Importance of detection of capitellar cartilage injuries concomitant with isolated radial head fractures: A retrospective clinical study

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ABSTRACT

Objective: This study aimed to analyze the injury pattern and clinical importance of concomitant capitellar cartilage defects (CCDs) among patients treated surgically for radial head fracture (RHF).

Methods: A total of 74 patients who were treated surgically for isolated RHFs were retrospectively reviewed. Of these, 12 patients with CCDs (16.2%) were classified as Group I (30 men; mean age, 41.3±12.8 years) and the remaining 62 patients without CCD as Group II (control group) (48 men; mean age, 50.8±13.1 years). The mean follow-up was 21.3±3.2 months in Group I and 18.7±6.4 in Group II. In Group I, 11 patients underwent open reduction and internal fixation, whereas 1 patient was treated by radial head resection. The preoperative range of motion (ROM) was recorded; the severity of RHF was assessed using the Mason classification. The location, size, and thickness of CCD injuries at the time of surgery were also documented. At the final follow-up, radiological assessment was performed to determine the bone union, and clinical measurements, including ROM and the Mayo elbow performance score (MEPS), were performed. The clinical features of the 2 groups were statistically analyzed.

Results: In Group I, 10 patients showed limited forearm rotation. CCD was located posteroslateral in 11 patients and anteroslateral in 1 patient. At the final follow-up, 11 patients from Group I who underwent open reduction and internal fixation showed complete union of RHF and full recovery of pronation and supination. According to the MEPS, 9 patients exhibited excellent results, and 3 patients exhibited good results. In Group I, RHFs were classified as Mason type II in 7 patients (58.3%) and type III in 4 patients (58.3%). In Group II, RHFs were type II in 45 patients (72.6%) and type III in 17 patients (27.4%). In comparative analyses, there was a significant difference in age [41.3±12.8 versus 50.8±13.0, p=0.041] between the 2 groups. Preoperative pronation/supination was higher in Group II [133.3±10.7 [Group I] versus 126.9±21.2 [Group II]] (p=0.384), final follow-up extension/flexion [133.3±10.7 [Group I] versus 126.9±21.2 [Group II]] (p=0.384), pronation/supination [151.2±9.1 [Group I] versus 151.2±13.3 [Group II]] (p=0.58), and the MEPSs (92.9±6.6 [Group I] versus 93.3±7.5 [Group II]) (p=0.701).

Conclusion: If a thorough physical examination of a patient with RHF reveals limited forearm rotation, effort must be made to identify the cause, and the possibility of CCD must be considered. Moreover, there is a need for careful observation during RHF surgery for not only fracture reduction or fixation but also possible CCD.

Level of Evidence: Level III, Therapeutic Study

Introduction

Radial head fracture (RHF) is the most common fracture observed in the elbow area. It is caused by axial or valgus loading after a fall, with the elbow extended and the forearm pronated (1). This force may cause simultaneous injury to the medial collateral ligament or interosseous membrane, and lateral collateral ligament injury or coronoid fracture may also occur because of posterolateral subluxation of the elbow (2, 3). Normally, 60% of the axial load directed toward the elbow is relayed to the radiocapitellar joint (4), but when an RHF occurs, the capitellum collides with the radial head and experiences shear force; consequently, capitellar fracture or cartilage injury may occur (5).

Although there have been few reports on RHFs accompanied by injuries of the capitellum, other accompanying injuries seem to be relatively less recognized. If the capitellar defect accompanying RHF involves cartilage injury, it may be neglected before surgery because such defects are difficult to identify by simple radiography or computed tomography (CT) (6). However, loose cartilage bodies detached from the capitellum, which become impinged in the joint, can cause mechanical limitations in pronation or supination. Moreover, these bodies may also become lodged on the RHF surface and interfere with the union of bone fragments.

This study included patients with capitellar cartilage injury among those diagnosed with and subsequently managed surgically for RHF. The pattern of injury and the clinical importance of these cases are reported here.

Materials and Methods

The study design was approved by the appropriate ethics review board (IRB No. VC18RESI0164). In the...
first round of selection, 124 patients who underwent open reduction and internal fixation for RHF between March 2014 and October 2017 were selected. In the second round, 74 out of the 124 patients were selected after excluding the patients with olecranon fracture, coronoid fracture, distal humeral fracture, elbow dislocation, or joint instability (e.g., terrible triad and Essex-Lopresti injuries) together with RHF. Finally, 12 out of the 74 patients who showed capitellar cartilage defect (CCD) were classified as Group I, and the remaining 62 patients without CCD were classified as Group II. The patient's evaluation and surgery were performed by a single surgeon.

It is very important to distinguish whether limited forearm rotation is due to pain or mechanical blockage. Aspiration of the elbow was performed using aseptic technique with the forearm maintained in pronation. The hemarthrosis was aspirated, and a local anesthetic was injected. The improvement in rotation suggests pain-limiting motion, whereas persistent restriction of rotation suggests a mechanical blockage requiring surgical treatment. For Mason type I and some type II patients who could consider conservative treatment in radiological imaging, we determined the indication of surgical treatment by measuring the range of motion (ROM) under local anesthesia. In contrast, we did not measure ROM under local anesthesia for Mason type III patients because surgical treatment is required in radiological imaging evaluation alone. The indications for surgery were established as RHFs with a displacement of ≥ 2 mm (Mason types II and III) or a mechanical blockage in forearm rotation before surgery even if the degree of displacement was small (Mason type I).

In the CCD group (Group I), the mean age of the patients was 41.3 (30-68) years, and there were 10 men and 2 women (Table 1). The mean follow-up period was 21.3 (16-28) months. Preoperative CT was performed for 11 patients, and magnetic resonance imaging (MRI) was performed for only 1 patient to confirm the ligament injury. Clinically data were used to assess the preoperative ROM, including extension/flexion/pronation/supination, CT: computed tomography; MRI: magnetic resonance imaging.

| No. | Age | Sex | Side | Injury mechanism | Mason type | Imaging study | Preoperative ROM [E/F/P/S] |
|-----|-----|-----|------|------------------|------------|--------------|--------------------------|
| 1   | 43  | M   | Rt.  | Fall from height (ladder) | II         | CT           | 0/120/80/45              |
| 2   | 49  | M   | Lt.  | Fall from height (3 m)    | II         | CT           | 0/150/80/80              |
| 3   | 36  | M   | Lt.  | Fall on the outstretched upper extremity | II        | CT           | 10/130/60/50             |
| 4   | 68  | M   | Lt.  | Fall from height (ladder) | I          | CT           | 40/110/40/50             |
| 5   | 38  | M   | Lt.  | Fall from height (stair)   | II         | CT           | 0/150/80/30              |
| 6   | 36  | M   | Rt.  | Fall on the outstretched upper extremity | II        | CT           | 0/150/80/80              |
| 7   | 38  | M   | Rt.  | Fall on the outstretched upper extremity | II        | CT           | 30/100/50/30             |
| 8   | 61  | F   | Rt.  | Fall on the outstretched upper extremity | II        | CT           | 10/120/70/40             |
| 9   | 21  | F   | Lt.  | Fall on the outstretched upper extremity | III        | CT           | 45/90/30/20              |
| 10  | 39  | M   | Lt.  | Fall from height (stair)    | III        | CT           | 30/90/50/40              |
| 11  | 37  | M   | Rt.  | Fall on the outstretched upper extremity | III        | CT           | 20/70/60/25              |
| 12  | 30  | M   | Rt.  | Fall from height (chair)    | III        | MRI          | 0/140/65/40              |

M: male; F: female; ROM: range of motion; Rt: right; Lt: left; E/F/P/S: extension/flexion/pronation/supination; CT: computed tomography; MRI: magnetic resonance imaging.

was recorded according to the Mason classification depending on the analysis of preoperative images.

In 11 out of 12 patients, open reduction and internal fixation were performed for RHF, and consequently, an exploratory procedure was performed on the capitellum and joint. The location of the CCD was identified, and the cartilage injury size was measured. Depending on the thickness of the damaged cartilage, we classified the injuries into the following 2 types: partial-thickness defects, which involved only a part of the cartilage, and full-thickness defects, which involved the entire cartilage (7).

### Statistical analysis

Age, sex, Mason type, pre- and postoperative ROM (extension, flexion, and pronation/supination), and Mayo elbow performance score (MEPS) measured at the last follow-up were statistically compared between Groups I and II. Statistical analysis was performed using Statistical Package for the Social Sciences 25.0 (IBM SPSS Corp., Armonk, NY, USA). The Fisher’s exact test was used to compare the categorical variables between the 2 groups, and the Mann-Whitney U test was used to compare the continuous variables. p<0.05 was considered statistically significant.

### Results

CCD was detected in 12 (16.2%) out of 74 patients with surgically treated isolated RHF. Preoperatively, during physical examination, 10 patients showed limited pronation/supination. Although the remaining 2 patients did not show limited rotation, they underwent surgery for RHF with displacement ≥2 mm. RHF types, based on Mason classification, were type I, II, and III fractures, in 1, 7, and 4 patients, respectively.

CCD location was posterolateral in 11 patients and anterolateral in 1 patient. The average size of the cartilage injury was 1.94 (0.5-6.0) cm². Concerning the classification of cartilage defect depending on the thickness, partial-thickness defect was detected in 1 patient and full-thickness defects were detected in 11 patients. Among the 7 patients with type II fractures, 6 had full-thickness defects (Figure 1), and 1 had a partial-thickness defect. In the case of type III fractures, all 4 patients had full-thickness defects.

Depending on the type of injury and decision of the surgeon, RHF and CCD were treated. In patients with RHF, there were 9 headless screw fixations, 2 plate fixations, and 1 radial head excision. In patients with CCD, there were 7 multiple drillings in the cartilage defect, and 5 patients underwent simple removal of cartilage fragments. At the final follow-up, all patients who underwent open reduction and internal fixation (11 patients) showed complete union of the
RHF and recovery of ROM within the normal range. According to the MEPS, we had 9 excellent and 3 good results (Table 2).

There was a significant difference in age (41.3±12.8 versus 50.8±13.0, p=0.041) and preoperative pronation/supination (106.3±31.6 versus 131.7±36.2, p=0.021) between the 2 groups; however, there were no significant difference in sex, follow-up period, Mason type, preoperative extension/flexion, last follow-up extension/flexion, pronation/supination, and MEPS (Table 3).

Discussion

RHF's are the most common fractures that occur in the elbow in adults (1). The classification system used most frequently to classify...
the RHF is the Mason classification, which categorizes them into the following 3 types: type I (nondisplaced fracture), type II (displaced fracture involving part of the radial head), and type III (comminuted fracture involving the whole radial head) (8). However, this classification system categorizes the fractures into types solely on the basis of radiological findings and does not consider any accompanying injuries; thus, this classification cannot be directly applied to determine the appropriate treatment strategy. In contrast, Hotchkiss et al. designed a new classification system based on both radiological and clinical findings and attempted to apply this system for treatments (9). Therefore, in addition to fracture fragment size, location, and extent of displacement, this classification considered clinical aspects, such as limitations in the forearm rotation. In this system, the fractures are classified as follows: type I is classified as nondisplaced or minimally displaced fracture (<2 mm) with no limitation in forearm rotation, which may be treated conservatively; type II is classified as displaced ≥2 mm with limited forearm rotation, which may be treated by open reduction and internal fixation; and type III is classified as nonrepairable comminuted fracture, which may be treated by radial head excision (9). However, some studies have reported that excellent outcomes can be achieved with conservative treatment even in cases of displaced RHF. There is still controversy regarding the treatment of RHFs, and a single classification system may not be able to resolve this issue. The recent treatment trend is to determine the treatment on the basis of comprehensive assessment of fracture stability, extent of displacement, involvement of articular surface, preservation of range of forearm rotation, maintenance of radiocapitellar alignment, and accompanying injuries (10). In particular, the preservation of range of forearm rotation has become a very important factor in determining the treatment method for both displaced and nondisplaced fractures (11, 12).

In 1916, Hitzrot (13) reported that the capitellar cartilage fragments, which are not observed before surgery, were detected in between the RHF fragments. This was the first report on an RHF accompanied by a CCD. In 1931, Milch (14) reported 2 patients with RHFs accompanied by osteochondral defects; in 1 of the cases, partial union of the radial head was achieved with the capitellar cartilage fragments still lodged between the RHF fragments. Similarly, in 1978, Heim and Trub (15) reported that detection of osteochondral fragments lodged between the RHF fragments in 2 out of 20 cases involved patients with RHFs, and in 1983, Newman (16) reported clinical cases with a similar pattern. Recently, Claessen et al. have termed the RHF with a concomitant capitellum fracture as the "kissing lesion" (17). Subsequently, similar cases were reported, and in most cases, the capitellar cartilage or osteochondral loose bodies were lodged between the RHF fragments, which, unfortunately, are difficult to detect with preoperative radiography (5, 6, 18, 19). Even in this study, the cartilage defects could be identified in advance at preoperative radiography in only 1 patient. This patient showed type III RHF and full-thickness cartilage with the small attachment of a part of the cortical bone detached from the capitellum. In our patients, because MRI was not a part of the basic examination performed on patients with isolated RHFs, any detachment of the cartilage fragments caused by capitellar injury would not have been easily detected by simple radiography or CT.

Different studies have reported different incidence rates of RHFs accompanied by CCDs. Michels et al. performed percutaneous internal fixation after arthroscopic reduction in 14 patients of Mason type II RHFs, and among them, capitellar cartilage lesions were detected in 2 (14%) patients (19). Geel (18) found capitellar osteochondral loose bodies lodged between the RHF fragments during surgery for RHFs in 3 out of 19 (16%) patients, whereas Nalbantoğlu et al. reported CCD in 10 out of 51 (20%) patients with Mason type II or III RHFs that were treated by open surgery (5). However, Ward and Nunley (20) reported that the incidence of RHFs with accompanying capitellar defects is approximately 1%, and Claessen et al. reported that only 0.2% of RHFs have the concomitant capitellum fractures (17). They are relatively lower than the incidence reported by others. In contrast, Itamura et al. performed MRI for 24 patients with Mason type II or III RHFs to determine the frequency of accompanying injuries and reported that capitellar bone bruises were observed in approximately 96% of the patients, while osteochondral defects were observed in 29%; these values were relatively higher than the incidence reported by others (21). In this study, capitellar capitellar lesions were detected in 12 out of 74 (16.2%) patients with RHFs. Among these patients, capitellar cartilage injury was identified preoperatively in only 1 patient, and the remaining 11 patients showed capitellar cartilage injury during surgery. Therefore, for more accurate determination of the incidence rate, additional studies with a higher number of patients must be performed.

The presence or absence of CCD cannot be accurately identified in all patients undergoing conservative treatment, and some of them might have been overlooked. The outcome of the neglect of the osteochondral loose bodies or the cartilage detached from the capitellum has not been identified to date. However, determining the treatment guidelines for RHFs solely on the basis of simple radiography findings can lead to unfavorable outcomes (Figure 2), such as limited ROM, nonunion, and post-traumatic osteoarthritis, and many studies have suggested capitellar cartilage injury as one of the reasons (5, 6, 13-16). In this study, 10 patients showed limited pronation, supination, or both during preoperative physical examination. In some of these cases, cartilage fragments that detached from the capitellum were lodged between the RHF fragments; thus, neglecting this might have made it difficult to achieve bone union. Most patients, especially those with a mechanical blockage, nearly recovered normal ROM immediately postoperatively. The causes of limited forearm rotation in patients with RHF included pain, capitellar cartilage, displaced fracture fragments of the radial head, and accompanying ligament injury. Therefore, it is difficult to know the exact contribution of cartilage loose bodies detached from the capitellum to cause a mechanical block. However, we found that the preoperative pronation/supination was significantly reduced in Group I compared with Group II (P<0.021). At the time of surgery, we tried to detect and remove as many incarcerated capitellar fragments as possible, and we verified that the passive ROM was within the normal range. Therefore, we believe that these observations support the improvement of the ROM immediately after the surgery.

Nalbantoğlu et al. reported that capitellar cartilage injuries are milder in more severe RHF cases, and they are more severe when there is less damage to the radial head (5). In this study, when comparing the Mason type of RHF between the 2 groups, there was no statistical significance. Therefore, we do not believe that there is a strong association between the severity of RHF and CCD. In 11 of 12 patients, the position of the CCD was at the posterolateral region. It does seem plausible that the capitellar injury could occur as a result of a shear injury to the radial head because it is loaded axially against the capitellum (20, 22). In most cases, it is thought that shear force will occur in the posteroarticular aspect of the capitellum owing to the transient posteroarticular subluxation of the radial head (23).

The treatment of CCD varies depending on the type of injury and the surgeon’s decision, and various treatments, such as simple cartilage fragment removal and multiple drilling in the cartilage defect area, have been attempted. In this study, we performed multiple drilling in 7 out of 12 patients in which no specific surgical indications were identified. Because all 12 patients showed good results after surgery,
it is believed that multiple drilling did not affect the outcome after surgery. We treated RHFs in a variety of ways, including headless screw fixation, plate fixation, radial head excision, and prosthetic replacement. At the final follow-up, there were no significant differences between the surgical methods when comparing the results of ROM and MEPS. Consequently, we believe that there was no significant difference in the clinical results depending on the treatment methods.

There are some limitations to this study. First, this is a retrospective study with a small sample size. Second, because patients who underwent surgery for RHFs were selected, there was no comparison with patients who were conservatively treated. Finally, “second-look operation” or MRI was not performed at the final follow-up; therefore, it was difficult to identify the final status of the CCD. However, this study was able to provide clinical information on this unique injury that was compared with the control group using statistical analysis. As data from more cases are collected in the future, a more meaningful investigation would be possible. If we design a prospective clinical study based on the results obtained in our study, we would need to confirm meaningful results from at least 75 patients ($n_1=23$, $n_2=52$, 80% test power).

The cartilage loose bodies detached from the capitellum can become lodged between the RHF fragments and interfere with bone union or cause mechanical limitation in the radiocapitellar joint. However, because MRI is not a part of the basic examination for RHFs, detachment of the cartilage fragments due to capitellar injury is not easy to detect using simple radiography or CT. Therefore, determining the treatment guidelines for RHF solely on the basis of radiological findings can lead to unfavorable outcomes.

Thorough preoperative physical examination should be performed to check for any limitation in the forearm rotation, and if such limitation is found, efforts should be made to identify the cause. In doing so, the possibility of capitellar cartilage injuries must be considered. Moreover, when performing the surgery for RHFs, in addition to fracture reduction or fixation, careful observation of CCDs should be made. In conclusion, this study demonstrated the clinical importance of CCD among those diagnosed with and subsequently managed surgically for RHF. CCD was detected in 16.2% of patients with surgically treated isolated RHF. It may be neglected before surgery because such defects are difficult to identify by simple radiography or CT. The preoperative pronation/supination was significantly reduced in Group I (with CCD) compared with Group II (without CCD). If a thorough physical examination of a patient with RHF reveals limited forearm rotation, effort must be made to identify the cause, and the possibility of CCD must be considered.

Ethics Committee Approval: Ethics committee approval was received for this study from the Institutional Review Board (IRB) of the Catholic University of Korea (IRB No. VC18RENI184).

Informed Consent: This study was the retrospective and proceeded in the manner of chart-review, so IRB board allowed us to waive the informed consent.

Acknowledgment: We thank Chang Deok Weon, a medical photographer of Bucheon St. Mary’s hospital, the Catholic University of Korea for helping in preparing the photos.

Author Contributions: Concept - S.H.K.; Design - I.J.P., S.H.K.; Supervision - Y.T.R.; Materials - Y.T.R.; Data Collection and/or Processing - S.H.S., H.Y.P.; Analysis and/or Interpretation - S.H.S., C.J.; Literature Review - H.Y.P., C.J., S.H.K.; Writing - I.J.P.; Critical Review - S.H.K.

Conflict of Interest: The authors have no conflicts of interest to declare.

Financial Disclosure: The authors declared that this study has received no financial support.

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