Wrisberg-Variant Discoid Lateral Meniscus: Current Concepts, Treatment Options, and Imaging Features With Emphasis on Dynamic Ultrasonography

Jean Jose, DO, Leonard T. Buller, MD, Sebastian Rivera, BS, Jaime A. Carvajal Alba, MD, and Michael Baraga, MD

Abstract

Discoid lateral menisci represent a range of morphologic abnormalities of the lateral meniscus. The Wrisberg-variant discoid lateral meniscus is an unstable type that lacks posterior ligament attachments, resulting in "snapping knee syndrome." Abnormally mobile discoid lateral menisci are difficult to diagnose both clinically and with traditional static imaging, such as magnetic resonance imaging.

In this article, we discuss the pathophysiology, clinical features, imaging findings, and treatment options for Wrisberg-variant discoid lateral menisci. We focus on the role of dynamic ultrasonography in revealing lateral meniscal subluxation during provocative maneuvers.

First described by Young[1] in 1889, discoid lateral meniscus covers a spectrum of meniscal disorders of varying morphology and stability. Determining the true incidence of discoid lateral menisci is difficult because of the large number of asymptomatic cases, though published estimates range from 1% to 17%[2-4] of the population, with bilaterality occurring in up to 20%.[5] The most commonly used classification system for discoid lateral menisci—reported by Watanabe and colleagues[6]—describes 3 types of meniscal pathology based on stability to probing and arthroscopic appearance. Type I is stable to probing, has normal tibial attachments, and is "block-shaped," with increased thickness spanning the entire lateral tibial plateau. Type II is stable to probing and has normal tibial attachments as well, but covers less than 80% of the lateral tibial plateau. Type III (the Wrisberg variant) is unstable because it lacks a posterior meniscotibial (coronary) ligament and has only 1 posterior attachment, the posterior meniscofemoral ligament, or Wrisberg ligament. Wrisberg-variant discoid lateral menisci are rare; estimated incidence is 0.2%.[7]

Pathophysiology

The normal lateral meniscus, with its flat tibial and concave femoral surfaces, is crucial to load transmission across the knee joint.[8] Embryologically differentiating from mesenchymal tissue within the limb bud during fetal development, a normal lateral meniscus never has a discoid shape.[8-10] The implication, that discoid lateral menisci represent a congenital anomaly, is further supported by ultrastructural studies involving transmission electron microscopy. These studies have demonstrated that discoid menisci have fewer collagen fibers with a more disorganized course compared with normal menisci.[11]

With considerable variability, the average normal lateral meniscus is 12 mm wide and 4 mm thick.[2] The blood supply to the lateral meniscus recedes during growth, with only the peripheral third remaining in adulthood[8] and the inner two-thirds receiving nutrients by diffusion from the intra-articular fluid.[5] In comparison, discoid lateral menisci often have poorer vascularity than normal menisci and therefore are more susceptible to tears.[8,12,13]

Ligamentous attachments to the lateral meniscus include the lateral meniscocapsular ligament, which attaches to the lateral joint capsule. In addition, 70% to 100% of people have accessory meniscofemoral ligaments, which insert anterior (ligament of Humphrey) or posterior (ligament of Wrisberg) to the posterior cruciate ligament.[14] There are no ligamentous attachments at the popliteus hiatus or lateral collateral ligament, allowing for 9- to 11-mm excursion of the lateral meniscus during knee flexion and extension.[3] Morphologically, the lack of a meniscotibial (coronary) ligament in the setting of a discoid lateral meniscus (Wrisberg variant) results in meniscal hypermobility. During knee range of motion, compressive forces between the femoral condyle and the tibial plateau spread through the peripheral portion of the meniscus and, without ligamentous attachments, allow it to displace anteriorly into the femoral intercondylar notch. This displacement results in impingement between the femur and the tibia[15-18] and leads to the characteristic symptoms of "snapping knee syndrome."[10]

Authors' Disclosure Statement: The authors report no actual or potential conflict of interest in relation to this article.

Clinical Features

Snapping knee syndrome was first described by Kroiss[19] in 1910.[5] Multiple authors have described patients' primary complaints as pain, swelling, locking, and a palpable or visible snap at terminal extension. Sudden movement of a soft-tissue structure across a bony prominence during a provocative maneuver is the source of the snapping. The syndrome has many etiologies. Extra-articular causes of lateral snapping knee syndrome include iliotibial band friction syndrome, soft-tissue tumors, hypermobile popliteus tendons, and abnormal anterior insertions of the biceps femoris tendons.[20,21] Common intra-articular etiologies include ganglion, synovial, and parameniscal cysts; intra-articular loose bodies; lateral meniscal tears; and discoid lateral menisci.[22] Patients with discoid lateral menisci often present with knee pain, popping, range-of-motion limitations, and snapping.[23,24] However, the symptoms are quite variable and depend on type of discoid meniscus, presence of a tear, and stability of the rim.[2,7,18]

Obtaining a thorough history is essential in evaluating patients with suspected discoid lateral menisci. Physical examination should include evaluation of the lateral joint line for bulges, effusion, and tenderness. Patients may experience knee pain with flexion to 30° to 40° when varus or valgus stress (modified McMurray maneuver) is applied.[10] In addition, a clunk may be appreciated with McMurray testing as a result of subluxation of the unstable lateral meniscus.[10] The contralateral knee should be carefully evaluated, given the frequency of bilateral discoid menisci.[10]

The figure-4 test, a maneuver developed by LaPrade and Konowalchuk[25] to detect peripheral meniscal tears or tears of the popliteomeniscal fascicles, is performed with the patient in the supine position, with the foot of the affected extremity placed on the contralateral knee. Normally, the popliteus tendon pulls the meniscus out of the joint when the knee is brought into the figure-4 position. However, without popliteomeniscal fascicles, the meniscus subluxes into the joint and becomes impinged. With the patient in the figure-4 position, reproduction of symptoms over the lateral joint line is a positive test and suggests peripheral meniscal tears and/or tears or absence of the popliteomeniscal fascicles.[25]

In the series reported by LaPrade and Konowalchuk,[25] all of the patients who experienced symptoms during figure-4 testing were found, on arthroscopic examination, to have lateral meniscal hypermobility caused by tears of the popliteomeniscal fascicles. Despite the success of those authors in using the figure-4 technique for diagnosis, others have reported that the accuracy of the clinical examination (vs arthroscopy) in diagnosing Wrisberg-variant discoid lateral menisci ranges from 29% to 93%.[5,26,27] This emphasizes the importance of diagnostic imaging in the work-up of patients with suspected Wrisberg-variant discoid lateral menisci.

Imaging Features

Radiography

In 1964, Picard and Constantin[28] recommended that patients with suspected discoid lateral menisci undergo standard anteroposterior, lateral, tunnel, and skyline radiographs as part of the diagnostic work-up. In patients with discoid lateral menisci, plain film radiographs are often normal[10] but may demonstrate lateral femoral condyle squaring, widening of the lateral joint line, lateral tibial plateau cupping, tibial eminence hypoplasia, and fibular head elevation.[5,29] Plain radiography is unreliable, however, and patients often require advanced imaging, such as knee magnetic resonance imaging (MRI).[10]

Magnetic Resonance Imaging

Because it clearly depicts soft-tissue structures, MRI is widely used to diagnose musculoskeletal pathology in and around the knee. Criteria for the diagnosis of discoid menisci include meniscal width of 15 mm or more, ratio of minimum meniscal width to maximum tibial width on coronal slice of more than 20%, ratio of sum of width of both lateral horns to meniscal diameter (on sagittal slice showing maximum meniscal diameter) of more than 75%, and continuity of anterior and posterior horns on at least 3 consecutive sagittal slices (bow tie sign).[5,30,31] Even in the presence of a tear, the described ratios have sensitivity and specificity of 95% and 97% in detecting discoid lateral menisci.[30]

However, the Wrisberg variant, which may consist of only a thickened portion of the posterior horn, is often more difficult to diagnose using these criteria and can even appear normal on MRI.[26,32] In a series by Neuschwander and colleagues,[7] none of the Wrisberg-variant menisci had a true discoid shape, suggesting that the size of the lateral meniscus may appear normal in affected patients. Appropriate positioning during MRI evaluation of patients suspected of having the Wrisberg variant was emphasized by Moser and colleagues,[33] who described a case of discoid lateral meniscus not observable on initial MRI but visible on MRI performed with the affected knee extended in the locked position.

The unstable lateral meniscus may be seen subluxed anteriorly or laterally because of lack of posterior attachments. A deficiency of normal popliteomeniscal fascicles and coronary ligaments is represented by a high T2 signal interposed between the discoid lateral meniscus and the posterior joint capsule, simulating a vertical peripheral tear and suggesting presence of the Wrisberg variant (**Figures 1A–1C**). In addition, the posterior horn of the enlarged discoid lateral meniscus may connect to a prominent and thickened meniscofemoral ligament of Wrisberg. Despite these characteristic imaging features, some studies have found low sensitivity of MRI in the diagnosis of Wrisberg-variant discoid lateral menisci.[26]

Ultrasonography

There is a growing interest in using ultrasonography in the diagnosis of Wrisberg-variant discoid lateral menisci because of its availability, multiplanar capability, and lower cost compared with MRI. Ultrasonographic criteria for the diagnosis of discoid menisci include absence of normal triangular shape, presence of abnormally elongated and thickened meniscal tissue, and demonstration of a heterogeneous central pattern.[5] Through use of a high-resolution probe, which better fits the

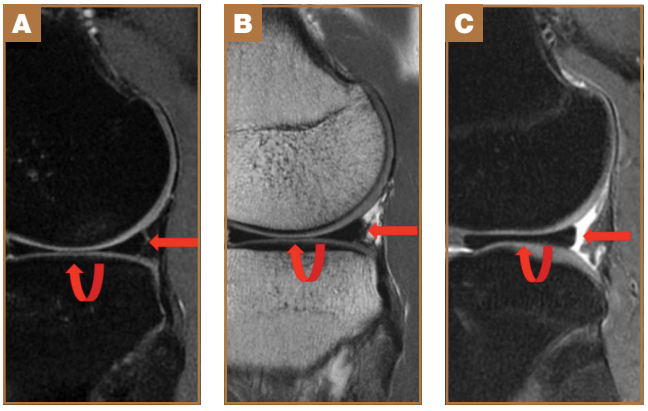

Figure 1. Sagittal proton density imaging (A) with and (B) without fat suppression shows normal lateral meniscus (curved arrows) and normal popliteomeniscal fascicles (straight arrows). (C) Sagittal proton density imaging with fat suppression shows elongated discoid lateral meniscus absent posterior capsular attachments, reflecting Wrisberg variant (straight arrow indicates lack of popliteomeniscal fascicles).

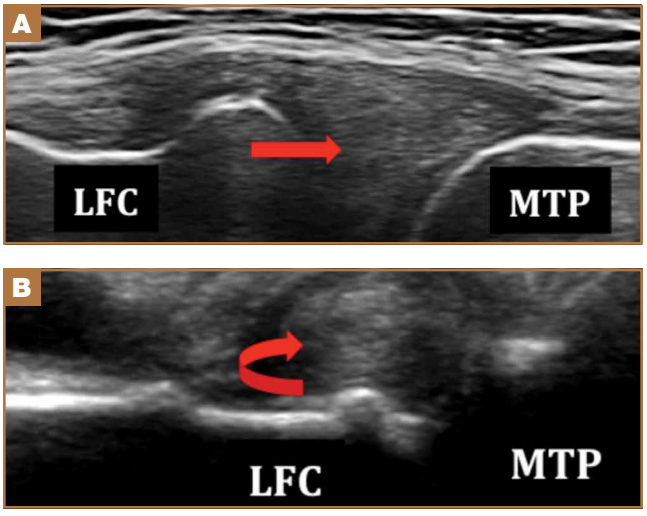

Figure 2. Longitudinal-axis ultrasonographic images of lateral knee compartment at rest and during provocative maneuver. (A) At rest, hypermobile Wrisberg-variant discoid lateral meniscus is anatomically situated in lateral compartment (arrow). (B) During provocative maneuver, Wrisberg-variant discoid lateral meniscus extrudes into lateral gutter (curved arrow), causing "snapping knee syndrome." Abbreviations: LFC, lateral femoral condyle; MTP, medial tibial plateau.

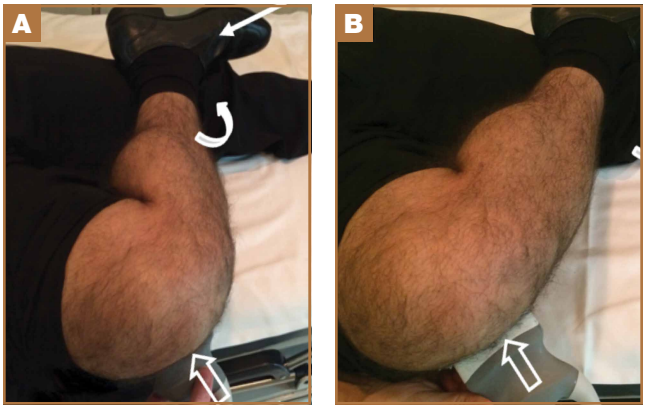

Figure 3. Ultrasonography figure-4 test. (A) Combination of foot of affected extremity (closed arrow) placed on contralateral knee (curved arrow) resembles numeral 4. (B) Linear transducer (open arrow) placed in lateral joint line. In symptomatic patient, this results in clicking, snapping, and/or pain along lateral joint line, and lateral meniscus is noted sonographically to extrude into lateral gutter.

anatomical concavity of the popliteal fossa, a positive predictive value of 95% and a negative predictive value of 100% have been reported for ultrasonography in the diagnosis of meniscal tears.[34]

Perhaps the main advantage of ultrasonography is the possibility of performing a dynamic study to evaluate the extrusion of the meniscus into the lateral gutter and to correlate this with knee snapping (**Figures 2A, 2B**).[35] One technique for sonographic evaluation of a hypermobile lateral meniscus involves placing the patient supine with the high-resolution (9 or 12 MHz) linear transducer along the lateral knee joint line. The patient is then asked to place the foot of the affected extremity on the contralateral knee; the combination resembles the numeral 4 (figure-4 test) (**Figures 3A, 3B**). In a symptomatic patient, this results in clicking, snapping, and/or pain along the lateral joint line, and the lateral meniscus is noted sonographically to extrude into the lateral gutter (**Figure 2B**), either the result of torn popliteomeniscal fascicles or the increased meniscal mobility of Wrisberg variants.

The main drawback of ultrasonography is operator dependence. As clinicians become more familiar with ultrasonography, dynamic ultrasonography should be used for what is often a difficult diagnosis both clinically and with nondynamic imaging.

Management

The historical treatment for symptomatic discoid lateral menisci, open total meniscectomy,[5,7,15,36] is no longer performed, as studies have shown it increases contact stresses proportional to the amount of meniscus removed, with up to a 235% increase after total meniscectomy,[37] predisposing patients to early degenerative changes and osteoarthritis.[38-41]

With an appreciation of the role of menisci as load distributors and joint stabilizers in cartilage nutrition, current treatments aim to preserve as much stable meniscal tissue as possible.[5] Surgical management of Wrisberg-variant discoid lateral menisci involves posterior stabilization with or without saucerization.[7,33,42] The goal of arthroscopic saucerization is to preserve healthy tissue and create a stable remaining meniscus (6-8 mm in width)[2,7,43,44] that provides adequate shock absorption without retearing.[10] Wrisberg-variant discoid menisci can be stabilized with use of all-inside sutures from the meniscus to the joint capsule (**Figures 4A–4F**) when there is sufficient residual meniscus to allow for suture fixation to the posterior capsule after débridement. In contrast, some prefer an inside-

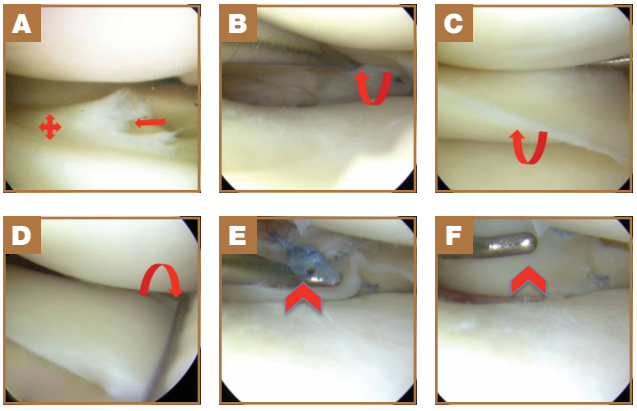

Figure 4. Intraoperative arthroscopic images. (A) Discoid lateral meniscus (cross) with mild fraying of inner margin (straight arrow). (B–D) Unstable Wrisberg-variant discoid lateral meniscus with deficiency of posterior capsular attachments and abnormal mobility on probing (curved arrows). (E, F) Suture repair and reattachment of lateral meniscus with posterior capsular and resultant stability on probing (chevrons).

out technique, as described by Neuschwander and colleagues,[7] with inclusion of a mini-open approach. Any meniscal tears are addressed at time of surgery, either by partial meniscectomy or repair. Relative indications for meniscal repair include longitudinal, vertical, nondegenerative tears that are within 3 mm of the periphery (vascular zone) and are less than 3 cm in length.[45] However, the majority of tears in adults are degenerative cleavage tears outside the vascular zone and therefore not amenable to repair.[45,46] Before surgery, patients treated with stabilization with or without saucerization are prescribed partial weight-bearing in a hinged knee brace with gradual range of motion to 90° by 6 weeks and return to sports in 3 to 4 months.

Clinical Results

As has been consistently demonstrated, the long-term outcomes of total meniscectomy are poor function[39,40,47] and radiographic evidence of lateral compartment arthritis.[48] Patients who previously underwent total meniscectomy should be offered meniscal allograft transplantation, as it may offset the increased peak local contact pressures in the lateral compartment[10] and improve function.[49]

With an appreciation for the importance of meniscus preservation, more recent studies have found encouraging results for arthroscopic saucerization and stabilization of Wrisberg-variant discoid lateral menisci. For example, Woods and Whelan[44] reported excellent results in 75% of patients at 37.5-month follow-up after open repair of discoid lateral menisci lacking posterior attachments. In another study, by Neuschwander and colleagues,[7] 4 of 6 patients who underwent arthroscopic repair of unstable discoid lateral menisci without posterior coronary ligaments had excellent outcomes. Although these studies demonstrated symptom resolution and lack of radiographic evidence of degenerative changes at midterm follow-up,[50] additional long-term studies should be performed to determine whether saucerization and stabilization prevent the onset of lateral compartment osteoarthritis.

Conclusion

Abnormally mobile discoid lateral menisci can result in painful lateral snapping knee syndromes but are often challenging to diagnose clinically and with traditional static imaging. Dynamic ultrasonography with provocative maneuvers can reveal lateral meniscal subluxation, which often cannot be appreciated on MRI, allowing for timely stabilization and symptom resolution.

Dr. Jose is Associate Professor of Clinical Radiology, Director of Imaging in Sports Medicine Clinic, and Faculty in Musculoskeletal Imaging Section, Department of Radiology, University of Miami Miller School of Medicine, Miami, Florida. Dr. Buller is Resident Physician, Department of Orthopaedic Surgery, University of Miami/Jackson Memorial Hospital, Miami, Florida. Mr. Rivera is a medical student, University of Miami Miller School of Medicine, Miami, Florida. Dr. Carvajal Alba is Resident Physician, Department of Orthopaedic Surgery, University of Miami/Jackson Memorial Hospital, Miami, Florida. Dr. Baraga is Assistant Professor of Orthopaedic Surgery and Faculty in Sports Medicine Clinic, Department of Orthopaedic Surgery, University of Miami Miller School of Medicine, Miami, Florida.

Address correspondence to: Leonard T. Buller, MD, Department of Orthopaedic Surgery, University of Miami, 92 SW 3rd St, Unit 2002, Miami, FL 33130 (tel, 216-780-6534; e-mail, l.buller@med.miami.edu).

Am J Orthop. 2015;44(3):135-139.

References

1. Young RB. The external semilunar cartilage as a complete disc. In: Cleland J, Mackey JY, Young RB, eds. *Memoirs and Memoranda in Anatomy*. London, England: Williams & Norgate; 1889:179.
2. Jordan MR. Lateral meniscal variants: evaluation and treatment. *J Am Acad Orthop Surg*. 1996;4(4):191-200.
3. Greis PE, Bardana DD, Holmstrom MC, Burks RT. Meniscal injury: I. Basic science and evaluation. *J Am Acad Orthop Surg*. 2002;10(3):168-176.
4. Ikeuchi H. Arthroscopic treatment of the discoid lateral meniscus. Technique and long-term results. *Clin Orthop*. 1982;(167):19-28.
5. Yaniv M, Blumberg N. The discoid meniscus. *J Child Orthop*. 2007;1(2):89-96.
6. Watanabe M, Takeda S, Ikeuchi H. *Atlas of Arthroscopy*. Tokyo, Japan: Igaku-Shoin; 1978.
7. Neuschwander DC, Drez D Jr, Finney TP. Lateral meniscal variant with absence of the posterior coronary ligament. *J Bone Joint Surg Am*. 1992;74(8):1186-1190.
8. Clark CR, Ogden JA. Development of the menisci of the human knee joint. Morphological changes and their potential role in childhood meniscal injury. *J Bone Joint Surg Am*. 1983;65(4):538-547.
9. Kaplan EB. Discoid lateral meniscus of the knee joint; nature, mechanism, and operative treatment. *J Bone Joint Surg Am*. 1957;39(1):77-87.
10. Kramer DE, Micheli LJ. Meniscal tears and discoid meniscus in children: diagnosis and treatment. *J Am Acad Orthop Surg*. 2009;17(11):698-707.
11. Atay OA, Pekmezci M, Doral MN, Sargon MF, Ayvaz M, Johnson DL. Discoid meniscus: an ultrastructural study with transmission electron microscopy. *Am J Sports Med*. 2007;35(3):475-478.
12. Nathan PA, Cole SC. Discoid meniscus. A clinical and pathologic study. *Clin Orthop*. 1969;(64):107-113.
13. Good CR, Green DW, Griffith MH, Valen AW, Widmann RF, Rodeo SA. Arthroscopic treatment of symptomatic discoid meniscus in children: classification, technique, and results. *Arthroscopy*. 2007;23(2):157-163.
14. Harner CD, Xerogeanes JW, Livesay GA, et al. The human posterior cruciate ligament complex: an interdisciplinary study. Ligament morphology and biomechanical evaluation. *Am J Sports Med*. 1995;23(6):736-745.
15. Smillie IS. The congenital discoid meniscus. *J Bone Joint Surg Br*. 1948;30(4):671-682.
16. Yoo WJ, Choi IH, Chung CY, et al. Discoid lateral meniscus in children: limited knee extension and meniscal instability in the posterior segment. *J Pediatr Orthop*. 2008;28(5):544-548.

17. Simonian PT, Sussmann PS, Wickiewicz TL, et al. Popliteomeniscal fasciculi and the unstable lateral meniscus: clinical correlation and magnetic resonance diagnosis. *Arthroscopy*. 1997;13(5):590-596.
18. Dickhaut SC, DeLee JC. The discoid lateral-meniscus syndrome. *J Bone Joint Surg Am*. 1982;64(7):1068-1073.
19. Kroiss F. Die Verletzungen der Kniegelenkoszwischenknorpel und ihrer Verbindungen. *Beitr Klin Chir*. 1910;66:598-801.
20. Lokiec F, Velkes S, Schindler A, Pritsch M. The snapping biceps femoris syndrome. *Clin Orthop*. 1992;(283):205-206.
21. Cooper DE. Snapping popliteus tendon syndrome. A cause of mechanical knee popping in athletes. *Am J Sports Med*. 1999;27(5):671-674.
22. Liu PC, Chen CH, Huang HT, et al. Snapping knee symptoms caused by an intra-articular ganglion cyst. *Knee*. 2007;14(2):167-168.
23. Bellier G, Dupont JY, Larrain M, Caudron C, Carlioz H. Lateral discoid menisci in children. *Arthroscopy*. 1989;5(1):52-56.
24. Washington ER 3rd, Root L, Liener UC. Discoid lateral meniscus in children. Long-term follow-up after excision. *J Bone Joint Surg Am*. 1995;77(9):1357-1361.
25. LaPrade RF, Konowalchuk BK. Popliteomeniscal fascicle tears causing symptomatic lateral compartment knee pain: diagnosis by the figure-4 test and treatment by open repair. *Am J Sports Med*. 2005;33(8):1231-1236.
26. Kocher MS, DiCanzio J, Zurakowski D, Micheli LJ. Diagnostic performance of clinical examination and selective magnetic resonance imaging in the evaluation of intraarticular knee disorders in children and adolescents. *Am J Sports Med*. 2001;29(3):292-296.
27. Stanitski CL. Correlation of arthroscopic and clinical examinations with magnetic resonance imaging findings of injured knees in children and adolescents. *Am J Sports Med*. 1998;26(1):2-6.
28. Picard JJ, Constantin L. Radiological aspects of the discoid meniscus [in French]. *J Radiol Electrol Med Nucl*. 1964;45:839-841.
29. Kerr R. Radiologic case study. Discoid lateral meniscus. *Orthopedics*. 1986;9(8):1142, 1145-1147.
30. Samoto N, Kozuma M, Tokuhisa T, Kobayashi K. Diagnosis of discoid lateral meniscus of the knee on MR imaging. *Magn Reson Imaging*. 2002;20(1):59-64.
31. Silverman JM, Mink JH, Deutsch AL. Discoid menisci of the knee: MR imaging appearance. *Radiology*. 1989;173(2):351-354.
32. Singh K, Helms CA, Jacobs MT, Higgins LD. MRI appearance of Wrisberg variant of discoid lateral meniscus. *AJR Am J Roentgenol*. 2006;187(2):384-387.
33. Moser MW, Dugas J, Hartzell J, Thornton DD. A hypermobile Wrisberg variant lateral discoid meniscus seen on MRI. *Clin Orthop*. 2007;(456):264-267.
34. Najafi J, Bagheri S, Lahiji FA. The value of sonography with micro convex probes in diagnosing meniscal tears compared with arthroscopy. *J Ultrasound Med*. 2006;25(5):593-597.
35. Marchand AJ, Proisy M, Ropars M, Cohen M, Duvauferrier R, Guillin R. Snapping knee: imaging findings with an emphasis on dynamic sonography. *AJR Am J Roentgenol*. 2012;199(1):142-150.
36. Nathan PA, Cole SC. Discoid meniscus. A clinical and pathologic study. *Clin Orthop*. 1969;(64):107-113.
37. Baratz ME, Fu FH, Mengato R. Meniscal tears: the effect of meniscectomy and of repair on intraarticular contact areas and stress in the human knee. A preliminary report. *Am J Sports Med*. 1986;14(4):270-275.
38. Fairbank TJ. Knee joint changes after meniscectomy. *J Bone Joint Surg Br*. 1948;30(4):664-670.
39. Manzione M, Pizzutillo PD, Peoples AB, Schweizer PA. Meniscectomy in children: a long-term follow-up study. *Am J Sports Med*. 1983;11(3):111-115.
40. Wroble RR, Henderson RC, Campion ER, el-Khoury GY, Albright JP. Meniscectomy in children and adolescents. A long-term follow-up study. *Clin Orthop*. 1992;(279):180-189.
41. Abdon P, Turner MS, Pettersson H, Lindstrand A, Stenstrom A, Swanson AJ. A long-term follow-up study of total meniscectomy in children. *Clin Orthop*. 1990;(257):166-170.
42. Rosenberg TD, Paulos LE, Parker RD, Harner CD, Gurley WD. Discoid lateral meniscus: case report of arthroscopic attachment of a symptomatic Wrisberg-ligament type. *Arthroscopy*. 1987;3(4):277-282.
43. Fleissner PR, Eilert RE. Discoid lateral meniscus. *Am J Knee Surg*. 1999;12(2):125-131.
44. Woods GW, Whelan JM. Discoid meniscus. *Clin Sports Med*. 1990;9(3):695-706.
45. Yue BW, Gupta AK, Moorman CT 3rd, Garrett WE, Helms CA. Wrisberg variant of the discoid lateral meniscus with flipped meniscal fragments simulating bucket-handle tear: MRI and arthroscopic correlation. *Skeletal Radiol*. 2011;40(8):1089-1094.
46. Weiss CB, Lundberg M, Hamberg P, DeHaven KE, Gillquist J. Non-operative treatment of meniscal tears. *J Bone Joint Surg Am*. 1989;71(6):811-822.
47. Lohmander LS, Englund PM, Dahl LL, Roos EM. The long-term consequence of anterior cruciate ligament and meniscus injuries: osteoarthritis. *Am J Sports Med*. 2007;35(10):1756-1769.
48. Kim SJ, Chun YM, Jeong JH, Ryu SW, Oh KS, Lubis AM. Effects of arthroscopic meniscectomy on the long-term prognosis for the discoid lateral meniscus. *Knee Surg Sports Traumatol Arthrosc*. 2007;15(11):1315-1320.
49. Kim JM, Bin SI. Meniscal allograft transplantation after total meniscectomy of torn discoid lateral meniscus. *Arthroscopy*. 2006;22(12):1344-1350.e1.
50. Ogut T, Kesmezacar H, Akgun I, Cansu E. Arthroscopic meniscectomy for discoid lateral meniscus in children and adolescents: 4.5 year follow-up. *J Pediatr Orthop B*. 2003;12(6):390-397.