Technical Note

Circumferential Cross-Stitch Suture for Longitudinal Lateral Meniscal Tear Around the Popliteal Tendon Hiatus Region

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Abstract: Lateral meniscal repair of the popliteal hiatus is technically demanding. The inside-out technique requires an additional incision and carries the risk of posterolateral soft tissue damage to the knee joint. In addition, the presence of the popliteal tendon limits the route of the suture thread. Within the current trend of the all-inside suture technique, meniscal suture-based all-inside repair demonstrates biomechanical advantages over anchor-based all-inside repair. We introduce a meniscal suture-based all-inside meniscal repair technique for longitudinal lateral meniscal tears.

The lateral meniscus has greater mobility than the medial meniscus, and its structure complicates surgical technique owing to the absence of a capsule attachment site at the popliteal hiatus and the presence of the popliteal tendon. Surgical treatment of meniscal tears has demonstrated that meniscectomy accelerates osteoarthritis progression. Owing to the stabilization and chondroprotective role of the meniscus, the indications for meniscal repair have been expanded to preserve function.

Modern arthroscopic meniscal repair procedures are primarily performed using inside-out, all-inside, or outside-in techniques. The inside-out technique, which is predominant among the meniscal repair procedures, fixes the meniscus to the soft tissue outside the capsule.[1] However, different from the all-inside repair, which secures the meniscus independent mobility from the surrounding soft tissue, the inside-out repair technique may obstruct the normal meniscus healing process during postoperative range of motion exercises because meniscus fixation to the capsule by tying a knot over the capsule firmly.[2] In addition, inside-out repair can be a risk factor for neurovascular component injuries. In particular, repairing the lateral meniscus at the popliteal hiatus via the inside-out technique requires a meticulous position of the suture needle to avoid popliteal tendon penetration and prevent damage to the posterolateral extracapsular knee structure.

To avoid the risks, the all-inside meniscal repair has been developing and increasing. This technique has led to their classification into two categories: transcapsular and non-transcapsular repairs.[1] The transcapsular technique usually involves capsule-based repair using anchor fixation over the joint capsule. By contrast, the non-transcapsular technique completes meniscal repair inside the capsule that avoids incorporation of the capsule or surrounding soft tissue with the meniscus.

In addition, a recent circumferential meniscal suture technique was introduced. Although it has been used to treat horizontal tears around the hiatus region or as a salvage procedure,[3,4] it has not yet been routinely adapted for longitudinal tears. Our present report describes a meniscal suture-based all-inside repair using a circumferential suture technique for a longitudinal lateral meniscus injury at the posterior segment and around the popliteal hiatus (Video 1).

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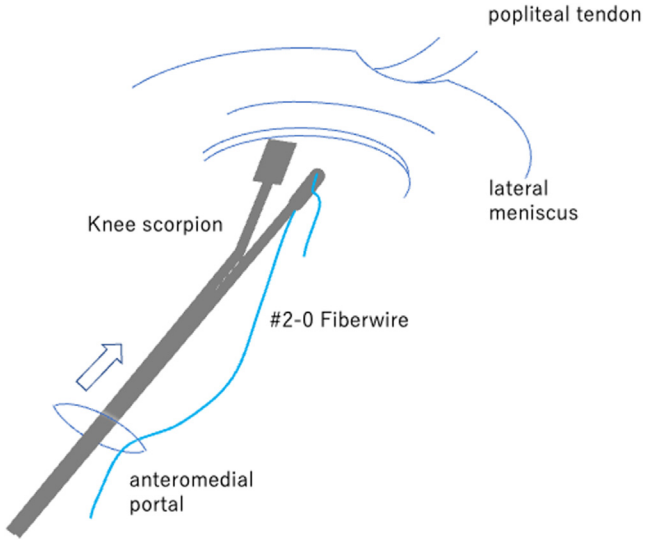

Fig 1. A Knee Scorpion is inserted through the portal. The Knee Scorpion is set with a 2-0 FiberWire. A cannula may be used to aid in the insertion of the device and avoid fat or synovial interference during the procedure.

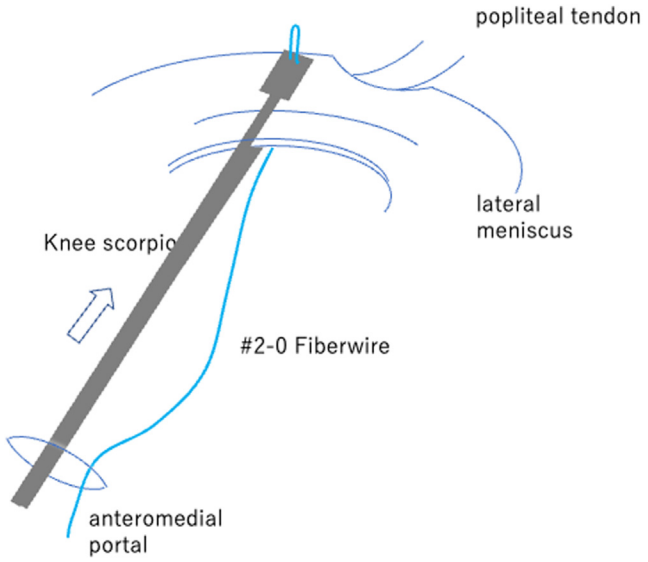

Fig 2. The Knee Scorpion captures and passes the needle through the peripheral rim of the lateral meniscus adjacent to the popliteal hiatus.

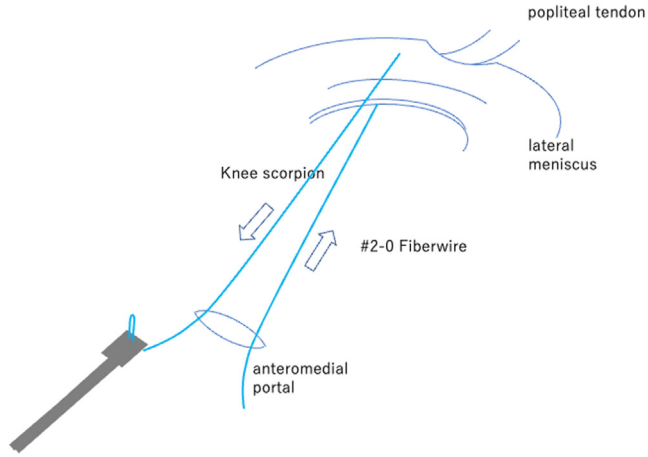

Fig 3. Retrieve the 2-0 FiberWire thread. Then draw out the thread through the portal.

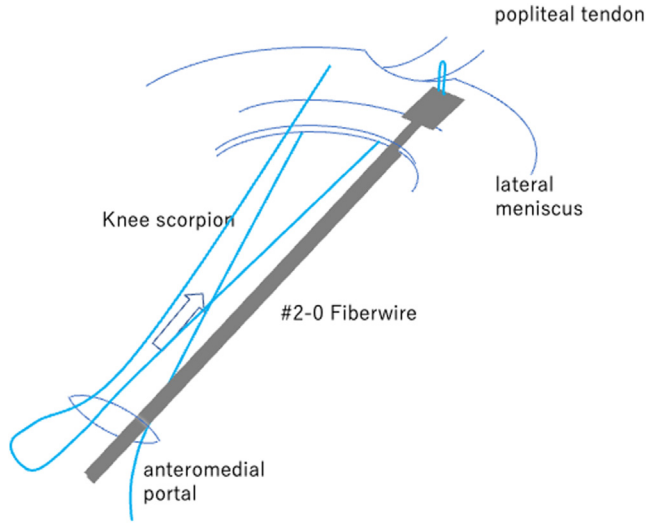

Fig 4. After setting the 2-0 FiberWire in the Knee Scorpion, it is inserted into the same portal. The Knee Scorpion captures and passes the suture needle thread from the tibial side to the femoral side at the outer rim of the opposite side of the hiatus.

Surgical Technique

Lateral meniscal repair is performed in the supine position with a spinal block. A pneumatic tourniquet is applied to the proximal thigh. Standard anterolateral and anteromedial portals are created. In the tailor's leg position, routine diagnostic arthroscopy is performed to detect longitudinal tears of the lateral meniscus at the posterior segment to the popliteal hiatus. First, the inner edge of the affected lateral meniscus is minimally trimmed. After debridement of the meniscal lesion using meniscal abrasion, a Knee Scorpion (Arthrex) is inserted through the portal (Fig 1). The Knee Scorpion captures the outer rim of the meniscus while a vertical suture is placed using 2-0 FiberWire (Arthrex) (Fig 2). After the FiberWire is retrieved through the portal, the femoral thread is reattached to the Knee Scorpion (Fig 3). The same procedure is performed 2 cm from the initial stitch through the same portal (Figs 4 and 5). If the thread slides smoothly, a sliding knot is used; if excessive friction prevents sliding, a normal tying knot is used (Figs 6 and 7). In case of a longitudinal tear in front of the popliteal hiatus, two needle passing points are created on either side of the popliteal hiatus. The V-shaped thread ties over the longitudinal tear in front of the hiatus. When the meniscal tear is longer, another

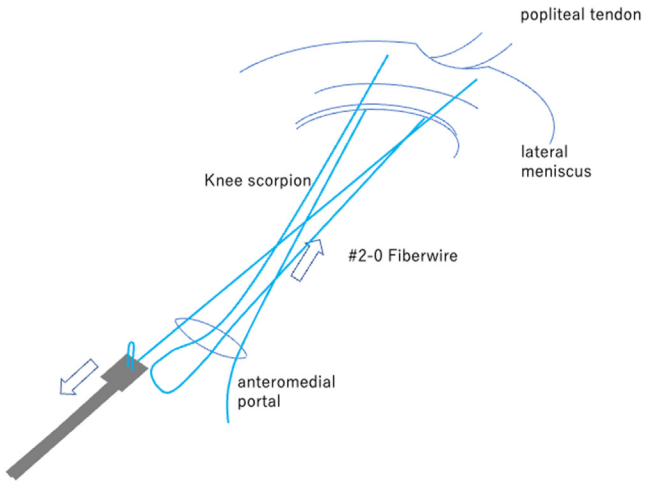

Fig 5. The Knee Scorpion is drawn through the portal.

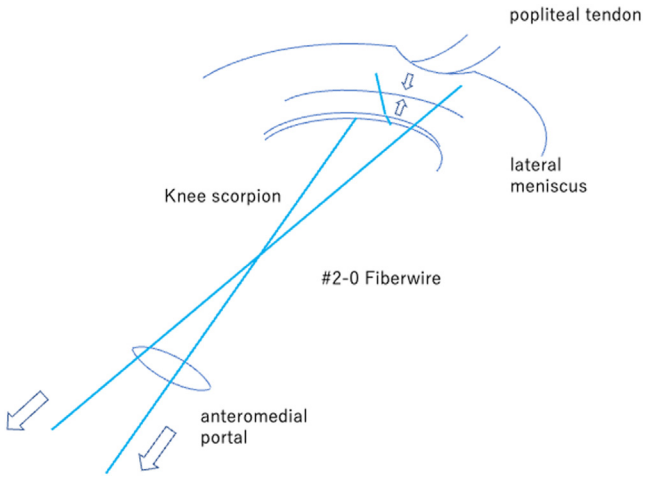

Fig 6. The two free ends of the thread are pulled to apply the proper compressive force on the meniscus lesion.

throw of the overlapped cross suture is fashioned like a net to secure a rigid meniscal repair (Fig 8). We instructed the pearls and pitfalls (Table 1), and advantages and disadvantages (Table 2).

Rehabilitation

For the first 4 weeks, knee range of motion is limited to 120 ° of flexion. Normal weightbearing, as tolerated, is immediately applied. The range of motion is gradually increased to full forward motion 8 weeks after surgery. A brace is not required for a solitary meniscal injury. Jogging is initiated after 8 weeks, and in the case of a solitary meniscal injury, the return to playing sports is typically initiated 4 months after surgery.

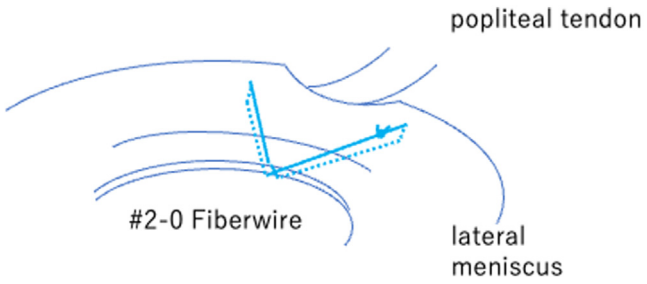

Fig 7. A sliding knot or standard surgical ligation is performed to secure the knot. Because the thread runs over the meniscus forming a "V" shape, the two compression points on the injury site are more central than the suture needle entry points.

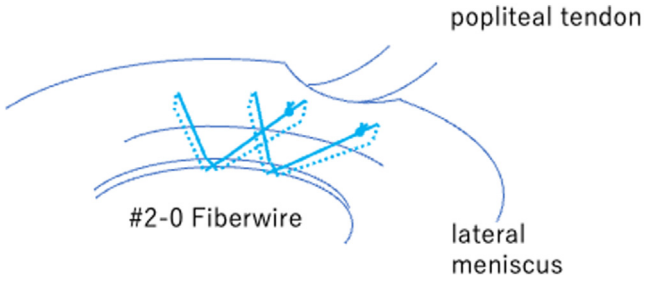

Fig 8. When a single circumferential cross-compression suture does not adequately cover the longitudinal tear, another half-overlapping suture can be fashioned on the meniscus as a consecutive additional suture, capturing and holding the meniscus securely like a net.

Discussion

In this report, we introduce a meniscal suturing technique for longitudinal tears of the lateral meniscus. lateral meniscal repair in front of the popliteal hiatus is particularly technically challenging, as it requires precise control of the suture thread while avoiding popliteal tendon damage. Our all-inside suture technique simplifies the suture needle passing maneuver while avoiding popliteal tendon injuries. With the suture needle passing on either side of the hiatus, the V-shaped cross suture thread ties over the longitudinal tear in front of the popliteal meniscus, and the suture line compression is more central than the needle passing site. Additionally, by fashioning consecutive cross-stitch placements with a half-pitch overlap, the meniscus can be supported like a net.

Current all-inside suture procedures are classified as two types: the non-transcapsular technique, which ties the suture knots inside the joint, and the transcapsular technique, which places anchors outside of the capsule. In this report, we advocate the non-transcapsular cross-stitch technique because of its biomechanical advantage. A biomechanical study using a longitudinal meniscal tear model showed that the non-transcapsular all-inside

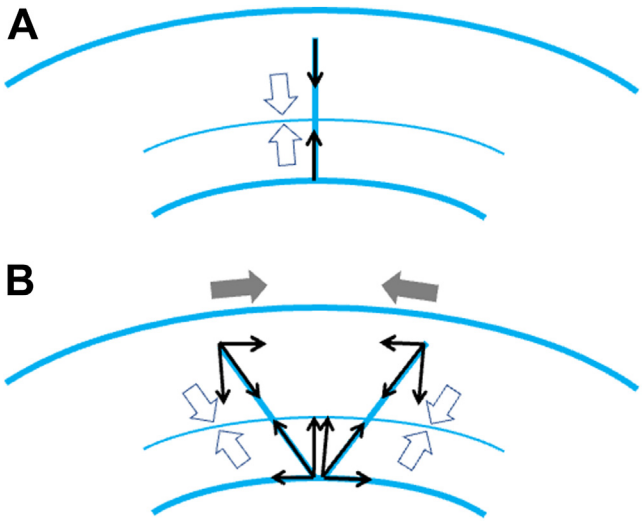

Fig 9. (A) Normally, a single vertical suture applies a vertical compression force to the meniscal tear region. (B) Two oblique running sutures apply a compression force on the longitudinal tear lesion (white arrows) and a transverse compression force along the outer rim of the meniscus (gray arrows). Consecutive cross stitches that apply a transverse compression force along the outer rim can maintain the hoop mechanism to prevent meniscal extrusion.

Table 1. Pearls and Pitfalls

Pearls	Pitfalls
Marginal chamfering before a circumferential suture thread cast.	Minimize the chamfering volume to preserve meniscus.
Peripheral meniscus is captured twice by the Knee Scorpion suture needle.	Insert the Knee Scorpion through medial of lateral. The thread should be retrieve and set the device carefully without tangling.
Selection of knot tying procedure.	A normal surgical knot tying using a arthroscopic knot pusher rather recommend to the sliding knot procedure because the cross stich suture does not allow smooth thread slide.

Table 2. Advantages and Disadvantages

Advantages	Disadvantages
Requires standard anteromedial and anterolateral portals only; no accessory portals are needed.	Requires a well-handling technique in the Knee Scorpion.
No risk of posterolateral neurovascular injury.	Chamfering of the inner edge of the intact lateral meniscus is required.
Requires a simple suture repair without complicated thread relay.	After reattachment of the retrieval thread the Knee Scorpion, insert the Knee Scorpion through the same portal again without thread tangling.
Suture repair can be managed for any longitudinal tear; this procedure is indicated for red-red, red-white, and white-white zone tears.	Intra-joint suture knot has a risk of iatrogenic chondral abrasion.
	The biomechanical properties and clinical outcomes of this procedure, including second arthroscopy, have not yet been investigated.

suture had superior failure load compared with the transcapsular technique.[5] According to the configuration of a stitch thread, a single cross-stitch suture is equivalent in failure load and stiffness to two parallel vertical stitches.[6] Additional advantages of the cross-stich suture showed that the repair technique decreased the tibiofemoral contact area and contact pressure compared with the intact joint surface in the medial meniscal bucket handle tear model, whereas the vertical mattress suture had no difference in contact area.[7] We hypothesized that the cross-stitch suture model would induce a central meniscal shift effect compared with the conventional vertical suture. A standard vertical suture was used to apply a vertical compression force to the injury site of the meniscus (Fig 9A). However, the oblique running route of the cross-stitch threads can divide the compression force into vertical and horizontal vectors. The vertical vector applies a compression force on the longitudinal tear site to heal the lesion, whereas the horizontal vector applies a transverse compression force at the peripheral meniscal site along the outer marginal meniscal rim (Fig 9B). This transverse compression force may play a role in decreasing the chondral contact area and pressure via the meniscal centralization effect. Thus, it will demonstrate a further optimal effect in terms of chondroprotection.

In addition, we introduce a circumferential suturing technique to repair longitudinal tears. A second-look arthroscopy study after meniscal repair reported a newly formed injury along the inner side of the meniscus along the entry path of the suture needles and implants, even when the original site healed.[8] Although the circumferential meniscal suture technique was originally introduced to treat horizontal tears or as a salvage procedure,[4] this technique is anticipated to be adapted to primary longitudinal tears to avoid iatrogenic second meniscal injury.

Despite the biomechanical advantages of suture-based all-inside meniscal repair over transcapsular anchor-based all-inside repair,[6] intra-joint suture knot creation could be another risk factor for new chondral lesions. Because a single cross stitch is equivalent to double vertical stitches,[7] the cross stitch has the advantage of reducing suture knots by half compared with conventional all-inside vertical suture repair.

This technique has several limitations. First, suture-based all-inside repair is technically more demanding

than anchor-based transcapsular all-inside repair. Second, the procedure requires chamfering the intact inner meniscal edge to stabilize the cross thread. Discrete, minimal resection is compulsory for this procedure. Third, clinical outcomes and the results of second-look arthroscopy remain unclear.

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