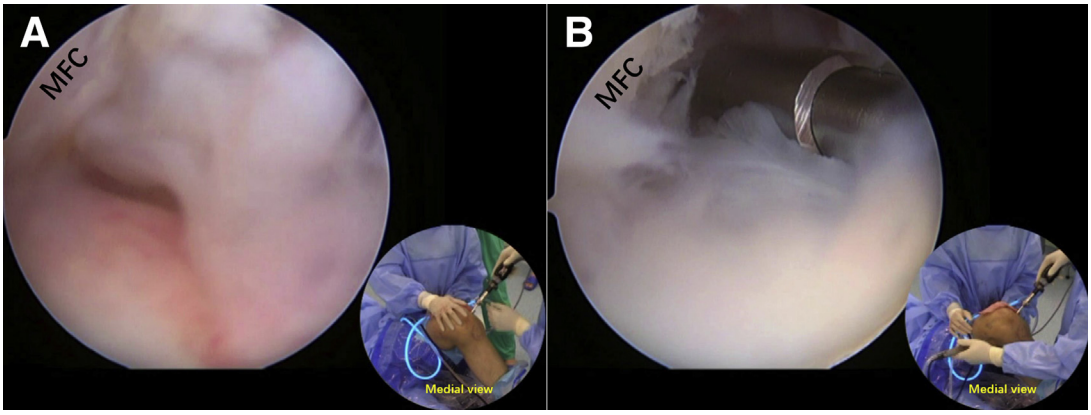

Fig 21. Arthroscopic view of posteromedial compartment of left knee through anteromedial portal showing posteromedial compartment filled with scar tissue (A) and after preliminary debridement (B). (MFC, medial femoral condyle.)

removed. In case of severe thickening of the medial collateral ligament, its anterior part is transected.

Re-establishment of Lateral Gutter

The lateral gutter is re-established by removing the scar tissue between the ITB and the lateral femoral condyle (Fig 13). In case of severe thickening of the ITB that causes friction with the lateral femoral condyle, the ITB is released. The calcified tissue within the ITB is removed.

Overlapping Z-Plasty of Rectus Femoris and Vastus Intermedius

Manual manipulation is performed to flex the knee, and tension of the quadriceps is assessed. In case of a quadriceps that is too tight, preventing the knee from being flexed to 90°, quadriceps-plasty is indicated and performed through a small longitudinal incision over the distal-lateral part of the vastus rectus.

A longitudinal incision on the AL side of the distal thigh is established, starting approximately 2 cm from the proximal lateral pole of the patella and extending proximally by about 4 cm. The quadriceps tendon is exposed.

A longitudinal incision is made between the rectus femoris and vastus medialis for a length of 3 cm. From this incision, the underside and the lateral margin of the rectus femoris muscle are detected by palpation. An incision is made at the lateral edge of the rectus femoris to separate it from the vastus intermedius and lateralis. The vastus lateralis is dissociated from the patella (Fig 14).

The rectus femoris is dissociated from the patella (Fig 15). While the connection of the vastus intermedius to the patella is maintained, the vastus intermedius is transected at the tendon-muscle junction (Fig 16).

The knee is flexed to detect the presence of residual fibrotic bands on the undersurface of the vastus medialis muscle, affecting knee flexion. If high-tension fiber strips are present, they are cut.

The knee is manipulated until it is flexed beyond 90°, which will result in proximal retraction of the rectus femoris. The extent of overlap between the rectus femoris tendon and the vastus intermedius tendon is determined at this knee flexion angle. The knee is extended. The proximally pedicled rectus femoris tendon and distally pedicled vastus intermedius tendon are stacked according to the degree of overlap determined by the aforementioned procedure and sutured together (Fig 17). At 90° of flexion of the knee, the vastus lateralis tendon detached from the patella is sutured to the vastus intermedius tendon.

Elimination of Anterior Impingement

The scar tissue on the distal-anterior side of the tibial insertion of the anterior cruciate ligament (ACL) and that within the femoral notch are removed to eliminate impingement to the ACL (Fig 18). The adhesion between the ACL and the posterior cruciate ligament (PCL) is released. Femoral notch—plasty is performed to eliminate scar tissue or bony impingement. The scar

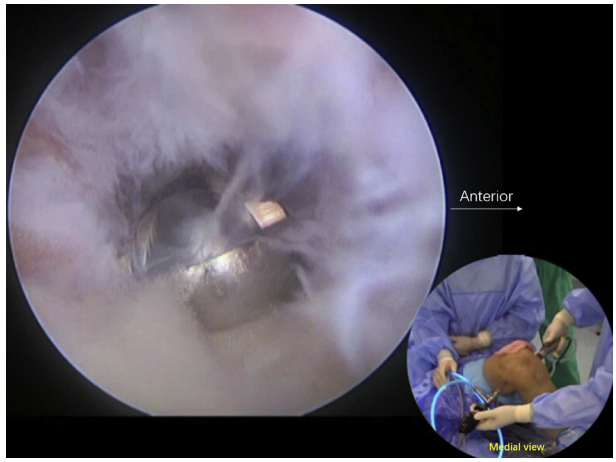

Fig 22. Arthroscopic view of posterolateral compartment of left knee through posteromedial portal and posterior septum showing scar tissue filling posterolateral compartment.

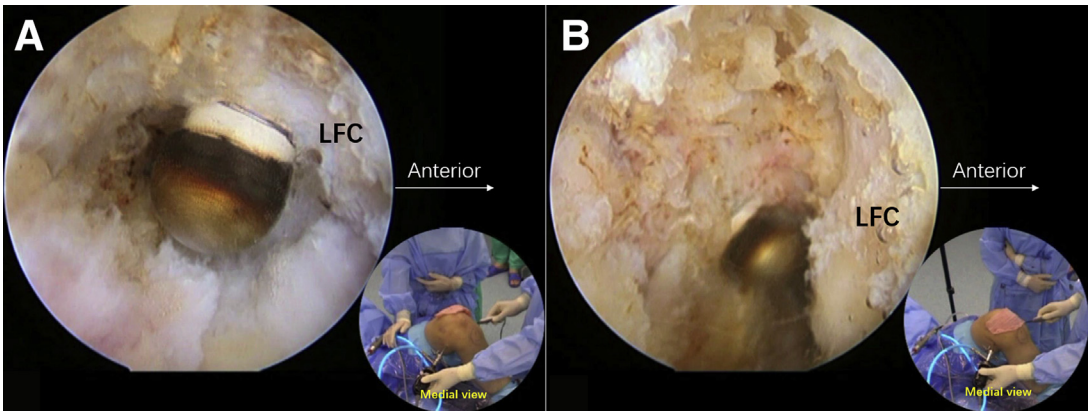

Fig 23. Arthroscopic view of left knee through posteromedial portal. The scar tissue is released from the posterior side of the lateral femoral condyle (LFC) (A), and the posterolateral compartment is re-established (B).

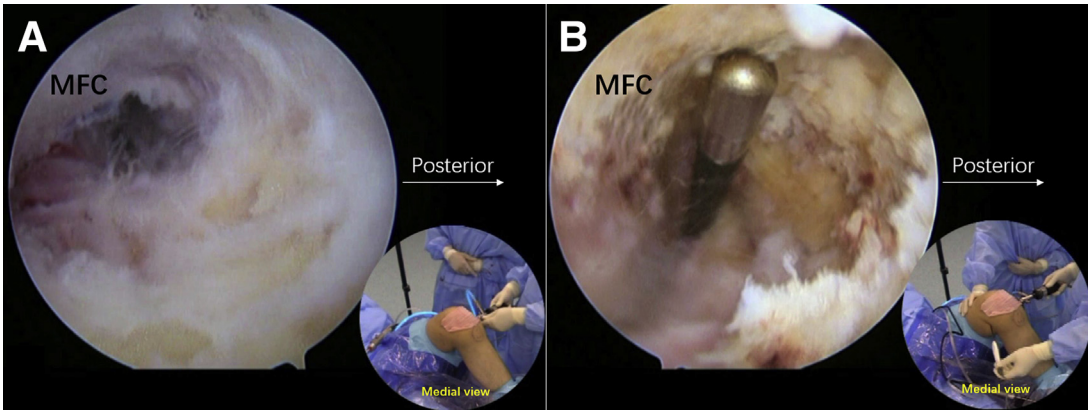

Fig 24. Arthroscopic view of left knee through posterolateral portal. The scar tissue is released from the posterior side of the medial femoral condyle (MFC) (A), and the posteromedial compartment is re-established (B).

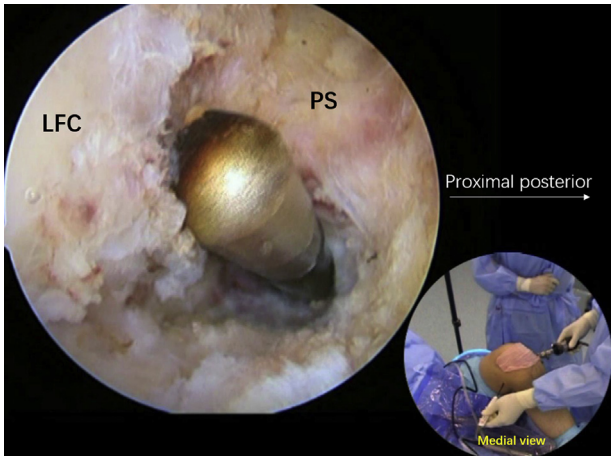

Fig 25. Arthroscopic view of left knee through posterolateral portal showing removal of fibrotic posterior septum (PS). (LFC, lateral femoral condyle.)

tissue over the anterior horns of the medial and lateral menisci is removed to expose the medial and lateral tibial eminences near extension (Fig 19).

Creation of Posteromedial and Posterolateral Portals

The adhesion between the PCL and the medial femoral condyle is released. The hypertrophied medial tibial eminence is removed, and the passage to the posteromedial (PM) compartment, which is formed by the PCL, the medial wall of the femoral notch, and the medial tibial eminence, is cleared (Fig 20). The knee is flexed at 30°. The obturator with a trocar is passed from the AL portal through this passage to the PM compartment. The knee is flexed at 90°. The obturator is replaced with the arthroscope. The PM portal is fabricated, and debridement is performed in the PM compartment to enlarge the view (Fig 21).

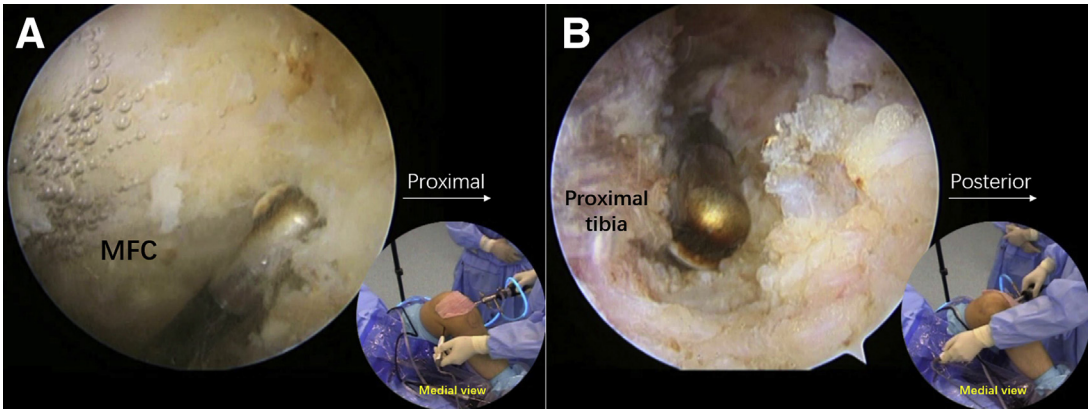

Fig 26. Arthroscopic view of left knee through posterolateral portal showing release of posterior capsule from its femoral (A) and tibial (B) insertions. (MFC, medial femoral condyle.)

The scope is placed into the PM compartment through the PM portal and passed through the posterior septum to the site of the posterolateral (PL) compartment. The PL portal is created (Fig 22).

Re-establishment of Posterior Compartments

With the arthroscope placed through the PM portal, the PL compartment is re-established by releasing the scar tissue from the posterior side of the lateral femoral condyle (Fig 23). The inner-layer scar tissue is removed from the lateral head of the gastrocnemius to expose it. Part of the posterior septum is removed.

With the arthroscope placed through the PL portal, the PM compartment is re-established by releasing the scar tissue from the posterior side of the medial femoral condyle (Fig 24). The inner-layer scar tissue is removed from the medial head of the gastrocnemius to expose it. The posterior septum is totally removed (Fig 25).

Posterior Capsule Release

The posterior capsule, along with the fibrotic layer of the medial and lateral heads of the gastrocnemius, is released from the posterior side of the distal femur. Finally, the capsule is released from its tibial attachment (Fig 26). Knee extension is assessed. If 5° of hyperextension is not obtained, posterior release is continued proximally along the posterior side of the distal femur. The knee is flexed and extended several times to ensure that over 150° of knee flexion and over 5° of hyperextension can be obtained (Fig 27).

Postoperative Management

Postoperatively, suction drainage is placed through the supralateral patellar portal and removed until the daily amount of drainage is less than 100 mL and blood effusion has changed to plasma effusion. Partial to full weight bearing begins immediately. Range-of-motion exercises begin immediately to keep the degree of flexion over 120° as far as possible. A knee brace is used at rest to lock the knee in full extension and during walking to restrict knee flexion to 45°. Muscle strengthening exercises begin at 7 weeks. The patient is allowed to run and jump at 3 months.

Discussion

There are many pathologic changes in the flexion- and extension-impeding stiff knee, which include mainly

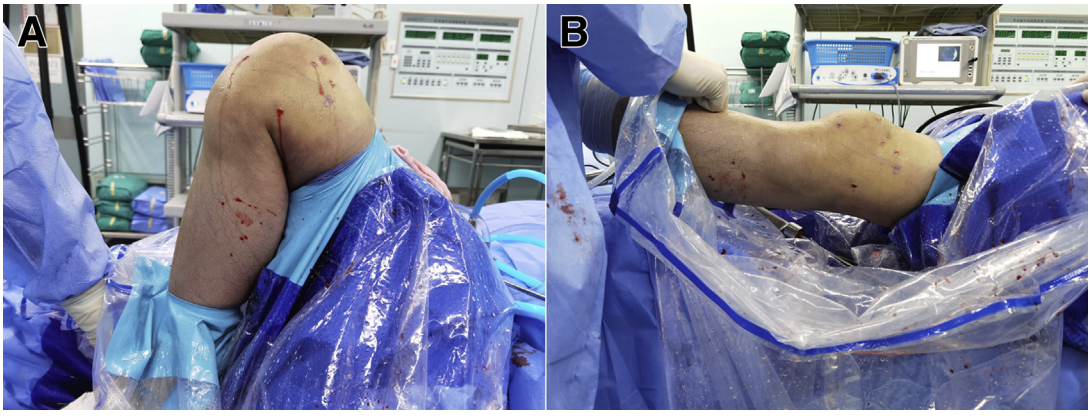

Fig 27. Postoperative degree of knee flexion (A) and extension (B).

Table 2. Pearls and Pitfalls of Arthroscopic Release of Severe Flexion- and Extension-Impeding Knee Stiffness With Inaccessible Joint

1.	Although this procedure is named a "release," all the scar tissue and the thickened fibrotic capsule should be removed to ensure the outcome.
2.	In case of extension limitation of the knee, the arthroscope cannot be inserted into the patellofemoral joint and suprapatellar pouch. The only accessible place is the anterior compartment.
3.	If the anterior compartment is also inaccessible because of fibrosis, trans—infrapatellar fad release should be performed.
4.	In case of severe patellar tendon contracture, if the position of the patella is too low, blocking access to the anterior compartment of the knee and access to the posteromedial compartment through the femoral notch, patellar tendon—plasty should be performed to restore the height of the patella.
5.	Arthroscopic access to the suprapatellar pouch is impossible at fixed knee flexion without releasing the medial retinaculum and lateral retinaculum. Thus, retinacular release is first performed.
6.	The posterior compartment is also inaccessible when the knee cannot be flexed to 90°, which makes creating the posteromedial and posterolateral compartments and performing posterior release extremely difficult and dangerous. Thus, anterior release should be conducted first to obtain high flexion degrees.
7.	Because the scar tissue is often very thick, arthroscopic debridement and release are time-consuming and require patience while operating.
8.	The intercondylar notch and anterior compartment of the knee should be sufficiently cleared to eliminate any possible impingement.
9.	During creation of the posteromedial and posterolateral portals, care should be taken to stay close to the femoral condyles, owing to the limitation or even absence of the posterior compartments, and to enlarge the working space and view bit by bit.
10.	Excision of the fibrotic capsule and pericapsular fibrotic tissue in the middle of the posterior side of the knee requires great care to avoid damaging the popliteal vessels and nerves.
11.	In the middle of the posterior side of the knee, the operation should be performed as little as possible in the adipose tissue outside the capsule. Otherwise, one may damage the lymphatic vessels inside, cause lymphatic edema of the lower extremity, and increase the difficulty of treatment. The safe method is to avoid the transverse incision of the posterior joint capsule but dissociate the joint capsule at the attachment of the femur and tibia and close to the bone.
12.	If knee flexion is close to 90° and there is room for instrument manipulation on the posterior side of the knee, release of the posterior knee can be performed first. After the knee can be fully extended, the medial and lateral knee and suprapatellar pouch are released. If the knee flexion angle is far from 90°, it is necessary to increase knee flexion before releasing the posterior side of the knee. The measures to increase the knee flexion angle include arthroscopic release with or without mini-open quadriceps-plasty or pure mini-open knee release with quadriceps-plasty.

patellar tendon and quadriceps tendon contracture, quadriceps fibrosis, quadriceps-femoral adhesion, adhesion of the retinaculum and capsule to the femoral condyle, fibrosis and/or contracture of the infrapatellar fat pad, contracture adhesion of the posterior joint capsule or posterior soft tissue, and anterior impingement at the femoral notch and the anterior horns of the medial and lateral menisci. Except for the shortening and fibrosis of the knee extensors that need open surgical procedures, all the other pathologic changes can be addressed arthroscopically. Although such treatment is time-consuming, it is effective to improve the range of motion of the knee.

The critical points of the current technique are obtaining access to the joint with the trans—infrapatellar fat pad release technique and establishing the PM and PL portals to re-establish the posterior compartments and release the posterior capsule. Pearls and pitfalls are listed in Table 2. An advantage of the current technique is that this difficult condition can be effectively addressed mainly arthroscopically. Disadvantages of this technique are that it is technically challenging and time-consuming. The range of motion obtained through release may decrease if the rehabilitation protocol is not strictly abided by.

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