



■ TRAUMA

Distal third clavicle fractures

A NATIONWIDE TRAINEE-LED COLLABORATIVE REVIEW OF CURRENT PRACTICE

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Third Clavicle
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Aims

Distal third clavicle (DTC) fractures are increasing in incidence. Due to their instability and nonunion risk, they prove difficult to treat. Several different operative options for DTC fixation are reported but current evidence suggests variability in operative fixation. Given the lack of consensus, our objective was to determine the current epidemiological trends in DTC as well as their management within the UK.

Methods

A multicentre retrospective cohort collaborative study was conducted. All patients over the age of 18 with an isolated DTC fracture in 2019 were included. Demographic variables were recorded: age; sex; side of injury; mechanism of injury; modified Neer classification grading; operative technique; fracture union; complications; and subsequent procedures. Baseline characteristics were described for demographic variables. Categorical variables were expressed as frequencies and percentages.

Results

A total of 859 patients from 18 different NHS trusts (15 trauma units and three major trauma centres) were included. The mean age was 57 years (18 to 99). Overall, 56% of patients (n = 481) were male. The most common mechanisms of injury were simple fall (57%; n = 487) and high-energy fall (29%; n = 248); 87% (n = 748) were treated conservatively and 54% (n = 463) were Neer type I fractures. Overall, 32% of fractures (n = 275) were type II (22% type IIa (n = 192); 10% type IIb (n = 83)). With regards to operative management, 89% of patients (n = 748) who underwent an operation were under the age of 60. The main fixation methods were: hook plate (n = 47); locking plate (n = 34); tigtrope (n = 5); and locking plate and tight rope (n = 7).

Conclusion

Our study is the largest epidemiological review of DTC fractures in the UK. It is also the first to review the practice of DTC fixation. Most fractures are being treated nonoperatively. However, younger patients, suffering a higher-energy mechanism of injury, are more likely to undergo surgery. Hook plates are the predominantly used fixation method followed by locking plate. The literature is sparse on the best method of fixation for optimal outcomes for these patients. To answer this, a pragmatic RCT to determine optimal fixation method is required.

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Introduction

The number of clavicle fractures has more than doubled in the last ten years,¹ with clavicular fractures accounting for up to 4% of all adult fractures.² Distal third clavicle

(DTC) fractures comprise up to 28% of all clavicle fractures.³⁻⁵

Recent research has shown that DTC fractures are more common in the elderly female population,^{2,3} with the age and incidence of

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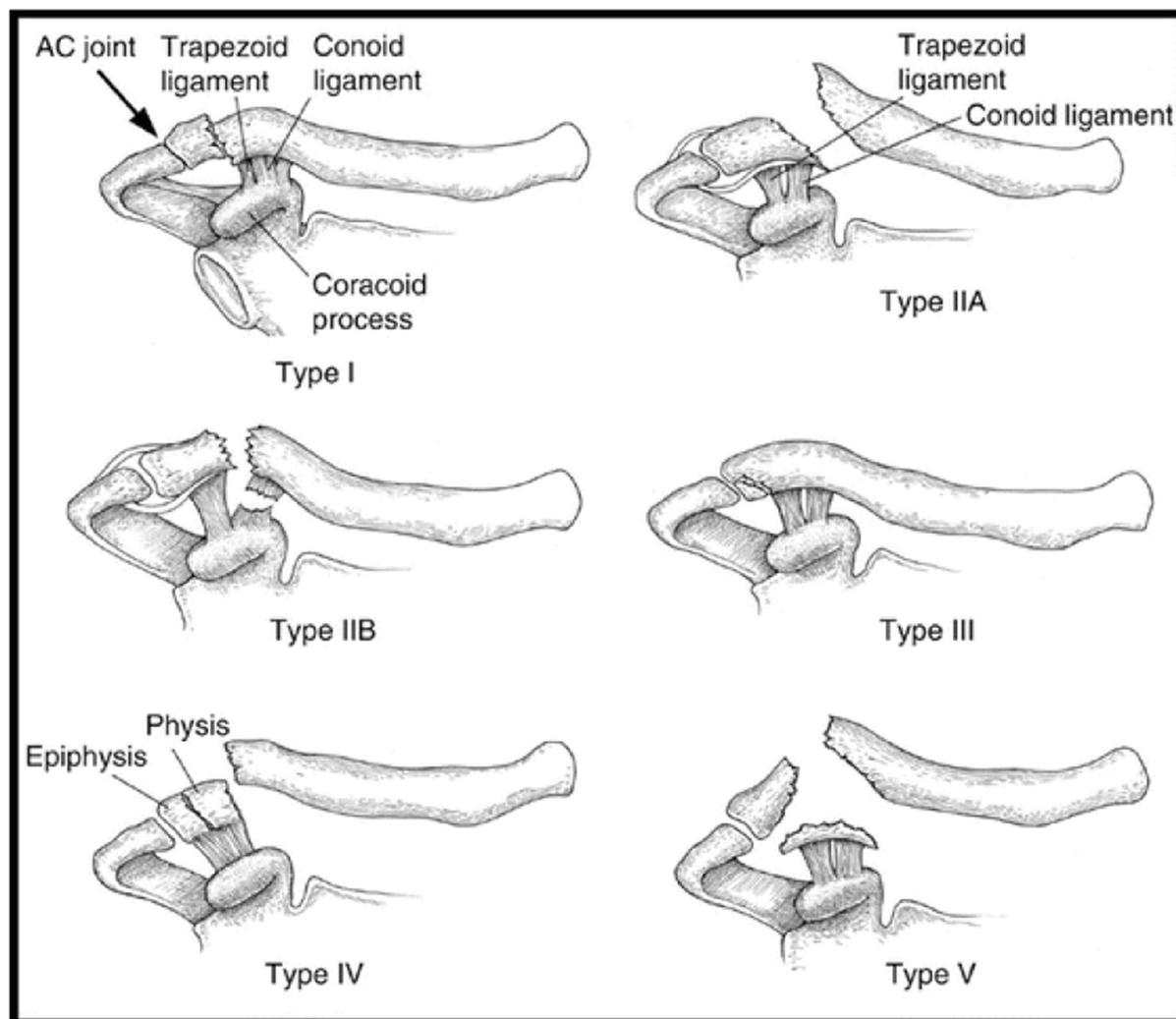


Fig. 1

Diagrammatic representation of the modified Neer classification for distal third clavicle fractures. AC, acromioclavicular.

Table I. A table summarizing the mechanisms of injury experienced and the number of patients in each category.

Mechanism of injury, n	Age group, yrs								
	18 to 20	21 to 30	31 to 40	41 to 50	51 to 60	61 to 70	71 to 80	81 to 90	91 to 100
Simple fall	6	34	37	37	75	75	93	105	25
High-energy fall	3	43	46	45	49	23	25	13	1
Pathological	0	0	0	0	1	0	0	0	0
RTA	1	15	8	8	10	7	1	3	0
Sport	1	7	12	3	1	0	0	0	0
Unknown	0	4	5	3	4	5	4	1	1
Direct blow	0	2	0	1	1	4	2	0	0
Assault	0	5	2	2	0	0	0	0	0

RTA, road traffic accident.

injury increasing in some parts of the UK.⁶ In the young active patient, fractures are often the result of direct trauma, frequently sport-related.³ However, in the elderly population, DTC fractures are often associated with low-energy falls combined with poor bone quality.³ Current

evidence also suggests that 10% to 50% of DTC fractures are displaced,² which may often play a role in management of the injury.

A number of different classification systems exist, but the modified Neer classification (Figure 1)⁷ describes the

Table II. A summary of the distribution of Neer classification.

Neer classification	n (%)
Type I	463 (54)
Type IIa	192 (22)
Type IIb	83 (10)
Type III	25 (3)
Type IV	8 (1)
Type V	77 (9)

Table IV. A breakdown of patients receiving operative versus conservative management according to Neer type.

Neer type	Treatment	
	Operative, n (%)	Conservative, n (%)
I	5 (1)	457 (99)
IIa	46 (24)	146 (76)
IIb	31 (37)	52 (63)
III	1 (4)	24 (96)
IV	2 (25)	6 (75)
V	23 (30)	54 (70)

fracture pattern in terms of displacement and the integrity of the associated coracoclavicular (CC) ligaments.^{8,9} Hence, it is a good indicator of stability and can be used as a method of determining when surgical treatment is indicated.^{2,3,5,9} It has been advocated that type I and III injuries, where the CC ligaments are intact, are stable and hence treated conservatively. Type II and V injuries are regarded as unstable with a higher risk of nonunion/malunion and are more often considered for surgical management.^{3,5}

The choice of operative management varies widely, with techniques ranging from plate fixation using a locking plate or hook plate to sling techniques for CC ligament reconstruction.³ There is significant evidence advocating each technique, with varying outcomes, but at present there is no consensus or guideline as to which technique offers the best outcomes nor robust comparative studies.^{3,5,9}

The primary aim of this study was to determine the number of distal clavicle fractures, their Neer type and mechanism of injury, their management (operative vs conservative), and the surgical techniques used. Secondary outcomes included observing the relationships between Neer type, bony union, management, and reoperation rates.

Methods

The study was reported according to Strengthening the Reporting of Observational Studies in Epidemiology guidelines.¹⁰ A multicentre collaborative retrospective cohort study was conducted. The study period was from 1 January 2019 to 31 December 2019, inclusive. Collaborators were

recruited from various NHS Trusts across the UK through a collaborative network, which included both major trauma centres (MTCs) and trauma units (TUs). Each collaborator registered the study locally with a clinical lead and with the clinical audit or research department of their respective trust. Collaborators compiled their individual data within an Excel spreadsheet (Microsoft, USA), which was prepared by the lead authors allowing ease for completion. This could then be transferred via secure NHS email accounts. To standardize data collection, strict inclusion and exclusion criteria as well as a detailed protocol was written and dispersed (Supplementary Material). Ethical approval from the Research Ethics Committee was not acquired as per the Health Research Authority decision tool. No patient-identifiable data were collected.

Operative techniques	n
Locking plate	34
Hook plate	47
Locking plate and anchor suture	1
Ligament fixation and fragment excision	1
Tight rope	5
Locking plate and ACJ recon	2
Locking plate and CC ligament recon	4
Suture fixation	2
Locking plate and tight rope	7
Excision of distal clavicle	1
Lockdown procedure	1
Not recorded	5

ACJ, acromioclavicular joint; CC, coracoclavicular.

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All patients over the age of 18 who presented with an isolated DTC fracture were included. Patients with concomitant acromioclavicular joint disruption were excluded. The following demographic variables were recorded for each patient: age at time of injury; sex; side of injury; mechanism of injury; and modified Neer classification grading. The number fixed operatively, whether the fracture went on to unite, complications of treatment and any subsequent procedures were also collected. Furthermore, the operative technique used was also noted. Union was determined by collaborators through review of the most recent radiograph for the patient, and any available correspondence for clinical assessment.

Statistical analysis. Baseline characteristics were described for demographic variables. Categorical variables were expressed as frequencies and percentages. Analysis was conducted using Excel. No direct comparison was made between trusts.

Table V. A summary of the Neer type and the operative technique used for each fracture type.

Neer type	Locking plate	Hook plate	Locking plate and anchor suture	Ligament fixation and fragment excision	Tight rope	Locking plate and ACJ recon	Locking plate and CC ligament recon	Suture fixation	Locking plate and tight rope	Excision of distal clavicle	Lockdown procedure	Not recorded
I	1	1	0	0	0	0	0	0	0	1	0	2
Ila	20	17	0	0	1	2	0	0	6	0	0	0
IIb	8	15	1	0	2	0	4	1	0	0	0	0
III	0	1	0	0	0	0	0	0	0	0	0	0
IV	0	1	0	0	1	0	0	0	0	0	0	0
V	3	12	0	1	1	0	0	1	1	0	1	3

ACJ, acromioclavicular joint; CC, coracoclavicular.

Table VI. A summary of radiological union at most recent follow-up.

Union	n (%)
Yes	478 (56)
No	125 (15)
Inconclusive	256 (30)

Table VII. A summary of the degree of bony union at most recent follow-up and treatment received.

Union	Operative, n (%)	Conservative, n (%)	Unknown, n (%)
Yes	83 (17)	395 (83)	0 (0)
No	8 (6)	117 (94)	0 (0)
Not recorded	19 (7)	236 (92)	1 (0.4)

Results

A total of 859 patients were recruited from 18 NHS trusts across England. Of the trusts included, 13 were MTCs and five were TUs. A total of 373 patients (43%) were from a MTC, while 57% were from a TU (n = 486). A full list of the participating trusts and the number of patients from each trust is available in the Supplementary Material. Overall, 56% of patients (n = 481) were male and the side of injury was evenly distributed. The mean age of patients was 57 years (18 to 99).

Primary outcomes. The mechanisms of injury and the number of patients in each category are summarized below (Table I). The distribution of Neer classification can be seen in Table II. Simple fall (57%) was the most common mechanism of injury followed by high-energy fall (29%). Only one patient suffered from a pathological fracture secondary to metastatic disease. The majority of simple falls occurred over the age of 60 years (61%). Conversely, 75% (n = 186) of high-energy falls occurred under the age of 60. All sports-related injuries occurred in patients aged 60 years or under.

A total of 87% of patients (n = 748) had conservative management. The remaining 110 patients had operative management while one patient had an unrecorded treatment.

Operative techniques used ranged from locking plate to excision of distal clavicle, and are summarized in Table III. The most common operative techniques were fixation with a locking plate (31%; n = 34) and a hook plate (43%; n = 47).

Of the 47 hook plate fixations, 32 required subsequent removal of metalwork. Four were due to pain, two were due to infection, and one was due to nonunion. The

indication for removal in the other patients were not recorded.

Secondary outcomes. A summary of Neer type versus treatment received is summarized in Table IV. It is important to note that type IIa fractures had the highest number of surgical treatments (n = 46), although this represents only 24% of all type IIa fractures.

Furthermore, a breakdown of Neer type and the operative technique used can be seen in Table V. A similar number of hook plate fixations were performed in type IIa, IIb, and V fractures (n = 17, 15, and 12, respectively). Interestingly, locking plate fixation was most frequently used in type IIa fractures, with 20 patients undergoing the procedure.

The full details of degree of bony union are summarized in Table VI. The majority of patients who had radiological bony union were treated conservatively (n = 395; 83%). The relationship between the degree of union and the treatment received is summarized in Table VII.

The relationship between the degree of union and the operative technique used is summarized in Supplementary Table ii. Patients with evidence of bony union had the widest range of operative techniques. Conversely, in patients who did not have evidence of union, the majority of patients had fixation with a locking plate (three patients) or hook plate fixation (four patients). The relationship between Neer type and union as well as management is described in Table VIII. Overall, 89% (n = 57) of type II fractures treated operatively went on to achieve bony union. Conversely, only 67% of type II injuries treated conservatively achieved bony union. Similarly, 94% of type V fractures treated operatively went

Table VIII. A summary of the relationship between Neer type, treatment received, and union rate.

Neer type	Operative treatment and bony union, n (%)	Operative treatment and nonunion, n (%)	Conservative treatment and bony union, n (%)	Conservative treatment and nonunion, n (%)
I	4 (100)	0 (0)	258 (82)	57 (18)
IIa	34 (94)	2 (6)	70 (71)	28 (29)
IIb	23 (82)	5 (18)	18 (55)	15 (45)
III	1 (100)	0 (0)	11 (69)	5 (31)
IV	2 (100)	0 (0)	4 (80)	1 (20)
V	17 (94)	1 (6)	26 (70)	11 (30)

on to unite but only 70% of those treated conservatively achieved bony union. In total, 82% of type I fractures treated conservatively achieved bony union.

Of the patients who did not go on to show any evidence of radiological union, 13 went on to have further operations (four awaiting procedure, two removal of metalwork, one removal of metalwork and revision of fixation, and six open reduction and internal fixation (ORIF)). The four patients awaiting procedure consisted of one type I fracture (treated conservatively), one type IIa requiring revision of hookplate fixation, and two type IIb treated conservatively with symptomatic nonunion. Of the six who required ORIF, all the patients had been initially treated with conservative management (one type I, three type IIa, one type IIb, one type IV). The two patients who required removal of metalwork had been treated operatively with hook plate fixation (one type IIa, one type IV). Similarly, the one patient (type V) requiring removal of metalwork and revision of fixation also had hookplate fixation.

Discussion

Our study provides the first and largest multicentre national review of DTC fractures in the UK. There was a similar distribution of patients from both TUs (57%) and MTCs (43%), providing a good representation of the general population. A total of 853 patients were recruited in this study, which is comparable to previous epidemiological studies and makes this one of the largest epidemiological studies to focus on DTC fractures to date.^{4,6,11}

A simple fall of 1 m or less onto the shoulder was the most common cause in this study. Current literature has reported that falls, road traffic accidents (RTAs) (mainly cycling), and sport-related injuries to be the most common mechanisms of injuries contributing to clavicular fractures overall.^{4,11–13} However, we found RTAs and sport-related activities made up 6% (n = 53) and 3% (n = 24) of mechanisms of injury, respectively. Additionally, falls from bicycles were classified as a high-energy fall, in addition to falls of over 2 m. Given the high proportion of high-energy falls in our study (29%), a significant number of these could have been bicycle-related injuries. Overall, 61% of simple falls occurred in patients over the age of 60. This is in keeping with the finding of Court-Brown et

al,¹⁴ which showed that falls were the leading cause of clavicle fractures in patients aged 65 or over.¹⁴ At this age, the risk of osteoporosis is much greater, thus patients are at higher risk of fragility fractures.¹⁵

The modified Neer classification has been shown to have good interobserver agreement.¹⁶ We can therefore use this fairly reliably and be relatively confident about collaborator classification consistency. In this study, 57% (488) of the fractures were undisplaced (54%, 463 type I, 3%, 25 type III), which is similar to previous epidemiological studies. Although using a different classification system, Nordqvist et al¹¹ also presented a majority of undisplaced distal clavicle fractures. At present, this study is the first to our knowledge to use the Neer classification in an epidemiological setting. Interestingly, eight patients were classified as having a Neer type IV injury and all patients were over the age of 18. This is unlikely to be truly accurate given that type IV injuries occur in skeletally immature children; these cases may well have signified delayed physal closure or possibly observer error.

Contrary to a recent national survey of British Elbow and Shoulder Society members,¹⁷ we have found a higher use of hook plate use; this discrepancy may well be related to surgical experience and preference. We found that there were slightly more hook plate fixations (43%) than locking plate fixations (31%). Hook plate fixation has been shown to produce similar functional outcomes and union rates when compared to CC ligament stabilization and locking plate fixation.¹⁸ Hook plate fixation also gives the added benefit of allowing immediate postoperative movement and active rehabilitation with subsequent quicker return to normal activities.^{19,20}

Overall, 68% (n = 32) of hook plates inserted in our patient cohort had subsequent removal of metalwork. This is unsurprising, as many authors and surgeons recommend the removal of the hook plate once fracture healing has occurred.^{19,21,22} The hook plate has been noted to cause discomfort on movement of the shoulder with additional complications, e.g. subacromial impingement and rotator cuff injury.^{19–21,23} In our study, 9% of hook-plate fixations required removal due to irritation of the metalwork on movement of the shoulder.

Type II (IIa 32%, IIb 37%) and V (30%) fractures had the highest rate of operative management. There is

ample evidence to suggest that type II fractures should be primarily treated with surgical fixation due to a higher rate of symptomatic nonunion following conservative management.^{5,23,24} This is reflected in our study as 89% (57) of patients with type II fractures treated operatively went on to achieve bony union. However, it is important to note that nonoperative management of type II fractures has also been advocated with similar functional outcomes between nonoperative and operative management, despite a higher incidence of nonunion with conservative management.^{23,25} In this study, 67% (n = 88) of type II fractures conservatively achieved bony union, while only 9% (n = 4) of the patients with nonunion required further operative management, implying that conservative management is a viable option for the treatment of type II fractures.

Similarly, type V fractures are also regarded as unstable due to the distal and proximal fragment not being connected to the coracoid process via the CC ligaments.²⁶ Therefore, operative management is also often advocated in this group.⁹ This is in keeping with our study where 30% (n = 23) of Neer type V fractures were treated operatively. Likewise, 94% (n = 17) of type V fractures treated operatively went on to develop bony union. However, the one patient who did not unite required revision fixation. Similarly, 30% of those treated conservatively developed nonunion, but none of these patients went on to have any further operations.

Unsurprisingly, 99% of Neer type I fractures were treated conservatively. Neer type I fractures are biomechanically stable due to the intact periosteum and CC ligaments which prevent further displacement.³ Hence, conservative management is the treatment of choice.³

The strengths of this study are that we have a large dataset which is multicentre and national, as well as a mix of MTCs and TUs, which provides a broad spectrum of clinician management. To our knowledge, this is the first and largest review of DTC fractures nationally.

We are also aware of the limitations of this study. The data were collected from a number of different trusts, each with their own different patient information storage systems. To standardize data and minimize bias, collaborators were provided with a clear protocol. However, we accept that this does not eliminate bias and some aspects of data collection will be subject to individual interpretation. We are also aware that there are no functional outcome data, which would be useful for comparative analysis. However, the aim of this study was to take a snapshot of current practice and with our current data, we can provide a summary of clinical practice in England.

In summary, this provides the first national review of operatively fixed DTC fractures. We have found that use of hook plates is still most common, with locking plate use not far behind. A pragmatic randomized controlled trial comparing both treatments and their outcomes would

be the next step in being able to provide robust data for optimal operative management of DTC fractures.



Take home message

- The majority of distal clavicle fractures are treated conservatively.
- Neer type II and V are the most common fracture patterns that are treated surgically, but there is some evidence to suggest conservative management may also be appropriate for these injuries.
- Locking plate and hook plate fixation are the most common surgical techniques used in distal clavicle fixation; no direct comparison has been performed and would be useful for future research.

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Supplementary material



The supplementary material contains a list of individual trusts and more information on the recorded outcomes.

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