Clavicle fractures: a comparison of five classification systems and their relationship to treatment outcomes

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Abstract We compared five classification systems for clavicle fractures. The aim of this study was to evaluate the prognostic value of each system. Over a two-year period we reviewed all new radiographs of the shoulder region and identified 487 clavicle fractures. Each radiograph was classified using five classification systems. We reviewed all subsequent X-rays and clinical records until the patient was discharged. We assessed each classification system's prognostic value in predicting delayed/non-union. Our data show that 79.3% of clavicle fractures occur in the middle third, 19.3% in the lateral third and 1.4% in the medial third. The overall prevalence of delayed/non-union was 7.3%, with 3.2% requiring operative management and 4.1% developing asymptomatic non-union. The incidence of non-union in the lateral third was 9.6%, but only 0.4% required operative management. Craig's classification had the greatest prognostic value for lateral third fractures, and Robinson's classification had the greatest prognostic value for middle third fractures. Fractures of the clavicle are common injuries but non-union is an uncommon occurrence. Non-union is more common in the lateral third, but we found these to be mostly asymptomatic. Middle third fractures are more likely to require operative fixation. Middle third fractures should be classified according to Robinson's classification system

and lateral third fractures according to Craig's classification. We did not assess sufficient medial third fractures for the data to be significant.

Introduction

Fractures of the clavicle are common, representing 2.6–10% of all fractures [1–4]. There are numerous epidemiological studies in the literature [3–6], and a number of classification systems have been developed for clavicle fractures [2, 3, 7–9]. The majority of these injuries are caused by a fall onto an outstretched hand or by a direct blow to the shoulder [3, 4]. They most commonly affect active and healthy people during sporting activities or road traffic accidents [3, 4]. Older studies report that most clavicle fractures have a good prognosis with few requiring operative management, a low incidence of non-union [5, 10] and few residual symptoms when healed [11]. More recent studies have reported that mid-shaft fractures have a higher incidence of symptomatic non-union than previously thought [12–15]. Some authors now recommend acute fixation of displaced mid-shaft fractures [12, 13], and some recommend acute fixation of some lateral third fractures [16, 17]. Most clavicle fractures are treated 'conservatively' in our institution, and we wanted to review this policy. The aim of this study was to review all clavicle fractures seen in our unit to determine aetiology, patients at risk, injury patterns and outcomes. Specifically, we aimed to assess the incidence of symptomatic non-union and determine which classification system best identifies fractures at risk of developing non-union. All fractures were classified using five widely accepted classification systems [2, 3, 7–9], and outcome results were compared to assess the prognostic value for each classification. This is a retrospective study reviewing patient records and radiographs.

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Materials and methods

All patients who sustain a fracture of the clavicle in our region are reviewed at a trauma clinic within seven days of their injury. Any patient who has not had specific radiographs of the clavicle taken has an anteroposterior (AP) and 15° caudal AP radiograph (clavicle radiographs) taken at the first outpatient visit (some clavicle fractures are identified on acromioclavicular joint or shoulder radiographs and referred to our service without clavicle radiographs being performed). Undisplaced or minimally displaced fractures are treated in a shoulder immobiliser for three weeks. Fractures with significant shortening are treated in a collar ‘n’ cuff for three weeks to allow the weight of the arm to act as traction on the clavicle. Patients who report significant pain at the three-week review may have their immobilisation prolonged until the pain settles. All patients are referred to a registered musculoskeletal physiotherapist for assessment and treatment at three weeks. Fractures in children are treated with immobilisation only whilst the child remains symptomatic. Children are not referred to a physiotherapist unless clinically warranted. Radiographs are taken at the first attendance and again at three weeks. Further radiographs are taken only when clinically indicated (ongoing pain, difficulty with mobilisation, markedly displaced fractures). Children have radiographs taken at their first attendance, and further radiographs are only taken if clinically warranted. All patients are reviewed clinically until both patient and surgeon are satisfied with the clinical outcome.

All radiological procedures in our institution are electronically logged on the AGFA IMPAX Web1000™ system. We used this system to identify all radiographs of the shoulder region performed over a two-year period. We excluded any patient whose fracture had occurred outside of the two-year period. This method identified all ‘first-presentation’ radiographs. We identified 6,360 radiographs performed for acute shoulder injuries sustained within the two-year period. All 6,360 radiographs were reviewed and 487 acute clavicle fractures were identified in 483 patients. One patient sustained bilateral fractures and three patients sustained two different fractures within the study period.

The initial 487 radiographs were reviewed and classified using the systems described by Allman [7], Neer [2], Craig [8], Nordqvist and Petersson [3], and Robinson [9]. Subsequent radiographs were reviewed to establish duration of radiographic review and radiographic outcome where appropriate. The patient records were reviewed to establish fracture aetiology, duration of clinical review and clinical outcome. We had no exclusion criteria in this part of the study.

All initial radiographs were reviewed by two orthopaedic surgeons and findings clarified with the radiological reports. Fractures were then classified by three orthopaedic

surgeons, blinded to the findings of the others. Where disagreement occurred on classification, radiographs were further reviewed until consensus was reached.

Of the 487 patients, six (1.2%) underwent operative reduction and fixation acutely. One was an open fracture and five were impending open fractures. Ten fractures (2.1%) were in neonates with birth-associated injuries. The remaining 471 (96.7%) were treated ‘conservatively’ as described previously; 21 patients were not resident in our area and were referred to their local institute for ongoing review, and 11 failed to re-attend after one visit. The remaining 439 (90.1%) patients were reviewed clinically until asymptomatic with full shoulder function (mean 13 ± 15.5 weeks, range 0–123 weeks). Radiographs were only obtained where clinically indicated (pain, limitation of function) and were discontinued as symptoms resolved (mean 10.5 ± 15 weeks, range 0–123 weeks), except in cases of delayed union when radiographs were taken until union/non-union was confirmed. Non-union was defined as a fracture that had not adequately healed four months after injury [18–20].

Results

We identified 487 fractures in 352 (72.3%) male and 135 (27.7%) female patients. There were 244 (50.1%) right-sided fractures (M:F=2.5:1) and 243 (49.9%) left-sided fractures (M:F=2.7:1). The age distribution of the group is shown in Fig. 1.

The mean age of the group was 23 ± 19.9 years and range one day to 95 years (male 21 ± 17.7 , range one day to 88 years; female 27 ± 24.3 , range one day to 95 years). Fractures in male patients peaked in the late teens and in female patients in childhood and adolescence. The incidence of clavicle fractures by calendar month is seen in Fig. 2. Fractures in children peaked in the summertime. Fractures in the group aged 18–65 had a peak in the winter and again in the summer, and fractures in those over 65 were uniform across the entire year. Fracture aetiology can be seen in Table 1. Fracture classification can be seen in Table 2.

Robinson’s classification describes displacement as more than 100% translation of fracture fragments. We adhered to this when using Robinson’s classification. When using the other classifications we took displacement to mean any amount of translation between fracture fragments.

Of 439 patients followed up until cessation of treatment, 32 (7.3%) developed non-union, confirmed on radiograph (mean age 41, range 19–80 years) (Table 3). Of the patients with non-union 18 were asymptomatic and declined operative management, and 14 (3.2%) proceeded to open reduction and internal fixation (ORIF). All symptomatic non-unions occurred in fractures associated with high

Fig. 1 Age distribution of all fractures

impact trauma; nine non-unions occurred in the lateral third and 23 in a the middle third. The 12 non-unions requiring ORIF were in the middle third, and two were in the lateral third. One non-union in the middle third was fixed with a plate and screws but did not unite. The patient returned complaining of pain associated with implant failure secondary to ongoing non-union. The fixation was revised with bone graft and repeat fixation, and progressed to union. The other 13 non-unions united after fixation.

Discussion

A government census conducted during the time period of this study shows the population in our catchment area as 290,438 (M:F=50.5:49.5) [21]. We identified 466 fractures in patients resident in this area, giving an incidence of 80 fractures per 100,000 population annually. Our study cohort demonstrates that almost three quarters of clavicle fractures occur in men with an equal distribution of right- and left-sided fractures. Fracture incidence peaked in the late teens in men and declined steadily with age in women. These data would seem to reflect the fact that fractures were sustained mostly during sports activities, falls from a height and road traffic accidents, activities and accidents that are generally associated with younger people.

Fig. 2 Monthly distribution of fractures by age group

Fractures in school-age children peaked during the summer months, when these patients would generally be on holiday from school and spending more time in recreational activities such as sport. Fractures in the over 65 age group were uniform throughout the year. The middle group of 18- to 65-year-old patients showed peaks in winter and summer. The winter peak reflects falls sustained in inclement weather and the summer peak reflects a higher incidence of sports-related trauma that occurs during holiday season. These aetiological factors associated with clavicle fracture are broadly similar to those documented in previous reports [3, 4].

Table 1 Mechanism of injury

	Total	% Total
Sport	146	30
Football	79	16.2
Hurling	25	5.1
Trampoline	22	4.5
Martial arts	8	1.6
Skating	5	1
Skiing	3	0.6
Gymnastics	3	0.6
	1	0.2
Fall onto shoulder	146	30
Fall from height	86	17.7
Horse	32	6.6
Bicycle	20	4.1
Other	34	7
Road traffic accident	60	12.3
Fall out of bed	14	2.9
Direct blow	13	2.7
Birth trauma	10	2.1
Fall down stairs	5	1
Assault	3	0.6
Seizure	2	0.4
Farming	1	0.2
Pathological	1	0.2

Table 2 Breakdown of all fractures by classification type

	Allman		Neer		Craig		Nordqvist and Petersson		Robinson	
	Type	%	Type	%	Type	%	Type	%	Type	%
Mid. 1/3	1	79.3	1	79.3	1	79.3	1A	27.9	2A1	13.8
							1B	33.3	2A2	19.5
							1C	18.1	2B1	31.6
									2B2	14.5
Lat. 1/3	2	19.3	2 (1)	12.3	2 (1)	10.9	2A	9.4	3A1	11.9
					2 (2A)	1.4				
			2 (2)	4.5	2 (2B)	2.8			3A2	1.6
					2 (3)	2.1	2B	9.9	3B1	4.9
			2 (3)	2.5	2 (4)	0			3B2	0.6
					2 (5)	2.1				
Med. 1/3	3	1.4	3	1.4	3 (1)	0.6	3A	0.4	1A1	1.2
					3 (2)	0.6			1A2	0
					3 (3)	0	3B	1.0	1B1	2
					3 (4)	0				
					3 (5)	0.2			1B2	0

We classified fractures according to the systems described by Allman, Neer, Craig, Nordqvist and Petersson, and Robinson. Allman described three groups of clavicle fractures: group 1 fractures involve the middle third, group 2 fractures involve the part of the clavicle that is distal to the coracoclavicular ligament and group 3 fractures involve the medial third. Neer had already described a classification system for lateral third fractures and incorporated this into Allman's classification [2, 22]. Craig then developed this classification further to differentiate between ligamentous injury patterns in the lateral third and include intra-articular and paediatric fractures. Non-union of clavicle fractures in children is extremely rare and the presence of a greenstick fracture must be taken as an excellent prognostic indicator [23]. The classification of Nordqvist and Petersson returned to the basic format of Allman, but included displacement and comminution as differentiating factors. Robinson's

classification is unique in that it is divided into fractures of the medial fifth, the lateral fifth and the intermediate three fifths. Despite this descriptive difference, the underlying anatomical principles remain the same, with the clavicle divided into sections based on the stabilising and distracting forces of attached muscles and ligaments. The term 'middle third' should be interpreted for the purposes of this discussion to refer also to the middle three fifths of Robinson's group 2.

Nordqvist et al. stated that non-union is significantly more prevalent in middle third fractures when they are displaced [14]. Our data show that 2.3% (3/130) of undisplaced middle third fractures developed non-union, with two requiring operative management (1.5%); 5% (11/222) of displaced middle third fractures developed non-union, with 4.5% (10/222) requiring operative management. Nowak et al. have shown that comminution in

Table 3 All non-unions expressed as % of total fractures for each type

	Allman		Neer		Craig		Nordqvist and Petersson		Robinson	
	Type	%	Type	%	Type	%	Type	%	Type	%
Mid. 1/3	1	6	1	6	1	6	1A	2.2	2A1	0
							1B	6.2	2A2	3.2
							1C	11.4	2B1	7.8
									2B2	11.4
Lat. 1/3	2	9.6	2 (1)	6.7	2 (1)	7.5	2A	4.3	3A1	5.2
					2 (2A)	0				
			2 (2)	18.2	2 (2B)	28.6			3A2	0
					2 (3)	10	2B	14.6	3B1	25
			2 (3)	8.3	2 (4)	0			3B2	0
					2 (5)	0				

clavicle fractures is a negative prognostic indicator [24]. In our series 2% (3/148) of displaced simple fractures and 9.3% (7/75) of comminuted fractures required operative management.

When classifying our group as described by Robinson however, undisplaced fractures had a non-union rate of 1.9% (3/158) while displaced fractures had a non-union rate of 9.3% (20/215). Robinson's classification identifies undisplaced but angulated fractures of the middle third (type 2, A2). It has been recommended that markedly angulated fractures should be fixed in order to prevent injury to surrounding soft tissues and overlying skin [25–27]. The undisplaced fractures that developed non-union were all angulated. Those progressing to operative management were 1.3% (2/158) of undisplaced fractures and 5.1% (11/215) of displaced fractures; 4.4% (6/137) of displaced simple fractures and 6.5% (4/62) of displaced comminuted fractures required operative management. Robinson's classification places fractures in the undisplaced group unless there is complete dissociation of the fracture ends, resulting in more fractures being classified as undisplaced compared with the classification of Nordqvist and Petersson. Dividing the clavicle into fifths Robinson's classification includes slightly more mid-shaft fractures than the other classifications.

In our study only 14 (3.2%) patients developed symptomatic non-union that required operative management and six (1.2%) fractures were fixed acutely. All fractures united, and one fracture required revision of fixation with bone grafting. Twenty-one fractures occurring in the middle third failed to unite (6%). Nine fractures occurring in the lateral third failed to unite (11%). Of 21 non-unions in the middle third, 12 (3.4% of all Nordqvist and Petersson type 1; 3.4% of all Robinson type 2) required fixation because of ongoing pain (57%). Of nine non-unions in the lateral third, two required fixation (22%).

Middle third fractures have recently been identified as potentially more problematic than previously thought [12–15]. The Nordqvist and Petersson and Robinson classifications are the only two of the five reviewed that subdivide this group. Robinson takes into account angulation of undisplaced fractures whilst Nordqvist and Petersson do not. Some authors report that angulation may cause injury to surrounding soft tissues [25, 26]. Our data show that the two undisplaced middle third fractures that developed non-union were both angulated. Conversely, all undisplaced and non-angulated middle third fractures healed, a fact that is not evident if the Nordqvist and Petersson classification is employed. On this basis we conclude that Robinson's classification of middle third fractures offers better prognostic value.

All three classifications differentiate between displaced and undisplaced fractures of the lateral third. Craig's and

Robinson's classifications also differentiate between intra-articular and extra-articular fractures, while the classification of Nordqvist and Petersson does not. Craig further subdivides displaced fractures on the basis of ligamentous integrity of specific ligaments of the coracoclavicular ligament complex (conoid and trapezoid ligaments). Craig also includes greenstick fractures as a separate subgroup.

The classification of Nordqvist and Petersson shows a non-union rate of 11% (9/82) overall in the lateral third. Eight of these non-unions were displaced according to the classification of Nordqvist and Petersson, giving an incidence of 20% (8/40) non-union in the displaced group and 2.4% (1/42) in the undisplaced group. Craig's classification allows for 'minimal displacement' of lateral third fractures, and as previously stated, Robinson considers displacement to mean more than 100% translation of fracture fragments. Interpreting both of these classifications in this manner resulted in four minimally displaced (Craig) and three undisplaced (Robinson) fractures developing non-union. All non-unions in the lateral third were extra-articular. Craig further subdivides displaced extra-articular fractures into two groups: (A) displaced 2° to fracture medial to the coracoclavicular ligaments, where both ligaments are attached, and (B) displaced 2° to fracture medial to the coracoclavicular ligaments, where the conoid ligament is torn but the trapezoid ligament remains attached. In this study, none of the seven group A fractures developed non-union, but 36.3% (4/11) of the group B fractures progressed to non-union. This leads us to conclude that this aspect of Craig's classification is important prognostically. Craig and Robinson both identify intra-articular fractures as a significant subtype. In this study, all six intra-articular fractures united. Craig's classification is the only classification that includes 'greenstick type' fractures of the lateral third. As this type of fracture is known to have an excellent outcome, it may be of benefit to exclude these fractures when attempting to analyse the incidence of non-union in other types of lateral clavicle fractures. However, in our study, we did not encounter any fractures of this type in the lateral clavicle. It may be of more benefit to include greenstick fractures in the classification of middle third fractures.

We feel that this study gives a good overview of the aetiology and prognosis of clavicle fractures in our region. In reviewing all clavicle fractures over a two-year period we have demonstrated age distribution of fractures and seasonal changes in aetiology in relation to this. We have also followed all patients through to completion of treatment and discharge. We acknowledge that this is a retrospective study. We also acknowledge that although we have a reasonable sized cohort to begin with, as the fractures are subdivided down into subgroups in accordance

with classification systems, our cohort numbers get smaller for each fracture type. Significantly, we did not encounter enough fractures of the medial third of the clavicle to draw any reasonable conclusions regarding classification.

Conclusion

The results of this study show that clavicle fractures are common, that few fractures require operative management and that non-union is relatively uncommon in the group as a whole. Few patients have residual symptoms when their fracture has healed. We have also shown that non-union is common in lateral third fractures overall, and especially in displaced lateral third fractures. Despite this, only 4% of lateral third fractures treated conservatively progressed to operative management; 78% of lateral third non-unions were asymptomatic and operative management was refused by the patient. Non-union of middle third fractures is less common than lateral third fractures, but a larger number of these patients were symptomatic and did progress to operative management. Overall, only 2.6% of our patients developed symptomatic non-union requiring operative management, and as such we will be continuing our policy of conservative management for all clavicle fractures except in specific circumstances (polytrauma, neurovascular injury, open/impending open fracture, floating shoulder). We would recommend that patients with displaced fractures be advised of the possibility of non-union developing with conservative management, and that patients with displaced fractures of the middle third be advised of the possible need for operative management in the event of non-union. We did not encounter enough medial third fractures to make any justifiable comment.

Although no one single classification system was found to be entirely superior to the others, we found that Robinson's classification was more specific for different fracture patterns in the middle third, while Craig's classification was more specific for fractures of the lateral third. We would suggest that greenstick fractures in the lateral third are rare, and that including this subgrouping in the classification of middle third fractures may be prognostically more relevant.

References

- Moore TO (1951) Internal pin fixation for fracture of the clavicle. *Am Surg* 17(7):580–583
- Neer CS (1968) Fractures of the distal third of the clavicle. *Clin Orthop Relat Res* 58:43–50
- Nordqvist A, Petersson C (1994) The incidence of fractures of the clavicle. *Clin Orthop Relat Res* 300:127–132
- Postacchini F, Gumina S, De Santis P, Albo F (2002) Epidemiology of clavicle fractures. *J Shoulder Elbow Surg* 11(5):452–456
- Neer CS (1960) Nonunion of the clavicle. *JAMA* 172:1006–1011
- Stanley D, Trowbridge EA, Norris SH (1988) The mechanism of clavicular fracture. A clinical and biomechanical analysis. *J Bone Joint Surg Br* 70(3):461–464
- Allman FL (1967) Fractures and ligamentous injuries of the clavicle and its articulation. *J Bone Joint Surg Am* 49(4):774–784
- Craig EV (2006) Fractures of the clavicle. In: Rockwood CA, Green DP (eds) *Fractures in adults*, vol 1, 6th edn. Lippincott Williams & Wilkins, Philadelphia, pp 1216–1217
- Robinson CM (1998) Fractures of the clavicle in the adult. Epidemiology and classification. *J Bone Joint Surg Br* 80(3):476–484
- Rowe CR (1968) An atlas of anatomy and treatment of midclavicular fractures. *Clin Orthop Relat Res* 58:29–42
- Stanley D, Norris SH (1988) Recovery following fractures of the clavicle treated conservatively. *Injury* 19(3):162–164
- Hill JM, McGuire MH, Crosby LA (1997) Closed treatment of displaced middle-third fractures of the clavicle gives poor results. *J Bone Joint Surg Br* 79(4):537–539
- McKee MD, Pedersen EM, Jones C, Stephen DJ, Kreder HJ, Schemitsch EH, Wild LM, Potter J (2006) Deficits following nonoperative treatment of displaced midshaft clavicular fractures. *J Bone Joint Surg Am* 88(1):35–40
- Nordqvist A, Petersson CJ, Redlund-Johnell I (1998) Mid-clavicle fractures in adults: end result study after conservative treatment. *J Orthop Trauma* 12:572–576
- Robinson CM, Court-Brown CM, McQueen MM, Wakefield AE (2004) Estimating the risk of nonunion following nonoperative treatment of a clavicular fracture. *J Bone Joint Surg Am* 86(7):1359–1365
- Lee KW, Lee SK, Kim KJ, Kim YI, Kwon WC, Choy WS (2010) Arthroscopic-assisted locking compression plate clavicular hook fixation for unstable fractures of the lateral end of the clavicle: a prospective study. *Int Orthop* 34(6):839–845
- Lee YS, Lau MJ, Tseng YC, Chen WC, Kao HY, Wei JD (2009) Comparison of the efficacy of hook plate versus tension band wire in the treatment of unstable fractures of the distal clavicle. *Int Orthop* 33(5):1401–1405
- Simpson NS, Jupiter JB (1996) Clavicle nonunion and malunion: evaluation and surgical management. *J Am Acad Orthop Surg* 4(1):1–8
- Wilkins RM, Johnston RM (1983) Ununited fractures of the clavicle. *J Bone Joint Surg Am* 65(6):773–778
- Manske DJ, Szabo RM (1985) The operative treatment of midshaft clavicular non-unions. *J Bone Joint Surg Am* 67(9):1367–1371
- <http://www.cso.ie/census>
- Neer CS (1963) Fractures of the distal clavicle with detachment of the coracoclavicular ligaments in adults. *J Trauma* 3:99–110
- Bishop JY, Flatow EL (2005) Pediatric shoulder trauma. *Clin Orthop Relat Res* 432:41–48
- Nowak J, Holgersson M, Larsson S (2004) Can we predict long-term sequelae after fractures of the clavicle based on initial findings? A prospective study with nine to ten years of follow-up. *J Shoulder Elbow Surg* 13(5):479–486
- Howard FM, Shafer SJ (1965) Injuries to the clavicle with neurovascular complications. A study of fourteen cases. *J Bone Joint Surg Am* 47(7):1335–1346
- Zenni EJ, Krieg JK, Rosen MJ (1981) Open reduction and internal fixation of clavicular fractures. *J Bone Joint Surg Am* 63(1):147–151
- Khalil A (2009) Intramedullary screw fixation for midshaft fractures of the clavicle. *Int Orthop* 33(5):1421–1424