ORIGINAL CLINICAL RESEARCH – TRAUMA

acta orthopaedica belgica, 2026, 92, online-only

doi.org/10.52628/92.1.15100

Correlation of radial head and coronoid process fractures in elbow trauma – a retrospective analysis of fracture patterns

M. SARTER[1], J. P. HOCKMANN[1], T. BABASIZ[1], V. RAUSCH[1], L. P. MÜLLER[1], T. LESCHINGER[1]

[1]*Department of Orthopedic, Trauma and Plastic Surgery, University Hospital of Cologne, Kerpener Str. 62, 50937 Cologne.*

Correspondence at: Michael Sarter, Department of Orthopedic, Trauma and Plastic Surgery, University Hospital of Cologne, Kerpener Str. 62, 50937 Cologne - Tel.: +49173 7224230 - Fax.: +49 221 478-4835 - E-mail: Michael.sarter@uk-koeln.de

ABSTRACT

While the relationship between radial head fractures (RHF) and coronoid process fractures (CPF) is biomechanically established, the exact frequency of CPF in RHF patients without focus on elbow dislocations is underexplored. To better estimate the likelihood of CPF, the analysis of typical fracture constellations is useful. The aim of this study was therefore to analyze the correlation between RHF severity and the presence and type of CPF. This retrospective study analyzed 356 RHF patients, evaluating the prevalence and correlation of CPF using CT and intraoperative data. Only cases with confirmed presence or absence of CPF based on CT imaging or surgical reports were included. CPF were classified according to O'Driscoll (OD) and correlated with the severity of the RHF according to Mason (MA). Descriptive statistics and correlation using Spearman correlation were performed. CPF was observed in 42.1 % of RHF patients. 51.3 % of CPF were OD Type 1, 26% Type 2 and 10.7% Type 3. The correlation between RHF severity and CPF presence was statistically significant but weak (Spearman r = 0.19). In this study cohort, a high proportion of additional CPF were found in the presence of RHF. Although the correlation was weak, increasing RHF severity was associated with a higher likelihood of CPF. These findings emphasize that in cases of RHF, the CP should be critically examined and CT imaging should be considered in unclear cases.

Keywords: Radial head fracture, coronoid fracture, coronoid process, correlation, terrible triad.

INTRODUCTION

As demonstrated in both biomechanical and clinical studies, the coronoid process (CP) of the ulna serves as a crucial static anterior stabilizer of the elbow joint against dorsal forces[1–3]. In recent years, coronoid process fractures (CPF) and their appropriate management have become an increasing focus in the literature[4–7].

CPF occur in approximately 2 – 15 % of patients following elbow dislocations[8] and are often associated with radial head fractures (RHF) and injuries to the lateral collateral ligament complex (LCLC)), commonly referred to as terrible triad injuries (TTI). These are among the most challenging elbow injuries and can lead to both acute and chronic posttraumatic instability of the ulnohumeral joint, contributing to early joint degeneration[9,10]. A meta-analysis demonstrated that early identification of specific CPF patterns, coupled with the use of suitable classification systems, was crucial for achieving satisfactory patient outcomes[5].

The basic diagnostic approach following elbow dislocation and reduction involves standard radiography, including anteroposterior (AP) and lateral views. In 1989, Regan and Morrey (RM) classified CPF into three types based on the fragment size observed in lateral radiographs[11]. In 2003, O'Driscoll et al. (OD) introduced an expanded classification system based on computed tomography (CT), which takes into account both the mechanism of injury and the precise anatomical localization of the fracture and provides treatment recommendations[12].

Li et al. analyzed the relationship between RHF and CPF in 102 patients with TTI in a retrospective study. It was demonstrated that there is a weak correlation between MA classification of RHF with RM and OD classifications of CPF. However, their analysis was limited to elbow fracture-dislocations and did not assess the overall incidence of CPF in RHF patients without dislocation[13]. To date, no large study has systematically analyzed the frequency and severity of CPF in a broader RHF population independent of elbow dislocation.

Therefore, the aim of this study is to analyze typical fracture patterns of RHF and CPF in order to better understand them and to improve the ability to assess the likelihood of a concurrent CPF.

MATERIALS AND METHODS

Population

This retrospective study examined 356 patients of a level-1 trauma center between 2020 and 2024 with conventionally radiologically or CT-graphically confirmed RHF. In addition, CT scans or surgical reports were used to determine how many of these patients also had CPF (Figure 1). Patients without CT imaging or surgical exploration were excluded. Further exclusion criteria were prior performed osteosynthesis, malformations and age under 18 years.

Imaging and analysis program

Imaging was performed using a direct radiography system (Philips DigitalDiagnost, Philips GmbH Market DACH, Health Systems, Hamburg, Germany) and using a multislice clinical CT scanner (Philips Brilliance iCT 256, Philips GmbH Market DACH, Health Systems, Hamburg, Germany). The axial slice thickness of the CT datasets was 0.8 mm. All patients were anonymized.

Analysis of radial head fractures and coronoid fractures

RHF were categorized using the Mason classification (MA). Type 1 fractures are defined as nondisplaced or displaced < 2 mm. Type 2 fractures are displaced more than 2 mm with less than 3 fragments. Type 3 fractures are displaced fractures with more than 3 fragments. Type 4 fractures were defined as RHF with persistent dislocation under the capitulum after reduction.

CPF were classified using the OD classification. Type 1 fractures are defined as tip fractures. Type 2 are fractures that involve the anteromedial facet. Type 3 fractures are basal fractures, involving more than 50 % of the height of the coronoid process. Subcategorizations of OD Type 1, 2 and 3 were not included. MA and OD were then correlated with each other (Fig. 1). The dependence of fracture severity on patient age was also investigated.

Classifications were independently performed by trauma surgeons with over five years of experience. In case of disagreement, fractures were classified by a senior elbow surgeon.

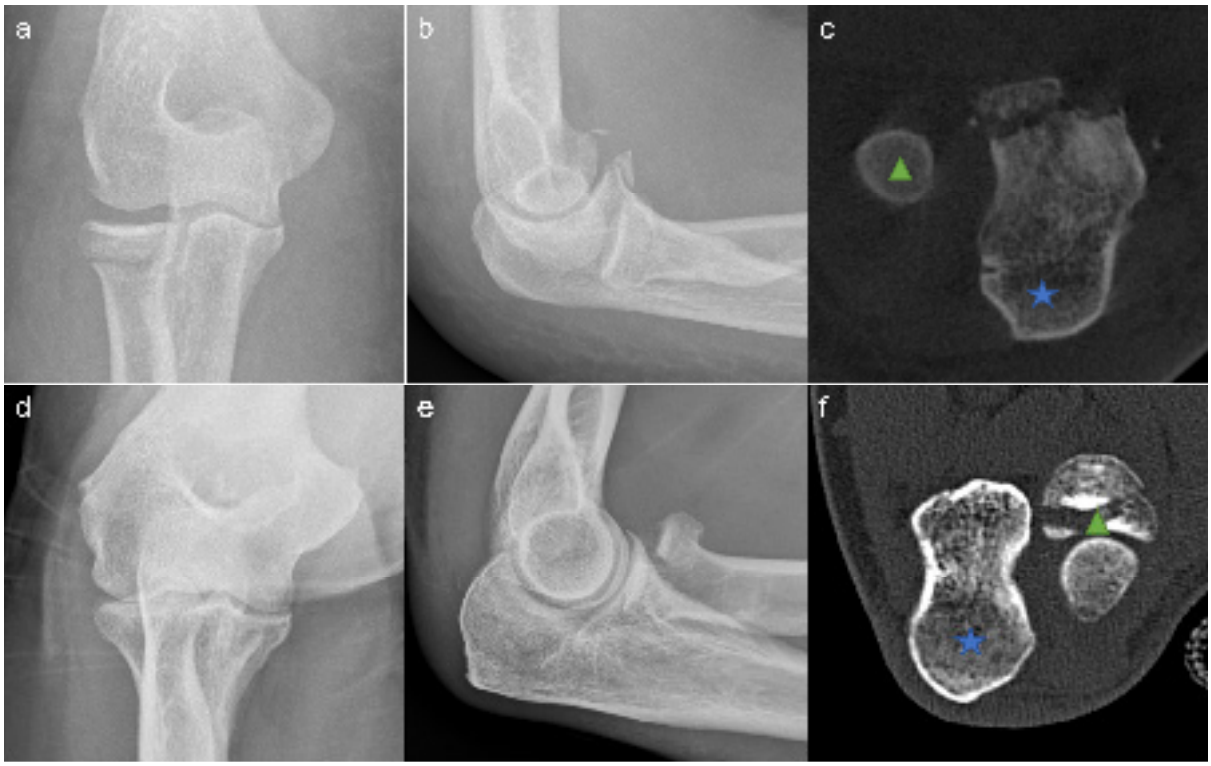

Fig. 1 — Patient with x-ray imaging of the elbow and presence of a RHF MA Type I and a CPF (a-b). Using a CT-scan, CPF can be classified as OD Type 1 (c; green triangle: radial head; blue star: CP). Another patient with x-ray imaging of the elbow presents a RHF MA Type 3 without a CPF, confirmed by a CT-scan (d-f, green triangle: radial head; blue star: CP).

Analysis of trauma mechanism

The trauma mechanism was recorded and divided into seven categories: fall from body height, fall at low speed on a bicycle or comparable means of transportation, high-velocity mechanism, fall on stairs, fall from over body height, recreational accident, other trauma mechanisms and no trauma mechanism documented.

Statistical analysis

The data were analyzed using SPSS. Descriptive statistics are presented. Correlation between classifications of RHF and CPF was performed by Spearman correlation. T-test for independent variables were used to compare means. The Kruskal-Wallis test, Mann-Whitney U test and Spearman correlation were used to investigate the dependence of fracture severity on patient age.

RESULTS

Descriptive statistics

Of the 356 patients, 188 were female (52.8 %) and 168 were male (47.2 %). Mean age was 51.4 years (range 18 – 95). Of the 356 radial head fractures, 334 could be clearly classified using MA. Of these, 59 were MA type 1 (17.7 %), 75 MA type 2 (22.5 %), 136 MA type 3 (40.7 %) and 64 MA type 4 (19.2 %). The other 22 patients were not included in the MA classification.

An additional CPF was present in 150 of the 356 RHF (42.1 %). Of these CPF, 134 were diagnosed via CT scan and 16 via surgical report. 56 % of the patients with CPF were female and 44 % male. The mean age was 55.9 years (range 18 - 95). 51.3 % of CPF were OD Type 1, 26 % Type 2 and 10.7 % Type 3 (Table I). Undependently of RHF, 62 of the 150 CPFs were treated non-operatively and 88 were treated operatively. The classification of fractures according to OD revealed a median age of 53.1 years for OD Type 1 fractures, 56.6 years for OD Type 2 fractures, and 58.3 years for OD Type 3 fractures. Statistical analysis showed no significant difference in median age between the three groups (Chi^2 = 3.65, df = 2, P = 0.161). Patients below and above 65 years of age were compared with respect to OD of the fractures. The difference between the two groups was not statistically significant (P = 0.134). Also, correlation analysis revealed no statistically significant connections between age and OD.

Correlation between radial head fractures and coronoid fractures

For RHF MA I, 76.3 % showed no CPF, 10.2 % OD Type 1, 11.9 % OD Type 2, and 1.7 % OD Type 3. For MA II fractures, 62.7 % showed no CPF, 26.7 % OD Type 1, 6.7 % OD Type 2, and 4 % OD Type 3. For MA III fractures, 61 % showed no CPF, 22.8 % OD Type 1, 12.5 % OD Type 2, and 3.7 % OD Type 3. For MA IV fractures, 43.8 % showed no CPF, 31.3 % OD Type 1, 14.1 % OD Type 2, and 10.9 % OD Type 3 (Fig. 2). The result of the Spearman correlation analysis demonstrated a weak but statistically significant correlation between RHF severity and CPF severity (r = 0.19; P = 0.001; Figure 2).

Coronoid fractures and trauma mechanism

CPF were present in 42.9 % at fall from body height, in 38.4 % at fall at low speed on a bicycle or comparable means of transportation with speed < 30 km/h, in 33.3 % at high-velocity mechanism (e.g. car crash), in 50 % at fall from over body height, in 16.7 % at recreational accidents, in 37.5 % at other trauma mechanisms and in 26.9 % at no trauma mechanism documented (Table II).

DISCUSSION

This study investigated the occurrence of CPF in patients with confirmed RHF, regardless of the presence of elbow dislocation. Although a statistically significant association between RHF severity and CPF presence was identified, the correlation strength was weak, indicating that fracture severity alone does not sufficiently predict CPF.

As the name suggests, TTI have long been associated with a poor outcome. In 2002, Ring et al. analyzed a case series of 11 patients with TTI in whom

Table I. — Distribution of 150 CPF according to the O'Driscoll classification.

O'Driscoll	n	%
1	77	51.3
2	39	26
3	16	10.7
CPF: coronoid process fracture.		

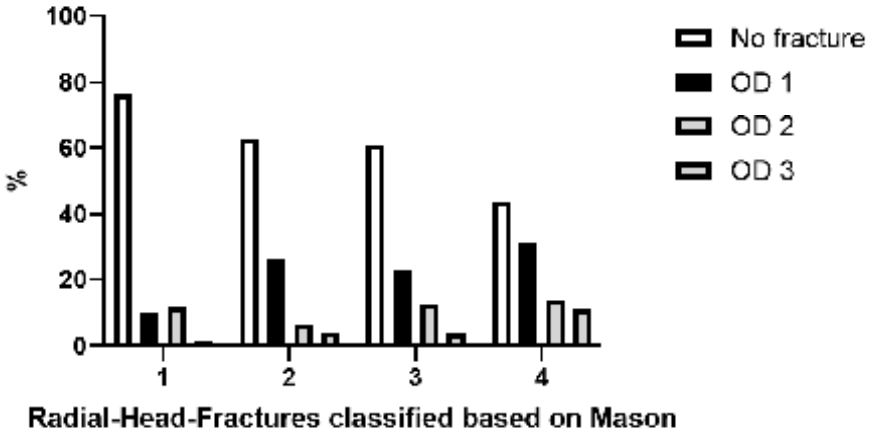

Fig. 2 — Dependence of CPF severity according to the O'Driscoll classification (OD; y -axis) on the severity of RHF according to the Mason classification (x-axis) In severe RHF, CPF is not seen in fewer percent of cases. The percentage of CPF OD Type 1, 2 and 3 fractures are highest in the presence of RHF MA Type 4.

Table II. — Frequency of CPF depending on trauma mechanism.

Trauma mechanism	Cases with CPF	% of CPF
Fall (body height)	75	42.9
Fall (Bike, E-Scooter, Inliner) (Speed <30km/h)	38	38.4
High-velocity mechanism (e.g. car crash)	3	33.3
Fall (> body height)	21	50
Recreational accident	2	16.7
Other trauma mechanisms	3	37.5
No trauma mechanism documented	7	26.9
CPF: coronoid process fracture.		

no surgical treatment of the CP and no reconstruction of the LCLC was performed. It was shown that postoperative dislocation occurred in 5 patients (45 %) and that 10 patients (91 %) had degenerative joint changes[14]. Furthermore, as shown by Pugh et al., 8 of 36 patients (22 %) with TTI, who underwent surgical treatment of CP by capsular repair or fixation, required reoperation[15]. A systematic review in 2014 reported subluxation or dislocation leading to another surgery in 11 of the 16 studies. However, there was a wide range of 3 – 45 %. Degenerative changes, most reported rates of less than 38 % after a mean of 1-5 years, were demonstrated in 7 of the 16 studies[16]. As shown in these studies, CPF have an important role in the outcome of TTI and should be considered critically in diagnosis and treatment. In order to better assess the probability of CPF, analyses of typical fracture constellations in large sample studies are helpful and necessary.

Demographic and clinical overview

This study cohort included 356 patients, with a fairly balanced gender distribution: 188 females (52.8 %) and 168 males (47.2 %). The mean age of 51.4 years with a range from 18 to 95 years reflects the broad spectrum of individuals affected by these types of fractures. As the results show, patient age does not seem to have a direct influence on the severity of CPF.

The mean age of patients with CPF was slightly higher at 55.9 years, and a majority (56 %) of these patients were female, which may indicate that women are at higher risk of CPF due to factors such as osteoporosis and ligament laxity.

Fracture classifications and severity

In terms of fracture severity, RHF cases were classified using the MA classification, with the following distribution: 17.7 % were MA Type 1, 22.5 % were Type 2, 40.7 % were Type 3, and 19.2 % were Type 4. This distribution suggests that the majority of RHF in the study were more severe, with type 3 fractures being the most prevalent. These results are not consistent with those of the study by Li et al 2018. They found 68% MA Type 2 and 32% MA Type 3 RHF in their collective of 102 patients with TTI13. Selection bias must be considered, as this study was

conducted at a tertiary referral center specializing in complex elbow injuries. This likely contributed to the high proportion of severe RHF (Mason III and IV) and may limit generalizability to lower-energy trauma populations. Furthermore, only patients with CT imaging or surgical confirmation were included, which may have excluded less severe RHF without advanced imaging and artificially increased the observed CPF incidence.

It is generally known that CPF often occurs in combination with RHF after a fall onto an outstretched arm with subluxation or dislocation of the elbow17–20. The analysis of the frequency of CPF depending on the trauma mechanism showed no significant differences. It appears that the height of the fall or the speed of an accident is not the primary factor in the development of CPF. Patients with CPF may or may not describe a subluxation or dislocation event. It is therefore even more important to be aware of typical fracture constellations in X-ray imaging. However, no study to date has investigated the frequency of CPF with diagnosed RHF in a large patient population. In this patient collective, coexisting CPF was present in 42.1 % of RHF patients, further underscoring the importance of considering both fractures when evaluating elbow trauma.

Correlation between radial head fractures and coronoid fractures

One objective of this study was to investigate the relationship between the severity of RHF and the incidence of CPF. The results demonstrate that the severity of RHF, as classified by the MA classification, was positively correlated with the presence of CPF. Specifically, for MA Type 1 fractures, 76.3 % of patients had no CPF, whereas for MA Type 4 fractures, only 43.8 % showed no CPF. The percentages of CPF OD Type 1, 2 and 3 fractures are highest in the presence of RHF MA Type 4. This suggests that as the severity of RHF increases, the likelihood of concomitant CPF increases. The Spearman correlation coefficient indicated a low positive correlation between the classification of RHF and CPF, which was statistically significant. While this correlation is weak, it is consistent with previous findings that examined the relationship between the severity of RHF and CPF in TTI[13]. Furthermore, the results also correspond to previous studies, which described RHF rather in combination with tip fractures of the CP, while RHF appear to play a more secondary role in cases of severe CPF[4,12,21].

Clinical implications and future directions

The results of this study show clinical relevance. The coexistence of RHF and CPF is a critical factor to consider when planning treatment for elbow injuries, as these fractures significantly compromise joint stability. The results of this study suggest that more severe RHF are more likely to be associated with CPF, underscoring the need for thorough diagnostic evaluation in patients presenting with complex elbow trauma. Future research could focus on refining classification systems that take into account the interrelationship between RHF and CPF.

Limitations

This study has several limitations. First, the retrospective design and tertiary referral setting likely resulted in selection bias toward complex fracture patterns. Second, only patients with confirmed CPF presence or absence based on CT or surgery were included, excluding potentially less severe RHF without advanced imaging. Third, no interobserver reliability analysis was performed for fracture classification. Finally, the lack of clinical and functional outcome data prevents conclusions regarding the impact of CPF on patient prognosis.

CONCLUSION

This study demonstrates a weak but statistically significant association between RHF severity and the presence of CPF in a large retrospective cohort. Given the weak correlation and methodological limitations, these findings should primarily inform diagnostic awareness rather than clinical outcome prediction. Clinicians should maintain a high index of suspicion for CPF in patients with RHF and consider CT imaging in unclear cases.

Institution where the study was carried out: Department of Orthopedic, Trauma and Plastic Surgery, University Hospital of Cologne, Kerpener Str. 62, 50937 Cologne.

REFERENCES

1. Doornberg J, Ring D, Jupiter JB. Effective treatment of fracture-dislocations of the olecranon requires a stable trochlear notch. Clin Orthop Relat Res. 2004;429.
2. Closkey RF, Goode JR, Kirschenbaum D, et al. The role of the coronoid process in elbow stability: A biomechanical analysis of axial loading. Journal of Bone and Joint Surgery. 2000;82.
3. Matzon JL, Widmer BJ, Draganich LF, et al. Anatomy of the Coronoid Process. Journal of Hand Surgery. 2006;31.
4. Wang X, Chang SM, Yu GR. Anteromedial coronoid facet fractures. European Journal of Orthopaedic Surgery and Traumatology. 2013;23.

5. Manidakis N, Sperelakis I, Hackney R, et al. Fractures of the ulnar coronoid process. Injury. 2012;43.
6. Doornberg JN, de Jong IM, Lindenhovius ALC, et al. The anteromedial facet of the coronoid process of the ulna. J Shoulder Elbow Surg. 2007;16.
7. Doornberg JN, Ring D. Coronoid fracture patterns. Journal of Hand Surgery. 2006;31.
8. Wells J, Ablove RH. Coronoid fractures of the elbow. Clin Med Res. 2008;6.
9. Morrey BF, An KN. Stability of the elbow: Osseous constraints. Journal of Shoulder and Elbow Surgery. 2005.
10. Ring D, Horst TA. Coronoid Fractures. J Orthop Trauma. 2015;29.
11. Regan W, Morrey B. Fractures of the coronoid process of the ulna. Journal of Bone and Joint Surgery - Series A. 1989;71.
12. O'Driscoll SW, Jupiter JB, Cohen MS, et al. Difficult elbow fractures: pearls and pitfalls. Instr Course Lect. 2003;52.
13. Li S, Li X, Lu Y. Analysis of radial head and coronoid process fractures in terrible triad of elbow. European Journal of Orthopaedic Surgery and Traumatology. 2019;29.
14. Ring D, Jupiter JB, Zilberfarb J. Posterior dislocation of the elbow with fractures of the radial head and coronoid. Journal of Bone and Joint Surgery. 2002;84.
15. Pugh DMW, Wild LM, Schemitsch EH, et al. Standard surgical protocol to treat elbow dislocations with radial head and coronoid fractures. Journal of Bone and Joint Surgery. 2004;86.
16. Chen HW, Liu GD, Wu LJ. Complications of treating terrible triad injury of the elbow: A systematic review. PLoS One. 2014;9.
17. Babst R, Schraner C, Beeres FJP. Operative treatment of terrible triad injury of the elbow: Open reduction and internal fixation. Oper Orthop Traumatol. 2017;29.
18. Sanchez-Sotelo J, Morrey M. Complex elbow instability: Surgical management of elbow fracture dislocations. EFORT Open Rev. 2016;1.
19. Chemama B, Bonnevialle N, Peter O, et al. Terrible triad injury of the elbow: How to improve outcomes? Orthopaedics and Traumatology: Surgery and Research. 2010;96.
20. Chen NC, Ring D. Terrible triad injuries of the elbow. Journal of Hand Surgery. 2015;40.
21. Ring D, Doornberg JN. Fracture of the anteromedial facet of the coronoid process: Surgical technique. Journal of Bone and Joint Surgery. 2007;89.