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Original Research

Magnetic Resonance Imaging Findings of Extensor Carpi Radialis Brevis Origin and Synovial Fold in Lateral Epicondylitis

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A R T I C L E I N F O

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Purpose: Magnetic resonance imaging (MRI) is the most widely used imaging to diagnose lateral epicondylitis (LE). However, the importance of MRI findings in LE remains unclear. This study aimed to classify the signal intensity changes of the extensor carpi radialis brevis origin and the shape and length of the synovial fold using MRI and compare them with clinical symptoms. We hypothesized that MRI findings in LE are not associated with clinical symptoms.
Methods: Two hundred and forty-three patients (261 elbows, mean age: 51.2 ± 8.5 years, mean duration of LE: 18.2 ± 11.3 months) who were evaluated using pretreatment MRI were included. The signal change of the extensor carpi radialis brevis origin was classified using coronal T2-weighted (T2) imaging and coronal fat-suppressed proton density T2 imaging, and the shape and length of the synovial folds were evaluated using coronal and sagittal T2 imaging. Furthermore, MRI findings were compared with clinical symptoms at the first visit.
Results: The number of elbows with high signal intensity on fat-suppressed proton density T2 was 252 of 261 (96.5%), and those on T2 were 207 of 261 (79.3%). Synovial folds were observed in 231 of 261 (88.5%) of the elbows, and synovial folds having a dull shape were observed in 95 of 261 (36.4%) elbows. The length of the synovial fold was >1/3 of the radial head in 87 of 261 (33.3%) of the elbows. There was no statistically significant correlation between the MRI findings and clinical symptoms.
Conclusions: A high rate of high signal intensity changes of the extensor carpi radialis brevis origin was observed, and fat-suppressed proton density T2 could detect finer signal changes than T2. Furthermore, synovial folds were found in many cases of LE. However, there was no association between MRI findings and clinical symptoms at first visit.
Type of study/level of evidence: Prognostic IV.

Lateral epicondylitis (LE) is a common condition diagnosed by history and physical examination findings, such as tenderness of the lateral epicondyle and pain with resisted wrist extension (worse with the elbow in full extension compared to flexion). Although imaging is not often initially performed, it is useful for excluding other elbow joint diseases.[1,2] Magnetic resonance imaging (MRI) is a commonly used imaging modality for patients with LE.[3] Miller et al[4] reported that the sensitivity of ultrasound for the detection of both lateral and medial epicondylitis ranged from 64% to 82%, whereas that of MRI ranged from 90% to 100%. However, Pasternack et al[5] reported that the common extensor tendon signal change existed in 14% of healthy volunteers and 50% of unaffected elbows; thus, the importance of MRI findings in LE remains unclear.

Although LE is generally treated using nonsurgical methods, some patients undergo further treatment, such as extracorporeal shock wave therapy and surgical management.[6–10] Therefore, several studies have classified the severity of LE by using findings on MRI T2-weighted (T2) images and fat-suppressed T2 images.[6,8,11] Although T2 and fat-suppressed T2 images are important tools for evaluating LE imaging, there are no reports which evaluated both T2 and fat-suppressed images, and few studies have compared MRI findings with clinical symptoms.[8]

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Table 1
Parameter of MRI Sequence

Plane	Sequence	TE (msec)	TR (msec)	ETL	Matrix	BW (Hz)	FOV (mm)	Thickness (mm)	Gap (mm)
Coronal	T2 FSE	100	3,500	14	256	200	150	3	0.3
Coronal	PDFS T2 FSE	100	2,000–3,500	3–6	256	200	150	3	0.3
Sagittal	T2 FSE	100	3,500	14	256	200	150	3	0.3

BW, bandwidth; ETL, echo train length; FOV, field of view; FSE, fast spin echo; MRI, magnetic resonance imaging; PDFS T2, fat-suppressed proton density T2-weighted; TE, echo time; TR, repetition time.

Table 2
MRI Classifications of High Signal Intensity Changes of ECRB Origin

ECRB Type	0	1	2	3	4	5
T2-weighted range	-	-	-	High ~1/3*	High 1/3–2/3*	High 2/3~*
PDFS T2	-	Iso	High	High	High	High

ECRB, extensor carpi radialis brevis; MRI, magnetic resonance imaging; PDFS T2, fat-suppressed proton density T2 weighted.
* Range of the high signal intensity change to the entire ECRB origin.

Furthermore, subclinical instability of the lateral elbow joint because of LE may affect synovial fold thickening, and the synovial fold could worsen symptoms of LE if it impinges on the radial head or interposes in the radiocapitellar joint.[12–16] Although Ruiz Ruiz de Luzuriaga et al[17] reported that MRI can detect abnormalities of the radiohumeral synovial fold associated with synovial fringe syndrome, few reports have evaluated the association between LE and synovial fold.

This study aimed to classify the signal intensity changes of the extensor carpi radialis brevis (ECRB) origin and the shape and length of the synovial fold using MRI in LE and compare them with clinical symptoms. We hypothesized that MRI findings in LE are not associated with clinical symptoms.

Material and Methods

After approval from our institutional review board (Institutional Review Board of Chiba University Graduate School of Medicine), we placed a public document on the homepage of the authors' affiliated institutions. Patients who contacted us expressing their desire not to participate in the research were excluded. Among 283 patients (294 elbows) diagnosed with LE at our hospital, 253 patients (261 elbows) with pretreatment MRI were included. Thirty patients (33 elbows) were excluded because a pretreatment MRI was not performed, and there were no patients who declined to participate in this study. Patients were diagnosed with LE when they exhibited symptoms of lateral epicondylar pain and had positive Thomsen and middle finger extension tests. The mean age was 51.2 ± 8.5 (30 to 72) years, the ratio of males to females was 140 elbows versus 121 elbows, and the mean duration of LE was 18.2 ± 11.3 (6 to 180) months. Magnetic resonance imaging was performed using a 1.5- or 3.0-T unit (Ingenia Elition; Philips Medical Systems) with a quadrature extremity surface coil (Table 1).[1] Imaging was performed with the patients in a supine position with the arm along the side of the body, the elbow extended, and the wrist supinated. The signal change of the ECRB origin was evaluated using coronal T2 imaging and coronal fat-suppressed proton density (PDFS) T2 imaging. Fat-suppressed proton density T2 is considered to be more sensitive in detecting water abnormalities than fat-suppressed T2 images, thus we used PDFS T2 for evaluation, as in previous reports.[18] The ECRB origin was evaluated in the slice in which the entire origin could be evaluated. Furthermore, the shape and length of the posterior synovial folds were evaluated using coronal T2 imaging, and the lateral synovial folds were evaluated using sagittal T2 imaging, as the posterolateral synovial folds were well described in relation to synovial fold syndrome.[19,20] The synovial folds were evaluated in the slice in which the transverse diameter of the radial head was the largest, and the synovial folds were well visualized. Imaging evaluations were performed by two board-certified orthopedic surgeons (K.I., N.O.) and a radiologist. Differences in opinion were resolved through discussion or by referring to a fourth person's opinion.

We newly classified a signal intensity change of ECRB origin in LE using both T2 and PDFS T2 to investigate the relationship between clinical symptoms and MRI findings. The degree of high signal intensity change and the range of that area to the entire ECRB origin were evaluated and classified into six types (Table 2, Fig. 1) as follows: type 0, no signal change on both T2 and PDFS T2; type 1, signal isointense to that of muscle on PDFS T2 but no signal change on T2; type 2, high signal intensity change on PDFS T2 but no signal change on T2; type 3: high signal intensity change on both T2 and PDFS T2, and an area of <1/3 of the entire ECRB origin on T2; type 4: high signal intensity change on T2 and an area of 1/3 to 2/3 of the entire ECRB origin on T2; and type 5, high signal intensity change on T2 and an area of >2/3 on T2.

The shape of the synovial fold was evaluated as sharp or dull (Fig. 2) and classified into three types as follows: type 0, no synovial fold; type 1, sharp shape; type 2, dull shape on either coronal or sagittal section; and type 3: dull shape on both coronal and sagittal sections (Table 3). The length was evaluated based on whether the length exceeded 1/3 of the radial head (Fig. 3) and classified into three types as follows: type 1, less than 1/3 of the radial head; type 2, 1/3 to 2/3 of the radial head on either coronal or sagittal section; and type 3, 1/3 to 2/3 of the radial head on both coronal and sagittal sections (Table 3). If the synovial fold did not extend over the radial head, it was considered absent. No patient had a synovial fold exceeding 2/3 of the radial head in length; thus, we evaluated based on whether the length exceeded 1/3 of the radial head.

We compared the ECRB type, shape, and length with clinical symptoms *Quick*DASH (Disabilities of the Arm, Shoulder, and Hand) score, visual analog scale of motion pain, and effect on grip ratio with unaffected side) at our first visit. The Kruskal–Wallis test was used to compare each type of clinical symptom. $P < .05$ was considered statistically significant.

Results

The ECRB type was type 0 in 9 (3.5%) elbows, type 1 in 14 (5.4%), type 2 in 31 (11.9%), type 3 in 74 (28.4%), type 4 in 90 (34.5%), and type 5 in 43 (16.5%). The number of ECRB type 1–5 with high signal intensity on PDFS T2 was 252/261 (96.5%) and that of ECRB type 3–5 with high signal intensity on both PDFS

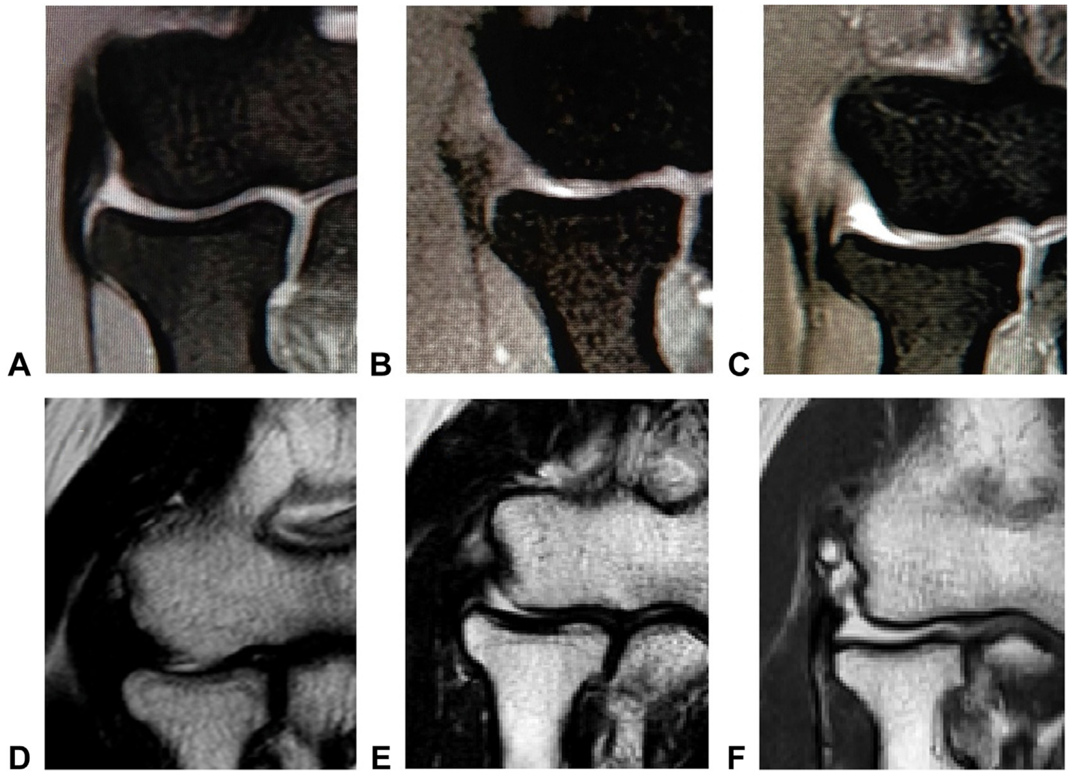

Figure 1. Typical imaging of the ECRB type. **A**–**C** PDFS T2 coronal. **D**–**F** T2 coronal. ECRB, extensor carpi radialis brevis; PDFS T2, fat-suppressed proton density T2-weighted.

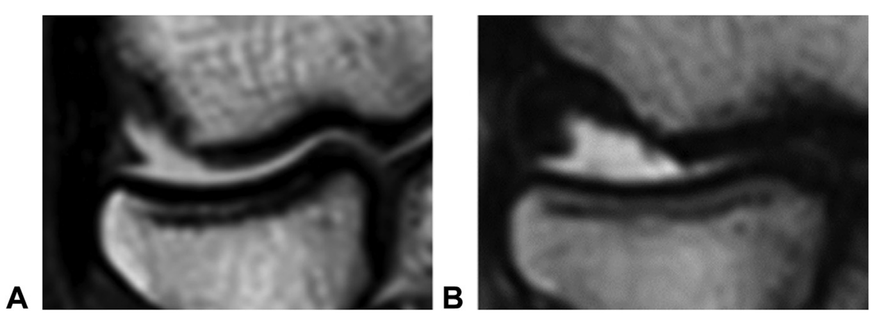

Figure 2. Typical imaging of the shape of the synovial fold. The shape of the synovial fold was characterized as follows: **A** Sharp. **B** Dull.

T2 and T2 was 207/261 (79.3%). Synovial folds were recognized in 231/261 (88.5%) elbows. The shape of the synovial fold was type 0 in 30 (11.5%) elbows, type 1 in 136 (52.1%) elbows, type 2 in 62 (23.8%) elbows, and type 3 in 33 (12.6%) elbows. Synovial folds with a dull shape (type 2 or 3) were observed in 95/261 (36.4%) patients. The length of the synovial fold was type 0 in 30 (11.5%) elbows, type 1 in 145 (55.6%) elbows, type 2 in 70 (26.8%) elbows, and type 3 in 16 (6.1%) elbows. The length of the synovial fold was >1/3 that of the radial head (type 2 or 3) in 87/261 (33.3%) elbows. A total of 132/261 (50.6%) elbows were type 2 or 3 in either shape or length. There was no statistically significant correlation among ECRB type, shape and length of synovial fold, and clinical symptoms (Tables 4 and 5).[1]

Table 3
MRI Classifications of the Shape and Length of the Synovial Fold

Shape Type	0	1	2	3
T2-weighted Coronal Sagittal	 - -	Sharp	Either dull	Dull
Length Type	**0**	**1**	**2**	**3**
T2-weighted Coronal Sagittal	 - -	~1/3*	Either 1/3~*	1/3~*

MRI, magnetic resonance imaging.
* Length as a percentage of the transverse radial head.

Discussion

We evaluated the high signal intensity changes of the ECRB origin in LE using T2 images and PDFS T2 images of MRI. The number of ECRB type 1–5 with high signal intensity on PDFS T2 images was 252/261 (96.5%) elbows, which was greater than that of ECRB type 3–5 with high signal intensity on both PDFS T2 and T2 images (207/261 elbows, 79.3%). These results were more frequent than in the previous report that examined healthy subjects and unaffected sides.[5] Regarding patients with LE, Aoki et al[21] reported

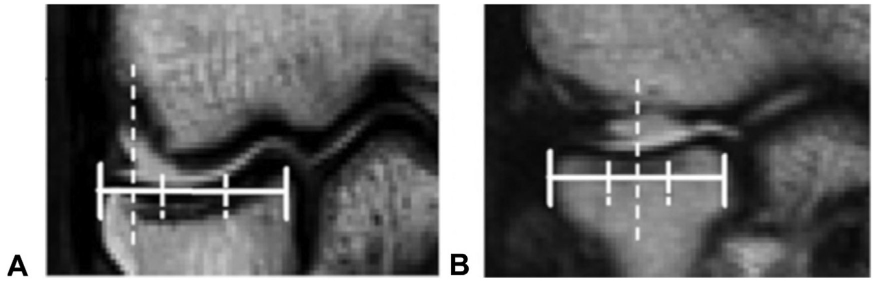

Figure 3. Typical imaging of the length of the synovial fold. The length of the synovial fold was characterized as follows: **A** Less than 1/3 of the radial head. **B** More than 1/3 of the radial head.

Table 4
Comparison of ECRB Type to Clinical Symptoms

ECRB Type	0	1	2	3	4	5	*P* Value
*Quick*DASH score (mean ± SD)	26.7 ± 14.0	33.9 ± 18.0	30.8 ± 17.7	31.0 ± 18.0	33.4 ± 20.1	31.8 ± 18.0	.950
Grip ratio (%) (mean ± SD)	65.0 ± 37.1	65.7 ± 28.5	75.8 ± 28.8	75.2 ± 32.7	72.1 ± 32.4	68.0 ± 32.8	.763
VAS* (mm) (mean ± SD)	49.2 ± 35.6	56.4 ± 25.7	58.5 ± 26.4	52.3 ± 26.2	58.0 ± 25.3	48.2 ± 28.9	.478

ECRB, extensor carpi radialis brevis; *Quick*DASH, Disabilities of the Arm, Shoulder, and Hand.
* Visual analog scale of motion pain.

Table 5
Comparison of Shape and Length Type of the Synovial Fold to Clinical Symptoms

Shape Type	0	1	2	3	*P* Value
*Quick*DASH Score (mean ± SD)	35.9 ± 18.8	32.6 ± 18.7	29.5 ± 18.1	30.6 ± 18.2	.433
grip ratio (%) (mean ± SD)	78.4 ± 32.9	69.9 ± 30.7	71.9 ± 32.3	76.1 ± 35.8	.655
VAS*,[1] (mm) (mean ± SD)	61.3 ± 29.4	52.6 ± 26.3	52.3 ± 26.9	60.2 ± 24.0	.238
Length Type	**0**	**1**	**2**	**3**	***P* Value**
*Quick*DASH Score (mean ± SD)	35.9 ± 16.8	29.2 ± 17.7	36.8 ± 19.1	29.1 ± 18.5	.071
Grip Ratio (%) (mean ± SD)	78.4 ± 32.9	70.7 ± 30.3	73.8 ± 35.1	66.2 ± 31.2	.628
VAS*,[1] (mm) (mean ± SD)	61.3 ± 29.4	52.3 ± 27.1	55.0 ± 24.7	59.9 ± 25.0	.344

*Quick*DASH, Disabilities of the Arm, Shoulder, and Hand; VAS, visual analog scale.
* Visual analog scale of motion pain.

that T2 images showed high signal intensity changes in 6 of 11 (54.5%) patients, and Cha et al[6] reported that fat-suppressed images showed high signal intensity changes in all 96 patients. Therefore, fat-suppressed images including PDFS T2 can detect finer signal changes than T2 images and are considered superior for detecting early lesions. However, given that signal changes in the common extensor tendon are present even in healthy volunteers, it is possible that the signal intensity changes in this study also capture normal MRI images that existed before the onset of LE.[6] In other words, even if the diagnosis of LE is based on symptoms and physical findings, there may be cases in which the MRI images are normal. This study did not investigate MRI findings in healthy subjects, thus further research on this possibility will be conducted in the future.

Regarding the synovial fold, Kitsukawa et al[12] reported that synovial folds were found in 102 of 160 elbows (63.7%) in healthy subjects; thus, they might be found more frequently (231 of 261 elbows, 88.5%) in patients with LE in this study. This difference might be attributed to the thickening of the synovial fold caused by chronic inflammation and elbow instability in LE.[13,14,22] This thickening may have increased the percentage identified on MRI. Conversely, because the synovial fold is also found in healthy subjects, some normal structures may be included in the synovial fold of patients with LE. Although the shape and length of the synovial fold in normal subjects are unknown, type 2 or 3 was found in 132 of 261 elbows (50.6%) in patients with LE in this study. Thus, if we assume that type 2 or 3 was defined as a thickening of the synovial fold, the synovial fold might be thick at high frequencies in LE, leading to synovial fold disorder.[15] Therefore, based on previous studies, we consider that complications of synovial fold disorders should be noted in patients with LE.[15,18,20] However, some reports suggest that there was no additional effect of adding posterior synovial fold excision on surgery for LE; thus, the relationship between LE and synovial fold disorders remains controversial.[23]

Moreover, we evaluated the correlation between MRI findings of LE and clinical symptoms at first visit and found no correlation with any of the MRI findings. Therefore, imaging and clinical symptoms might not always coincide, and we might not be overly concerned with MRI findings when determining the indication for treatment at first visit. However, radial tunnel syndrome is a confusing disease to differentiate from LE because of lateral elbow pain.[24,25] MRI is useful for its differentiation, and MRI may be helpful to rule out other diseases than LE.[26] Regarding other imaging findings of LE, Sasaki et al[27] reported that computed tomography arthrography showed a stronger correlation with joint capsular rupture, which was diagnosed during arthroscopy, than MRI in 19 patients who underwent surgery for LE. However, the correlation between joint capsular rupture and clinical symptoms is unknown; thus, the indication for treatment should be determined based on the clinical course and patient background.

This study has several limitations. First, we did not compare the MRI findings with the treatment response. However, this study aimed to evaluate MRI findings in patients with LE and to investigate whether they were associated with clinical symptoms at that time. We intend to conduct further research in this regard in the future. Second, we did not examine physical findings related to synovial fold disorders, such as the fringe impingement test. Third, we did not perform dynamic evaluations using ultrasonography or other means. Finally, we did not have a control group. Therefore, it is unclear how much more high signal intensity changes of the ECRB origin and thickening of the synovial fold were seen compared to healthy subjects.

Conflicts of Interest

No benefits in any form have been received or will be received related directly to this article.

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