



# Modified Outside-In Plus Suture Technique for Repair of the Anterior and Middle Segments of the Meniscus: Technical Note

Ba Rom Kim, M.D., Dong Hwi Kim, M.D., Ph.D., Gwang Chul Lee, M.D., Ph.D., and Dong Seop Lim, M.D.

**Abstract:** Traditionally, an outside-in suture technique is appropriate to repair longitudinal tears of the anterior and middle segments of the meniscus. However, it has a fundamental weakness of not creating a vertical mattress-type suture. To overcome this weakness, the modified outside-in technique was developed using a suture hook to create a vertical mattress-type suture in the inner fragment. However, it still has the disadvantage of requiring an open skin incision to prevent neurovascular damage during knot tying. Thus, we developed the modified outside-in plus technique to make a vertical mattress suture without an open skin incision in the knee joint. With this technique, the use of both vertical and horizontal mattress sutures is possible. Although this technique is similar to the modified outside-in technique, a suture knot is made inside the knee joint. Therefore, it compensates for the disadvantage of the outside-in technique. The modified outside-in plus technique is able to achieve good reduction and sufficient stability through a vertical mattress suture technique without additional skin incisions.

Recently, with the paradigm shift in the concept of meniscal treatment, the meniscus should be preserved as much as possible, and interest in repair techniques for the meniscus is increasing.<sup>1</sup> Inside-out, all-inside, and outside-in techniques can be used, depending on tear location. Technically, to achieve firm fixation and anatomic reduction at the tear site by grasping more circumferential collagen fibers, a vertical mattress suture is recommended rather than a horizontal mattress suture.<sup>2,3</sup>

The outside-in technique is mainly used to repair longitudinal tears to fix a perpendicular trajectory in the anterior and middle parts of the meniscus.<sup>4</sup>

Generally, the outside-in technique involves introducing a suture from outside the capsule into the joint, engaging the 2 fragments of the meniscal tear, and subsequently retrieving the suture outside of the capsule. The knots are tied to the external surface of the capsule. The advantage of this technique is that it is easy to perform repair without the need for special equipment. However, it has a fundamental weakness of not creating a vertical mattress-type suture; moreover, an additional incision is required. Other techniques have been introduced to overcome this weakness. Ahn et al.<sup>3</sup> introduced a vertical mattress suture method using a suture hook, but a limitation of their technique is the creation of an additional incision for knot tying outside the joint. Although other techniques had no additional incision, which had to penetrate the meniscus with a spinal needle and had a limitation of difficulty in obtaining vertical mattress suture.<sup>5-8</sup> Thus, we developed the modified outside-in plus technique to create a vertical mattress suture without an open skin incision in the knee joint.

## Surgical Indications

When a repairable tear of the anterior and middle segments of the meniscus is identified, suture repair is preferred. The indications for this technique are similar to those established for previous outside-in techniques.

From the Department of Orthopaedic Surgery, Chosun University, Chosun University Hospital, Dong-gu, Republic of Korea.

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Address correspondence to Dong Hwi Kim, Department of Orthopaedic Surgery, Chosun University Hospital, 365 Pilmundae-ro, Dong-gu, Gwangju, 61453, Republic of Korea. E-mail: [oskdh@chosun.ac.kr](mailto:oskdh@chosun.ac.kr)

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## Surgical Technique

The patient is positioned for standard knee arthroscopy. Our technique creates a vertical suture in a meniscal longitudinal tear and require an 18-gauge spinal needle, suture retriever, suture hook (Linvatec, Largo, FL), and absorbable suture material (No. 1 PDS; Ethicon, Somerville, NJ). After standard anteromedial and anterolateral portals are created, the tear site of the meniscus is checked using a probe (Fig 1). To make the outer suture fragment, 1 end of the suture material is first introduced by a spinal needle into the joint at the lower part of the meniscus (Fig 2). It is easier to orient the suture than to pass it through the superior border of the meniscus. Then, 1 end of the suture is retrieved outside the joint (Fig 3), and grasping is performed using mosquito forceps outside the joint while a spinal needle is sustained between the tibia and meniscus (inferior border of the meniscus). We then withdraw the needle until the joint capsule is felt and advance it into just the upper part of the meniscocapsular junction (Fig 4). The other end of the suture material inside the joint, and the suture material is retrieved again using the same methods (Fig 5). Fixation to the inner fragment is similar to that in the modified outside-in technique<sup>3</sup> using a suture hook, as applied in all-inside techniques, to grasp a vertical suture (Fig 6). The inferior part of the suture end in each fragment is then tied and retrieved using the shuttle-relay technique to obtain 1 suture passing each fragment (Fig 7). After confirmation that both ends of the single suture are located in the upper portion of the meniscus, all-inside knot tying is performed using a knot pusher (Fig 8). This is then repeated as firm and stable fixation is achieved (Video 1). Pearls and pitfalls of our technique are listed in Table 1, and advantages and disadvantages are presented in Table 2.

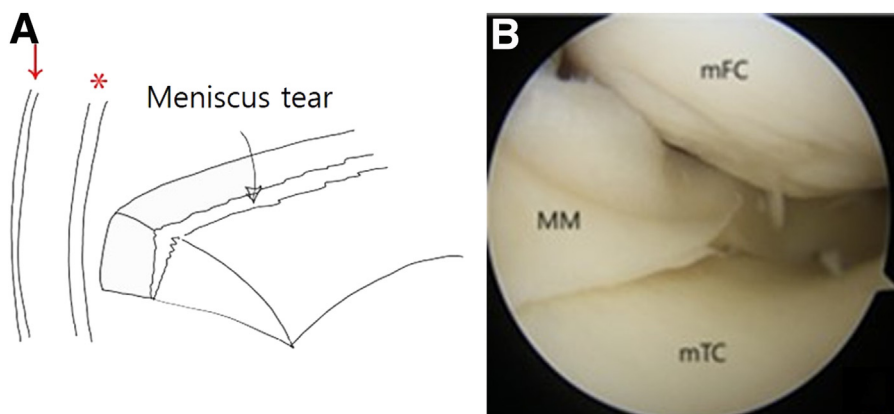
## Postoperative Recovery and Rehabilitation

During the postoperative period, all patients are allowed partially weight bearing with crutches for the first 6 weeks and then progress as tolerated. All patients are instructed to perform quadriceps-setting exercises. Knee flexion is limited to 0° to 90° for the first 6 weeks and then progresses as tolerated. Any significant squatting, kneeling, or sitting on the floor is avoided for a minimum of 6 months to avoid excess stress on the meniscus.

## Discussion

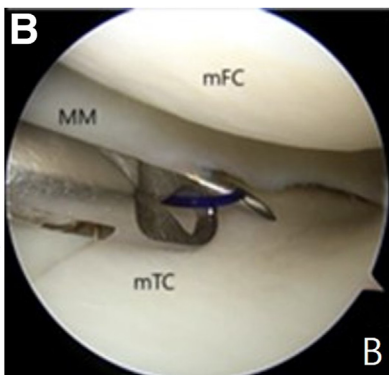
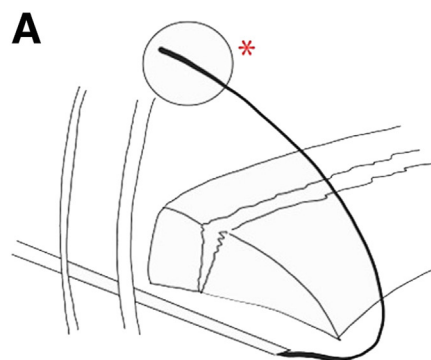
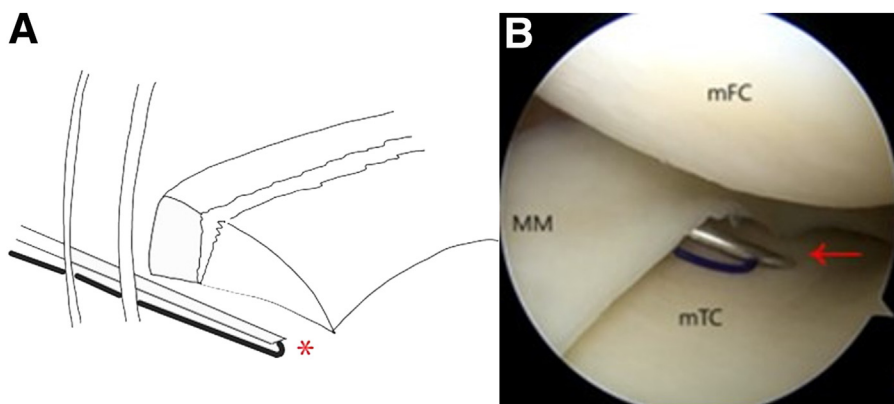
The outside-in technique with only a spinal needle makes vertical mattress suturing difficult; therefore, the modified outside-in technique of Ahn et al.<sup>3</sup> makes vertical mattress suturing easier using a suture hook (Linvatec). However, even with the modified outside-in technique, which requires an open skin incision to prevent neurovascular damage, vertical mattress suturing is a time-consuming procedure and is not cosmetic.<sup>6</sup> Therefore, our technique allows vertical mattress sutures without additional skin incisions by knot tying in the joint.

The advantages of the modified outside-in plus technique are as follows: First, this technique is technically easy to implement. Penetration of the capsule only parallel to the joint line with a spinal needle is easier than penetration of both the capsule and the meniscus proper, which is relatively resistant when performing an outside-in technique, thus sometimes causing chondral damage. When suturing the outer rim of the tear site similar to the traditional outside-in technique,<sup>9</sup> passing the suture first under the inferior margin of the meniscus, that is, between the meniscus and tibia, it is easier to orient the spinal needle than to pass the suture between the meniscus and femoral condyle. This is a result of the tibial condylar articular surface being

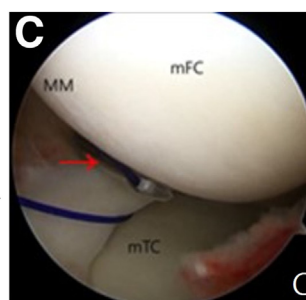
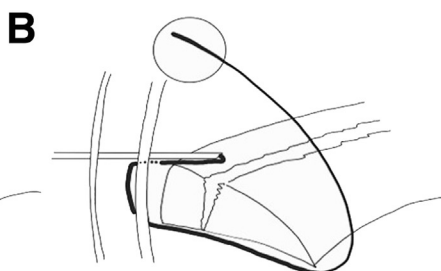
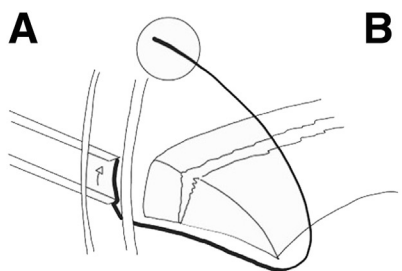


**Fig 1.** (A) Schematic overview. Longitudinal tear of meniscus. The asterisk indicates the capsule, and the arrow indicates the skin. (B) Arthroscopic image. Longitudinal tear of middle segment. The patient is positioned for standard knee arthroscopy of the left knee; anterolateral viewing portal. mFC, medial femur condyle; MM, medial meniscus; mTC, medial tibia condyle.

**Fig 2.** (A) Schematic overview. Suture material (PDS), introduced by the spinal needle (asterisk), enters the joint, underneath the tear site. (B) Arthroscopic image. Suture material (PDS), introduced by the spinal needle (arrow), enters the joint, underneath the tear site. The patient is positioned for standard knee arthroscopy of the left knee; anterolateral viewing portal. mFC, medial femur condyle; MM, medial meniscus; mTC, medial tibia condyle.

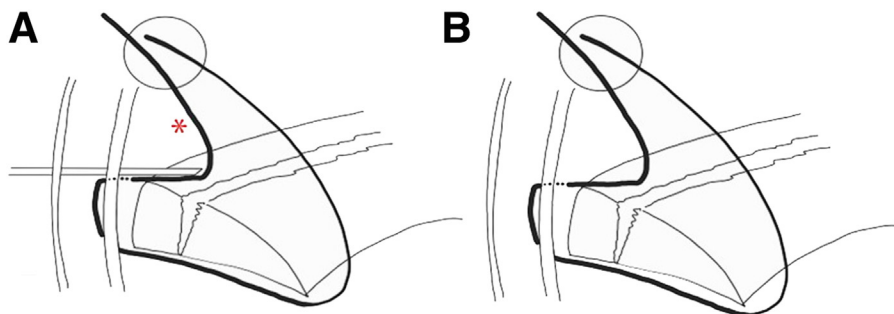


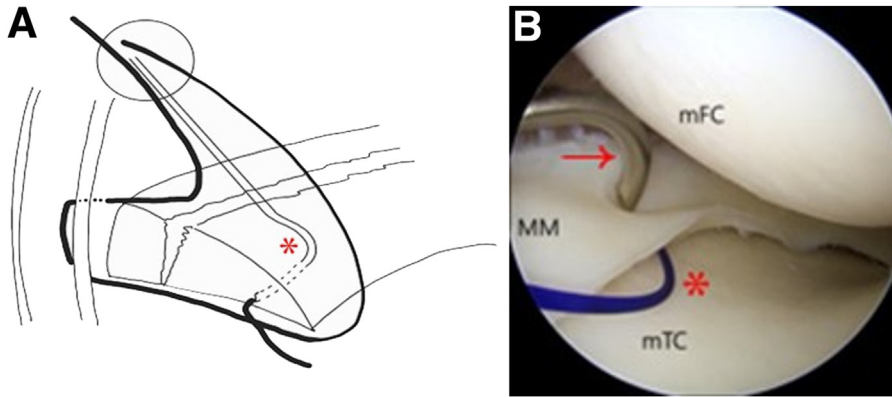
**Fig 3.** (A) Schematic overview. One end of the suture is retrieved outside of the joint. The asterisk indicates the portal. (B) Arthroscopic image. One end of the suture is retrieved outside of the joint. The patient is positioned for standard knee arthroscopy of the left knee; anterolateral viewing portal. mFC, medial femur condyle; MM, medial meniscus; mTC, medial tibia condyle.



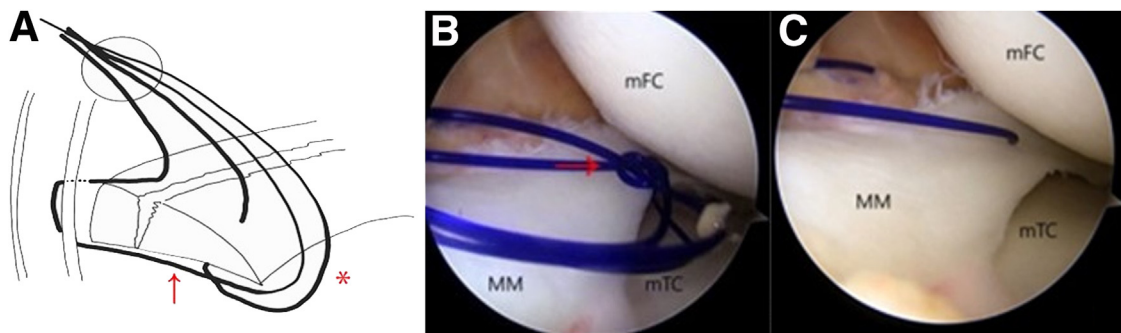
**Fig 4.** (A, B) Schematic overview. The needle is withdrawn until the joint capsule is felt. It then advances into just the upper part of the meniscocapsular junction. (C) Arthroscopic image. The needle is withdrawn until the joint capsule is felt; it is then advanced into just the upper part of the meniscocapsular junction (arrow) and used to retrieve the other end of the suture material. The patient is positioned for standard knee arthroscopy of the left knee; anterolateral viewing portal. mFC, medial femur condyle; MM, medial meniscus; mTC, medial tibia condyle.

**Fig 5.** (A, B) Schematic overview. The other end of the suture (asterisk) is retrieved outside of the joint through the portal. One loop is made around the torn meniscus, especially including the joint capsule. mFC, medial femur condyle; MM, medial meniscus; mTC, medial tibia condyle.

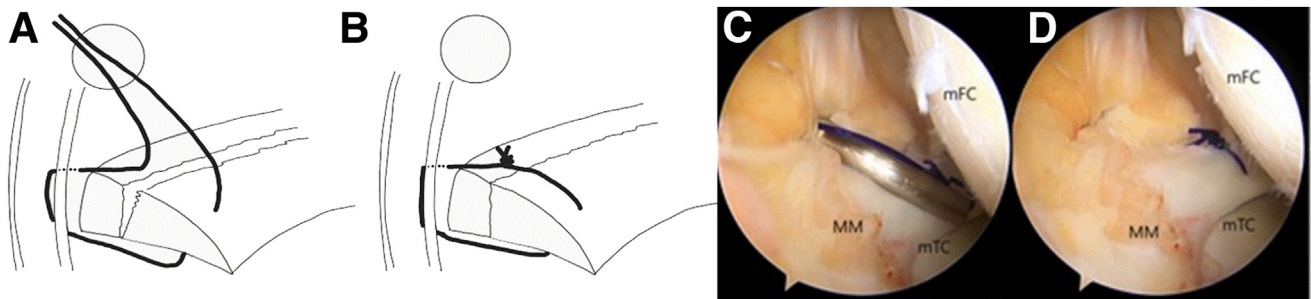




**Fig 6.** (A) Schematic overview. The inner part of the torn meniscus is pierced by orienting the suture hook (asterisk) in a vertical direction. (B) Arthroscopic image. Vertical suture using suture hook (arrow) for inner fragment. The asterisk indicates the PDS, previously introduced by a spinal needle, which obtains purchase in the posterior capsule. mFC, medial femur condyle; MM, medial meniscus; mTC, medial tibia condyle.



**Fig 7.** (A) Schematic overview. One end of the suture from the suture hook (asterisk) is retrieved outside the joint, and the inferior part of the suture (asterisk and arrow) in each fragment is tied and retrieved by the shuttle-relay technique to obtain 1 suture passing each fragment. (B, C) Arthroscopic images. The inferior part of the suture end in each fragment is tied and retrieved by the shuttle-relay technique (arrow) to obtain 1 suture passing each fragment. mFC, medial femur condyle; MM, medial meniscus; mTC, medial tibia condyle.



**Fig 8.** (A, B) Schematic overview. The same knot used in the all-inside suture technique is made. A vertical mattress knot is tied inside the joint. (C, D) Arthroscopic images. An all-inside knot is tied using a knot pusher. mFC, medial femur condyle; MM, medial meniscus; mTC, medial tibia condyle.

oriented parallel to the inferior surface of the meniscus. The inner rim of the tear site is thinner than the periphery; therefore, it is easy to create a vertical suture with a suture hook, which facilitates anatomic reduction and coaptation of the tear site. Second, the results of the described technique are cosmetically superior. A knot is formed within the joint, and no additional wounds are required. Finally, with this technique, the

use of both vertical and horizontal mattress sutures is possible.

There are some risks and limitations of our technique. First, this method is technically demanding with a slow learning curve. Second, there is a potential risk of nerve injury and cartilage irritation caused by the suture knot in the knee joint. In addition, with this technique, suturing the posterior part of the meniscus is difficult.

**Table 1.** Pearls and Pitfalls of Modified Outside-In Plus Technique

Surgical Step	Pearls and Pitfalls
Obtain instruments	For repair of the meniscus, only a spinal needle, PDS, suture hook, and knot pusher are required. However, this repair is technically demanding.
Suture outer fragment of tear site	The spinal needle is first introduced into the joint at the lower part of the meniscus. It is easier to orient the suture than to pass the suture between the meniscus and femoral condyle because the inferior border of the meniscus is parallel to the joint line. When withdrawing the spinal needle, the surgeon should feel the joint capsule and advance the needle into just the upper part of the meniscocapsular junction. If multiple attempts are made, the surrounding soft tissue may become caught when the shuttle-relay procedure is performed.
Suture inner fragment of tear site	It is easy to repair tears located near the meniscocapsular junction compared with other techniques. Using a suture hook, the surgeon can easily pass the suture material because the inner fragment is relatively thinner than the outer fragment of the tear site.
Make suture knot	A suture knot is made inside the knee joint capsule and prevents subcutaneous knot irritation. However, cartilage irritation can be caused by the suture knot in the knee joint.

**Table 2.** Advantages and Disadvantages of Modified Outside-In Plus Technique

Advantages	Disadvantages
Anatomic reduction and coaptation are achieved using a vertical mattress suture without additional skin incisions compared with other techniques (inside-out and outside-in).	The surrounding soft tissue may become trapped.
The technique is less costly than all-inside fixation techniques because only PDS, a spinal needle, and a suture hook are needed.	The technique is technically demanding.
The technique is useful for repairing the anterior and middle segments of the torn meniscus.	Suturing the posterior part of the meniscus is difficult.

In conclusion, the modified outside-in plus technique can achieve good reduction and sufficient stability using a vertical mattress suture technique without additional skin incisions. Although this technique is similar to the modified outside-in technique, a suture knot is made inside the knee joint. Therefore, it compensates for the disadvantages of the outside-in technique.

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