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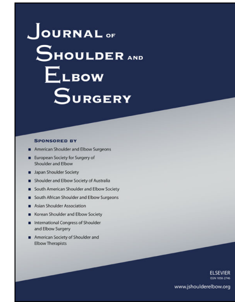

Fracture Patterns, Outcomes, and Complications of Terrible Triad Injury in Elderly Patients

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Fracture Patterns, Outcomes, and Complications of Terrible Triad Injury in Elderly Patients

Run Title: Terrible Triad in the elderly

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1 **Fracture Patterns, Outcomes, and Complications of Terrible Triad Injury in Elderly Patients**

2

3

4 **Abstract**

5

6 **Aims:** The aim of this study was to describe the fracture patterns of terrible triad elbow injury (TTEI)
7 and to evaluate complications, functional and radiographic outcomes in mid-term follow-up in
8 patients older than 65 years.
9 **Methods:** A retrospective study of 29 patients, mean follow-up of 48.7±4.6 months (range 65-78).
10 Fractures were classified according to the Mason and Regan-Morrey classifications. All patients were
11 evaluated by the Mayo Elbow Performance Scale (MEPS), Quick-Dash, EQVAS, EQ5D scores, and
12 ROM measurement.
13 **Results:** The mean age was 72.3 years and 79% were women. Mason Type III (72%) and Reagan-
14 Morrey type II (69%) were the most frequent fracture type. All patients were managed with a lateral
15 approach consisting of repair or replacement of the radial head and repair of the lateral ulnar collateral
16 ligament (LUCL); of these patients, 19 underwent re-attachment of the coronoid process or anterior
17 capsule. Mean functional scores were MEPS 90.3±7.5, Quick-DASH 18.4±4.6, EQ5D .89 ±0.33, EQ-
18 VAS 86.2 ±21, and VAS 2.2 ±1.5. Mean postoperative flexo-extension arc of elbow motion was 105º
19 (range, 65º-145º). Two patients (7%) required revision surgery. We did not observe any joint
20 instability in the elbow after surgery.

21 **Conclusions:** Patients over 65 years old with a terrible triad elbow injury (TTEI) are at substantial
22 risk of complex fracture patterns, particularly Mason type III radial head fractures and Regan-Morrey
23 type II coronoid fractures. Complications such as joint stiffness and heterotopic ossification are
24 infrequent, while associated capitellum fractures are not rare and should be considered in the
25 assessment as they can impact elbow stability. Despite these challenges, surgical management
26 generally achieves favorable functional outcomes with low complication and reoperation rates.

27

28 Level of evidence: Level IV; Case Series; Treatment Study

29

30 **Keywords:** terrible triad; radial fracture; complex dislocation; fracture pattern; complications;
31 coronoid pocess

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34
35 Elbow fractures account for approximately 4.1% of all fractures in the elderly. In this
36 population they usually occur as a result of low-energy mechanisms, such as falls from standing
37 height. These injuries present complex challenges due to insufficient bone quality, comminution,
38 articular fragmentation, and preexisting conditions, such as arthritis [19]. Terrible triad injury of the
39 elbow (TTIE) describes a dislocation of the elbow with associated fractures of the radial head and
40 coronoid process of the ulna. This condition involves all elbow stabilizers (primary and secondary),
41 and as a result surgery is needed in almost all patients with very few carefully selected exceptions.
42 Although clinical outcomes of TTIE have improved after surgical treatment [2,7], the revision
43 surgery rate remains high, mostly due to hardware complications, instability, stiffness, and ulnar
44 nerve lesions [20,26]. Additionally, there is still a lack of consensus on TTIE treatment [4,8] likely due
45 to limited understanding and insufficient foundational research regarding the various injury types and
46 mechanisms of the terrible triad [3,27,22].
47 While extensive literature exists on the terrible triad in general [1, 11, 27], there are no reports
48 that specifically assess the effect of age on fracture pattern, complications, and functional outcomes
49 in the setting of a terrible triad. Given the increasing aging population, investigating the most effective
50 and tailored approaches for this demographic is crucial.
51 The aim of this study was to evaluate radiographic and functional outcomes and complications
52 after surgical treatment of terrible triad in patients older than 65 years to further define the impact of
53 surgical technique, fracture pattern, and concomitant injuries.

54 We hypothesized that patients older than 65 years with a terrible triad elbow injury (TTEI)
55 present complex fracture patterns and a high rate of associated injuries, complications and
56 reinterventions.

57
58 **Material and Methods**

59 After obtaining institutional review board approval, we retrospectively reviewed institutional
60 databases to identify 63 surgically treated TTEI patients, including 31 aged over 65 years. Clinical
61 and radiographic assessments were performed by two independent orthopedic surgeons not involved
62 in patient management. Functional evaluation included the Mayo Elbow Performance Score (MEPS),
63 shortened Disabilities of the Arm, Shoulder, and Hand (QuickDASH) scale, and range of motion
64 (ROM) measurements. Elbow stiffness was graded by residual arc of motion (severe ≤60°, moderate
65 61°-90°) [27]. Quality of life was assessed using EQ5D and EQ-VAS, pain via Visual Analogue Scale
66 (VAS), and medical condition by Charlson Comorbidity Index (CCI).

67 Radiographic assessment included anteroposterior and lateral views of the affected elbow,
68 with fractures classified based on initial radiographs, preoperative CT scans (only present in 23
69 patients), and intraoperative findings using Regan-Morrey and O´Driscoll classification for coronoid
70 fractures and Mason for radial head fractures. Postoperative evaluation covered fracture union,
71 reduction loss, screw complications, assessment of heterotopic ossification (Hasting and Graham
72 classification [12]) and post-traumatic osteoarthritis (Broberg and Morrey classification [6]). For radial
73 head arthroplasty, signs of loosening and stress shielding were monitored. Revision surgery was
74 defined as subsequent procedures related to the index operation.

75

76 *Statistical analysis*

77 The descriptive methods to evaluate the data were the median and the interquartile range. Differences
78 in continuous variables were evaluated with the Student's t-test. Differences in categorical variables
79 were evaluated using the Fisher exact test. Scores were compared by fracture classification and
80 epidemiological data using the Mann-Whitney U or Kruskal-Wallis tests. The level of significance
81 was set at .05.

82

83

84 **Results**

85

86 *Epidemiological data*

87 The initial sample comprised 31 patients aged over 65 years, of whom two were excluded—
88 one due to non-surgical-related death and the other due to loss of follow-up—resulting in a final
89 sample of 29 patients. The mean follow-up to latest functional and radiological assessment was 49±36
90 months (range, 26–73).

91 The mean age was 72.38 years (range 65-81) with 79% females. Trauma mechanism included
92 falls from a standing height in all cases, and none had previous injury to the affected elbow. In 18
93 cases (62%), the affected elbow was the dominant side. Eighty-nine percent were fully independent
94 for activities of daily living. The mean CCI was 3.9 ±2.3. Fracture types included 21 (72%) Mason
95 type III radial head fractures and 20 (69%) Regan-Morrey type 2 coronoid fractures. Of the patients
96 who had preoperative CT scans, 7 had a type I fracture, 10 had a type II fracture, and 6 had a type III fracture
97 according to the O'Driscoll classification of coronoid fractures. Seven patients (24%) had concomitant
98 injuries (one triceps rupture, three capitellum fractures, two olecranon fractures, and one proximal
99 humeral fracture). The three concomitant capitellum fractures were small posterior impaction
100 fractures that did not require fixation. In the cases with an associated olecranon fracture a posterior
101 skin incision was made, through which the reduction and fixation of the olecranon fracture were

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102 performed using tension band wiring. Through a lateral window, prosthetic replacement and
103 reattachment of the lateral ligament complex were carried out, without the need for a medial window
104 in neither case.
105 Epidemiological data are summarized in Table I.
106
107 *Surgical technique*
108 All cases were operated on under general anesthesia in the supine position with the arm placed
109 on a hand table. A tourniquet was used in all cases. The principles of the technique were 1) to restore
110 stability of the coronoid process by means of osteosynthesis if the size of the fragment is above 50%
111 of the coronoid height, or by means of capsular re-anchoring if it was very small or comminuted. This
112 surgical procedure was performed in cases with important preoperative instability (subluxation or
113 complete dislocation of the elbow with ≥ -45º of extension) 2) to restore the stabilizing role of the
114 radial head through osteosynthesis or prosthetic replacement 3) to restore lateral stability by repairing
115 the lateral ligamentous complex and the supinator extensor musculature. Them the hanging arm test
116 was performed to assess stability and if persisted the medial ligamentous complex was repaired
117 through a medial approach. External fixation was used if, despite all the aforementioned, the repair
118 was not stable enough to allow early mobility. All the patients were treated with a single lateral
119 Kocher approach, a separate medial approach was not necessary in any case of the present series
120 because after repairing the lateral complex there weren´t cases of medial instability. In 24 patients
121 (83%), the radial head was treated by implantation of a prosthesis (Ascension MRH - MedcomTech
122 or Radial Head Arthroplasty – DePuy Synthes). Internal fixation of the radial head was performed
123 with screw in 4 cases (14%) (Acutrak headless screws Acumed, Hillsboro, OR, USA and Herbert
124 screws; Zimmer, Warsaw, IN, USA) and excision of a very small fragment from the peripheral area
125 of the radial head that was too small to be fixed was performed in one patient (3%). The anterior
126 capsule and coronoid were re-attached in 19 patients (65.5%), an anchor was employed in 14 cases,
127 and in 5 the coronoid was fixed with a screw.
128 In all the patients, the lateral ulnar collateral ligament (LUCL) was re-attached using an anchor
129 (Figure 1). All elbows were immobilized postoperatively at 90° flexion for a mean of 13 days (range,
130 8-21). Our postoperative protocol includes: early phase (Day 7-14): Hinged brace, passive range of
131 motion (30-90 degrees), and shoulder/wrist exercises. Intermediate phase (Week 2-4): Increase range
132 (20-110 degrees), start supination/pronation, and active-assisted exercises. Advanced phase (Week
133 4-6): Active range (15-130 degrees), isometric strengthening, and light activities. Final phase (Week
134 6-12): Full range (0-140 degrees), isotonic strengthening, and functional use. Prophylaxis against
135 heterotopic ossifications is not employed systematically reserving it for those patients with

136 identifiable risk factors, such as previous history of HO, severe trauma, prolonged immobilization, or
137 neurological injuries.
138
139 *Functional results*
140 The functional results are summarized in Table 2. The average MEPS, Quick Dash, and VAS
141 score were 90.3 points (19 excellent results, 8 good results, and 2 fair results), 18 points (SD 4.6),
142 and 2.2 (SD 1.5) respectively. For ROM, the mean averages were flexion 125° (100°-150°), extension
143 −20° (0° to −45°), pronation 85° (50°-90°), and supination 75° (50°-90°).
144
145 *Radiographic evaluation and complications*
146 No loss of fracture reduction or intraarticular screw perforation was found in patients treated
147 with open reduction and internal fixation of the radial head fracture.
148 Radiographic assessment revealed several findings: five cases of post-traumatic osteoarthritis
149 (Grade 1 Broberg and Morrey), 1 case of asymptomatic Grade IIA heterotopic ossification (Hasting
150 Graham classification). Regarding radial head arthroplasty radiological findings include 4 cases of
151 asymptomatic stress shielding and 2 cases of progressive radiolucent lines, one with clinical
152 symptoms of complete loosening that required RHA removal 8 months post-surgery (Table 2).
153 Another patient experienced severe elbow stiffness, necessitating anterior capsular release and RHA
154 removal. Furthermore, one patient had transient ulnar nerve neuropathy. The overall reoperation rate
155 was 7%, and no residual instability was detected.
156
157
158 **Discussion**
159
160 Challenges arise in addressing elbow injuries among elderly individuals due to factors like
161 compromised bone quality, comminution, articular fragmentation, and preexisting conditions such as
162 arthritis [19].
163 The demographic characteristics of our study population revealed a preponderance of female
164 patients (79%), reflecting a greater propensity for falls among elderly women and the result of
165 fragility fractures secondary to the lower bone mineral density seen in postmenopausal women. The
166 mean age of 72.3 years underscores the advanced age of this cohort, and the exclusive occurrence of
167 falls from a standing height as the trauma mechanism emphasizes the fragility of the elderly
168 population in sustaining such injuries. This advanced age (72 years) could also play a role in the
169 different pattern of the radial head and coronoid fractures present in this study. In most series, the
170 most prevalent radial head fracture in TTEI is Mason Type II, [17-23] and Reagan and Morrey type I

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171 [10, 25, 28] while for others[25] Mason III (54%) and Regan Morey I 50% followed by Regan Morrey II.
172 In the present series the most prevalent radial head fracture was Mason type III, and Reagan and
173 Morrey coronoid fracture type II. We speculate that probably a decrease in the natural reflex action
174 of elbow and arm extension as protection against a fall (delayed in elderly patients) makes many falls
175 likely to occur with the elbow in a semi flexed position instead of outstretched. Previous experiments
176 have suggested that determining whether a coronoid or radial head fracture will occur is based on the
177 degree of elbow flexion, [3] coronoid fractures being more likely to occur in extension while radial
178 head fractures occur with greater elbow flexion. The presence of more complex (Mason Type III)
179 radial head fracture supports this hypothesis and the associated injuries (one triceps rupture, three
180 capitellum fractures, two olecranon fractures), which typically occur due to a fall with the arm at a
181 certain degree of flexion, also suggest this injury mechanism. Additionally, it has been described that
182 sizes of pieces of fractured bones of the coronoid process and the radial head are inversely
183 proportional to the degree of forearm ER [22]. Therefore, due to the presence of larger-than-usual
184 coronoid fractures (type II), we believe that, in addition to a semiflexion position of the elbow, there
185 is a certain component of internal rotation of the arm.

186 As mentioned previously, the most prevalent coronoid fracture in the present study was coronoid type
187 II fracture (more than avulsion but less than 50% of the coronoid height). Reattaching the anterior
188 capsule and coronoid tip fixation have been a subject of debate in coronoid fractures in TTEI with
189 many studies [4-5, 21] concluding that reattaching the anterior capsule or even a type II coronoid fracture
190 yields minimal benefits. However, most of these clinical studies do not take into consideration the
191 extent of the soft tissue injury [5, 9] and only analyze the size of the coronoid fracture fragment. Other
192 authors pointed out that despite its small size, the coronoid process is an important capital bony
193 stabilizer of the humeroulnar articulation and posterior dislocation of the ulna relative to the distal
194 humerus can be adequately reduced by stable fixation of the coronoid, achieving congruent
195 articulation [8, 14, 24]. In elderly patients, poor bone quality makes it very difficult to perform a coronoid
196 synthesis. Drilling, reducing, and obtaining screw purchase can be challenging because of the
197 comminution as a result of the injury or iatrogenically induced after attempted screw fixation. The
198 low number of medial approaches used to reconstruct the medial complex in the present series is
199 likely related to the tension achieved through anterior joint capsule reattachment (present in the 65,5%
200 of the patients). As previously noted by Hou et al[13], this procedure can provide satisfactory stability
201 to the humeroulnar joint by preventing the humerus from disengaging with the trochlea and
202 maintaining the concentric reduction necessary for collateral ligament healing.

203 Previous studies in TTEI support the idea of fixing the coronoid and justify this because of the high
204 presence of postero-medial rotatory instability (PMRI) [(29)] . In the present study, we fixed the coronoid
205 or reattached the anterior capsule of those elbows that were especially unstable in the preoperative
206 exploration (65.5%). The authors observed that TTEI in the elderly often present a high degree of
207 instability, which can be attributed to several factors. One significant factor is the high-grade medial
208 soft tissue injuries associated with comminuted and larger-sized radial head fractures that have been
209 previously described[16].These injuries have been described to extend beyond the lateral ulnar collateral
210 ligament (LUCL) and affect the overlying flexor-pronator teres group resulting in a complete loss of
211 ulnar-side stability due to the loss of both static and dynamic ulnar stabilizers[16]. Additionally, we
212 found in the present study a high association of posterior cartilage capitellum fractures. This is likely
213 due to the more complex injuries to the radial head present in this series. In cases of comminuted,
214 displaced radial head fractures, the frequency of associated cartilage injury of the capitellum can be
215 as high as 25%, compared to the 2% incidence of capitellum injuries in nondisplaced or minimally
216 displaced radial head fractures. In the present series, three cases of posterior cartilage capitellum
217 fractures (10%) were identified, and it is possible that not all were diagnosed, suggesting that the
218 incidence could be higher. It has been described that some patients with posterolateral fracture
219 dislocations of the elbow sustain a posterior impaction fracture of the capitellum, which may
220 compromise elbow stability even after the radial head and ligaments are repaired[(15)].

221 There is concern about anterior capsular reinsertion due to the complication with post-surgical
222 stiffness, however, only one patient in the present series developed stiffness. Additionally, no further
223 incidence of heterotypic ossification was found. In fact, the incidence of heterotopic ossification in
224 the present study was lower than previously published, that is, around 11%, [(25)] a reduced
225 inflammatory response in elderly patients probably plays a role in both processes: the low incidence
226 of stiffness and heterotypic ossification.

227 Our functional results indicate a favorable average MEPS score of 90.3, with most patients achieving
228 excellent outcomes. Stambulic et al in a revision including 43 studies with 1749 elbows [(25)] found, as
229 in the present study, a substantial improvement in outcomes since the injury's original description
230 with an average MEPS score of 90 from 1609 patients. Across the 37 studies, including MEPS scores,
231 all had average scores were reported as good to excellent (MEPS > 75). The average DASH was
232 similar to the present study, a score of 16 from 441 elbows and therefore suggesting good functional
233 outcomes in activities of daily living after surgical treatment. Regarding patient-reported outcomes
234 (PROs), the present study demonstrates that although there is a mild loss of extension (20º), the
235 perceived quality of life is quite good (EQ-VAS: 86.2).

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236 Complications were infrequent, with no residual instability noted. A previous review reported an
237 overall complication rate (including radiographic heterotopic ossification) around 30% [(25)]. The
238 overall reoperation rate of the present series (6%) contrasts with previous series with higher
239 reoperation rates 45% [(20)]. Perhaps the low functional demands of elderly patients also play a role in
240 this aspect.

241

242 *Limitation of the study*

243 The retrospective design, with its inherent biases, and the small sample size are the primary
244 limitations of this study. While a prospective recruitment approach would have been ideal, the low
245 incidence of TTEI in elderly patients would have extended the recruitment period significantly. The
246 absence of randomization is another source of bias; however, the surgeons always guided their
247 decisions about treatment using the same criteria. Another important limitation is that not all the
248 patients had a preoperative or postoperative CT scan witch difficult the O´Driscoll classification
249 employment and the assessment of the coronoid union.

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250 Conclusion

251 Patients over 65 years old with a terrible triad elbow injury (TTEI) are at substantial risk of complex
252 fracture patterns, particularly Mason type III radial head fractures and Regan-Morrey type II coronoid
253 fractures. Complications such as joint stiffness and heterotopic ossification are infrequent, while
254 associated capitellum fractures are not rare and should be considered in the assessment as they can
255 impact elbow stability. Despite these challenges, surgical management generally achieves favorable
256 functional outcomes with low complication and reoperation rates.

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368 **Figure 1.** Terrible triad in a 76-year-old woman. (a) Lateral x-ray view of the injury. (b)
369 Anteroposterior and lateral intraoperative fluoroscopy showing the radial head prosthesis,
370 reattachment of the anterior capsule and the lateral collateral ligament using anchors. (c) Mobility
371 achieved after 6 months.

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Table 1 Patients demographics	
Patients (n)	29
Follow up *(months)*	49± 36
Age*, yr*	72.3 (range 65-81 years)
Sex, *male/female*	6 (21%) / 23 (79%)
Side, *dominant / nondominant*	18 (62%) / 11 (38%)
Trauma mechanism *Fall, low energy*	29 (100%)
Independent (ADL)	26 (89%)
CCI *mean ± SD*	3.9± 2.3
Radial head fracture Mason I Mason II Mason III Radial neck fracture	 0 (0%) 4 (14%) 21 (72%) 4 (14%)
Coronoid fracture Reagan Type I Reagan Type II Reagan Type III	 8 (27%) 20 (69%) 1 (3%)
Associated fractures Triceps rupture Capitellum fracture Olecranon fracture Proximal Humerus fracture	7 (24%) 1 (3.4%) 3 (10%) 2 (7%) 1 (3.4%)
LCL repair MCL repair	100% 0%

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ADL, activities of daily living; CCI, Charlson Comorbidity Index; SD, standard deviation.
Data are presented as “number of patients (percentage)”, unless otherwise indicated

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Table 2- Functional and radiographic outcomes at last follow-up

Functional evaluation	
MEPS *(max, 100 points)*	90.3 ± 7.5
QUICKDASH *(max, 0 points)*	18 ± 4.6
EQ-VAS *(max, 100)*	86.2 ± 21
EQ 5D (*max* 1)	.89± .33
VAS *(max, 10)*	2.2± 1.5
Elbow ROM	
Flexion, º	125º (100º-150º)
Extension, º	-20º (0º-45º)
Supination, º	75º (50º-90º)
Pronation, º	85º(50º-90º)
Mean flexion-extension motion arc	105º (65º-145º)
Mean pronation-supination motion arc	165º ± 5º (20º-180º)
Radiographic evaluation	
Post-traumatic OA	5 (17%)
Heterotopic ossification	1 (3.4%)
Stress shielding RHA	4 (13.8%)
Progressive radiolucent lines	2 (6.9%)
Ulnar nerve neuropathy	1 (3.4%)
Revision surgery	2 (7 %)
RHA implant loosening	1 (3.4%)
Elbow stiffness	1 (3.4%)

EQ-VAS: Quality of life visual analog scale, MEPS: Mayo Elbow Performance Score, ROM: Range of Motion; VAS: visual analogue scale.
Score in functional scales is presented as mean ± SD
ROM is presented in grades
OA: Osteoarthritis
RHA: Radial head arthroplasty

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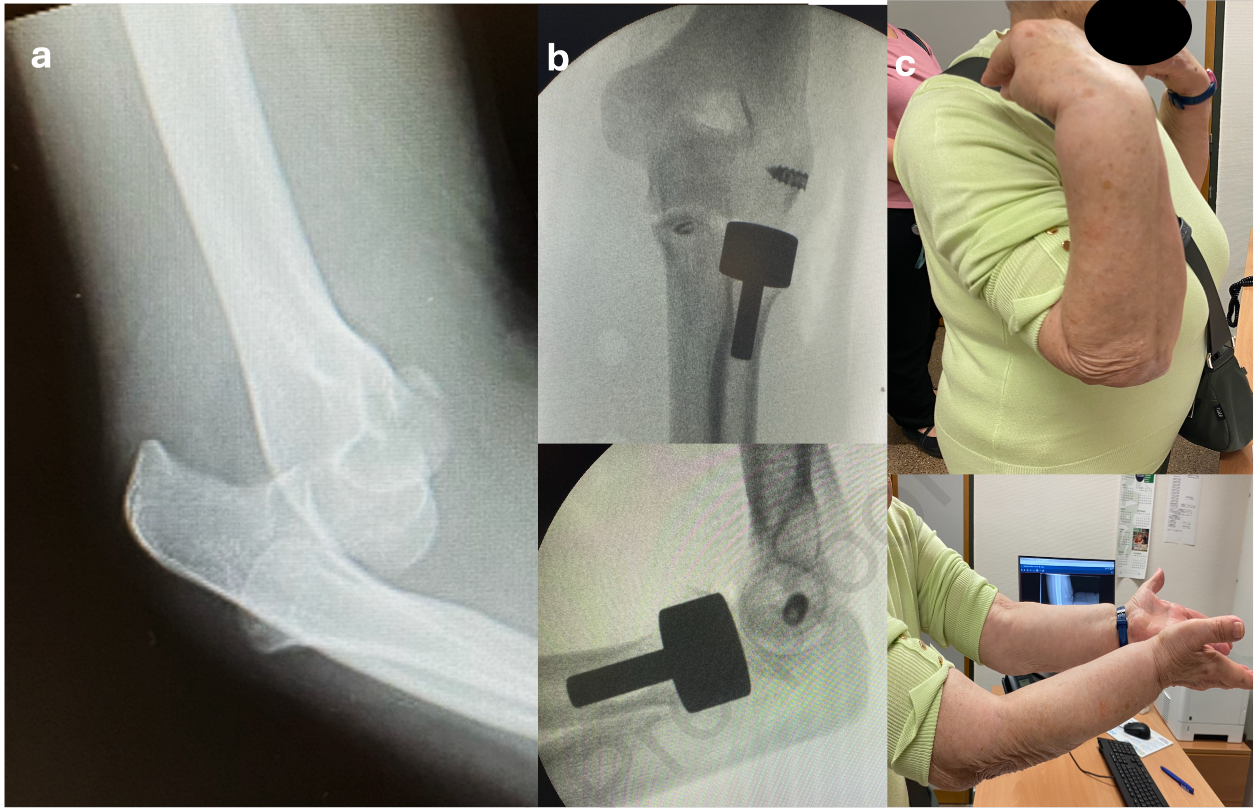

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