

Quantitative assessment of trabecular bone structure in the presence of bone marrow edema-like lesions (BMEL): IDEAL versus FIESTA-c

R. I. Bolbos¹, D. Kuo¹, A. Shimakawa², H. Yu², M. Ries³, S. Majumdar^{1,3}, and X. Li¹

¹Department of Radiology and Biomedical Imaging, University of California San Francisco, San Francisco, California, United States, ²Applied Science Laboratory, GE Healthcare – ASL West, Menlo Park, California, United States, ³Department of Orthopaedic Surgery, University of California San Francisco, San Francisco, California, United States

INTRODUCTION: Bone Marrow Edema-like lesions (BMEL) are defined as trabecular bone areas of high signal intensity in T2-weighted, fat-saturated magnetic resonance (MR) images or in short inversion time inversion-recovery (STIR) images. These lesions are present in knee and hip osteoarthritis (OA) (1,2), as well as acute knee injuries (ACL tear) (3). The trabecular bone structure, commonly reported using Fiesta-c imaging (4,5) cannot be evaluated within the region with BMEL. The reason is that using this sequence the trabecular bone quantification is based on indirect visualization of marrow which shows high intensity signal while bone shows dark. With presence of BMEL, the water contained in BMEL region is also dark due to its long T1, making the trabecular bone assessment difficult in this particular area. Iterative decomposition of water and fat with echo asymmetry and least-squares estimation (IDEAL) is used for robust fat and water separation with very high SNR efficiency (5,6). In the in-phase images reconstructed from IDEAL acquisition, both water and fat appear as bright signals, which facilitates the trabecular bone (which is dark) quantification. The aim of this study is to employ IDEAL imaging technique to quantitatively assess the trabecular structure within the BMEL region, and to validate the measurements using high-resolution peripheral quantitative CT (HR-pQCT).

METHODS: Seven specimens (6 tibiae and one femoral head) were collected after Total Knee/Hip Arthroplasty (TKA/TKH), and were studied using a 3T GE MR scanner and an 8 channel phased-array knee coil. To evaluate the presence of BMEL, fat-suppressed T2-weighted FSE images were acquired with the following parameters: TR/TE = 4300/51 ms, FOV = 8 cm, matrix = 512 x 256, slice thickness = 1.5 mm, ETL = 9, NEX = 2. To quantify the trabecular bone structure, 3D GRAPPA-based (7) Fiesta-c images (acceleration factor = 2, TR/TE = 11/3.75 ms, matrix = 512 x 384, flip angle = 60°, FOV = 10 cm, slice thickness = 1 mm, scanning time = 10 min.), as well as an investigational version of IDEAL based on SPGR (8) images (TR/TE = 24/5.30 ms, flip angle = 12, NEX = 2.67, bandwidth = 62.5 kHz, FOV = 10 cm, matrix = 512 x 384, slice thickness = 1 mm, scanning time = 16 min.) were acquired. The FSE T2 and Fiesta-c images were both registered to IDEAL images. Two sets of ROIs were defined: one containing the BMEL region, and one adjacent to the BMEL region containing normal trabecular bone. The trabecular structure within these two sets of ROIs was evaluated in both Fiesta-c and fat-only IDEAL images by computing parameters such as: apparent bone fraction (app. BV/TV), apparent trabecular number (app. Tb.N [1/mm]), apparent trabecular spacing (app. Tb.Sp [mm]) and apparent trabecular thickness (app. Tb.Th [mm]). Standard t-tests were performed between data acquired using Fiesta-c and IDEAL imaging methods.

RESULTS: There was no significant difference in trabecular bone parameters between Fiesta-c sequence compared with in-phase IDEAL within BMEL or outside BMEL regions. However, Fiesta-c displayed higher bone structure quantification within the BMEL region compared with in-phase IDEAL images (Figure 2). This difference between the two imaging techniques is larger within the BMEL than outside BMEL region. The fat-sat T2-w FSE image (Figure 1, A) confirmed the presence of BMEL. Visually, HR-pQCT (Figure 1, D) displayed trabecular bone structure within the BMEL region similarly with in-phase IDEAL (Figure 1, C), and in contrast with Fiesta-c (Figure 1, B) images which showed potential overestimations of bone structure.

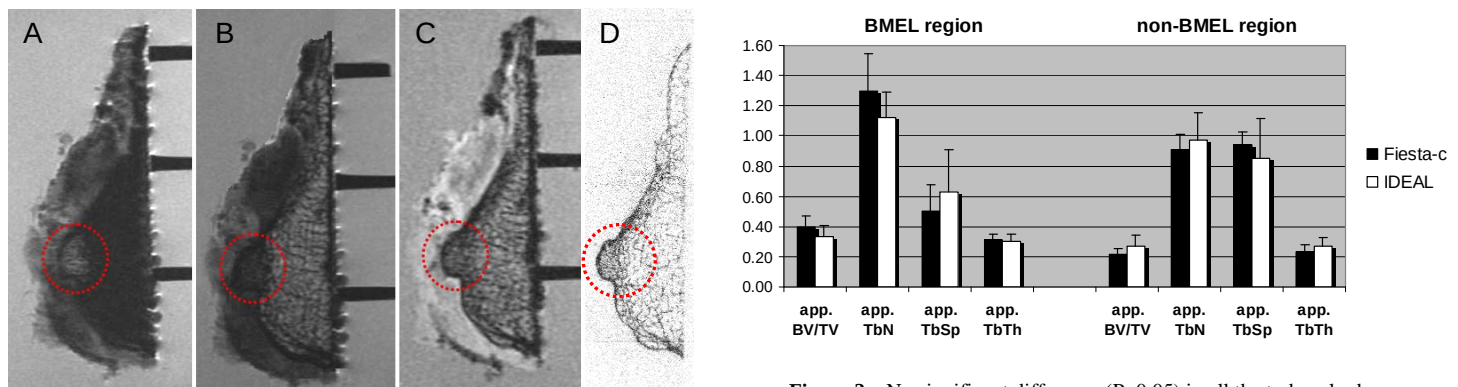


Figure 2 – No significant difference ($P < 0.05$) in all the trabecular bone parameters was found between Fiesta-c and IDEAL imaging technique; however, larger differences are displayed by Fiesta-c compared with IDEAL within the BMEL region.

Figure 1 – Representative MR images from fat-sat FSE T2-weighted (A), Fiesta-c (B), and IDEAL-SPGR (C), as well as from μ CT (D) acquisitions are displayed; BMEL region is shown in red.

DISCUSSION: This study demonstrated the capability of IDEAL imaging technique to quantify the trabecular bone structure within the area with BMEL, compared with the commonly employed technique, Fiesta-c, which seems to overestimate the trabecular bone quantification within this region. This method needs further investigation and validation using HR-pQCT, and this could potentially contribute to *in vivo* quantitative assessment of the trabecular structure in patients with BMEL.

REFERENCES:

1. Felson DT, et al., Ann Intern Med 2003.
2. Taljanovic M, et al., Skeletal Radiol 2008.
3. Costa-Paz M, et al, Arthroscopy 2001.
4. Krug R, et al, Osteoporos Int. 2006.
5. Reeder SB, et al, Magn Reson Med 2004.
6. Siemann DB, Am J Radiol 2008.
7. Griswold, et al. - Magn Reson Med. 2002
8. Reeder SB, et al, Magn Reson Med 2005.

ACKNOWLEDGEMENTS: This research was supported by UCSF REAC grant, NIH K25 AR053633 and RO1 AR46905.