# Clinical Performance of 3D-FSE-Cube in the Upper Extremity

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**Introduction**
Musculoskeletal MR imaging studies usually comprise of multiple two-dimensional fast-spin-echo (2D-FSE) sequences acquired in orthogonal planes. Three-dimensional fast-spin-echo Cube (3D-FSE-Cube) enables isotropic voxel acquisition allowing subsequent image reformation in any desired scan plane. This may make the acquisition of multiple additional sequences unnecessary, and ultimately decrease overall scan time. The thinner slice thickness in 3D-FSE-Cube also results in less partial volume artifact. 3D-FSE-Cube has shown promising results in the evaluation of asymptomatic knees and ankles, as well as the painful knee [1-3]. The aim of our study was to evaluate whether 3D-FSE-Cube has a similar clinical performance as 2D-FSE in the evaluation of the symptomatic joints in the upper extremity at 3.0T using arthroscopic results as a reference standard.

**Methods**
8 shoulders, 5 elbows and 25 wrists of symptomatic subjects, who subsequently underwent arthroscopy, were imaged in a GE MR 750 3.0T MRI scanner (GE Healthcare, Milwaukee, WI). 3D-FSE-Cube was acquired using the parameters given in Figure 1. Conventional 2D-FSE sequences were acquired in the coronal, axial and sagittal planes using similar TR/TE, matrix size, FOV and bandwidth to 3D-FSE-Cube, with a slice thickness of 2.0 mm and ETL between 2-8. Two readers independently reviewed each case twice to identify pathology; the first using only the 2D-FSE sequences, and the second time using only 3D-FSE-Cube. Cartilage lesions were graded on a modified Noyes scale. Ligaments, tendons, synovium and fibrocartilagenous structures were graded on a 4 point scale and other findings such as fractures, bone marrow edema, joint bodies and cysts were documented as present or absent. The sensitivity, specificity and accuracy of conventional 2D-FSE and 3D-FSE-Cube in grading pathology the same or within one grade were calculated using arthroscopy as the reference standard. The sensitivity, specificity and accuracy of FSE-Cube for detecting bone marrow edema lesions were calculated using 2D-FSE with fat saturation as the reference standard. Discrepancies between readers were resolved by consensus. The sensitivity and specificity between methods were compared with paired McNemar tests.

**Results**
There was no significant difference ($P$=0.0625-0.999) between 3D-FSE-Cube and 2D-FSE in sensitivity and specificity in detecting cartilage lesions, ligament tears, tendon pathology, synovial pathology, fibrocartilagenous lesions and other findings such as fractures, joint bodies and cysts. Using arthroscopy as a reference standard, 3D-FSE-Cube identified 87.5% of cartilage lesions, 92.1% of ligament tears, 96.9% of tendon pathology, 95.7% of synovial pathology, 94.4% of fibrocartilagenous lesions and 94.4% of other findings such as fractures, joint bodies and cysts. 2D-FSE identified 75.0% of cartilage lesions, 89.5% of ligament tears, 87.5% of tendon pathology, 78.3% of synovial pathology, 77.8% of fibrocartilagenous lesions and 83.3% of other findings such as fractures, joint bodies and cysts (Figure 2). Using conventional 2D-FSE as a reference standard, 3D-FSE-Cube identified 94.1% of bone marrow edema lesions. Correctly identified pathologies were seen on a significantly larger number of slices with 3D-FSE-Cube than compared to the 2D-FSE sequences, increasing diagnostic confidence. Smaller lesions and obliquely oriented pathology could be evaluated similarly or better with 3D-FSE-Cube images due to the ability to reformat images in any desired orientation (Figure 3).

**Conclusion**
3D-FSE-Cube showed a similar clinical performance to conventional 2D-FSE sequences in the identification of cartilage, ligament, tendon, synovial and fibrocartilagenous pathology, as well as fractures, bone marrow edema, joint bodies and cysts in the shoulder, elbow and wrist. The thinner slices of 3D-FSE-Cube, and the ability to reformat images in arbitrary scan planes, enabled optimal visualization of smaller lesions and obliquely oriented pathology.

| | Shoulder | Elbow | Wrist |
|---|---|---|---|
| Coil | 8-channel shoulder | 8-channel knee | 8-channel wrist |
| Plane | Axial | Coronal | Coronal |
| TR/TE | 2500/35ms | 3000/35ms | 3000/35ms |
| Matrix size | 384 x 288 | 288 x 256 | 288 x 224 |
| Thickness | 0.6 mm | 0.6 mm | 0.6 mm |
| FOV | 20 cm | 14 cm | 14 cm |
| Bandwidth | ±31 kHz | ±50 kHz | ±50 kHz |
| ETL | 60 | 60 | 60 |

**Figure 1**. 3D-FSE-Cube imaging parameters for 3D-FSE-Cube.

| Pathology | Sensitivity (%) | | Specificity (%) | | Accuracy (%) | |
|---|---|---|---|---|---|---|
| | 2D-FSE | 3D-FSE | 2D-FSE | 3D-FSE | 2D-FSE | 3D-FSE |
| Cartilage | 75.0 | 87.5 | 97.0 | 93.9 | 94.6 | 91.9 |
| Ligament | 89.5 | 92.1 | 66.7 | 61.1 | 78.4 | 77.0 |
| Tendon | 87.5 | 96.9 | 100 | 90.5 | 97.2 | 93.2 |
| Synovium | 78.3 | 95.7 | NA | NA | NA | NA |
| Fibrocartilage | 77.8 | 94.4 | 64.3 | 60.7 | 67.6 | 68.9 |
| Other | 83.3 | 94.4 | 94.1 | 94.1 | 91.9 | 89.2 |

**Figure 2.** Sensitivity, specificity and accuracy of 3D-FSE-Cube and 2D FSE in detecting pathology. Discrepancies between readers were resolved by consensus. No significant differences were seen between the sequences.

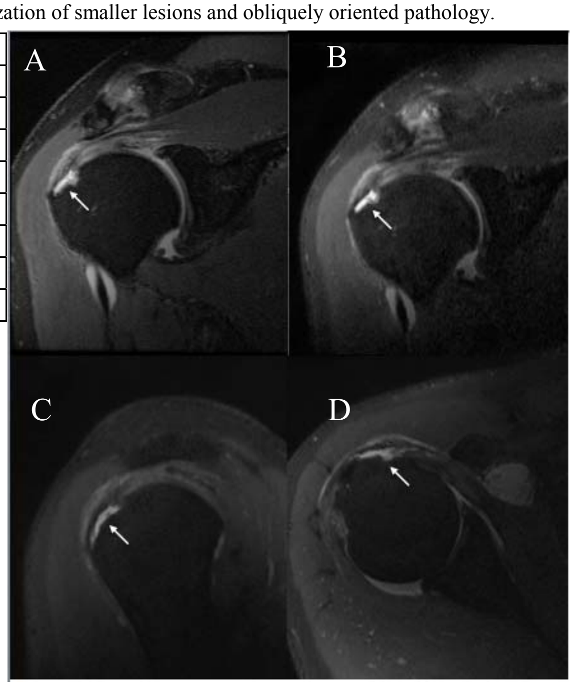


**Figure 3.** The surgically confirmed partial thickness tear of the rotator cuff (arrows) was detected correctly by both readers on the 2D-FSE and 3D-FSE-Cube sequences. **A**, an oblique coronal 2D-FSE image, **B**, a 3D-FSE-Cube oblique coronal reformat, **C**, a 3D-FSE-Cube oblique sagittal reformat, **D**, a 3D-FSE-Cube axial source image. Due to its isotropic nature, 3D-FSE-Cube can be reformatted without loss of quality.

**References**: 1. Gold et al., AJR 2007; 188: 1287-1293, 2. Stevens et al., Radiology 2008: 249: 1026-33, 3. Yao et al., AJR 2007; 188: W199-W201.
**Acknowledgements**: NIH EB002524, NIH EB005790, GE Healthcare, SCBT/MR