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# Is the flexion-abduction-supination magnetic resonance imaging view more accurate than standard magnetic resonance imaging in detecting distal biceps pathology?

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**Background and hypothesis:** Partial biceps tendon pathology is difficult to diagnose. The flexion-abduction-supination (FABS) magnetic resonance imaging (MRI) view has been advocated to improve the accuracy of MRI investigation. The purpose of this study was to evaluate the accuracy of the FABS view MRI in the diagnosis of distal biceps tendon pathology.
**Methods:** The study included 50 patients with surgically confirmed distal biceps tendon pathology and 50 patients with other elbow disorders. In both groups, standard elbow MRI (retrospective review of previously obtained MRI data) was performed in half of the patients whereas FABS views MRI were obtained in the other half. These were evaluated by 2 independent musculoskeletal radiologists. The sensitivity and specificity of both MRI views were determined. Tendinosis and grade of rupture were reported from MRI and then compared with surgical findings.
**Results:** There were no significant differences in sensitivity and specificity in detecting partial distal biceps injuries when the FABS view MRI (sensitivity, 84%; specificity, 86%) and standard MRI (sensitivity, 76%; specificity, 98%) were compared. The interobserver reliability was 92% for the FABS view MRI with biceps pathology and 68% for standard MRI. In the control group, the interobserver reliability was 88% for the FABS view MRI and 96% for standard MRI. FABS MRI was significantly better regarding grade of injury.
**Conclusions:** No significant differences in sensitivity and specificity were found between the FABS view and standard elbow MRI in the diagnosis of partial distal biceps tendon injuries, with high sensitivity and specificity for both views. Inter-rater reliability was better for FABS views, and FABS views were significantly more accurate than surgical findings in grading the extent of pathology.
**Level of evidence:** Level IV; Case-Control Design; Diagnostic Study


**Keywords:** MRI; elbow; distal; biceps; tendon; partial; rupture; FABS

The diagnosis of a complete tear of the distal biceps tendon is mainly based on clinical examination findings.[10,11] A variety of clinical tests have been described.[8,11] However, for a complete tear with an intact lacertus fibrosus, a partial

This study was approved by the ethical committee of AZ Monica (OG 106).

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tear, tendonitis, or bursitis, the clinical image may be less obvious.[1,3,9,12,13]

Patients often complain of pain in the antecubital region, exacerbated by activity. Biceps strength is usually good, and the findings of resistance tests may be negative. This often results in a significant delay in diagnosis, or the diagnosis may be missed altogether.[1,3,9]

Magnetic resonance imaging (MRI) investigation (Fig. 1) has been proposed if the diagnosis in unclear. Although MRI has been proved very sensitive for complete distal biceps tendon tears, the sensitivity for partial tears or other distal biceps tendon pathology is significantly lower.[2,4-6] In 2004, Giuffrè and Moss[7] suggested the flexion-abduction-supination (FABS) view to optimally view the distal biceps tendon from the musculotendinous junction to its insertion, usually on a single image (in 1 or, at most, 2 sections) (Fig. 2). Although it was widely adopted in clinical practice, the sensitivity and specificity of the FABS view for partial distal biceps tendon tears and other distal biceps tendon pathology have not been studied. The purpose of this study was to evaluate the sensitivity, specificity, and reproducibility of the FABS view MRI in detecting distal biceps tendon pathology and compare this with standard elbow MRI investigation.

## Materials and methods

This study included 100 patients with elbow pathology who underwent MRI investigation. All patients were treated by the senior author, and MRI scans were performed at a single institution. To be included in this study, patients had to have biceps pathology confirmed by biceps endoscopic surgery. Magnetic resonance images had to satisfy the following criteria: (1) The area proximal to the biceps musculotendinous junction and distal to the radial tuberosity was viewable on the study; (2) the MRI hardware had a magnet strength of 1.5 T; and (3) no contrast was used. The scanner currently used is the Siemens 1.5-T Magnetom Aera (Siemens, Erlangen, Germany); images taken before 2015 were obtained with the Siemens 1.5-T Symphony. The standard MRI protocol uses a 15-channel knee coil and includes axial T2 turbo spin echo (TSE) with fat saturation, axial T1 TSE, coronal T1 TSE, coronal T2 TSE with fat saturation, and sagittal T2 TSE with fat saturation. The patient is positioned prone with the elbow extended above the head and thumb up (Superman position). The scan time for the standard elbow examination is 11 minutes 17 seconds. The FABS-view protocol has the following specifications: 16-channel shoulder coil, including axial proton and T2 TSE with fat saturation, coronal T1 TSE and T2 with fat saturation, sagittal T2 TSE with fat saturation, and axial and coronal 3-dimensional double-echo steady state with water excitation. For the FABS view MRI, patient positioning is very different: The patient lies prone with the arm in FABS (Fig. 2) during the total scan time. The scan time for the FABS elbow examination was 15 minutes 6 seconds. Detailed resolution of all MRI sequences is presented in Table I. The standard magnetic resonance images of 25 patients with distal biceps tendon pathology and 25 patients with other elbow problems were retrospectively included from the surgeon's database. Clinical and surgical notes were used to confirm the pathology. Starting in 2018, 25 patients with distal biceps tendon pathology and 25 patients with other elbow problems were included prospectively and FABS views were obtained for these 50 patients.

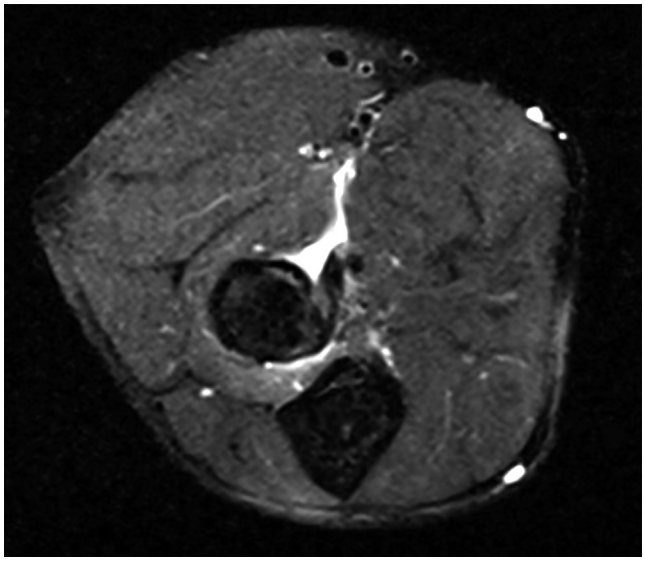

**Figure 1** Standard magnetic resonance imaging view of distal biceps tendinosis. It should be noted that only a small portion of the tendon can be seen per the image. Courtesy of MoRe Foundation.

The patients were divided into 4 groups. The first group had FABS-view images with distal biceps tendon pathology, surgically confirmed and graded during biceps endoscopy. A low-grade partial tear was defined as a $\leq$25% tear of the width of the distal biceps tendon attachment (Fig. 3), an intermediate-grade tear was defined as a 25%-50% tear of the width (Figs. 4 and 5), and a high-grade partial tear was defined as a >50% tear of the width (Fig. 6).

The second group comprised patients with various elbow pathologies other than distal biceps tendon problems, such as lateral epicondylitis, ulnar nerve pathologies, and medial epicondylitis, with FABS views. They did not complain of anterior elbow and forearm pain, and the findings of clinical tests for distal biceps tendon pathology were negative.

The third group included patients with surgically confirmed distal biceps tendon pathology and preoperative standard MRI studies. Finally, the fourth group consisted of patients with elbow pathologies other than distal biceps tendon problems who underwent standard MRI investigations.

All investigations were blinded, randomized, and evaluated by 2 independent radiologists, highly experienced in musculoskeletal imaging, with 8 and 22 years of practice. The participating radiologists were not involved in the original care of any patient in this study and did not receive any clinical information. They were asked to provide a general diagnosis and, if the MRI findings proved positive for distal biceps tendon pathology, to specify according to the following criteria: (1) partial tear, characterized as either a high-, intermediate-, or low-grade tear using the definition provided earlier; (2) presence of tendinosis; and (3) presence of bicipital bursitis.

MRI interpretations were then correlated to the intraoperative findings, and the results were statistically analyzed (SPSS software; IBM, Armonk, NY, USA). Comparison of FABS and standard MRI

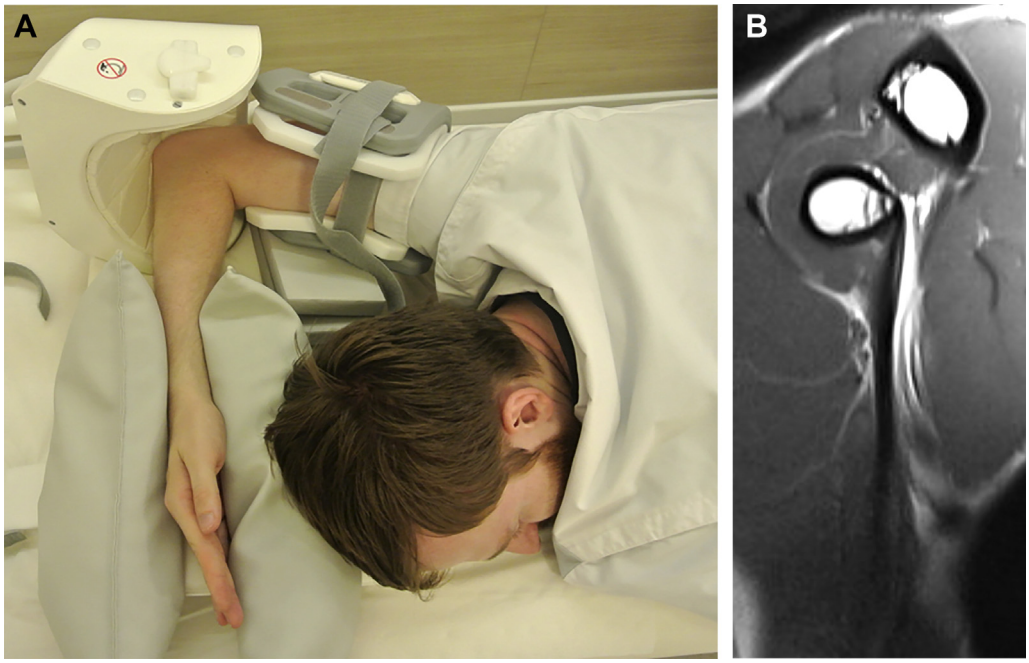


**Figure 2** **(A)** Flexion-abduction-supination–view positioning with shoulder abduction and elbow flexion-supination. **(B)** Flexion-abduction-supination magnetic resonance imaging view (3-dimensional double-echo steady state with water excitation) showing normal distal biceps tendon. The entire tendon can be viewed from the insertion to the musculotendinous junction on a single image. Courtesy of MoRe Foundation.

**Table I** Detailed resolution of MRI sequences for both standard elbow MRI and FABS views MRI

| | T2, mm | T1, mm | PD, mm | 3D DESS WE, mm |
|---|---|---|---|---|
| Standard elbow MRI sequences | | | | |
| Axial | 0.5 × 0.5 × 3 | 0.3 × 0.3 × 3 | — | — |
| Coronal | 0.6 × 0.6 × 2.5 | 0.6 × 0.6 × 2.5 | — | — |
| Sagittal | 0.4 × 0.4 × 3 | — | — | — |
| FABS view MRI sequences | | | | |
| Axial | 0.3 × 0.3 × 3 | — | 0.3 × 0.3 × 3 | 0.3 × 0.3 × 2 |
| Coronal | 0.6 × 0.6 × 2.5 | 0.6 × 0.6 × 2.5 | — | 0.3 × 0.3 × 1.5 |
| Sagittal | 0.4 × 0.4 × 2.5 | — | — | — |

*MRI*, magnetic resonance imaging; *FABS*, flexion abduction supination; *T2*, fat and water highlighted; *T1*, fat highlighted; *PD*, proton density weighted, *3D DESS WE*, 3-dimensional double-echo steady state with water excitation.

was evaluated using the *t* test, and the significance level was set at .05. The sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated. Furthermore, we evaluated the interobserver reliability (IRR). For biceps pathology, the IRR in group 1 (FABS view) and group 3 (standard MRI) was based on the different types of distal biceps tendon pathology, as described earlier. The IRR for the other elbow pathologies was calculated in patients with either medial or lateral epicondylitis, as these patients were similarly distributed in group 2 (FABS view, 13 patients) and group 4 (standard MRI, 15 patients).

## Results

A total of 100 MRI scans were included for review. Groups 1 and 3 each included 25 surgically confirmed distal biceps tendinitis or partial ruptures. Groups 2 and 4 each contained 25 MRI scans of non-biceps pathologies. The mean ages in groups 1 and 3 were 55 years (range, 36-77 years) and 59 years (range, 34-87 years), respectively. In groups 2 and 4, the mean ages were 48 years (range, 31-60 years) and 53 years (range, 26-73 years), respectively. Group 1 consisted of 6 women and 19 men; group 2, 8 women and 17 men; group 3, 8 women and 17 men; and group 4, 13 women and 12 men. In both groups 1 and 2, the dominant elbow was involved in 60% of patients. In groups 3 and 4, the dominant elbow was involved in 56% and 68%, respectively.

In group 1, endoscopic findings included tendinosis or bicipital bursitis (12%) and low-grade (20%), intermediate-grade (12%), and high-grade (56%) partial distal biceps ruptures (Table II). In group 3, there were no cases of tendinosis or bicipital bursitis, and partial tears were

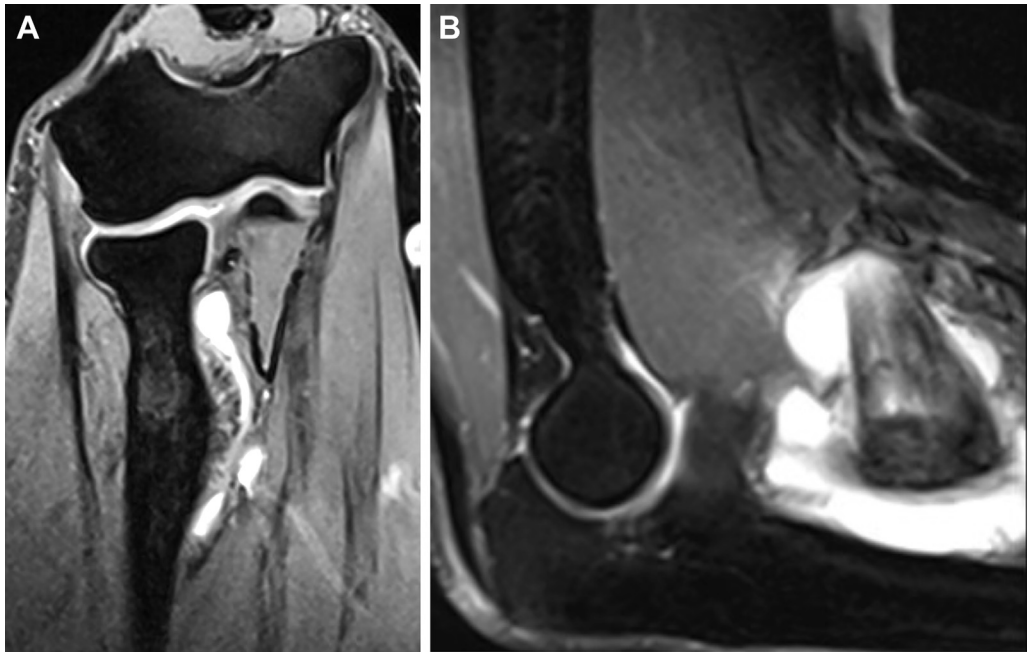


**Figure 3** **(A, B)** Flexion-abduction-supination magnetic resonance imaging views (3-dimensional double-echo steady-state with water excitation) showing low-grade partial tear of distal biceps tendon and bicipital bursitis. Courtesy of MoRe Foundation.

**Figure 4** Flexion-abduction-supination magnetic resonance imaging view (3-dimensional double-echo steady-state with water excitation) showing intermediate-grade partial tear of distal biceps tendon (long head tear with short head intact). Courtesy of MoRe Foundation.

divided into 60% low-, 8% intermediate-, and 32% high-grade tears (Table III).

In the biceps pathology groups (groups 1 and 3), MRI interpretations were compared with intraoperative findings. Biceps pathology was correctly reported from FABS views MRI in 84% of patients and from standard MRI scans in 76% ($P = .32$).

In the FABS view MRI group, 83% of tendinosis cases, 50% of low-grade tears, 67% of intermediate-grade cases, and 57% of high-grade partial tears were correctly identified (Table II). In the standard MRI group, 23% of low-grade cases, no intermediate-grade cases, and 6% of high-grade partial tears were correctly identified (Table III). There was a significant difference between FABS and standard MRI when tear grading was compared ($P = .002$). In the control groups (groups 2 and 4), asymptomatic biceps tendinosis was reported in 14% of cases on FABS views MRI and in 2% on standard MRI.

The overall sensitivity in detecting distal biceps tendon pathology for the FABS view MRI was 84%, and the specificity was 86%. Standard MRI had an overall sensitivity and specificity in detecting distal biceps tendon pathology of 76% and 98%, respectively. No significant difference was found between the FABS and standard MRI views in sensitivity ($P = .32$) or specificity ($P = .31$). The PPV for the FABS view MRI was 86%, and the NPV was 84%. For standard MRI, the PPV and NPV were 97% and 80%, respectively.

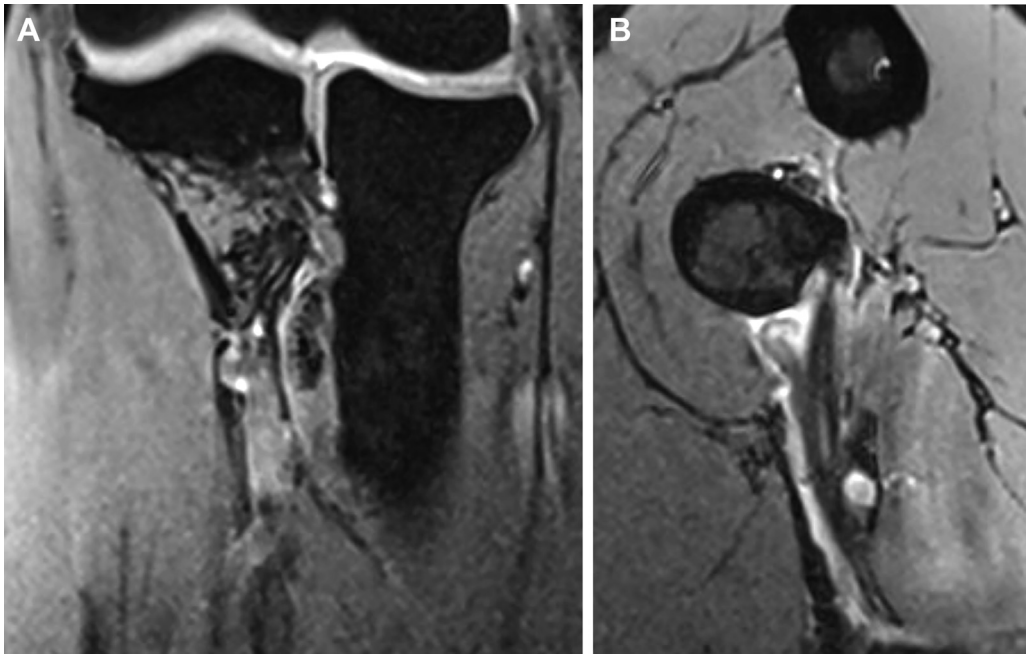


**Figure 5** Flexion-abduction-supination magnetic resonance imaging views (3-dimensional double-echo steady-state with water excitation). **(A)** Intermediate-grade partial tear of distal biceps tendon with long head intact and short head tear. **(B)** Intermediate-grade partial tear of distal biceps tendon. Courtesy of MoRe Foundation.

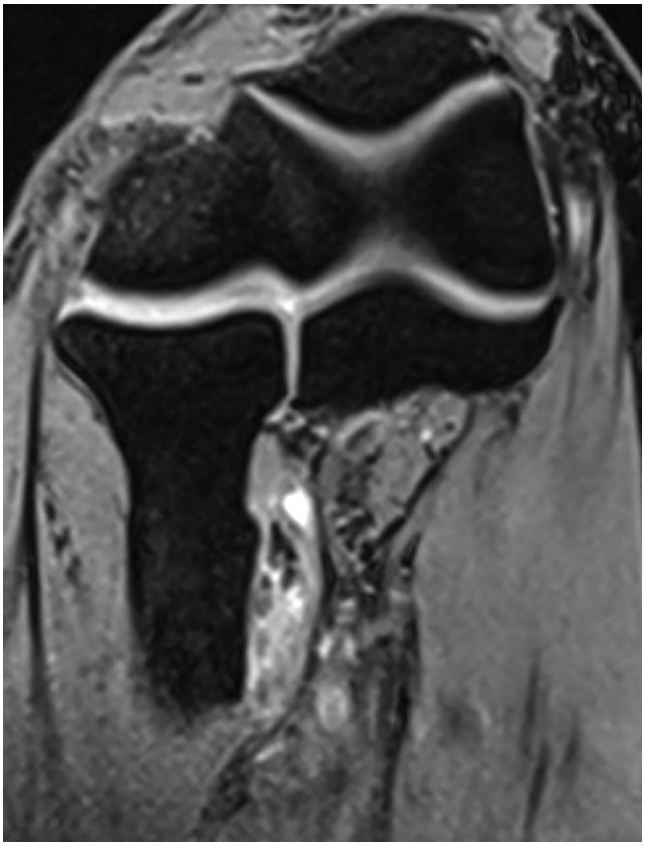

**Figure 6** Flexion-abduction-supination magnetic resonance imaging view (3-dimensional double-echo steady-state with water excitation) showing high-grade partial tear of distal biceps tendon. Courtesy of MoRe Foundation.

The IRR was 92% for the FABS views MRI with biceps pathology vs. 68% for the standard MRI scans with biceps pathology. In the control groups, the IRR was 88% for the FABS view MRI and 96% for the standard MRI scans (Table IV).

## Discussion

Partial ruptures of the distal biceps tendon are relatively uncommon injuries. Diagnosis is difficult because the symptoms and clinical examination are often vague and nonspecific.[1,3,9,12,13] The literature has shown MRI of the elbow to be a useful tool in the diagnosis of distal tendon pathology.[4,6] However, most studies have evaluated complete ruptures of the distal biceps tendon. In a study comparing the effectiveness of standard elbow MRI for complete and partial ruptures, the sensitivity of MRI was only 59% for partial tears compared with 100% for complete ruptures.[5] The sensitivity of standard MRI views in our study (76%) is higher than the previous reported sensitivity of 59%.

To improve the accuracy of MRI diagnosis of distal biceps tendon pathology, the FABS view was described by Giuffrè and Moss[7] in 2004. Although it has been used clinically, no specific research on the accuracy of the FABS view MRI has been published. Our data did not show a significant difference in sensitivity and specificity for the FABS view MRI compared with standard MRI in the detection of distal biceps injuries.

**Table II** Comparison of MRI interpretation reported by radiologists 1 and 2 with surgical findings (endoscopy) for FABS view MRI (group 1)

| Group 1: biceps pathology with FABS view MRI | Radiologist 1, n | Radiologist 2, n | Endoscopy, n |
|---|---|---|---|
| Partial tears distal biceps tendon | 14 | 11 | 22 |
| Low grade (<25%) | 7 | 4 | 5 |
| Intermediate grade (25%-50%) | 2 | 3 | 4 |
| High grade (>50%) | 5 | 4 | 13 |
| Tendinosis | 5 | 10 | 2 |
| Bicipital bursitis | 2 | 0 | 1 |
| No biceps pathology | 4 | 4 | 0 |

*MRI*, magnetic resonance imaging; *FABS*, flexion abduction supination.

**Table III** Comparison of MRI interpretation reported by radiologists 1 and 2 with surgical findings (endoscopy) for standard elbow MRI (group 3)

| Group 3: biceps pathology with standard MRI | Radiologist 1, n | Radiologist 2, n | Endoscopy, n |
|---|---|---|---|
| Partial tears distal biceps tendon | 13 | 9 | 25 |
| Low grade (<25%) | 9 | 7 | 15 |
| Intermediate grade (25%-50%) | 4 | 1 | 2 |
| High grade (>50%) | 0 | 1 | 8 |
| Tendinosis | 6 | 9 | 0 |
| Bicipital bursitis | 0 | 0 | 0 |
| No biceps pathology | 6 | 7 | 0 |

*MRI*, magnetic resonance imaging.

**Table IV** Accuracy of FABS view and standard MRI view of partial distal biceps tendon ruptures

| | FABS view, % | Standard MRI, % |
|---|---|---|
| Sensitivity | 84 | 76 |
| Specificity | 86 | 98 |
| PPV | 85 | 97 |
| NPV | 84 | 80 |
| IRR | 92 | 68 |

*FABS*, flexion abduction supination; *MRI*, magnetic resonance imaging; *PPV*, positive predictive value; *NPV*, negative predictive value; *IRR*, inter-rater (interobserver) reliability.

The advantage of our study is that the radiologists were blinded to the purpose of this investigation. Only after the first distinction were they told to grade the distal biceps tendon ruptures as described before. In previous studies, the investigators were told that the MRI scans suggested distal biceps pathology.[14]

There are several limitations to this study. First, standard MRI and FABS MRI obtained in the same patient were not directly compared. However, because the radiologists were not aware that they were evaluating distal biceps tendon pathologies in either group, we believe that the results of the study were not influenced. Second, we did not consider tear chronicity. Previous research evaluated this and saw no influence on the results.[5] Third, our protocol for the FABS view MRI included coronal and axial 3-dimensional sequences with a slice thickness of 1.5 mm whereas the standard elbow MRI protocol had a slice thickness of 3 mm. The accuracy and consistency of the MRI examination may have been influenced in favor of the FABS view by using a thinner slice thickness than with the standard MRI protocol. Finally, grading of the tear was based on surgical findings. This may have introduced an error, but we believe this was the most accurate possible method.

## Conclusion

The FABS view has shown to be a valuable tool in the diagnosis of partial distal biceps tendon injuries. No significant difference was found in sensitivity and specificity when FABS and standard views were compared; however, inter-rater reliability was higher with FABS views, and FABS views were significantly

more accurate than surgical findings in grading the extent of the pathology.

## Disclaimer

Roger van Riet is a consultant with Acumed. All the other authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

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