Technical Note

Arthroscopic Transtibial Pullout Repair and Tibial Condylar Valgus Osteotomy for Medial Meniscus Posterior Root Tear With Varus Knee

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Abstract: As an important structure for maintaining the hoop tension of the medial meniscus of the knee joint, the posterior root is receiving increasing attention. Medial meniscus posterior root tear is an important reason for the occurrence, development, and kinematics changes of knee osteoarthritis. It is necessary to repair the posterior root of meniscus for restoring joint kinematics and improving clinical efficacy. This Technical Note reports a medial meniscus posterior root tear repair technique using arthroscopic transtibial pullout repair (ATPR) combined with tibial condylar valgus osteotomy. The aim of this technique is to repair the posterior root of the medial meniscus while correcting the force line through osteotomy, opening the joint gap, improving the joint surface fit, providing a good mechanical environment for meniscus repair, thereby improving the healing rate of the posterior root of the meniscus and reducing the risk of retear. Although clinical evidence is currently limited, we believe that this technology may have more clinical advantages compared with ATPR alone or ATPR combined with high tibial osteotomy.

The posterior root of the knee joint meniscus is the attachment point of the meniscus in the posterior area of the tibial intercondylar spine. It penetrates deep into the bone and firmly anchors the meniscus to the tibial plateau. Its integrity is crucial for maintaining the circumferential tension of the meniscus.[1] Tear of the posterior root of the medial meniscus is a tearing injury or radial tear that occurs within 1 cm of the attachment area between the posterior root of the medial meniscus and the tibia.[2] Hwang et al.[3] reported that medial meniscus posterior root tear (MMPRT) is particularly common among Asian people, who like to bend their knees and squat, and the incidence rate can be as high as 27.8%. They also proposed that women, greater body mass index, larger mechanical axis varus angle, and lower levels of physical activity are all risk factors for MMPRT.

Once the posterior root of the medial meniscus is torn, the circumferential tension of the meniscus is lost, the meniscus protrudes from the joint space, and the contact stress between the femur and the tibia increases, further leading to articular cartilage damage and knee osteoarthritis.[4]

MMPRT often is associated with genu varum osteoarthritis, and the 2 affect each other. MMPRT leads to the loss of circumferential tension and an increase in contact stress between the femur and tibia, leading to the occurrence and development of knee osteoarthritis; knee osteoarthritis causes narrowing of the joint space and compression of the medial meniscus, resulting in MMPRT.

The treatment of MMPRT includes conservative management, resection, and repair. Conservative management mainly improves short-term efficacy and does not prevent the degeneration of the medial compartment[5]; after meniscus resection, the contact stress between the femur and tibia increases, which will also lead to knee joint degeneration.[6] Therefore, for MMPRT, at present, scholars often advocate the use of surgery for meniscus repair.[7] Widely used surgical methods in clinical practice mainly include ATPR, anchor nail repair, and combined high tibial osteotomy (HTO).[4,8-10]

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However, the treatment of MMPRT with varus knee remains controversial. Some scholars only repair posterior root tears of the medial meniscus. Feucht et al.[11] carried out a systematic retrospective analysis study: 172 patients who received arthroscopic transtibial pullout repair (ATPR) to treat posterior root tears of medial meniscus were included in the cohort. The average follow-up was 30.2 months. Lysholm score increased from 52.4 points before surgery to 89.5 points after surgery. The secondary arthroscopy and magnetic resonance imaging examination showed that the complete healing rate was 62%, the partial healing rate was 34%, and the failure healing rate was 3%. Different scholars have reported different healing rates for the repair of MMPRT. However, in the short-term follow-up, the functional outcome score of most patients after surgery has significantly improved, which seems to prevent the progress of osteoarthritis.[12-15] However, since the varus knee's deformity has not been corrected, the risk of dislocation and fracture of the posterior root still exists due to the narrow joint space and increased tibiofemoral contact stress. Furumatsu et al.[16] reported that 32 patients with posterior root tear of medial meniscus were treated with ATPR, with an average follow-up of 36.1 months. Among them, 1 patient needed second arthroscopy debridement, and 1 patient needed second posterior root repair of medial meniscus.

Some scholars have proposed the MMPRT combined with HTO procedure.[17-20] In the study of Huang et al.,[21] 25 cases of MMPRT with varus knee were treated with ATPR combined with HTO. The average follow-up was 13.0 months. The secondary arthroscopy examination showed that the complete healing rate was 48%, the partial healing rate was 36%, the scar healing rate was 12%, and the failure healing rate was 4%; The first-grade rate of cartilage regeneration was 36%, the second-grade rate was 28%, and the third-grade rate was 36%. The combined surgery effectively improved the lower-limb strength line, increased the healing rate of the posterior meniscus root and the degree of cartilage regeneration, and achieved satisfactory clinical efficacy. However, in the early postoperative period, the recovery effect of posterior root repair on the medial space and meniscus protrusion is not obvious, nor is its beneficial effect on knee biomechanics and osteoarthritis observed. However, longer-term follow-up observations may lead to different conclusions.

Nakamura et al.[22] proposed to combine meniscus "centralization" and HTO while repairing the meniscus, in order to reduce the protrusion of the meniscus and maintain circumferential tension, as well as reduce the load on the medial compartment, thereby reducing the risk of retear of the posterior root of the medial meniscus. However, there is not yet sufficient clinical research evidence to prove the effectiveness of this technology. Further exploration is needed to determine whether a combination of meniscus "centralization" and HTO is necessary.

Here, we report a MMPRT repair technique using ATPR combined with tibial condylar valgus osteotomy (TCVO). The purpose of this technology is to (1) correct varus knee's deformity, restore normal lower-limb force lines, and balance the load of the inner and outer compartments; (2) raise the medial tibial plateau, open the medial joint gap, reduce tibial contact stress, and reduce the risk of meniscus protrusion; and (3) it is beneficial for joint alignment and improves joint stability. The aforementioned advantages can provide a good mechanical environment for meniscus healing and may effectively reduce the risk of root retear after the meniscus. Table 1 shows the advantages and disadvantages of this technique.

Surgical Indications

This technique is applicable when a patient satisfies the following criteria: (1) magnetic resonance imaging results show complete MMPRT with white meniscus sign and/or truncation sign[23,24]; (2) within 6 months after onset; (3) meniscus compression width <5 mm[25]; (4) patient age <65 years; and (5) medial compartment Kellgren—Lawrence grade I-III.

Surgical Method (With Video Illustration)

Preoperative Preparation

The patient is placed in a supine position, and after successful administration of general anesthesia, a baffle is placed on the lateral side of the proximal femur on the surgical side to open the medial compartment of the affected knee during surgery. The routine disinfection towel is operated under the tourniquet.

Surgical Process

Arthroscopy

Take the anteromedial and anterolateral infrapatellar approaches and place the knee under arthroscopy (AR-3200-0001T; Arthrex, Naples, FL) for examination. Evaluate and record the degree of meniscus injury, intra-articular cartilage injury, and compartment degeneration.

Tibial Condylar Valgus Osteotomy (TCVO)

Make a 5.0 to 7.0 cm incision from the medial central point of the tibia, 1.0 cm from the distal end of the joint, toward the lower edge of the tibial tubercle, to separate the distal insertion point of the medial collateral ligament, along with the medial cortical bone of the tibia, from the tibial shaft and lift it up (Fig 1A). The prefabricated anatomical locking steel plate (Wego,

Table 1. Advantages and Disadvantages

Advantages	Disadvantages
Restores normal lower-limb force line, opens the medial joint space, and benefits joint alignment, all of which are beneficial to meniscus healing and reduce the risk of root retear after the meniscus.	The correction angle is limited and is not suitable for patients with severe varus deformity.
Retains a bone cortex of 0.5 cm to reduce the possibility of widening the tibial plateau.	No clinical evidence.
Less trauma, better prognosis, and reduces the risk of damaging the common peroneal nerve.	
Bone grafting is generally not required.	
Technically speaking, moving the tibial insertion point of the medial collateral ligament upwards brings the following advantages:	
A higher transverse osteotomy point can be selected, thereby reducing trauma.	
Reduces the pressure caused by the elevation of the medial tibial plateau.	
Facilitates the opening of osteotomy and joint gaps, while also facilitating the installation of anatomical steel plates.	
In addition, the tibial tunnel provides good blood supply and healing conditions for meniscus healing.	

Shandong, China) on the inner side of the tibial plateau is located below the goosefoot tendon, and the Kirschner wire (Bestbio Technical, Tianjin, China) is fixed and the C-arm fluoroscopy (BV Endura R2.3; Philips, Amsterdam, the Netherlands) position is satisfactory (Fig 1 B and C). The electric knife marks a rough "L"-shaped osteotomy line on the bone surface. The transverse osteotomy line is 4.0 cm below the platform, inclined toward the direction of the fibular head, and the longitudinal osteotomy line extends from the tip of the lateral intercondylar eminence of the tibia to the distance (usually located on the inner edge of the patellar ligament). The intersection of the 2 lines is the top point of the "L"-shaped osteotomy line (Fig 1D). Insert a 2.0 mm Kirschner wire under fluoroscopy. Insert the transverse Kirschner wire parallel from the medial osteotomy line to the direction of the upper tibiofibular joint, and the longitudinal Kirschner wire vertically and backwards from the osteotomy line. Note that the longitudinal Kirschner wire does not need to penetrate the posterior cortical bone but only serves to guide the longitudinal osteotomy direction, which can reduce the probability of posterior neurovascular injury. Use a thin bone knife with a scale (Wego) to drive in the direction of the Kirschner wire for osteotomy, and try to maintain the knee flexion position during osteotomy to avoid nerve and blood vessel damage when cutting off the posterior cortical bone. Longitudinal osteotomy should preserve a bone cortex of 0.5 cm at the proximal end of the tibia as much as possible as the osteotomy hinge, while reducing the possibility of platform widening (Fig 1E). After the osteotomy is completed, start to brace. The angle of support can be determined based on preoperative design or intraoperative force line perspective, as well as the angle between the inner and outer platform lines (Fig 1F and G). Move the medial collateral ligament along with the bone fragment at the tibial insertion point upward, and then use the anatomical plate on the medial side of the tibial plateau for fixation. Moving up the insertion point of the medial collateral ligament can, on the one hand, select a higher transverse osteotomy point, thereby reducing the increased trauma caused by moving down the transverse osteotomy point due to concerns about damaging the tibial insertion point of the medial collateral ligament; on the other hand, it can alleviate the pressure caused by the elevation of the medial tibial plateau (Fig 1H).

Arthroscopic Transtibial Pullout Repair

Repair the damaged inner meniscus with basket forceps, plane knives, and radiofrequency (Fig 2A), and use sutures and hooks to sew vertically on a 5.0-mm mattress at the edge of the tear (Fig 2B). Place the anterior cruciate ligament locator (Arthrex) at the insertion point of the posterior root of the medial meniscus, drill a guide needle along the guide, drill a tibial bone canal with a diameter of 5.0 mm (Fig 2C), guide the suture out of the tibial tunnel through an inhaul cable (PDS II, 3.5 European Pharmacopoeia; Ethicon, LLC, Somerville, NJ), and pass through a loop steel plate on the anterior medial surface of the tibia. Tie the tail line tightly on the steel plate to check the tension of the posterior root of the medial meniscus (Fig 2D) (Video 1).

Postoperative Rehabilitation

On the second day after surgery, active and passive range of motion exercises will begin. During the first 2 weeks of bed rest, a pillow will be used to elevate the affected limb, and the active and passive knee flexion will be less than 30°; starting from the third week after

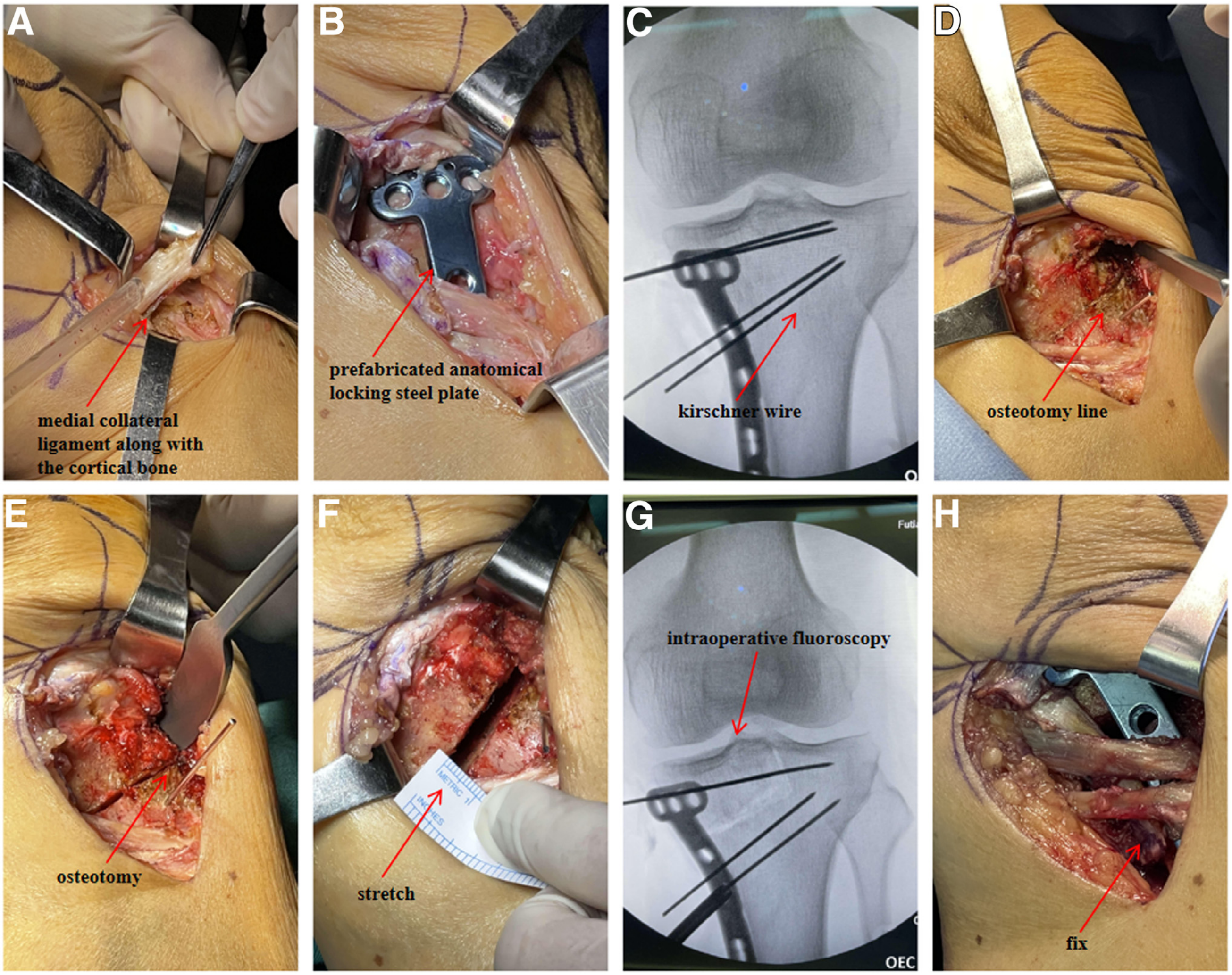

Fig 1. Tibial condylar valgus osteotomy (TCVO). The patient's left leg is placed in a supine position. (A) Make a 5.0- to 7.0-cm incision from the medial central point of the tibia, 1.0 cm away from the distal end of the joint, toward the lower edge of the tibial tubercle, to separate the distal insertion point of the medial collateral ligament, along with the medial cortical bone of the tibia, from the tibial shaft, and lift it up. (B) The prefabricated anatomical locking steel plate on the inner side of the tibial plateau is located below the goosefoot tendon and fixed with Kirschner wire. (C) Intraoperative fluoroscopy position. (D) The electric knife marks a rough "L"-shaped osteotomy line on the bone surface. The transverse osteotomy line is 4.0 cm below the platform, inclined toward the direction of the fibular head, and the longitudinal osteotomy line extends from the tip of the lateral intercondylar eminence of the tibia to the distance. (E) Insert a 2.0 mm Kirschner wire under fluoroscopy, with the transverse Kirschner wire inserted parallel from the medial osteotomy line to the upper tibiofibular joint direction, and the longitudinal Kirschner wire inserted vertically and backwards from the osteotomy line. Use a thin bone knife with a scale to drive the osteotomy in the direction of the Kirschner wire, and preserve the bone cortex at the proximal end of the tibia as the osteotomy hinge in the longitudinal direction. (F) Start stretching after the osteotomy is completed. (G) Intraoperative fluoroscopy showing osteotomy. (H) Move the medial collateral ligament and the bone fragment at the tibial insertion point upwards, and then fix it with the medial anatomical plate of the tibial plateau.

surgery, the bedside leg droops and the active and passive knee flexion can reach 90°; during the first 4 weeks after surgery, excessive flexion and extension exercises are not recommended to avoid worsening swelling, and range of motion is limited to 90°. Advise the patient to use double crutches within the first 4 weeks after surgery, perform partial weight-bearing from the third week after surgery, and perform full weight-bearing from the fifth week after surgery.

Discussion

The advantages and disadvantages of this program are as follows (Table 1): Joint TCVO has the following advantages: (1) Corrects varus deformity, restores normal lower-limb force line, and balances the load of the internal and external compartments. (2) Raises the medial tibial plateau, opens the medial joint space, and reduces the risk of meniscus protrusion. (3) It is beneficial for joint alignment and improves joint stability.[26]

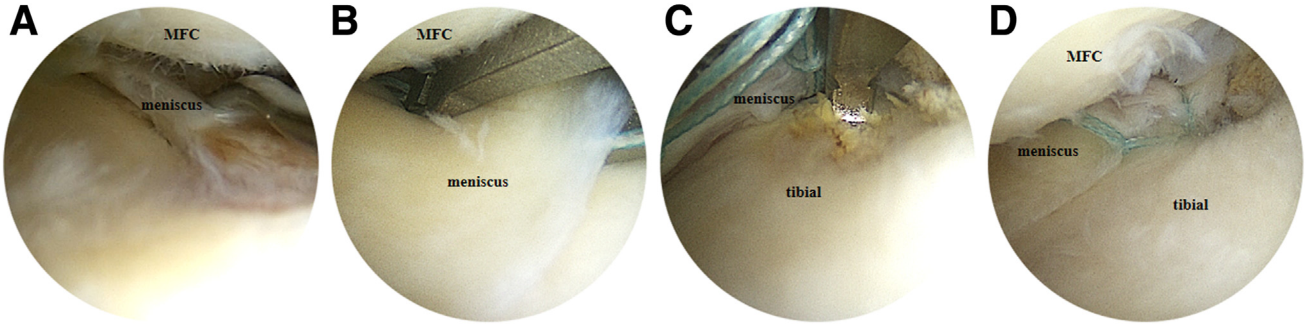

Fig 2. Traction repair under arthroscopy. Arthroscopic findings of traction repair. (A) Arthroscopy image of the left knee through the front outer door. Use a probe to confirm the posterior root tear of the medial meniscus. (B) Arthroscopy image of the left knee through the front outer door. Repair the damaged inner meniscus and apply sutures and hooks to the edge of the tear using a 5.0-mm vertical mattress suture. (C) Arthroscopy image of the left knee through the front outer door. Create a tibial tunnel on the posterior root attachment of the medial meniscus using an anterior cruciate ligament reconstruction guide. (D) Arthroscopy image of the left knee through the front outer door. Guide the suture out of the tibial tunnel through an inhaul cable and pass it through a loop steel plate on the anterior inner surface of the tibia, tying the tail thread tightly on the steel plate.

The aforementioned advantages can provide a good mechanical environment for meniscus healing and may effectively reduce the risk of root retear after the meniscus. (4) During longitudinal osteotomy, a bone cortex of 0.5 cm at the proximal end of the tibia is retained as the osteotomy hinge instead of complete amputation, reducing the possibility of widening the tibial plateau. (5) Compared with HTO, TCVO has a smaller osteotomy surface and the osteotomy line does not reach the outer side of the tibia. On the one hand, it has less trauma and better prognosis; on the other hand, it reduces the risk of damaging the common peroneal nerve. (6) The angle of extension is relatively small, and bone grafting is generally not required.

Technically speaking, moving the tibial insertion point of the medial collateral ligament upwards brings the following advantages: (1) a greater transverse osteotomy point can be selected, thereby reducing the potential increase in trauma caused by moving the transverse osteotomy point downwards due to concerns about damaging the tibial insertion point of the medial collateral ligament; (2) reduces the pressure caused by the elevation of the medial tibial plateau; and (3) facilitates the opening of osteotomy and joint gaps while also facilitating the installation of anatomical steel plates.

In addition, using traction repair method, due to the establishment of the tibial tunnel, the release of bone marrow stem cells or cytokines inside the tibial tunnel provides good blood supply and healing conditions for promoting meniscus healing. The main drawback of the combined surgery is that TCVO belongs to intra-articular osteotomy, and its correction angle is limited, which is not suitable for patients with severe varus deformity.[27]

The risks of this technique are: (1) common peroneal nerve injury; (2) fracture of proximal tibial osteotomy hinge; (3) insufficient correction angle, recurrent knee varus; and (4) without bone grafting, there is a risk of bone nonunion. In conclusion, ATPR combined with TCVO for the treatment of MMPRT with varus knee may improve the results of posterior root repair, and has technical advantages.

Disclosures

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