Original Research

Distribution of Osteochondral Lesions in Patients With Simple Elbow Dislocations Based on MRI Analysis

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Background: The clinical relationship between osteochondral lesions and long-term outcomes and patterns in the elbow joint has not yet been established. A sole evaluation from plain standard radiography may underestimate the severity of bony lesions in patients with simple dislocations. It has been suggested that the mechanism of a posterior elbow dislocation could be inferred from the pattern of bony contusions and osteochondral lesions visible on magnetic resonance imaging (MRI) in patients with simple elbow dislocations.

Purpose/Hypothesis: The purpose of this study was to describe the incidence and distribution of osteochondral lesions based on MRI findings in patients with simple elbow dislocations. We hypothesized that (1) osteochondral lesions are consistently found in patients with simple elbow dislocations and (2) the distribution and severity of osteochondral lesions may explain the mechanism of the simple elbow dislocation.

Study Design: Cohort study; Level of evidence, 3.

Methods: A retrospective review of 43 patients with simple elbow dislocations was performed in tertiary-level hospitals from January 2010 to August 2019. Two orthopaedic surgeons separately assessed the initial plain radiographs and MRI scans. Osteochondral lesions were evaluated and categorized based on whether they were located (1) on the lateral side (posterolateral capitellum and radial head; type 1) or (2) on the medial side (posterior trochlea and anteromedial facet of the coronoid; type 2). The severity of the osteochondral lesions was assessed according to the Anderson classification.

Results: Of the 43 patients, 21 (48.8%) presented with osteochondral lesions on MRI. The type 1 pattern of osteochondral lesions was the most frequently observed on MRI in patients with simple elbow dislocations (69.8% of cases), and these were confirmed by simple radiography. Posterolateral capitellum osteochondral lesions were found in 13 patients. Among them, 10 (76.9%) were advanced-stage lesions (stages III and IV according to the Anderson classification).

Conclusion: Osteochondral lesions were found on MRI after simple elbow dislocations at a rate of 48.8%. Osteochondral lesions in the posterolateral capitellum were associated with an advanced stage. Clinically, these findings may help surgeons in the diagnosis of osteochondral lesions and in determining how to manage patients with the progression of arthritic changes.

Keywords: simple elbow dislocation; osteochondral lesions; osteochondral stages; patterns of osteochondral lesions

Simple elbow dislocation is defined as a dislocation without associated fractures, which comprises approximately 10% of all elbow dislocation cases.[6] However, studies have reported that patients presented with concomitant bony or osteochondral injuries after a simple joint dislocation.[2,10] Hence, using only plain standard radiography may underestimate the severity of bony lesions in patients with simple dislocations.[5] To identify cartilage injuries in the absence of fractures, additional examinations, such as magnetic resonance imaging (MRI), may be useful.

In the knee or ankle joint, the clinical relationship between osteochondral lesions and long-term clinical outcomes and patterns has been well established.[9,15] Even a bone contusion could be a poor prognostic factor for arthritic changes.[9,15] However, there is limited knowledge regarding the existence and patterns of osteochondral injuries in the elbow joint.

Studies have attempted to describe the mechanism of a simple elbow dislocation.[13,16] The mechanism of a simple elbow dislocation has generally been explained by the direction of injury, and posterolateral elbow dislocations are the most frequently occurring type.[7] Rhyou and Kim[17] suggested identifying the mechanism of an acute elbow posterior dislocation using bone contusion patterns identified via

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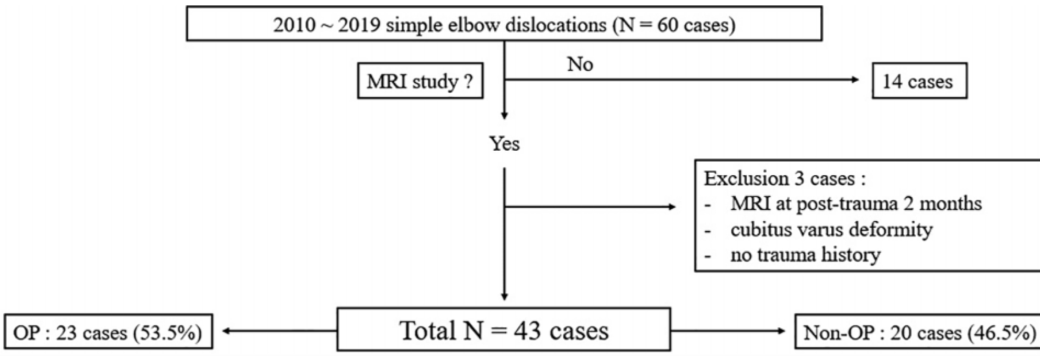

Figure 1. Study design. MRI, magnetic resonance imaging; OP, operative.

MRI. However, during an arthroscopic examination, more severe osteochondral lesions, missed on MRI and presurgical evaluation, have often been identified.[5] In addition, Rhyou and Kim[17] noted that bone contusion patterns consistently occurred on the lateral side of the elbow joint, which include the radial head and lateral epicondyle, however they were unable to explain posterolateral dislocation cases with osteochondral lesions on the medial side, which include the anteromedial facet of the coronoid and the posterior trochlea. Therefore, there is a need to evaluate the incidence and patterns of osteochondral lesions and to revisit the mechanisms of simple elbow dislocation on the basis of bone injury patterns.

The purpose of this study was to describe the incidence and common locations of osteochondral lesions on the basis of MRI findings in patients with simple elbow dislocation. We hypothesized that (1) osteochondral lesions are consistently found in patients with simple elbow dislocation and (2) the distribution and severity of osteochondral lesions can suggest the mechanism of the dislocation.

METHODS

This retrospective cohort study included 60 patients with a simple elbow dislocation between January 2010 and August 2019. Institutional review board approval was obtained before this study. The inclusion criteria consisted of the following: (1) a simple elbow dislocation confirmed with standard plain radiography at the time of the initial injury or with a definite history of dislocation and reduction in the medical record before visiting the clinic, (2) no major bone fracture associated with a dislocation confirmed using radiography (except Regan and Morrey type 1 fractures of the coronoid process), and (3) elbow MRI performed within 4 weeks after trauma. The exclusion criteria consisted of patients with (1) concurrent ipsilateral upper extremity injuries, (2) previous surgery of the affected elbow, (3) a history of lateral elbow pain before dislocations, (4) autoimmune diseases such as rheumatoid arthritis, (5) skeletal immaturity identified via radiography, and (6) congenital deformities of the injured elbow.

Of the 60 patients eligible for this study, 17 were excluded; 15 patients did not undergo elbow MRI within the 4-week period, 1 had no trauma history, and 1 had a cubitus varus deformity (Figure 1). Thus, 43 patients were eligible for this study. Plain standard elbow radiographs in the anteroposterior and lateral views were used for classifying the dislocations based on direction: (1) posterolateral or (2) posteromedial.

All the patients were initially managed with closed reduction in the emergency unit under local or intravenous analgesia. An orthopaedic resident performed the reduction by gentle traction on the forearm with firm pressure applied posteriorly to the olecranon to bring it distally and anteriorly around the humeral trochlea after adequate muscular relaxation and appropriate analgesia. An evaluation of elbow joint stability after reduction was performed by fellowship-trained surgeons who specialized in shoulder and elbow surgery. Surgical treatment was indicated if (1) closed reduction failed and (2) the ulnohumeral articulation was not congruent at elbow flexion less than 30°.[11]

MRI Evaluation

The 43 elbows were evaluated using MRI regarding bony injury patterns, including intra-articular osteochondral

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Figure 2. Osteochondral lesion stages on magnetic resonance imaging in patients with simple elbow dislocation. (A) Stage I: osteochondral lesion in the posterior trochlea with only subchondral edema. (B) Stage II: osteochondral lesion in the radial head, which was partially detached with edema. (C) Stage III: osteochondral lesion in the posterior trochlea, which was fully detached as a free osteochondral fragment. (D) Stage IV: osteochondral lesion in the posterolateral capitellum as a loose body. Osteochondral lesions are marked by an asterisk (*).

lesions and loose bodies. The mean time from the initial injury to MRI was 6 days (range, 0-12 days). In each case, coronal, axial, and sagittal images were available in non–fat saturated T1-weighted and proton density–weighted sequences as well as fat-saturated T2-weighted/proton density–weighted sequences.

The MRI scans were first evaluated by a musculoskeletal radiologist. Then, 2 fellowship-trained orthopaedic surgeons who specialized in shoulder and elbow surgery (H.K., E.K.) separately re-evaluated the MRI scans based on the radiologist's readings. In case of disagreement, a mutual consensus was established through negotiation with a third orthopaedic surgeon (I.-H.J.). Osteochondral lesions were defined as those that involved articular cartilage and showed signal change in T1-weighted and fat-suppressed proton density–weighted sequences on MRI.[21] If the area surrounding the lesion was combined with bone contusions, we regarded those lesions as acute.

We evaluated osteochondral lesions using 2 factors: anatomic location and severity. The location was classified as lateral or medial based on MRI (lateral: radial head and posterolateral capitellum; medial: anteromedial facet of the coronoid and posterior trochlea). The severity was determined using the Anderson classification system.[1] The lesions were divided into 4 stages. In stage I, there was a small area of compression of subchondral bone or subchondral edema. Stage II involved a partially detached osteochondral fragment (flap) with a cyst/edema on MRI. In stage III, a completely detached osteochondral fragment remained in the defect. Stage IV also showed a free osteochondral fragment (loose body)[1,14] (Figure 2). Stages I and II were defined as low-stage, and stages III and IV were defined as advanced-stage lesions.

Statistical Analysis

Statistical analysis was conducted using SPSS for Windows version 21.0 (IBM Corp). The mean and standard deviation were calculated for continuous variables. The t test was used for age comparisons of low-stage

TABLE 1
Demographic Data of Study Population[a]

Sex	
Male	25 (58.1)
Female	18 (41.9)
Age, mean (range), y	40.8 (17-67)
Side injured	
Left	23 (53.5)
Right	20 (46.5)
MRI protocol	
1.5 T	8 (18.6)
3.0 T	35 (81.4)
Osteochondral lesion	21 (48.8)
Loose bodies	6 (14.0)
Coronoid fracture (type 1)	6 (14.0)
Treatment	
Operative	22 (51.2)
Nonoperative	21 (48.8)
Dislocation direction on radiography	
Posterolateral	28 (65.1)
Posteromedial	5 (11.6)
Unknown	10 (23.3)

[a]Data are shown as No. (%) unless otherwise indicated. MRI, magnetic resonance imaging.

TABLE 2
Common Locations of Osteochondral Lesions[a]

Distal humerus	19
Posterolateral capitellum	13
Posterior trochlea	6
Proximal radioulnar area	8
Radial head	5
Anteromedial facet of coronoid	3

[a]Data are shown as No.

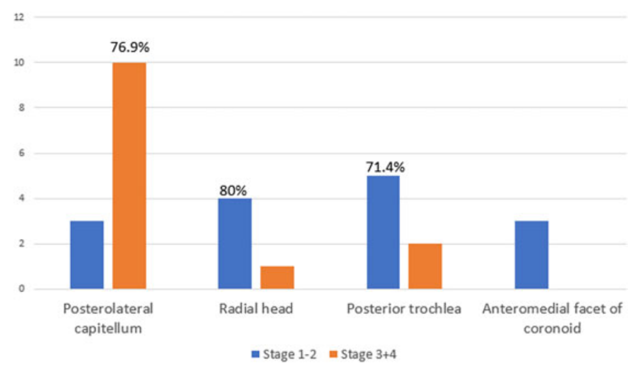

Figure 3. Number of low- and advanced-stage osteochondral lesions found on magnetic resonance imaging per location: posterolateral capitellum, radial head, posterior trochlea, and anteromedial facet of the coronoid.

osteochondral lesions versus advanced-stage lesions (level of significance: $P < .05$).

RESULTS

The demographics for the 43 patients are summarized in Table 1. The mean age of the patients was 40.8 years (range, 17-67 years). Osteochondral lesions were found in 21 patients (48.8%). There were 22 patients (51.2%) in the operative group and 21 patients (48.8%) in the nonoperative group. On the basis of initial plain radiography in 33 patients, 28 (65.1%) had posterolateral dislocations and 5 (11.6%) had posteromedial dislocations; 10 patients (23.3%) did not have initial radiographs at the time of the dislocation. A coronoid tip fracture (type 1) occurred in 6 patients (14.0%).

The MRI evaluation revealed osteochondral lesions in the posterolateral capitellum, radial head, anteromedial facet of the coronoid, and posterior trochlea (Table 2). Osteochondral lesions were also found more often in the distal humerus than the proximal radioulnar area. Among the osteochondral lesions identified, those located in the posterolateral capitellum were in the advanced stage (stages III and IV), which were found in 10 cases (76.9%) (Figure 3). There was no significant difference between patients with advanced-stage versus low-stage lesions based on age ($P = .245$) (Table 3).

The osteochondral lesions we found could be divided into the following 2 types: type 1, which involved the lateral side (posterolateral capitellum and radial head), and type 2, which involved the medial side (posterior trochlea and anteromedial facet of the coronoid) (Figure 4). Overall, 30 cases (69.8%) were categorized as type 1, 10 (23.3%) as type 2, and 3 (7.0%) as neither pattern.

TABLE 3
Age of Patients With Low- and Advanced-Stage Osteochondral Lesions

	Low Stage (I and II; n = 30)	Advanced Stage (III and IV; n = 13)	*P* Value
Age, y	37.1	42.5	.245

DISCUSSION

The present study found that osteochondral lesions were consistently observed in as high as 48.8% of patients with simple elbow dislocations. The most frequently found locations of the lesions were the posterolateral capitellum, radial head, posterior trochlea, and anteromedial facet of the coronoid. The posterolateral capitellum had osteochondral lesions with a more advanced stage.

The underestimation of concomitant injuries in patients with simple dislocations has been well described in the knee and ankle joint.[9,15] However, little is known regarding the elbow joint after a simple dislocation because of the scarcity of the literature. Good long-term outcomes have been reported after nonoperative treatment for simple elbow dislocations. However, 2% of patients will require a surgical intervention, and 8% of patients will have persistent instability after nonoperative treatment.[18] This small

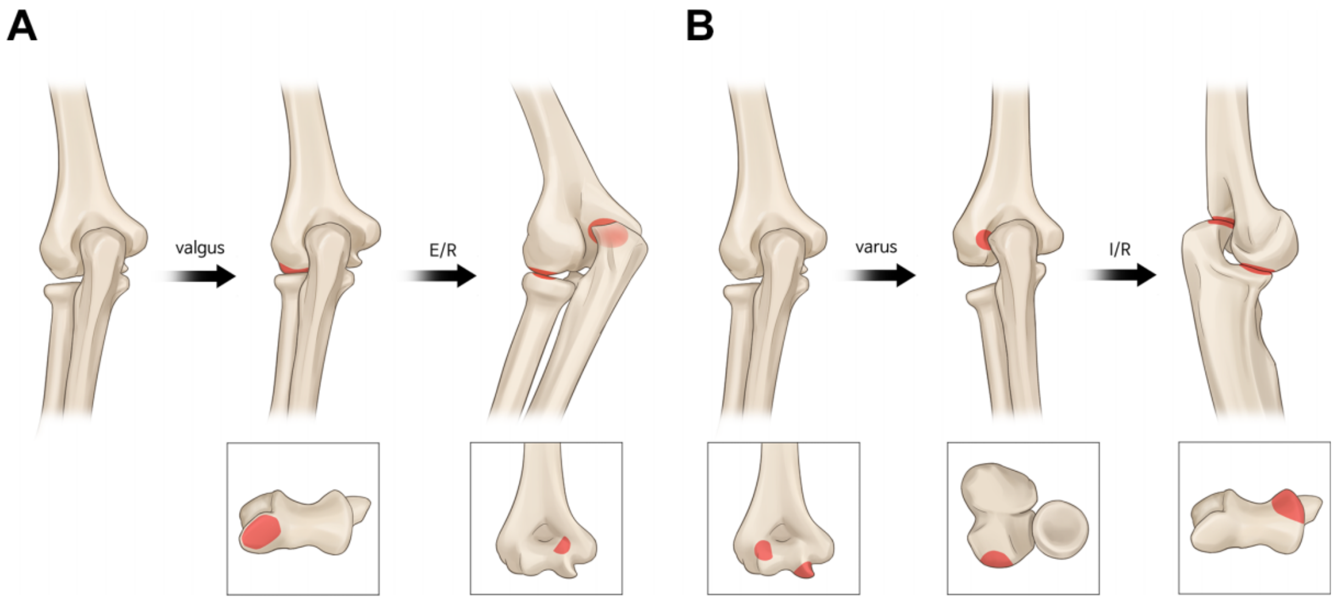

Figure 4. Patterns of osteochondral lesions: (A) type 1 and (B) type 2. E/R, external rotation; I/R, internal rotation.

proportion of patients was shown to have concomitant injuries that extended to soft tissue injuries.

Studies have described the role of MRI in describing the injured structures after simple elbow dislocation.[10,20,22] Luokkala et al[11] evaluated 16 patients with simple elbow dislocations with regard to concomitant ligamentous injuries. In their study, soft tissue lesions were observed in 16 elbows on MRI, and the anterior capsule, medial collateral ligament, and lateral collateral ligament complex were found to be injured.[11] They found that complete ligamentous tears were found more on the medial side than on the lateral side. However, these previous studies only evaluated soft tissue injuries and disregarded the role of osteochondral lesions in patients with simple elbow dislocation. Therefore, our study aimed to demonstrate that concomitant osteochondral lesions are of importance. These lesions should not be taken lightly, as they could serve as a prognostic factor for treatment and outcomes.[9,15] Moreover, the presence of osteochondral lesions can help explain the mechanism of an elbow dislocation to guide treatment.

On the basis of our MRI evaluation, we found the following 2 patterns of osteochondral lesions: type 1, which involved lateral-side osteochondral lesions of the radial head and posterolateral capitellum; and type 2, which involved medial-side osteochondral lesions of the posterior trochlea and anteromedial facet of the coronoid (Figure 4). Type 1 comprised posterolateral dislocations caused by external rotation, valgus force, and axial compression.[16] Type 1 dislocations also required shearing or traction force on the lateral side of the elbow joint, causing injuries to the radial head and capitellum.[8] Our MRI evaluation revealed that bony involvement was extended to articular cartilage, which is consistent with the results of a previous study.[2] Type 2 injuries involved the medial side of the osteochondral lesions, which consisted of varus posteromedial rotational force in forearm pronation.[3,4,12,17,19] The medial facet of the anteromedial facet of the coronoid and posterior trochlea was involved in the type 2 pattern. However, considering initial plain radiography, there was some discrepancy between the MRI type and the direction of dislocations on radiographs, particularly between type 2 and posteromedial dislocations (Table 4). This was because quite a number of cases were reduced before the examination via plain radiography (10 patients; 23.3%). In addition, the dislocation direction on plain radiography was the result of the dislocation's final stage, hindering an interpretation of the exact dislocation mechanism.

TABLE 4
Elbow Dislocation Classification According to Plain Radiography and MRI[a]

	Radiography		
MRI	Posterolateral	Posteromedial	Unknown
Type 1	22	—	8
Type 2	6	2	2
Unspecified	—	3	—

[a]Data are shown as No. Dash indicates that no patients were found for the specific category. MRI, magnetic resonance imaging.

Osteochondral lesions in the posterolateral capitellum were found to be in the advanced stage (76.9%) as free fragments or loose bodies. Although our study population was older than generally described, our subgroup analysis showed that there was a weak correlation between age and severity of osteochondral lesions (Table 3). The lesions resembled Osborne-Cotterill lesions (OCLs), as described by Jeon et al.[9] An OCL results from a shear or depression fracture of the capitellum, which has also been found in patients with posterolateral rotatory instability. Anatomically, the OCL is closely attached to the lateral ulnar collateral ligament. Therefore, any injury that avulses osteochondral fragments may also injure the lateral ulnar collateral ligament and later cause posterolateral rotatory instability. The advanced stage of avulsed osteochondral lesions might be related to OCLs. Considering the pathomechanism of an OCL, it could expose subchondral bone and result in deep articular cartilage injuries, which could in turn result in the progression of arthritic changes.[23]

There are a few limitations to our study. First, the study design was retrospective in nature. Second, we did not assess interobserver and intraobserver agreement. However, to improve accuracy, 2 fellowship-trained orthopaedic surgeons reviewed the MRI separately to obtain consistent findings. Third, we did not consider soft tissue injuries for evaluating the mechanism. However, MRI for soft tissue injuries has weak interobserver and intraobserver agreement.[20] Last, this was a preliminary report; a longer follow-up period is necessary to prove the prognosis of osteochondral lesions.

CONCLUSION

Osteochondral lesions were found in 48.8% of cases using MRI after simple elbow dislocation. The severity of osteochondral lesions was highest in the posterolateral capitellum.

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