



Arthroscopic Meniscal Repair With Second-Generation Platelet-Rich Fibrin Clot Augmentation

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Abstract: Meniscal tears are among the most common injuries in the knee, and partial as well as total meniscectomy has been advocated as the treatment for meniscal injury. Over the years, the role of the meniscus as a shock absorber, load transmitter, and secondary anterior stabilizer, along with its proprioceptive and lubrication role, has been well established, and meniscal repair is recommended, especially in younger individuals. Factors such as tear location, pattern, chronicity, size, and extent; repair technique; and patient age and habits can influence meniscal repair, and to enhance meniscal healing, a variety of augmentation techniques have been introduced. These include needling, trephination, synovial abrasion, and the use of adjuvants such as platelet-rich plasma, platelet clots, fibrin clots, bone marrow clots, and stem cells. A second-generation platelet derivative called “platelet-rich fibrin” (PRF) has predictable platelet, growth factor, and cell mediator concentrations without using any anticoagulants. We describe a reproducible and simple way to harvest PRF and create and use a PRF clot, along with detailed instructions on how to integrate the clot with a meniscal repair arthroscopically.

Meniscal tears are among the most common injuries in the knee, which are distributed in a bimodal fashion between the younger active population and the elderly population.^{1,2} Historically, menisci were considered vestigial remnants, and partial as well as total meniscectomy was advocated as the treatment for meniscal injury.³⁻⁵ Over the years, the role of the meniscus as a shock absorber, load transmitter, and secondary anterior stabilizer, along with its proprioceptive and lubrication role, has been well established.⁶⁻⁸ Various studies also proved the onset of early degenerative changes after meniscectomy. Given this scientific evidence, meniscal repair is recommended, especially in younger individuals.⁹⁻¹¹

The success or failure of meniscal repair is highly influenced by factors such as tear location, pattern, chronicity, size, and extent; repair technique; and patient age and habits.^{12,13} A recent meta-analysis by Xu and Zhao¹⁴ concluded that better long-term outcomes are obtained after meniscal repair than after meniscectomy, but the reoperation rate is on the higher side. Recently, to enhance meniscal healing, a variety of augmentation techniques have been introduced. These include needling, trephination, synovial abrasion, and the use of adjuvants such as platelet-rich plasma (PRP), platelet clots, fibrin clots, bone marrow clots, and stem cells.¹⁵⁻¹⁷ Of these, fibrin clots have gained interest because of the low cost, minimal invasiveness, and ease of preparation, but the concentration of biological components in a fibrin clot has not been properly documented in the literature.

Recently, a second-generation platelet derivative called “platelet-rich fibrin” (PRF) was developed by Choukroun et al.,¹⁸ with predictable platelet, growth factor, and cell mediator concentrations without using any anticoagulants. Unlike PRP, PRF has the unique property of progressive release of cytokines and growth factors during fibrin matrix remodeling over a period of up to 4 weeks, thereby enhancing healing.¹⁹⁻²¹ In addition, PRF does not have any negative influence of the chemicals added during PRP preparation. We

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describe a reproducible and simple way to harvest PRF and create and use a PRF clot, along with detailed instructions on how to integrate the clot with a meniscal repair arthroscopically.

Surgical Technique

Preoperative Preparation

Proper preoperative evaluation clinically and radiologically is important to identify the meniscal tear pattern and location, thereby allowing the planning of meniscal repair techniques and the need for biological adjuvants. Arthroscopic instrumentation and implants required for meniscal repair, along with supplemental accessories required for PRF preparation, should be made available preoperatively.

Patient Positioning

The patient is placed in the supine position. At our center, the preferred type of anesthesia for meniscal repair is spinal anesthesia, and a high-thigh tourniquet

is applied after the operative leg has been well padded. The side support is positioned to exert valgus stress intraoperatively.

Portal Creation, Diagnostic Arthroscopy, and Suture Placement

Standard anterolateral and anteromedial portals are made; additional accessory portals are made to ensure the accessibility of instruments to both the medial meniscus and lateral meniscus. The initial diagnostic arthroscopy is performed, and the location of the meniscal tear is confirmed without any ramp lesion or root tear (Fig 1). Pie crusting of the medial collateral ligament can be performed to improve visualization of the medial meniscus if needed. For the lateral meniscus, the figure-of-4 position is used for repair. After confirmation of the tear pattern and morphology, the decision to perform biological augmentation with PRF is made. The meniscal tear is freshened with a meniscal rasp and an arthroscopic shaver. Trephination is performed to create blood channels from the capsule.

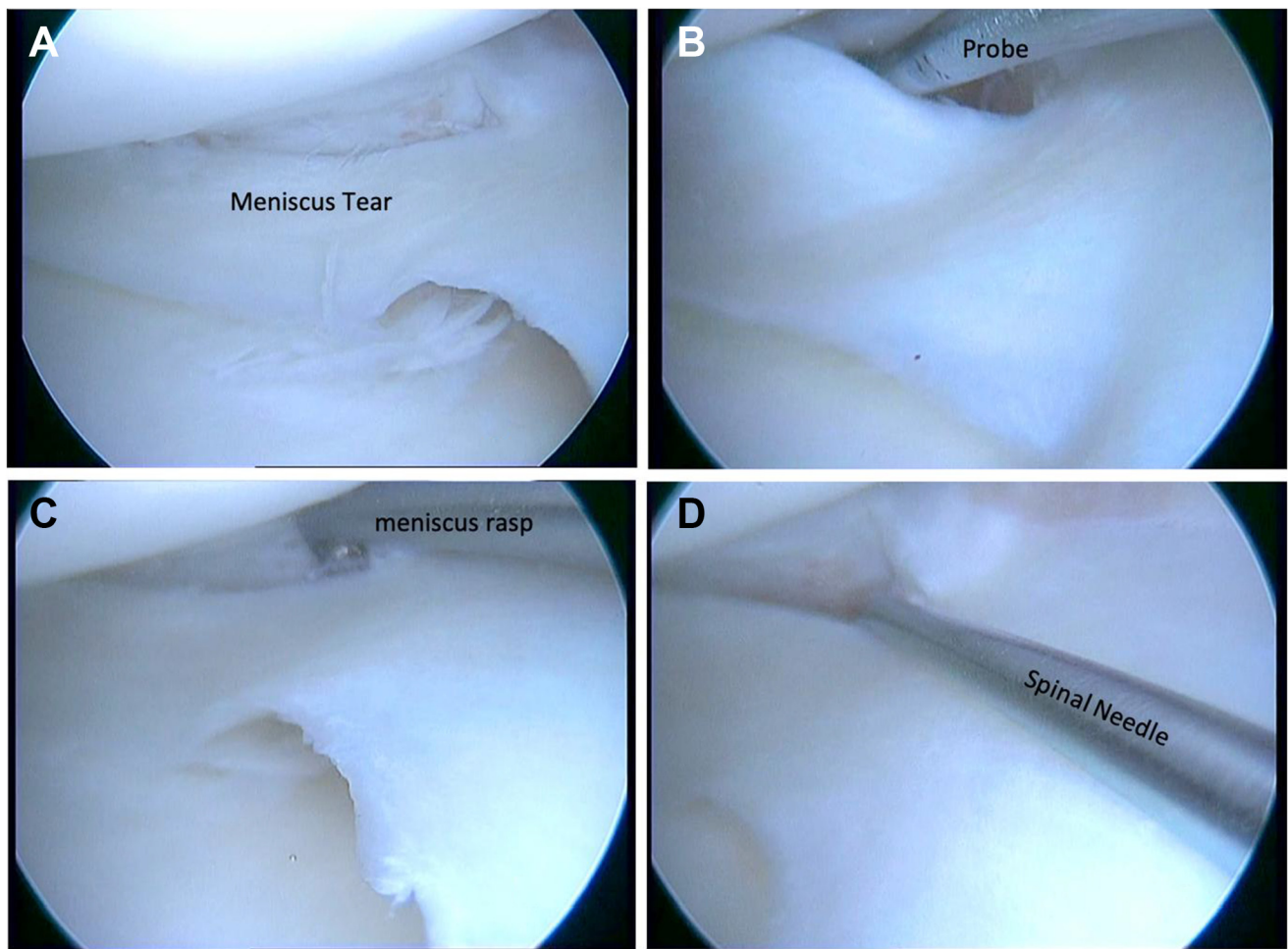


Fig 1. (A) Viewing from anterolateral portal a longitudinal meniscal tear is noted on the posterior horn of the medial meniscus during diagnostic arthroscopy. (B) The meniscus is probed through the anteromedial portal to identify the tear pattern. (C) The tear edges are freshened with a meniscal rasp. (D) Trephination is performed with an 18-gauge spinal needle to create blood channels.

After proper debridement and preparation of the tear margins, the tear is anatomically reduced. We use the inside-out technique for posterior- and middle-third tears, whereas the all-inside technique is the preferred technique when the tear is at the posterior horn. Using the inside-out technique, we place the sutures in the correct position but keep them loose without knot tightening.

PRF (Clot) Preparation

Once the tear is confirmed as repairable, 20 mL of blood is collected from the patient and is transferred to 2 sterile glass tubes, each with a capacity of 10 mL. The blood is centrifuged in a conventional programmable centrifugation machine at 400g force (3,000 rpm for 12 minutes). The machine we use is a horizontal swing-bucket centrifuge (Medico Plus; Remi Lab World) with incremental control of speed and time, as well as a brushless inductor motor with smooth acceleration and braking (Fig 2). This process will create a PRF clot. The clot can be left idle for 5 to 10 minutes for better consolidation. Once the clot is consolidated, it is taken out of the sterile tube in a sterile fashion and is transferred to a sterile cloth or gauze, where the red clot at the bottom is trimmed just below the red-white zone (Fig 3). The reason that we use this technique is that the concentration of platelets in the PRF clot is more

concentrated toward the junction of the white and red zones. Gentle squeezing is performed to remove the platelet-poor plasma. The clot is later divided into pieces of the required shape and size as needed using a scalpel and forceps.

Implantation of Clot Into Meniscus

The trimmed PRF clot is now introduced into the joint using a suture retriever (ElitePremium Suture Grasper [Blue Handle]; Smith & Nephew) through the respective portals, depending on the location of the tear (Video 1). The PRF clot is now negotiated into the tear using a standard arthroscopic probe (Arthroscopic Hook Probe, Karl Storz, 5-mm Tip, Tri Handle). For tears in the middle and anterior part of the meniscus, the PRF clot can be placed between the tear edges, whereas for posterior-third and posterior root tears, if clot placement between the tear edges is difficult (because of constrained space), the clot can be tucked under the meniscal tear at the bone-meniscus interface. Perfect positioning of the clot can be achieved through manipulation with the probe. Although the clot, being denser, will not be affected by fluid flow, the surgeon may use a low-flow arthroscope or perform dry arthroscopy if preferred. Once the clot is positioned properly, the sutures are tightened to complete the repair (Fig 4). Additional sutures can be placed if needed.

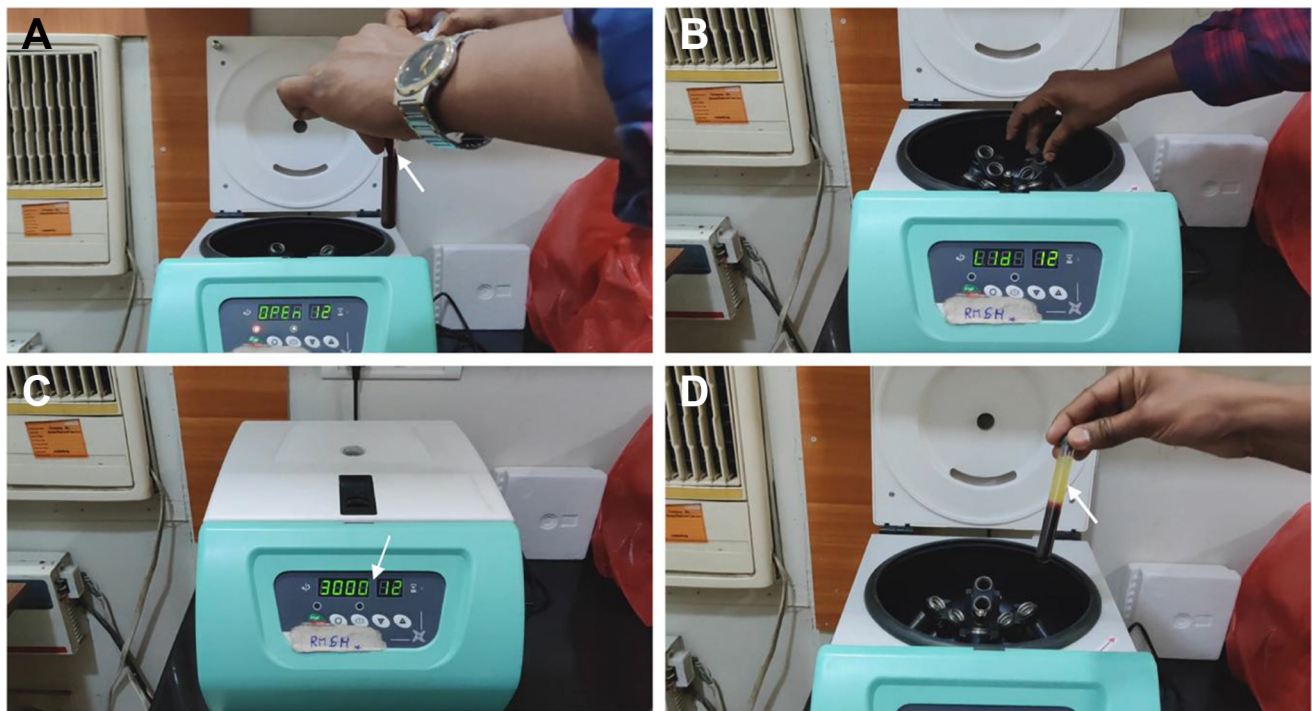


Fig 2. (A) The blood collected (arrow) from the patient for platelet-rich fibrin clot preparation is transferred to glass tubes. (B) The 2 glass tubes with blood are placed in the centrifugation machine. (C) The desired protocol for preparation of the platelet-rich fibrin clot is set on the machine: 3,000 rpm (arrow) for 12 minutes at 400 g. (D) After completion of centrifugation, an extra 5 to 10 minutes of settling time is allowed for clot consolidation, after which the tube containing the platelet-rich fibrin clot (arrow) is removed from the centrifugation machine.



Fig 3. (A) The platelet-rich fibrin (PRF) clot is taken out of the glass tube using an artery forceps in a sterile fashion. (B) The clot is trimmed just below the red clot and white clot junction to include a small portion of the red clot. (C) The trimmed clots (arrow) are placed on a kidney tray. (D) The clots (arrow) are transferred to a gauze to squeeze out the platelet-poor plasma in the PRF clot before application.

PRF Clot Augmentation in Rotator Cuff Repair

Similarly to PRF clot application for meniscal repair, PRF clot integration into rotator cuff repair can be performed securely. This technique is applicable when a double-row repair is performed. The medial-row sutures are placed and tightened first. This is followed by placement of the PRF clot at the cuff-bone interface using a suture retriever or any such instrument that will not crush the clot. Optimal final positioning of the clot can be achieved using a probe. Once the clot is placed, the lateral-row anchors are placed, securing the clot at the cuff-bone interface.

Postoperative Rehabilitation

A postoperative rehabilitation protocol for meniscal repair is followed depending on the location of the tear repair. Patients are allowed non-weight-bearing mobilization with support for 3 weeks. Partial weight bearing with a brace is allowed from 3 to 6 weeks. From the sixth week onward, full weight bearing is allowed. At 3 months after the repair, moderate physical activity such as light jogging is allowed. Return to sports is allowed after 6 months. Physical therapy was started postoperatively and included gentle range of motion with movements limited to 45° of flexion until 4 weeks

and 90° until week 6, followed by knee-strengthening exercises (Table 1).

Discussion

Concentrates of platelets have been extensively researched in the past decade, and their property of facilitating tissue regeneration has been well validated. PRF is a second-generation platelet concentrate developed by Choukroun et al.¹⁸ and is distinctive from PRP on 2 counts: (1) the absence of any anticoagulants or activators for its preparation and (2) its solid form obtained by a single centrifugation process.^{19,21,22} Because no anticoagulants are added, their interference with the wound healing cascade will not occur.²³ The other advantages of PRF over PRP are minimal manipulation of blood, extended growth factor release, higher flexibility and elasticity of PRF clots, and inexpensiveness.^{21,23} The advantages and disadvantages of PRF compared with PRP are given in Table 2.

Compared with fibrin clots that are extensively used as biological adjuvants in ligament and meniscal repairs and are composed of 94% red blood corpuscles, 5% platelets, and 1% white blood corpuscles, PRF contains 85% to 95% platelets.^{24,25} The advantages of PRF over

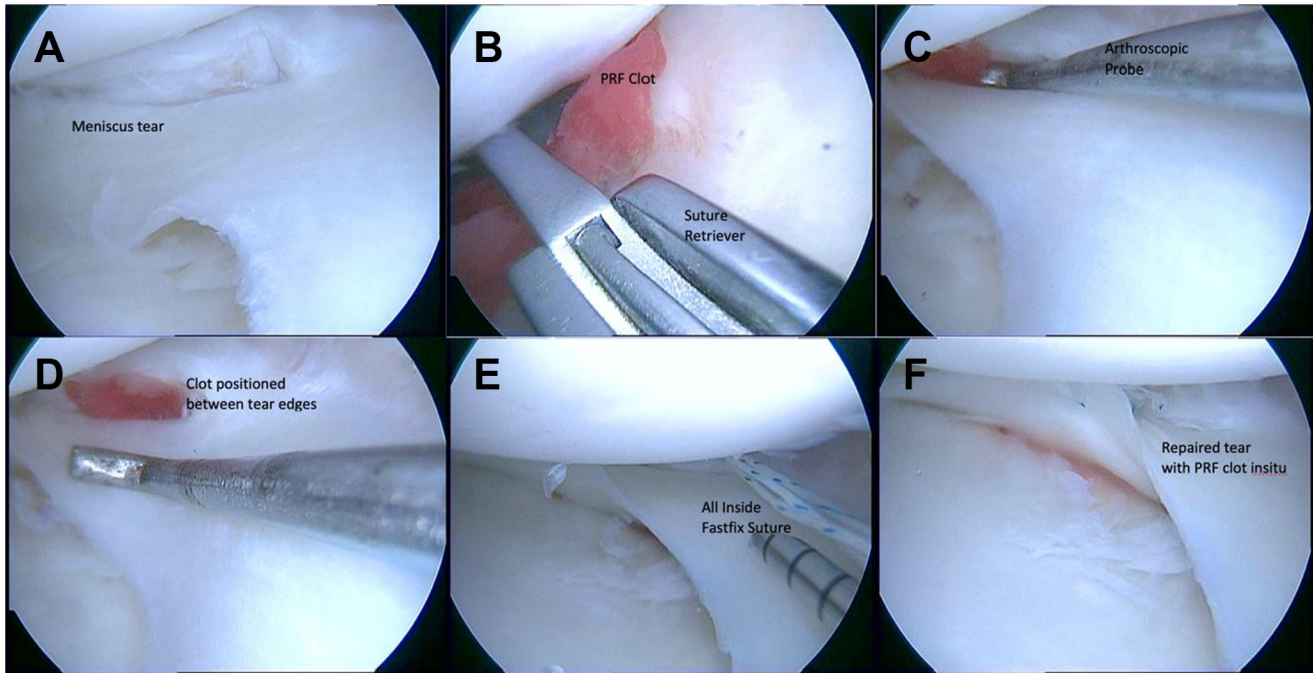


Fig 4. (A) Viewing through the anterolateral portal a longitudinal tear is noted on the posterior horn of the medial meniscus. (B) The platelet-rich fibrin (PRF) clot is introduced into the knee using a suture retriever through the antromedial portal and placed into the tear. (C) The clot is manipulated and positioned using the elbow of the arthroscopic probe. (D) The PRF clot is positioned between the torn edges of the meniscus. (E) An all-inside suture technique (FAST-FIX; Smith & Nephew) is used to approximate the tear with the clot sandwiched between the edges. (F) Final repair of torn meniscus.

fibrin clots are listed in Table 3. The microscopic contents and biomolecular characteristics of PRF have been studied in detail in the literature and are well documented.²⁶⁻²⁸ In addition to platelets, PRF comprises fibrin matrix polymer and leukocytes, cytokines, and

stem cells.²⁷ PRF also has antimicrobial properties through release of antimicrobial peptides trapped in the fibrin matrix, as well as through release of antimicrobial proteins on degradation of platelets.²³

Various studies have evaluated the platelet concentration of PRF clots. It was reported that immediate centrifugation of blood samples at between 2,700 and 3,000 rpm at 400g for 10 to 12 minutes gives the optimum concentration of platelets.^{23,29} Coagulation of the sample in a PRF preparation happens on contact with the glass tube.²² During centrifugation, the cells will sediment in the order of increasing specific

Table 1. Pearls and Pitfalls of Technique

Pearls

- The decision to use a clot needs to be made during the diagnostic arthroscopy itself.
- The fibrin clot should be left idle for 5-10 minutes after centrifugation for better clot consolidation.
- A smaller part of the red clot at the white clot–red clot interface of the PRF should be included for maximum harvest.
- Other augmentation techniques, including needling, trephination, and synovial abrasion, should be combined to promote maximum healing.
- Dry arthroscopy can be used to position the clot during the initial learning phase.
- Only a blunt instrument such as a trocar, Wissinger rod, or elbow of a probe should be used for final clot positioning.

Pitfalls

- Blood collected for preparation of PRF should be transferred immediately to the glass tube and centrifuged within 2 min.
- When using a probe to position the clot, the surgeon should avoid engaging the tip of the probe on the clot to avoid inefficient handling.
- An aseptic technique needs to be followed while preparing the clot to avoid a therapeutic risk of infection even though platelets have antimicrobial properties.

PRF, platelet-rich fibrin.

Table 2. Advantages and Disadvantages of PRF Compared With PRP²²

Advantages

- PRF, being a clot, can be accurately delivered to the target site.
- A single-step centrifugation technique can be performed without any activators or anticoagulants.
- Conventional centrifugation machines can be used.
- Slow polymerization favors the healing process.
- Minimal manipulation of blood is required.
- The activity of growth factors, being embedded in a natural fibrin network, will be maintained for a longer period, thereby effectively stimulating tissue regeneration.

Disadvantages

- A glass tube or glass-coated tube is needed.
- Quick handling of blood is required.

PRF, platelet-rich fibrin; PRP, platelet-rich plasma.

Table 3. Advantages of PRF Over Fibrin Clot

A PRF clot is denser than a fibrin clot, which is fragile and more bulky. A PRF clot has a platelet concentration of up to 95% compared with 95% RBCs with only 5% platelets in a fibrin clot.

PRF, platelet-rich fibrin; RBC, red blood corpuscle.

gravity—that is, plasma, platelets, leukocytes, and red blood cells—and thus, the fibrin clot is obtained at the top and the red blood corpuscle clot is obtained at the bottom. The fibrin matrix will entrap the platelets and leukocytes and favor the slow and gradual release of growth factors over time.^{24,30} The protocol we use (3,000 rpm for 12 minutes at 400g) is consistent with the protocols of various other studies to obtain the maximum platelet concentration in the PRF clot.

Multiple ways to deliver biological augmentations such as fibrin clots have been described, but many of these are difficult to reproduce and the chance of a clot being fragmented and irrigated away is high. PRF, being denser than the red fibrin clot, can be handled easily with arthroscopic instruments and delivered to the desired area of interest with ease and with less chance of washout. When performing our technique, we have used a suture retriever to deliver the PRF clots without loss or damage. We believe that our technique of PRF preparation, as well as its delivery and incorporation into the repair, is not only less technically challenging but also very reproducible (Table 4). Furthermore, we have been performing this technique routinely for the past few years and have been able to achieve good

Table 4. Advantages and Limitations of Technique

Advantages

- The technique facilitates repair of the meniscus and better functional outcomes compared with partial meniscectomy.
- The clot can be shaped easily to obtain the required size and shape.
- Growth factors are delivered directly at the repair target site.
- PRF has predictable concentrations of platelets, growth factors, and cell mediators.
- Consistent and sustained release of platelet and growth factors occurs locally for up to 4 wk, which matches the healing phase of meniscal tears.²¹
- PRF is less expensive because it can be prepared with a conventional centrifugation machine.
- Clot placement does not require any special instruments.
- The higher density of the clot will favor easy clot handling with fluid flow.
- The procedure can be performed by an all-arthroscopic technique.
- Because no sutures are used for delivery of the clot, any type of meniscal repair technique, including an all-inside technique, can be performed.

Limitations

- Proper PRF clot preparation requires the centrifugation machine setup to be near the operating theater to allow immediate blood transfer, thereby preventing clot formation.
- There is a learning curve associated with proper positioning of the clot.

PRF, platelet-rich fibrin.

outcomes. We believe that long-term studies are needed to evaluate the outcomes of repair with PRF augmentation.

References

1. Clayton RA, Court-Brown CM. The epidemiology of musculoskeletal tendinous and ligamentous injuries. *Injury* 2008;39:1338-1344.
2. Sukopp M, Schall F, Hacker SP, Ignatius A, Dürselen L, Seitz AM. Influence of menisci on tibiofemoral contact mechanics in human knees: A systematic review. *Front Bioeng Biotechnol* 2021;9, 765596.
3. Shimomura K, Hamamoto S, Hart DA, Yoshikawa H, Nakamura N. Meniscal repair and regeneration: Current strategies and future perspectives. *J Clin Orthop Trauma* 2018;9:247-253.
4. Di Matteo B, Moran CJ, Tarabella V, et al. A history of meniscal surgery: From ancient times to the twenty-first century. *Knee Surg Sports Traumatol Arthrosc* 2016;24: 1510-1518.
5. Jeong HJ, Lee SH, Ko CS. *Meniscectomy*. *Knee Surg Relat Res* 2012;24:129-136.
6. Zhang K, Li L, Yang L, et al. The biomechanical changes of load distribution with longitudinal tears of meniscal horns on knee joint: A finite element analysis. *J Orthop Surg Res* 2019;14:237.
7. Voloshin AS, Wosk J. Shock absorption of meniscectomized and painful knees: A comparative in vivo study. *J Biomed Eng* 1983;5:157-161.
8. Hollis JM, Pearsall AWIV, Niciforos PG. Change in meniscal strain with anterior cruciate ligament injury and after reconstruction. *Am J Sports Med* 2000;28:700-704.
9. Twomey-Kozak J, Jayasuriya CT. Meniscus repair and regeneration: A systematic review from a basic and translational science perspective. *Clin Sports Med* 2020;39: 125-163.
10. Weber J, Koch M, Angele P, Zellner J. The role of meniscal repair for prevention of early onset of osteoarthritis. *J Exp Orthop* 2018;5:10.
11. Reito A, Harris IA, Karjalainen T. Arthroscopic partial meniscectomy: Did it ever work? *Acta Orthop* 2021;93: 1-10.
12. Karia M, Ghaly Y, Al-Hadithy N, Mordecai S, Gupte C. Current concepts in the techniques, indications and outcomes of meniscal repairs. *Eur J Orthop Surg Traumatol* 2019;29:509-520.
13. Uzun E, Misir A, Kizkapan TB, Ozcamdalli M, Akkurt S, Guney A. Factors affecting the outcomes of arthroscopically repaired traumatic vertical longitudinal medial meniscal tears. *Orthop J Sports Med* 2017;5, 2325967117712448.
14. Xu C, Zhao J. A meta-analysis comparing meniscal repair with meniscectomy in the treatment of meniscal tears: The more meniscus, the better outcome? *Knee Surg Sports Traumatol Arthrosc* 2015;23:164-170.
15. Kamimura T, Kimura M. Meniscal repair of degenerative horizontal cleavage tears using fibrin clots: Clinical and arthroscopic outcomes in 10 cases. *Orthop J Sports Med* 2014;2, 2325967114555678.

16. Doral MN, Bilge O, Huri G, Turhan E, Verdonk R. Modern treatment of meniscal tears. *EFORT Open Rev* 2018;3: 260-268.
17. Anz AW, Hackel JG, Nilssen EC, Andrews JR. Application of biologics in the treatment of the rotator cuff, meniscus, cartilage, and osteoarthritis. *J Am Acad Orthop Surg* 2014;22:68-79.
18. Choukroun J, Diss A, Simonpieri A, et al. Platelet-rich fibrin (PRF): A second-generation platelet concentrate. Part V: Histologic evaluations of PRF effects on bone allograft maturation in sinus lift. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2006;101:299-303.
19. Miron RJ, Zhang Y. Autologous liquid platelet rich fibrin: A novel drug delivery system. *Acta Biomater* 2018;75: 35-51.
20. Elbehwashy MT, Hosny MM, Elfana A, et al. Clinical and radiographic effects of ascorbic acid-augmented platelet-rich fibrin versus platelet-rich fibrin alone in intra-osseous defects of stage-III periodontitis patients: A randomized controlled clinical trial. *Clin Oral Invest* 2021;25: 6309-6319.
21. Wu CL, Lee SS, Tsai CH, Zhao JH, Chang YC. Platelet rich fibrin increases cell attachment, proliferation and collagen related protein expression of human osteoblasts. *Aust Dent J* 2012;57:207-212.
22. Borie E, Oliví DG, Orsi IA, et al. Platelet-rich fibrin application in dentistry: A literature review. *Int J Clin Exp Med* 2015;8:7922-7929.
23. Pavlovic V, Ciric M, Jovanovic V, Trandafilovic M, Stojanovic P. Platelet-rich fibrin: Basics of biological actions and protocol modifications. *Open Med (Wars)* 2021;16:446-454.
24. Sharma R, Sharma P, Sharma SD, Chhabra N, Gupta A, Shukla D. Platelet-rich fibrin as an aid to soft- and hard-tissue healing. *J Maxillofac Oral Surg* 2021;20:496-501.
25. Desai T, Babu SS, Lal JV, et al. Fibrin clot augmented repair of longitudinal tear of medial meniscus. *Arthrosc Tech* 2021;10:e2449-e2455.
26. Grecu AF, Reclaru L, Ardelean LC, Nica O, Ciucă EM, Ciurea ME. Platelet-rich fibrin and its emerging therapeutic benefits for musculoskeletal injury treatment. *Medicina (Kaunas)* 2019;55:141.
27. Feng M, Wang Y, Zhang P, et al. Antibacterial effects of platelet-rich fibrin produced by horizontal centrifugation. *Int J Oral Sci* 2020;12:32.
28. Ratajczak J, Vangansewinkel T, Gervois P, et al. Angiogenic properties of 'leukocyte- and platelet-rich fibrin. *Sci Rep* 2018;8, 14632.
29. Shah R, Gowda TM, Thomas R, Mehta DS. An update on the protocols and biologic actions of platelet rich fibrin in dentistry. *Eur J Prosthodont Restor Dent* 2017;25:64-72.
30. Miron RJ, Chai J, Zheng S, Feng M, Sculean A, Zhang Y. A novel method for evaluating and quantifying cell types in platelet rich fibrin and an introduction to horizontal centrifugation. *J Biomed Mater Res* 2019;107:2257-2271.