58 Arthroscopic Arthroplasty for Knee Osteoarthritis

Jinzhong Zhao

Knee osteoarthritis (OA) can cause joint pain, stiffness, and limited movement. Surgery is the last resort in the comprehensive treatment, in which minimally invasive arthroscopic surgery was once reported to be effective [1–3]. However, clinical studies have shown that arthroscopic joint debridement is not effective as placebo surgery or conservative treatment [4, 5]. Based on these studies, recent reviews have found no advantage of arthroscopic surgery over conservative treatment [6–8]. Therefore, many researchers limit the indications of arthroscopic treatment of knee OA to the presence of mechanical symptoms [9–13], although the main clinical symptoms of knee OA are not mechanical. Currently, although arthroscopy for knee OA is still being performed for various reasons [14, 15], the practice seems to lack academic support.

The specific arthroscopic techniques used to treat Knee OA vary widely in the literature, ranging from simple joint irrigation to complex chondroplasty. Most of the reported techniques are arthroscopic joint debridement. Since 2000, we have adopted a special arthroscopic technique to treat knee OA, which is named arthroscopic arthroplasty, with the expectation to realize the pain-relieving mechanism of joint replacement through arthroscopic procedures. It is generally believed that the pain sources are subchondral bone, synovial membrane, joint capsule ligament, patellofemoral joint, femoral notch, tendon insertions, and muscles [16–18], with synovial-derived pain and subchondral osteogenic pain as the main sources. Thus, corresponding procedures are designed to address these pain sources (Table 58.1) to realize the pain-relieving mechanisms of joint replacement with arthroscopic arthroplasty. This technique can be used alone or combined with other arthroscopic procedures or deformity-correcting osteotomy for all three categories of knee OA (Table 58.2). The indication of this technique is knee OA with severe pain symptoms (VAS score > 6), an obvious impediment to daily life, and failure of conservative treatment, especially in patients not over 70 years old.

J. Zhao (✉)
Department of Sports Medicine, Shanghai Sixth People's Hospital, Shanghai Jiao Tong University, Shanghai, China
e-mail: jzzhao@sjtu.edu.cn

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Table 58.1 Pain-relieving mechanisms of joint replacement versus arthroscopic arthroplasty

Origin or causes of pain in knee OA	Pain-relieving mechanisms of joint replacement	Pain-relieving mechanisms of arthroscopic arthroplasty	Differences in the results
Subchondral bone	Removal of the disordered subchondral bone layer	Denervation of the disordered subchondral bone layer	Arthroscopic subchondral denervation of the proximal tibial is less complete than joint replacement
	Relieving overloading through alignment correction	Relieving overloading through combined osteotomy	Equal
Synovium	Removal of inflammatory or hyperplastic synovium	Removal of inflammatory or hyperplastic synovium	Arthroscopic removal of the synovium is more complete, especially in the posterior compartments of the knee
Ligament	Removal of irritating osteophyte	Osteophyte removal	Equal
Patellofemoral joint	Patella plasty Patella denervation	Patella plasty Patella denervation Lateral retinaculum release	Lateral retinaculum release is emphasized in arthroscopic arthroplasty but always overlooked in joint replacement
Femoral notch	Notch plasty	Notch plasty	Equal
Tendon insertion	Postoperative exercises	Postoperative exercises	Equal
Muscles	Postoperative exercises	Postoperative exercises	Equal

Table 58.2 Categories of knee OA and related procedures

Categories of knee OA	Abnormal lower limb alignment (Over 5° varus or valgus)	Mechanical symptoms	Arthroscopic arthroplasty	Combined operation
Type I	–	–	√	–
Type II	–	+	√	Related arthroscopic procedures to relieve the mechanical symptoms
Type III	+	+	√	Osteotomy to correct alignment

Table 58.3 Step-by-step procedures of arthroscopic arthroplasty for knee OA

1. Debriding the medial and lateral compartment of the knee through the anterolateral and anteromedial portals
2. Releasing the medial collateral ligament through medial incision
3. Performing femoral notch plasty
4. Creating the passage to the posteromedial compartment
5. Removing the posterior septum
6. Debriding the posterior compartments
7. Performing plasty and denervation for the posterior femoral condyles
8. Releasing the posterior capsule and muscles
9. Performing distal femur denervation from the anterior, medial, and lateral sides
10. Performing denervation at the anterior side of the proximal tibia
11. Performing denervation of the anteromedial side of the tibia
12. Performing patella plasty and denervation

Surgical Procedures

Since most patients undergoing arthroscopic arthroplasty have both medial tibiofemoral and patellofemoral arthritis and have mild flexion contracture, arthroscopic management for this kind of patient is described subsequently as the standard procedure of arthroscopic arthroplasty (Table 58.3).

Debridement of the Medial and Lateral Compartment of the Knee

The high anteromedial and high anterolateral portals are established. The medial and infrapatellar plicas are removed. The medial and lateral compartments are examined. The injured or degenerated meniscus is first addressed through meniscectomy or trimming. All unstable cartilage tissue is removed.

Releasing the Medial Collateral Ligament

The tension of the medial collateral ligament (MCL) is examined through the varus stress near the knee extension position. If the medial joint space is less than 5 mm, the MCL contracture is defined. A 1 cm incision is made over the MCL at a level corresponding to the body of the medial meniscus. The MCL is released through multiple stabs (acupuncture release) with a sharp-pointed knife through this incision till the medial joint space can be opened.

Femoral Notch Plasty

The femoral notch is examined to determine whether there is any impingement between the femoral notch and the anterior cruciate ligament, the femoral notch and the tibial eminences, and the anterior opening of the femoral notch and the third tibial eminence (Fig. 58.1). Femoral notch plasty and removal of the third tibial eminence are performed to eliminate any bony impingement (Fig. 58.2) The thickened

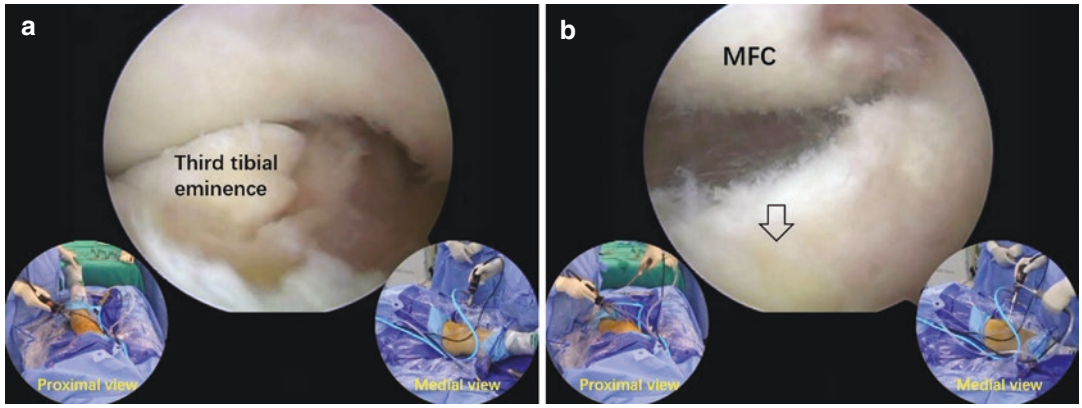

Fig. 58.1 The third tibial eminence impinges the roof of the femoral notch at knee extension (**a**) and is removed (**b**) (Arthroscopic view of the left knee through the anterolateral portal). MFC, medial femoral condyle. (Reproduced with permission from Zhao J. Arthroscopic Arthroplasty for Knee Osteoarthritis: Denervation of Subchondral Bone and Comprehensive Synovectomy. Arthroscopy Techniques. 2021;10(12):e2651–e2657)

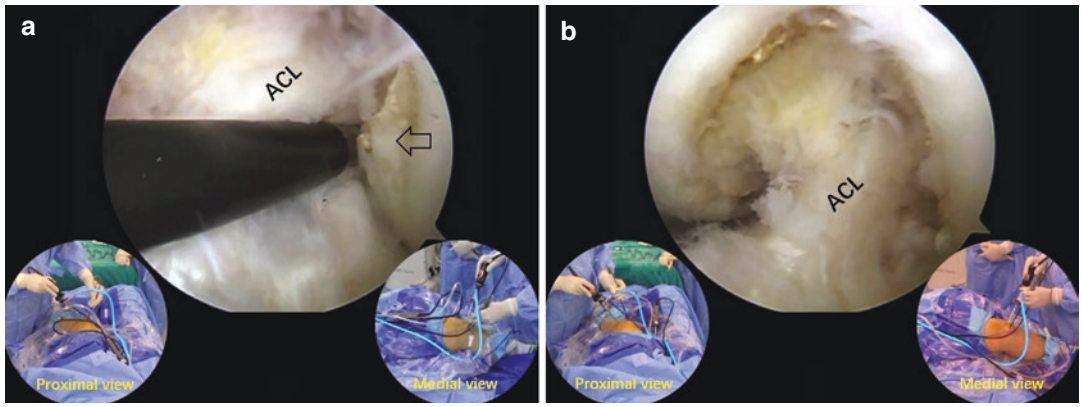

Fig. 58.2 Osteophyte impinging the anterior cruciate ligament is defined (**a**), and femoral notch plasty is performed (**b**) (Arthroscopic view of the left knee through the anterolateral portal). ACL, anterior cruciate ligament. (Reproduced with permission from Zhao J. Arthroscopic Arthroplasty for Knee Osteoarthritis: Denervation of Subchondral Bone and Comprehensive Synovectomy. Arthroscopy Techniques. 2021;10(12):e2651–e2657)

synovium on the surface of the posterior cruciate ligament is removed to eliminate soft tissue impingement between the anterior and the posterior cruciate ligaments.

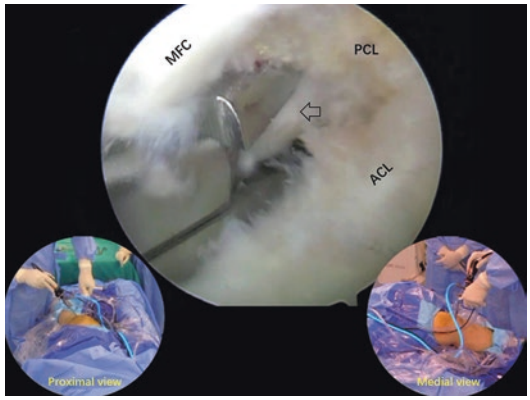

Fig. 58.3 Osteophyte at the medial wall of the femoral notch (arrow) is removed (Arthroscopic view of the left knee through the anterolateral portal). *MFC* medial femoral condyle. *ACL* the anterior cruciate ligament. *PCL* the posterior cruciate ligament. (Reproduced with permission from Zhao J. Arthroscopic Arthroplasty for Knee Osteoarthritis: Denervation of Subchondral Bone and Comprehensive Synovectomy. Arthroscopy Techniques. 2021;10(12):e2651–e2657)

The osteophytes on the medial wall of the femoral notch are removed to enlarge the passage between the posterior cruciate ligament and the medial wall of the femoral notch to the posteromedial compartment for subsequent procedures (Fig. 58.3).

Debridement in the Posterior Compartments

The arthroscope is placed through the anterolateral portal and the femoral notch into the posteromedial compartment. A posteromedial portal is established. The arthroscope is placed into the posteromedial compartment, pressed against the center of the posterior septum, and placed into the posterolateral compartment. The posterolateral portal is created.

An arthroscopic shaver is placed through the posterolateral portal to the posterior septum following the retrieval of the arthroscope to the posteromedial compartment. The posterior septum is then removed to connect the posterior compartments (Fig. 58.4). The posterior compartment is debrided.

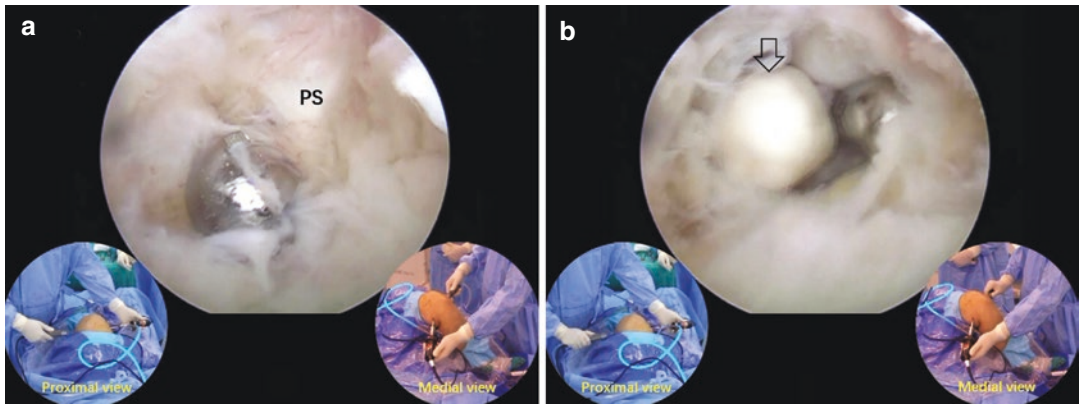

Fig. 58.4 A shaver is placed into the posterior septum (**a**) to remove it (**b**) (Arthroscopic view of the posteromedial compartment of the left knee through the posteromedial portal). Arrow, free body in the posterior septum. *PS* the posterior septum. (Reproduced with permission from Zhao J. Arthroscopic Arthroplasty for Knee Osteoarthritis: Denervation of Subchondral Bone and Comprehensive Synovectomy. Arthroscopy Techniques. 2021;10(12):e2651–e2657)

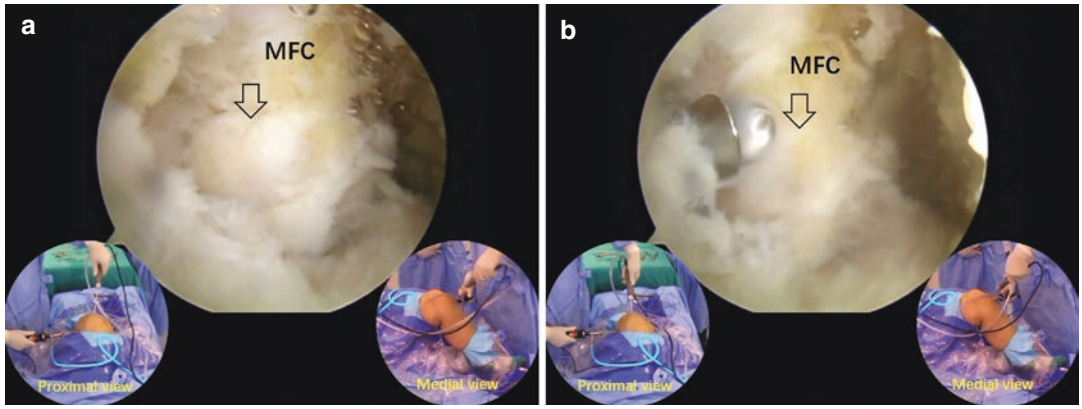

Fig. 58.5 Osteophyte at the posterior outlet of the femoral notch that impinges the posterior cruciate ligament is defined (**a**) and removed with instruments placed through the anteromedial portal (**b**) (Arthroscopic view of the posterior compartments of the left knee through the posterolateral portal). *MFC* medial femoral condyle. (Reproduced with permission from Zhao J. Arthroscopic Arthroplasty for Knee Osteoarthritis: Denervation of Subchondral Bone and Comprehensive Synovectomy. Arthroscopy Techniques. 2021;10(12):e2651–e2657)

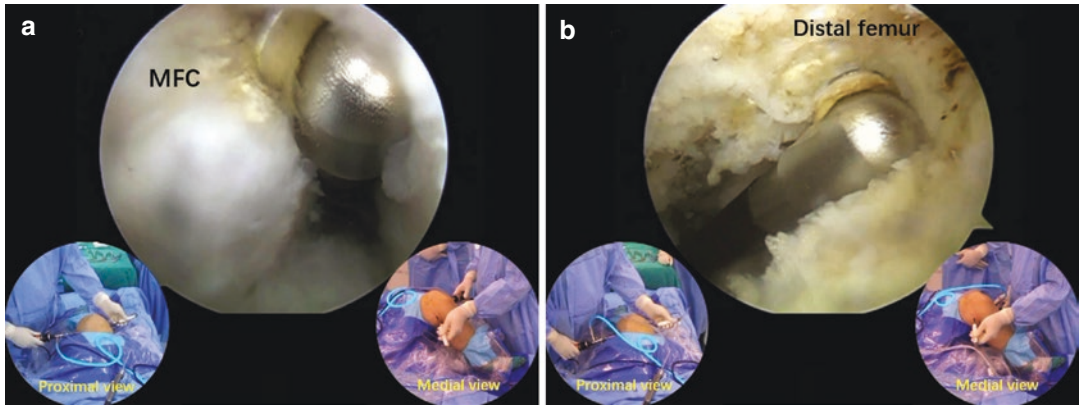

Fig. 58.6 The periosteum between the posterior cartilage edge and the capsule attachment of the medial femoral condyle is removed (**a**) to realize denervation, and the capsule is released from the femur to address flexion contracture (**b**) (Arthroscopic view of the posteromedial compartment of the left knee through the posterolateral portal). MFC, medial femoral condyle. (Reproduced with permission from Zhao J. Arthroscopic Arthroplasty for Knee Osteoarthritis: Denervation of Subchondral Bone and Comprehensive Synovectomy. Arthroscopy Techniques. 2021;10(12):e2651–e2657)

Plasty and Denervation of the Posterior Femoral Condyles

Through the posteromedial and the posterolateral portals, the osteophytes at the posterior side of the femoral condyles are removed. If the osteophyte at the posterior opening of the femoral notch impinges on the posterior cruciate ligament, plasty of the posterior opening of the femoral notch is performed (Fig. 58.5). The synovium and periosteum between the attachment site of the capsule and the cartilage margin are removed to realize the denervation of the posterior femoral condyles (Figs. 58.6a and 58.7a).

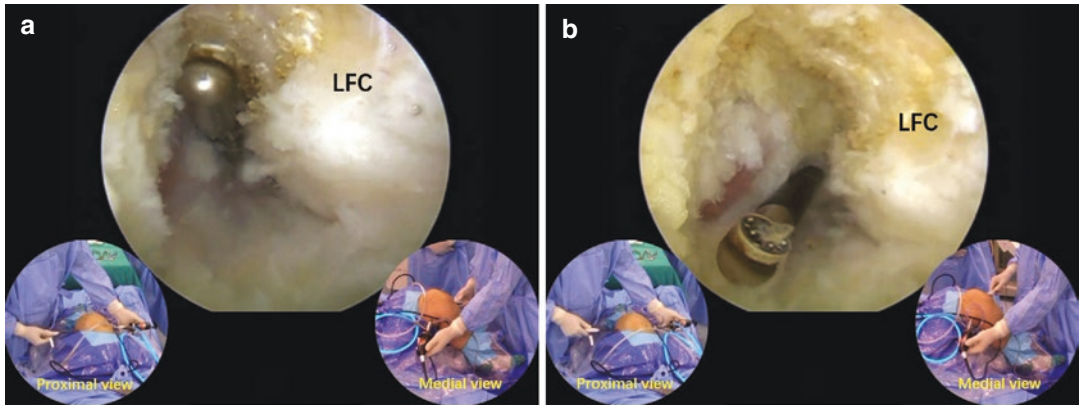

Fig. 58.7 The periosteum between the posterior cartilage edge and the capsule attachment of the lateral femoral condyle is removed (**a**) to realize denervation, and the capsule is released from the femur to address flexion contracture (**b**) (Arthroscopic view of the posterolateral compartment of the left knee through the posterolateral portal). *LFC* lateral femoral condyle. (Reproduced with permission from Zhao J. Arthroscopic Arthroplasty for Knee Osteoarthritis: Denervation of Subchondral Bone and Comprehensive Synovectomy. Arthroscopy Techniques. 2021;10(12): e2651–e2657)

Release of Posterior Capsule and Muscles

The knee is attempted to be extended. If full extension of the knee still cannot be reached, posterior contracture is defined. The posterior capsule is first released from the femur. The tendinous portion of the gastrocnemius muscle is released close to the posterior femoral cortex until its posterior muscular portion is visible (Figs. 58.6b and 58.7b).

Distal Femur Denervation from the Anterior, Medial, and Lateral Sides

With full knee extension, the arthroscope is inserted into the anterior compartment of the knee. A supralateral patellar portal is established. The osteophytes along the medial and lateral edges of the femoral condyles and those at the proximal edge of the femoral trochlea are removed.

The soft tissue on the anterior side of the distal femur or the bottom of the suprapatellar pouch (Fig. 58.8), the medial side of the medial femoral condyle (Fig. 58.9a), the lateral side of the lateral femoral condyle (Fig. 58.9b) is removed to realize denervation of the distal femoral condyle.

Denervation at the Anterior Side of the Proximal Tibia

With the knee in extension position, the arthroscope is placed through the supralateral patellar portal. Part of the infrapatellar pad is removed to expose and remove the soft tissue on the anterior side of the proximal tibia to realized denervation of the proximal tibia.

Denervation of Anteromedial Side of the Tibia

The arthroscope is placed through the anterolateral portal, the periosteum on the anteromedial side of the proximal tibia, with the MCL, the pes anserinus, and the tibial tubercle as boundaries, is removed with a radiofrequency probe.

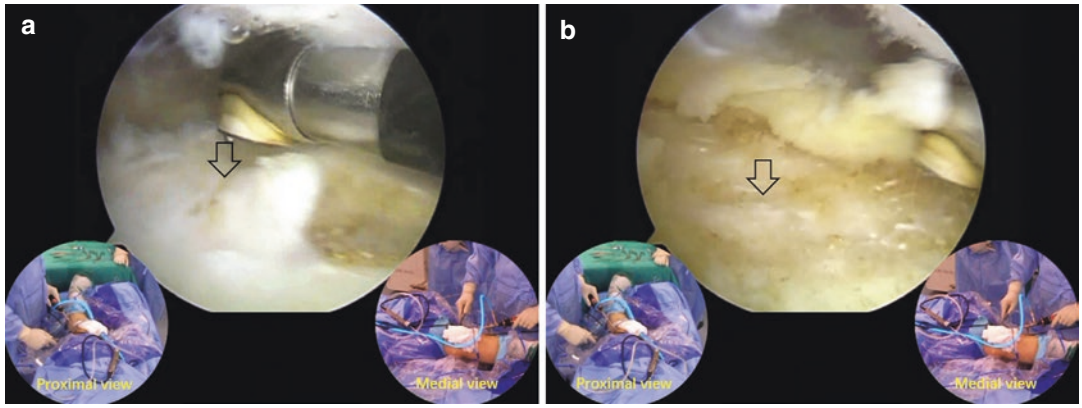

Fig. 58.8 The periosteum (arrow) at the bottom of the suprapatellar pouch is removed (**a**) to denude (arrow) the anterior side of the distal femur (**b**) to realize the denervation of the cartilage at a more distal site. (Arthroscopic view of the suprapatellar pouch of the left knee through the anterolateral portal). (Reproduced with permission from Zhao J. Arthroscopic Arthroplasty for Knee Osteoarthritis: Denervation of Subchondral Bone and Comprehensive Synovectomy. Arthroscopy Techniques. 2021;10(12):e2651–e2657)

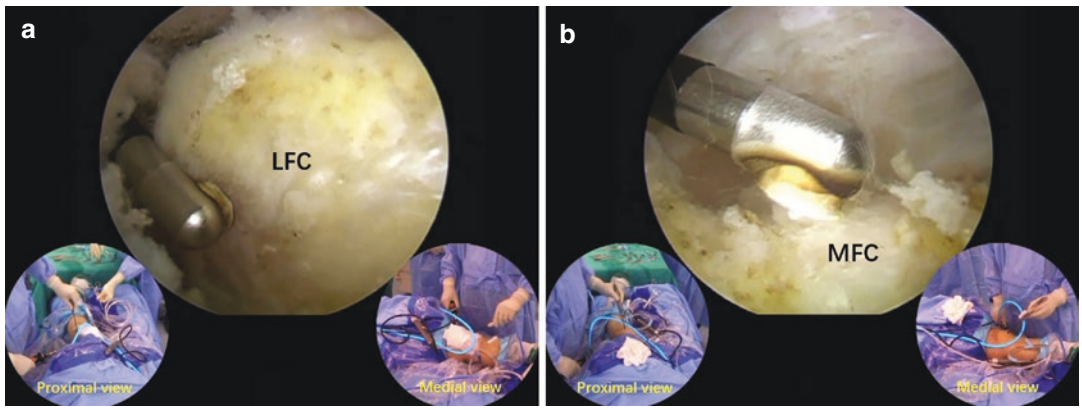

Fig. 58.9 Removal of the periosteum at the lateral side of the lateral femoral condyle (**a**, Arthroscopic view of the lateral gutter of the left knee through the supralateral patellar portal) and that at the medial side of the medial femoral condyle (**b**, Arthroscopic view of the medial gutter of the left knee through the supralateral patellar portal). *LFC* lateral side of the lateral femoral condyle. *MFC* medial side of the medial femoral condyle. (Reproduced with permission from Zhao J. Arthroscopic Arthroplasty for Knee Osteoarthritis: Denervation of Subchondral Bone and Comprehensive Synovectomy. Arthroscopy Techniques. 2021;10(12):e2651–e2657)

Patella Plasty and Denervation

Osteophytes on the upper and lower poles of the patella, as well as the hyperplastic lateral edge of the patella, are removed through the anterolateral portal and the supralateral patellar portal. The synovium around the patella is removed to realize partial patella denervation. Lateral retinaculum release is performed in case of its contracture.

Comments on the Current Technique

The standard arthroscopic arthroplasty technique includes 11 types of surgical procedures: subchondral bone denervation by adjacent periosteum removal (with the consideration that the subchondral bone is innervated mainly through the nearby periosteum instead of through the medullary canal), synovectomy, resection of the

hyperplastic infrapatellar fat pad, osteophyte removal at proximal tibia, distal femur and patella, cancellous bone surface devitalization, femoral notch plasty, resection of the hyperplastic lateral surface of the patella, the release of the lateral retinaculum of the patella, MCL release, the release of the posterior capsule and gastrocnemius muscle, trimming of the articular cartilage and meniscus. This technique is quite different from the reported arthroscopic operations for knee OA to realize the pain-relieving mechanism through arthroscopic procedures.

From the technical level, arthroscopic arthroplasty of the knee is the highest level in the field of knee arthroscopy, requiring all arthroscopic portals, involving the operation of various compartments of the knee, among which operation in the posterior compartments of the knee is the most difficult. The key ensuring the effectiveness of the operation is to complete each step as planned. Therefore, arthroscopic arthroplasty is not suitable for beginners. This procedure should be performed only after the master of the comprehensive arthroscopic techniques, especially those related to the posterior compartment of the knee and the patellofemoral joint.

Arthroscopic arthroplasty is a "big deal" that upends patients' understanding of arthroscopic surgery, which they expect to have a mild surgical reaction. The biggest problem with this procedure is that there is relatively severe edema for the first 2–3 weeks after surgery, and some patients may have significant swelling around the knee. The most effective measure to eliminate edema and swelling is active activity training. The patient should be informed preoperatively about the possible situation after the operation to obtain the patient's understanding and cooperation.

The main advantages of the current procedure are that the pain-relieving mechanisms of joint replacement can be realized through arthroscopic arthroplasty to avoid the placement of artificial joint, that stability and soft-tissue balance of the knee are maintained and synovitis can be better relieved through the arthroscopic procedure. The main disadvantages of the current procedure are that arthroscopic arthroplasty is time-consuming and technically challenging and that relatively severe and prolonged postoperative edema occurs quite often. The pearls and pitfalls of this technique are listed in Table 58.4. We performed this procedure in over 1400 patients and found its effectiveness. The mean operation time is less than 90 minutes.

Postscript: This chapter is based on an Elsevier source [19] (https://www.arthroscopytechniques.org/) with permission.

Table 58.4 Pearls and pitfalls of arthroscopic arthroplasty for knee OA

1.	Preoperative anteroposterior and lateral view radiography in the weight-bearing position should be taken to evaluate the joint space, subchondral bone layer, osteophyte hyperplasia, and free body
2.	A full-length X-ray film of the lower extremities is required to evaluate the alignment of the lower limb
3.	CT examination should be performed mainly to evaluate the patellofemoral joint and to determine the specific methods of patellofemoral joint plasty
4.	MRI examination is required to evaluate articular cartilage and synovium status, as well as bone edema. The examination of bone edema is particularly important because it indicates the disorder or destruction of the microstructure of the bone
5.	Isolated arthroscopic arthroplasty can often be performed well in patients with abnormal lower limb alignment but no bone edema
6.	The abnormal lower limb alignment with unicondylar bone edema suggests the need for osteotomy to change the stress distribution; the effect of isolated arthroscopic arthroplasty is poor
7.	If there is edema in both tibial or femoral condyles, the patient's weight or other arthritic factors should be considered

Table 58.4 (continued)

8. The efficacy of arthroscopic arthroplasty mainly depends on the denervation of subchondral bone and synovectomy, but this surgery is not a complete knee denervation, and patients still experience pain (muscle, tendon, ligament-derived) after surgery, mainly manifested by the transfer of the pain from the joint to the periarticular area. Postoperative active exercise is the best way to relieve periarticular pain
9. The integrity of the hooping structures of the meniscus is checked. If the hooping structure is intact, the meniscus is retained; otherwise, the meniscus is excised
10. Release of the medial collateral ligament may be indicated in the case that the medial joint space is too tight to conduct resection of the posterior horn of the medial meniscus. However, in case osteotomy is to be performed to correct varus deformity of the knee, the medial collateral ligament should not be released. Otherwise, instability may occur following valgus osteotomy
11. The resulting cancellous bone surface following osteophyte removal is devitalized with a radiofrequency probe
12. During the release of the posterior capsule from the femur, put the radiofrequency probe against the femur to prevent neurovascular damage

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