

# Meniscal Repair Using Fibrin Clots Made From Bone Marrow Blood Wrapped in a Polyglycolic Acid Sheet



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**Abstract:** Meniscal repair is one of the most common procedures for meniscal tears; however, a previous systematic review showed meniscal repairs have a greater reoperation rate compared with partial meniscectomies. Therefore, an improvement of existing meniscal repair techniques is warranted. Clinical results of polyglycolic acid (PGA) sheets have been reported for rotator cuff repairs. In recent years, we have performed meniscal repairs using wrapped fibrin clots in PGA sheet. We considered the use of wrapped fibrin clots with a PGA sheet to treat meniscus tears. The purpose of this paper is to introduce a step-by-step guide to our new delivery technique using fibrin clots.

The meniscus serves an important role for shock absorption, load-bearing, load transmission, joint lubrication, and proprioception in the knee joint.<sup>1</sup> Meniscal tears are common injuries and are associated with the onset of early osteoarthritis.<sup>2</sup> Thus, it is important to preserve the meniscus to prevent osteoarthritis. Meniscus repair procedures are currently the most popular treatment option for meniscus tears to preserve meniscal function.<sup>2</sup> However, meniscus blood supply is limited only in the peripheral 10% to 25% of the tissue where load stress is applied.<sup>1</sup> The damaged meniscus in the avascular area is difficult to heal. A previous systematic review showed that failure rate of 17% to 33% after meniscus repairs and repair success rates were worse for adolescents with complex tear patterns compared with simple tear patterns.<sup>3</sup> Therefore, we believe that improvements in existing meniscal repair procedures are warranted.

Fibrin clots have been reported and used in meniscal treatment to improve healing. Fibrin clots are composed of fibrin and platelets. Arnoczky and Warren<sup>4</sup> showed that fibrin clots helped the histologic healing of menisci. Fibrin clots can serve as a scaffold to stimulate the reparative process in meniscus repair. A previous clinical study has shown promising results with high rates of meniscal healing after repair with fibrin clots.<sup>5</sup> However, the outcomes of meniscal repair with fibrin clots are worse than expected, and some technical problems remain to be solved. For example, fibrin clots could be caught on the portal and dissolved during delivery to the damage area. Moreover, the clot could be difficult to form into a suitable shape for grafting. We believe that these problems must be addressed to improve postoperative clinical outcomes.

We currently perform meniscal suture repairs with fibrin clots wrapped in a polyglycolic acid (PGA) sheet (NEOVEIL; Gunze Medical Japan Ltd., Kyoto, Japan). PGA is a soft, thin, flexible, and absorbable semi-crystalline liner polyester and one of the most commonly used artificial biomaterials. We hypothesized that the use of wrapped fibrin clots in PGA sheets would improve the performance of the delivery system. The purpose of this paper is to describe a step-by-step guide to our new delivery technique of fibrin clots.

## Surgical Technique (With Video Illustration)

### Indication

The indication for using wrapped fibrin clots in PGA sheets is the same as that of a normal meniscal suture with fibrin clot. We use the material in various types of

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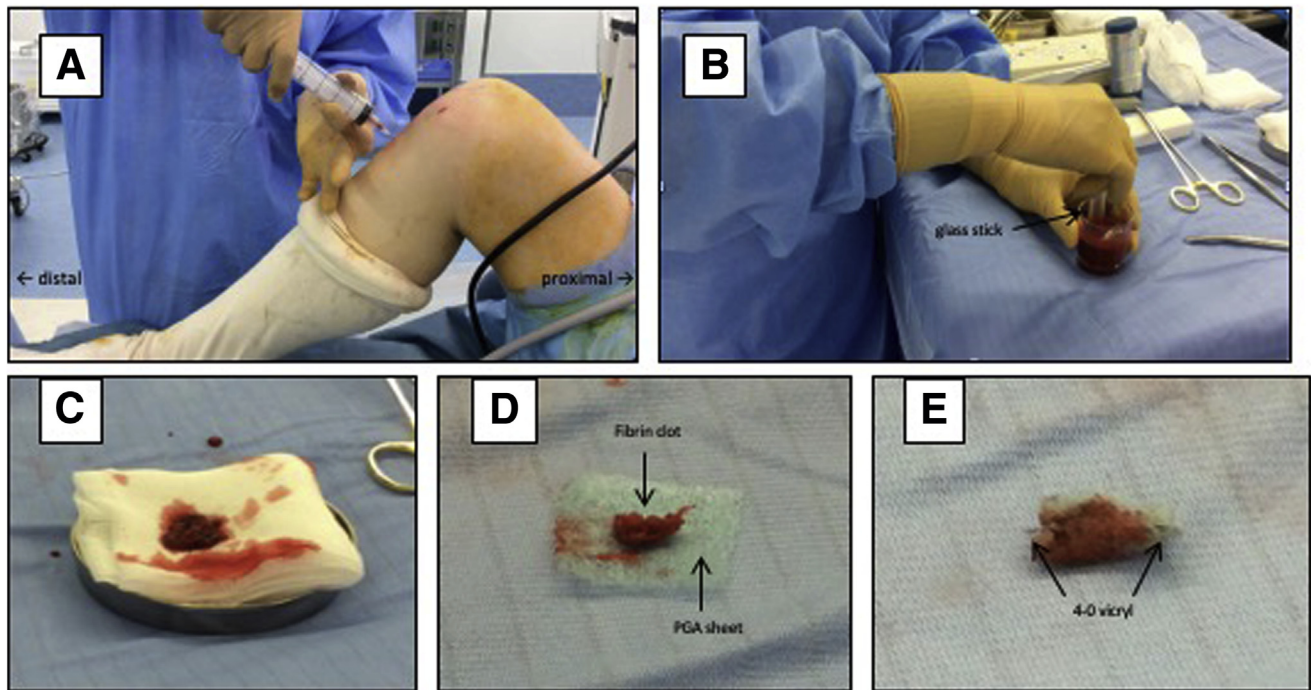
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**Fig 1.** Collection and preparation of the fibrin clot. The following steps are performed to prepare fibrin clots. (A) After constructing a hole with a 1.5-mm Kirschner wire, approximately 20 mL of bone marrow blood is drawn via the same hole using a 20-mL syringe with 18-G needle. (B) The blood is stirred for approximately 5 minutes using a glass stick to induce clot formation around the glass stick. (C) The fibrin clot is squeezed with a gauze, and the rest of bone marrow blood is removed for concentration. (D) The fibrin clot is shaped and wrapped into a polyglycolic acid sheet of approximately 3 cm<sup>2</sup> in size. (E) The fibrin clot is sutured with 4-0 VICRYL.

meniscal tears, especially for degenerative tears and/or avascular regions.

### Arthroscopic Examination and Treatment by Meniscal Suture

The patient is placed in the supine position with the knee in 90° flexion on the operating table. The patient undergoes general or lumbar anesthesia. A tourniquet is wrapped on the proximal thigh of the operative side that is inflated in case of severe intraoperative bleeding.

Standard medial and lateral infrapatellar portals are made for arthroscopic examination and treatment of the meniscus. To treat the medial meniscus, the knee is flexed approximately 30°, and valgus stress is applied. For the lateral meniscus, the knee is positioned as shown in figure-of-4, and varus stress is applied.

Meniscal suture repair is our preferred method of repair. After routine arthroscopy, meniscal repair procedures are performed. In general, the all-inside technique is indicated for injury of the posterior and/or middle segment, inside-out technique for the middle and/or posterior segment, and outside-in technique for the anterior segment. In cases that are difficult to achieve

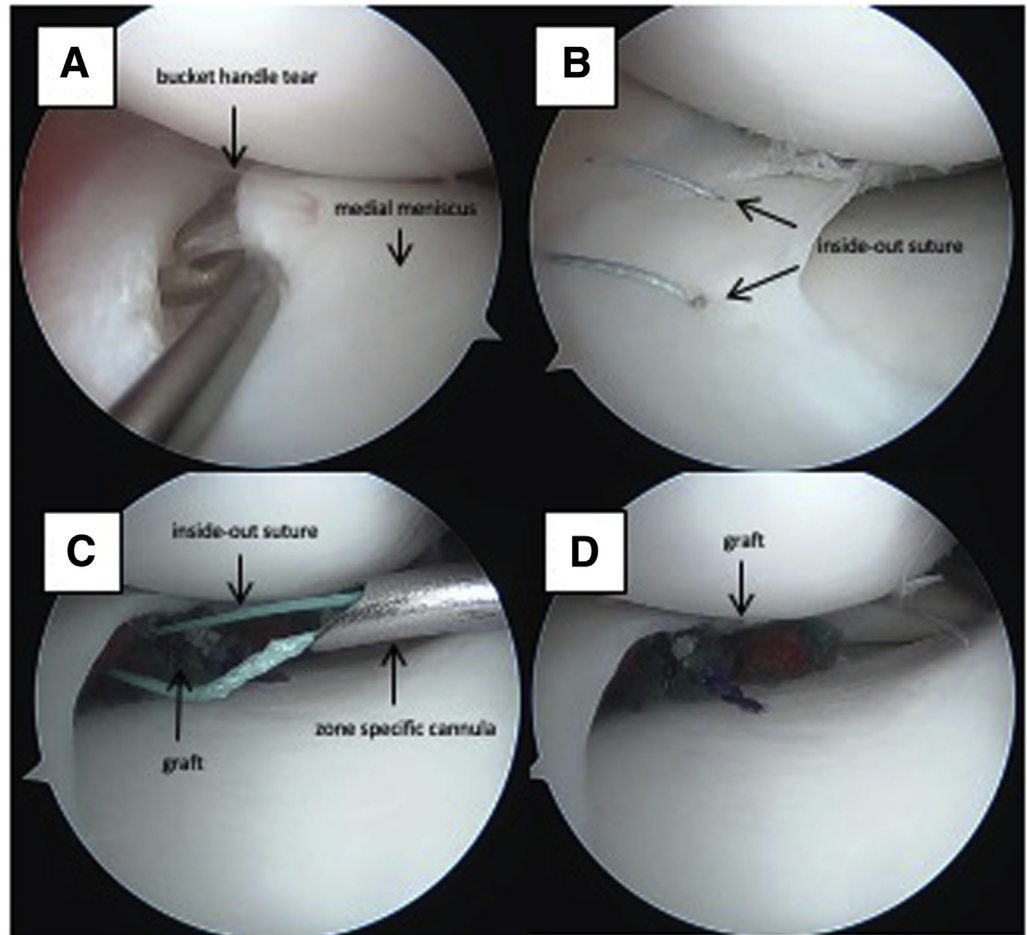
healing such as flap tears or severe degenerative tears, partial meniscectomy is performed.

### Preparation of Fibrin Clots

We use bone marrow blood to make fibrin clots. First, a surgeon drills the proximal tibia with a 1.5-mm Kirschner wire and draws approximately 20 mL of bone marrow blood via the same hole using a 20-mL syringe with an 18-G needle. Next, the blood is stirred using a glass stick for approximately 5 minutes to induce clot formation around the glass stick. The clot formation is removed from the glass syringe and placed on a gauze. Fibrin clots are squeezed with the gauze, and the rest of bone marrow blood is removed for concentration. Fibrin clots are molded into a suitable shape using a blade. Finally, the fibrin clots are wrapped in a PGA sheet approximately 3 cm<sup>2</sup> in size and sutured around the fibrin clots with 4-0 VICRYL (Ethicon Inc, Somerville, NJ) (Fig 1). Before implantation of the graft, we prepare 2 or 3 pieces of fibrin clots.

### Implantation of the Fibrin Clot

A surgeon performs meniscal suture repairs with an appropriate technique, and sutures are tightened by a



**Fig 2.** Representative case of a bucket-handle tear. For bucket-handle tears, the fibrin clot is placed between the damaged areas. (A) Arthroscopic view from the lateral portal. Bucket handle tear of the medial meniscus in the right knee. (B) Suture the meniscus with the inside-out technique using 2-0 FiberWire. (C) Pass the needle through the fibrin clot and joint capsule. (D) Image of completed meniscal suture with graft.

2-0 FiberWire or FiberTape (Arthrex Inc, Naples, FL). A surgeon subsequently inserts fibrin clots in the knee via the medial or lateral portal using forceps. The fibrin clots are implanted inside or between the damaged areas of the meniscus. For maintaining the grafts in position, we hook the fibrin clots with FiberWire/Tape or pass a needle through the fibrin clots and joint capsule. Finally, after implanting the fibrin clot, a surgeon presses down on the fibrin clot using the hook probe or forceps and ties the FiberWire/Tape. In cases of vertical or radial tears, we place the fibrin clot between the damaged areas (Figs 2 and 3). In cases of horizontal tears, we insert the fibrin clot into the damaged area (Fig 4). Finally, the surgeon checks to keep the wrapped fibrin clots at the sutured lesions. Table 1 and Video 1 provide a step-by-step summary of our procedure.

### Postoperative Rehabilitation

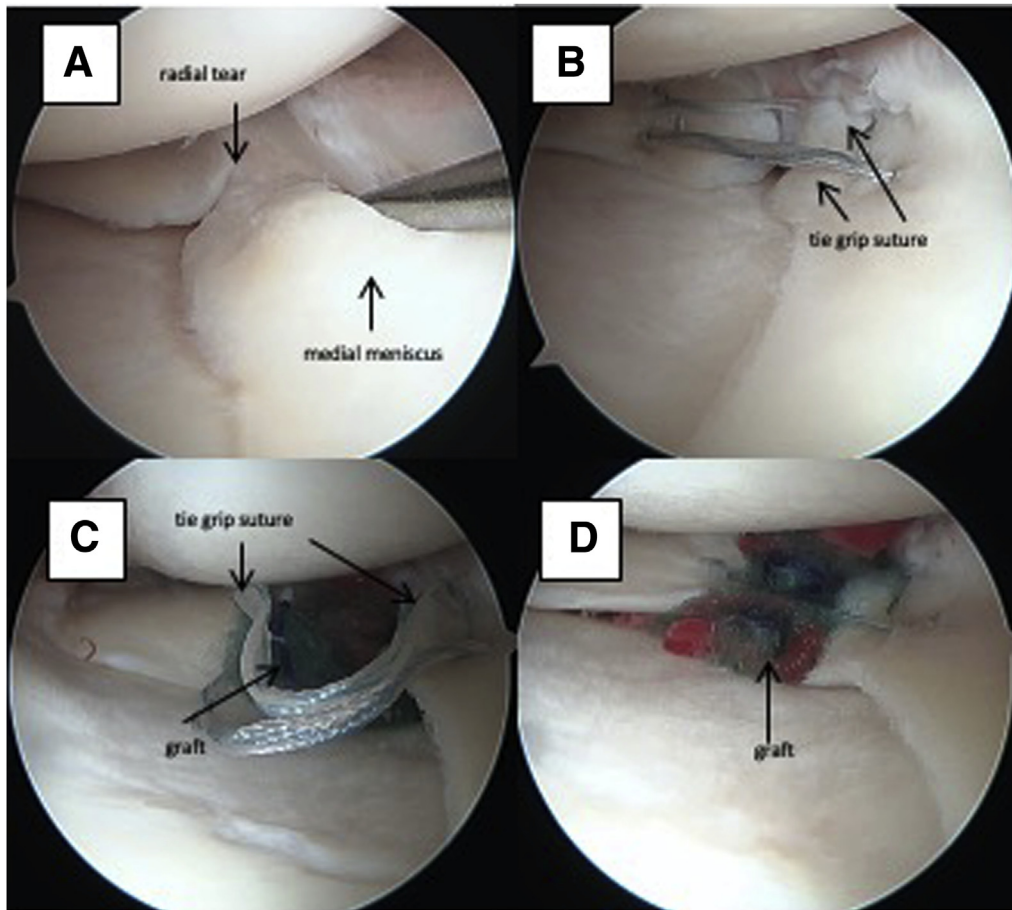
Patients are immobilized in a knee brace for 2 weeks postoperatively. In addition, patients begin rehabilitation

without use of the knee joint at this time. Partial weight-bearing and range of motion exercise are allowed at 2 weeks after operation. Full weight-bearing is allowed 6 weeks after operation. Physical activities of moderate intensity such as running are allowed at 3 months after surgery. At 6 months postoperatively, patients achieve full range of motion, muscle strength, and normal function to allow their return to sports.

### Discussion

We believe that our technique has several advantages and may lead to the improvement of clinical outcomes. First, we confirmed that the wrapped fibrin clots graft could be easily delivered to the damaged lesion. The surgeon can be less burdened to check the area of implantation due to the slower to disintegration and dissolution. Moreover, we can clearly find the clots after implantation without obfuscation. Second, the PGA sheet might delay the rate at which the fibrin clot





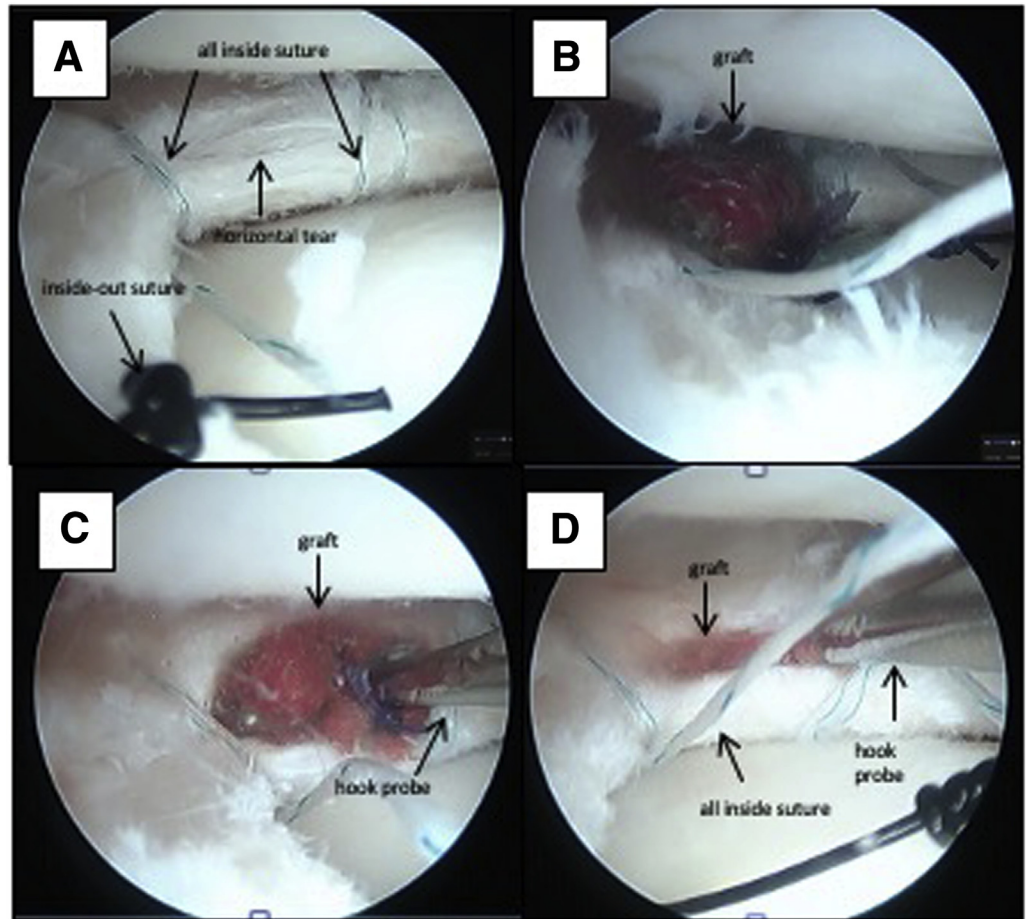
**Fig 3.** Representative case of a radial tear. For radial tears, the fibrin clot is placed between the damaged areas. (A) Arthroscopic view from the lateral portal. Radial tear of the medial meniscus is shown in the right knee. (B) Suture the meniscus with tie grip suture and FiberTape. (C) Hook the fibrin clot with the suture. (D) Image of completed meniscal suture with graft.

dissolves and increase its coagulation time at the damaged area. The PGA sheet has been used in various surgical applications as a scaffold. In tissue-engineering techniques, scaffolds have an important role in the healing process. In orthopaedic surgery, a previous study has described rotator cuff repairs using the PGA sheet with good clinical results.<sup>6</sup> The simultaneous use of fibrin clots and PGA sheets has advantages in meniscal repair, as the PGA enhances cell–cell interaction at high cell densities and stimulates extracellular matrix production.<sup>7</sup> Third, the use of PGA sheets can be handled safely and easily. With the use of PGA sheets to make grafts, we can make a lump of the same shape and adjust the graft size to fit the damaged area. Furthermore, fibrin clots do not easily disintegrate and dissolve during delivery when wrapped in PGA sheets; therefore, implantation of the fibrin clot at the targeted area is an uncomplicated procedure.

We used bone marrow blood to make fibrin clots. A previous experiment showed the amount of cytokines (vascular endothelial growth factor, insulin-like growth

factor-1, fibroblast growth factor basic, hepatocyte growth factor, and stromal cell-derived factor-1) of fibrin clots is greater than that in peripheral blood.<sup>8</sup> Therefore, we considered the use of bone marrow blood to have a high potential for meniscal treatment.

There are some disadvantages in our technique. First, additional assistance and/or time may be required during surgery for preparing the graft. Second, there are additional costs involved in the use of the PGA sheet. Third, previous studies have reported mild inflammation with the use of PGA; however, this reaction is rare. In our case series, we did not observe any side effects such as inflammation and infection. The PGA sheet is hydrolyzed in the body for approximately 15 weeks postoperatively. Therefore, the PGA sheet does not remain in the knee and does not cause catching and locking. [Table 2](#) summarizes the advantages and disadvantages of our surgical technique. In conclusion, there are some advantages in the use of wrapped fibrin clot in PGA sheet for meniscal repair.



**Fig 4.** Representative case of a horizontal tear. For horizontal tears, the fibrin clot is inserted into the damaged area. (A) Arthroscopic view from the lateral portal. Suture the meniscus using the all-inside and outside-in technique and tighten the suture. (B) Place the graft around the damaged area. (C) Insert the graft using a hook probe. (D) Press down on the graft using the hook probe and tie the suture.

**Table 1.** Step-by-step Guide for the Procedure

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Collection and preparation of the fibrin clot
Draw approximately 20 mL of bone marrow blood.
Stir the blood using a glass stick for approximately 5 minutes to induce clot formation.
Squeeze the fibrin clot using a blade.
Wrap the fibrin clots in an approximately 3-cm <sup>2</sup> PGA sheet and suture with 4-0 VICRYL.
Implantation of the fibrin clot
Apply the meniscal suture using an appropriate technique and tighten the wire.
Implant inside or between the damaged meniscal area.
Hook the fibrin clot with the wire or pass the needle through the fibrin clot.
Press down on the fibrin clot using the hook probe or forceps and tie the suture.

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PGA, polyglycolic acid.

**Table 2.** Advantages and Disadvantages

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Advantages
Surgeons can verify the implantation of the graft after suturing
Less burden on surgeon to check implantation
PGA sheet may delay the dissolving of fibrin clot
PGA sheet may increase the coagulation time of fibrin clot
Few complications to the patient's body
Disadvantages
Need for assistance and/or time to make grafts
Additional costs

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PGA, polyglycolic acid.

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