Technical Note

An Insertion Device for Effective Delivery of Fibrin Clot to the Meniscus Tear

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Abstract: The menisci have a poor intrinsic healing capability. Biological augmentation is used to promote meniscal healing in conjunction with suture techniques as the result of their poor healing rate. A fibrin clot (FC) is a well-known treatment option for meniscal injuries that are difficult to heal. Several methods for delivering FCs to target sites have been reported; however, all available methods have drawbacks such as unstable delivery, low maneuverability, and/or clot sizes that are too large. We use a dedicated device to efficiently deliver FCs of a suitable size for the tear. In this method, an FC formed to a size of 5 mm is stored and delivered in a thin syringe with a built-in plunger. This method enables an accurate delivery of a suitably sized FC to the desired location and fixes FCs to the tear site when used in combination with conventional suture methods. In this report, we will succinctly describe how to make and deliver an FC using the aforementioned device with a step-by-step instructional technique and an illustrative video.

The concept of "saving the meniscus" after meniscus injury is becoming more common because of the increased risk of osteoarthritis resulting from the loss of load distribution. Because of the low potential of healing, various augmentation techniques have been developed for meniscal repair.[1,2] The use of a fibrin clot (FC) is an easy-to-prepare, low-cost, and safe treatment option. The cytokines and chemotactic factors contained in the FC are believed to contribute to the promotion of meniscal healing. In contrast, several reports have been made on clot-delivering methods, which are the premise for discussing the effectiveness of FCs.[3,4] We developed a method to effectively fill FCs into the void of the torn meniscus with high reproducibility using a simple dedicated device (Fig 1). In this Technical Note, we will report and describe our method of making and delivering FCs using an insertion device and filling the void of the torn meniscus.

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Surgical Technique

FC Preparation

Using a tourniquet at 100 mmHg to dilate the vein, 40 mL of venous blood is collected from a cutaneous vein of the leg. A cap is placed on the outer cylinder of a 50-mL syringe, transferred to the venous blood, and stirred slowly with a glass rod for 10 minutes (Fig 2A). After 10 minutes, the glass rod (Fig 2B) is taken out, and the attached clot is placed on a clean piece of gauze (Fig 2C). The blood is squeezed out, and the gauze is changed several times to complete the preparation of FC (Fig 2D). The prepared FC is wrapped and stored in a dry piece of gauze until use. Immediately before use, the clot is cut to miniature pads of 5 to 6 mm in size to pack into the device (Fig 2E).

FC Delivery System

Our delivery system consists of 3 devices: a clot introducer, cylindrical funnel, and clot pusher (Farmax Medical, Nagano, Japan). The main device is a clot pusher that can be packed and filled with FC at the tip of the pusher. By pushing the lever at the end, the packed clot is pushed out from the tip of the pusher. There are 2 types of tips, straight and curved. A cylindrical funnel and a clot introducer are used to fill the

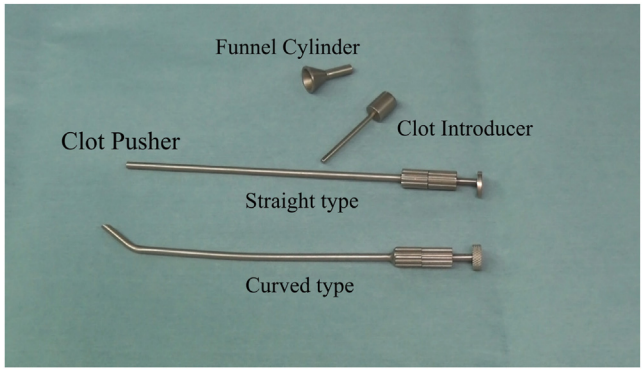

Fig 1. Original devices for the fibrin clot delivery. Two types of devices are used: straight and curved. A cylindrical funnel and clot introducer is used to fill the FCs.

clot into the tip of the clot pusher. A cylindrical funnel is attached to the tip of the clot pusher (Fig 3A), and the FC is packed into the pusher using a clot introducer (Fig 3B-D). When using the device, the FCs are cut into a 5- × 5-mm squares, and the tip of the outer cylinder is filled using the funnel-shaped part of the device.

Meniscal Repair Using the FC Delivery System

The FC delivery system is used in conjunction with several suturing methods. When using the inside-out technique, the suturing is first performed from the femoral side (Fig 4A-C). The tip of the delivery device is applied to the meniscal tear, which is prepared in advance and ready for use before suturing. The clot pusher is pushed out to deliver the FC (Fig 4D). While suturing, the FCs are packed into the torn area of the meniscus by a probe as needed. The number of suturing with clots is determined according to the length of the tear to make the meniscal shape natural (Fig 4E). Because the torn meniscus is lifted for better visibility when the femoral side is sutured first, the tibial side of the torn meniscus is easier to control and maneuver.

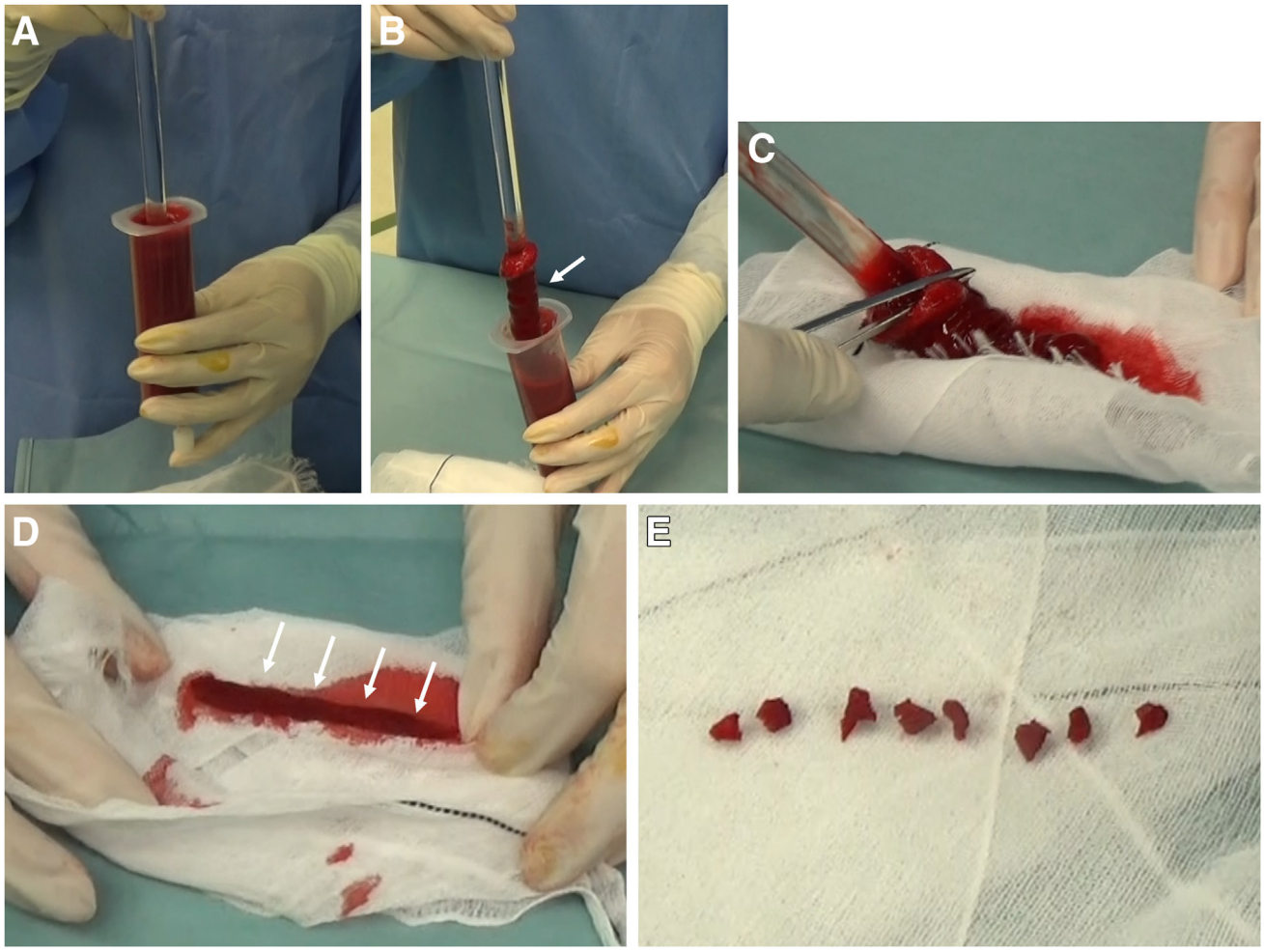

Fig 2. Preparation of the fibrin clot. (A) Stir the venous blood in a 50-mL syringe for 10 minutes using a glass rod. (B) Slowly take out the glass rod without touching the syringe wall. White arrow shows the fibrin clot with the glass rod. (C) Peel off the FC from the glass rod and place it on gauze. (D) Squeeze out excess blood while replacing the gauze. White arrows show the squeezed fibrin clot. (E) Cut the prepared fibrin clot into 5-mm pieces.

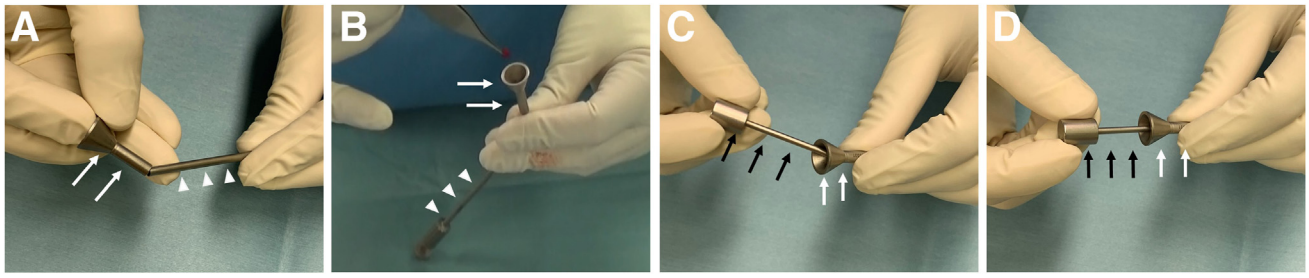

Fig 3. How to refill the clot to the delivery device. (A) Attach the funnel cylinder (white arrows) to the tip of the clot pusher (white arrowheads). (B) Place the fibrin clot into the funnel cylinder (white arrows). White arrowheads show the clot pusher. (C) Push the clot from the funnel cylinder (white arrows) to the clot pusher using the clot introducer (black arrows). (D) Push the clot into the clot pusher with the clot introducer (black arrows). White arrows show the funnel cylinder connecting to the clot pusher.

Before suturing, we place enough FCs to account for the length of the meniscotibial recess using the device (Fig 4F). Then, the torn meniscus is stitched over the FCs (Fig 4 G and H). The outside-in technique is used for longitudinal tears of the anterior horn of the meniscus (Fig 5A). As is in the case of the femoral side when using the inside-out technique, the tip of the clot pusher is inserted into the torn part of the meniscus (Fig. 5 B and C). The FC is pushed in immediately before tying the suture (Fig 5D). In both the all-inside and inside-out techniques, the placement of the suture is performed before FC delivery (Fig 6 A and B) while the tightening is performed after delivery (Fig 6 C and D).

Discussion

Meniscal tears are known to be difficult to heal because of their poor blood flow.[2] Keller et al.[5] provided a systematic review and reported healing rates of meniscal repairs between 60% and 80%, but these

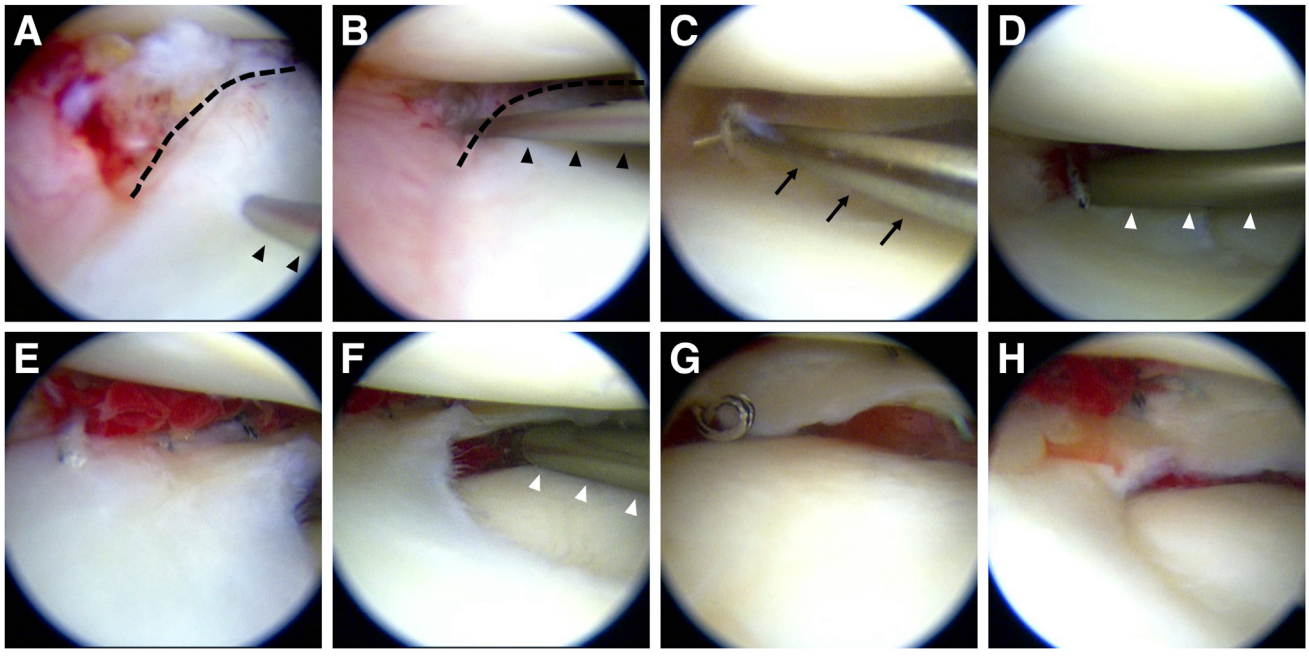

Fig 4. Meniscal repair using the inside-out technique. This is a case of a longitudinal tear on the middle part of lateral meniscus of the right knee. The arthroscopic view is from the anterolateral portal, and the arthroscopic probe is inserted through the anteromedial portal. (A) When using the inside-out method, prepare sutures on the femoral side of the tear first. The torn area is shown as the black dashed line. The inside-out needle (black arrowheads) is inserted to the torn meniscus. (B) Another side of the needle (black arrowheads) is inserted to the articular capsule side of the torn part. (C) The tension of the suture is loosened using an arthroscopic probe (black arrow) for easier delivery of the clot under the suture. (D) Deliver the clot with the clot pusher (white arrowheads) under the prepared suture. (E) Complete the suturing of the femoral side. (F) Suture the tibial side after completion of the femoral side. Place a clot on the tibial side first. White arrowheads show the clot pusher. (G) Suture the meniscus across the clot. (H) Completion of suturing after the repair.

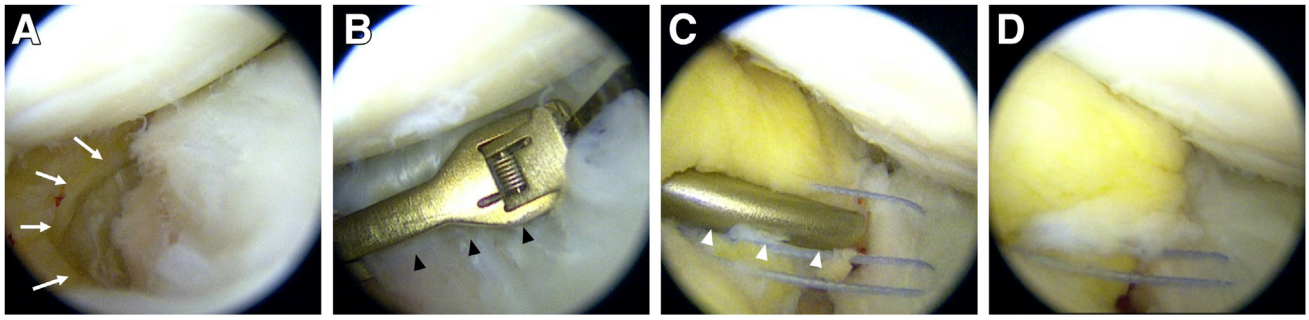

Fig 5. Meniscal repair using outside-in technique. This is a case of a longitudinal tear on the anterior part of lateral meniscus of the right knee. The arthroscopic view is from the anteromedial portal, and the devices are inserted through the lateral incision. (A) White arrows show the torn area. (B) The suture is prepared before the fibrin clot delivery using a meniscal Knee Scorpion (Arthrex, Naples, FL) suture passer (black arrowheads). (C) The fibrin clot is delivered using the clot pusher (white arrowheads). (D) Suture the meniscus across the clot.

repairs can also be fraught with relatively high rates of failure (up to 30%). To address the shortcomings of status quo treatment options for meniscal tears, biological augmentation techniques have been reported to improve treatment outcomes.[6] The FC technique was developed to supply the blood-derived material to the torn site to promote better healing.

The FC consists of platelet and fibrinogen containing various cytokines and chemotactic factors.[7] Growth factors for meniscal repair have been validated in vitro for cell migration and proliferation with matrix production. Specifically, fibroblastic growth factor-2 and connective tissue growth factor have demonstrated enhancement of meniscal repair in vivo in a rabbit model. The advantages of using FCs in a clinical setting is its simple operative procedure, long history of use, and large body of evidence that demonstrates its good healing capacity. Henning et al.[8] reported that the failure rate of meniscal repair was 41% in the group without FCs and 8% in the group with FCs. Thus, the FC technique is known as one of the established methods for augmentation of meniscus repair.

FCs have some challenging issues, especially in terms of their intraoperative handling and delivery. To obtain good healing with FCs, it is necessary to (1) place the clot in the proper position, (2) stabilize it firmly, and (3) place it uniformly in the tear site (especially in longitudinal and bucket-handle tears). However, during an arthroscopic procedure, the FCs often get caught in soft tissues or are washed away by irrigation and cannot be uniformly placed in the desired position. Rodriguez et al.[3] have reported a method of guidance using a shuttling suture with FCs. However, large FCs obstruct the arthroscopic view and hinder subsequent procedures, whereas small FCs are difficult to attach to the suture.

In our delivery system, we use a simple "clot pusher" device to deliver the FCs that can be used in conjunction with the standard procedure of meniscal repair (Table 1). The clot pusher consists of a metal pusher and an outer cylinder, and the pusher returns to its original position with a spring. The clot cut into 5- × 5-mm squares are used to fill the outer cylinder, which are then delivered to the desired area. The outer cylinder

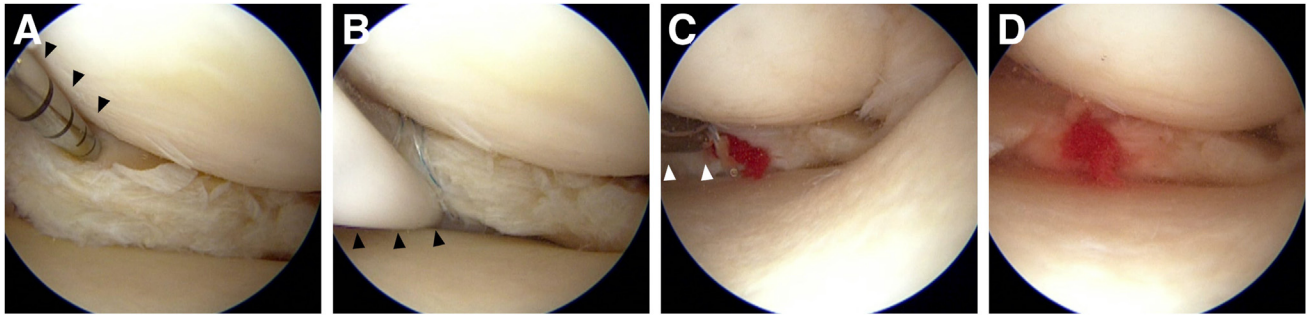

Fig 6. Meniscal repair using all-inside technique. This is a case of a horizontal tear on the posterior part of lateral meniscus of right knee. The arthroscopic view is from the anteromedial portal, and the devices are inserted through the anterolateral portal. In this case, we used a JuggerStitch Meniscal Repair Device (Zimmer Biomet, Warsaw, IN). (A) The device (black arrowhead) is inserted to the femoral side of the torn meniscus. (B) The device (black arrowhead) is inserted to the tibial side of the torn meniscus. The suture is prepared before the fibrin clot delivery. (C) The fibrin clot is delivered using the clot pusher (white arrowheads). (D) Suture the meniscus across the clot.

Table 1. Tips and Pearls

• The delivery device is made of metal and consists of a plunger and an outer cylinder.
• Cut the FC into a 5- × 5-mm size and pack in delivery device.
• The device is made of metal and is highly maneuverable, so you can place the tip where you want it.
• By pressing the pusher, the clot can be placed at the tip position.
• It is possible to reproduce a natural form of the meniscus by filling multiple small clots into the tear that has been sutured in advance.

FC, fibrin clot.

Table 2. The Advantages and Disadvantages of Our Method

Advantages
• The FC can be placed in the desired position.
• The FC will not disappear or disintegrate on the way to the desired position.
• Because many small clots can be filled, the meniscus can be restored to a more physiological shape.
• No unnecessary guide suture is interposed in the torn part of the meniscus.
Disadvantages
• A dedicated device is required.
• Surgery takes time when packing a large number of clots.

FC, fibrin clot.

acts as a protective barrier to prevent the FCs from being washed away by irrigation fluid or getting trapped by soft tissues, resulting in the reduction of clot delivery failure. Because a rigid device is used in this system, the FCs can be delivered with the same maneuverability as an arthroscopic probe and take full advantage of various portals. In addition, the size of clot could be smaller than the guide suture-based technique, enabling a large number of clots to be placed uniformly in a desired position at the tear site (Table 2). Depending on the morphologic and positional characteristics of the tear, the system can be adopted and combined with various suturing techniques, such as the inside-out, outside-in, or the all-inside technique.

The use of FCs for the repair of complex tears, irreparable meniscal defects, and chronic degenerative tears will likely be popularized in the future. Thus, our technique using a simple device to overcome the difficulties of the conventional technique and make it possible to deliver the FC to desired position with simple procedure. We believe this technique enables a more accurate delivery of FC and improves the outcome of meniscal repair.

Disclosures

All authors (K.Y., K.T., Y.M., D.K., H.S., H.H. and J.T.) declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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