



The Meniscal Grammar Signs: Comma and Apostrophe Signs for Characterization of a Displaced Fragment in the Meniscal Recess

Ashley J. Bassett, M.D., Christopher J. Hadley, B.S., Fotios Tjoumakaris, M.D., and Kevin B. Freedman, M.D., M.S.C.E.

Abstract: Vertical flap tears, or parrot beak flap tears, are oblique tears of the meniscus thought to originate as a central radial tear and propagate longitudinally towards the periphery, generating a partially detached unstable fragment that can subsequently displace into the meniscal recess. Although magnetic resonance imaging (MRI) is frequently used to diagnose and characterize meniscus pathology, imaging findings for displaced flap tears are not well described in the literature. The recently published meniscal comma sign describes inferior displacement of a meniscus flap tear into the meniscotibial recess that, when seen on MRI, resembles a comma. In the present article, we define the meniscal apostrophe sign, characterized by superior displacement of a meniscus flap tear into the meniscofemoral recess found on MRI. Displaced fragments in the meniscal recess are crucial to identify, as they often result in significant pain and mechanical symptoms related to tenting of the deep medial collateral ligament, which responds poorly to nonoperative treatment. Misdiagnosis of these unstable flap tears as degenerative meniscus extrusion or isolated progression of osteoarthritis can lead to a delay in treatment.

The meniscus is a crescent-shape wedge of fibrocartilage composed predominantly of type I collagen that is crucial to knee function and long-term joint health. The meniscus functions to increase knee stability, distribute axial load, absorb shock, and provide lubrication and nutrition to the knee joint.¹ The peripheral third of the meniscus is well vascularized by geniculate branches, whereas the inner two-thirds receive nourishment from synovial fluid, which has important implications for healing of meniscus tears.

Meniscus tears are the most common intraarticular knee injury, with a reported incidence rate in physically active populations ranging from 0.33 to 8.27 per 1,000 person-years.^{2,3} In the United States, >1 million meniscal surgeries are performed annually, and arthroscopic partial meniscectomy is the most common procedure performed by orthopaedic surgeons.^{4,5} There has been a recent increase in the number of isolated meniscus repairs without a concomitant increase in meniscectomies, reflecting an increased focus on meniscus preservation.⁶ Selection of the optimal surgical treatment of meniscus tears, including repair versus meniscectomy, depends on appropriate characterization of the tear and correlation with patient symptoms.

Tears of the meniscus are classified by location from anterior to posterior, rim width, and tear pattern.⁷ Patterns of meniscus tears include horizontal or cleavage, vertical or longitudinal, radial, flap, and complex tears. A flap tear arises from propagation of a horizontal or vertical fissure with meniscus detachment in 1 plane, often with displacement of the mobile fragment into the meniscal recess, joint space, or intercondylar notch. These unstable tears are often refractory to conservative management because of persistent pain and mechanical symptoms and tend to require resection of the flap fragment for resolution of symptoms. Proper

From the Department of Orthopaedic Surgery, Rothman Orthopaedic Institute, Thomas Jefferson University (A.J.B., C.J.H., F.T., K.B.F.), Philadelphia, Pennsylvania, U.S.A.; Sidney Kimmel College of Medicine, Thomas Jefferson University (F.T., K.B.F.), Philadelphia, Pennsylvania, U.S.A.

The authors report that they have no conflicts of interest in the authorship and publication of this article. Full ICMJE author disclosure forms are available for this article online, as [supplementary material](#).

Received January 7, 2019; accepted March 10, 2019.

Address correspondence to Kevin B. Freedman, M.D., M.S.C.E., Rothman Institute, Medical Arts Pavilion Ste 200, 825 Old Lancaster Rd, Bryn Mawr, PA 19010, U.S.A. E-mail: Kevin.Freedman@rothmanortho.com

© 2019 by the Arthroscopy Association of North America. Published by Elsevier. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

2212-6287/1926

<https://doi.org/10.1016/j.eats.2019.03.008>



Fig 1. Coronal T2-weighted magnetic resonance image of a right knee showing an inferiorly displaced meniscal fragment with a downward-curved “comma” appearance (arrow).

identification and excision of a displaced tear is crucial to successful treatment, as failure to remove a displaced meniscal fragment is a well-recognized cause of poor outcomes after partial meniscectomy.⁸

Magnetic resonance imaging (MRI) (General Electric 1.5 or 3 XL scanner) is a noninvasive diagnostic tool for assessment of meniscal pathology and can be helpful to identify a displaced flap tear preoperatively. MRI has high sensitivity and specificity for the detection of meniscus tears, ranging from 86% to 94%.⁹ However, a flap tear with a displaced fragment can be more difficult to identify, as the remaining meniscal tissue in the joint space can appear normal without an obvious tear. Jung et al.¹⁰ reported that the sensitivity of MRI for preoperative detection of flap tears with displaced fragments in the meniscotibial recess was only 69% compared with 91% sensitivity for detection of flap tears without displaced fragments. After diagnostic arthroscopy, displaced fragments were identified on postoperative review of the same MR images, with a sensitivity of 93%.¹⁰ Furthermore, flap tears with large fragments displaced into the meniscal recess can be mistakenly characterized as meniscus extrusion, which is often associated with degenerative pathology and is less likely to improve with arthroscopic surgery. Therefore, it is imperative to highlight the unique MRI findings of displaced flap tears in the meniscal recess to improve both the recognition and classification of this tear pattern and guide appropriate surgical treatment.

Many MRI signs have been described in the literature and validated for detection of displaced meniscus tears.

The double posterior cruciate ligament sign, double anterior cruciate ligament sign, double anterior horn sign, and disproportionate posterior horn sign are all associated with meniscus tears with fragment displacement within the femorotibial articulation or intercondylar notch.¹¹ Until recently, there were no specific MRI signs to describe the subset of meniscus tears with displaced fragments in the meniscal recess. The newly coined “meniscal comma sign” represents the MRI finding of an inferiorly displaced vertical flap tear, also known as a parrot beak tear, of the medial meniscus into the meniscotibial recess.¹² Although unstable parrot beak tears can also displace superiorly, there is no radiographic description of a displaced flap tear in the meniscofemoral recess.

The purpose of this article is to review the MRI findings of displaced parrot beak flap tears of the medial meniscus incarcerated in the meniscal recess and to present the “meniscal apostrophe sign”: the MRI finding of a superiorly displaced parrot beak flap tear in the meniscofemoral recess.

Surgical Technique

Preoperative Patient Evaluation

The typical patient with a displaced flap tear of the meniscus is 40-60 years of age. Patients with horizontal cleavage and flap tears tend to be 10-15 years older than patients with vertical and radial tears. Flap tears

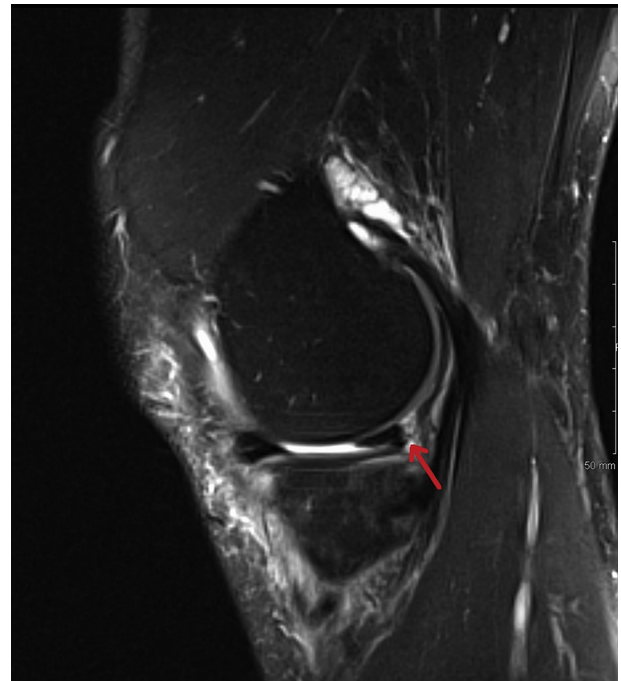


Fig 2. Sagittal T2-weighted magnetic resonance image of a right knee showing an inferiorly displaced meniscal fragment in the meniscotibial recess (arrow).

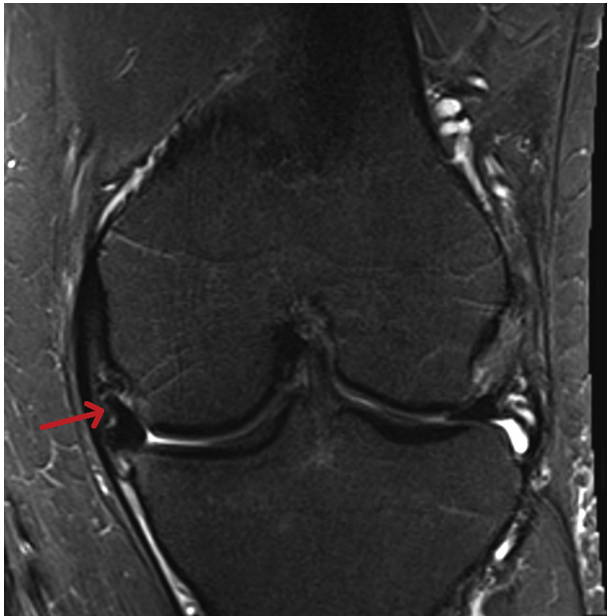


Fig 3. Coronal T2-weighted magnetic resonance image of a left knee showing a superiorly displaced meniscal fragment with an upward-curved “apostrophe” appearance (arrow).

most commonly involve the posterior horn and body of the medial meniscus.¹³ The patient often endorses pain at the medial joint line or just above or below the joint line, depending on the location of the incarcerated flap. Displacement of the tear fragment into the meniscal recess is thought to result in pain by tenting of the deep medial collateral ligament (MCL), increasing traction at the meniscocapsular junction. The pain tends to be more severe than a nondisplaced meniscus tear and often worsens with standing. Intermittent knee swelling and mechanical symptoms, such as catching, giving way, or locking of the knee, are frequently associated with unstable flap tears.¹⁴

Physical examination may reveal a knee effusion and painful range of motion, particularly with hyperflexion and hyperextension. Localized joint line tenderness is the most sensitive examination finding and is found in nearly all patients with flap tears displaced into the meniscal recess.¹¹ Provocative tests, such as the McMurray’s test, often provoke pain and may reveal a positive click.

Plain radiographs of the knee may be normal or may reveal mild to moderate joint space narrowing. MRI findings of a displaced flap tear in the meniscal recess are best visualized on coronal T2-weighted images but can be seen on sagittal TE images as well, particularly in cases of posteromedial displacement. The meniscal comma sign (Figs 1 and 2) is characterized by inferior displacement of the torn meniscal fragment into the meniscotibial recess, producing the typical downward-curved appearance resembling a comma.¹² There is truncation of the meniscal body remaining in the

femorotibial compartment. Conversely, the meniscal apostrophe sign (Fig 3) is illustrated by superior displacement of the torn meniscal flap into the meniscoc femoral recess, producing an upward-curved appearance resembling an apostrophe. These are both in contrast to meniscus extrusion, in which the entire meniscus body displaces beyond the tibial margin, seen in meniscal root tears and large complex tears in degenerative knees (Fig 4). Surgical pearls and pitfalls of diagnosis and treatment of meniscus comma and apostrophe fragments are detailed in Table 1.

Arthroscopic Partial Meniscectomy

Although displaced flap tears of the meniscus tend to have a degenerative etiology and occur in older individuals, the mechanical symptoms and intractable pain caused by the entrapped fragment within the meniscal recess do not resolve with the conservative treatment usually prescribed to patients with traditional degenerative meniscus tears, including physical therapy and intra-articular injections. Conversely, unstable flap tears are more likely to respond well to surgical treatment with arthroscopic partial meniscectomy than conventional degenerative meniscus tears, because of their distinct preoperative mechanical symptoms.

Knee arthroscopy is performed under general anesthesia with a 4-mm-diameter, 30° arthroscope. Instruments are introduced to the knee via anteromedial and anterolateral portals. After a systematic diagnostic arthroscopy, the medial and lateral meniscus are carefully assessed along the superior and inferior surfaces with use of a 4-mm probe. In the case of an inferiorly displaced flap tear, the torn fragment is poorly visualized, as it is tucked beneath the meniscus and displaced medially out of the joint space (Fig 5), lodged between

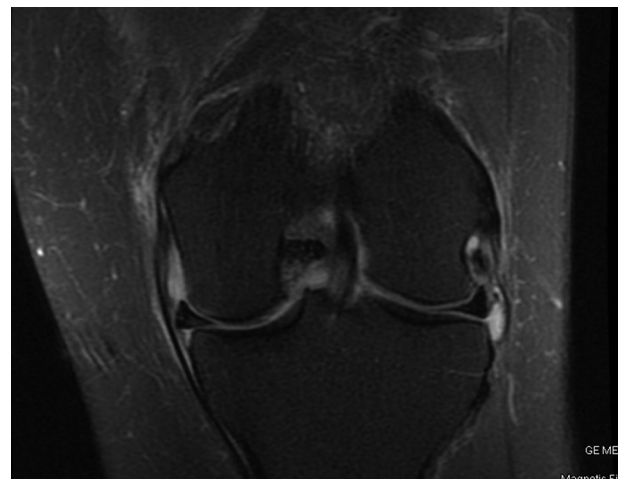


Fig 4. Coronal T2-weighted magnetic resonance image of a left knee showing extrusion of the medial meniscus in the setting of a meniscal root tear. Note the absence of any meniscal flap in the superior or inferior meniscal recess.

Table 1. Pearls and Pitfalls of Diagnosis and Surgical Treatment of Meniscus Comma and Apostrophe Fragments

Pearls	Pitfalls
• If truncation of the meniscus is noted on MRI, the meniscofemoral and meniscotibial gutters should be carefully inspected for a displaced flap fragment. • The meniscus should be thoroughly probed along the superior and inferior surfaces to assess for a displaced flap fragment. • The displaced flap fragment should be reduced back to the tibiofemoral joint space before debridement to ensure the proper level of resection and preserve as much meniscus as possible. • Change viewing and working portals to achieve proper visualization of the tear and adequate access for resection.	• Failure to identify a displaced flap fragment in the meniscofemoral or meniscotibial gutter on MRI can lead to a delay in appropriate surgical treatment. • Failure to identify and completely resect an unstable meniscal flap fragment can result in persistent mechanical symptoms and pain.

MRI, magnetic resonance imaging.

the tibial plateau and the deep MCL. Using the probe, the medial meniscus is lifted to visualize the exiting flap tear. The flap fragment is then elevated along the medial tibial plateau and reduced back onto the joint surface (Video 1, Fig 6). With a superiorly displaced flap tear, the torn fragment can be visualized flipped up and exiting the joint space along the surface of the meniscus, wedged between the medial femoral condyle and the deep MCL (Fig 7). The displaced flap is manipulated with the probe and pulled inferiorly to reduce the fragment back into the joint space (Video 1, Fig 8). After reduction of the flap fragment, a partial meniscectomy is then performed with a combination of arthroscopic biters (Arthrex, Naples, FL) and shaver (Smith & Nephew, Andover, MA). The previously dislodged meniscus flap is resected until a stable rim of healthy tissue is obtained (Fig 9). Advantages and disadvantages of surgical treatment of meniscus comma and apostrophe fragments are highlighted in Table 2.

Discussion

Vertical flap tears, or parrot beak tears, are oblique tears of the meniscus that are thought to originate as a radial tear at the inner rim and propagate longitudinally towards the periphery, generating a partially detached fragment. This tear pattern commonly involves the medial meniscus at the body and posterior horn. The unstable flap can subsequently displace out of the compartment to the meniscal recess or intercondylar notch. Displacement of the flap inferiorly to the meniscotibial recess is more common than superior displacement to the meniscofemoral recess.^{15,16} Instability and migration of the fragment results in pain and mechanical symptoms that are often recalcitrant to conservative treatment. Failure to identify this specific tear pattern and presence of a displaced recess fragment on MRI can result in an unnecessary delay in treatment. The purpose of this article is to review the MRI signs of displaced flap

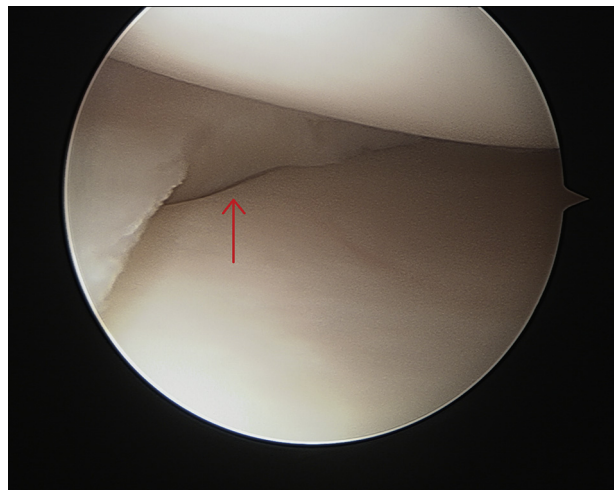


Fig 5. Arthroscopic image from the anterolateral viewing portal in a left knee showing the medial meniscus flap tear displaced beneath the intact meniscus, exiting the joint space medially into the inferior meniscal recess (arrow).

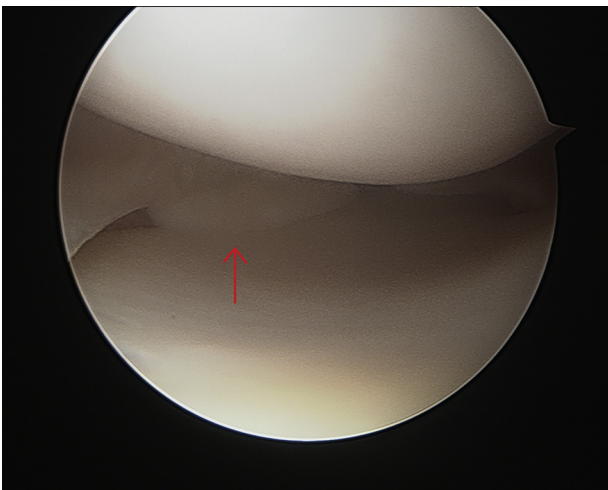


Fig 6. Arthroscopic image from the anterolateral viewing portal in a left knee showing the displaced medial meniscus fragment after reduction from the inferior meniscotibial gutter onto the joint surface with a probe.

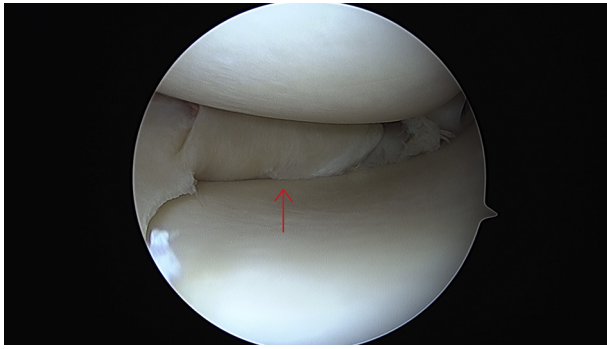


Fig 7. Arthroscopic image from the anterolateral viewing portal in a left knee showing the medial meniscus flap tear displaced above the intact meniscus, exiting the joint space medially into the superior meniscal recess.

tears in the meniscal recess and improve recognition of this tear pattern.

The meniscal comma sign is a recently described MRI finding of an inferiorly displaced parrot beak flap tear of the medial meniscus into the meniscotibial recess, which has a downward-curved appearance resembling a comma.¹² Similarly, the meniscal apostrophe sign defined in this article is a previously undescribed MRI finding of a superiorly displaced parrot beak flap tear of the medial meniscus into the meniscomfemoral recess. Vande Berg et al.¹⁷ investigated the use of MRI for identification of displaced meniscus tears with recess fragments and found a sensitivity of 71% and specificity of 98%. The lower sensitivity for detection of recess fragments compared with other meniscus tear patterns previously reported may be due to the smaller size of flap fragments, the dynamic nature of unstable flap tears, and difficulty differentiating degenerated meniscal tissue from osteophytes, ligament fragments, and loose bodies. Vande Berg et al.¹⁷ also reported that the absent bow tie sign, an indication of tissue loss from the free edge of the meniscus, was found to enable the detection of displaced meniscus flap tears in the intercondylar notch and meniscal recess on MRI. The absent

bow tie sign does not depend on the displacement pattern of the meniscal fragment, and presence of this sign should prompt close inspection of the meniscal recess on MRI.

Appropriate diagnosis and management of symptomatic displaced flap tears of the meniscus may be further complicated by the presence of associated articular cartilage loss. Salem et al.¹² reported that 90.7% of patients with a meniscal comma sign had an associated chondral defect. Unstable meniscus tears are more prone to articular cartilage injury than stable tears, likely because of the loss of meniscus volume with fragment displacement out of the joint space and subsequent increased focal contact pressures experienced by the hyaline cartilage and underlying subchondral bone.¹⁸ Despite underlying osteoarthritis, arthroscopic surgical treatment of these unstable meniscus tears is recommended. The characteristic symptoms of displaced flap tears, including exquisite pain from tenting of the deep MCL by the entrapped recess fragment and mechanical catching of the knee, are distinct from symptoms of osteoarthritis and are successfully treated with arthroscopic surgery.

Patients who present with either a meniscal comma sign or a meniscal apostrophe sign, indicative of an unstable flap tear of the meniscus with displacement into the meniscal recess, benefit from surgical treatment to remove the offending fragment incarcerated deep in the MCL. Surgical options for displaced meniscus tears include partial meniscectomy and meniscus repair. Unstable meniscus flap tears with entrapped recess fragments tend to be complex tears located in the nonvascular region of the meniscus, have poor quality of the flap tissue after reduction, have the potential to revert back to the displaced configuration, and occur in older patients with less healing potential for repair. For these reasons, the authors prefer the use of partial meniscectomy to resect the displaced fragment and debride the remaining meniscus to a stable and well-contoured rim.

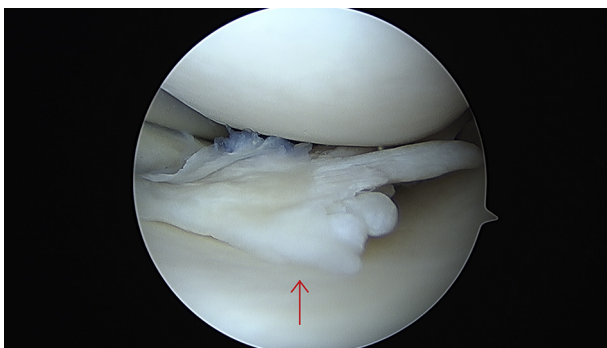


Fig 8. Arthroscopic image from the anterolateral viewing portal in a left knee showing the displaced medial meniscus fragment after reduction from the superior meniscomfemoral gutter onto the joint surface with a probe.

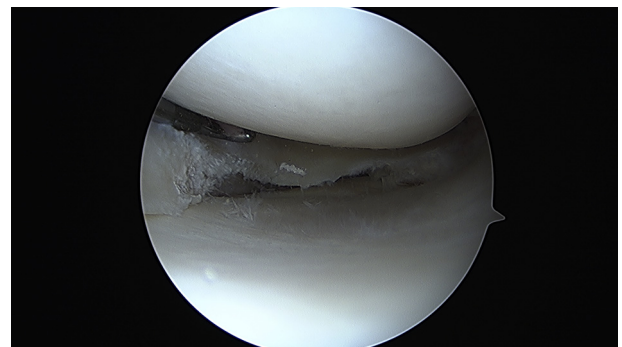


Fig 9. Arthroscopic image from the anterolateral viewing portal in a left knee showing the medial meniscus after partial meniscectomy of the previously displaced flap tissue.

Table 2. Advantages and Disadvantages of Surgical Treatment of Meniscus Comma and Apostrophe Fragments

Advantages	Disadvantages
• Quick and reliable pain relief • Detailed intraarticular examination for assessment of concomitant pathology (e.g., chondral injury)	• Basic arthroscopy knowledge required • Risks associated with knee arthroscopy, including iatrogenic injury to articular cartilage if instruments not handled carefully, postoperative stiffness, and infection • Incomplete resection of displaced meniscal fragment can result in persistent symptoms

Conclusions

Future studies are required to clarify the association of these specific MRI signs and clinical symptoms. Research focused on mid- and long-term outcomes after arthroscopic partial meniscectomy of displaced flap tears is necessary to elucidate the true benefit of surgical treatment in these patients, particularly in the setting of osteoarthritis.

References

1. Fox AJ, Bedi A, Rodeo SA. The basic science of human knee menisci: Structure, composition, and function. *Sports Health* 2012;4:340-351.
2. Lauder TD, Baker SP, Smith GS, Lincoln AE. Sports and physical training injury hospitalizations in the army. *Am J Prev Med* 2000;18:118-128.
3. Jones JC, Burks R, Owens BD, Sturdivant RX, Svoboda SJ, Cameron KL. Incidence and risk factors associated with meniscal injuries among active-duty US military service members. *J Athl Train* 2012;47:67-73.
4. Cook JL. The current status of treatment for large meniscal defects. *Clin Orthop Relat Res* 2005;435:88-95.
5. Cullen KA, Hall MJ, Golosinskiy A. Ambulatory surgery in the United States, 2006. *Natl Health Stat Rep* 2009;11:1-25.
6. Abrams GD, Frank RM, Gupta AK, Harris JD, McCormick FM, Cole BJ. Trends in meniscus repair and meniscectomy in the United States, 2005-2011. *Am J Sports Med* 2013;41:2333-2339.
7. Anderson AF, Irrgang JJ, Dunn W, et al. Interobserver reliability of the International Society of Arthroscopy, Knee Surgery and Orthopaedic Sports Medicine (ISAKOS) classification of meniscal tears. *Am J Sports Med* 2011;39:926-932.
8. Eastwood DM. The failures of arthroscopic partial meniscectomy. *Injury* 1985;16:587-590.
9. Mackenzie R, Palmer CR, Lomas DJ, Dixon AK. Magnetic resonance imaging of the knee: Diagnostic performance statistics. *Clin Radiol* 1996;51:251-257.
10. Jung M, Lee DH, Kim SJ, et al. Preoperative diagnosis and treatment outcomes of incarcerated inferiorly displaced flap tear of the medial meniscus: Comparison between flap tears with and without incarcerated fragment. *BioMed Res Int* 2018;2018:5941057.
11. Chen HC, Hsu CY, Shih TT, Huang KM, Li YW. MR imaging of displaced meniscal tears of the knee: Importance of a "disproportional posterior horn sign." *Acta Radiol* 2001;42:417-421.
12. Salem HS, Carter AH, Shi WJ, et al. The meniscal comma sign: Characterization and treatment of a displaced fragment in the meniscotibial recess. *Orthopedics* 2018;41:e442-e444.
13. Jarraya M, Roemer FW, Englund M, et al. Meniscus morphology: Does tear type matter? A narrative review with focus on relevance for osteoarthritis research. *Semin Arthritis Rheum* 2017;46:552-561.
14. Kamimura M, Umehara J, Takahashi A, Aizawa T, Itoi E. Medial meniscus tear morphology and related clinical symptoms in patients with medial knee osteoarthritis. *Knee Surg Sports Traumatol Arthrosc* 2015;23:158-163.
15. Lance V, Heilmeier UR, Joseph GB, Steinbach L, Ma B, Link TM. MR imaging characteristics and clinical symptoms related to displaced meniscal flap tears. *Skeletal Radiol* 2015;44:375-384.
16. Le PH, Charousset C, Duranthon LD, et al. Magnetic resonance imaging of medial meniscus tears with displaced fragment in the meniscal recesses. *Rev Chir Orthop Reparatrice Appar Mot* 2007;93:357-363.
17. Vande Berg BC, Malghem J, Poilvache P, Maldague B, Lecouvet FE. Meniscal tears with fragments displaced in notch and recesses of knee: MR imaging with arthroscopic comparison. *Radiology* 2005;234:842-850.
18. Zamber RW, Teitz CC, McGuire DA, Frost JD, Hermanson BK. Articular cartilage lesions of the knee. *Arthroscopy* 1989;5:258-268.