DOI 10.18019/1028-4427-2017-23-4-444-449

"Pitfalls" of magnetic resonance imaging in diagnosis of meniscus injury

A.S. Stulov, A.N. Tarasov

LDC MIBS-Astrakhan Ltd., Astrakhan, Russia
Federal State Budgetary Educational Institution of Higher Professional Education Astrakhan State Medical University of the RF Ministry of Health, Astrakhan, Russia

Presented is visualisation of normal anatomic intra-articular structures simulating meniscus injury based on comparative analysis of magnetic resonance imaging scans of the knee joint to differentiate from true pathological conditions.
Keywords: meniscus, magnetic resonance imaging, anatomy, injury

Evaluation of intraarticular knee injury relies on the clinical examination and diagnostic imaging [1, 2, 3, 4]. Magnetic resonance imaging (MRI) has become widely accepted as a sensitive and specific 'gold standard' in non-invasive evaluation for knee pathology

Objective The purpose of the article is to identify anatomical variations of the knee joint simulating meniscus injury to differentiate abnormalities using magnetic resonance imaging.

Menisci are crescent-shaped fibrocartolagenous structures with collagen fibres increasing joint congruence and stability, distributing axial loading and synovium. Lateral meniscus is S-shaped haing similar thickness and height all along the cross section. The medial meniscus is somewhat larger, has a banana-shaped appearance and a narrower radius of curvature, with the posterior horn being larger than the anterior horn.

Fibrocartolagenous structures of the knee joint are evaluated in 3 mutually perpendicular planes coronal (frontal), sagittal (lateral) and transverse (axial). Sagittal plane images were more informative to evaluate configuration, size and structures of all intraarticular and the majority of juxtarticular structures, so images are basically interpreted using the plane. Peripherally menisci are visualized as butterflies and as triangles in the central aspects (anterior and posterior horns), however, anatomically posterior horn of the medial meniscus is larger than the anterior horn as compared with symmetrical sizes of the lateral meniscus [5, 6, 7]. Coronal plane images are also informative for diagnosis, the horns appear as continuous plates from the root to a free edge peripherally, and as triangles in the central aspects with the sharp end pointing at intercodylar tubercle. Axial plane images are not that informative due to the minimal number of slices (up to two 4-mm slices) available taking up fibrocartolagenous plates, however, foreign authors report a number of MRI features that provide information for revealing abnormalities [8].

Normal MRI signal of meniscus is homogenously dark (hypointense) in the weighted images and an abnormal high signal intensity is graded with Stoller et al. scoring system using sagittal plane. Grades I and II are indicative of degenerative changes while grade III is referred as a definite meniscal tear. Graphic interpretations of anterior intermeniscal, oblique meniscomeniscal, meniscofemoral ligaments, popliteal tendon, distal portion of anterior cruciate ligament, meniscal flounce are also associated with high intrameniscal and juxtmeniscal signal which is not abnormal [9, 10, 11, 12]. Differentiation between normal and abnormal meniscal anatomy is very important for accurate diagnosis and preoperative planning.

Anterior intermeniscal ligament attaches to the anterior horns of menisci and is visualized in 94 % of the cases arthroscopically and in 58 % with MRI. Differentiated diagnosis is made to rule out anterior horn tear that can be simulated at the attachment of transverse ligament in sagittal slices. A series of sagittal sequences with distinct plain diameter is needed to confirm normal anatomy and to compare them with axial sequences to visualize it as a whole in an image [10, 13, 14] (**Fig. 1**).

Fan-shaped attachment of the distal segment of anterior cruciate ligament is another variation of the normal anterior horn. Sometimes fibres in posterolateral bundle of the ligament grow in anterior horn root that is reflected in heterogeneously diffuse high MRI signal in sagittal T1 and PD WI (speckled). Coronal sequence is practical to confirm normal anatomy tracing ligament fibres and fibrocartolagenous layer of the meniscus [9, 22] (**Fig. 2**).

Stulov A.S., Tarasov A.N. "Pitfalls" of magnetic resonance imaging in diagnosis of meniscus injury. *Genij Ortopedii*. 2017. T. 23. No 4. pp. 444-449. DOI 10.18019/1028-4427-2017-23-4-444-449. (In Russian)

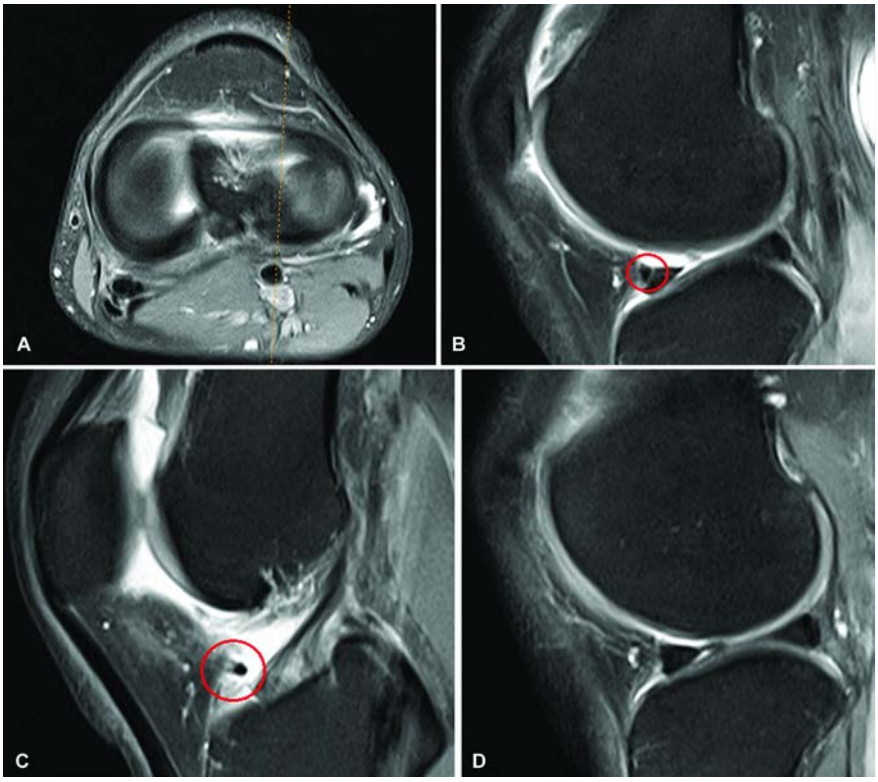

Fig. 1 MRI scans of the left knee in a 25-year-old patient M. showing: **A** – tight meniscomeniscal ligament in transverse view; **B, C, D**, – sagittal view (**B** – meniscomeniscal ligament portion attached to the lateral meniscus being susceptible of a tear; **C** – cross section of the ligament in the central meniscal aspects; **D** – distinct contour of the anterior horn of the lateral meniscus)

Fig. 2 MRI scans of the right knee in a 19-year-old patient P. showing: **A** – sagittal slices of anterior horn of the lateral meniscus having heterogeneously diffuse MRI signal due to differently hyperintense areas being susceptible of a root tear; **B** – coronal images demonstrating singular ACL fibres growing in the lateral meniscus root

Anterior horn tears of the lateral meniscus are not common and observed in 2 % of meniscal injuries. The meniscus contour appears to be equivocal and distorted with MRI signal being more vibrant indicating to fluid leaking, and osteochondral complex is to be considered as well.

The oblique meniscomeniscal ligaments are intermeniscal ligaments with a reported prevalence ranging from 2 % to 4 %. The oblique meniscomeniscal ligaments attach to the opposing horns of the medial and lateral menisci. Differentiated diagnosis is made to rule out displaced meniscus or 'buckle handle' tear that can be simulated in the central aspects of the joint in sagittal sequences. Axial images are practical to confirm the normal anatomy of the oblique meniscomeniscal ligaments [10, 15, 16] (**Fig. 4**).

Accessory meniscofemoral ligaments (the anterior MFL of Humphrey, the posterior MFL of Wrisberg) play an important role as stabilisers and protectors for the posterolateral femorotibial compartment and run from the posterior horn of the lateral meniscus to the lateral aspect of the medial femoral condyle or the posterior cruciate ligament. Both anterior and posterior meniscofemoral ligaments are present in a third of the cases and an inci-

dence of 93 % is reported for one of the ligaments. Differentiated diagnosis is made to rule out marginal tears of the posterior horn of the lateral meniscus that can be simulated at the attachments sites in seen in sagittal images. A series of sagittal sequences with regular appearance of the cross section is practical to confirm the normal anatomy with coronal images added to identify the intact run of the ligaments at the meniscus.

In a minority of cases, hypertrophied anterior meniscofemoral ligament of Humphrey can mimic a displaced 'buckle handle' meniscal fragment and be identified as a duplication of the posterior cruciate ligament. The suspicious structure appears to be intact with regard to the meniscus in the coronal image, which is also known as a pseudo-double PCL sign described in *Skeletal Radiology* Journal [10, 17, 18, 19] (**Fig. 5**).

By contrast, flapped tears with centrally displaced fragment are characterised by rougher architectonics with irregular meniscal height, fragmented structure seen on coronal plane showing meniscal fragment at the intercondylar tubercle (**Fig. 6**).

The popliteus tendon is a major posterolateral structure which is intracapsular and extrasynovial, and its course follows the popliteal tendon sheath. The fluid in the popliteal tendon sheath can be mistaken for marginal lateral meniscus tear on coronal and sagittal planes. However, the usage of standard and targeted sections helps to avoid the diagnostic error [20, 21] (**Fig. 7**).

By contrast, marginal meniscal tear is irregular in outline with additional pathological lines seen on specific sequences (**Fig. 8**).

Meniscal flounce is a wavy inner edge of the medial meniscus and thought to be a normal meniscal variant and transient physiological distortion. It is seen in 5 % of the cases at the posterior horn and the body of the medial meniscus with neutral position of the knee that is characteristic for standard MRI patient position [9, 23, 24] (**Fig. 9**).

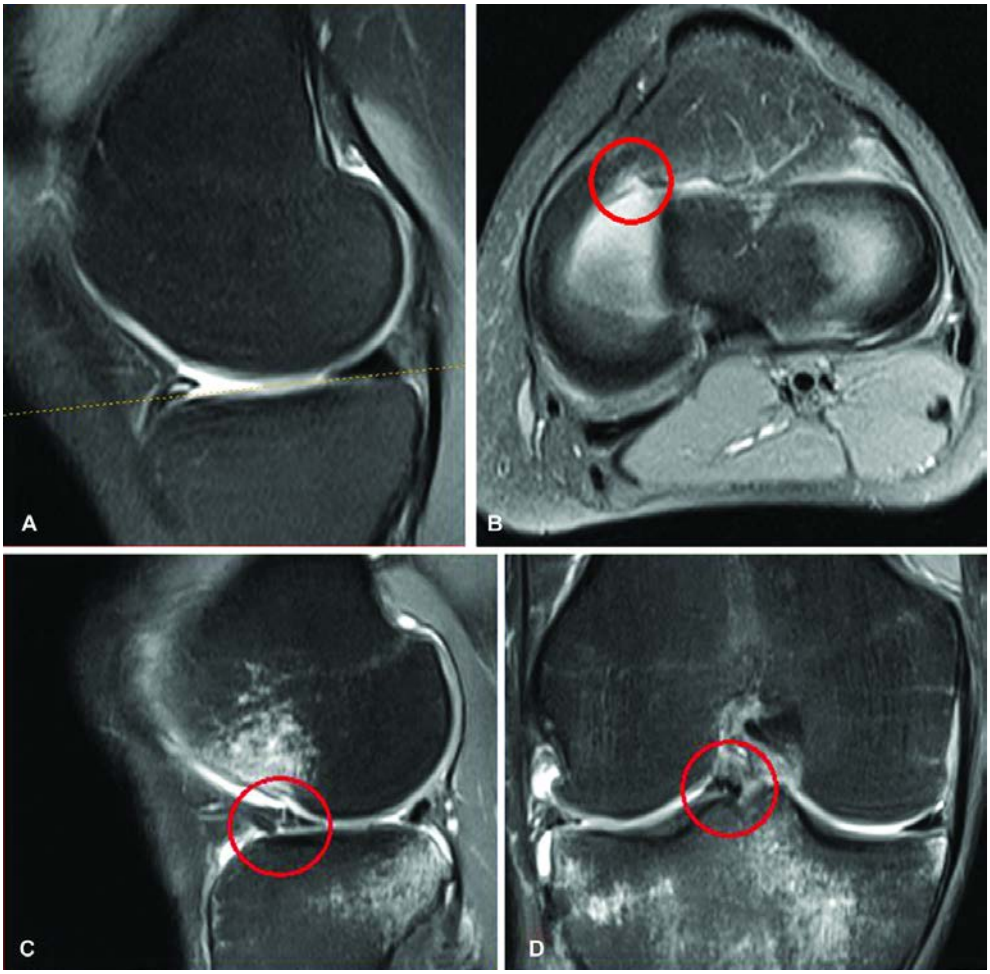

Fig. 3 MRI scans of the left and right knees in a 2-year-old patient T. showing: **A** – sagittal view demonstrating longitudinal linear portion in the anterior horn of the medial meniscus (left knee) Stoller grade III; **B** – transverse image demonstrating architectonics of the anterior horn root tear of the medial meniscus; **C** – sagittal view demonstrating vertical linear portion in the anterior horn of the lateral meniscus (right knee) Stoller grade III; **D** – transverse view showing displaced lateral meniscus (bucket handle tear) in intercondylar tubercle

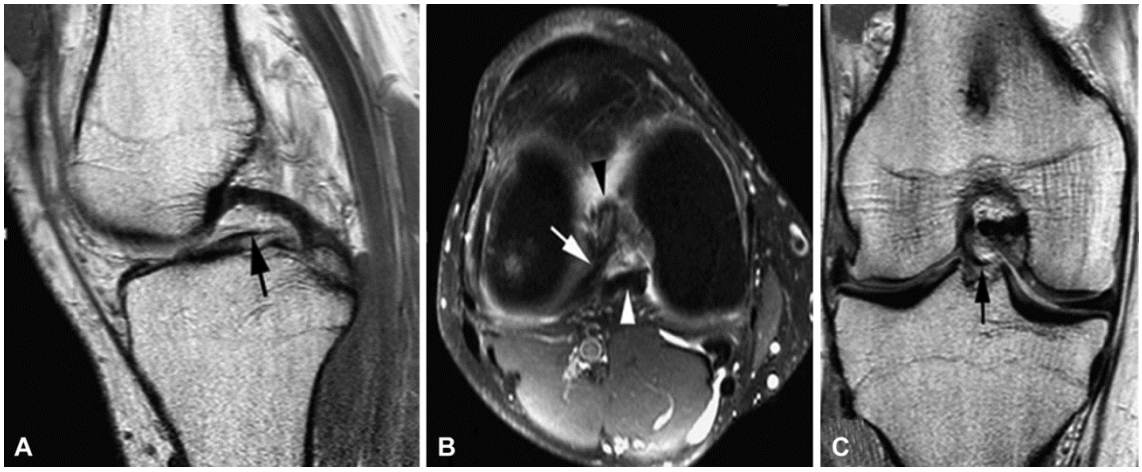

Fig. 4 MRI scans of the right knee in a 35-year-old patient I. showing: **A** – sagittal view demonstrating linear structure susceptible of displaced meniscus; **B** – transverse view demonstrating hypointense oblique linear structure in intercondylar notch; **C** – coronal view demonstrating meniscus disconnected ligamentous structure (oblique intermeniscal ligament)

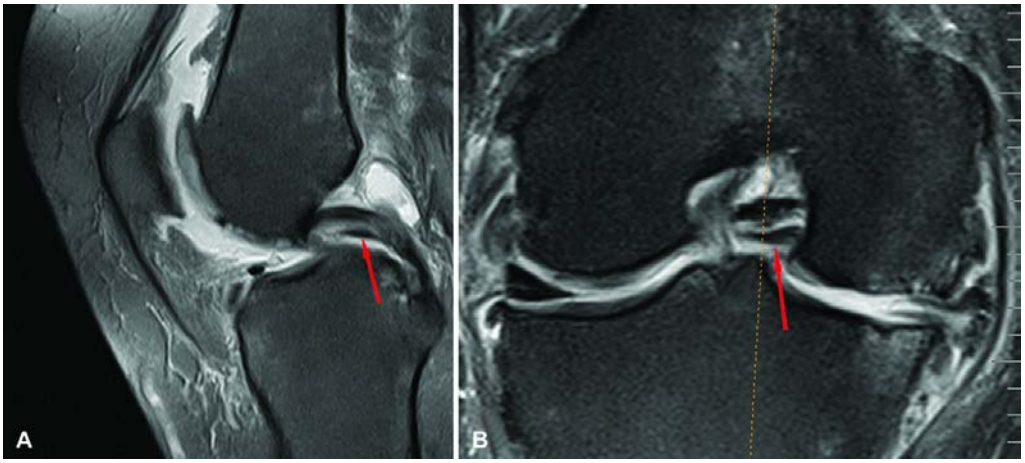

Fig. 5 MRI scans of the right knee showing: **A** – sagittal view demonstrating additional hypointense structure at the posterior cruciate ligament (PCL pseudo-duplication); **B** – coronal view demonstrating meniscus disconnected linear structure (ligament of Humphrey)

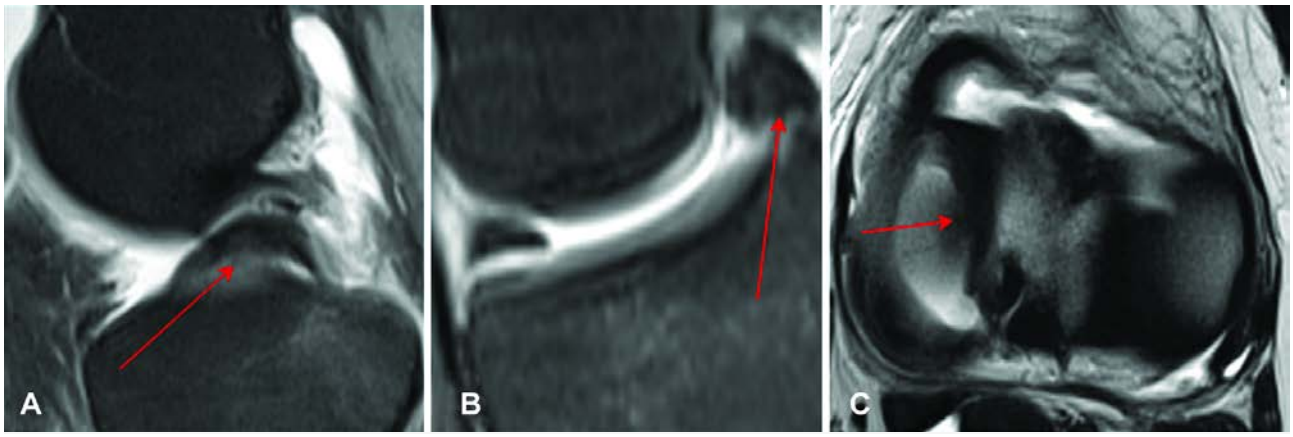

Fig. 6 MRI scans of the right knee in a 18-year-old patient A. showing: **A** – sagittal view demonstrating additional hypointense structure at the posterior cruciate ligament (PCL duplications); **B** – coronal view demonstrating displaced meniscus in intercondylar notch; **C** – transverse view demonstrating displaced meniscus in the central aspects of the joint

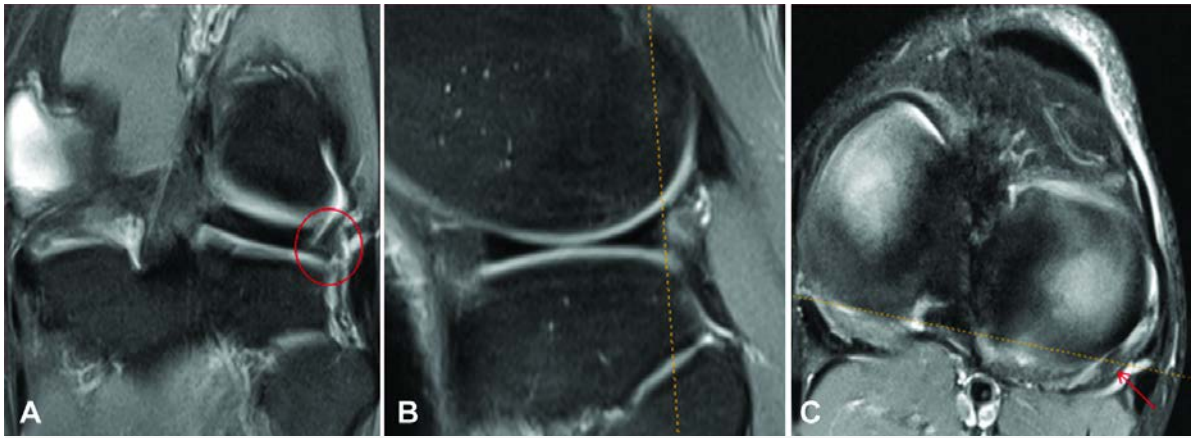

Fig. 7 MRI scans of the left knee in a 26-year-old patient F. showing: **A** – coronal view demonstrating high MRI signal at the edges of posterior horn of the lateral meniscus being susceptible of a tear*;* **B** – sagittal view demonstrating homogenous hypointense MRI signal; **C** – transverse view demonstrating hyperintense MRI signal being typical for fluid at the popliteal tendon

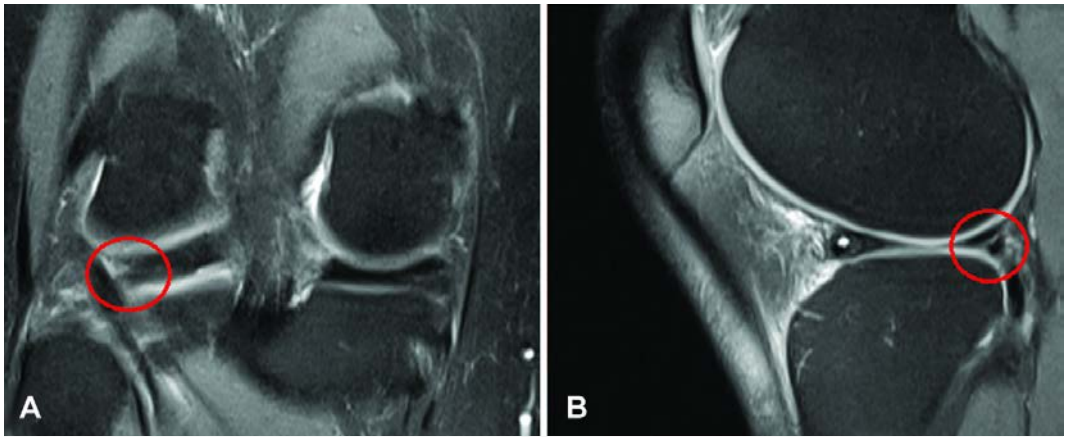

Fig. 8 MRI scans of the right knee in a 29-year-old patient K. showing: **A** – high MRI signal at marginal portions of the posterior horn of the lateral meniscus susceptible of a tear on coronal plane*;* **B** – horizontal area seen in the posterior horn of the lateral meniscus (Stoller grade III) on sagittal plane

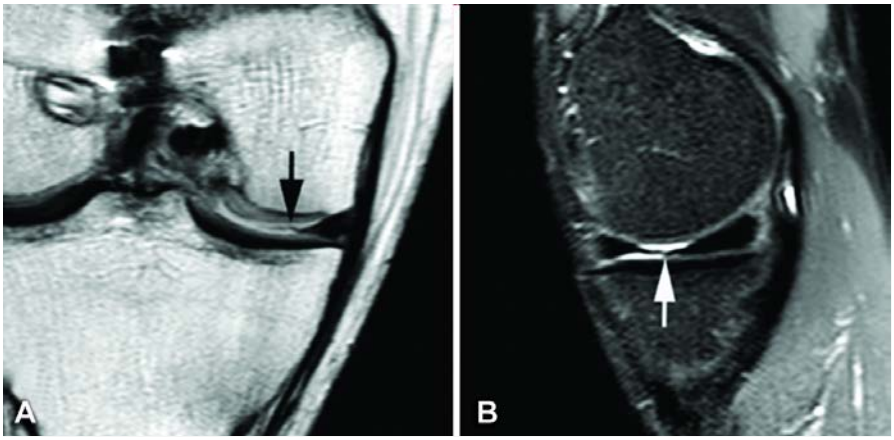

Fig. 9 MRI scans of the right knee in a 32-year-old patient V.: **A** – deformed course of the inner meniscal edge on coronal plane; **B** – deformed meniscal 'butterfly' shape with no signs of distortion of meniscal flounce on sagittal plane

Therefore, MRI enables a detailed and comprehensive evaluation of meniscus in three standard planes. High intrameniscal and juxtmeniscal MRI signal does not always indicate to pathological process. The knowledge of anatomical variants and similar pathological MRI findings of the ligaments, tendons and fibrocartilaginous structures of the knee allows physicians to avoid diagnostic errors.

REFERENCES

1. Gumerov R.A., Abzalilov A.A., Gumerov A.A., Khasanov R.Sh. Sravnitel'naia otsenka rezul'tatov nizkopol'noi magnitno-rezonansnoi tomografii i artroskopii v diagnostike patologii kolennogo sustava u detei [Comparative evaluation of the results of low-field magnetic-resonance tomography and arthroscopy in diagnosing the knee pathology in children]. *Kazan. Med. Zhurn*., 2005, vol. 86, no. 4, pp. 336-338. (In Russ.)
2. Briukhanov A.V., Vasil'ev A.Iu. Magnitno-rezonansnaia tomografiia v diagnostike povrezhdenii meniskov i sviazok kolennogo sustava [Magnetic-resonance tomography in diagnosing the knee meniscus and ligament injuries]. *Med. Vizualizatsiia*, 2005, no. 2, pp. 124-133. (In Russ.)
3. Udochkina L.A., Galushko T.G., Grinberg E.B. Strukturnye preobrazovaniia kolennogo sustava u iunoshei-futbolistov po dannym ul'trazvukovoi sonografii. Tez. Vseros. nauch. konf. s mezhdunar. uchastiem «Ekologicheskie aspekty morfogeneza» [Structural transformations of the knee in youth footballers according to ultrasound sonography data. Proc. of All-Russian Scientific Conference with international participation "Morphogenesis Ecological Aspects"]. *Zhurn. Anatomii i Gistopatologii*, 2015, vol. 4, no. 3(15), pp. 121. (In Russ.)
4. Grinberg E.B., Udochkina L.A. Forma i razmery myshchelkov bedrennoi i bol'shebertsovoi kostei po dannym anatomicheskikh i ul'trazvukovykh issledovanii [Shape and size of femoral and tibial condyles by the data of anatomical and ultrasound studies]. *Astrakhanskii Med. Zhurn*., 2011, vol. 6, no. 4, pp. 43-49. (In Russ.)
5. Van Dyck P., Gielen J.L., Vanhoenacker F.M. Sports-related meniscal injury In: Vanhoenacker F.M., Maas M., Gielen J.L., eds. Imaging of Orthopedic Sports Injuries. Berlin, Heidelberg, Germany, Springer-Verlag, 2007, pp. 265-282. DOI: 10.1007/978-3-540-68201-1.
6. Trufanov G.E., Vikhtinskaia I.A., Pchelin I.G. Luchevaia diagnostika povrezhdenii kolennogo sustava [Radiation diagnosing of the knee injuries]. SPb., ELBI SPb., 2014, pp. 18-20. (In Russ.)
7. Trofimova T.N., Karpenko A.K. MRT diagnostika travmy kolennogo sustava [MRI diagnosis of the knee trauma]. SPb., Izdatel'skii dom SPbMAPO, 2006, pp. 8-15. (In Russ.)
8. Lee J.H., Singh T.T., Bolton G. Axial fat-saturated FSE imaging of knee: appearance of meniscal tears. *Skeletal Radiol*., 2002, vol. 31, no. 7, pp. 384-395. DOI: 10.1007/s00256-002-0507-y.
9. Tyler P., Datir A., Saifuddin A. Magnetic resonance imaging of anatomical variations in the knee. Part 1: ligamentous and musculotendinous. *Skeletal Radiol*., 2010, vol. 39, no. 12, pp. 1161-1173. DOI: 10.1007/s00256-009-0870-z.
10. Tyler P., Datir A., Saifuddin A. Magnetic resonance imaging of anatomical variations in the knee. Part 2: miscellaneous. *Skeletal Radiol*., 2010, vol. 39, no. 12, pp. 1175-1186. DOI: 10.1007/s00256-010-0904-6.
11. Snoeckx A., Vanhoenacker F.M., Gielen J.L., Van Dyck P., Parizel P.M. Magnetic resonance imaging of variants of the knee. *Singapore Med. J*., 2008, vol. 49, no. 9, pp. 734-744.
12. Miller T.T. Knee: A. Radiologic Perspective: Magnetic Resonance Imaging of the Knee. In: Pedowitz R., Chung C.B., Resnick D. Magnetic Resonance Imaging in Orthopedic Sports Medicine. New York: Springer, 2008, pp. 313-315.
13. Sintzoff S.A. Jr., Stallenberg B., Gillard I., Gevenois P.A., Matos C., Struyven J. Transverse geniculate ligament of the knee: appearance and frequency on plain radiographs. *Br. J. Radiol*., 1992, vol. 65, no. 777, pp. 766-768. DOI: 10.1259/0007-1285-65-777-766.
14. Nelson E.W., LaPrade R.F. The anterior intermeniscal ligament of the knee. An anatomic study. *Am. J. Sports Med*., 2000, vol. 28, no. 1, pp. 74-76. DOI: 10.1177/03635465000280012401.
15. Dervin G.F., Paterson R.S. Oblique menisco-meniscal ligament of the knee. *Arthroscopy*, 1997, vol. 13, no. 3, pp. 363-365.
16. Sanders T.G., Linares R.C., Lawhorn K.W., Tirman P.F., Houser C. Oblique meniscomeniscal ligament: another potential pitfall for a meniscal tear – anatomic description and appearance at MR imaging in three cases. *Radiology*, 1999, vol. 213, no. 1, pp. 213-216. DOI: 10.1148/radiology.213.1.r99oc20213.
17. Cho J.M., Suh J.S., Na J.B., Cho J.H., Kim Y., Yoo W.K., Lee H.Y., Chung I.H. Variations in meniscofemoral ligaments at anatomical study and MR imaging. *Skeletal Radiol*., 1999, vol. 28, no. 4, pp. 189-195.
18. Gupte C.M., Smith A., McDermott I.D., Bull A.M., Thomas R.D., Amis A.A. Meniscofemoral ligaments revisited. Anatomical study, age correlation and clinical implications. *J. Bone Joint Surg. Br*., 2002, vol. 84, no. 6, pp. 846-851.
19. Amis A.A., Gupte C.M., Bull A.M., Edwards A. Anatomy of the posterior cruciate ligament and the meniscofemoral ligaments. *Knee Surg. Sports Traumatol. Arthrosc*., 2006, vol. 14, no. 3, pp. 257-263. DOI: 10.1007/s00167-005-0686-x.
20. Park L.S., Jacobson J.A., Jamadar D.A., Caoili E., Kalume-Brigido M., Wojtys M.E. Posterior horn lateral meniscal tears simulating meniscofemoral ligament attachment in the setting of ACL tear: MRI findings. *Skeletal Radiol*., 2007, vol. 36, no. 5, pp. 399-403. DOI: 10.1007/s00256-006-0257-3.
21. Stoller D.W. Magnetic resonance imaging in orthopaedics & sports medicine. 3rd ed. United States, Lippincott Williams & Wilkins, 2007.
22. Shankman S., Beltran J., Melamed E., Rosenberg Z.S. Anterior horn of the lateral meniscus: another potential pitfall in MR imaging of the knee. *Radiology*, 1997, vol. 204, no. 1, pp. 181-184. DOI: 10.1148/radiology.204.1.9205243.
23. Yu J.S., Cosgarea A.J., Kaeding C.C., Wilson D. Meniscal flounce MR imaging. *Radiology*, 1997, vol. 203, no. 2, pp. 513-515. DOI: 10.1148/radiology.203.2.9114114.
24. Park J.S., Ryu K.N., Yoon K.H. Meniscal flounce on knee MRI: correlation with meniscal locations after positional changes. *AJR. Am. J. Roentgenol*., 2006, vol. 187, no. 2, pp. 364-370. DOI: 10.2214/AJR.05.0339.

Received: 30.11.2016

Information about the authors:

1. Andrei S. Stulov, M.D., LDC MIBS-Astrakhan Ltd., Astrakhan, Russia, roentgenologist
2. Aleksei N. Tarasov, M.D., Ph.D., FSBEI HPE Astrakhan State Medical University of the RF Ministry of Health, Astrakhan, Russia, Department of Traumatology and Orthopaedics, assistant professor; Email: tarasov_an@mail.ru