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Failure of fat suppression? MRI of serous atrophy of the bone marrow: a follow-up case with the literature review

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Versagen der Fettunterdrückung? MRT der serösen Atrophie des Knochenmarks: ein Fallbericht mit Verlaufsuntersuchungen und Literaturrecherche

Teaching point. SABM can be misinterpreted as failed fat suppression on MRI due to a technical error resulting in unnecessary repetition of MRI.

Introduction

Serous atrophy of bone marrow (SABM) is an indicator of severe chronic malnutrition illness, most commonly in anorexia nervosa and cachexia (Böhm J. Gelatinous transformation of the bone marrow: the spectrum of underlying diseases. Am J Surg Pathol. 2000; 24(1):56–65; Boutin RD et al. MRI findings of serous atrophy of bone marrow and associated complications. Eur Radiol. 2015; 25(9):2771–8). Other possible conditions include oncological diseases, malabsorption, chronic infection, kidney disease and heart failure, cytotoxic drugs, alcoholism (Böhm J. Gelatinous transformation of the bone marrow: the spectrum of underlying diseases. Am J Surg Pathol. 2000; 24(1):56–65; Boutin RD et al. MRI findings of serous atrophy of bone marrow and associated complications. Eur Radiol. 2015; 25(9):2771–8; Tins B et al. Marrow changes in anorexia nervosa masking the presence of stress fractures on MR imaging. Skeletal Radiol. 2006; 35(11):857–60; DiVasta AD et al. MR Imaging in a case of severe anorexia nervosa: the "flip-flop" effect. Pediatr Radiol. 2015; 45(4):617–20). Nonspecific clinical and laboratory findings include anemia, weight loss and findings associated with malnutrition (Böhm J. Gelatinous transformation of the bone marrow: the spectrum of underlying diseases. Am J Surg Pathol. 2000; 24(1):56–65; Boutin RD et al. MRI findings of serous atrophy of bone marrow and associated complications. Eur Radiol. 2015; 25(9):2771–8).

Case Report

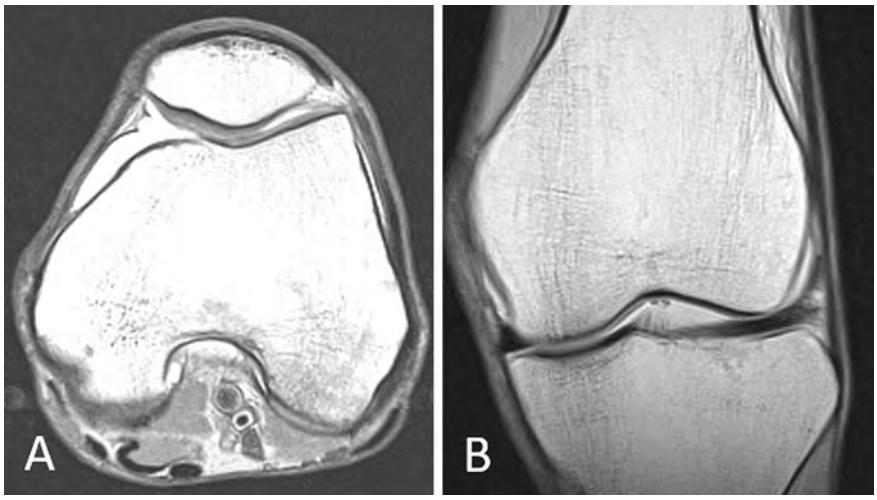
A 40-year-old female was referred for MRI of the painful left knee. Imaging findings include unusually hyperintense signal of bone marrow and thin subcutaneous fat on proton density fat suppressed (PDFS) sequences (▶ **Fig. 1**). The series were repeated several times because MRI malfunction had been suspected, always with the same result.

At follow up MRI of the same knee after two years imaging findings show moderate hypointense T1, hyperintense PDFS and hyperintense signal on short tau inversion recovery (STIR) sequences (▶ **Fig. 2**). Similar findings were also at 3-year, and 4-year follow up on different scanners (▶ **Fig. 3** and ▶ **Fig. 4A**, **B**). Five years after initial exam MRI of the left foot was performed. Findings were similar as previously (▶ **Fig. 4C**,**D**). Additional queries revealed that the patient had anorexia nervosa (BMI 10.45 kg/m^2), lactose intolerance, systemic osteoporosis, hypercalciuria.

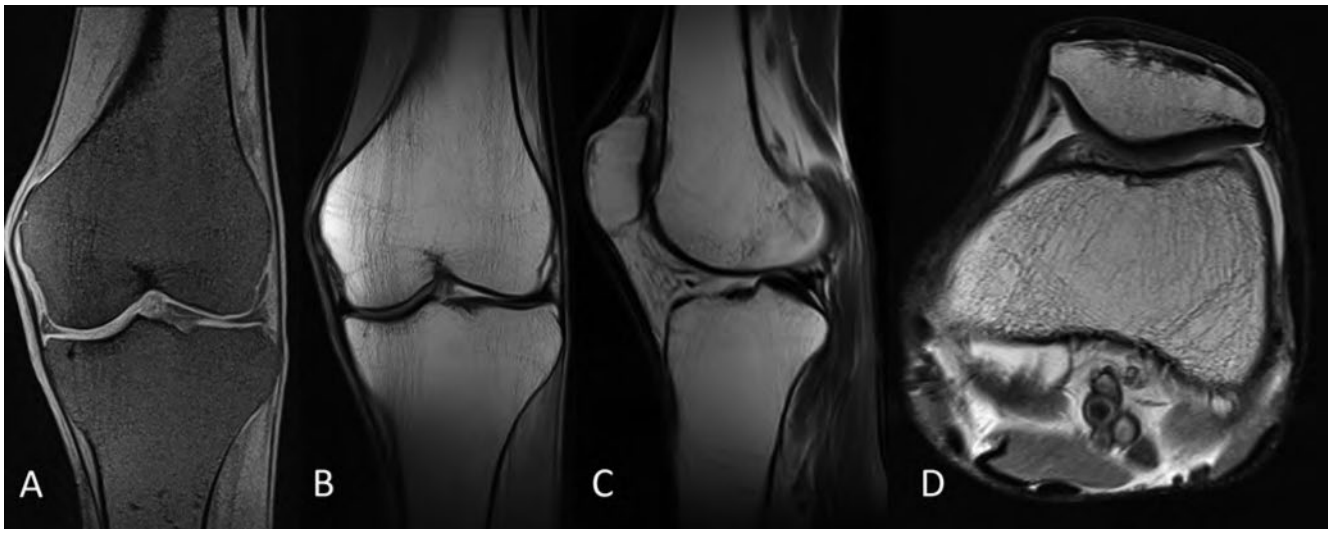
Discussion

In SABM there is histopathologically significant atrophy of hematopoietic and fat cells with deposition of extracellular gelatinous material, composed of hyaluronic acid-rich mucopolysaccaride, in the bone marrow stroma (Böhm J. Gelatinous transformation of the bone marrow: the spectrum of underlying diseases. Am J Surg Pathol. 2000; 24(1):56–65; Boutin RD et al. MRI findings of serous atrophy of bone marrow and associated complications. Eur Radiol. 2015; 25(9):2771–8).

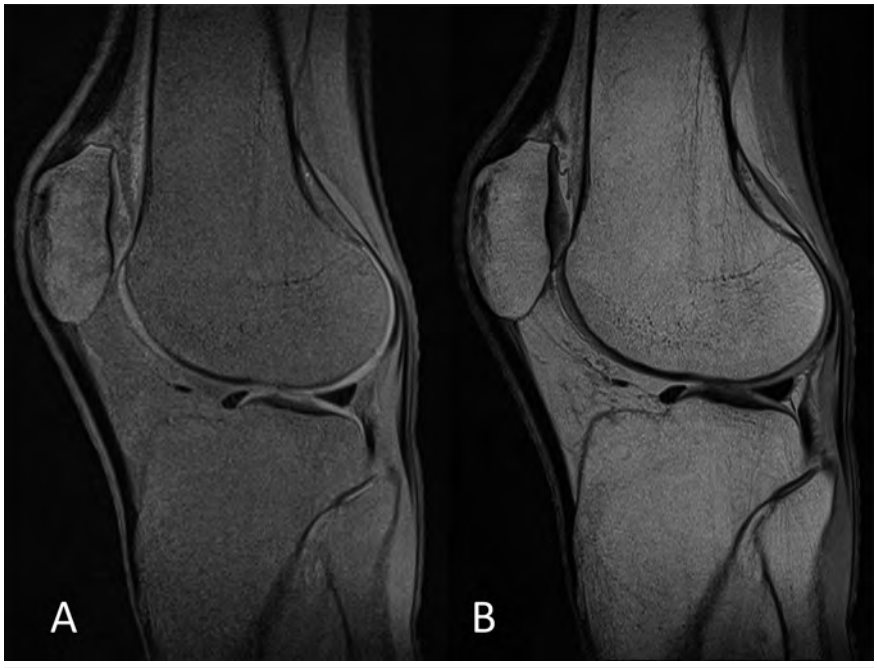
Typical MRI findings in SABM consist of focal or diffuse hypointense marrow signal compared to the adjacent muscle on T1 weighted images and corresponding abnormal marrow hyperintensity on fluid sensitive sequences with fat suppression (Boutin RD et al. MRI findings of serous atrophy of bone marrow and associated complications. Eur Radiol. 2015; 25(9): 2771–8; Tins B et al. Marrow changes in anorexia nervosa masking the presence of stress fractures on MR imaging. Skeletal Radiol. 2006; 35(11):857–60; DiVasta AD et al. MR Imaging in a case of severe anorexia nervosa: the "flip-flop" effect. Pediatr Radiol. 2015; 45(4):617–20; Vande Berg BC et al. Distribution of serouslike bone marrow changes in the lower limbs of patients with anorexia nervosa: predominant involvement of the distal extremities. Am J Roentgenol. 1996; 166(3):621–5). The abnormal bone mar-



▶ **Fig. 1A** Left knee MRI. Transverse PDFS. Minimal effusion, diffusely hyperintense signal of bone marrow. **B** Left knee MRI. Coronal PDFS. Minimal effusion, diffusely hyperintense signal of bone marrow.



▶ **Fig. 2** 2-year follow-up. Coronal T1 (**A**), PDFS (**B**), STIR (**C**), transverse PDFS (**D**). Diffusely hypointense (**A**), hyperintense (**B, C, D**) signal of bone marrow and soft tissues. Reduced subcutaneous fat, lack of fat suppression of infrapatellar, popliteal fat (**C, D**).



▶ **Fig. 3** 3-year follow-up. Hypointense T1 (**A**); hyperintense PDFS bone marrow, thin subcutaneous and deep soft tissue fat (**B**).

row signal and fat may be misinterpreted as technical error from insufficient fat suppression resulting in unnecessary repeated imaging (Boutin RD et al. MRI findings of serous atrophy of bone marrow and associated complications. Eur Radiol. 2015; 25(9):2771–8; Tins B et al. Marrow changes in anorexia nervosa masking the presence of stress fractures on MR imaging. Skeletal Radiol. 2006; 35(11):857–60; DiVasta AD et al. MR Imaging in a case of severe anorexia nervosa: the "flip-flop" effect. Pediatr Radiol. 2015; 45(4):617–20). Usually thin layers of subcutaneous and deep soft tissue fat show the same abnormal signal characteristics as the bone marrow (Boutin RD et al. MRI findings of serous atrophy of bone marrow and associated complications. Eur Radiol. 2015; 25(9):2771–8).

Interpreting MRI bone marrow changes in cachectic patient is challenging. SABM typically begins in fatty marrow. In contrast, other bone marrow replacement disorders typically occur at sites of red marrow (Boutin RD et al. MRI findings of serous atrophy of bone marrow and associated complications. Eur Radiol. 2015; 25(9):2771–8; Tins B et al. Marrow changes in anorexia nervosa masking the presence of stress fractures on MR imaging. Skeletal Radiol. 2006; 35(11):857–60). In addition to the location of marrow changes, the presence of subcutaneous fat with normal signal intensity on MRI in marrow replacement disorders can help differentiate from SABM (Böhm J. Gelatinous transformation of the bone marrow: the spectrum of underlying diseases. Am J Surg Pathol. 2000; 24(1):56–65; Boutin RD et al. MRI findings of serous atrophy of bone marrow and associated complications. Eur Radiol. 2015; 25(9):2771–8; Tins B et al. Marrow changes in anorexia nervosa masking the presence of stress fractures on MR imaging. Skeletal Radiol. 2006; 35(11):857–60; DiVasta AD et al. MR Imaging in a case of severe anorexia nervosa: the "flip-flop" effect. Pediatr Radiol. 2015; 45(4):617–20). MR spectroscopy has also been proposed for the evaluation of the bone marrow in SABM with the smallest peak of the lipid methylene protons in SABM compared to the smallest peak of water, seen normally, a so-called "flip-flop" effect (DiVasta AD et al. MR Imaging in a case of severe anorexia ner-

▶ **Fig. 4** 4- and 5-year follow-up. Axial (**A**), sagittal (**B**) PDFS at 4-year follow-up demonstrate lack of fat suppression of bone marrow and of the infrapatellar fat. Transverse images of the foot at the 5-year follow-up demonstrate hypointense signal of bone marrow and subcutaneous fat on T1 (**C**); hyperintense signal of bone marrow, subcutaneous, deep soft tissue fat on PDFS (**D**).

vosa: the "flip-flop" effect. Pediatr Radiol. 2015; 45(4):617–20).

Diagnosing insufficiency fractures on MRI in SABM can be difficult because bone marrow changes can obscure fracture lines and the adjacent edema. In the presented case, we could not identify the cause of pain with certainty. MRI in SABM patients should be carefully evaluated with a low threshold for CT examination in the case of clinically suspected fracture (Böhm J. Gelatinous transformation of the bone marrow: the spectrum of underlying diseases. Am J Surg Pathol. 2000; 24(1): 56–65; Boutin RD et al. MRI findings of serous atrophy of bone marrow and associated complications. Eur Radiol. 2015; 25(9):2771–8; Tins B et al. Marrow changes in anorexia nervosa masking the presence of stress fractures on MR imaging. Skeletal Radiol. 2006; 35(11):857–60; DiVasta AD et al. MR Imaging in a case of severe anorexia nervosa: the "flip-flop" effect. Pediatr Radiol. 2015; 45(4):617–20; Vande Berg BC et al. Distribution of serouslike bone marrow changes in the lower limbs of patients with anorexia nervosa: predominant involvement of the distal extremities. Am J Roentgenol. 1996; 166(3):621–5).

Conclusions

SABM is characterized by fluid-like serous replacement of fatty marrow components, resulting in the inability for MRI to fat suppress marrow. The atypical MRI appearance of SABM may be misinterpreted as failed fat suppression. Correlation with clinical history and sequence parameters are useful. Insufficiency fracture may be more difficult to diagnose due to the absence of detectable bone marrow edema.

Conflict of Interest

The authors declare that they have no conflict of interest.

Authors

Mitja Rupreht[1, 2], Miraude Adriaensen[3], Lea Gril Jevšek[1, 2], Nina Schweighofer[1, 2]

[1] Radiology Department, UMC Maribor, Maribor, Slovenia

[2] Medical Faculty, University of Maribor, Maribor, Slovenia

[3] Department of Medical Imaging, Zuyderland Medical Center, Sittard-Geleen, Brunssum, Kerkrade, Heerlen, The Netherlands

Correspondence

Lea Gril Jevšek, MD
Radiology Department
UMC Maribor
Ljubljanska 5
2000 Maribor
Slovenia
lea.gril@gmail.com

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