

Arthroscopic Medial Meniscus Posterior Root Reconstruction and Pull-Out Repair Combined Technique for Root Tear of Medial Meniscus



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Abstract: Repair of medial meniscus posterior root tear is important in preventing rapid progression of knee osteoarthritis. There are many repair techniques for medial meniscus posterior root tears, and good clinical results have been reported. Conversely, in terms of improving extrusion and healing meniscal injuries, sufficient results have not been obtained. Reconstruction of the medial meniscus posterior root can restore meniscal hoop action and normal knee biomechanics. Moreover, pull-out repair technique provides strong traction. We describe arthroscopic medial meniscus posterior root reconstruction and pull-out repair technique combined technique for medial meniscus root tear.

Introduction

Appropriate treatment of medial meniscus (MM) posterior root tear (MMPRT) is important in preventing the rapid progression of knee osteoarthritis. The meniscus provides important biomechanical functions, shock absorption, joint stabilization, lubrication, and proprioception.^{1,2} MMPRT is defined as a radial tear <10 mm from the root attachment and has recently gained attention.^{3,4} Allaire et al. reported in biomechanical consequences that MMPRT disrupted the hoop-strain mechanism, increased peak contact pressure in the knee joint by 25%, and approximated after total meniscectomy.⁵ Furthermore, they showed that MMPRT repair has the same effect as the normal meniscus in both contact area and pressure.⁵ Conservative treatment, meniscectomy, pull-out repair, and

suture anchor repair are treatment options for MMPRT.⁶⁻¹¹ Conservative treatment and meniscectomy have poorer clinical results than pull-out repair.⁷⁻⁹ While good clinical results have been reported for pull-out repair, sufficient results in terms of improving extrusion and healing meniscal injuries have not been reported.^{12,13} Reconstruction of the lateral meniscus using the peroneus longus tendon has been performed after excision of the discoid lateral meniscus.¹⁴ Moreover, studies using rabbits have reported that semitendinosis and gracilis are more useful for meniscal reconstruction.¹⁵ Thus, reconstruction of the MM posterior root (MMPR) can be a useful technique for MMPRT. Therefore, we describe the treatment with the combination of reconstruction of the MMPR using the autologous tendon of the gracilis and pull-out repair technique.

Ethical Standards

This study adhered to the tenets of the Declaration of Helsinki and was approved by the ethics committee of Nihon Koukan Hospital. Informed consent regarding the use of patient information in this study was obtained.

Surgical Technique

Confirmation and Refresh of the Tear

The presence of MMPRT is confirmed by probing using the anteromedial portal (Fig 1, Video 1). After MMPRT is confirmed, the ruptured part is refreshed. The tibial attachment of the MMPR has good blood

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Full ICMJE author disclosure forms are available for this article online, as supplementary material.

Received August 12, 2021; accepted September 21, 2021.

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2212-6287/211175

<https://doi.org/10.1016/j.eats.2021.09.008>

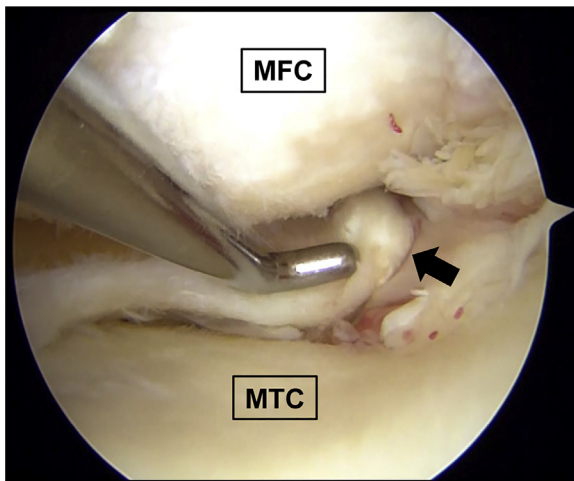


Fig 1. While viewing from the anterolateral portal of the left knee, the torn part (black arrow) is examined by probing using the anteromedial portal. MFC, medial femoral condyle; MTC, medial tibial condyle.

flow, and refreshing can promote good repair of the MM.¹⁶

Autologous Gracilis Tendon Harvest and Preparation

A 4-cm diagonal skin incision is made on the medial side of the tibia. A 3-cm sartorius incision is made in the direction of the fiber, and the gracilis just below is confirmed and harvested. Using the same incision, we peeled off the superficial layer of the medial collateral ligament from the tibial attachment part to widen the medial femorotibial joint space and secure a sufficient working space (Table 1).¹⁷ The 10-cm tendon part of the harvested gracilis is double-folded, and the polyethylene braided suture (no. 2 ULTRABRAID, Smith & Nephew) is hung on the folded part. Baseball-glove sutures are placed at the end of the double fold of the tendon with no. 2 ULTRABRAID to create a 5-mm graft (Fig 2).¹⁸

Tibial Tunnel Preparation

A 7-mm transverse incision is made 2 cm distal to the Gerdy nodule on the lateral side of the tibia, and the tibialis anterior muscle below the incision is partially detached. Viewing from the anterolateral portal to confirm the tibial attachment of MMPR, simultaneously, the landmarks, which are medial intercondylar ridge and posterior cruciate ligament anterior border of the tibial attachment, are confirmed. Viewing from the anterolateral portal, the guide pin is inserted from the incision made on the lateral of the tibia using the anterior cruciate ligament reconstruction tibial tunnel guide (3M) into the tibial attachment part of the MMPR (Fig 3, Video 1, Table 1). After it is confirmed that the guide pin is inserted in the correct position, a 4.5-mm diameter drill is used, and a 2.5-cm-deep

socket-shaped tibial tunnel is made with a 6.0-mm retrograde drill (AI-Drill, AI-Medic, Tokyo, Japan) (Video 1, Table 1). The tibial tunnel is enlarged to mimic the anatomical MM attachment in an elliptical shape with bone rasp (Smith & Nephew).

Graft Passage

The margin of the posterior segment of the MM is cut on the femoral and tibial sides with a 3.5-mm 90° hook electrode (Mitek VAPR 3 system, DePuy Mitek). Furthermore, by expanding and penetrating the same part from both ends to inside with 60° hooked rotary scissors (ACUFEX, Smith & Nephew), a 5-mm soft tissue tunnel is created at the margin of the posterior segment of the MM. Using the posteromedial portal, we insert an arthroscopic suture passer (Micro SutureLasso, Arthrex) into the soft tissue tunnel and passed from the femur to the tibial side. A thin polyester braided suture (no. 5 ETHIBOND, Ethicon) is pulled out with Micro SutureLasso and hung in a U shape. Graft is passed through the soft tissue tunnel by replacing no. 5 ETHIBOND and No. 2 ULTRABRAID on the graft stump using the shuttle relay method (Fig 4, Video 1). The No. 2 ULTRABRAID is used at both ends of the graft through the soft tissue tunnel into the tibial tunnel.

Assist Suture Using Anchor Technique and Pull-Out Suture

A 1.8-mm all-suture anchor (Q-FIX MINI, Smith & Nephew) is placed on the edge of the tibial plateau ~5 mm from the posteromedial portal (Fig 5, Video 1).

Table 1. Pearls and Pitfalls

Pearls

1. A sufficient working space for the medial tibiofemoral joint is secured by release of the superficial medial collateral ligament layer.
2. When the surgeon uses anterior cruciate ligament reconstruction tibial tunnel guide, the tibial tunnel in the anatomical footprint is accurately created, and only the articular surface side with a retrograde drill is enlarged.
3. By creating a tibial tunnel from the lateral of the tibia, the intra-bone hole stress on the graft can be reduced. Moreover, using a pull-out button, it can be performed with a small skin incision of 7 mm and only little invasiveness.
4. The graft and pull-out sutures are pulled together into the tibial tunnel.
5. Assist suture is tied after fixing the graft.

Pitfalls

1. If the hole in the posterior margin of the medial meniscus is not adequately opened for the tendon to pass through, the area may be damaged.
2. In the case of a tear at a site farther than the footprint (so-called posterior horn tear), the hole at the margin of the meniscus may collapse.
3. If the meniscus extrusion is strong, it can be reduced by releasing the meniscotibial capsule from the tibial and removing the tibial spine.



Fig 2. The 10-cm tendon part of the harvested gracilis is double-folded, and the No. 2 ULTRABRAID thread is hung on the folded part. Baseball-glove sutures are placed at end of the double fold of the tendon with no. 2 ULTRABRAID to create a 5-mm graft.

Polydioxanone suture (2-0 PDSII, Ethicon) is passed through the area 5 mm from the MMPR with the Meniscal Viper (Arthrex), and the Q-FIX MINI suture is replaced using the shuttle relay method. Next, the 2-0 PDSII is passed to MMPR near the ruptured part of the MMPR using a Meniscal Viper (Fig 6, Video 1). The 2-0 PDSII is replaced with a no. 2 ULTRABRAID using the shuttle relay method. The same procedure is used to suture no. 2 ULTRABRAID in two places on the femoral side and one placed on the tibial side.

Fixation

The graft and no. 2 ULTRABRAID between the MMPR and graft are pulled out together from the tibial tunnel (Table 1). All sutures are ligated on an artificial ligament fixture (pull-out button, AI-Medic). In this

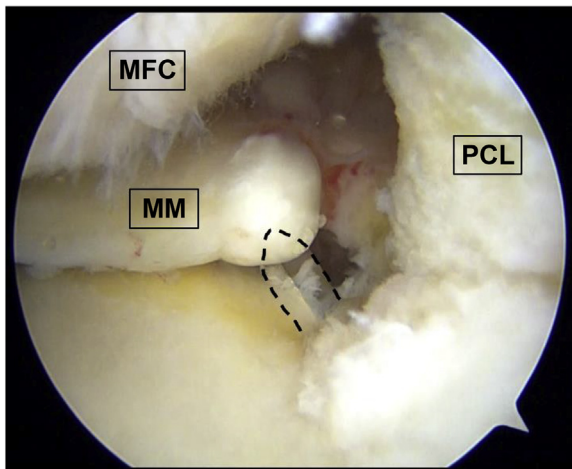


Fig 3. View from the anterolateral portal of the left knee, after the guide pin (dotted line) is inserted into the medial meniscus posterior root attachment using the ACL guide. It is confirmed that the guide pin is placed in the correct position. ACL anterior cruciate ligament; MFC, medial femoral condyle; MM, medial meniscus; PCL, posterior cruciate ligament.

procedure, MMPR reconstruction and pull-out repair are performed simultaneously. Further, the above-mentioned Q-FIX thread is sutured to form a reinforcing suture (assist suture). These procedures reposition the MM that was extruded by MMPRT to its original position (Fig 7, Video 1).

Postoperative Rehabilitation

Postoperatively, patients were non-weight bearing 2 weeks postsurgery, 1/3-weight bearing 3 weeks postsurgery, 1/2-weight bearing 4 weeks postsurgery, 2/3-weight bearing 5 weeks postsurgery, and full-weight bearing 6 weeks postsurgery. Postoperatively, patients were allowed active motion of up to 90° after the first 4 weeks, 120° from 4 to 6 weeks, and 130° from 6 to 12 weeks. Full flexion and squatting were allowed 3 months postoperatively. Patients returned to sports after 6 months postoperatively.

Discussion

When MMPRT is triggered, the hoop action of the meniscus is disrupted, leading to rapid progression of knee osteoarthritis and osteonecrosis.^{19,20} Conversely, in studies using cadavers and those using pig knees, the contact pressure and contact area of tibiofemoral joints increase after MMPRT and are improved by repair.^{5,10} Thus, repair of MMPR and hoop action is important. In pull-out repair, to insert the torn part into the bone hole, it is necessary to further internalize the MMPR because it is shortened by the length of the remnant. Conversely, in reconstruction, it can be anatomically repaired without applying an excessive load to the torn part. In this study, we describe MMPR reconstruction using gracilis. Concurrently, the combined use of arthroscopic MMPR reconstruction and pull-out repair technique reduced the mechanical stress on the transplanted tendon and further increased the fixing force of the transplanted tendon (Table 2).

Thus far, pull-out repair and suture anchor repair have been reported, and the pull-out repair is widely used. Moon et al. performed the pull-out repair and reported improvement in Lysholm score from 48.3 points preoperatively to 83.2 points.¹³ In contrast, they showed that extrusion of MM increased from an average of 3.6 mm preoperatively to an average of 5.0 mm postoperatively, and exacerbation of chondral lesions was observed in 9.7%.¹³ Moreover, Chung et al. conducted the pull-out method and reported that the width of medial joint and K-L grade significantly worsened 5 years postoperatively.⁹ Seo et al. examined 11 of 21 patients who underwent the pull-out repair and were able to obtain a second look, with no patient experiencing complete healing, 5 patients with lax healing, 4 patients with scar healing, and 2 patients with failed healing.¹² Jung et al. reported that suture anchor repair had a second look with 50% of complete

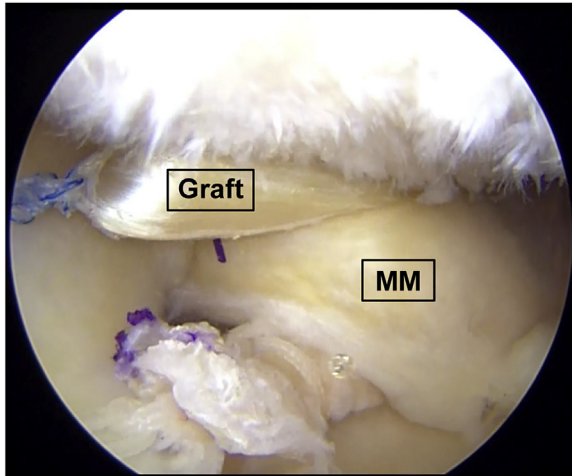


Fig 4. View from the anterolateral portal of the left knee. The graft is passed through the soft tissue tunnel at the margin of the posterior segment of the medial meniscus using the anteromedial portal.

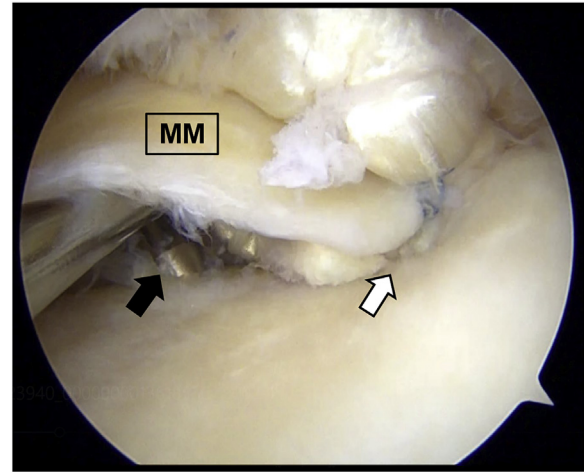


Fig 6. View from the anterolateral portal of the left knee. Q-FIX MINI (black arrow) is placed on the edge of the tibial plateau ~5 mm from the medial meniscus posterior root attachment (white arrow) from the posteromedial portal.

healing, 40% of partial healing, and 10% of no healing.⁶ Moreover, recently, there are a few reports on MMMPR reconstruction techniques.^{17,21} In MMMPR reconstruction, hoop tension can be maintained, and anatomical structure can be restored to their original state.¹⁷ Conversely, there is a risk of damage of the torn part of the meniscus, and it may be difficult to pass the transplanted tendon in the degenerated meniscus.¹⁷ In our method, by passing the transplanted tendon through the soft tissue behind the meniscus, the risk of meniscus injury can be reduced, and the method can be performed regardless of the degenerative state of the meniscus (Table 2). Furthermore, we simultaneously

use the pull-out repair technique. A study using pig knees found that the failure load of the pull-out repair using a washer was 189.9 N.²² Thus, our method can apply stronger traction.

The meniscus is a structure mainly composed of fibrochondrocytes, type I collagen fibers, proteoglycan, and few type II collagen fibers.²³ Particularly, type I collagen is abundant in the outer region of the meniscus, and a mixture of type I and type 2 collagen is abundant in the inner region.²⁴ The tendon is a tissue consisting of type I collagen tissue similar to the margin of the meniscus and can be replaced with the meniscus.¹⁵ Studies using rabbits have reported that semitendinosus and gracilis are more useful as donors for meniscus reconstruction.¹⁵ It is a well-known fact that semitendinosus and gracilis have good

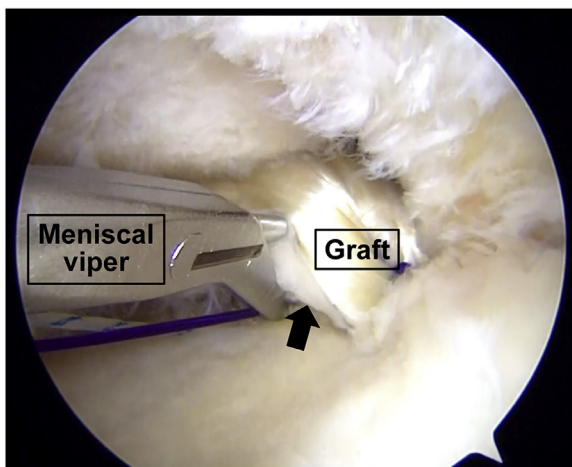


Fig 5. View from the anterolateral portal of the left knee. The 2-0 PDSII is passed to the overlapping part of the graft and medial meniscus posterior root (MMPR) near the ruptured part of the MMPR using the Meniscal Viper from the anteromedial portal. Subsequently, 2-0 PDSII is replaced with No. 2 ULTRABRAID using the shuttle relay method.

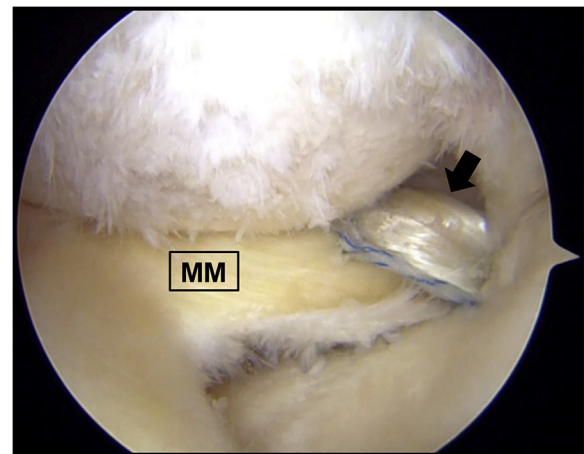


Fig 7. View from the anterolateral portal of the left knee. After the graft (black arrow) is fixed, the hoop action of the meniscus is restored. MM, medial meniscus.

Table 2. Advantage and Disadvantages**Advantages**

1. Reconstruction of the medial meniscus posterior root can enable hoop tension of the medial meniscus and suppress cartilage degeneration.
2. Reconstruction using autologous tendons does not cause an immune response, and there are no ethical issues. Moreover, using the gracilis, good bone–tendon healing can be expected.
3. In addition to reconstruction, pull-out repair and assist suture are used together, and mechanical stress on the graft can be reduced compared to reconstruction alone.
4. Since the soft tissue tunnel is made on the margin of the posterior segment of the medial meniscus, graft passage can be safely performed regardless of the degeneration of the torn meniscus.
5. When performing simultaneous surgery with high tibial osteotomy, tendons can be harvested using the same skin incision as osteotomy.

Disadvantages

1. Since the procedure is complex, extensive skills are required, and the operative time is prolonged.
2. A posteromedial portal is required and can be more invasive than a simple suture repair.
3. Donor site morbidity may develop.

bone–tendon healing in anterior cruciate ligament reconstruction.²⁵ Therefore, the graft can be expected to be replaced by meniscus and further engrafted in bone by bone–tendon healing (Table 2).

We create the tibial tunnel from the lateral side of the tibia (Table 1). The MMPR attaches to the footprint from the posteromedial to the anterolateral region. The “killer turn” is said to be graft ablation caused by the anterior medial tibial foramen route, especially during posterior cruciate ligament reconstruction.²⁶ We believe that creating a tibial tunnel from the lateral side of the tibia can reduce the “killer turn”-like effect on the graft.

In summary, we described MMPR pull-out repair and reconstruction repair combined technique. Our technique has several advantages compared with other techniques (Table 2). In the future, postoperative clinical results will be required.

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