

Title:

Scapula Fractures: Interobserver Reliability of Classification and Treatment

Short Title: Reliability of Scapula Fracture Classification

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Conflicts of Interest and Source of Funding:

VN has received a grant from the Bangerter Foundation Switzerland.

AB has received grants from VSB fonds, Beurs Prins Bernhard Cultuur fonds, beurs/Banning-de Jong fonds, Stichting Anna fonds, the Netherlands

TG had no conflicts of interest.

DCR has no conflicts related to this research.

IRB approval/Research Ethics Committee:

IRB approved, Protocol #: 2009-P-001019/89; MGH

The Science of Variation Group authorship:

See Supplemental Digital Content 1.

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1 **Abstract:**

2 Objectives: There is substantial variation in the classification and the management of
3 scapula fractures. The first purpose of this study was to analyze the interobserver
4 reliability of the OTA/AO and the New International Classification of scapula fractures.
5 The second purpose was to assess the proportion of agreement among orthopaedic
6 surgeons on operative or nonoperative treatment.

7 Design: Web-based reliability study

8 Setting: Independent orthopaedic surgeons from several countries were invited to classify
9 scapular fractures in an online survey.

10 Participants: One-hundred and three orthopaedic surgeons evaluated 35 movies of 3DCT-
11 reconstruction of selected scapular fractures, representing a full spectrum of fracture
12 patterns.

13 Main Outcome Measurements: Fleiss' kappa (κ) was used to assess the reliability of
14 agreement between the surgeons.

15 Results: The overall agreement on the OTA/AO Classification was moderate for the types
16 (A, B, and C, $\kappa = 0.54$) with a 71% proportion of rater agreement (PA) as well as for the
17 nine groups (A1 to C3, $\kappa = 0.47$) with a 57% PA. For the New International
18 Classification, the agreement about the intra-articular extension of the fracture (Fossa (F),
19 $\kappa = 0.79$) was substantial, the agreement about a fractured body (Body (B), $\kappa = 0.57$) or
20 process was moderate (Process (P), $\kappa = 0.53$), however PAs were more than 81%. The
21 agreement on the treatment recommendation was moderate ($\kappa = 0.57$) with a 73% PA.

22 Conclusions: The New International Classification was more reliable. Body and process
23 fractures generated more disagreement than intra-articular fractures and need further clear
24 definitions.

25 Key words: OTA/AO Fracture Classification; New International Classification for
26 Scapular Fractures; Reliability; Scapula

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27 **Introduction**

28 Our traditional complacency with fractures of the shoulder girdle was altered by recent
29 data showing that operative treatment of displaced clavicle fractures reduces the risk of
30 nonunion and pain as well as improves functional results.¹⁻³ Now, some are suggesting
31 that more frequent operative treatment of scapula fractures should be considered.⁴⁻⁹ The
32 indications for surgery are not clearly defined and the role of classification schemes is
33 uncertain. A New International Classification for Scapular Fractures was recently
34 developed by a study group of 6 orthopaedic trauma surgeons hoping to develop a better
35 fracture classification system and later to clarify the prognostic value of it for indications
36 for operative treatment.¹⁰

37

38 This study sought to compare the OTA/AO classification with the New International
39 Classification for Scapular Fractures. Our primary study aim was to measure the
40 reliability of the OTA/AO classification and the New International Classification of
41 Scapula Fractures. The second aim was to evaluate the agreement on operative treatment.

42

43 **Patients and Methods**

44 *Study Design*

45 Orthopaedic surgeons from 25 countries participating in the Science of Variation Group
46 (SOVG), a web-based collaborative of experienced orthopaedic surgeons, were invited to
47 evaluate and rate 35 movies of 3DCT-reconstruction of scapular fractures in an online
48 survey in May and June 2012.¹¹ The movies were presented online in a random order and
49 were assessed independently by the raters. A description of the OTA/AO¹² classification

50 and the New International Classification¹⁰ was provided for each movie. No other
51 information (additional injuries, treatment, outcome) was made available. The raters were
52 asked to classify the presented scapular fractures (OTA/AO and the New International
53 Classification) and to propose operative or nonoperative treatment in young, active, and
54 healthy patients. There was no time limit to complete the questionnaire.

55

56 *Raters*

57 One-hundred sixty eight of the 802 invited surgeons (21%) agreed to participate in the
58 study (a large percentage of our collaborative do not treat scapula fractures) and 103
59 (61%) completed all questions (Table 1). They were not involved in the treatment of the
60 patients presented in this study cohort and did not receive any incentives other than an
61 acknowledgement in this paper.

62

63 *Fractures*

64 Under IRB-approval a total of 457 scapular fractures were identified from a prospectively
65 collected trauma database (from 2002 to 2011) at two level-1 trauma centers. Inclusion
66 criteria were 1) adult patients (≥ 18 years) and 2) adequate quality (slice thickness
67 ≤ 2.5 mm) and completeness of CTs for 3D-reconstruction, leaving a cohort of 225
68 suitable fractures. Thirty-five fractures were selected with complete, high-quality CTs
69 and representing a full spectrum of scapular fracture patterns. Sex, age, side, concomitant
70 injuries, Injury Severity Score (ISS), radiological measurements (intra-articular step-off,
71 medialization, translation, angulation, glenopolar angle, presence of a double disruption
72 of the superior shoulder suspensory complex (SSSC)), and the received treatment (either

73 operative or non-operative) were independently of the surgeons' ratings recorded for
74 readers information (Appendix(See Appendix, See Supplemental Digital Content 1,
75 <http://links.lww.com/BOT/A85>)). The radiographic measurements were done with the
76 Aquarius workstation (Version 4.4.6; TeraRecon Inc., San Mateo, CA) for one and with
77 the Centricity software (GE Healthcare, Little Chalfont, Buckinghamshire, U.K.) for the
78 other institution by an independent experienced orthopaedic surgeon. The movies were
79 created with Osirix¹³ (OsiriX Foundation / Pixmeo, Geneva, Switzerland) and were
80 rotating (360 degrees around a vertical axis with a duration of 10 seconds) 3DCT
81 reconstructions of the whole scapula with humerus and clavicle subtracted. The raters
82 could replay the videos as needed.

83

84 *Statistical analysis*

85 For each fracture the most commonly proposed answers and the proportion of agreement
86 (in percentage, PA) were presented and analyzed. The multirater agreement of the
87 nominal variables (OTA/AO classification; the New International Classification;
88 recommended treatment) were calculated with the Fleiss' generalized Kappa^{14, 15}, which
89 is a statistical chance-corrected measure for assessing multirater agreement with binary or
90 nominal ratings. The calculated measures are presented as a value between 0 and 1 and
91 are called Kappa value. They were interpreted in accordance to the guidelines by Landis
92 and Koch¹⁶: 0.01 through 0.20 represent slight agreement, 0.21 to 0.40 fair agreement,
93 0.41 to 0.60 moderate agreement, 0.61 to 0.80 substantial agreement, and above 0.81 is
94 considered almost perfect agreement. In another study a value of 0.70 was considered an
95 adequate sign of reliability.¹⁷

96

97 *Sources of Funding*

98 No funding was received in direct support of this study. No authors have any connections
99 to either of the classification systems.

100

101 **Results**102 *OTA/AO Classification (Table 2)*

103 The proportion of the most proposed AO group of all answers varied between 26% and
104 99% for the 35 cases. The most proposed AO group was A3 in 13 fractures, C3 in 10
105 fractures, B1 in 3 fractures, C2 in 3 fractures, and other groups in 6 fractures. The overall
106 agreement on the OTA/AO Classification was moderate for the three types of fracture (κ
107 = 0.54) with a 71% PA as well as for the nine groups of fracture (κ = 0.47) with a 57%
108 PA. There was a higher agreement on type A fractures (κ = 0.72), and a lower one on
109 type C (κ = 0.46) and B (κ = 0.37) fractures. While the agreements on the groups A1 (κ =
110 0.77), A3 (κ = 0.74), and A2 (κ = 0.65) were highest, they were lowest for the C1 (κ =
111 0.25), C2 (κ = 0.20), and B2 (κ = 0.02) fractures. Most disagreements were between B1
112 (Anterior rim fracture), C2 (Intra-articular fracture with neck), and A2 (Coracoid
113 fracture). For example, 41% of the raters classified the fracture 11 (Figure 1) as an AO
114 type B1 (Partial articular; Anterior rim fracture), 28% as an A2 (Extra-articular coracoid
115 fracture), and 19% as a C2 (Intra-articular fracture with neck). Another point of
116 disagreement was between C2 (Intra-articular fracture with neck) and C3 (Intra-articular
117 fracture with body) in certain circumstances (Figure 2). The years of practice did not

118 affect the degree of overall agreement. Shoulder surgeons were more likely to agree on
119 the OTA/AO classification.

120

121 *The New International Classification (Table 3)*

122 Agreement about the intra-articular extension of the fracture was substantial ($\kappa = 0.79$,
123 PA 90%), and for shoulder and hand surgeons almost perfect ($\kappa = 0.83$ and $\kappa = 0.80$,
124 respectively). The agreement about a fractured body ($\kappa = 0.57$, PA 82%) or process was
125 moderate ($\kappa = 0.53$, PA 80%). Another source of disagreement was fracture of the
126 glenoid neck (Figure 3), which was less of a problem with the OTA/AO Classification.
127 The further in-depth classification showed a fair agreement for body fractures (B1, B2, or
128 B not applicable; $\kappa = 0.35$, PA 58%) and a moderate agreement on fractures involving the
129 fossa (F0, F1, F2, or F not applicable; $\kappa = 0.59$, PA 74%) as well as process fractures (P1,
130 P2, P3, or P not applicable; $\kappa = 0.46$, PA 73%).

131

132 *Recommended Treatment (Table 4)*

133 Nonoperative treatment was most often recommended in 21 and operative treatment in 14
134 fractures. The agreement was moderate ($\kappa = 0.57$) with an average PA of 73%, ranging
135 from 52% to 98% with similar agreement for operative as well as nonoperative
136 recommendations. More experienced doctors were less likely to recommend operative
137 treatment. The specialization did not affect the treatment recommendation.

138

139 **Discussion**

140 We found moderate overall agreement regarding classification of scapular fractures,
141 better for articular than for body or process involvement. The average proportion of
142 observers agreeing with the most popular treatment recommendation was 73%.

143

144 Readers should consider several limitations. The data may not be valid outside the group
145 of surgeons that participate in the SOVG although we feel the large number of surgeons
146 of various specialties and countries improves external validity beyond that of the typical
147 reliability study. Nearly 40% of the participating surgeons did not answer all questions,
148 which may have influenced our results. We did not measure the time surgeons spent
149 looking at the movies, which could also correlate with agreement. In trying to present as
150 many different fracture patterns as possible, we may have introduced a spectrum bias. For
151 instance, intra-articular fractures were overrepresented.¹⁷ However, an overpresentation
152 of intra-articular fractures can rather positively contribute to the study as these fractures
153 have more impact on the treatment decision and outcome. Other downsides were that
154 surgeons could not rotate the 3D models to their needs and OSIRIX may have affected
155 the image resolution and consequently the interpretation of the fracture patterns by
156 rendering issues. However, all surgeons had the same kind of movies to interpret, which
157 equalizes these problems. And last there was no way to assess accuracy as there is no
158 gold standard / reference classification.

159

160 The OTA/AO classification distinguishes extra-articular (type A), partial articular (type
161 B), and complete articular (type C) fractures. While the agreement for type A scapula
162 fractures was substantial, the agreement about type B and C was moderate or even fair for

163 some subgroups. In comparison, the overall agreement for diaphyseal fractures was
164 higher in one recent study and the level of experience and specialization did not affect
165 their results.¹⁸ In our study, shoulder specialists had the best agreement. Perhaps an in-
166 depth knowledge and greater familiarity with complex scapular anatomy and injuries may
167 contribute to better understanding and classification of the fractures. Level of training is
168 often associated with greater reliability when surgeons in training are observers¹⁹, but
169 level of experience did not affect agreement in our study of fully trained surgeons. The
170 lesser experience of younger surgeons may be balanced by their greater familiarity with
171 3DCTs and greater reliance on the definitions.¹¹

172
173 The New International Classification of Scapula Fractures distinguishes fractures
174 extending into the body, fossa, or processes. This classification had almost perfect
175 agreement if the fracture lines extend into the glenoid fossa and moderate agreement on
176 body and process fractures. In comparison, the expert panel in the development study¹⁰
177 had comparable agreement on intra-articular ($\kappa = 0.78$) but a clearly higher agreement on
178 process ($\kappa = 0.61$) or body fractures ($\kappa = 0.75$), which may indicate that their intensive
179 dispute and training about scapula fracture classification and their knowledge about the
180 definitions improved their agreement. This new classification helped us to better
181 understand the reasons for disagreement of the raters with the OTA/AO classification.

182
183 Some surgeons advocate more frequent operative treatment of scapula fractures.⁴⁻⁹ In
184 40% of our selected fractures more than 50% of the surgeons recommended operative

185 treatment. The agreement on treatment recommendation was only moderate, remains
186 controversial, and merits further study.

187

188 In conclusion, the simpler New International Classification proved more reliable **than the**
189 **OTA/AO classification**. Surgeons find it more difficult to distinguish body and process
190 fractures than glenoid fractures. Improved definitions and training may further help to
191 improve reliability of scapula fracture classification.²⁰

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192 **Figures**

193

194 Figure 1: Presented here is fracture 11, anterior and Y-view of the 3DCT-reconstruction.

195 Surgeons had problems deciding if the body and/or the process were involved.

196

197 Figure 2: Forty-three percent of the raters classified fracture 9, which is very similar to

198 fracture 3, as a C2 (total articular; intra-articular fracture with neck) and 40% as a C3

199 (Intra-articular fracture with body) fracture.

200

201 Figure 3: This glenoid neck fracture (fracture 30) caused a high disagreement in the New

202 International Classification; it was classified as a body fracture in 63% and as an intra-

203 articular fracture in 54%.

204

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206

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- 256
- 257

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Table 1. Surgeons' demographics.

Parameter	n
All questions answered	103
Sex	
Male	96
Female	7
Area of practice	
Australia	4
Canada	4
Europe	28
United Kingdom	3
United States	47
Other	17
Years of independent practice	
0 - 10	51
More than 10 years	52
Specialization	
Orthopaedic traumatology	44
Shoulder and elbow	23
Hand and wrist	25
General orthopaedics or other	11

n, number of surgeons

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Table 2. OTA/AO Classification.

Fracture no.	Raters (n=)	Most proposed AO type	% of all answers
1	162	C3	59
2	153	A3	95
3	137	C2	26
4	131	A3	99
5	131	A3	99
6	129	A1	99
7	124	A3	75
8	119	C3	70
9	115	C2	43
10	114	A2	94
11	111	B1	41
12	110	A3	78
13	109	C3	52
14	108	A3	82
15	107	A1	93
16	106	A3	88
17	106	C3	69
18	105	A3	35
19	103	A3	96
20	103	A3	84
21	103	B1	34
22	103	C3	40
23	103	B1	72
24	103	C3	56
25	103	B3	75
26	103	A3	88
27	103	C3	61
28	103	C2	60
29	103	B3	43
30	103	C1	64
31	103	A3	77
32	103	C3	69
33	103	A3	82
34	103	C3	69
35	103	C3	55

Parameter	Agreement	Kappa	PA (%)
Overall			
3 Types (A, B, C)	Moderate	0.54	71
9 Groups (A1 - C3)	Moderate	0.47	57
Years of practice			
0 - 10	Moderate	0.48	58
More than 10 years	Moderate	0.46	56
Specialization			
Orthopaedic traumatology	Moderate	0.46	56
Shoulder and elbow	Moderate	0.51	61
Hand and wrist	Moderate	0.43	53

PA, Proportion of agreement

Table 3. New International Classification for Scapular Fractures.

Fracture no.	Raters (n=)	Body (B)	% of all answers	Fossa (F)	% of all answers	Process (P)	% of all answers
1	162	Fractured	81	Intraarticular	97	Not involved	99
2	153	Fractured	99	Extraarticular	98	Not involved	100
3	137	Not fractured	55	Intraarticular	68	Involved	52
4	131	Fractured	100	Extraarticular	99	Not involved	99
5	131	Fractured	100	Extraarticular	98	Not involved	94
6	129	Not fractured	98	Extraarticular	100	Involved	98
7	124	Fractured	92	Extraarticular	98	Involved	61
8	119	Fractured	79	Intraarticular	96	Not involved	62
9	115	Not fractured	51	Intraarticular	97	Involved	72
10	114	Not fractured	98	Extraarticular	99	Involved	99
11	111	Not fractured	95	Intraarticular	77	Involved	68
12	110	Fractured	96	Extraarticular	93	Not involved	95
13	109	Fractured	80	Intraarticular	93	Not involved	79
14	108	Fractured	99	Extraarticular	96	Not involved	100
15	107	Not fractured	79	Extraarticular	99	Involved	81
16	106	Fractured	98	Extraarticular	97	Not involved	98
17	106	Fractured	90	Intraarticular	97	Involved	73
18	105	Fractured	89	Extraarticular	61	Not involved	66
19	103	Fractured	98	Extraarticular	100	Not involved	96
20	103	Fractured	99	Extraarticular	97	Not involved	99
21	103	Not fractured	81	Intraarticular	90	Involved	64
22	103	Fractured	87	Intraarticular	94	Involved	81
23	103	Not fractured	100	Intraarticular	100	Not involved	100
24	103	Fractured	78	Intraarticular	97	Involved	55
25	103	Not fractured	98	Intraarticular	99	Not involved	100
26	103	Fractured	99	Extraarticular	99	Not involved	100
27	103	Fractured	77	Intraarticular	99	Not involved	96
28	103	Not fractured	85	Intraarticular	98	Involved	57
29	103	Fractured	67	Intraarticular	99	Not involved	99
30	103	Fractured	63	Intraarticular	54	Not involved	97
31	103	Fractured	97	Extraarticular	97	Not involved	100
32	103	Fractured	89	Intraarticular	97	Not involved	98

33	103	Fractured	99	Extraarticular	99	Not involved	99
34	103	Fractured	89	Intraarticular	97	Not involved	85
35	103	Fractured	86	Intraarticular	82	Not involved	94

Parameter	Agreement	Kappa For Body (B)	PA (%)	Agreement	Kappa For Fossa (F)	PA (%)	Agreement	Kappa For Process (P)	PA (%)
Overall	Moderate	0.57	82	Substantial	0.79	90	Moderate	0.53	81
Years of practice									
0 - 10	Moderate	0.59	83	Substantial	0.79	90	Moderate	0.55	82
More than 10 years	Moderate	0.57	80	Substantial	0.79	90	Moderate	0.52	80
Specialization									
Orthopaedic traumatology	Moderate	0.55	80	Substantial	0.78	89	Moderate	0.52	81
Shoulder and elbow	Substantial	0.61	85	Almost perfect	0.83	92	Moderate	0.54	81
Hand and wrist	Moderate	0.53	79	Almost perfect	0.80	90	Moderate	0.52	80

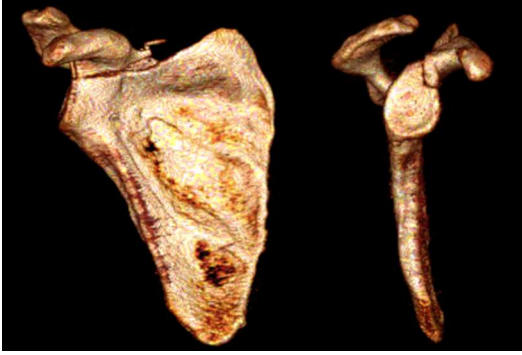
PA, Proportion of agreement

Table 4. Recommended treatment.

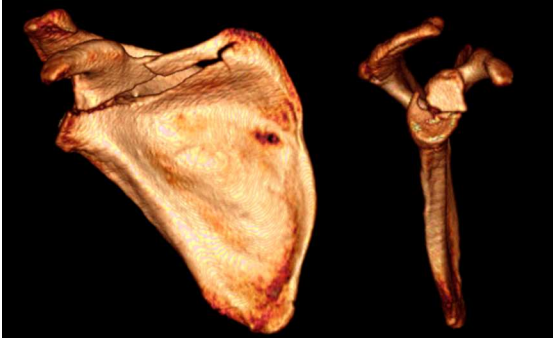
Fracture no.	Raters (n=)	Recommended treatment	% of all answers
1	162	Operative	82
2	153	Nonoperative	98
3	137	Nonoperative	58
4	131	Nonoperative	98
5	131	Nonoperative	91
6	129	Nonoperative	52
7	124	Nonoperative	56
8	119	Operative	89
9	115	Operative	90
10	114	Operative	52
11	111	Nonoperative	65
12	110	Nonoperative	96
13	109	Nonoperative	72
14	108	Nonoperative	63
15	107	Nonoperative	84
16	106	Nonoperative	95
17	106	Operative	69
18	105	Nonoperative	81
19	103	Nonoperative	98
20	103	Nonoperative	83
21	103	Nonoperative	78
22	103	Operative	52
23	103	Operative	97
24	103	Operative	91
25	103	Nonoperative	79
26	103	Nonoperative	88
27	103	Operative	87
28	103	Operative	97
29	103	Operative	55
30	103	Operative	87
31	103	Nonoperative	71
32	103	Operative	90
33	103	Nonoperative	88
34	103	Operative	92
35	103	Nonoperative	90

Parameter	Agreement	Kappa	PA (%)
Overall			
Recommended treatment	Moderate	0.45	73
Years of practice			
0 - 10	Moderate	0.48	75
More than 10 years	Moderate	0.41	71
Specialization			
Orthopaedic traumatology	Moderate	0.44	72
Shoulder and elbow	Moderate	0.45	73
Hand and wrist	Moderate	0.48	74

PA, Proportion of agreement



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