The Egyptian Journal of Hospital Medicine (October 2022) Vol. 89 (2), Page 7348- 7355

# Role of Magnetic Resonance Imaging in Evaluation of Elbow Pain

**Ghada Adel AbdelHamid*, Marwa Elsayed Abd Elhamed, Ahmed Gamil Ibrahim Abd El Megid**
Department of Radiodiagnosis, Faculty of Medicine, Zagazig University, Egypt
***Corresponding author:** Ghada Adel AbdelHamid, **Mobile:** (+20)01061915719, **E-Mail:** aghada243@gmail.com

## ABSTRACT

**Background:** Elbow pain is a growing problem particularly among overhead athletes. Understanding the involved lesion is sometimes challenging problem because of anatomical complexity. So, precise diagnosis is a key to appropriate treatment and successful return to normal daily activities.

**Objective:** This study aimed to emphasize the MRI role in detecting the tendinous, ligamentous, osseous, muscular, nerve and synovial based lesions in patients with elbow pain

**Subjects and methods:** Our current retrospective study enrolled 60 patients complaining from elbow pain or discomfort in the period from January 2022 to August 2022. They were recruited from Orthopedic Surgery Outpatient Clinic and Radio-diagnosis Department, Zagazig University Hospitals for MRI evaluation. All patients were correlated with arthroscopic data as a gold standard.

**Results:** Out of 60 patients, tendinous elbow lesions (flexor and extensor tendon injury) were the most frequent lesions (54/168, 32.1%), followed by ligamentous lesions (medial and lateral collateral ligament injuries) (40/168, 23.8 %), bony lesions (38/168, 22.6 %), muscle lesions (24/168, 14.3%) and nerve lesions were the least frequent (16/168, 9.6%). No significant difference between arthroscopy and MRI in detection of elbow pathology, with p value = 0.923169. MRI had 100% sensitivity for osseous lesions and excellent sensitivity in the diagnosis of tendon lesions (94.74%) as well as ligament lesions (90.91%). Also, it had good sensitivity in nerve lesions (76.19%). finally, MRI was highly specific tool with excellent accuracy in detecting all elbow pathologies.

**Conclusion:** MRI has to be considered non-invasive precise diagnostic tool of elbow pain causes.

**Keywords:** Magnetic resonance imaging, Ulnar nerve neurography.

## INTRODUCTION

Elbows are intricate joints that can handle a wide variety of dynamic forces. Localizing an elbow injury by pain's origin can be done in one of four ways, depending on whether the pain is felt in the anterior, posterior, medial, or lateral aspects of the elbow [1]. Because of its high spatial resolution, multiplanar imaging, and superior soft tissue contrast, magnetic resonance imaging is the imaging modality of choice for the examination of the painful elbow. High-field scanners have improved image quality while decreasing scanning time and cost [2]. Abnormalities of the elbow, such as tendon and ligament injuries, entrapment neuropathy, bone lesions, synovial and inflammatory illnesses, and soft-tissue tumors, are best assessed with magnetic resonance imaging (MRI) [3]. Lateral epicondylitis is due to a frequent overuse that can lead to painful elbows (tennis elbow). There is no clear gender bias in the 1%-3% of the population who suffer from lateral epicondylitis (LE). It is possible to see the lateral epicondyle's internal anatomy in great detail with a MRI scan [4].

Damage to the articular cartilage and the underlying subchondral bone, known as osteochondral lesions, occurs when the elbow is subjected to shear pressures or recurrent impaction. Images are used mostly to learn more about the osteochondral fragment's stability. By virtue of its high resolution and high soft-tissue contrast, MRI provides unobstructed views of the articular cartilage and the osteochondral lesion's interaction with the surrounding natural bone [5]. Peripheral nerves can be visualized using magnetic resonance neurography (MRN). It provides both direct and indirect assessment of the nerve lesion such as associated muscle denervation. Also, MRN provides better anatomic localization of the site of nerve entrapment than EMG studies, as well as better identification of the nature of the underlying lesion (e.g., fibrosis, benign or malignant mass lesions) [6].

Our current study aimed to analyze and describe the different patterns of tendinous, ligamentous, osseous, muscular, nerve and synovial based lesions in patients with an elbow pain and subsequent magnetic resonance imaging (MRI) evaluation with correlation to arthroscopic results.

## PATIENTS AND METHODS

Our current retrospective study enrolled 60 patients complaining from elbow pain or discomfort more than 2 weeks in the period from January 2022 to August 2022. They were recruited from Orthopedic Surgery Outpatient Clinic and Radio-diagnosis Department, Zagazig University Hospitals.

**Ethical consent: An approval of the study was obtained from Zagazig University Academic and Ethical Committee (IRB No. #10134). Every patient signed an informed written consent for acceptance of participation in the study. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.**



Received: 01/09/2022
Accepted: 02/10/2022

**Inclusion criteria:** Patients with elbow pain, discomfort, swelling or limitation of movement at elbow more than 2 weeks, and clinically fit to participate in the study.

**Exclusion criteria:** Patients with recent trauma with fracture or recent wound. Patients who were unable to undergo an MRI because of metal implants or pacemakers.

**Methods:**

**Full history taking:** Present history of elbow pain or discomfort more than 2 weeks. Onset and relation of pain to exertional efforts. Other symptoms as tingling, numbness, limitation of movement and swelling.

**Clinical examination:** Including general examination and local examination followed by MRI examination.

**MRI examination:** A closed MRI machine 1.5-Tesla superconducting magnet (Achieva, Philips Medical System, Best, Netherlands). MRI system was used with the patients were in supine position with the arm at the side and the palm up.

**The MRI Scanning Protocol Included:**

1. Scout 3 planes T1 weighted images (T1WI) for localization of the subsequent images.
2. Axial T1 weighted images (TR /TE = 600-800 /15-30) and axial T2 weighted images (TR/ TE =2000-5000 /60-120).
3. Sagittal T1 & T2 and gradient weighted images (TR/TE =500–600/12-20).
4. Coronal T1 & T2 weighted images & coronal STIR (short time inversion recovery) (TR/TE=4000-6000/20-40).
5. Imaging was performed within 30 minutes of intravenous (IV) administration of 0.1 mmol/kg Gd-DTPA (Gadolinium diethylene triamine penta acetic acid) (Magnivest) and 5 ml saline (for 15 patients), yielding post contrast T1 WIs.
6. Magnetic resonance neurography (MRN): (STIR) short time inversion recovery imaging & (FIESTA) Fast Imaging Employing Steady-state Acquisition.
7. Field of view (FOV) ranged from 12 to 16 cm with matrix size 256 x 256; slice thickness was about 2 to 4 mm and inter-slice gap was about 0.2 to 0.5 mm.

**Arthroscopy:** After image analyses, our MRI findings were compared to which arthroscopy data in all 60 patients.

**Statistical analysis:**

IBM's SPSS software program, version 20.0, was used to examine the data that was input into the computer (Armonk, NY: IBM Corp). Quantitative and percentage descriptions were used for qualitative information. Minimum and maximum values, as well as means, standard deviations, medians, and interquartile ranges, were used to characterize the quantitative data (IQR). The Chi-square tests were used for categorical variables. A two-tailed significance threshold was used to determine each p-value. If the probability was less than 0.05 .Validity measurements (sensitivity, specificity, NPV, PPV and accuracy were also calculated.

**RESULTS**

Our retrospective study included 60 patients with (38 male, 22 female). Data from (**Table 1**) showed that patients' ages ranged from 20 to 60, with a mean of 40.03 ± 6.84 years. Tendon tears were identified most frequently, followed by ligament, bone, muscle, bursal and finally nerve lesions, noting that several MRI findings were found in the same patient.

**Table (1):** Demographics of all patients (60 patients)

| **Variable** | **Studied group (n=60)** | |
|---|---|---|
| Age (years): | | |
| • Mean ± SD | 40.03±6.84 | |
| • Range | 20 – 60 | |
| | No | % |
| Sex: | | |
| • Female | 22 | 36.6 |
| • Male | 38 | 63.4 |

Regarding different elbow lesions as shown in (table 2)**, tendinous** lesions were the most frequent elbow lesions in this study (54/168, 32.1%). Lateral epicondylitis tendinopathy was more common (36/54, 66.6%) than medial epicondylitis tendinopathy (18/54, 33.4%). Ligamentous lesions were the second most common lesions whereas, medial collateral ligament lesions were more common (28/40, 70%) than the lateral collateral ligament lesions (12/40, 30%). As regards osseous lesions, they represented (38/168, 22.6%), bony erosions were the most common (18 /38, 47.4%), followed by osteophytes (11/38, 28.9%), bony masses (7/38, 18.4%); four of them were osteochondromas, the other three were giant cell tumors. Lastly, there were two cases of osteochondritis dissecans (5.3%). Muscle lesions reached 22 cases in our study with the most common pathology encountered was 12 cases of myositis (54.5%), 6 cases of muscle hematoma (27.3%), two cases of intramuscular collection as well as two cases of myositis ossificans represented (9.1%) each. Regarding nerve lesions we detected 16 cases of ulnar nerve neuropathy in which altered ulnar nerve signal represented (9/16, 56%), thickened ulnar nerve detected in (4/16, 25%), while both pathologies were seen in 3/16 (19%). Bursal & synovial lesions were the least frequent in our study, one case of olecranon bursitis and one case of venous malformation, each represented 1/168 (0.6%).

**Table (2):** Showing MRI findings of different lesions according to tissue involvement

| Bony lesions (38) | MR Findings | No (%) |
|---|---|---|
| Erosions | Breaks in the bone cortex | 18 (47.4%) |
| Osteophytes | Bony spur following the same signal intensity of bone | 11 (28.9%) |
| Osteochondroma | Sessile mass arising from supero- lateral aspect of radius, covered by cartilaginous cap eliciting intermediate T1WI signal and high T2WI signal | 4 (10.5%) |
| Giant cell tumor | Expansible mass arising from lower medial aspect of humerus with low T1WI signal and intermediate T2&PD FAT SAT WIs signal and heterogeneous enhancement | 3 (7.9%) |
| Ostochondritis dissecans stage III | A small nondisplaced bone fragment is seen arising from intra-articular surface of capitulum with high T2WI signal around (rim sign) | 2 (5.3%) |
| **Ulnar Nerve Lesions (16)** | **MR Findings** | **No (%)** |
| Altered nerve signal | Abnormal nerve signal displaying high signal intensity on T2 WI and STIR image. | 9 (56%) |
| Thickened nerve | Increased nerve caliber, enlarged nerve. | 4 (25%) |
| Altered signal and thickened nerve | Abnormal nerve signal displaying high signal intensity on T2 WI and STIR image. Increased nerve caliber, enlarged nerve. | 3 (19%) |
| **Synovium and bursa (2)** | **MR Findings** | **No (%)** |
| Olecranon bursitis | Well defined cystic lesion with incomplete septae inside, seen posterior to the olecranon process of the ulna displaying slightly hyperintense signal to muscle on T1WI (proteinaceous content), high T2WI & STIR WIs signals with marginal enhancement. | 1 (0.6%) |
| Venous malformation (cavernous hemangioma) | Well-circumscribed lobulated mass that appears isointense compared with muscle onT1-weighted sequences and contain areas of high signal intensity from interspersed fat. T2-weighted sequences appear heterogeneously hyperintense because of pooled blood in larger vessels. Areas of signal voids related to fast-flowing blood or calcified phleboliths. | 1 (0.6%) |

| Tendon lesions (54) | Tendinosis | No (%) | Partial tear | No % | Complete tear | No (%) |
|---|---|---|---|---|---|---|
| Lateral epicondylitis (36) | Thickening of tendons, with areas of intermediate signal intensity on both T1WI and T2WI | 18 (50%) | High T2 signal within or surrounding tendon | 10(27.7%) | Complete tendon disruption & high T2 fluid signal in the gap | 8(22.3%) |
| Medial epicondylitis (18) | | 9(50%) | | 6(33.3%) | | 3(16.7%) |
| Ligamentous lesions (40) | Grade I | No (%) | Grade II | No (%) | Grade III | No (%) |

There was no significant difference between arthroscopy and MRI in detection of elbow pathology, with p value = 0.923169 (Table 3).

**Table (3):** Showing comparison between MRI and arthroscopy

| Pathology (60) | MRI | Arthroscopy | % MRI | % Arthroscopy | p-value |
|---|---|---|---|---|---|
| Tendon lesions | 54 | 57 | 90 | 95 | 0.23169(NS) |
| Ligament lesions | 40 | 44 | 66.7 | 73.33 | |
| Osseous lesions | 38 | 38 | 63.33 | 63.33 | |
| Nerve lesions | 16 | 21 | 26.7 | 35 | |

(NS) non-significant .0.05

MRI showed (100%) sensitivity for osseous lesions and it had excellent sensitivity in the diagnosis of tendon lesions (94.74%) and ligament lesions (90.91%) as well as good sensitivity to detect nerve lesions (76.19%). MRI was highly specific in detecting all elbow pathologies (Table 4).

**Table (4):** Showing interpretation of statistical findings

| Pathology | TP | FN | TN | FP | Sensitivity% | Specificity% | PPV% | NPV% | Accuracy% |
|---|---|---|---|---|---|---|---|---|---|
| Tendon | 54 | 3 | 3 | 0 | 94.74 | 100 | 100 | 50 | 95 |
| Ligament | 40 | 4 | 14 | 2 | 90.91 | 87.5 | 95.23 | 77.78 | 96 |
| Osseous | 38 | 0 | 22 | 0 | 100 | 100 | 100 | 100 | 100 |
| Nerve | 16 | 5 | 38 | 1 | 76.19 | 97.44 | 94.11 | 88.37 | 90 |

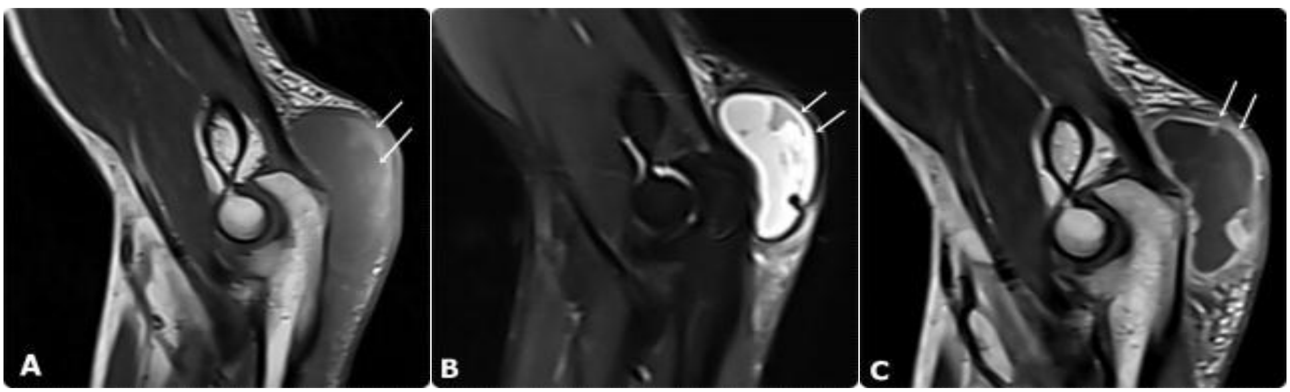


**Figure (1):** A 30 years old female patient presented by elbow pain for two months. (A) Sagittal T1 WI, (B) Sagittal STIR image, (C) Sagittal post-contrast T1 WI at elbow joint, showing a well-defined cystic lesion (White arrows) seen posterior to the olecranon process of the ulna displaying low signal at T1WI, (A) and high signal at STIR image (B), areas of high T1 and low T2 signals posteriorly suggesting proteinaceous content. The lesion elicited marginal post-contrast enhancement (C). No solid component or underlying bony erosion. A case of olecranon bursitis.

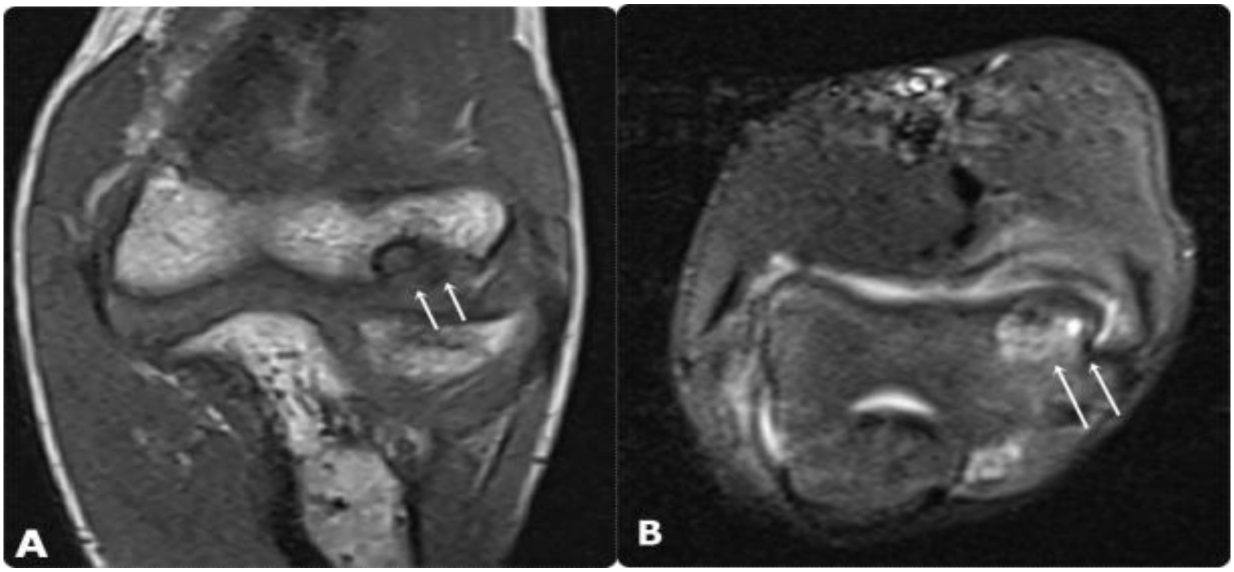


**Figure (2):** A 33 years old male patient presented by lateral elbow pain and swelling (A) Coronal T1 WI, (B) Axial STIR image at elbow joint, showing a focal non-detached area of subchondral osteochondral defect (White arrows) involving the capitellum of the humerus, displaying low to intermediate signal on T1WI and STIR WI with surrounding high signal line (rim sign) on STIR image denoting stage III osteochondritis dissecans of the capitellum. **A case of stage III** osteochondritis dissecans of the capitellum.

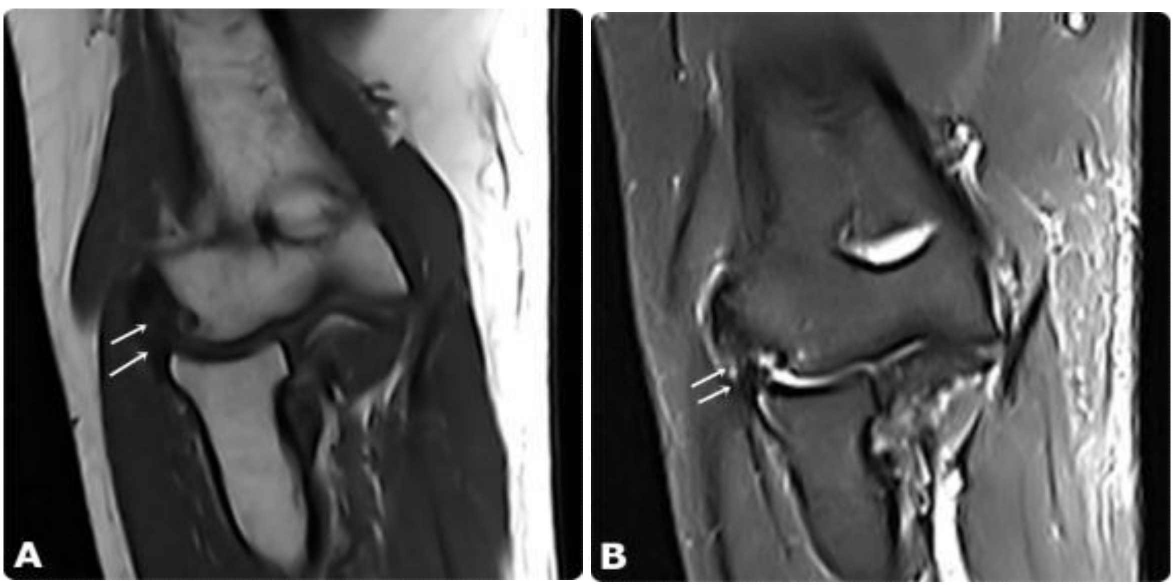


**Figure (3):** A 45 years old female complained from pain for 2 years at the lateral aspect of the right elbow. (A) Coronal T1 WI and (B) Coronal STIR image at elbow joint showing abnormal thickening and abnormal increased signal of the common extensor tendon origin (White arrows), displaying subtle intermediate signal on T1 WI and high signal on STIR image. A case of lateral epicondylitis **(A** case of tendinosis of the common extensor tendons origin).

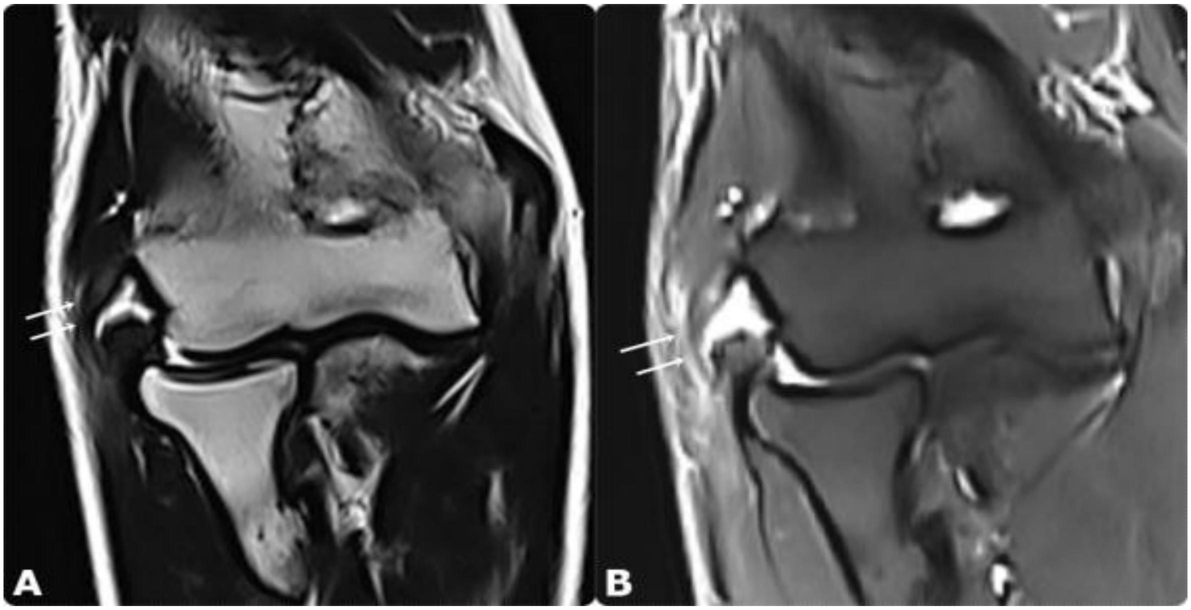


**Figure (4):** A 39 years old male complained from pain for 3 weeks at the lateral aspect of the right elbow. (A) Coronal T2 WI and (B) Coronal STIR image at elbow joint, showing avulsion of the lateral collateral ligament, which is seen containing high T2 & STIR fluid signals (White arrows). A case of grade III injury of the lateral collateral ligament.

## DISCUSSION

Many inflammatory diseases and overuse illnesses manifest in the elbow. Ultrasound computed tomography (CT), and magnetic resonance imaging (MRI) are all viable options for evaluating the elbow. Evaluation of ligaments, tendons, and osseous lesions of the elbow is greatly aided by imaging technology [7]. Magnetic resonance imaging (MRI) is a highly effective diagnostic tool for evaluating the condition of ligaments and tendons near the elbow joint in addition to a variety of bony and soft tissue diseases [8].

Our retrospective study included sixty patients (38 male & 22 female) with variable elbow joint lesions. In the study males represented 63.4% of all patients while females represented 36.6%, with their ages ranged from 20-60 years with mean age of 40 ± 6.84 years. The right side was more frequently affected than the left side, as right sided affection was 68.3 % of the total cases, while left side represented 31.7%. This agrees with **Hasan *et al.*** [9] whose study was performed on 36 patients, with male representing 52.7% and females representing 47.2% who ranged between 20 to 64 years (mean age, 31 years), right side was affected by (61%), and the left side (39%).

In this study common extensor origin injury (lateral epicondylitis) was more frequent than common flexor tendon (medial epicondylitis) with 66.6% to 31.5 % of total tendinosis lesions. This agrees with **Shiri *et al.*** [10] who conducted a random study on 4.783 population in which lateral epicondylitis represented 61% and medial epicondylitis represented 39% of these population.

In this study, we detected 18 cases (50%) of lateral tendinopathy with three different grades, with grade1 (Tendinosis) was the most common type of tendinous injury, followed by 10 cases (27.7%) with grade II injury (Partial tear) & 8 cases (22.3%) grade III complete tear. This coincides with **Zhang *et al.*** [11], who concluded that grades of lateral tendinopathy are also three grades with grade I is the most common type of injury with 38 cases (39.6%), 31 cases (32.3%) grade 2, and 27 cases (28.1%) grade 3.

As regards ligamentous injury, medial collateral ligament injury was more frequently affected (28/40, 70%) than lateral collateral ligament injury (12/40, 30%). This agrees with **Bethapudi *et al.*** [12]**,** who reported that medial collateral ligament injury was the most frequently injured ligament in the study group.

In this study, there was a great association between lateral collateral ligament injury and lateral epicondylitis, which agrees with **Liang *et al.*** [13], who stated that lateral epicondylitis was mostly associated with other abnormalities, mostly RUCL injury.

Concerning the grades of injury of medial collateral ligament, grade I injury was the most common type with 19 cases (67.8%) of total ligamentous injury, grade II injury came second with 5 cases (17.9%) and finally grade III injury with 4 cases (14.3%) of total ligamentous injury. This agrees with **Sheta *et al.*** [14], who concluded that grade I injury was the most common type of medial collateral ligament injury with 64.2% of total ligamentous injury. Grade II injury came second with (21.4%) and lastly grade III injury with 4 cases (14.2%) of total ligamentous injury, but disagree with **Ford *et al.*** [15] who reported that grade II was the most common type of elbow injury with 40%, followed by grade III & lastly grade I.

In our study two cases of capitular osteochondritis dissecans that were diagnosed as a cause of elbow pain.

OCD is a disorder of articular cartilage and subchondral bone, which is classified into five stages. Our cases were of stage III in which there was a non-displaced bone fragment with high T2 signal around (rim sign) involving the Capitulum, its location is in capitulum of humerus. This agrees with **Van Bergen *et al.*** [16] who stated that OCD of the elbow typically involves the humeral capitellum and leads to lateral elbow pain.

As regards elbow joint bony neoplasm, our study included seven neoplastic cases, which represented 11.6% of total cases. Four patients were diagnosed as osteochondroma at upper radius and the other three patients were diagnosed as giant cell tumor seen at lower humerus. This coincides with **Halai *et al.*** [17] who reported that primary bony tumors of the elbow are uncommon and account for approximately 1% of all osseous tumors encountered in the study group.

Regarding ulnar nerve affection, we used MR neurography (STIR and FEISTA sequences). Altered nerve signal was detected at 9 cases (56%), thickened ulnar nerve was detected at 4 cases (25%) of total ulna nerve lesions & 3 cases (19%) had both findings. This agrees with **Keen *et al.*** [18] who found that an increase in ulnar nerve size was observed in 19 of 21 patients reporting ulnar neuropathy. There was a significant rise in ulnar nerve signal strength in 17 of them.

Regarding validity of MRI compared to the arthroscopy finding as the gold standard regarding the tendon, ligament, osseous and nerve lesions, MRI showed (100%) sensitivity for osseous lesions and it had excellent sensitivity in the diagnosis of tendon lesions (94.74%) and ligament lesions (90.91%) as well as good sensitivity to detect nerve lesions (76.19%). MRI was highly specific in detecting all elbow pathologies. This agrees with **Matthew *et al.*** [19]**,** who concluded that sensitivity was 86-95%.

The present study had several limitations. First, arthroscopic correlations were not covering all involved elbow lesions. However, MRI findings were well correlated with available arthroscopic findings. Second, we did not use grading for clinical assessments of pain severity. Third, MRI elbow assessment can be subjective. This was mitigated by incorporating two or more experienced readers to reach a consensus.

## CONCLUSION

MRI is a beneficial non-invasive option. Diseases included tendon abnormalities, ligament lesions, osteochondral lesions, neuropathies, bony and osseous masses as well as bursal conditions. Because it can rule out many potential clinically significant illnesses, MRI is a great tool for use in circumstances where a diagnosis is in doubt, and especially when surgical interference is being considered.

**List of abbreviations**

| | |
|---|---|
| CT | computed tomography |
| FIESTA | Fast Imaging Employing Steady-state Acquisition |
| FN | False Negative |
| FOV | Field of view |
| FP | False Positive |
| Gd-DTPA | Gadolinium diethylene triamine penta acetic acid |
| LE | Lateral Epicondylitis |
| MRI | Magnetic Resonance Imaging |
| MRN | Magnetic Resonance Neurography |
| NPV | Negative Predictive Value |
| NS | Non-significant |
| OCD | Osteochondritis Dissecans |
| PPV | Positive Predictive Value |
| RUCL | Radial Ulnar Collateral Ligament |
| SD | Standard Deviation |
| STIR | Short Term Inversion Recovery |
| TN | True Negative |
| TP | True Positive |

**Financial support and sponsorship:** Nil.
**Conflict of interest:** Nil.

## REFERENCES

1. **Kane S, Lynch J, Taylor J (2014):** Evaluation of elbow pain in adults. Am Fam Physician, 89 (8): 649-57.
2. **Hauptfleisch J, English C, Murphy D (2015):** Elbow Magnetic Resonance Imaging. Topics in Magnetic Resonance Imaging, 24: 93-107.
3. **Melloni P, Valls R (2005):** The use of MRI scanning for investigating soft-tissue abnormalities in the elbow. European Journal of Radiology, 10: 303–313.
4. **Ma K, Wang H (2020):** Management of Lateral Epicondylitis: A Narrative Literature Review. Pain Research and Management, 20: 6965381. DOI:10.1155/2020/6965381
5. **Anderson M, Chung C (2021):** Elbow Imaging with an Emphasis on MRI: Diagnostic imaging 2021: Musculoskeletal diseases. IDKD Springer Series. https://pubmed.ncbi.nlm.nih.gov/33950626/
6. **Nordin M, Frankel V (2003):** Basic biomechanics of the musculoskeletal system. 3rd ed. Lippincott Williams & Wilkins, Philadelphia. https://pt.lwwhealthlibrary.com/book.aspx?bookid=1033
7. **Nocerino E, Cucchi D, Arrigoni P *et al.* (2018):** Acute and overuse elbow trauma: radio-orthopedics overview Acta Biomed., 89: 124–137.
8. **Stein J, Cook T, Simonson S *et al.* (2011):** Normal and variant anatomy of the elbow on magnetic resonance imaging. Magnetic Resonance Imaging Clinics of North America, 10: 609–619.
9. **Hasan N, Alam-Eldean M, Mousa S (2015):** Stiff elbow in adult. MR imaging findings. The Egyptian Journal of Radiology and Nuclear Medicine, 46 (4): 1037–1048.
10. **Shiri R, Viikari-Juntura E, Varonen H *et al.* (2006):** Prevalence and Determinants of Lateral and Medial

Epicondylitis: A Population. Study American Journal of Epidemiology, 164 (11): 1065–1074.

11. **Qi L, Zhang Y, Yu R *et al.* (2016):** Magnetic resonance imaging of patients with chronic lateral epicondylitis. Medicine, 95 (5): e2681. doi: 10.1097/MD.0000000000002681.
12. **Bethapudi S, Robinson P, Engebretsen L *et al.* (2013):** Elbow Injuries at the London 2012 Summer Olympic Games: Demographics and Pictorial Imaging, Review American Journal of Roentgenology, 201 (3): 535–549.
13. **Qi L, Zhu Z, Wang R (2013):** MR imaging of patients with lateral epicondylitis of the elbow: is the common extensor tendon an isolated lesion? PLoS One, 8 (11): e79498. doi: 10.1371/journal.pone.0079498.
14. **Sheta R, Lotfy R, Elkhouly R *et al.* (2020):** Role of Ultrasound and Magnetic Resonance Imaging in Evaluation of Elbow Pain. International Journal of Medical Imaging, 8 (4): 114-125.
15. **Ford G, Genuario J, Kinkartz J *et al.* (2016):** Return-to-play outcomes in professional baseball players after medial ulnar collateral ligament injuries. The American Journal of Sports Medicine, 44 (3): 723–728.
16. **Van Bergen C, Van den Ende K, Ten Brinke B *et al.* (2016):** Osteochondritis dissecans of the capitellum in adolescents. World Journal of Orthopedics, 7 (2): 102–108.
17. **Halai M, Gupta S, Spence S *et al.* (2015):** Primary osseous tumors of the elbow: 60 years of registry experience. Shoulder Elbow, 7(4): 272–281.
18. **Keen N, Chin C, Engstrom J *et al.* (2011):** Diagnosing ulnar neuropathy at the elbow using magnetic resonance neurography. Skeletal Radiology, 41 (4): 401– 407.
19. **Matthew D, Kathryn J, Lynne S (2016):** Elbow Imaging in Sport: Sports Imaging Series. Radiology, 279: 1-18. https://doi.org/10.1148/radiol.2016150501