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# Magnetic resonance imaging of patients with lateral epicondylitis: Relationship between pain and severity of imaging features in elbow joints

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ABSTRACT

*Objective:* The aim of this study was to determine the inter- and intra-observer reliabilities of magnetic resonance imaging (MRI) for the diagnosis of lateral epicondylitis, to examine whether degree of common extensor tendon (CET) injury is related to other elbow abnormalities on MRI, and to investigate the correlation between elbow abnormalities on MRI and patients' symptoms.

*Methods:* Fifty-one patients (32 women and 19 men; mean age: 50 years (range, 22–63)) with a diagnosis of lateral epicondylitis were included in the study. The average duration of symptoms was 2.3 years. MRI scoring system was used to grade the CET injuries and associated injuries in the elbow joint. Three independent radiologists retrospectively reviewed MRI images. Inter- and intra-observer reliabilities for diagnosing lateral epicondylitis were calculated using kappa statistics, and Spearman's rank correlation analysis was used to analyze relationships between degree of CET injury and the associated abnormalities of elbow joints. Statistical relations were considered significant for $p$ values of <0.05. In addition, using Spearman's rank correlation analysis, CET injuries and associated abnormalities of elbow joints were correlated with clinical symptoms using visual analog scale pain scores.

*Results:* Various degrees of CET injuries were found in total of 51 patients. Radial collateral ligament and lateral ulnar collateral ligament (RCL/LCL) was the most common accompanying elbow abnormality other than CET injuries. Inter- and intra-observer agreements of CET and RCL/LUCL injuries on MRI were excellent. There were significant correlation between degrees of CET and RCL/LUCL injuries (correlation coefficient $r = 0.667$, $p < 0.01$) and between degree of RCL/LUCL injuries and visual analog 11-point pain box scale (VAS) scores (correlation coefficient $r = 0.478$, $p = 0.033$).

*Conclusion:* MRI showed excellent inter- and intra-observer reliabilities for the evaluation of lateral epicondylitis. In addition to common extensor tendinopathy, RCL/LUCL abnormality was the most common accompanying finding and degree of RCL/LUCL injuries positively correlated with degree of CET injuries. Furthermore, degree of RCL/LUCL injuries positively correlates with severity of pain.

*Level of evidence:* Level IV, Diagnostic study.



*Abbreviations:* MRI, magnetic resonance imaging; CET, common extensor tendon; RCL, Radial collateral ligament; LCL, lateral ulnar collateral ligament; RCL/LCL, radial collateral ligament and lateral ulnar collateral ligament; VAS, visual analog 11-point pain box scale; CFT, common flexor tendon; MCL, medial collateral ligament; US, ultrasonography; PRTEE, patient-rated tennis elbow evaluation.

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## Introduction

Lateral epicondylitis is caused by repetitive stress of the wrist/forearm extensor and supinator muscles. It involves the common extensor tendon (CET), and its most common location is at the origin of the extensor carpi radialis brevis tendon. Histopathologically the affected tendon shows microtear, progressive mucoid degeneration, immature repair, and angiofibroblastic tendinosis.[1–3]

In most cases, diagnosis of lateral epicondylitis is made by history taking of clinical symptoms and physical examination. In general, imaging is not initially performed, but it is helpful for evaluating disease extent, excluding other elbow joint diseases, and for surgical planning. Magnetic resonance imaging (MRI) is the most widely used imaging modality and has high sensitivity, specificity, and accuracy for diagnosing lateral epicondylitis.[4–6] CET injury is a characteristic imaging finding of lateral epicondylitis, and previous studies have shown a radial collateral ligament (RCL) or lateral ulnar collateral ligament (LUCL) abnormality is a finding that frequently accompanies CET injury.[1,7–9] Although several studies had investigated the relationship between the imaging findings of CET injuries and clinical symptoms,[8,10,11] the relationship remain controversial. One study[10] showed no significant correlation between CET injuries and clinical symptoms, however others have shown significant correlation.[8,11]

The purpose of this study was to document the inter- and intra-observer reliabilities of MRI for the diagnosis of lateral epicondylitis and to examine whether degree of CET injury is related to other elbow MR abnormalities. In addition, we also investigated whether degrees of CET injuries and other accompanying MR abnormalities were correlated with patients' symptoms.

## Materials and methods

### *Study population*

This retrospective study was approved by our Institutional Review Board. The study involved reviewing and analyzing the MR images, radiographs, and medical records of 51 patients with a clinical diagnosis of lateral epicondylitis treated at our institute from August 2009 to June 2016. There were 32 female and 19 male with a mean age of 50.0 years (range, 22–63 years). The average duration of symptoms was 2.3 years (range, 1 week–20 years). Patients that have received a corticosteroid injection at the lateral elbow within 3 months of MRI, major trauma or a history of elbow surgery were excluded. Of the 51 patients, 24 received conservative management and 27 underwent surgery. All surgical procedures were performed within two weeks of MRI examination and the surgical procedures were debridement and repair of extensor compartment. All 51 patients underwent radiography of the elbow to exclude the possibility of a bony abnormality. Patients were asked to answer the questionnaire: a visual analog 11-point pain box scale (VAS). The minimum obtainable score is 0 (no pain) and the maximum is 10 (worst possible, unbearable, excruciating pain).

### *Imaging assessments*

MRI was performed using a 1.5-T unit (Intera, Philips Healthcare, Best, Netherlands) or a 3.0-T unit (Signa HDxt, GE Medical Systems, Milwaukee, Wisconsin, USA) with a quadrature extremity surface coil. Imaging was performed with patients supine with the arm along the side of the body, the elbow extended, and the wrist supinated. Parameters of MR sequences are provided in Table 1. All MR images and radiographs were assessed separately by 3 radiologists; one fellowship trained musculoskeletal radiologist with 10 years of experience, and two radiologists with 23 and 10 years of experience at interpreting musculoskeletal images. The three reviewers were unaware of all clinical information, MRI and radiographic reports, and results of surgery. Each radiologist reviewed the images on two separate sessions at least 3 weeks apart. The reviewers recorded the following MRI features: (1) Degrees of CET, common flexor tendon (CFT), and ligament injuries (classified as mild, moderate, or severe) (Table 2); (2) Presence of muscle, cartilage, and bone injuries (Table 3); (3) Presence of joint effusion (Table 3); (4) Presence of bone abnormalities on radiographs.[9,12,13]

### *Statistical analysis*

Kappa statistics were used to determine the inter- and intra-observer reliabilities of MRI findings of the CET, RCL and LUCL (RCL/LUCL). Kappa values of 0.41–0.60 were considered to represent fair, 0.61–0.80 good, and 0.81–1.00 excellent agreements. MR scores for each interpretation by the 3 radiologists were averaged, and Spearman's rank correlation analysis was used to analyze relationships between degree of CET injury and associated elbow joint abnormalities. Statistical correlation was considered significant at $p < 0.05$. Spearman's rank correlation analysis was used to investigate correlations between VAS scores and degrees of CET injuries and associated other elbow joint abnormalities. All statistical analysis was performed using SPSS version 20 (IBM Corporation, Armonk, NY, USA).

## Results

Fifty-one patients (51 elbows; 33 right, 18 left) were included in the study. Average MRI score for CET injury was grade 0 in 1 (2.0%), grade 1 in 18 (35.3%) (Fig. 1A), grade 2 in 18 (35.3%) patients (Fig. 2), and grade 3 in 14 (27.5%) patients (Fig. 3A). Averaged MRI score for RCL/LUCL injury was grade 0 in 10 (19.6.0%), grade 1 in 20 (39.2%) (Fig. 1A), grade 2 in 8 (15.7%) (Fig. 2), and grade 3 in 13 (25.5%) patients (Fig. 3A), respectively.

Kappa values for inter- and intra-observer agreement for each reader with corresponding 95% confidence intervals are presented in Tables 4 and 5. Both inter- and intra-observer agreements for MRI grades of the degrees of CET and RCL/LUCL injuries were excellent.

Table 6 shows the imaging patterns of associated elbow joint abnormalities. RCL/LUCL injury was observed in 41 patients, CFT injury in 10, medial collateral ligament (MCL) injury in 10, extensor

**Table 1**
Parameters of MR sequence.

| Plane | Sequence | TR (ms) | TE (ms) | ETL | Matrix | BW (Hz) | FOV (mm) | Thickness (mm) | Gap (mm) |
|---|---|---|---|---|---|---|---|---|---|
| Coronal | T2 FSE | 2500–4000 | 65–80 | 12 | 256 × 224/320 × 192 | 21–31 | 110–120 | 3 | 0.3 |
| Coronal | T2 FS FSE | 3000–4500 | 50–60 | 12 | 256 × 224/320 × 192 | 21–31 | 110–120 | 3 | 0.3 |
| Coronal | PD FSE | 2000–3000 | 30–36 | 7–8 | 256 × 224/320 × 224 | 21–31 | 110–120 | 3 | 0.3 |
| Axial | T1 FSE | 600–750 | 10–15 | 3 | 256 × 224/320 × 224 | 21–31 | 110–120 | 3 | 0.3 |
| Axial | T2 FSE | 2500–4000 | 65–80 | 12 | 256 × 224/320 × 192 | 21–31 | 110–120 | 3 | 0.3 |
| Axial | T2 FS FSE | 2000–4000 | 50–60 | 12 | 256 × 224/320 × 192 | 21–31 | 110–120 | 3 | 0.3 |
| Sagittal | T2 FS FSE | 2000–3500 | 50–70 | 12 | 256 × 224/320 × 192 | 21–31 | 110–120 | 3 | 0.3 |

FSE: fast spin echo, FS: fat suppressed, TR: repetition time, TE: echo time, ETL: echo train length, BW: bandwidth, FOV: field of view.

**Table 2**
MR classifications of common extensor tendon and ligament injuries.

| Injury degree | Common extensor tendon | Ligament |
|---|---|---|
| 0 Normal | Complete homogenous low signal intensity without tendon thickening | Complete homogenous low signal intensity without ligament thickening |
| 1 Mild | Tendon thickening or thinning with increased internal signal intensity on fat-suppressed T2 image | Thickened ligament characterized by normal to increased signal intensity without interruption on fat-suppressed T2 image |
| 2 Moderate | A fluid-filled gap affecting 20–80% of the thickness | Ligament thinning with increased signal intensity within and surrounding the ligament |
| 3 Severe | A fluid-filled gap affecting more than 80% of the thickness | A complete rupture and discontinuity of the fibers with fluid-like intensity |

**Table 3**
Imaging classifications of injuries of muscle, cartilage, or bone and joint effusion.

| Injury degree | Muscle | Cartilage | Bone | Joint effusion |
|---|---|---|---|---|
| 1 | Normal | Normal | Normal | Normal |
| 2 | High SI | Cartilage defect | High SI<br>Enthesophyte or calcification adjacent to lateral epicondyle | The fluid increased |

SI: signal intensity.

muscle injury (Fig. 2) in 3, flexor muscle injury in 3, anconeus muscle injury in 1, joint effusion in 7, cartilage defect in 4, bone marrow edema (Fig. 3B) in 6, and enthesophyte or calcification (Fig. 1B, C) in 13 patients (25.5%). RCL/LUCL injury was the most common finding (80.4%) associated with CET injury. Spearman's rank correlation analysis identified a significant positive correlation between degrees of the CET and RCL/LUCL injuries (correlation coefficient $r = 0.667$, $p < 0.01$, Table 7).

VAS scores were available for 20 of the 52 patients. Mean VAS score was 7.6 (range 2–10). Mean VAS scores for degrees of CET injuries were; grade 0 was 9, grade 1 was 7, grade 2 was 7.8, and grade 3 was 7.5. The mean VAS scores for degrees of RCL/LUCL injuries were; grade 0 was 5.9, grade 1 was 8.4, grade 2 was 8.5, and grade 3 was 8.6. Spearman's rank correlation analysis demonstrated significant positive correlation between degree of RCL/LUCL injury and VAS scores (correlation coefficient $r = 0.478$, $p = 0.033$). Other abnormalities, including CET, were not found to be correlated with VAS scores (Table 8).

## Discussion

In general, lateral epicondylitis is a disease entity that is diagnosed clinically. Imaging is not initially performed but it is helpful for evaluating disease extent, for excluding other entities that cause lateral elbow pain, and for surgical planning. Ultrasonography (US) enables patients' symptoms to be correlated with findings in real time, but is considered highly operator-dependent. Levin et al[14]

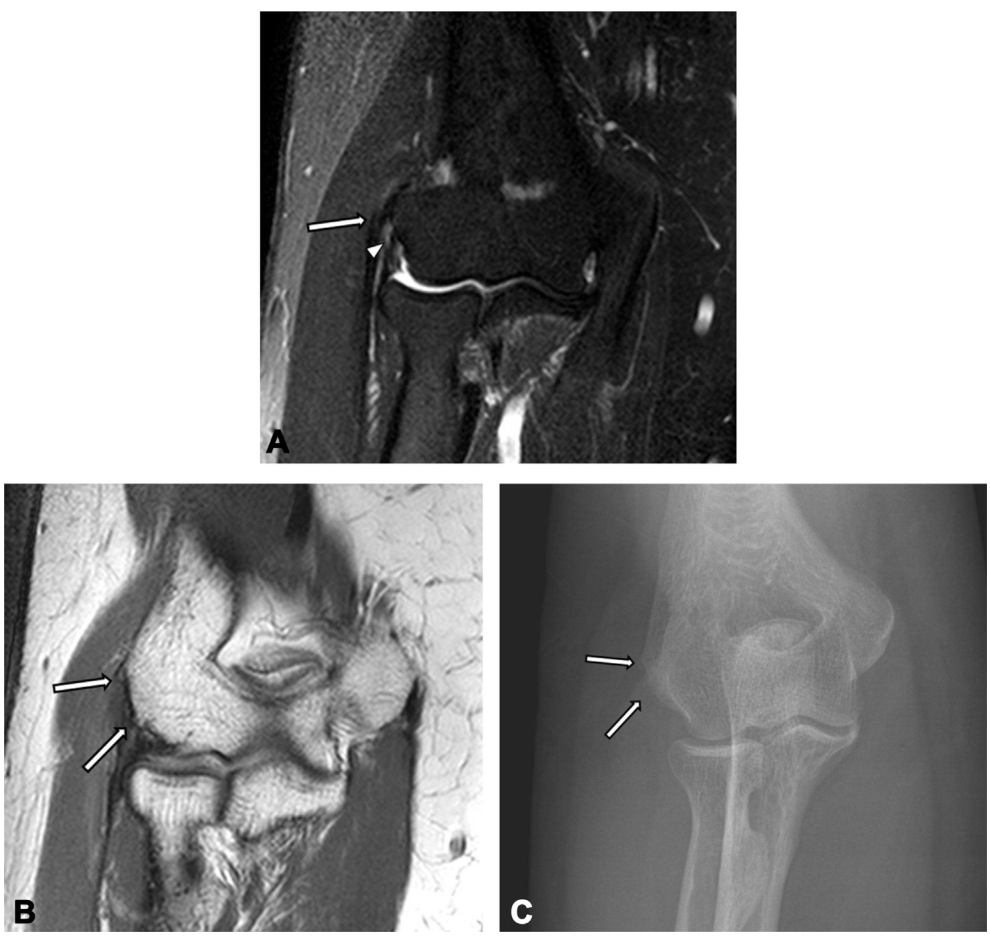


**Fig. 1.** A 60-year old female with right elbow pain for 5 weeks. A. Coronal fat-suppressed FSE T2-weighted image showing mild thickening of the proximal portion of the common extensor tendon with increased signal intensity (arrow), suggesting mild injury. Irregular thickening with increased signal intensity in the proximal portion of the lateral collateral ligament (arrowhead) is also noted, suggesting mild injury. B and C. Coronal PD FSE image and oblique radiograph showing cortical irregularity of the lateral epicondyle (arrows), a finding suggestive of enthesophytes.

**Fig. 2.** A 51-year-old female with left elbow pain for 1 year. Coronal fat-suppressed FSE T2-weighted image showing fluid signal intensity affecting about 50% of the thickness of the common extensor tendon (arrow), suggesting moderate injury. Irregularly thin proximal portion of the lateral collateral ligament with increased signal intensity in the proximal portion of the lateral collateral ligament (arrowhead) is also noted, suggesting moderate injury. Intramuscular edema is observed as a high signal intensity area in the extensor carpi radialis longus muscle (empty arrow).

reported poor inter-observer reliability and low specificity for the evaluation of lateral epicondylitis by US. MRI is the most widely used modality for diagnosing lateral epicondylitis and also has higher sensitivity than US.[15] In the present study, MRI showed all but one of the 51 patients had morphologic or signal abnormalities of the CET and all patients had RCL/LUCL abnormalities with excellent intra-observer and inter-observer reliability. Furthermore, MRI findings were well correlated with surgical findings of tendons or ligaments in all 27 surgically treated patients. In our study, more than half of the patients underwent surgery. This high surgery rate might be explained by intractable pain despite of the conservative treatments and we believe that was correlated with rather high mean VAS score (7.6).

**Table 4**
Inter- and intra-observer reliabilities for grading the degree of common extensor tendon injury.

| | ICC (95% CI) |
|---|---|
| Inter-observer reliability | 0.827 (0.725–0.896) |
| Intra-observer reliability | |
| Reader 1 | 0.976 (0.957–0.986) |
| Reader 2 | 0.916 (0.852–0.952) |
| Reader 3 | 0.855 (0.746–0.917) |

ICC: intraclass correlation coefficient; CI: confidence interval.

**Table 5**
Inter- and intra-observer reliabilities for grading the degree of radial collateral ligament/lateral ulnar collateral ligament injury.

| | ICC (95% CI) |
|---|---|
| Inter-observer reliability | 0.898 (0.838–0.938) |
| Intra-observer reliability | |
| Reader 1 | 0.993 (0.988–0.996) |
| Reader 2 | 0.945 (0.904–0.969) |
| Reader 3 | 0.899 (0.822–0.942) |

ICC: intraclass correlation coefficient; CI: confidence interval.

When evaluating lateral elbow pain by MRI, it is also important to investigate structures other than the CET, such as, RCL, LUCL, extensor muscles, synovium, cartilage, and subchondral bone, for coexistent abnormalities that might need a modification of surgical procedure.[12] Besides CET, other accompanying abnormalities may be observed in MRI of patients with lateral epicondylitis. In the present study, RCL/LUCL injury was the most common finding (80.4%) and its degree was found to be positively correlated with degree of CET injuries. In a study by Bredella et al,[9] 63% of patients with lateral epicondylitis had LUCL abnormality on MR imaging. According to the recent study by Qi et al,[7] 92% of patients showed LUCL abnormalities and had positive correlation with CET abnormalities on MRI.

The LUCL originates from the lateral epicondyle as a continuation of the RCL posteriorly, and then courses along the lateral and posterior aspects of the radius and inserts on the tubercle of the supinator crest of the ulna.[6,7,9] The LUCL contribute to ligamentous constraint against varus stress, and its disruption leads to posterolateral rotatory instability of the elbow.[6,7,9] The LUCL should be carefully evaluated preoperatively, particularly in patients with


**Fig. 3.** A 58-year-old male with right elbow pain for 4 years. A. Coronal fat-suppressed FSE T2-weighted image showing complete tear of the proximal portion of the common extensor tendon and lateral collateral ligament (arrow), suggesting severe injury. Cortical irregularity along the lateral epicondyle (arrowheads) is shown. B. Coronal fat-suppressed FSE T2-weighted image (posterior to A) showing subcortical bone marrow edema as high signal intensity in the lateral epicondyle (arrow).

**Table 6**
Radiologic injuries of elbow joints in patients with lateral epicondylitis.

| Injury degree | CET | RCL/LUCL | CFT | MCL | Extensor muscle | Flexor muscle | Anconeus muscle | Joint effusion | Cartilage defect | BME | Radiography |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 10 | 41 | 41 | – | – | – | – | – | – | – |
| 1 | 18 | 20 | 9 | 10 | 48 | 48 | 50 | 44 | 47 | 45 | 38 |
| 2 | 18 | 8 | 1 | 0 | 3 | 3 | 1 | 7 | 4 | 6 | 13 |
| 3 | 14 | 13 | 0 | 0 | – | – | – | – | – | – | – |

CET: common extensor tendon, RCL: radial collateral ligament, LUCL: lateral ulnar collateral ligament, CFT: common flexor tendon, MCL: medial collateral ligament, BME: bone marrow edema.

**Table 7**
Correlations between common extensor tendon injury and associated elbow abnormalities.

| Associated abnormalities | CET injury | |
|---|---|---|
| | *R* | *p* |
| RCL/LUCL | 0.667 | **<0.001** |
| Extensor muscle | 0.124 | 0.387 |
| Anconeus muscle | 0.039 | 0.784 |
| Bone marrow edema | 0.073 | 0.610 |
| Osteoarthritis | 0.094 | 0.510 |
| Common flexor tendon | 0.046 | 0.746 |
| Medial collateral ligament | 0.255 | 0.070 |
| Flexor muscle | 0.092 | 0.521 |
| Radiograph | 0.265 | 0.061 |

CET: common extensor tendon, RCL: radial collateral ligament, LUCL: lateral ulnar collateral ligament.
Bolds results are due to statistically significant findings as $P < 0.05$.

**Table 8**
Correlation between VAS scores and associated elbow abnormalities.

| Associated abnormalities | VAS | |
|---|---|---|
| | *R* | *p* |
| CET | 0.091 | 0.702 |
| RCL/LUCL | 0.478 | **0.033** |
| Extensor muscle | −0.053 | 0.826 |
| Anconeus muscle | 0.279 | 0.234 |
| Bone marrow edema | 0.113 | 0.634 |
| Osteoarthritis | 0.253 | 0.283 |
| Common flexor tendon | −0.160 | 0.501 |
| Medial collateral ligament | 0.018 | 0.941 |
| Flexor muscle | 0.138 | 0.561 |
| Radiograph | 0.433 | 0.057 |

CET: common extensor tendon, VAS: visual analog scale, RCL: radial collateral ligament, LUCL: lateral ulnar collateral ligament.
Bolds results are due to statistically significant findings as $P < 0.05$.

moderate or severe lateral epicondylitis, because surgical release of the CET may lead to further destabilization of the elbow.[9] In the present study, we evaluated the RCL and LUCL as one structure, because they originate from the lateral epicondyle as a continuation and it is near impossible to separate the proximal portions of the LUCL and RCL accurately on MRI or during surgical dissection.[16,17] Bredella et al[9] showed MR morphologic changes of the LUCL usually involve the ligament origin in lateral epicondylitis. For these reasons, it appeared reasonable to evaluate the LCUL and RCL as a single structure.

In our study, in addition to CET and RCL/LUCL abnormalities, other abnormalities of elbow joint were noted in patients with lateral epicondylitis. However, none of these abnormalities were correlated with degree of CET injury and these results were concordance with previous study.[7]

A CFT abnormality is a hallmark MR finding of medial epicondylitis and abnormalities of the MCL and flexor muscle also may be observed.[12] In the present study, CFT, MCL and flexor muscle abnormalities were noted in 10 (19.6%), 10 (19.6%) and 3 (5.9%) patients, respectively, which also agree with the findings of a previous study.[7] We suppose these changes represent subclinical medial epicondylitis.

Intramuscular edema may be noted in the common extensor muscles in lateral epicondylitis.[12] In our study, abnormalities of extensor and anconeus muscles were only found in 3 patients (5.9%) and 1 patient (2.0%), respectively, and these results were in accordance with those of previous studies.[7,10,18] Anconeus muscle signal change in chronic lateral epicondylitis may represent edema, inflammation or granulation tissue related to abnormal motion caused by pain.[19] In contrast, some authors have noted these changes in acute lateral epicondylitis.[7,20] In the present study, no correlation was found between symptom chronicity and muscle signal abnormality.

The radiocapitellar and ulnotrochlear joints also need to be evaluated for focal chondral defects and signs of secondary osteoarthritis.[12] We observed bone marrow edema at 7 sites in 6 patients, capitellum in 3, lateral epicondyle in 2 and radial head in 2 patients. Cartilage thinning or defects were found in the radial head of all 4 patients with cartilage abnormalities. Joint effusion may be seen on MRI in patients with lateral epicondylitis.[7] In the present study, 7 patients (13.7%) showed increased effusion in the elbow joint, which is lower than the prevalence reported in a previous study (25%),[7] though no universally adopted standard method is available for measuring the amount of joint effusion.

Relationships between the imaging findings of CET injury and clinical symptoms of lateral epicondylitis have not been well established. In a study by Savink et al,[10] no significant difference in VAS scores was found between patients with or without CET injury on MRI. Furthermore, MR signal changes did not reflect the effect of treatment regardless of improvement of patient's symptom. Similarly, we also did not found the relationship between degree of CET injury and VAS scores. In contrast, positive correlation was found in recent studies between clinical symptoms as determined using a patient-rated tennis elbow evaluation (PRTEE) and degree of CET abnormalities on MRI and US.[8,11] This discrepancy between the results may be explained by the use of different imaging modalities, and/or different clinical assessments of lateral epicondylitis.

Clarke et al[8] commented the presence of RCL tear and size of intrasubstance CET tear on US contribute to poor outcomes. In our study, a positive correlation was found between pain level and degree of RCL/LUCL injuries on MRI, and a significant positive correlation was found between degrees of RCL/LUCL and CET injuries. Therefore, the importance of evaluating other accompanying abnormalities, especially of the RCL and LUCL, that can affect treatment decision making and patient outcomes cannot be overemphasized. We believe that this is the first attempt to investigate the relationship between accompanying abnormalities of elbow joint other than CET injuries and pain level.

In a study by Levin et al[14] intratendinous calcification and adjacent bony irregularity were found to be significantly related with pain and tenderness on the lateral elbow, and in the present study, radiographic abnormalities, such as, enthesophyte in the lateral epicondyle or calcification adjacent to the lateral epicondyle, were observed in 13 patients (25.5%). However, these abnormalities were not significantly correlated with pain level.

The present study has several limitations. First, no histopathologic correlation was available. However, 53% of the patients underwent surgical treatment and MRI findings were well correlated with surgical findings regarding degeneration or tear of the tendon and ligament in all of these patients. Second, we used VAS for clinical assessments of pain severity, but did not assess functional disability. However, VAS is the most widely used method of quantifying pain and almost all patients included in this study complained of pain rather than functional deficits. Third, VAS scores were available for only 20 of the 51 patients (39.2%), which might have introduced bias.

## Conclusion

The inter- and intra-observer reliabilities of MRI for evaluating patients with lateral epicondylitis were excellent. In addition to common extensor tendinopathy, RCL/LUCL abnormality was the most common accompanying finding and degree of RCL/LUCL injuries was positively correlated with degree of CET injuries. Furthermore, degree of RCL/LUCL injuries was positively correlated with severity of pain.

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## Conflict of interest

None.

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