

# Repair Technique for Displaced Meniscal Flap Tears Indicated by MRI Comma Sign



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**Abstract:** The meniscus comma sign has been described for displaced flap tears of the meniscus. These meniscus tears are displaced into the tibia or femoral recesses and can be often difficult to diagnose intraoperatively. We describe the technique of diagnosis and treatment of a large displaced lateral meniscus flap tear, presenting as a meniscus comma sign. The identification of the meniscus comma sign on consecutive magnetic resonance imaging (MRI) cuts suggest a flap tear of a significant size that indicates reparability. The technique would be to lift the meniscus flap from the meniscotibial recess, reduce it and then repair it with an all-inside meniscus repair or by hybrid meniscus repair techniques.

## Introduction

Meniscal tears are common in knee injuries and often associated with anterior cruciate ligament (ACL) tears. Meniscal tears can be classified according to the morphological patterns such as vertical tear, flap tear, radial tear, and horizontal tear. There was an incidence of 6.4% of displaced meniscus flap tears in patients who underwent knee magnetic resonance imaging (MRI) after a knee injury.<sup>1</sup>

Meniscus flap tears can displace into the femoral notch, posterior femoral compartment, or meniscotibial recess. The meniscus comma sign describes the MRI appearance of a displaced flap tear.<sup>2</sup> The majority of such cases described in the literature have been managed with partial menisectomy.<sup>2-4</sup> We describe the assessment of a displaced meniscus flap tear and the surgical technique to repair the radial lateral meniscus flap tear with an illustrative case.

## Preoperative Assessment

It is crucial to make the preoperative diagnosis of a displaced flap tear, otherwise the displaced meniscus fragment can often be missed intraoperatively. The assessment can be made on history, physical examination, and MRIs. Meniscus flap tears can cause persistent knee pain and effusion as well as symptoms such as locking and clicking. The displaced flap tear is reported to cause worse pain compared to the undisplaced flap tear. This is postulated to be caused by pressure and traction of the displaced fragment at the meniscocapsular junction, which is well innervated.<sup>3</sup>

In terms of physical examination, joint line tenderness is considered to be the most accurate clinical sign for the meniscus tear.<sup>4</sup> The positive rate of exquisite joint line tenderness in patients with displaced flap tears especially in the meniscotibial recess is even higher.<sup>3</sup>

The MRI is the diagnostic tool of choice for meniscus tears. Wong et al. reported that MRIs have an accuracy of 86% for medial meniscus tears and 74% for lateral meniscus tears.<sup>5</sup> Jung et al. reported that the MRI diagnostic accuracy for inferiorly displaced flap tear preoperatively ranged from 68% to 72%.<sup>3</sup>

The meniscus comma sign is best appreciated in sagittal cuts of the MRI T2-weighted imaging. If the meniscus comma sign can be seen in multiple consecutive sagittal cuts, it is representing a large displaced flap tear (Fig 1). The large displaced meniscus flap tear is potentially repairable and ideally should be repaired. In coronal cuts of the MRI imaging, a displaced flap tear might resemble a horizontal cleavage tear, which represents the infolded double layers of the meniscus (Fig 2). The radial tear component is best appreciated in the axial cut (Fig 3). These features

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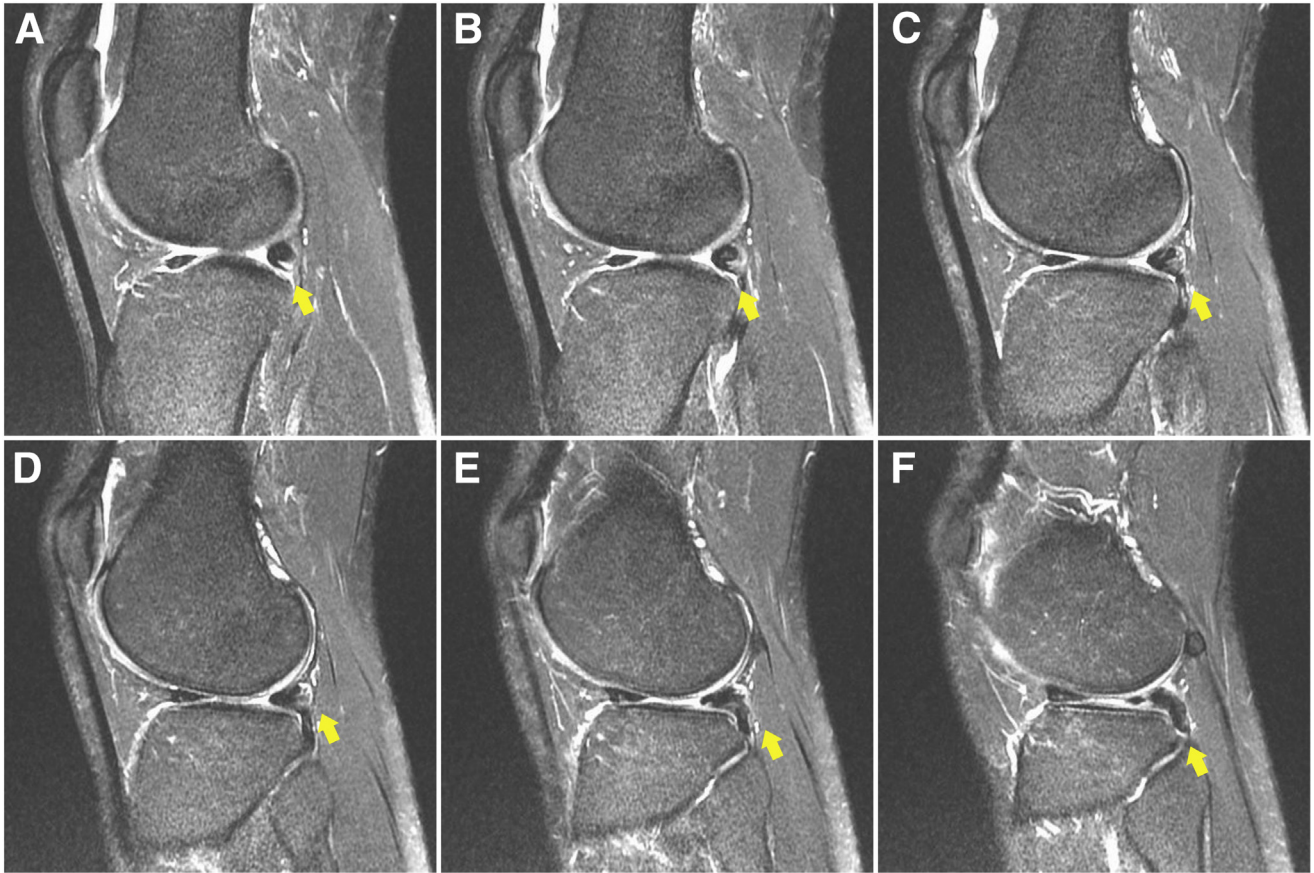
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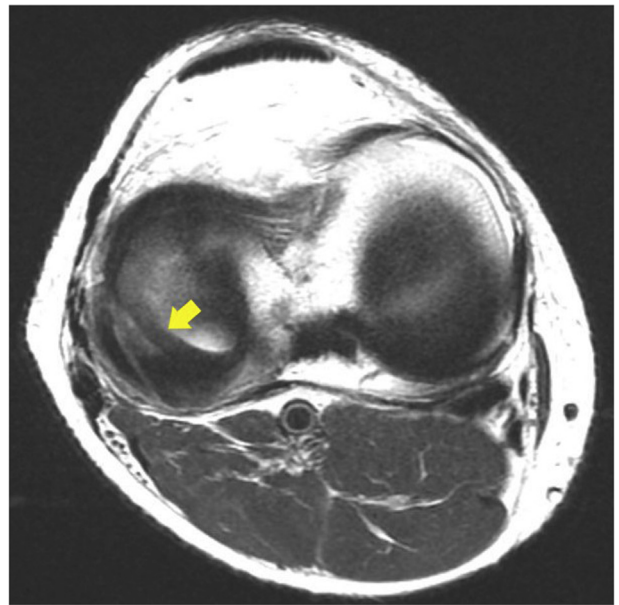
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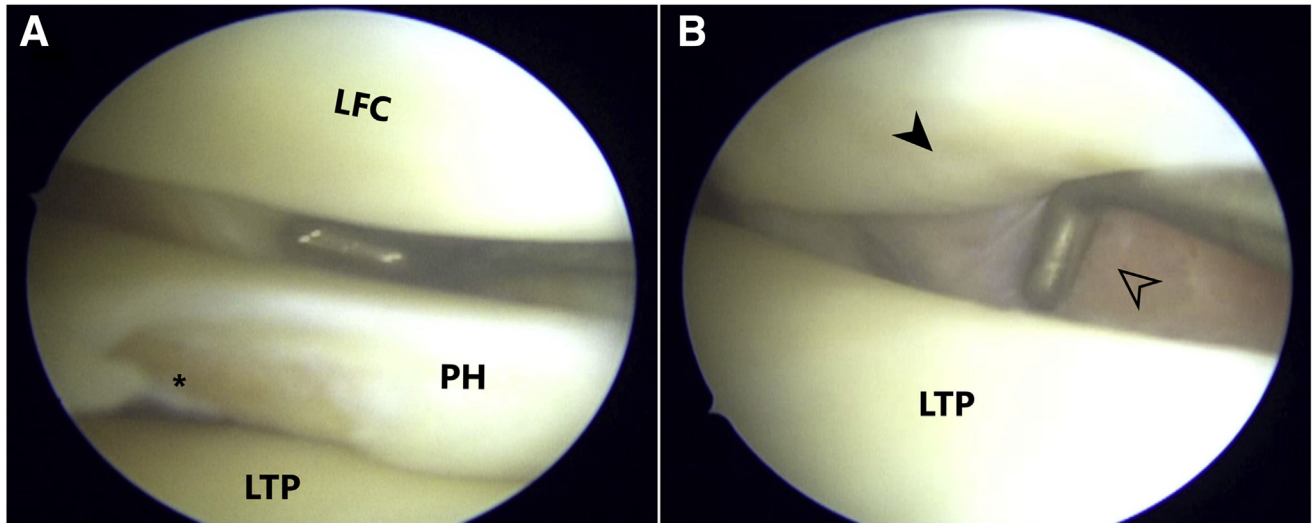
**Fig 1.** Consecutive six sagittal cuts of MRI T2 weighted imaging show the displaced flap tear (3 mm cut), indicating the width of the tear is at least 18 mm. The comma sign is best appreciated in A and B. The yellow arrow indicates the displaced flap tear. In D-F, the meniscus flap is folded and displaced in the mediscotibial recess.



**Fig 2.** The coronal cut of T2-weighted MRI imaging shows double layers of the meniscus, which indicates the displaced flap is folded underneath the meniscus (yellow arrow).



**Fig 3.** The axial cut of the T2-weighted MRI shows the radial tear at the posterior horn junction (yellow arrow).



**Fig 4.** The arthroscopic photo of the right knee from the anterolateral viewing portal when the knee is in a figure of 4 position, with instruments introduced from the anteromedial working portal. (A) Asterisk (\*) indicates meniscus deficiency in the posterolateral aspect of the lateral meniscus. The posterior horn of the lateral meniscus is significantly thickened. (B) A probe is used to elevate the posterior horn, and the displaced flap is seen in the meniscotibial recess. The solid arrowhead shows the displaced flap fragment, and the hollow arrowhead shows the meniscotibial recess. LFC, lateral femoral condyle; LTP, lateral tibial plateau; PH, posterior horn.

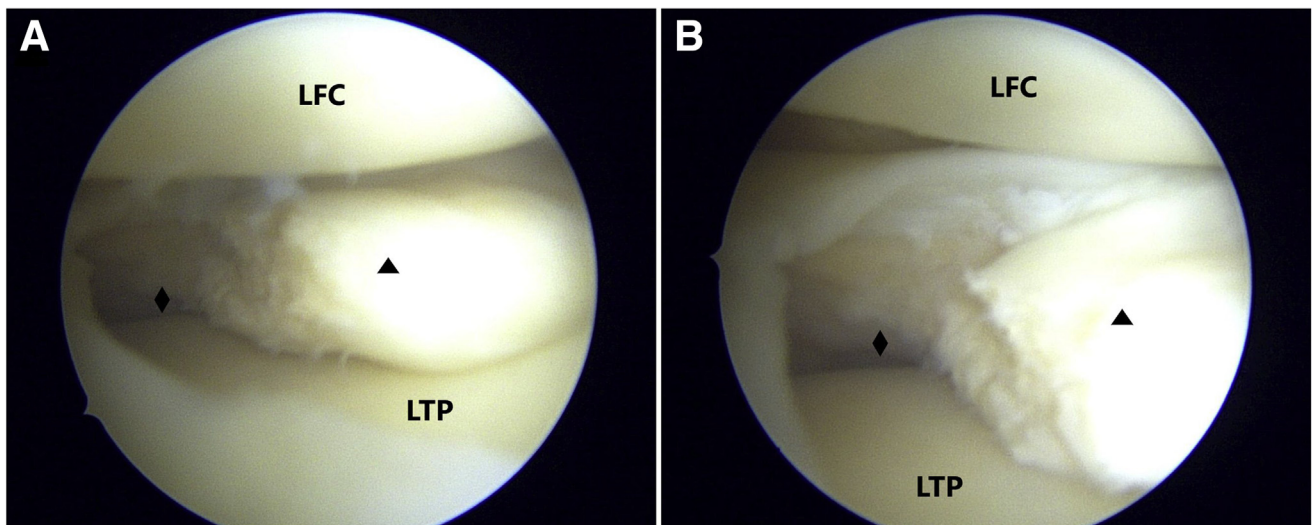
enable the diagnosis of a large displaced flap tear preoperatively.

#### Intraoperative Assessment

The displaced meniscus fragment is often trapped in the meniscocapsular recess and cannot be seen on the standard arthroscopy. The adjacent meniscus tissue may appear normal or subtly abnormal, or even as an area of meniscal tissue loss (Fig 4). Therefore, a high index of suspicion is required, otherwise the diagnosis of such lesions can be missed.

During arthroscopy, careful examination of the deficient meniscus area should be performed. The meniscus defect site might appear thinner than the surrounding meniscus. And the folded flap tear with native meniscus might appear to be thickened. The rolled edges of the flap can suggest the chronicity of the lesion.

A probe can be used to examine the undersurface and the meniscotibial recess (Fig 4). A probe can also be used to pull the displaced flap centrally and into the joint. Due to the chronicity of the lesion, the reduced flap tear may redisplace inferiorly again into the recess.



**Fig 5.** The arthroscopic photo of the right knee from the anterolateral viewing portal when the knee is in a figure of 4 position. The meniscus flap is reduced, and the radial tear component is appreciated. The triangle shows the meniscus flap fragment. The diamond shows the radial tear gap. LFC, lateral femoral condyle; LTP, lateral tibial plateau.

**Table 1.** Tips and Pitfalls to Diagnose the Meniscus Comma Lesion

1. The displaced flap tear can be missed in the MRI.
2. Assess the size of the flap to determine reparability.
3. Inability to visualize flipped fragment on arthroscopy because it is hidden in the recess.
4. Suspicion is raised with a segment of missing meniscus tissue.
5. Thickened and rolled edges are suggestive of a chronic displaced meniscus flap.
6. Redisplacement of the reduced meniscus fragment into the recess suggests instability.

This instability has a significant bearing on the fixation technique for radial meniscus tear repair. One can make use of multiple “rip-stop” protection stitches to the capsule to prevent redisplacement.

After reduction of the displaced flap, the radial tear of the lateral meniscus can be visualized at the posterior horn junction (Fig 5). The comma meniscus tissue has been freed from the inferior meniscus tibia recess after reduction. The tips and pitfalls for the assessment of the meniscus coma lesion are shown in Table 1.

#### All-Inside Repair of the Displaced Meniscus Flap Tear

The previously described displaced meniscus flap tears in the literature were small in size and seen on only one or

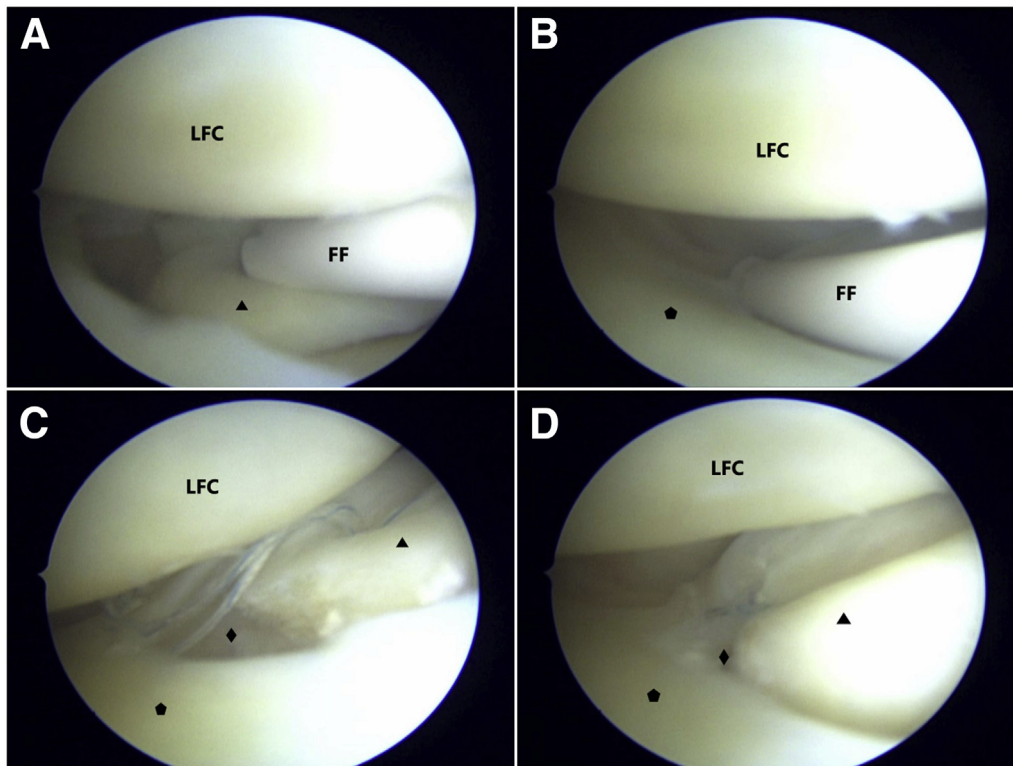
two cuts of the MRI. Partial meniscectomies are performed in these cases.<sup>2,3</sup> However, meniscus repair should be attempted in the case of a large displaced flap tear.

The complex radial lateral meniscus tear is repaired using the all-inside meniscus repair device (FAST FIX 360, Smith & Nephew, London, UK) (Video 1). The repair is accomplished with three side-to-side repairs on the upper surface of the meniscus (one peripheral, one middle, and one central (Figs 6-8). These three sutures are placed across the radial tear, perpendicular to the tear.

Two horizontal “ripstop” stitches are placed over the posterior horn to stabilize the meniscus flap and avoid redisplacement of the flap; one on the superior surface of the meniscus and one on the inferior surface of the meniscus (Figs 9 and 10). Two vertical “ripstop stitches” are placed from the posterior horn to the posterior capsule (Figs 11 and 12). These 4 stitches further stabilize the posterior horn of the meniscus and protect the side-to-side repair sutures, reducing the tension across the radial repair site. The meniscus is stable after all-inside repair (Fig 6). The technical pearls for the all-inside repair of complex radial meniscus tears are summarized in Table 2.

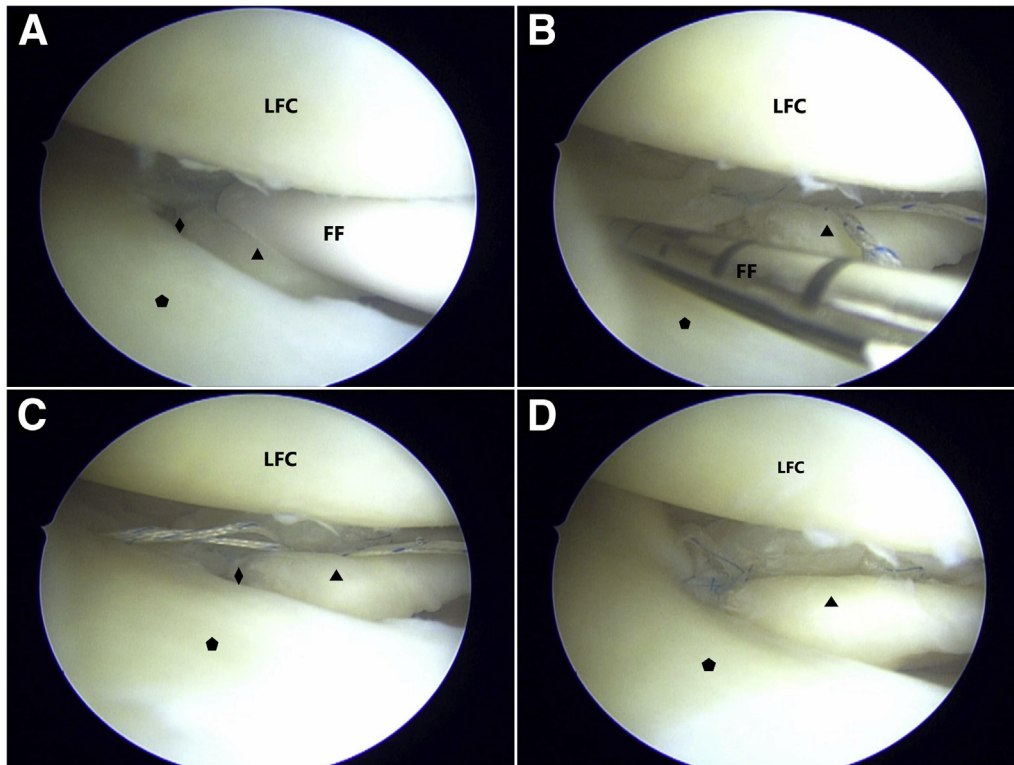
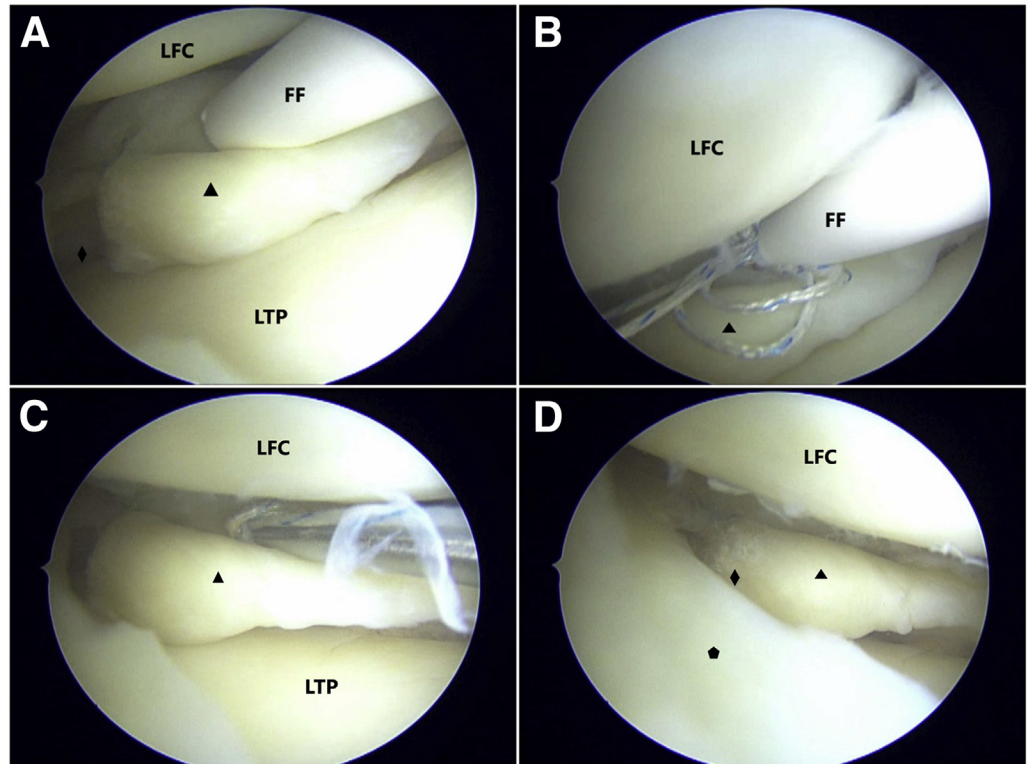
#### Postoperative rehabilitation

The physiotherapy is commenced immediately to regain a good range of motion, as well as the muscle

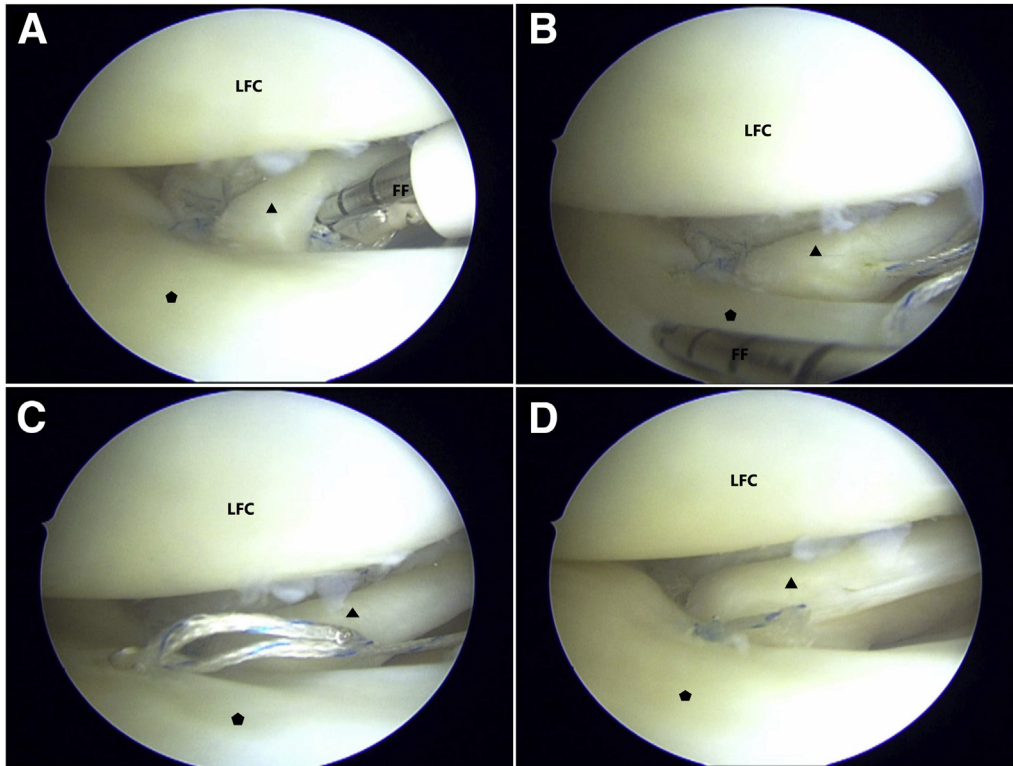


**Fig 6.** The arthroscopic photo of the right knee from the anterolateral viewing portal when the knee is in a figure of 4 position, with repair device introduced from the anteromedial working portal. The first side-to-side stitch (FAST FIX 360; Smith & Nephew) is applied at the peripheral aspect of the tear. The radial tear gap is significantly reduced after the side-to-side stitch. The triangle shows the meniscus flap fragment. The diamond shows the radial tear gap. The pentagon shows the meniscus body. FF, FAST FIX 360; LFC, lateral femoral condyle.

**Fig 7.** The arthroscopic photo of the right knee from the anterolateral viewing portal when the knee is in a figure of 4 position, with repair device introduced from the anteromedial working portal. The second side-to-side stitch (FAST FIX 360; Smith & Nephew) is applied at the middle aspect of the tear. The radial tear gap is reduced further after the second side-to-side stitch. The triangle shows the meniscus flap fragment. The diamond shows the radial tear gap. The pentagon shows the meniscus body. FF, FAST FIX 360; LFC, lateral femoral condyle.



**Fig 8.** The arthroscopic photo of the right knee from the anterolateral viewing portal when the knee is in a figure of 4 position, with repair device introduced from the anteromedial working portal. The third side-to-side stitch (FAST FIX 360; Smith & Nephew) is applied at the central aspect of the tear. The radial tear gap is closed after the third side-to-side stitch. The triangle shows the meniscus flap fragment. The pentagon shows the meniscus body. FF, FAST FIX 360; LFC: lateral femoral condyle.

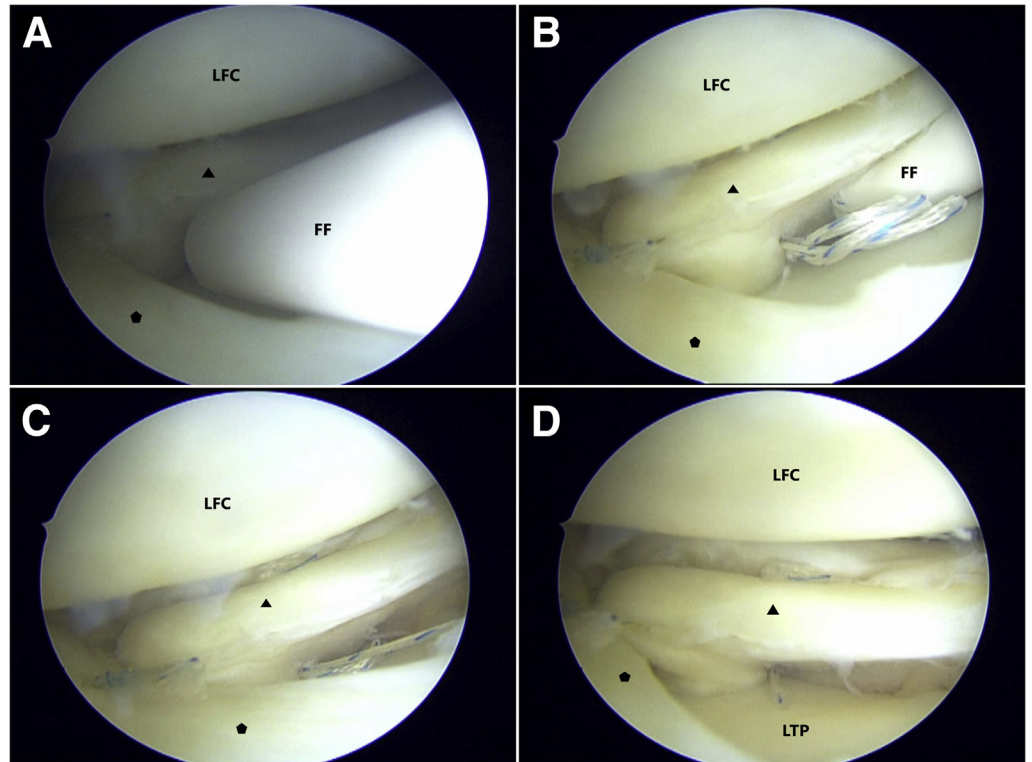


**Fig 9.** The arthroscopic photo of the right knee from the anterolateral viewing portal when the knee is in a figure of 4 position, with repair device introduced from the anteromedial working portal. One horizontal “ripstop” stitch (FAST FIX 360; Smith & Nephew) is applied at the superior surface of the posterior horn to stabilize the meniscus flap and avoid redisplacement of the flap. The triangle shows the meniscus flap fragment. The diamond shows the radial tear gap. The pentagon shows the meniscus body. FF, FAST FIX 360; LFC, lateral femoral condyle; LTP: lateral tibial plateau.

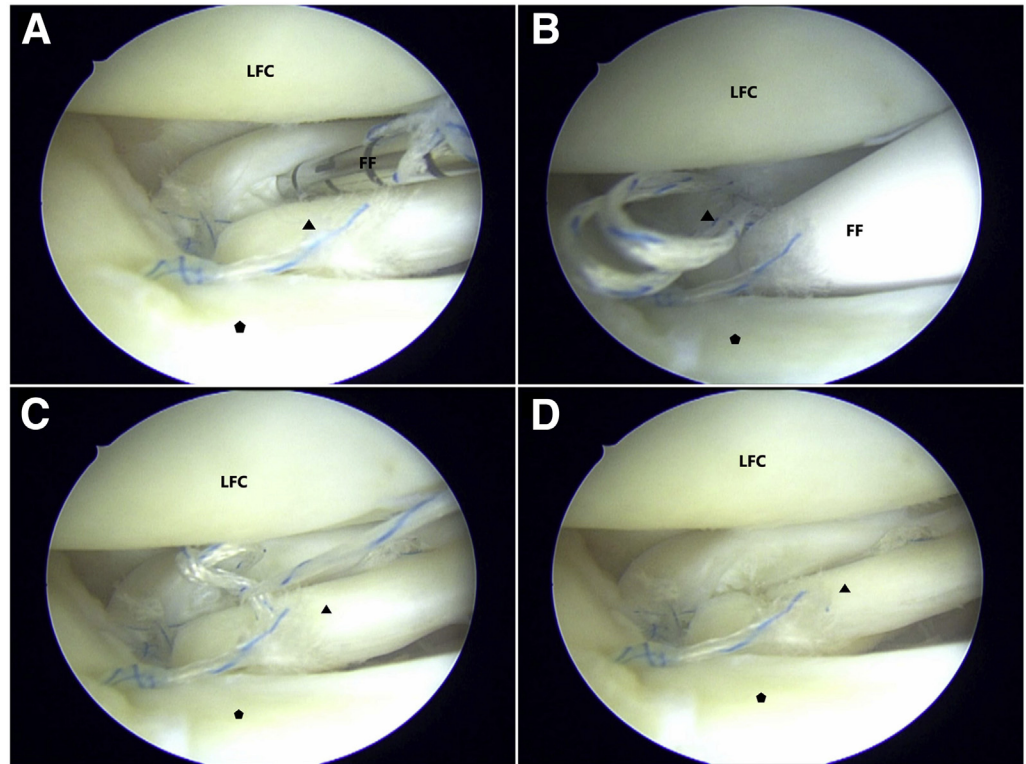
function. The knee is protected with a ranger brace with 0-90 degrees of knee flexion allowed for the first 6 weeks. The patient has protected toe touch weight-bearing for 6 weeks. Full weight bearing and full

range of knee motion are allowed after 6 weeks from the surgery. The patient is allowed to return to sports only after 9 months, depending on adequate strength and agility recovery.

**Fig 10.** The arthroscopic photo of the right knee from the anterolateral viewing portal when the knee is in a figure of 4 position, with repair device introduced from the anteromedial working portal. One horizontal “ripstop” stitch (FAST FIX 360; Smith & Nephew) is applied at the inferior surface of the posterior horn to stabilize the meniscus flap and avoid redisplacement of the flap. The triangle shows the meniscus flap fragment. The pentagon shows the meniscus body. FF, FAST FIX 360; LFC, lateral femoral condyle; LTP, lateral tibial plateau.



**Fig 11.** The arthroscopic photo of the right knee from the anterolateral viewing portal when the knee is in a figure of 4 position, with repair device introduced from the antero-medial working portal. The first vertical “ripstop” stitch (FAST FIX 360, Smith & Nephew) is applied at the posterior horn to the posterior capsule to stabilize the meniscus flap and avoid redisplacement of the flap. The triangle shows the meniscus flap fragment. The pentagon shows the meniscus body. FF, FAST FIX 360; LFC, lateral femoral condyle.



## Discussion

Displaced meniscus flap tears can potentially be displaced into superior and inferior meniscus recesses and the intercondylar notch. The “meniscus comma sign” was described to characterize the inferiorly displaced flap tear into the meniscotibial recess. Other names are used to describe the same pathology, including menisco-osseous impingement and trapped meniscus.<sup>2,4</sup>

The comma sign describes the morphology of such tear that is seen on the sagittal MRI scan. The MRI can help in detecting such tears and assessing the reparability of these tear patterns. The appearance of the meniscus comma tissue in multiple consecutive cuts indicates a meniscus flap tear of significant size and important value in preserving.

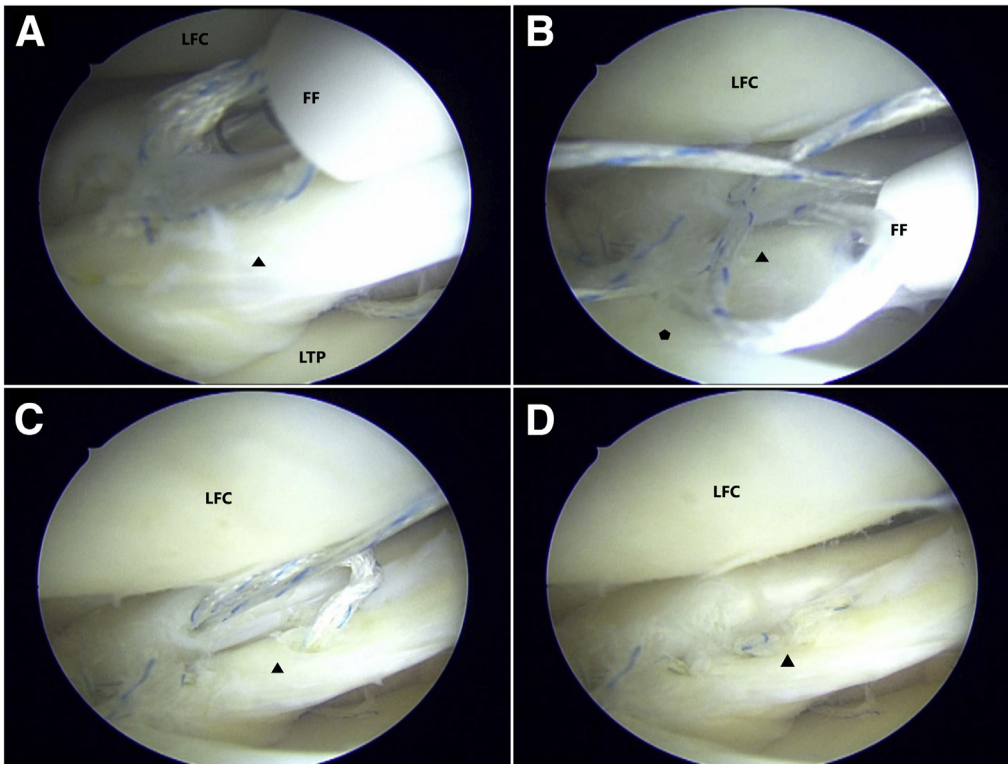
Displaced flap tears that are incarcerated inferiorly in the meniscotibial recess are often treated with partial meniscectomy in the older patient population.<sup>3</sup> Displaced flap tears treated with partial meniscectomy have shown improvement in pain and functional outcome in up to 80% of patients.<sup>6</sup> However, the evidence has shown that partial meniscectomy produces inferior long-term outcomes and increases risks of early osteoarthritis compared with meniscus repair.<sup>7</sup>

Persson et al. reported that meniscus repair resulted in about 25-50% lower risk of knee osteoarthritis, as compared to partial meniscectomies.<sup>8</sup> Thomas et al. reported that meniscus repair produced better sports activity

recovery and lower risk of osteoarthritis in the long-term follow up compared with partial meniscectomy.<sup>9</sup> Therefore, where possible, attempts should be made to preserve and repair the large torn meniscus in younger patients. Indeed, Abrams et al. has shown that there was an increasing number of meniscus repairs being performed in the United States from 2005 to 2011.<sup>10</sup>

The circumferentially oriented deep layers and more radially oriented superficial layers microstructure of the menisci provide stability, as well as convert axial compressive forces, to horizontal hoop stresses, for load transmission and shock absorption.<sup>11,12</sup> The presence of a radial tear defunctions the meniscus and prevents it from fulfilling its role in load transmission and stability. The repair of a radial tear can decrease high contact pressure seen after partial meniscectomy.<sup>13</sup> This shows the theoretical importance of radial meniscus repair. Clinically, the repair of radial meniscus tears has been shown to have improved pain scores and knee outcome scores.<sup>14,15</sup>

Lee et al. has shown that all-inside meniscus devices have equivalent radial meniscus tear biomechanical fixation stability, as compared to the gold-standard inside-out meniscus repair technique.<sup>16</sup> Therefore, the repair of the large displaced radial lateral flap tear can be achieved without the need for additional accessory incisions, which would have been required if inside-out techniques were used. Radial meniscus tears are



**Fig 12.** The arthroscopic photo of the right knee from the anterolateral viewing portal when the knee is in a figure of 4 position, with repair device introduced from the anteromedial working portal. The second vertical “ripstop” stitch (FAST FIX 360; Smith & Nephew) is applied at the posterior horn to the posterior capsule to stabilize the meniscus flap and avoid redisplacement of the flap. The triangle shows the meniscus flap fragment. The pentagon shows the meniscus body. FF: Fast fix 360; LFC, lateral femoral condyle; LTP, lateral tibial plateau.

difficult tears to repair, and other authors have proposed adjunct techniques, such as the ripstop sutures to supplement the usual all-inside meniscus repair techniques to increase the rate of repair success and improve the contact biomechanics.<sup>17-19</sup> Ripstop sutures are used to protect the side-to-side radial repair and to enhance the repair strength.

Other techniques of the meniscus radial tear repair have also been described. Patrick et al. reported the rebar technique of meniscus radial repair. Two vertical and 2 horizontal sutures are applied to repair the radial tear.<sup>20</sup> The horizontal sutures restore the hoop stresses, and the vertical sutures function as ripstop sutures to decrease tension and avoid pulling out. However, with the large displaced flap component, these sets of stitches might not be adequate to prevent flap redisplacement. Additional ripstop stitches over the meniscus flap are

necessary to stabilize the reduced meniscus flap. Another disadvantage of this technique is that it requires a mini-open approach. Takaki et al. reported an all-inside suture technique with a figure of 8 configuration in repairing meniscus radial tear.<sup>21</sup> This technique potentially provides adequate gripping and bundling force without an additional incision. However, the fixation strength has not been tested biomechanically.

There are some limitations in the described all-inside meniscus repair technique. There is a potential risk of injuring the popliteal neurovascular bundle while the posterior horn “ripstop” stitches are applied. The risk could be minimized by setting the correct penetration depth of the all-inside device and avoiding the insertion from the anterolateral portal. The cost of multiple all-inside devices might be high which could increase the patient’s economic burden.

**Table 2.** Tips and Pearls for All-Inside Repair of Complex Radial Meniscus Tear

1. Stable reduction of displaced meniscus fragment
2. Side to side repair across the radial tear on upper meniscus surface—at least 2 or 3 stitches across the radial tear
3. Place one side-to-side suture in the peripheral region and another in the central region of the meniscus.
4. Ripstop stitches from the meniscus to capsule to reduce tension on side-to-side repair of the radial meniscus tear
5. Ripstop stitches should only be placed when there is a minimal gap across radial tear repair site.

## Conclusion

We describe the features to diagnose displaced meniscus flap tear seen as a meniscus comma sign. We highlight the surgical techniques to reduce the displaced flap and repair these tears using all-inside meniscus techniques successfully.

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