

Low field MRI for the detection of acute knee injuries shows good diagnostic accuracy and interobserver agreement

Jonas Bürk¹, Philippe Dovi-Akue¹, Matthias Benndorf¹, Benjamin Fritz¹, Philipp Lenz¹, and Tobias Baumann¹
¹Radiology, University Hospital Freiburg, Freiburg, Baden Württemberg, Germany

Targeted audience: Radiologists, Trauma surgeons, Physicists.

Purpose: The goal of this study was to evaluate the capability of low field extremity MRI of the newest generation in the detection of musculoskeletal knee injuries of acute trauma patients in comparison to arthroscopy and CT.

Materials and Methods: We included 62 Patients with acute knee trauma, who received in our Institution a low field MRI of the knee as well as knee arthroscopy during January 2012 to March 2013. Two radiologists reviewed the low field knee MRI of the 62 Patients and compared them to the findings during knee arthroscopy. During that span of time we additionally included 19 patients who received low field MRI as well as CT. MR imaging was performed on a 0.31 T extremity-dedicated scanner (O-Scan, Esaote, Genoa, Italy) in which only the targeted anatomy needs to be inside the system. Gradients support ± 20 mT/m with a slew rate of 50 mT/m/ms. Dual Phased Array dedicated RF coils were used for all the examinations, according with the specific body part under investigation. The patient was sitting in a recumbent position next to the extremity -dedicated system. In order to position the joint correctly in the center of the FOV, a scout image was performed, which is displayed on a screen placed directly on the MR scanner. Customized clinical knee protocol was as follows: Coronal STIR (TR = 2250 ms, TE = 25 ms, Field Of View [FOV] = 180×180 mm², Matrix [M] = 192×152 , Thickness [TH] = 4 mm, Acquisition Time [TA] = 5'49'') and SE T1 (TR = 1000 ms, TE = 26 ms, FOV = 180×180 mm², M = 288×208 , TH = 4 mm, TA = 5'17''), sagittal GRE T1 with Fat-Water-Separation (TR = 940 ms, TE = 11 and 22 ms, Flip Angle [FA] = 90°, FOV = 180×180 mm², M = 256×192 , TH = 3.5 mm, TA = 5'48''), axial FSE T2 (TR = 5460 ms, TE = 100 ms, FOV = 180×180 mm², M = 240×220 , TH = 4 mm, TA = 4'22''), sagittal 3D SHARC (TR = 30 ms, TE = 15 ms, FA = 40°, FOV = $180 \times 180 \times 100$ mm³, M = $224 \times 224 \times 42$, TA = 5'39''). Also a sagittal FSE T2 sequence (TR = 4920 ms, TE = 100 ms, FOV = 180×180 mm², M = 240×220 , TH = 3 mm, TA = 4'25''), dedicated to the cruciate ligament imaging, was used.

Results: Knee arthroscopy showed 32 meniscal tears, including 13 bucket-handle tears, 31 anterior cruciate ligament (ACL) tears and no posterior cruciate ligament (PCL) tear. The sensitivity (sens) and specificity (spec) of low field MRI for meniscal tears was 95.8%/97.4% for the medial meniscus (MM) and 93.3%/93.6% for the lateral meniscus (LM). For the diagnosis of bucket-handle tears, the sensitivity and specificity for the medial meniscus was 100%; for the lateral meniscus the sensitivity was 80% and the specificity was 100%. The diagnosis of ACL tears showed a sensitivity and specificity of 100%. Among the 19 patients who were examined by low field MRI and by CT 8 patients had fractures, including 7 with articular involvement. The sensitivity and specificity of low field MRI in the diagnosis of fractures was 100%.

Discussion: The most severe limitations of low field MR-scanners in comparison to MR-scanners using higher magnetic field are lower SNR and resolution ¹. This notwithstanding, several clinical studies have already shown that low field MR-scanners have similar diagnostic capabilities in detecting meniscal tears and cruciate ligament ruptures as medium and high field MR-scanners ². In accordance to former publications, this study showed very good sensitivity and specificity in the detection of traumatic meniscal tears and cruciate ligament ruptures using a low field MR-scanner of the newest generation. Besides traumatic musculoskeletal lesions of the knee, fractures in all imaged joints were reliably detected. The advantages of low field MR-scanners are low purchase and maintenance costs. Previous data estimated the purchase and installation costs for a 1.5T MR-scanner about 2.7 times higher than the costs of a low field MR-scanner. The maintenance costs of a 0.3 T MR-scanner are about 37% lower compared to a 1.5 T MR-scanner ³. Because of little overall costs the operating breakeven is readily reached. It follows that high patient throughput based on economic pressure is not necessary, allowing to keep examination slots free for acute trauma patients. A common advantage of the low magnetic field is little development of magnetic susceptibility artifacts ⁴ and, in general, a much easier handling of safety issues, like specific absorption rate and projectile effect ⁵. In particular, the MRI scanner used in this study is not capable of operation at acoustic noise levels, gradient output levels and SAR levels above the Normal Operating Mode. According to the definition of the standard IEC 60601-2-33 ed3.0, the Normal Operating Mode of the MR equipment is such that none of the outputs have a value that can cause physiological stress to patients. Indeed, another advantage of our low field MR-scanner is the fact that there is very little noise development during examination. Low field MR-scanners are also very beneficial for the examination of patients with claustrophobia as well as for children, since there is usually no sedation necessary. A few more restrictions result through the narrow architecture. The examination of joints with relatively large volume might be limited, since the small gantry results in a small coil diameter (smallest diameter: wrist coil 7 cm, knee coil 15 cm, foot/ankle/elbow coil 10 cm). Anyway, in our institution so far only 2 of 600 patients couldn't be examined because their knee joints were too big. Whereas concerning other joints no limitations as a result of little coil diameters have occurred so far.

Conclusion:

Despite the limitations of low field MRI in terms of available signal-to-noise ratio, low field MR-scanners of the newest generation showed very good sensitivity and specificity in the diagnosis of traumatic meniscal tears, ACL tears as well as fractures.



Fig. 1: Typical examination setup for the lower extremities: only the body part to be investigated is positioned inside the magnet.

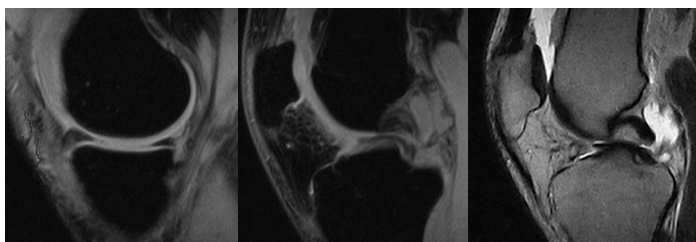


Fig. 2: Bucket-handle tear of the internal meniscus with a double PCL-sign, coming along with articular effusion. From left to right: two water-only-images of the X GRE T1 sequence and a FSE T2).

References: 1. Maubon A, Ferru J, Berger V, et al. Effect of field strength on MR images: comparison of the same subject at 0.5, 1.0, and 1.5 T. *Radiographics* 1999;19:1057-1067. 2. Ghazinoor S, Crues JV 3rd, Crowley C. Low-field musculoskeletal MRI. *J Magn Reson Imaging*. 2007 Feb;25(2):234-4. 3. Hayshi N, Watanabe Y, Masumoto T, et al. Utilization of low-field MR scanners. *Magn Reson Med Sci* 2004;3:27-38. 4. Matsuura H, Inoue T, Ogasawara K, et al. Quantitative analysis of magnetic resonance imaging susceptibility artifacts caused by neurosurgical biomaterials: comparison of 0.5, 1.5, and 3.0 Tesla magnetic fields. *Neurol Med Chir (Tokyo)*. 2005 Aug;45(8):395-8; discussion 398-9. 5. Kanal E, et al. ACR Guidance Document on MR Safe Practices 2013. *J Magn Reson Imaging*. 2013 Jan;37(3):501-530.