Appearance of histopathologic changes of rotator cuff tendons in MRI

F. M. Buck[1], H. Grehn[2], B. Jost[2], M. Hilbe[3], S. Manzanell[4], and J. Hodler[1]

[1]Department of Radiology, Balgrist University Hospital, Zurich, Switzerland, [2]Orthopedic Surgery, Balgrist University Hospital, Zurich, Switzerland, [3]Institute of Veterinary Pathology, Vetsuisse Faculty, University of Zurich, Zurich, Switzerland, [4]MSRU, Equine Hospital, Vetsuisse Faculty, University of Zurich, Zurich, ZH, Switzerland

Background

Signal changes in tendons due to magic angle artifacts or degeneration are commonly encountered on MR images and have been evaluated in a number of publications. However, there are other reasons for signal abnormalities which have not been evaluated systematically, to our knowledge. The histopathologic changes in tendinopathy and the characteristics of magic angle artifacts have been described. Thus, the purpose of our study was to relate histologic changes in degenerated rotator cuff tendons with their MR appearance.

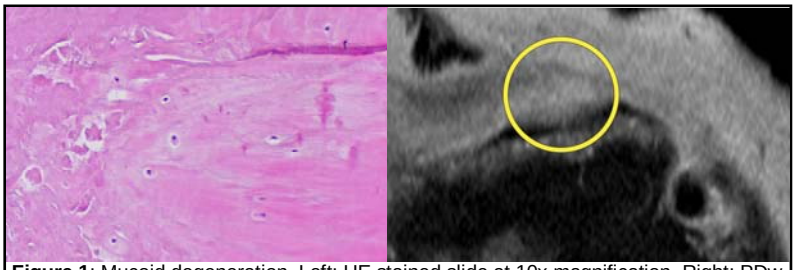

Figure 1: Mucoid degeneration. Left: HE stained slide at 10x magnification. Right: PDw fs image of the corresponding area in the subscapularis tendon.

Materials and Methods

Eighteen cadaveric shoulder specimens were scanned in a 1.5T MRI system. T1-weighted (T1w; section thickness, 3mm; repetition time [TR], 539 msec; echo time [TE], 15 msec; field of view, 14x14 cm; matrix size, 512x512; numbers of excitations [NEX], 2), T2-weighted fat-saturated (T2w fs) fast spin-echo (section thickness, 3 mm; TR, 3040 msec; TE, 71 msec; field of view, 14x14 cm; matrix, 512x512; NEX, 1; echo train length [ETL], 7), and proton density-weighted fat-saturated (PDw fs; section thickness, 3 mm; TR, 2640 msec; TE, 15 msec; field of view, 14x14 cm; matrix, 512x512; NEX, 2; ETL, 7) spin-echo sequences were acquired. After scanning supraspinatus, infraspinatus, and subscapularis tendons were evaluated histologically. Hematoxylin and eosin (HE) stained slides were evaluated. The distance of pathologic changes from the bony attachment of the tendon and the length of pathologic areas were measured using a light microscope and digital photography. A region of interest (ROI) was defined for all tendon areas with abnormal histology. Areas with mucoid degeneration (MD) were further graded based on the percentage of tendon diameter involved (I: <25%, II: 25-50%, III: 50-75%, IV: >75%). Additional ROIs were set in parts of the tendons with normal histology, with and without suspected magic angle (MA) artifact. The resulting ROI were evaluated by two musculoskeletal radiologists independently and blinded to the histological results. Signal alterations were graded using the signal intensity of bone, muscle, and fat as references. Interreader agreement was calculated (Intraclass correlation coefficient). MR results were compared to histologic findings (Wilcoxon signed rank test).

Table 1: Signal intensity of different histologic changes

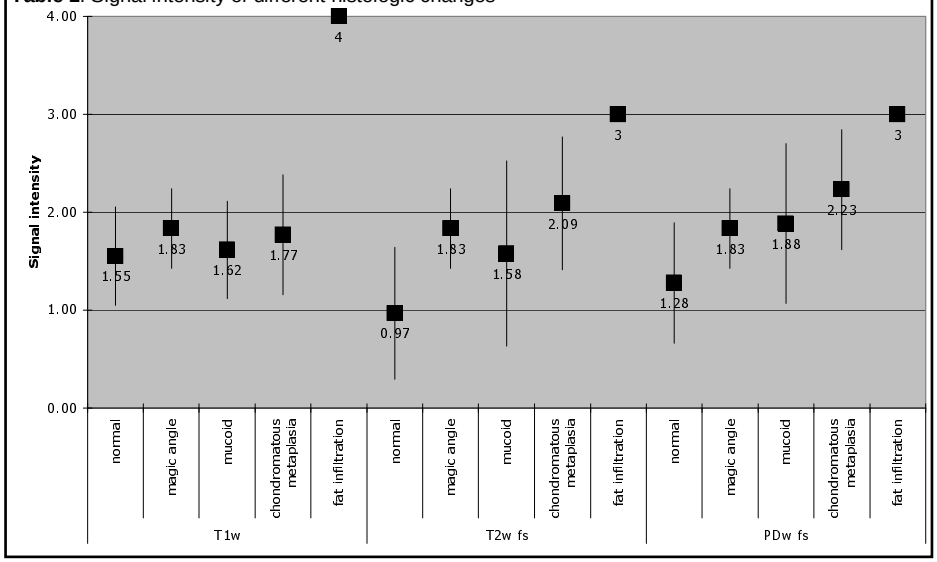

Table 2: Differences in signal intensities of different histological findings (Wilcoxon signed rank)

	Sequence	Normal	Magic angle	Mucoid	Fatty infiltration
Magic angle	T1w	0.180			
	T2w fs	0.083 ↑			
	PDw fs	0.317			
Mucoid	T1w	0.197	**0.046** ↓		
	T2w fs	**0.007** ↑	0.100 ↓		
	PDw fs	**0.006** ↑	0.083 ↑		
Fat infiltration	T1w	0.180	0.180	0.157	
	T2w fs	0.180	0.157	0.157	
	PDw fs	0.157	0.157	0.157	
Chondromatous metaplasia	T1w	**0.029** ↑	0.180	0.166	0.180
	T2w fs	**< 0.001** ↑	1.000	**0.038** ↑	0.157
	PDw fs	**0.001** ↑	0.317	0.074 ↑	0.157

Note: Bold arrow: significant difference. Arrow: trend (p≤0.10). Arrow up/down, hyperintensity/hypointensity of the item on the left side versus the item above.

Results

Based on histology MD (n=13; grade I: 2; grade II: 7; grade III: 4), chondromatous metaplasia (CM) (n=11), fatty infiltration (FI) (n=1), and granuloma formation due to suturing material (n=1) was found and assigned to a ROI. Three ROIs were set in a suspected MA artifact as diagnosed on MR images. A total of 29 ROIs placed within tendon parts with abnormal MR signal were compared to 29 ROIs within normal tendon (NT) histologically. Interreader agreement with regard to signal intensity was moderate on T1w images (Intraclass correlation coefficient [ICC] 0.557, p=0.001), almost perfect on T2w fs images (ICC 0.837, p<0.001), and substantial on PDw fs images (ICC 0.754, p<0.001). ICC with regard to the location of MR versus histological findings was 0.237/p=0.155, 0.346/p=0.056, and 0.073/p=0.079 respectively. The grading results of the signal intensity of the different histologic findings are presented in Tables 1 and 2. 2. There was no significant difference in signal intensity between the different severity grades. There was moderate agreement (ICC 0.492, p=0.048) between histologic and MR evaluation of tendon diameter involvement using T2w fs, whereas T1w and PDw fs evaluation was not successful (ICC < 0.20).

Conclusion

Mucoid tendon degeneration is hyperintense on T2w fs and PDw fs sequences. T2w fs sequences are more precise in the demonstration of the extent of tendon degeneration than T1w or PDw fs sequences. Chondromatous metaplasia is a common finding in rotator cuff tendons and appears hyperintense on T1w, T2w fs, and PDw fs sequences.