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Published in:

Injury-International Journal of the Care of the Injured

Publication status and date:

Published: 01/01/2013

DOI (link to publisher):

[10.1016/j.injury.2012.08.003](https://doi.org/10.1016/j.injury.2012.08.003)

Document Version

Publisher's PDF, also known as Version of record

Citation for the published version (APA):

Mahabier, K., Vogels, LMM., Punt, BJ., Roukema, GR., Patka, P., & Van Lieshout, E. M. M. (2013). Humeral shaft fractures: Retrospective results of non-operative and operative treatment of 186 patients. *Injury-International Journal of the Care of the Injured*, 44(4), 427-430. <https://doi.org/10.1016/j.injury.2012.08.003>

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1 **Humeral shaft fractures: retrospective results of non-operative and operative**
2 **treatment of 186 patients**

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5
6 **Running title:** Outcome after treatment of humeral shaft fractures

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21
22 **Keywords:** Humeral shaft fracture; Treatment; Operative; Non-operative; Consolidation time;

23 Radial nerve palsy; Delayed union; Complications

24 **ABSTRACT**

25

26 **Background:** Humeral shaft fractures account for 1-3% of all fractures and 20 % of the fractures
27 involving the humerus. The aim of the current study was to compare the outcome after operative
28 and non-operative treatment of humeral shaft fractures, by comparing the time to radiological
29 union and the rates of delayed union and complications.

30 **Methods:** All patients aged 16 years or over treated for a humeral shaft fracture during a five-
31 year period were included in this retrospective analysis; periprosthetic and pathological fractures
32 were excluded. Radiographs and medical charts were retrieved and reviewed in order to collect
33 data on fracture classification, time to radiographic consolidation and the occurrence of adverse
34 events.

35 **Results:** A total of 186 patients were included; 91 were treated non-operatively and 95 treated
36 operatively. Mean age was 58.7 ± 1.5 years and 57.0% were female. In 83.3% of the patients
37 only the humerus was affected. A fall from standing height was the most common cause of the
38 fracture (72.0%). Consolidation time varied from a median of 11 to 28 weeks. The rate of radial
39 nerve palsy in both groups was similar; 8.8% versus 9.5%. In 5.3% of the operatively treated
40 patients the palsy resulted from the operation. Likewise, delayed union rates were similar in both
41 groups; 18.7% following non-operative treatment versus 18.9% following surgery.

42 **Conclusion:** The data indicated that consolidation time and complication rates were similar after
43 operative and non-operative treatment. A prospective randomized clinical trial comparing non-
44 operative with operative treatment is needed in order to examine other aspects of outcome,
45 meaning shoulder and elbow function, post-operative infection rates, trauma related quality of
46 life and patient satisfaction.

47

48 **INTRODUCTION**

49

50 Fractures of the shaft of the humerus account for 1-3% of all fractures¹ and approximately 20%
51 of all fractures involving the humerus.² The incidence is 14.5 per 100,000 per year, gradually
52 increasing from the fifth decade and reaching its peak of 60 per 100,000 per year in the ninth
53 decade. Also a minor peak is seen in the third decade.^{1,3}

54 Both operative and non-operative treatment is used in the management of humeral shaft
55 fractures. Traditionally, the treatment has generally been non-operative, nowadays using the
56 Sarmiento brace as functional bracing therapy.⁴ Operative approaches include intramedullary
57 nailing, plate osteosynthesis and an external fixation.⁵

58 Both non-operative and operative treatment strategies have their pros and cons. Although
59 functional treatment is believed to be associated with a very low rate of delayed union and
60 excellent functional results,⁶ in certain groups of patients functional bracing does not provide
61 sufficient immobilization. For instance, non-operative treatment in overweight patients result in a
62 high rate of delayed union.⁷

63 There is substantial controversy on the best approach of humeral shaft fractures. Kocht et
64 al. for example stated that though newer intramedullary techniques are probably less invasive
65 and technically less complicated, the Sarmiento brace remains the gold standard and first
66 treatment of choice.⁸ Schratz et al. on the contrary favors intramedullary nailing.⁹ Schittko et al.
67 claimed that the operative therapy should be considered as the gold standard because of the
68 development of new intramedullary and rotation stable implants in addition to the classical
69 osteosynthesis using a plate.⁵

70 So the best treatment is still at debate and the type of treatment highly depends on the
71 physician's personal view. The current literature lacks an answer to the question whether
72 operative or non-operative treatment results in different clinical outcomes The aim of the current
73 study was to compare the outcome after operative versus non-operative treatment of humeral
74 shaft fractures, by comparing the time to radiological union and the rates of delayed union and
75 complications.

76

77 **PATIENTS AND METHODS**

78

79 All patients aged sixteen years or over treated for a humeral shaft fracture in the Erasmus MC
80 (Rotterdam, the Netherlands) between January 2002 and December 2006, the Albert Schweitzer
81 Hospital (Dordrecht, the Netherlands) between January 2003 and December 2007, and the
82 Maastad Hospital (Rotterdam, the Netherlands) between January 2004 and December 2008
83 were included in this retrospective analysis. Periprosthetic and pathological fractures were
84 excluded.

85 The patients were identified from the radiology program PACS (Picture Archiving and
86 Communication System). Reports of all radiographs of the upper arm, including the shoulder and
87 elbow, were searched using ‘Humerus’ AND ‘Fracture’ as search terms. Eligible patients with
88 humeral shaft fractures were further identified by reading all radiology reports and reviewing all
89 radiographs.

90 Humeral shaft fractures were defined as the area between the surgical neck and the area
91 immediately above the supracondylar ridge. All fractures were classified using the AO-system¹⁰
92 by reviewing the radiographs (K.C.M.).

93 Information about the affected side, the consolidation period, and presence of a delayed
94 union were collected from the radiographs, radiology reports and the patient’s hospital records.
95 Radiological consolidation was defined as cortical bridging of at least three out of four cortices
96 and was expressed in weeks from the day of the fracture. Delayed union was defined as a failure
97 to heal at twenty-four weeks post fracture with no progress toward healing seen on the most
98 recent radiographs.¹¹

99 The medical charts of all patients were reviewed and the following items were retrieved:
100 age, gender, trauma mechanism, other injuries besides the humeral shaft fracture, type of
101 treatment and radial nerve palsy. The type of treatment was non-operative or operative. The
102 decision between the two was made by the attending physician at each hospital and was based
103 upon the surgeon's best judgment, knowledge and expertise.

104 The trauma mechanism was classified as a simple fall, meaning a fall from persons
105 height, high-energetic (e.g., a traffic-related accident) or 'other'.

106 Data were analyzed using the Statistical Package for the Social Sciences (SPSS) version
107 16.0 for Windows. Outcome after operative and non-operative treatment was compared. Results
108 of categorical variables (gender, AO-types and subtypes, delayed-union, radial nerve palsy,
109 injuries, and trauma mechanism) were analyzed using Chi-square test. Results of numerical
110 variables (age and consolidation time) were analyzed using the Mann-Whitney U-test. All tests
111 were two sided. P-values < 0.05 were considered statistically significant.

112

113 **RESULTS**

114

115 In total 186 patients were included in this study. Table 1 shows the demographic data of this
116 cohort for the patients in this study. Ninety one patients had been treated non-operatively. The
117 majority was female (60.4%) and the mean age was 58.7 ± 1.5 years. The operatively treated
118 group consists of 95 patients, 53.7% was female, with a median age of 61.1 years. No
119 statistically significant difference could be found with respect to this data between the groups.

120 In the non-operatively treated group the left humerus was affected in 51.6% of patients,
121 which was not statistically different from the operative group (62.2%). In 83.3% of the patients
122 the humeral shaft injury was a solitary injury, and in 72% of patients the fracture resulted after a
123 simple fall. No statistical difference was found between both groups. In the operative group
124 82.1% of the patients were treated using intramedullary nailing, 11.6% using plate
125 osteosynthesis, 5.3% using external fixation and in 1 (1.1%) patient only Cerclage wires were
126 used.

127 Figure 1 shows a detailed overview of fractures by AO subgroups. This shows type A
128 humeral shaft fractures were found most frequently (50.0% of the patients) and type C was least
129 common (8.1% of the patients). In the non-operatively treated group the A1 spiral fracture was
130 the most common subtype (28.6%) and in the operatively treated group the A3 transverse
131 fracture (26.3%).

132 Table 2 shows the time it took to achieve radiological consolidation in weeks from the
133 day of the fracture per AO type and subtype. In the non-operatively treated group the time to
134 achieve radiological consolidation ranged from a median of 11 weeks in the AO type A2
135 subgroup to 15 weeks in the B2 and A3 subgroups. In the operative group, time to consolidation

136 ranged from a median of 12 weeks (A2 subtype) to 28 weeks (B3 subtype), which did not differ
137 statistically from the non-operative group.

138 Overall, 17 of the patients (9.1%) developed radial nerve palsy (Table 4). No statistically
139 significant difference was found between the two groups. In the non-operatively treated group
140 this originated from the trauma or fractures itself in eight patients. In the operatively treated
141 group, radial nerve palsy originated from the trauma or fracture in 13 patients. In 4 patients it
142 occurred after surgery.

143 Delayed union occurred in 18.8% of the patients, *i.e.*, in 18 patients treated non-
144 operatively and in 18 patients treated operatively ($p>0.05$; 14 treated with intramedullary nailing,
145 two with plate osteosynthesis, one with an external fixator and one with cerclage wires).

146

147 **DISCUSSION**

148

149 The aim of the current retrospective study was to compare the outcome after operative versus
150 non-operative treatment of humeral shaft fractures, by comparing the the time to radiological
151 union and the rates of delayed union and complications. In this series of 186 patients, no
152 statistically significant differences were found in the time to radiological consolidation between
153 the two groups, nor in the rates of delayed union or occurrence of radial nerve palsy.

154 The demographic data of the current study are to a large extent in agreement with
155 published epidemiologic studies on humeral shaft fractures.^{1, 3} In the most recent epidemiologic
156 study the average age of patients with a humeral shaft fracture was 62.7 years,¹ the average age
157 of the patients in our study was 58.7 years..

158 Data from previous studies showed delayed union rates of 2-23%¹²⁻¹³ after non-operative
159 treatment versus 15-30%¹⁴ for operatively treated patients. Data of the current study (18.7%
160 versus 18.9%, respectively) are consistent with the literature data. Increased delayed union rates
161 as suggested previously¹⁵ could not be confirmed in the current study.

162 Due to the high variability in fracture subtypes, our study lacked adequate statistical
163 power to show statistically significant difference in time to radiographic healing between both
164 groups. For the B3 type fractures, a trend was seen, suggesting that the time to radiographic
165 healing was shorter in the non-operative group (median 12 weeks) than in the operative group
166 (median 28 weeks).

167 In the current study 9.1% of the patients had radial nerve palsy. Rates between 2 and 17%
168 are described of in the literature¹⁶, but a review by Shao et. al reported an average rate of
169 11.8%.¹⁷ Even though primary radial nerve palsy is considered by many an absolute indication

170 for surgery⁵ the data of our study do not support this, as radial nerve palsies occurred equally
171 frequent in both groups. In the operatively treated group less radial nerve palsies were seen as a
172 result of the fracture or the trauma (8.8 vs 5.3%). Spontaneous recovery is seen in 70.7% of the
173 patients treated conservatively for the palsy, and after including surgical management the overall
174 recovery rate is 88.1% as reported by Shao et al.

175 The retrospective nature and the lack of randomization was a limitation of our study. The
176 decision between operative and non-operative treatment was made by the attending surgeon,
177 based upon his preferences and previous experience. Given the low and similar rates of delayed
178 union in both groups, it is tempting to speculate that the surgeons were quite good at identifying
179 which fractures should be operated. Whether or not this is true should be studied in more detail.

180 Data on other essential aspects of outcome were unavailable. Possible residual deformity
181 of the arm or impaired function could be a disadvantage of non-operative treatment compared
182 with operative treatment. Rotational or axial malalignment up to 20–25 degrees and shortening
183 less than 2 cm are regarded as acceptable following non-operative treatment.^{13, 18-19} Surgery
184 could improve the alignment of the fracture site; but is unclear at this moment if improved
185 alignment also results in better functional outcome. As a disadvantage of surgery shoulder
186 impairment is often mentioned, though impaired shoulder function may also occur following
187 non-operative treatment.²⁰ Moreover, infections after surgery, the time and ability to full
188 resumption of activities of daily living, and patient satisfaction with the outcome are all
189 important factors that should be taken into consideration in the treatment of humeral shaft
190 fractures.

191

192 **CONCLUSION**

193

194 In conclusion, the current study revealed similar time to consolidation and rates of delayed union
195 and radial nerve palsy after non-operative and operative treatment of humeral shaft fractures. A
196 randomized clinical trial comparing non-operative with operative treatment is needed in order to
197 examine all aspects of outcome, taking into account consolidation time, delayed union and radial
198 nerve palsy rates as well as the shoulder and elbow function, pain, post-operative infection rates,
199 numbers of patients returning to their previous work and residual deformity.

200

201

202 **CONFLICT OF INTEREST STATEMENT**

203

204 The authors state that no conflicts of interest, financially or otherwise, exist.

205

206

207 **FUNDING SOURCE**

208

209 No funding was obtained for this study

210

211 **REFERENCES**

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- 256
- 257

258 **TABLES AND FIGURES**

259

260 **Table 1: Characteristics of the study population by type of treatment**

261

	Overall	Non-operative	Operative	P-value
	(N=186)	(N=91)	(N=95)	
Female¹	106 (57.0)	55 (60.4)	51 (53.7)	0.377 ⁺
Age² (year)	60.8 (44.2-76.5)	60.6 (45.7-77.7)	61.1 (39.7-74.7)	0.424 ⁺⁺
Left side affected¹	106 (57.0)	47 (51.6)	59 (62.1)	0.183 ⁺
Concomitant injuries:				0.092 ⁺
Monotrauma¹	155 (83.3)	79 (86.8)	76 (80.0)	
Polytrauma¹	29 (15.6)	10 (11.0)	19 (20.0)	
Unkown¹	2 (1.1)	2 (2.2)	0 (0.0)	
Trauma mechanism:				0.147 ⁺
Simple fall¹	134 (72.0)	69 (75.8)	65 (68.4)	
High energy¹	32 (17.2)	10 (11.0)	22 (23.2)	
Other¹	13 (7.0)	8 (8.8)	5 (5.3)	
Unknown¹	7 (3.8)	4 (4.4)	3 (3.2)	

262

263 ⁺ Pearson Chi-square test, ⁺⁺Mann-Whitney U-test264 Data are shown as ¹ number of patients with the percentages given within brackets, or as ²

265 median with the first and third quartile given within brackets.

266

267 **Table 2: Consolidation time in weeks from day of humeral shaft fracture per AO type and**
 268 **subtypes by type of treatment**

269

	Overall	Non-operative	Operative	P-value
A all	14 (11-18)	13 (8-18)	14 (11-19)	0.169
A1	14 (10-18)	13 (9-18)	16 (11-18)	0.381
A2	11 (8-13)	11 (6-13)	12 (10-20)	0.221
A3	15 (12-22)	15 (11-22)	14 (12-23)	0.890
B all	15 (12-22)	14 (11-21)	17 (13-23)	0.166
B1	16 (12-21)	14 (9-18)	18 (14-23)	0.065
B2	15 (12-21)	15 (14-26)	14 (11-20)	0.173
B3	22 (12-31)	12 (9-22)	28 (23-34)	0.034
C all	22 (16-24)	No data	22 (16-24)	N.A.
C1	20 (16-24)	No data	20 (16-24)	N.A.
C2	No data	No data	No data	N.A.
C3	22 (22-22)	No data	22 (22-22)	N.A.

270

271 Data are shown as median with the first and third quartile given within brackets. P-values were
 272 calculated with the Mann-Whitney U-test.

273 N.A., not applicable.

274

275 **Table 3: Origin of radial nerve palsy and delayed union in patients with humeral shaft**
 276 **fractures by type of treatment**

277

	Overall	Non-operative	Operative	P-value
Radial nerve palsy				
Trauma/fracture	13 (7.0)	8 (8.8)	5 (5.3)	
Surgery	4 (2.2)	N.A.	4 (4.2)	
Total	17 (9.1)	8 (8.8)	9 (9.5)	0.053
Delayed union	35 (18.8)	18 (18.7)	18 (18.9)	0.580

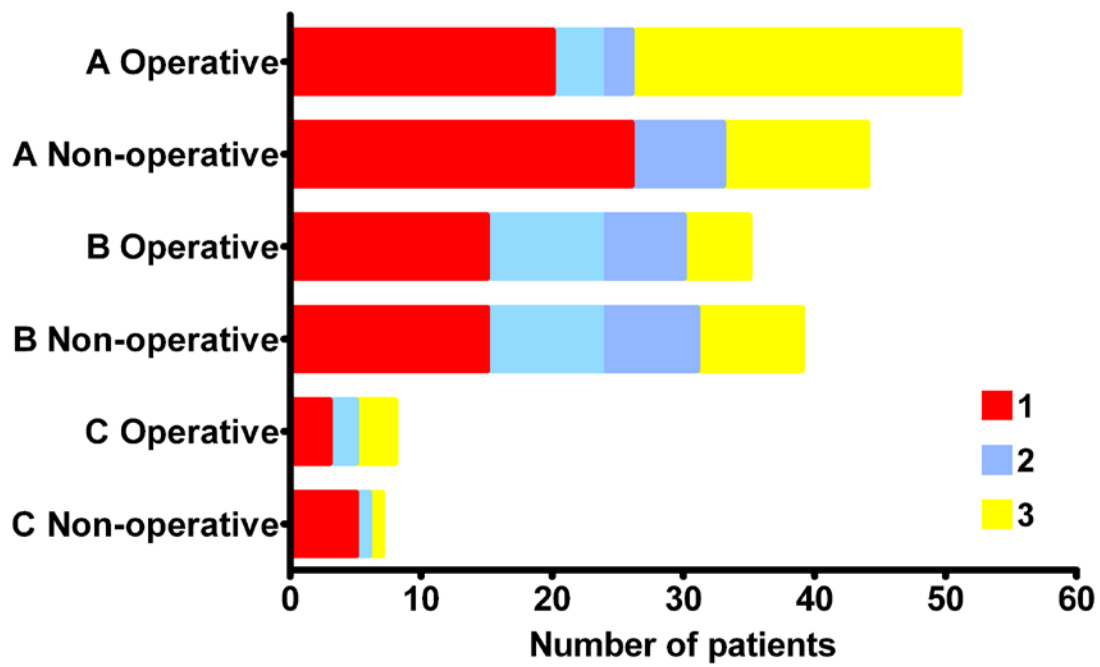
278

279 Patient numbers are displayed, with the percentages given within brackets. P-values were

280 calculated with the Pearson Chi-square test.

281 N.A., not applicable.

282



283

284 **Figure 1: Distribution of the humeral shaft fractures into AO types and subtypes by type of**

285 **treatment**