Technical Note

Fibrin Clot Augmented Repair of Longitudinal Tear of Medial Meniscus

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Abstract: Repair of meniscus injuries always posed a significant problem, especially in relatively avascular zones. Several methods to augment the repair were devised, but only a few had convincing results. Fibrin clot augmentation is one of the augmentation procedures that shows good promise in this premise. The major hurdle to it is difficulty in delivering into the meniscus tear under constant irrigation during arthroscopic procedures. This article presents a simple and unique way to prepare and transfer a fibrin clot into a meniscal tear in a step-by-step manner.

The menisci are 2 semilunar fibrocartilaginous structures in the knee that play a pivotal role in stress distribution, force transmission, shock absorption, provision of joint stability, lubrication, and proprioception.[1] The vascularization of the menisci is achieved by a network of arborizing blood vessels in the perimeniscal capsule and synovium.[2] These vessels send out radial branches into the meniscal tissue. Based on this blood supply, the outer zone of the meniscus is well vascularized, with a good healing response to injuries.[3,4] This highly vascular outer third of the meniscus is called the red-red zone, and the other less vascular zones are called red-white and white-white zones. These 2 zones, especially the white-white zone, have a scanty blood supply and a poor healing response.[1-3,5,6]

Meniscal resection, even partial, abnormally increases the joint contact pressures affecting the shock absorption and joint stability.[7] It has been demonstrated that resection of 15% to 30% of meniscus can increase the joint pressures by 350%, which may lead to cartilage damage and early osteoarthritis.[8] Successful surgical restoration of a meniscal tear has always been a challenge. In recent times, several procedures have been developed to augment the meniscal repair and enhance the healing, such as abrasion therapy (rasping of the meniscocapsular junction and trephination),[2,9,10] platelet-rich plasma,[11] and cell therapy.[12] Most of these augmentation procedures were demonstrated in animal models with minimal evidence in human beings also; fibrin clot is the only procedure with good success rate, with the only drawback being difficulty of the procedure.[13] First described by Arnoczky et al.,[2] fibrin clot has been considered as a potential method to augment meniscal repair in avascular zones of meniscus.[14,15]

Because arthroscopic meniscal repair is done under continuous irrigation with normal saline solution, it is often very difficult to deliver the fibrin clot in to the meniscal tear and hold it in place. This article describes a method to prepare, deliver, and contain a fibrin clot in a meniscal repair.

Surgical Technique

Indications

Acute and chronic meniscus tears of traumatic or degenerative origin can be considered for our technique. Longitudinal, horizontal, or radial tears involving the relatively avascular white-white zone can benefit from this procedure. Late stages of osteoarthritis and significant malalignment are contraindications for this procedure. Although delayed meniscus repair is not a

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contraindication and most of the patients presenting with chronic meniscal injury present with early stages of osteoarthritis, some of these are relative indications. However, meniscus defects involving the root area, total and subtotal meniscus defects cannot be repaired with this procedure.[14] Before surgery, thorough clinical examination and investigation including magnetic resonance imaging (Fig 1) helps in planning the procedure.

Preoperative Preparation

Apart from the regular arthroscopic meniscus repair instrumentation, additional instrumentation required to prepare and deliver the fibrin clot are mentioned in Table 1. Because the preparation of the fibrin clot should be done simultaneously with the repair, an additional assistant would be helpful to conserve time.

Patient Positioning

The patient is draped and painted in the supine position. A tourniquet is optional. However, when we don't use a tourniquet, it gives us an opportunity to inspect the meniscus tear and viability of the tissue before and after rasping. Side support should be placed in an optimal position to exert valgus stress to open up the medial joint space. Alternatively, the index leg can be hanged over the end of the table using a leg holder depending on surgeon preference. At our center, knee arthroscopy is done with the patient in the supine position with lateral side support. Although a tourniquet is applied, it is inflated in only a few cases with bleeding tendencies.

Diagnostic Arthroscopy

Initial diagnostic arthroscopy is performed using standard anterolateral and anteromedial arthroscopy portals. In the described case (Video 1), a longitudinal tear in the posterior horn of the medial meniscus in the red-white zone is found. To improvise visualization and aid in further instrumentation, medial collateral ligament pie-crusting is done using a spinal needle. The superficial medial collateral ligament is marked before surgery, and the direction of the spinal needle during pie-crusting should point toward the posterior cruciate ligament. Once the morphology of the tear is clear, the decision to use a fibrin clot to augment the tear is made. Meniscal tear edges are freshened using an arthroscopic rasp. It is imperative that the entire lateral meniscus should be visualized to rule out any associated tears in the lateral meniscus. The cruciate tears, if any, should be assessed and dealt with accordingly.

Fibrin Clot Preparation

As soon as the decision to use a fibrin clot as an augment to the meniscal repair is made, 50 mL of peripheral venous blood is drawn from patient's forearm and is collected into a glass beaker (Video 1). Using a 4 mm sintered glass rod, stirring should be started immediately in small concentric circles avoiding contact with the edges of the beaker (Fig 2). In normal circumstances, around 8 to 10 minutes would be needed to form a fibrin clot. The formed fibrin clot is slowly transferred on to a wet gauze to be soaked with normal saline solution to promote clot formation, then transferred onto a dry gauze, and kept covered (Fig 3). Once the consistency of the clot is firm, adequate size of the clot is cut using a scalpel or Metzenbaum scissors. The consistency of the wall of the fibrin clot determines its fragility. If the wall is too thin, then the clot will be too fragile to hold sutures.

Once a decent-sized firm clot is isolated, both the ends of clot are tied by taking bites into the clot using 2-0 Vicryl sutures. This gives a spindle-shaped construct with sutures on both ends (Fig 3).

Implantation of Fibrin Clot Into the Meniscus Defect

After freshening the edges of the meniscus tear, posteromedial compartment of the knee is visualized and inspected for associated ramp lesions. A spinal needle is inserted into the posteromedial compartment, and a 2-0 PDS guide suture is passed through it (Fig 4A). Once sufficient length of suture is passed, a 45° up slingshot (Stryker, Sunnyvale, CA) is passed through the tear into the posteromedial compartment under direct vision, and the guide suture (2-0 PDS) is retrieved (Fig 4B). Now the guide suture is retrieved from the posteromedial compartment through the meniscal tear and exits through the anteromedial portal of the knee anteriorly.

For medial tears, Fastfix 360 (Smith & Nephew, Andover, MA) all-inside meniscal repair sutures are deployed in a vertical configuration across the tear (Fig 5). The tails of the sutures are secured but not tightened because it will not compromise the visualization of the tear and gives room to place the fibrin clot. A 5 mm × 75 mm threaded DRI-LOK cannula (Stryker, Greenwood, CO) is inserted through the anteromedial portal, and a guide suture is retrieved through it. The suture tails (2-0 Vicryl) of the fibrin clot are tied to the guide suture (2-0 PDS), and the clot is shuttled through the cannula and into the meniscal defect, and the tail sutures (2-0 Vicryl) are retrieved through the posteromedial aspect of the knee. By maintaining continuous pull on the tails of the sutures, a switching stick is used to assist the clot into the meniscal defect (Fig 6).

Once the clot is secured in the defect, the all-inside sutures are simultaneously tightened to close the meniscal tear on to the clot (Video 1). An additional all-inside meniscal suture maybe applied, vertically spanning over the clot for additional stability.

Postoperative Rehabilitation

A locking knee brace is applied, and the flexion of the knee is limited to 60° for the first 6 weeks. The patient is allowed nonweightbearing walking for the first

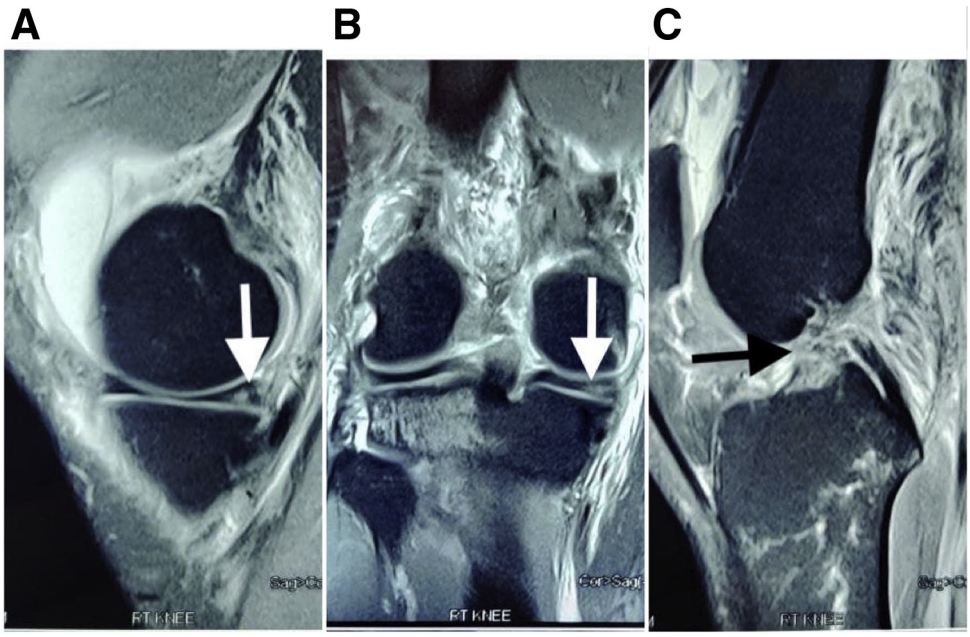

Fig 1. Proton density fat suppression magnetic resonance images of the patient showing (A) sagittal section showing longitudinal tear in posterior horn of medial meniscus (white arrow), (B) coronal section showing longitudinal tear in the posterior horn of medial meniscus (white arrow) and partial tear of the medial collateral ligament (red asterisk), and (C) sagittal section showing associated anterior cruciate ligament tear (black arrow).

3 weeks. From 3 to 6 weeks, partial weightbearing with support is allowed. From 6 to 12 weeks, full weightbearing and walking with the brace is allowed. Moderate physical activity like jogging is permitted at 4 months after surgery. Return to sport and full squatting are permitted at 6 to 9 months after

Table 1. Pearls and Prerequisites

Pearls
Create the anteromedial portal and ensure that the spinal needle can reach the meniscus tear and parallel to the tibial articular margin. This will facilitate the instrumentation and further procedure.
The decision to use fibrin clot augmentation in the meniscus repair should be made early because the process of preparation takes around 20 to 30 minutes to complete.
Harvesting and preparation of the clot should begin concomitantly with the meniscus repair.
During the meniscus repair, all-inside sutures should be placed across the meniscus tear but not tightened before the insertion of the fibrin clot because:
It reduces the space for clot placement.
Early tightening also reduces access to visualize the meniscus tear.
Use of a sintered glass rod and saline washing of the fibrin clot hastens the process of clot formation.
Use a 5 mm DRI-LOK cannula (Stryker, Greenwood, CO) in the anteromedial portal to shuttle the clot to avoid soft tissue bridges and the entanglement of the clot in fat pad.
Retrieve the 2-0 PDS suture from the posteromedial compartment into the meniscus tear and through the antero-medial portal, a minimal impact instrument like the Slingshot (Stryker, Sunnyvale, CA) should be used.
After the insertion of the clot into the desired location of the tear, the in-situ all-inside Fast Fix 360 (Smith & Nephew, Andover, MA) sutures should be tightened simultaneously to avoid extrusion of the clot.
A stabilizing suture spanning over the fibrin clot can be deployed to add further stability to the repair construct and meniscus
Prerequisites
For the preparation of the fibrin clot, the following instruments are necessary:
Glass beaker of sufficient volume
4-mm Sintered glass rod
2-0 Vicryl suture for suturing and creating an appropriately shaped clot
For the described delivery system, apart from regular knee arthroscopic instruments, the following instruments are required:
Spinal needle/Tuohy epidural needle
2-0 PDS suture for suture shuttling
Slingshot (Stryker, Sunnyvale, CA) for suture retrieval
5 mm × 75 mm threaded DRI-LOK cannula (Stryker, Greenwood, CO)
Fastfix 360 all-inside meniscus suture (Smith & Nephew, Andover, MA)/inside-out meniscus repair sutures
The technique described for meniscus repair is All-Inside meniscus repair system, Fast-Fix 360 (Smith & Nephew).
Alternatively, inside-out meniscal sutures can also be used depending on the zone of meniscus tear.

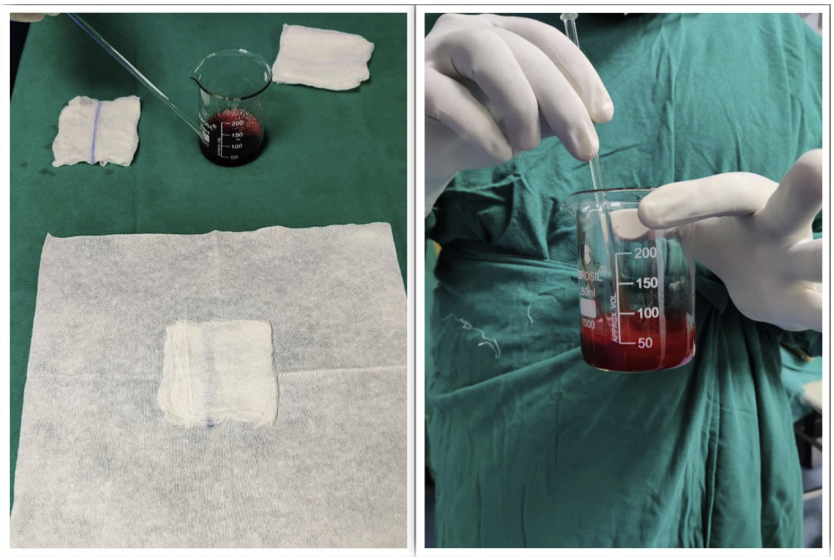

Fig 2. The collected blood in the beaker and preparation of the fibrin clot using a sintered glass rod.

supervised physiotherapist evaluation. If there are any associated injuries viz cruciate ligament injuries, cartilage injuries, the physiotherapy protocol should be modified accordingly.

Discussion

The quintessential point of this Technical Note is that, it demonstrates an easier way of delivering the fibrin clot into the meniscus defect under direct vision when continuous irrigation is there using minimal instrumentation. This method is especially useful in complex meniscus tears or radial tears, where the containment of the fibrin clot is a challenge.

Meniscus tears in the poorly vascularized zones poses a substantial problem to repair because of its poor healing response. For this reason, in many cases partial meniscectomy is reluctantly performed to alleviate the symptoms caused by the meniscus tear. However, it has been proved that even partial meniscectomy would alter the joint forces and may contribute to cartilage damage, which eventually may lead to degenerative osteoarthrosis.

The recent trend of "joint-preserving surgery" has encouraged surgeons to devise innovative treatment protocols to restore the integrity of an injured meniscus, as well as the joint per se. Fibrin clot augmentation of

Fig 3. The drying and suturing of the fibrin clot to appropriate shape with 2-0 Vicryl.

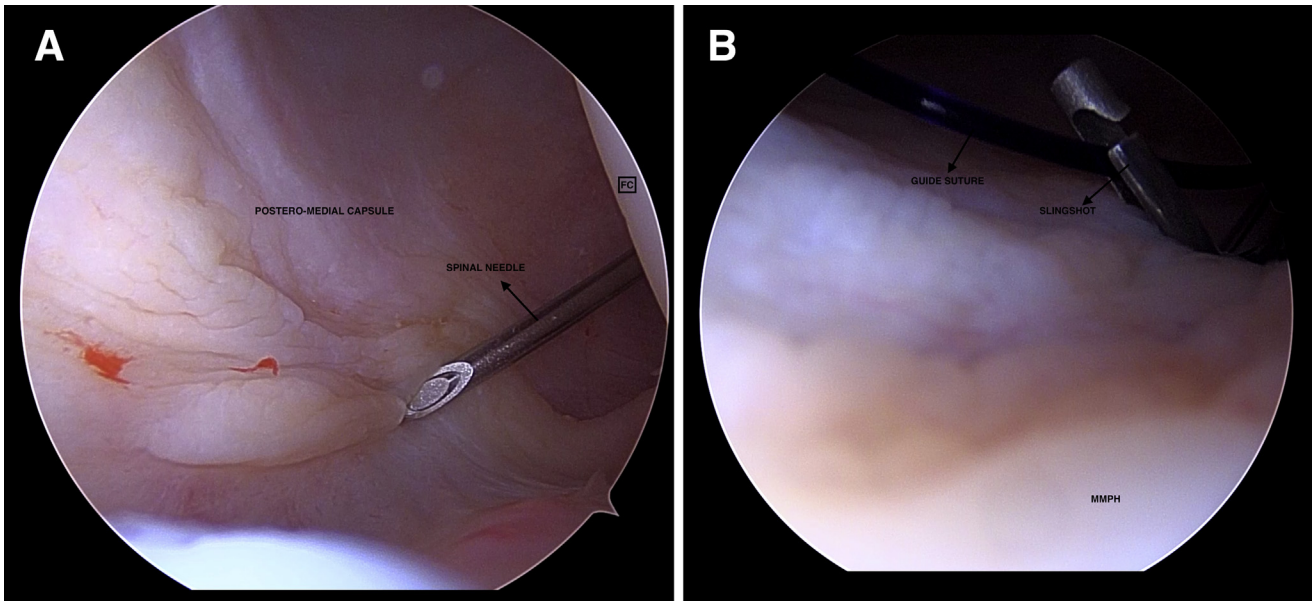

Fig 4. (A) Arthroscopic image of the right knee in mid flexion with valgus stress, viewing from the standard anterolateral portal, visualizing the posteromedial compartment via the Gillquist maneuver, showing the spinal needle. (FC, femoral condyle). (B) Arthroscopic image of the right knee in mid flexion with valgus stress, viewing from standard anterolateral portal, visualizing the posteromedial compartment showing retrieval of guide suture (2-0 PDS) with the help of a champion slingshot (Stryker, Sunnyvale, CA). (MMPH, medial meniscus posterior horn).

the meniscus repair is one such procedure. Although described in 1983 by Arnoczky et al.,[2] it has gained popularity in the past decade because of its additional property of acting as a scaffold on which the mesenchymal stem cells latch on to, apart from being a source of platelet-derived growth factors, which brings about chemotactic and mitogenic response enabling the healing response in the torn meniscus.

The advantage of our technique is the simplicity of the procedure. The instrumentation is simple, and the whole process is done under controlled vision. The fibrin clot inserted into the torn meniscus defect ensures an early healing response. It fills the meniscus defect and maintains the continuity between the torn edges, ensuring the regeneration. The pearls and prerequisites and advantages and limitations of the procedure are enumerated in Tables 1 and 2. The steps of the procedure are listed in Table 3.

Although further studies are required to establish the validity of the described procedure, the authors firmly

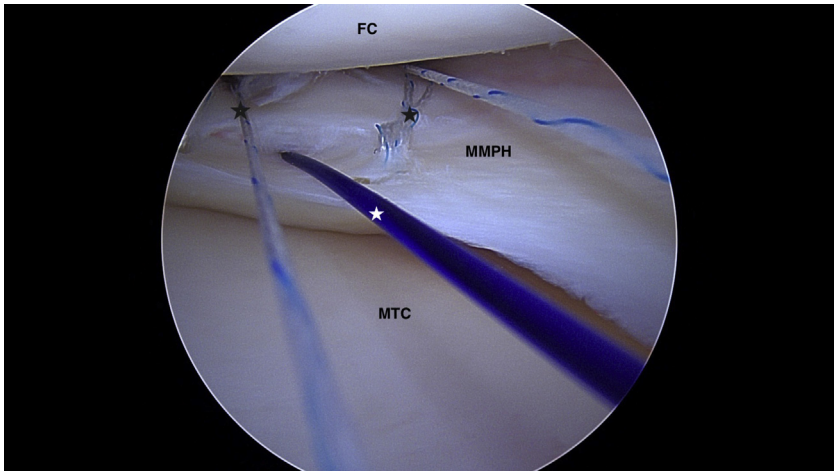

Fig 5. Arthroscopic image of the right knee in flexion, viewing from the standard anterolateral portal, showing the retrieved guide wire (2-0 PDS) (white asterisk) through the tear of medial meniscus and into the anteromedial portal. Note the location of all-inside meniscal sutures (black asterisk). (FC, femoral condyle; MMPH, medial meniscus posterior horn; MTC, medial tibial condyle.)

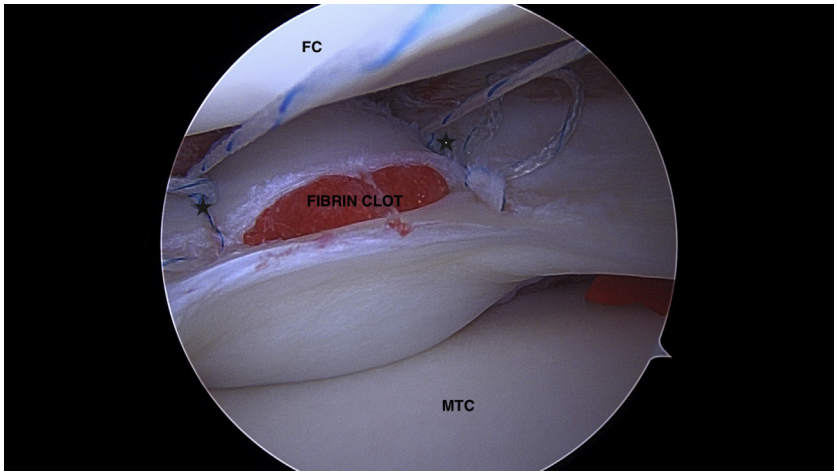

Fig 6. Arthroscopic image of right knee in flexion, viewing from standard anterolateral portal, showing the fibrin clot being secured into the medial meniscal defect. (FC, femoral condyle; black asterisk, all-inside meniscal suture; MTC, medial tibial condyle.)

Table 2. Advantages and Limitations of the Procedure

Advantages/Benefits
Fibrin clot acts like a scaffold on which mesenchymal stem cells can imbibe and differentiate into native meniscal tissue.
Growth factors derived from the fibrin clot are chemotactic and mitogenic.
The process of fibrin clot preparation is autogenous and cheap. No harvesting of additional tissue is necessary.
The instruments required for preparation and implantation of the fibrin clot are simple and readily available in most operating rooms.
The dimensions of the clot can be easily tailored to the meniscus defect.
The placement and retrieval of the clot is done under controlled vision.
Limitations
Excessive debridement of the meniscus tissue cannot be done as it makes the clot containment difficult.
This technique cannot be used for meniscus root tears.
Common complications of arthroscopic meniscus repair should be considered like deep vein thrombosis, infection, knee stiffness after immobilization.

Table 3. Step-by-step Description of the Procedure

1. Patient is draped and painted in supine position on a standard arthroscopy table.
2. Diagnostic arthroscopy is performed to determine the tear configuration and location. Decision regarding use of fibrin clot augmentation should be done at this step.
3. In case of medial meniscus posterior horn tear (case described in the article), medial collateral ligament pie-crusting should be done to have better visualization of the posterior horn of medial meniscus.
4. Simultaneously harvest 40-50 mL of autologous peripheral venous blood and fibrin clot is prepared as follows.
   - Continuous stirring of the blood in circular fashion using a sintered glass rod for 10 minutes.
   - Collecting the clot onto a wet gauze and wash it with normal saline and allow the clot to settle.
   - Once the clot is firm, Cut the clot to desired size, and both ends are sutured with a 2-0 Vicryl suture to form a desired shaped clot.
5. Viewing through the Gillquist portal a spinal needle through posteromedial aspect of the knee, a 2-0 PDS suture of adequate length should be inserted through it.
6. Inspect the posteromedial compartment to identify any RAMP lesions of the meniscus.
7. A 45° champion, slingshot (Stryker, Sunnyvale, CA) should be used to retrieve the PDS through the meniscus tear.
8. All-inside sutures Fastfix 360 (Smith & Nephew, Andover, MA) should be placed with adequate spacing but should not be tightened before the insertion of the clot.
9. The clot is retrieved through the cannula with the help of shuttling suture (2-0 Vicryl).
10. By maintain a continuous pull on the suture tails (2-0 Vicryl), a Wissinger rod can be used to assist the placement of the clot into the meniscus tear.
11. Simultaneous tightening of all-inside meniscus sutures is done to secure the fibrin clot.
12. An additional meniscus suture may be used to stabilize the fibrin clot and the meniscus tear.
13. Portals are closed and dressed and a hinged lock knee brace is applied to the index limb.

believe that using a fibrin clot in the meniscus repair can be done relatively more easily and accurately. The scope of using fibrin clots could serve as an option to manage complex and degenerative meniscus defects in the relatively avascular zones.

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