Chapter 7

The relationship between trauma mechanism, fracture type and treatment of midshaft clavicular fractures.

Sylvia A. Stegeman, Charlotte W.J. Roeloffs, Jephta van den Bremer, Pieta Krijnen, Inger B. Schipper

Eur J Emerg Med, 2013; 20 (4): 268-272

Abstract

Objective

The debate on whether midshaft clavicular fractures should preferably be treated operatively or non-operatively still continues. Several patient-related factors may influence this treatment decision. A retrospective study was carried out to investigate the relation between fracture type and trauma mechanism, age and sex, and the influence of these factors on the choice of primary treatment.

Methods

Data on trauma mechanism and treatment of 232 adult patients, who presented with a midshaft clavicular fracture in two hospitals in the Netherlands during the years 2006-2009, were collected. The extent of clavicular shortening, displacement, and fracture type on the primary X-ray were scored.

Results

Traffic accidents are the main cause of midshaft clavicular fractures. After correction for age, no relation was found between trauma mechanism and fracture type. Older age correlated with more comminuted and displaced fractures. Extensive shortening (>20mm) was identified as the main clinical indication for primary surgery, whereas displacement and fracture classification seemed less relevant. Operative treatment was increasingly favored from 5% in 2006 to 44% in 2009, which could not be explained by an increase of more complex fractures, nor by age-related or trauma mechanism-related factors.

Conclusion

Age has a major influence on the fracture type, whereas the trauma mechanism does not. The choice for the surgical treatment of midshaft clavicular fractures is primarily determined by the amount of axial shortening of the clavicle, rather than by overall displacement or fracture type. Over the years, the choice of treatment seems, increasingly influenced by the patient's and surgeon's preferences.

Introduction

Clavicular fractures represent five percent of all fractures in adults. The vast majority (69-82 percent) of these fractures are located in the midshaft of the clavicle.[1-5] Most midshaft clavicular fractures are caused by a direct axial compressive force to the shoulder after a sudden stop or fall during sports, such as cycling and horse riding.[5,6] It is currently not known how trauma mechanism and patient characteristics relate to the degree of comminution of the fracture.

Furthermore, the optimal management of midshaft clavicular fractures is still unclear. Several Randomised Controlled Trials (RCTs) have been conducted to determine whether displaced and comminuted midshaft clavicular fractures should be treated operatively with plate fixation or intramedullary nailing, or non-operatively with sling immobilization, in order to optimize union rates and functional outcomes. These studies seemed to favor operative treatment with plate fixation, which was also found in a meta-analysis of these studies.[7] However, the effect of operative treatment may have been overestimated due to methodological flaws in some of the RCTs. In the RCTs by Altamimi and McKee[8], Judd *et al*.[9] and by Mirzatolooei *et al*.[10] significantly more patients in the non-operative group were lost to follow-up than in the plate fixation group. This difference in the length of follow-up may have favored the functional outcomes and union rates in the plate fixation groups in these studies. Research has not shown convincingly that operative treatment is better for displaced and comminuted fractures, because the treatment outcome may depend on patient characteristics as well.

In this retrospective study, we examined whether the type of midshaft clavicular fractures depends on trauma mechanism, age and sex. Furthermore, we investigated whether the choice of primary operative treatment is influenced by any of these factors.

Methods

Patients

In this retrospective cohort study, all patients of 18 years of age and older, who presented with a midshaft clavicular fracture between January 2006 and December 2009 in two hospitals in the mid-western region of the Netherlands, were selected from the hospital registries. Patients were excluded if no primary radiograph of the midshaft clavicular fracture taken within two weeks after injury was available or if no information was available on primary and final treatment, because the patient received further treatment in another hospital.

Data

Data on year of trauma, sex, age at fracture, trauma mechanism, fracture characteristics, type of treatment, treatment period and clinical outcome were gathered from the medical files. Trauma mechanisms were subdivided into (a) traffic accidents involving bikes, mopeds, motorcycles and cars (fractures induced by direct pressure of the seat belt), (b) fall from height, such as a fall from a staircase or a household ladder (c) sports injuries, and (d) low-energy injuries, such as fall from standing. Age was classified into: (a) 18-29 years, (b) 30-49 years, and (c) 50 years and older. This classification was made on the basis of age-related changes in bone mass, structure and strength, as bone starts to degenerate from the age of 25-30 years,[11] and the chance of a fragility fracture is increased above the age of 50 years.[12,13] The following fracture characteristics were determined from the anteroposterior radiograph: fracture side, fracture type according to the Robinson classification defined as type 2A (undisplaced or with only an angulation) and type 2B (simple or wedge comminuted and isolated or comminuted segmental fractures; Figure 1),[4] displacement ad latum defined as (a) less than one shaft width or (b) more than one shaft width in the craniocaudal or the anteroposterior direction, and clavicular axial shortening categorized as follows: (a) 0–14mm, (b) 15–19mm and (c) at least 20mm. Treatment was classified as operative or non-operative. A distinction was made between the primary treatment and the final treatment. The follow-up period was defined as the number of weeks between the first presentation at the emergency department or the outpatient clinic and the last visit to the outpatient clinic.

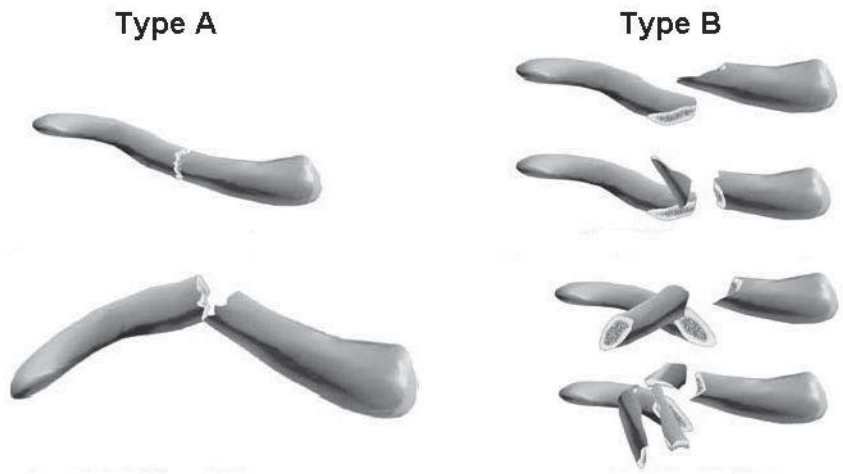

Figure 1 Robinson classification of midshaft clavicular fractures.
Figure reprinted with permission of C.M. Robinson.[4]

Statistical analyses

Univariate comparisons between patient groups were tested using the *t*-test or analysis of variance for continuous variables, and with the χ2-test for categorical data. Multivariate analyses for binary outcome parameters were performed using logistic regression analysis, in which variables with a univariate association ($P<0.05$) with the outcome variable were included as independent factors. Statistical analyses were carried out using statistical package for the social sciences version 17.0 (SPSS Inc., Chicago Illinios, USA).

Results

In the study period, 257 adult patients with a midshaft clavicular fracture were seen in the Emergency Departments of the two hospitals. After excluding the patients of whom radiographs or information on treatment were missing, 232 patients remained (188 men, 44 women; mean age 41.2 years, SD±16.6). Of this group, 189 patients had received primary non-operative treatment by means of a sling and 43 patients had received primary operative treatment using plate fixation. The characteristics of the study group are presented in Table 1.

Trauma mechanism by age and gender

Type of trauma mechanism, subdivided into four categories, was associated with age (P<0.001; Figure 2). Traffic accidents were the main trauma mechanism in the study group as a whole (60%), as well as in the separate age groups (Figure 2). Sports injuries were the second most common trauma mechanism in the youngest age groups, whereas low-energy injuries were the second most common trauma mechanism in patients older than 50 years of age. Men more often sustained a clavicular fracture during traffic accidents, whereas women sustained a clavicular fracture equally frequent because of traffic accidents as low-energy accidents, such as a fall on the street (P<0.001; Figure 2).

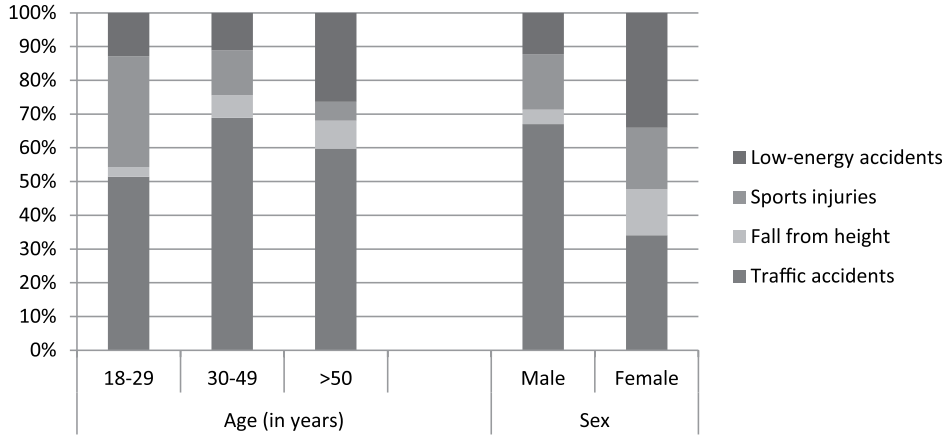

Figure 2 Trauma mechanism by age and gender in patients with midshaft clavicular fractures.

Table 1 Characteristics of 232 patients with midshaft clavicular fractures, according to primary treatment.

Parameter		Total N (%)*	Non-operative treatment N (%)*	Operative treatment N (%)*	P-value
Total fractures		232	189	43	
	Gender				P=0.947
	Male	188 (81)	153 (81)	35 (81)	
	Female	44 (19)	36 (19)	8 (19)	
Age at trauma					P=0.305
	18-29 yr	70 (30)	60 (32)	10 (32)	
	30-49 yr	90 (39)	69 (37)	21 (49)	
	>50 yr	72 (31)	60 (32)	12 (28)	
Trauma mechanism					P=0.275
	Traffic accident	141 (60)	115 (61)	26 (61)	
	Fall from height	14 (6)	14 (7)	0 (0)	
	Sports injury	39 (17)	30 (16)	9 (21)	
	Low-energy injury	38 (16)	30 (16)	8 (19)	
Side of fracture					P=0.962
	Left	121 (52)	98 (52)	23 (53)	
	Right	111 (48)	91 (48)	20 (47)	
Fracture type					P=0.004
	2A1	15 (7)	14 (7)	1 (2)	
	2A2	24 (10)	23 (12)	1 (2)	
	2B1	132 (57)	111 (58)	21 (49)	
	2B2	61 (26)	41 (22)	20 (47)	
Displacement ad latum					P=0.016
	No dislocation	28 (12)	26 (14)	2 (5)	
	< 1 shaft width	102 (44)	75 (40)	27 (63)	
	> 1 shaft width	102 (44)	88 (47)	14 (33)	
Axial shortening					P<0.001
	0-14 mm	143 (62)	132 (70)	11 (26)	
	15-19 mm	24 (10)	21 (11)	3 (7)	
	> 20 mm	65 (28)	36 (19)	29 (67)	
Length of follow-up (weeks), median (range)		7.2 (0-185)	6.3 (0-185)	15.6 (1-88)	P<0.001
Year of diagnosis					P<0.001
	2006	59 (25)	57 (30)	2 (5)	
	2007	51 (22)	45 (24)	6 (14)	
	2008	66 (28)	50 (26)	16 (37)	
	2009	56 (24)	37 (20)	19 (44)	

*Percentages may not add up to 100% due to rounding

Fracture characteristics by gender, age and trauma mechanism

Comminuted and displaced (type 2B) fractures were far more common than undisplaced (type 2A) fractures (73 vs. 17%). Fracture type did not differ between men and women (*P*=0.24), but the proportion of type 2B fractures increased with age (*P*=0.002, data not shown). The probability of sustaining a comminuted displaced (type 2B) fracture increased with age: compared with the youngest age group, the odds ratio (OR) was 2.96 (95% confidence interval (CI) 1.26–6.98) for a type 2B fracture in the intermediate age group and 3.12 (95%-CI: 1.20 – 8.06) in the eldest age group (Table 2). Fracture type and trauma mechanism were univariately associated (P=0.04, Figure 3). In a multivariate analysis, this association was no longer present after correction for age.

Table 2 Multivariate logistic regression analysis for predicting a comminuted (type B) fracture in patients with a midshaft clavicular fracture.

		OR	95%-CI	P
Age (in years)				
	18-29	1		
	30-49	2.96	1.26-6.98	0.01
	>50	3.12	1.20-8.09	0.02
Trauma mechanism				
	Traffic accident	1		
	Fall from height	0.70	1.14-3.49	0.66
	Sports injury	0.43	0.18-1.06	0.07
	Low-energy injury	0.48	0.18-1.27	0.14

Displacement ad latum, scored as more than one shaft width, was observed on 88% of the primary radiographs (Table 1). The nondisplaced fractures were caused, in similar numbers, by sports injuries and by traffic accidents, whereas the fractures with more than one shaft width displacement resulted less often from sports accidents and more often from traffic accidents (Figure 3). Few fractures showed extensive axial shortening on the primary radiograph: shortening of 15 - 20 mm was seen in 10%, and shortening of at least 20 mm in 28% (Table 1). Trauma mechanism was not related to the extent of shortening (*P*=0.73, Figure 3).

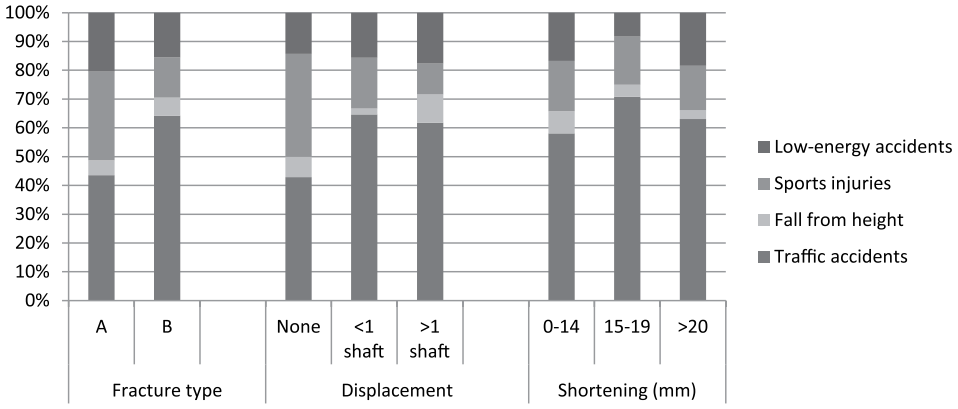

Figure 3 Fracture characteristics of patients with a midshaft clavicular fracture, by trauma mechanism.

Choice of primary treatment

According to the medical files, shortening of the clavicle of at least 20 mm was the main indication for surgery for the 43 patients who were operated as primary treatment (*n*=25). Other indications for primary surgery included skin perforation (*n*=1) and significant displacement of the fracture fragments (*n*=5). In the other patients (*n*=12), surgical treatment was preferred by the patient, for instance to enable early mobilization of the shoulder and return to work (p<0.001). In the univariate analyses, the primary operative treatment was not associated with age, sex and trauma mechanism (*P*>0.05, Table 1). Primary surgery was associated, however, with type B fractures, more displaced fractures and extensive (≥20 mm) clavicular shortening (p<0.001). After combining the fracture characteristics in a logistic regression analysis, the choice of primary treatment seemed mainly to be determined by the extent of clavicular shortening: the OR for primary surgery was only statistically significantly increased for patients with a clavicular shortening of 20 mm or more (Table 3). In a multivariate regression analysis, the probability of primary operative treatment increased markedly over time within the study period of 4 years (for 2009 compared with 2006: OR 34.49, 95%-CI: 5.53 – 182).

Table 3 Logistic regression analysis for predicting surgery as primary treatment in patients with a midshaft clavicular fracture.

Fracture characteristics			OR*	95%-CI	P
Classification	Shortening	Displacement			
A			1 (reference)		
B	0-14 mm	<1 shaft	2,37	0,43-12,99	0,32
B	0-14 mm	>1 shaft	1,30	0,23-7,45	0,77
B	15-19 mm	<1 shaft	4,11	0,51-33,27	0,19
B	15-19 mm	>1 shaft	1,68	0,14-20,35	0,68
B	≥ 20 mm	<1 shaft	21,77	4,56-103,87	<0.0001
B	≥ 20 mm	>1 shaft	8,76	1,72-44,68	0,009

* OR=Odds Ratio for primary operative treatment.

Final treatment

Sixteen of the 189 non-operatively treated patients developed pain and impaired shoulder function. Of these 16 patients, 11 patients were operated an average of 21 weeks (4-106 weeks) after trauma because of incomplete fracture healing. Thus, a total of 54/232 patients had received operative treatment at the end of the follow-up period.

Discussion

This study was carried out to determine whether the type of midshaft clavicular fractures and choice of primary operative treatment depend on trauma mechanism, age and sex.

Theoretically, it would seem likely that the force and the energy of a direct blow onto the shoulder strongly correlate with the amount of comminution of the fracture, and therefore, would determine the type of fracture. However, in our study, no association was found between the trauma mechanism and fracture type after correction for age. Midshaft clavicular fractures were caused by different trauma

mechanisms in different age groups, which might explain why age and not trauma mechanism was shown to be the principal determinant of fracture type in this study. In the elderly, it is likely that less force is required to produce a comminuted fracture, as it has been established that bone quality declines slowly after 30 years of age and that osteoporosis sets in after the age of 50.[11-13]

In this study, clavicular axial shortening of 20 mm or more was found to be the main indication for operative treatment. The other fracture characteristics on the radiograph, the Robinson classification and the extent of displacement ad latum, seemed less relevant for the choice of treatment. However, the decision to operate in daily clinical practice does not only depend on the findings on radiograph, but may depend on the patient's and surgeon's preference for a specific type of treatment because of the patient's work or social activities such as sports. In the present study, 12 patients were operated on because of their preference for early mobilization and fast return to work and not because of the surgeon's preferences or surgical indication. If medically admissible, it is advised to weigh the patient's goals and activity level in choice for method of treatment of midshaft clavicular fractures.[14]

The proportion of midshaft clavicular fractures that were operated upon has increased markedly during the study period of 4 years. This increase could not be explained by an increased proportion of more complex fractures, and was therefore probably because of surgeons' and patients' preferences for surgical intervention. The publication of an RCT of Altamimi and McKee *et al.*,[8] showing that operative treatment with plate fixation might be better than non-operative treatment for shortened and displaced (type 2B) midshaft clavicular fractures, may have led surgeons to operate more often over time during the study period. However, the results and conclusions of this study[8] should be interpreted with caution, because of the selective loss to follow-up that occurred mainly in the non-operatively treated group. For this reason, yet another RCT is currently being performed by the authors.[15]

Similar to all retrospective studies, the present study has its limitations. The retrospective design led to the exclusion of 25 patients (9.8%), however random, because not all relevant data could be retrieved from the medical files. Moreover, the data on trauma mechanism could not be further specified. More detailed information may have helped to further clarify the relation between trauma mechanism and fracture type.

Conclusion

Age and not trauma mechanism seems to be the principal determinant of fracture type. In terms of the choice for primary surgical treatment of midshaft clavicular fractures, extensive axial shortening (>20mm) is the most relevant clinical factor. Yet, the patient's and surgeon's preferences also seem to play an important role.

References

1. Allman, F.L., Jr. (1967) *Fractures and ligamentous injuries of the clavicle and its articulation*. J. Bone Joint Surg. Am. 49 (4): 774-784.
2. Khan, L.A., Bradnock, T.J., Scott, C., and Robinson, C.M. (2009) *Fractures of the clavicle*. J. Bone Joint Surg. Am. 91 (2): 447-460.
3. Postacchini, F., Gumina, S., De, S.P., and Albo, F. (2002) *Epidemiology of clavicle fractures*. J. Shoulder. Elbow. Surg. 11 (5): 452-456.
4. Robinson, C.M. (1998) *Fractures of the clavicle in the adult. Epidemiology and classification*. J. Bone Joint Surg. Br. 80 (3): 476-484.
5. Stanley, D., Trowbridge, E.A., and Norris, S.H. (1988) *The mechanism of clavicular fracture. A clinical and biomechanical analysis*. J. Bone Joint Surg. Br. 70 (3): 461-464.
6. Nowak, J., Mallmin, H., and Larsson, S. (2000) *The aetiology and epidemiology of clavicular fractures. A prospective study during a two-year period in Uppsala, Sweden*. Injury. 31 (5): 353-358.
7. Zlowodzki, M., Zelle, B.A., Cole, P.A., Jeray, K., and McKee, M.D. (2005) *Treatment of acute midshaft clavicle fractures: systematic review of 2144 fractures: on behalf of the Evidence-Based Orthopaedic Trauma Working Group*. J. Orthop. Trauma. 19 (7): 504-507.
8. Canadian Orthopaedic Trauma Society (2007) *Non-operative treatment compared with plate fixation of displaced midshaft clavicular fractures. A multicenter, randomised clinical trial*. J. Bone Joint Surg. Am. 89 (1): 1-10.
9. Judd, D.B., Pallis, M.P., Smith, E., and Bottoni, C.R. (2009) *Acute operative stabilization versus non-operative management of clavicle fractures*. Am. J. Orthop. (Belle. Mead NJ). 38 (7): 341-345.
10. Mirzatolooei, F. (2011) *Comparison between operative and non-operative treatment methods in the management of comminuted fractures of the clavicle*. Acta Orthop. Traumatol. Turc. 45 (1): 34-40.
11. Mosekilde, L. (2000) *Age-related changes in bone mass, structure, and strength—effects of loading*. Z. Rheumatol. 59 Suppl 1: 1-9.
12. Dennison, E., Cole, Z., and Cooper, C. (2005) *Diagnosis and epidemiology of osteoporosis*. Curr. Opin. Rheumatol. 17 (4): 456-461.
13. van Staa, T.P., Dennison, E.M., Leufkens, H.G., and Cooper, C. (2001) *Epidemiology of fractures in England and Wales*. Bone. 29 (6): 517-522.

14. van der Meijden, O.A., Gaskill, T.R., and Millett, P.J. (2012) *Treatment of clavicle fractures: current concepts review.* J Shoulder. Elbow. Surg. 21 (3): 423-429.

15. Stegeman, S.A., de Jong, M., Sier, C.F., Krijnen, P., Duijff, J.W., van Thiel, T.P., de Rijcke, P.A., Soesman, N.M., Hagenaars, T., Boekhoudt, F.D., de Vries, M.R., Roukema, G.R., Tanka, A.F., van den Bremer, J., van der Meulen, H.G., Bronkhorst, M.W., van Dijkman, B.A., van Zutphen, S.W., Vos, D.I., Schep, N.W., Eversdijk, M.G., van Olden, G.D., van den Brand, J.G., Hillen, R.J., Frolke, J.P., and Schipper, I.B. (2011) *Displaced midshaft fractures of the clavicle: non-operative treatment versus plate fixation (Sleutel-TRIAL). A multicentre Randomised Controlled Trial.* BMC. Musculoskelet. Disord. 12 (1): 196.