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Radiographic Predictors of Medial Collateral Ligament Injury and Stability of the Elbow

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Background: It has been postulated that injury to the medial collateral ligament (MCL) of the elbow is rare in cases of elbow fracture-dislocation, and if the MCL is torn, it does not require surgical repair. Elbow fracture-dislocations with MCL insufficiency are associated with recurrent instability, secondary surgery, and the development of posttraumatic arthritis. With the current study, our aim was to investigate whether evidence of an MCL attachment-site fracture on a radiograph or computed tomography (CT) scan is predictive of MCL insufficiency, the need for MCL repair, and postoperative instability.

Methods: This retrospective study included 219 patients (median age of 50 years; 53% female) with elbow fracture-dislocations treated at 2 Level-I trauma centers during the period of 2005 to 2016. Patients were followed for a median of 6.3 years to determine postoperative stability. Operative notes and radiology reports were reviewed to confirm MCL insufficiency and periarticular fractures. Radiographs and CT scans were analyzed by a musculoskeletal fellowship-trained emergency radiologist and a board-certified upper-extremity orthopaedic surgeon.

Results: Of the 33 patients with confirmed fractures at an MCL attachment site, 26 (79%) had MCL insufficiency, whereas of the 186 patients without fracture at an MCL attachment site, only 17 (9%) had MCL insufficiency. Of the 6 patients with an attachment-site fracture and MCL insufficiency who did not undergo initial MCL repair, 5 required reoperation. Of the 7 patients without an attachment-site fracture and with MCL insufficiency who did not undergo initial MCL repair, only 1 required reoperation.

Conclusions: Fractures involving an MCL attachment site, regardless of their size, help to predict MCL insufficiency. These fractures can be visualized using initial radiographs and CT scans that are routinely obtained. Additional research is required to assess these findings. Our findings further suggest that repairing an MCL-complex injury in cases of fracture-dislocation in which the fracture has occurred at an MCL attachment site may improve elbow stability and decrease the likelihood of requiring reoperation.

Level of Evidence: Prognostic Level IV. See Instructions for Authors for a complete description of levels of evidence.

The medial collateral ligament (MCL) of the elbow extends from the medial epicondyle of the distal aspect of the humerus and attaches to the sublime tubercle of the proximal aspect of the ulna[1,2]. The anterior band of the MCL complex functions as a primary stabilizer of the elbow, resisting valgus stress, and the posterior band resists pronation of the ulna on the humerus[2-6]. In elbow fracture-dislocations, the ligamentous and osseous structures often fail from lateral to medial, with the MCL being the last stabilizer to fail[7,8]. Therefore, although the status of the MCL has been used as a marker of injury severity, it has been postulated that MCL injuries are rare and that they do not generally require surgical repair[9-15]. Elbow fracture-dislocations with MCL insufficiency are associated with recurrent instability, secondary surgery, and the development of posttraumatic arthritis[16]. Intraoperatively, a surgeon can test the MCL by applying a valgus force and then decide whether to repair the MCL. Because repairing the MCL may require an additional surgical approach, it would valuable to know before surgery whether the MCL is critically injured[17-19].

In the current study, we investigated whether evidence of fracture at an MCL attachment site on a radiograph or computed tomography (CT) scan is predictive of MCL insufficiency and the need for MCL repair, potentially preventing the need for reoperation if addressed at the initial operation.

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Materials and Methods

This institutional review board-approved study was performed at 2 affiliated, urban academic Level-I trauma centers.

Cohort Identification

Using Current Procedural Terminology (CPT) codes, we queried the electronic medical system for patients who had open treatment of a periarticular fracture and/or dislocation of the elbow (fracture distal humerus and proximal ulna and/or proximal radius) during the period of July 2005 to December 2016. The query identified 280 patients. Twenty-seven patients were excluded because they did not have accompanying radiographs or CT scans from initial presentation, and another 34 patients were excluded because they initially presented to another site and only presented to 1 of the study centers postoperatively or for further work-up. A total of 219 patients met the inclusion criteria (Fig. 1).

Data Collection

One of the co-investigators, who did not subsequently grade the radiographic studies, recorded patient demographics, including age, sex, date of operation, and follow-up duration. Radiographic reports and operative notes were reviewed for MCL status, related fractures, surgical procedure performed, and whether reoperation (MCL repair in a secondary procedure or reoperation for another reason) was necessary.

Confirming MCL Insufficiency

MCL insufficiency was determined on the basis of laxity on intraoperative fluoroscopy. Valgus stress was applied to the elbow both at full extension and at 30° of flexion. The laxity was evaluated by the use of live fluoroscopy, by observing the angle between the proximal aspect of the ulna and the distal aspect of the humerus on an anteroposterior image. Any widening of the medial joint space of >4 times normal under stress was interpreted as unstable, at which point the repair of the MCL was left to the discretion of the surgeon.

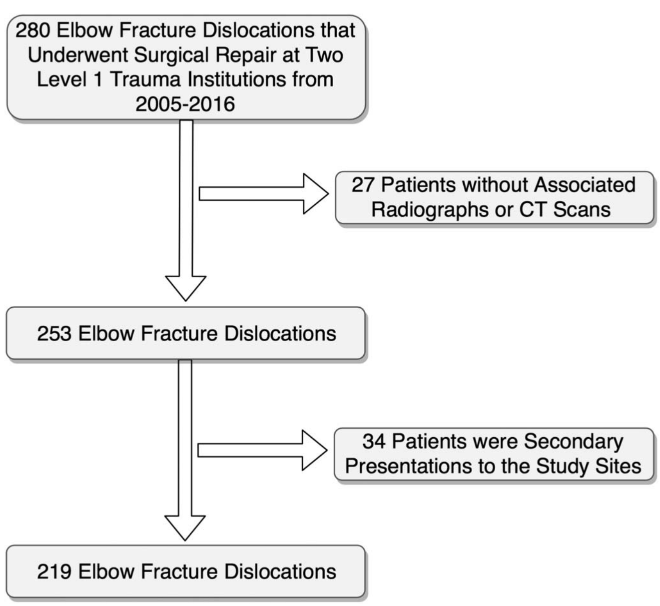

Fig. 1
Flowchart demonstrating the case selection.

TABLE I Study Demographics

Measurement	All Patients (N = 219)	Male (N = 103)	Female (N = 116)
Age *(yr)*			
Median	50	45.5	54
Mean	49	45	53
Range	14-95	14-85	16-95
Duration of follow-up *(yr)*			
Median	6.3	6.6	5.8
Mean	6.1	5.9	6.3
Range	0.5-12.1	0.5-11.5	2.2-12.1

TABLE II Associations with MCL Injury Among Elbow Fracture-Dislocations (N = 43)

Procedure	
LCL repair	81% (35/43)
Reoperation required	28% (12/43)
Location of fracture	
Medial epicondyle	42% (18/43)
Sublime tubercle	19% (8/43)
Proximal ulna	63% (27/43)
Coronoid process	58% (25/43)
Radial head	63% (27/43)
Capitellum	12% (5/43)

Review of Radiographic Findings

Radiographs and CT scans of patients with confirmed MCL tears by the operative or radiology report were further analyzed by a musculoskeletal fellowship-trained emergency radiologist with 14 years of experience and an elbow surgeon with 10 years of clinical experience. The radiographs and CT scans were analyzed for the presence of fracture of the medial epicondyle, the sublime tubercle, the coronoid process, the radial head, or the capitellum. All patient data, including the original radiology reports, were blinded for evaluation.

Follow-up

Among all cases reviewed, the median duration of follow-up was 6.3 years (range, 0.5 to 12.1 years).

Statistical Analysis

Sensitivity, specificity, positive predictive value, negative predictive value, and chi-square statistics were analyzed to assess the ability of an MCL attachment-site fracture to predict MCL insufficiency, elbow instability, and the need for MCL repair.

Fig. 2

A radiograph of a 50-year-old male who presented to the emergency department following a motor vehicle accident. The arrow is pointing to a medial epicondylar fracture fragment.

Significance was set at the level of $p < 0.05$. Confidence intervals for sensitivity and specificity were calculated as Clopper-Pearson confidence intervals. Confidence intervals for the predictive values were the standard confidence intervals as described by Mercaldo et al.[20].

Results

Demographics

The demographics of our patient population were consistent with those of other elbow fracture-dislocation studies[14,16]. The median patient age was 50 years, and the mean age of the male patients was 5 to 10 years younger than that of the female patients (Table I).

Fractures and Procedures Associated with MCL Insufficiency

Table II summarizes the fractures and procedures associated with confirmed MCL tears (n = 43). In terms of MCL attachment-site fractures, 42% (18 of 43) had medial epicondylar fractures and 19% (8 of 43) had sublime tubercle fractures. Figure 2 shows a sample radiograph from our study indicating a fracture fragment that was not mentioned in the original radiology report. Of the 30 patients who underwent MCL repair, 29 of 30 also required a lateral collateral ligament (LCL) repair.

MCL Attachment-Site Fracture as a Predictor of MCL Insufficiency

Of the 219 patients with elbow fracture-dislocations, 33 had fractures at an MCL attachment site (Fig. 3). These fractures varied in size from a punctate ossific focus to an entire medial epicondyle. Of the 33 patients with MCL attachment-site fractures, 79% (26 of 33) were found to have MCL insufficiency, whereas of the 186 without an MCL attachment site-fracture, 9% (17 of 186) were found to have MCL insufficiency (Fig. 3). The chi-square statistic from analysis of the relationship

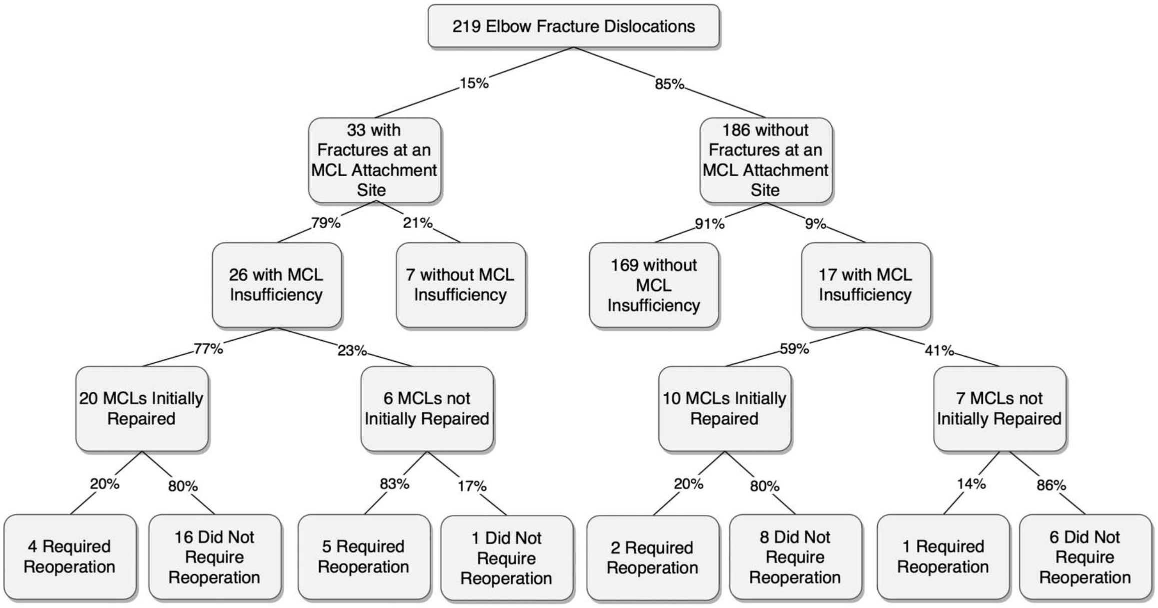

Fig. 3

Diagram stratifying MCL attachment-site injury by MCL status, fracture type, and the need for surgical repair.

between attachment-site fracture status and MCL status was 86.1605 ($p < 0.05$) (Table III).

MCL Attachment-Site Fracture as a Predictor of the Need for MCL Repair

MCL repair refers to the repair of the MCL with local tissue involving direct reattachment of the ligament to, or near to, the anatomic attachment site. The decision to repair the MCL was based on intraoperative fluoroscopic examination to assess valgus stability. For 61% (20) of the 33 patients with elbow fracture-dislocation involving a fracture at an MCL attachment site, the case was deemed unstable enough to require MCL repair on initial presentation. Only 5% (10) of the 186 patients without a fracture at an MCL attachment site required MCL repair on initial presentation. The chi-square statistic from analysis of the relationship between attachment-site fracture status and stability (as measured by intraoperative fluoroscopic examination and decision to repair the MCL) was 72.3159 ($p < 0.05$) (Table IV).

MCL Attachment-Site Fracture as a Predictor of the Need for Reoperation

Six patients with fractures at an MCL attachment site and with a confirmed MCL tear did not undergo MCL repair during the initial operation. Of these patients, 5 of 6 ultimately required reoperation (Fig. 3). Of the 5 patients requiring reoperation, 4 required MCL repair. The fifth patient required reoperation due to ankyloses of both medial and lateral compartments. Seven patients who had MCL insufficiency but did not have an attachment-site fracture did not initially undergo MCL repair. Of these 7 patients, only 1 required reoperation (Fig. 3); that patient required reoperation for heterotopic ossification rather than instability. The chi-square statistic from analysis of the relationship between MCL status and need for reoperation was 6.1978 ($p < 0.05$) (Table V).

TABLE III Chi-Square Contingency Table for Use of an MCL Attachment-Site Fracture as a Predictor of MCL Insufficiency*

	MCL Insufficiency	No MCL Insufficiency
Fracture of an MCL attachment site	26 (6.48) [58.81]	7 (26.52) [14.37]
No fracture of an MCL attachment site	17 (36.52) [10.43]	169 (149.48) [2.55]

*The values are given as the actual value, with the expected cell total in parentheses and the chi-square statistic for the cell in square brackets.

TABLE IV Chi-Square Contingency Table for Use of an MCL Attachment-Site Fracture as a Predictor of MCL Repair*

	MCL Repaired During Initial Operation	MCL Not Repaired During Initial Operation
Fracture of an MCL attachment site	20 (4.52) [53.01]	13 (28.48) [8.41]
No fracture of an MCL attachment site	10 (25.48) [9.40]	176 (160.52) [1.49]

*The values are given as the actual value, with the expected cell total in parentheses and the chi-square statistic for the cell in square brackets.

TABLE V Chi-Square Contingency Table for Use of an MCL Attachment-Site Fracture as a Predictor of the Need for Reoperation*

	Reoperation Needed	No Reoperation Needed
Fracture of an MCL attachment site, MCL not initially repaired	5 (2.77) [1.80]	1 (3.23) [1.54]
No fracture of an MCL attachment site, MCL not initially repaired	1 (3.23) [1.54]	6 (3.77) [1.32]

*The values are given as the actual value, with the expected cell total in parentheses and the chi-square statistic for the cell in square brackets.

Discussion

A fracture at either the medial epicondyle or the sublime tubercle (MCL attachment site) was found to be a significant predictor of the need for MCL repair at initial operation. Furthermore, an MCL attachment-site fracture, as assessed by clinical examination under fluoroscopy, was found to be a significant predictor of instability. Lastly, in cases in which the surgeon initially chose not to repair the MCL, an attachment-site fracture was found to be a significant predictor of the need for reoperation. Therefore, identifying these fractures may serve to alert surgeons to more extensively evaluate for MCL insufficiency and consider MCL repair.

While our findings imply that these fractures may have the potential to guide management by more extensive investigation of MCL status, additional research into the associations between such fractures and outcomes is required.

This study had limitations. There was not complete uniformity in the identification of subtle fractures, as some patients did not have preoperative CT scans. While the study included 219 patients with elbow fracture-dislocations, only 33 of these patients were found to have fractures at an MCL attachment site. Furthermore, only 43 patients had MCL insufficiency confirmed intraoperatively. A more robust study population would further strengthen our findings. Another limitation of this study was that the inclusion criteria selected for patients who were treated operatively. These patients likely had more severe injuries than the average elbow fracture-dislocation. This could have led to greater proportions of MCL insufficiency and the need for reoperation. Furthermore, we interpreted the occurrence of a second surgery as indicative of failure of initial management, but some reoperations may have been necessary regardless of management during the initial operation. Attachment-site fractures may have been underreported within the non-MCL-insufficiency cohort because we scrutinized the insufficiency cohort more closely. Lastly, the study was limited in that it was retrospective. Therefore, our analyses included patients who were lost to follow-up, variations in follow-up duration, and injury variations, and the study lacked controls.

Overall, our findings suggest that the presence of fractures involving the medial epicondyle or the sublime tubercle can help guide clinical management and may be predictive of ligamentous injury. These fractures can often be missed. The identification of these fractures may be useful for surgeons in planning management and predicting MCL insufficiency. Surgical repair of a torn MCL in cases of MCL attachment-site fracture may reduce the need for future reoperation in patients with elbow fracture-dislocation. Additional research is needed to confirm whether using medial epicondylar and sublime tubercle fractures as predictors of MCL status could improve diagnosis, inform surgical management, and prevent postoperative instability. ■

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