ESSR Sports Imaging Subcommittee - The interesting Paper 2022 Q3

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CT-like MRI: a qualitative assessment of ZTE sequences for knee osseous abnormalities

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Background:

Several MR imaging techniques are currently being evaluated aiming to create CT-like MRI for proper depiction of hyperintense bony and calcified structures on a "dark" background. Since technically challenging, zero echo-time (ZTE) imaging is a technique not broadly applied for this purpose yet. ZTE imaging has the advantage of very short echo times like 0.1ms and is therefore able to acquire signal from structures with very short T2 relaxation properties such as bone and calcifications (relaxation times of around 0.4ms). Post-processing and inverse rescaling of the images results in the CT-like images. While ZTE imaging has been applied for imaging of the shoulder and hip earlier and a similar value as compared to standard CT imaging has been demonstrated, application at the knee was lacking so far. Spoiled gradient recalled acquisition (SPGR) is one of the alternative T1 contrast images used for CT-like MRI, particularly established for imaging of trabecular bone.

Manuscript summary:

In their article in published in the August 2022 issue of Skeletal Radiology, Bharadwaj UU et al. optimized ZTE and SPGR sequences (with similar scan times) for imaging of osseous findings at the knee. The ZTE sequence was applied in n=100 patients who received standard knee MRI for complaints such as pain, suspected internal derangement of the knee, trauma and postoperative imaging. In a subset of n=57 patients the SPGR sequence was applied additionally. The images were evaluated regarding different features and diagnostic confidence by 3 radiologists by the use of 5-point Likert scales. Image quality, including the attributes contrast, sharpness, artifact, motion, cortical bone depiction, and trabecular bone depiction was evaluated as at least good (minimal impairment of image, but preservation of all structural detail) in 93% of cases. Diagnostic certainty regarding osseous findings was improved in 74% over standard sequences and in 61.4% over SPGR. The authors state that soft tissue frequently (67.9%) limited evaluation of osseous structures on SPGR. Trabecular bone depiction was better on SPGR sequences. Structures evaluated (decreasing confidence in this order) were osteophytosis, subchondral cysts, soft tissue calcifications and

fractures. Use of ZTE images in the presence of metal artifacts after reconstruction of the anterior cruciate ligament was visualized. Bharadwaj UU et al. conclude, that incorporating ZTE sequences in the standard knee MRI protocol was technically feasible and improved diagnostic confidence for osseous findings in relation to standard MR sequences and SPGR.

Plus:

- Well-structured and presented manuscript
- Achieved good image quality with a promising technique
- Examples given show the advantage of ZTE above the other sequences: The osseous and calcified structures with short T2 times are singularly shown bright, whereas in the other sequences such as SPGR for example also fat and muscle and other soft tissue structures may appear bright.
- Patients with metal hardware may also benefit from application of ZTE techniques.

Limitations:

- Only a subset of 57/ 100 patients also had the control sequence SPGR.
- No comparison to CT imaging or alternative CT-like MR imaging techniques. However examples with an additional plain radiograph are provided in figure 3 and 4. And this comparison was performed earlier in other research studies.
- Information on scan time missing! The authors only state that both sequences were optimized to maximize contrast between bone and soft tissue within similar scan times and that images were inverted for CT-like visualization.
- Still, soft tissue calcifications are hard to detect and also certainty for the presence of fractures (71% cases with high confidence) was not perfect, although nice examples with better depiction of fractures as compared to standard MR sequences are provided in the manuscript.
- Moderate to fair reproducibility

Comment:

Bharadwaj UU et al. nicely demonstrate the application of optimized ZTE images for standard knee MRI imaging to obtain CT-like images. In contrast to other gradient echo sequences where also muscle, ligaments, fat, meniscus etc. may appear bright, on inverted ZTE most background structures demonstrate a hypointense signal, which is a major advantage. On the contrary, ZTE techniques have particular limitations regarding visualization of trabecular bone and may therefor potentially be combined with other CT-like MR techniques. ZTE is technically challenging and imaging sequences have to be optimized by MR physicists and vendors before broad application can be expected. Images are frequently blurred and show other artifacts that need to be overcome. However, this may be one

way to go for future MSK imaging and despite the remaining limitations, this is another step towards proper visualization of bone and calcified structures on MRI. It may certainly help standard knee MRI evaluation in case of missing x-ray or CT imaging.