Technical Note

Ultrasound-Assisted Arthroscopic All-Inside Repair Technique for Posterior Lateral Meniscus Tear

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Abstract: Arthroscopic repair of the posterior horn of the lateral meniscus (LM) from an anterolateral portal has a risk of popliteal artery injury. Here, we present an ultrasound-assisted, arthroscopic, all-inside repair technique for a posterior LM tear to reduce the risk of neurovascular injury. An ultrasound probe covered with a sterile sleeve is placed horizontally at the popliteal fossa by an assistant surgeon, and the popliteal artery and posterior LM are confirmed. From the anterolateral portal, an arthroscopic probe is inserted to push the posterior capsule of the lateral compartment, while an ultrasound image detects the tip of the probe. After the probe is confirmed not to be directed toward the popliteal artery, an all-inside suture device is introduced from the anterolateral portal. While the meniscus is penetrated, the surgeon can confirm by ultrasound images that the needle is directed away from the popliteal artery. The guide suture is pulled anteriorly to secure the anchors tightly, and an ultrasound confirms that the anchors are positioned behind the posterior portion of the LM. All sutures are secured under the assistance of ultrasound images, followed by arthroscopic confirmation of a properly secured LM by the all-inside repair technique.

Introduction

Recently, the ratio of meniscal repair versus meniscectomy has increased,[1] with growing acceptance of the concept of "saving the meniscus"[2] and improvements in meniscal repair devices. Surgical approaches for meniscal repair include "inside-out," "outside-in," and "all-inside" techniques, and the appropriate procedure should be applied depending on the location and type of meniscus injury.[3,4] Satisfactory clinical results of meniscus repair have been reported in both short-term and long-term follow-up.[5-7]

Nevertheless, meniscus repair has a certain degree of risk of neurovascular injuries, especially in cases with all-inside repair for a tear in the posterior horn of the lateral meniscus (LM).[8,9] Some cadaveric or magnetic resonance imaging (MRI) studies showed that repair of the posterior LM through an anterolateral portal increased the risk of popliteal artery injury,[10-14] and this was recognized as a relative contraindication. However, performing meniscus repair of the posterior LM from an anteromedial portal to avoid vascular injury requires that a suture device penetrate the meniscus obliquely. This may provide inadequate security of the repair site; therefore, a vertical stitch against the meniscus tear is ideal for better healing of the meniscus.

Ultrasound is useful for diagnosing meniscus pathology, especially in cases of meniscus extrusion.[15-17] It can also detect the posterior structures of the knee joint, including ramp lesions.[18] Therefore, ultrasound is more than just a diagnostic tool, as new ultrasound-assisted surgical procedures have been reported with the development of new devices.[19-23] Here, we present an ultrasound-assisted arthroscopic all-inside repair for a posterior LM tear that avoids popliteal artery injury.

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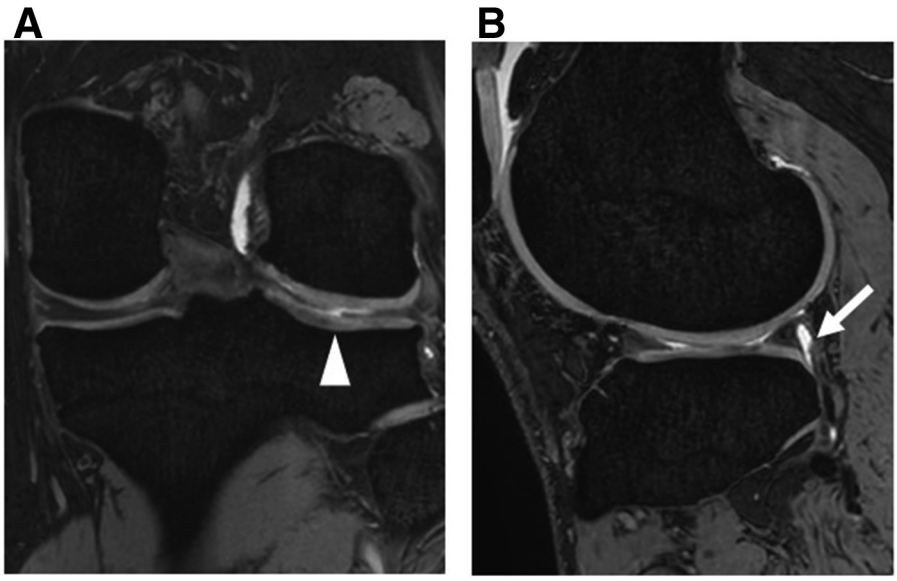

Fig 1. Preoperative MRI of the left knee joint (A: coronal planes; B: sagittal planes). (A) Disruption of the lateral meniscus (LM) is observed (arrowhead). (B) A gap is observed between the posterior LM and the capsule (arrow).

Indications, Preoperative Patient Evaluation, and Imaging

This technique is indicated for patients with LM injury of the posterior portion who have symptoms, such as knee pain, effusion, catching, locking, or limited range of motion (ROM). For preoperative patient evaluation, a physical examination should be performed, including joint line tenderness at the lateral compartment, limitation of ROM, and a McMurray test. Preoperative MRI is necessary to evaluate the tear location and pattern (Fig 1, A and B). On the basis of the physical examination and MRI findings, a surgical indication for posterior LM injury is determined.

Surgical Technique (With Video Illustration)

The patient is positioned supine on a standard operating table. An anteromedial and an anterolateral portal are used for the standard arthroscopic examination. In an arthroscopic view from the anterolateral portal with a figure 4 position, the posterior LM is pulled anteriorly over the center of the lateral compartment by probing from the anteromedial portal, thereby confirming the unstable LM lesion (Fig 2, A and B).

For the ultrasound-assisted repair of the posterior LM, an ultrasound probe (11-MHz linear probe, SONIMAGE MX1, Konica Minolta, Inc. Tokyo, Japan), covered with a sterile sleeve, is placed horizontally at the popliteal fossa by an assistant surgeon (Fig 3A). At the joint space between the lateral femoral condyle and the lateral tibial plateau, the location of a popliteal artery and posterior portion of the LM is confirmed by ultrasound (Fig 3, B and C). In an arthroscopic view from the anteromedial portal, an arthroscopic probe is inserted from the anterolateral portal to push the posterior capsule of the

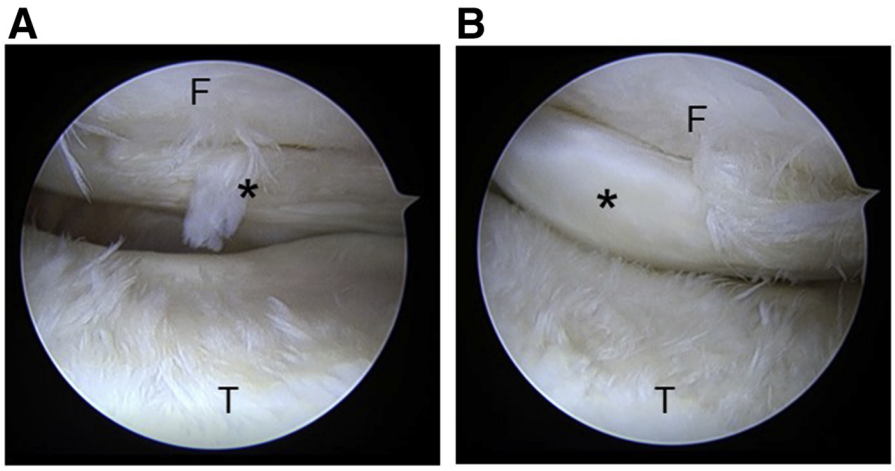

Fig 2. Arthroscopic images of the lateral meniscus (LM) injury in the left knee joint (viewed from an anteromedial portal). (A) The posterior portion of the LM shows fraying (asterisk) and disruption. (B) The posterior LM (asterisk) is pulled anteriorly over the center of the lateral compartment by probing. F, femoral condyle; T, tibial plateau.

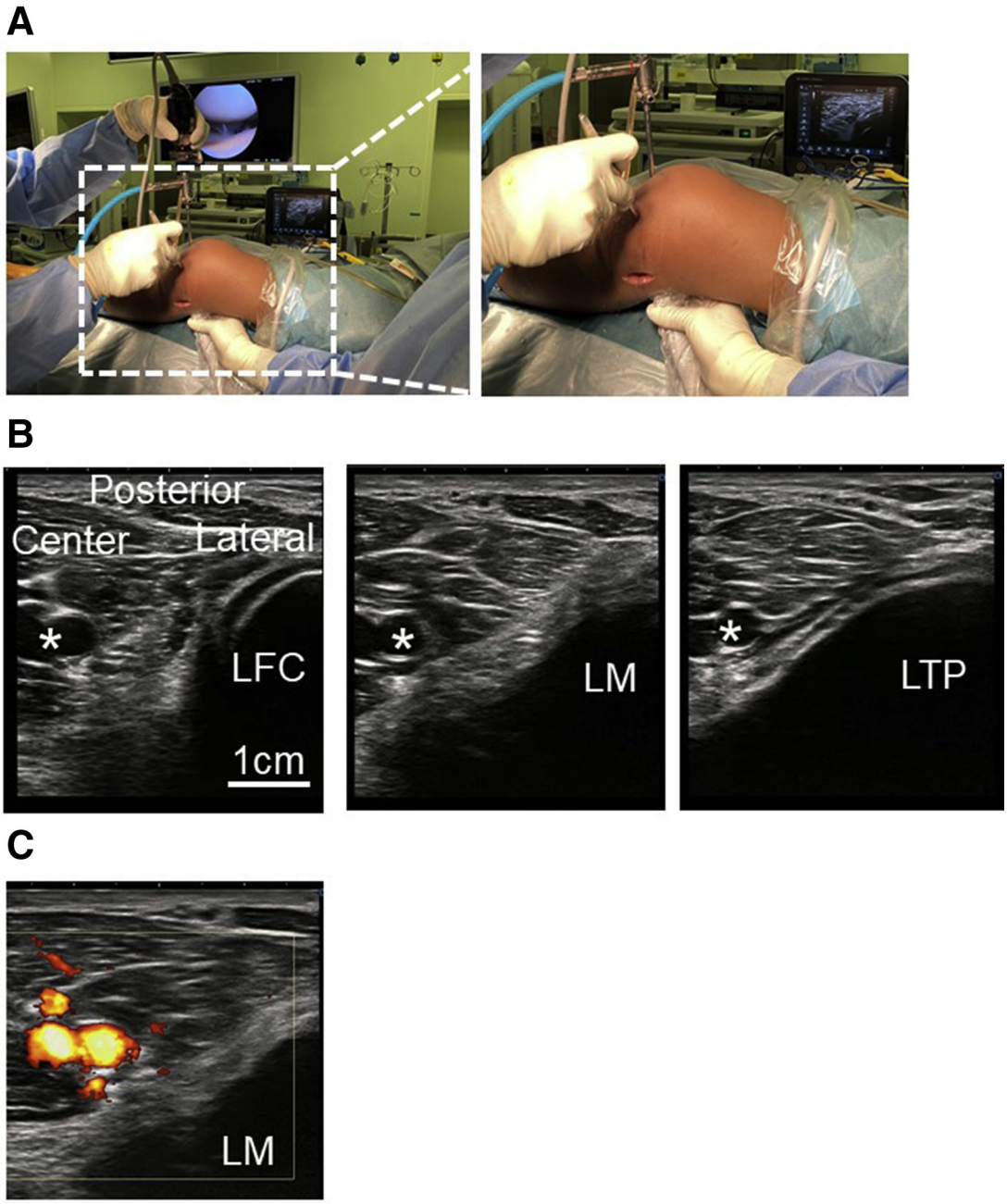

Fig 3. Settings of ultrasound-assisted arthroscopic lateral meniscus repair in the left knee joint and ultrasound images of the posterior knee compartment. (A) Under an arthroscopic view from an anteromedial portal, a probe is inserted from the anterolateral portal with a figure 4 position. An ultrasound probe, covered with a sterile sleeve, is placed horizontally at the popliteal fossa by an assistant surgeon. (B) Ultrasound image of the posterior knee compartment showing the lateral femoral condyle (left panel), lateral meniscus (center panel), and lateral tibial plateau (right panel). The asterisk (*) denotes popliteal artery. (C) Doppler image of the posterior knee compartment. LFC, lateral femoral condyle; LM, lateral meniscus; LTP, lateral tibial plateau.

lateral compartment, while the ultrasound image detects the tip of the probe. After the probe is confirmed not to be directed toward the popliteal artery, an all-inside suture device (JuggerStitch, Zimmer-Biomet, Warsaw, IN) is introduced from the anterolateral portal. Although the meniscus is penetrated, the surgeon can observe that the needle is not being directed to the popliteal artery in the ultrasound image (Fig 4, A and B). Two anchors are introduced at the posterior side of the LM, and the guide suture is pulled anteriorly to secure the anchors tightly (Fig 4C). The ultrasound image confirms the position of the anchors on the capsule, behind the posterior portion of the LM (Fig 4D). All sutures are secured under the assistance of the ultrasound image. The final

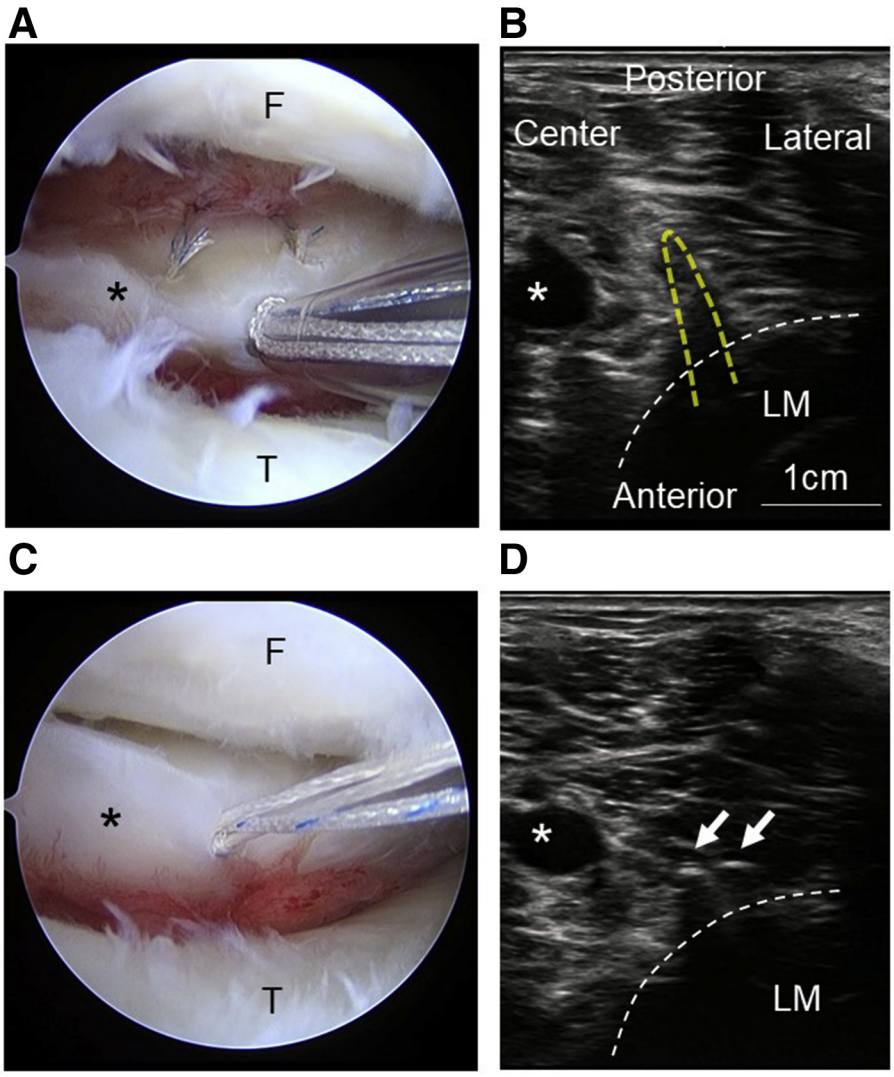

Fig 4. Ultrasound-guided arthroscopic lateral meniscus repair in the left knee joint (arthroscopic view from an anteromedial portal and ultrasound image of the posterior lateral meniscus; LM). (A) All-inside suture device (JuggerStitch) is introduced from the anterolateral portal, and the meniscus (asterisk) is penetrated. (B) Ultrasound image shows the needle (yellow dashed line) avoiding the neurovascular structures (asterisk). (C) After two anchors are introduced at the posterior side of the LM (asterisk), (D) Ultrasound image confirms the anchors (arrowheads) are secured behind the posterior portion of the LM. Popliteal artery (asterisk). F, femoral condyle; T, tibial plateau.

arthroscopic examination shows the properly secured repair and the stabilized posterior LM by probing (Fig 5, A and B). The tips and pitfalls of this technique are described in Table 1.

Postoperative Course

After the surgery, the routine postoperative protocol for meniscus repair includes ROM exercises and partial weight bearing with a knee immobilizer and crutches.

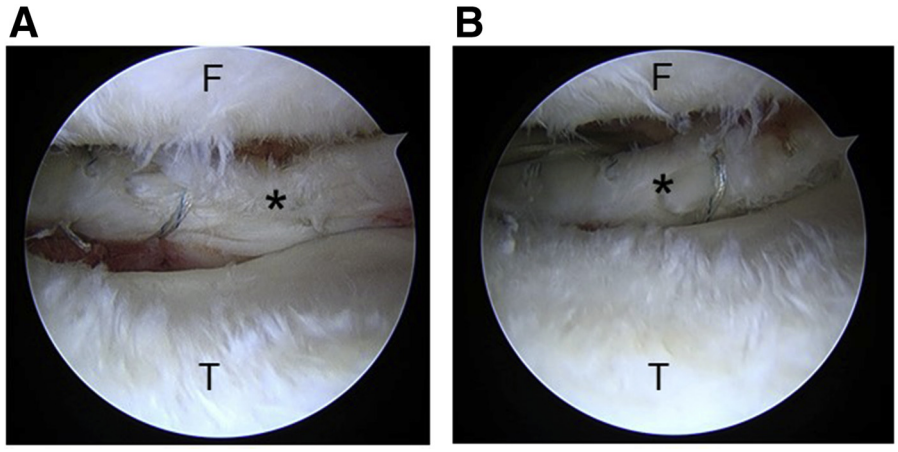

Fig 5. Arthroscopic findings after meniscus repair under ultrasound guidance in the left knee joint (arthroscopic view from an anterolateral portal). (A) Arthroscopic examination shows the properly secured LM (asterisk) following the all inside repair technique. (B) Posterior LM (asterisk) is stabilized and is not pulled anteriorly over the center of the lateral compartment by probing.

Table 1. Tips and Pitfalls

Tips	Pitfalls
• The ultrasound must be handled by an assistant surgeon, and the ultrasound probe should be placed horizontally between the lateral femoral condyle and the lateral tibial plateau to detect the posterior LM. • Upon detection of the bone outline of the lateral femoral condyle or the lateral tibial plateau, the probe should be moved proximally or distally to obtain an LM image within the joint space. • An arthroscopic probe is inserted from the anterolateral portal to push the posterior capsule of the lateral compartment, and the ultrasound image should confirm that the tip of the probe is directed away from the popliteal artery.	• When the all-inside device is directed toward the neurovascular structure, the surgeon should change the direction of the device or bend the needle of the device to avoid injuring the neurovascular structure. • In patients with obesity, the posterior LM may be detected deep in the ultrasound image; therefore, clear detection of the posterior LM may be difficult.

LM, lateral meniscus.

Walking without the knee immobilizer is permitted at 4 weeks postoperatively, and full weight bearing is permitted at 6 weeks. Deep squatting over 90° is prohibited for 3 months. After the healing of the meniscus is confirmed in MRI at 3 months (Fig 6, A and B), deep squatting over 90° is allowed.

Discussion

We have introduced an ultrasound-assisted arthroscopic all-inside repair of a posterior LM tear. Ultrasound enables the detection of the posterior LM, the neurovascular structure, and the all-inside device inserted from the anterolateral portal. Under ultrasound guidance, meniscus repair of the posterior LM can be achieved safely with a reduced risk of popliteal artery injury.

A cadaveric study showed significant differences in the distance between the popliteal artery and the repair device from an anterolateral portal at different knee flexion angles.[24] A total of 20 specimens were investigated, and a distance from the popliteal artery of less than 10 mm was observed in 2 knees at 90°, 8 knees at 45°, and 18 knees at 0°. A lateral meniscus repair has a lower risk of vascular injury when conducted at 90° of knee flexion than at smaller knee flexion angles, but it cannot provide sufficient evidence of safety. An MRI study showed that the average distances of simulated trajectories to the popliteal neurovascular bundle ranged from .3 mm to 4.7 mm in cases of aiming at the posterior LM from an anterolateral portal.[14]

The most critical point of the current procedure is clear detection of the posterior LM in the ultrasound image. The ultrasound must be handled by an assistant surgeon, and the ultrasound probe should be placed horizontally between the lateral femoral condyle and the lateral tibial plateau to detect the posterior LM. When the bone outline of the lateral femoral condyle or the lateral tibial plateau is detected, the probe should be moved proximally or distally

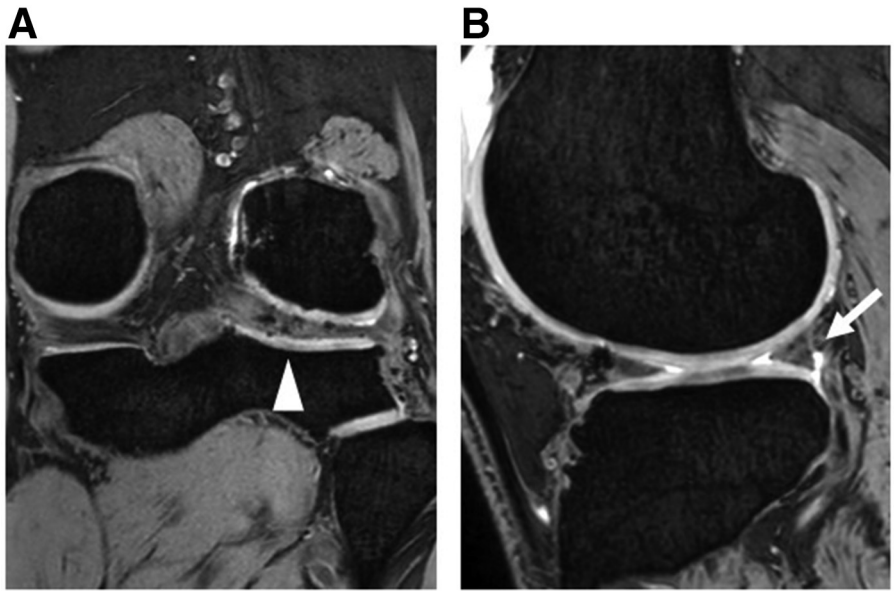

Fig 6. Postoperative magnetic resonance image 3 months after arthroscopic meniscus repair under the guidance of ultrasound in the left knee joint. (A) Healing of the lateral meniscus (LM) is observed (arrowhead). (B) The gap between the posterior LM and the capsule has disappeared.

Table 2. Advantages and Limitations of this Technique

Advantages	Limitations
• Meniscus repair of the longitudinal tear of the posterior LM is possible with an all-inside device through an anterolateral portal with an ideal suture angle. • The neurovascular structure can be detected, thereby reducing the risk of neurovascular injury.	• Detection of the posterior LM clearly in the figure 4 position by ultrasound can be technically demanding for an assistant surgeon, especially in obese patients. • If the surgeon lost the tip of the needle in the ultrasound, it has a risk of the neurovascular injury. It is important to collaborate with the assistant surgeon to obtain a good ultrasound image of the posterior structures of the knee joint.

LM, lateral meniscus.

to obtain an LM image within the joint space. An arthroscopic probe is then inserted from the anterolateral portal to push the posterior capsule of the lateral compartment, and the ultrasound image should confirm that the tip of the probe is not being directed toward the popliteal artery. While the all-inside device is being inserted, ultrasound guidance should again be used to ensure that the neurovascular structure is not injured.

This procedure has some pitfalls. One is that when the all-inside device is directed to the neurovascular structure, the surgeon needs to change the direction of the device or bend the needle of the device to avoid injuring the neurovascular structure. Another is that, in patients with obesity, the posterior LM may be detected deep in the ultrasound image; therefore, clear detection of the posterior LM may be difficult. One option is to use a convex probe when the posterior LM is too deep to observe the posterior structures of the knee joint.

The critical advantage of this surgical technique is that it can achieve meniscus repair of a longitudinal tear of the posterior LM with an all-inside device through an anterolateral portal with an ideal suture angle. It can also detect neurovascular structures and reduce the risk of neurovascular injury (Table 2). The main disadvantage of this technique is that detecting the posterior LM clearly in the figure 4 position by an ultrasound is technically demanding for an assistant surgeon (Table 2). If the surgeon lost the tip of the needle in the ultrasound, it has a risk of the neurovascular injury. It is important to collaborate with the assistant surgeon to obtain a good ultrasound image of the posterior structures of the knee joint.

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