



## Anatomically based classification of medial clavicle fractures

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Medial clavicle fractures represent less than 5% of all clavicle injuries. The purpose of this study was to evaluate reliability of a new anatomically based (AB) classification system compared to other classification systems and to evaluate the clinical outcome of nonoperative treated fractures.

55 acute medial clavicle fractures (55 patients) were 3D reconstructed and evaluated using the Edinburgh (ED), Throckmorton (TR) and new AB classification. The AB classification classified the fracture as medial (Type 1) or lateral (Type 2) to the costoclavicular ligament and no or minimal displaced (Type A) or displaced (Type B). Next, a consecutive retrospective clinical evaluation of 38 of these patients was performed using the Oxford Shoulder and Constant Score.

An anatomically based classification shows the highest inter- and intra-observer reliability. In case the fracture line originate medial to the costoclavicular ligament and is displaced the Constant and Oxford scores are significantly less.

**Keywords :** Medial Clavicle fracture.

### INTRODUCTION

A medial clavicle fracture is a rare injury, accounting less than 5% of all clavicle fractures (1,7,8). Several classification systems have been described. According to the classification system of Allman, a medial clavicle fracture is localized in the medial one-third of the clavicle (1). The Edinburgh classification (ED) describes a different

segmentation of the clavicle with type 1 medial fractures located within the one-fifth of clavicle bone lying medial to a vertical line drawn upward from the center of the first rib (Fig 1). In addition, subclassifications A and B describe the aspect of displacement. Displacement is defined as greater than 100% translation of the major fragments. Finally, type-1A and type-1B fractures are further subdivided into extra- or intra-articular (8). In 2007, Throckmorton (TR) described a new classification system in two ways, one system based on fracture pattern and another based on fracture displacement (Fig 2). Fractures were classified as transverse, oblique intra-articular, oblique extra-articular, comminuted, or avulsion. Fractures were classified as minimally displaced if there was less than

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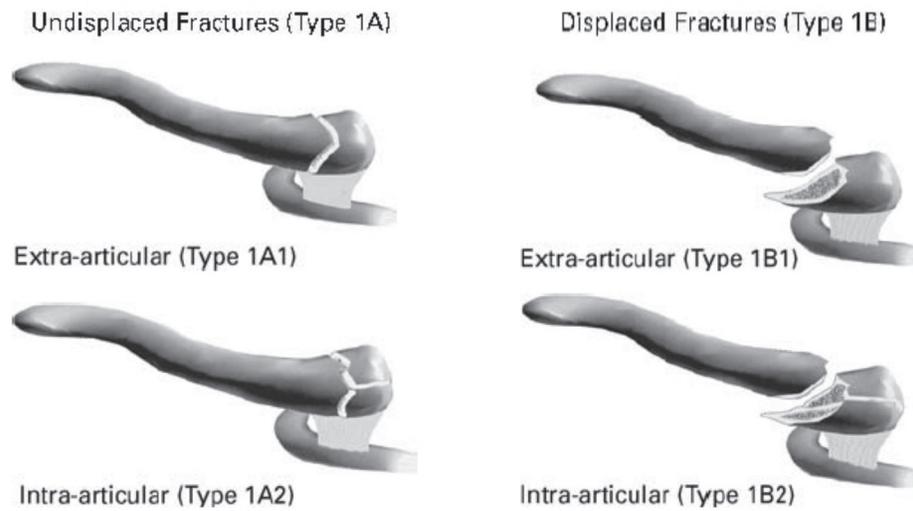
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*Fig. 1.* — Edinburgh classification

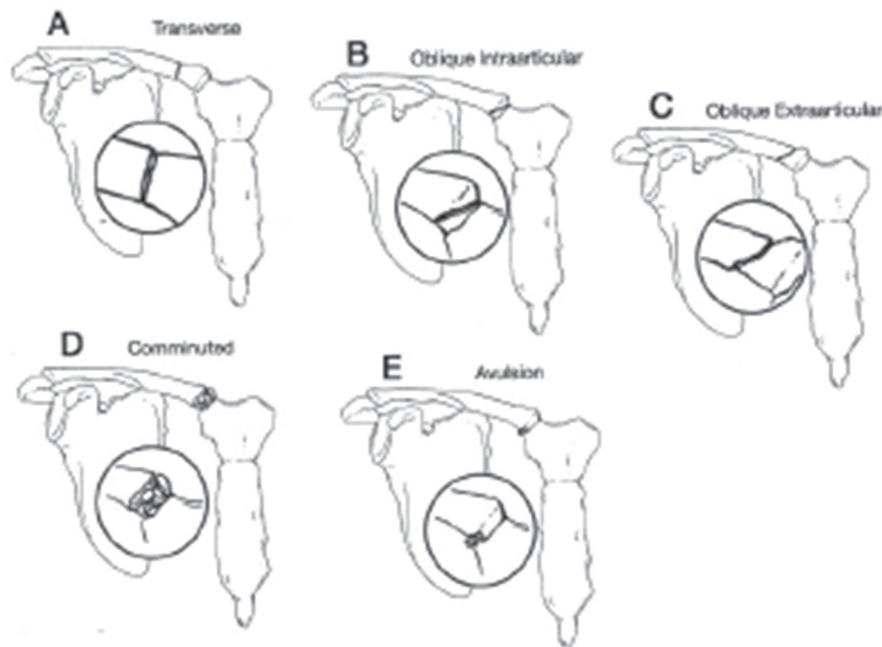
2 mm between fracture fragments. Moderately displaced fractures were those with 2 to 10 mm of gapping between fragments. Those fractures with more than 10 mm between fragments were classified as severely displaced (11). In contrast to the commonly used classification of Neer for distal clavicle fractures which is based on the location of the fracture in relation to the coracoclavicular ligaments and their intactness, no such classification is known for the medial clavicle fracture (4). Also, no clinical consequences have been attributed to the several medial clavicle fracture classifications. The purpose of this study was to describe a new anatomical based (AB) classification based on the location of the fracture line and its relation with the costoclavicular ligament, to evaluate the inter and intra-observer reliability of this new classification system compared to the ED and TR classification and to evaluate the correlation AB classification and the clinical outcome of nonoperative treatment.

This study has been reviewed by the ethics committee, a positive advice was give for this protocol by the Ethics committee UZ Ghent, Chairman: Prof. Dr. Rubens Registration number: B670201317840 EC 2013/475.

## MATERIALS AND METHODS

A retrospective analysis was performed on 55 patients diagnosed with a medial clavicle fracture who obtained a CT-scan in the acute setting between January 2007 and March 2014. All fractures were 3D reconstructed. A medial clavicle fracture was defined as a fracture located within the one-fifth of clavicle bone lying medial to a vertical line drawn upward from the center of the first rib (definition medial clavicle fracture ED classification). In all patients a nonoperative treatment was proposed by using a sling for comfort for six weeks and analgetics. After six weeks, if still using, the sling was removed and if still symptomatic a further use of analgetics was proposed. A nonoperative treatment was proposed of minimum 6 months post trauma. If symptoms were beyond 6 months post-trauma, a new CT-scan was performed.

A new AB classification was developed based on the location of the fracture line and its anatomical relation to costoclavicular ligament and the joint capsule, and the fracture displacement (bony contact or no contact between fragments). The AB classification classified the fracture as medial (Type 1) or lateral (Type 2) to the costoclavicular ligament and non or minimal displaced (Type A) or displaced



*Fig. 2.* — Throckmorton classification

(no contact between both fragments (Type B) (Fig 3).

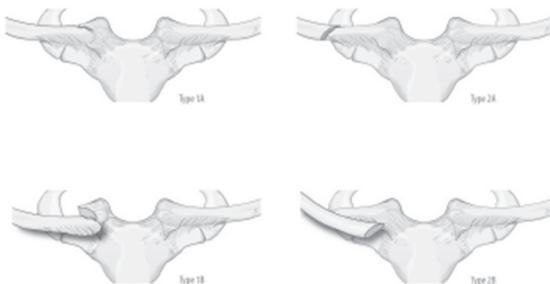
An intra- and interobserver reliability was evaluated for three classification systems (AB, ED, TR) Three different examiners (AVT, SVD, LDW) evaluated all clavicle fractures. One examiner (AVT) repeated the evaluation with a time interval of 21 days.

At last, a correlation was evaluated between the AB classification and the clinical outcome. If

no surgical treatment or long-term follow-up was performed, patients were contacted in May 2015 to complete a patient-based Constant-score and Oxford score (2,3). In case of symptomatic non-union or malunion, the pre-operative Constant score and the Oxford score were used as data for clinical outcome of nonoperative treatment of medial clavicle fracture.

Data was compiled in Microsoft Excel® and statistical analyses were performed with SPSS (IBM SPSS Statistics for Windows, Version 21.0). The intra- and interobserver reliability was assessed by Intraclass Correlation Coefficients (ICC) based on two-way random effect models, using an absolute agreement definition (10). Concerning the interpretation of the ICC: 0-0.2 indicates poor agreement; 0.3-0.4 indicates fair agreement; 0.5-0.6 indicates moderate agreement; 0.7-0.8 indicates strong agreement; and > 0.8 indicates almost perfect agreement.

Statistical analyses was performed using the Mann-Whitney U test.



*Fig. 3.* — Anatomically based classification

## RESULTS

In total, 55 reconstructed 3D CTs of acute medial clavicles fractures (55 patients) were analysed.

The intraobserver reliability of the ED, TR and AB was respectively strong, strong and almost perfect.

The interobserver reliability of the ED, TR and AB was respectively strong, strong and almost perfect (Table 1).

Demographic information is presented in Table 2. Concerning the clinical follow-up, 7 patients died as a result of the trauma associated with their injury and 4 patients died of a cause unrelated to the trauma. Forty-four patients were contacted with a minimum follow-up of 6 months of nonoperative treatment and a total of 38 patients filled in the questionnaire (Table 2). There was a significant difference in clinical outcome between Type 1B and Type 1A in both the Constant Score ( $p = 0.007$ ) and Oxford Shoulder Score ( $p = 0.036$ ). Because of the small number of Type 2 fractures, statistical analyses could not be performed. Of the Type 1B fractures, four were symptomatic non-unions. The patient with the symptomatic malunion had a Type 2B fracture.

## DISCUSSION

Currently the most common used classification systems for medial clavicle fractures are the Edinburgh classification and the Throckmorton classification. However both classifications have not been tested on intra and interobserver reliability and no clinical consequences have been attributed to these classifications. We developed a new classification based on the principle of the

Neer classification for distal clavicle fractures by analyzing the location of the fracture pattern and its anatomical relation to the costoclavicular ligament.

When analysing the fracture pattern of medial clavicle fractures, the most common fracture line originates medial to the costoclavicular ligament. This fracture line starts just anteriorly at the limit of the articular surface but includes a larger piece of bone posteriorly. As described by Van Tongel et al, there is a thick posterior sternoclavicular ligament/capsule that is attached to the superior and posterior two-thirds of the area of the medial surface of the clavicle and the posterior surface of the clavicle (13). It seems in this type of fracture pattern, the posterior piece of bone is still attached to the posterior sternoclavicular capsule.

If there is no or minimal displacement, it seems the costoclavicular ligaments are still attached to the lateral fragment (Type 1A). In case of rupture of the costoclavicular ligaments, the pectoralis major can pull the clavicle to the front and causes anterior displacement of the lateral fragment (Type 1B).

A much less common pattern is a Type 2 fracture. In this Type, the fracture line is lateral to the costoclavicular ligament. In contrast to the oblique pattern in Type 1, the fracture line is transverse. In case of displacement, shortening is probably caused by scapular protraction and loss of strut by the clavicle (12).

The new classification showed a higher inter and intra-observer reliability with an almost perfect agreement (Table 1).

In our opinion this is also the first study that correlates a classification of medial clavicle fracture with the clinical outcome of nonoperative treatment.

Overall, patients with a Type 1B fracture also showed lower Oxford Score and Constant Score and a higher non-union rate.

Table I. — Intra and interclass correlation coefficient

Classification systems	Intraclass correlation	95% confidence interval	Interclass correlation	95% confidence interval
Edinburgh classification	0,741	[0,412-0,886]	0,753	[0,521-0,883]
Throckmorton classification	0,719	[0,362-0,876]	0,775	[0,563-0,894]
Anatomical based classification	0,921	[0,820-0,965]	0,847	[0,702-0,928]

Table II. — Demographics

	Number of patients (Male/Female)	Average age	Lost for follow up	Number of patients follow-up (Male/Female)	Average follow-up (months)	Constant Score	Oxford Score
Type 1A	27 (17/10)	56 (between 29 and 83)	8 (3 associated death - 2 death unrelated to trauma - 3 non-responders)	19 (13/6)	53 (between 14 and 101)	79 (SD 14)	43 (SD 6)
Type 1B	19 (12/7)	58 (between 33 and 84)	6 (2 associated death - 2 death unrelated to trauma - 2 non-responders)	13 (8/5)	40 (between 6 and 67)	70 (SD 14)	38 (SD 11)
Type 2A	4 (3/1)	33 (between 23 and 69)	2 (1 associated death - 1 non-responder)	2 (1/1)	55 (between 48 and 63)	90 (SD 0)	48 (SD 0)
Type 2B	5 (3/2)	54 (between 19 and 80)	1 (1 associated death)	4 (2/2)	48 (between 29 and 60)	79 (SD 10)	41 (SD 4)
Total	55 (35/20)	56 (between 19 and 84)	17 (7 associated death - 4 death unrelated to trauma - 6 non-responders)	38 (24/14)	49 (between 6 and 101)	77 (SD11)	42 (SD 8)

The frequency of displacement in medial clavicle fractures has been described previously in several studies. Robinson et al evaluated all medial clavicle fractures between 1988 and 1994, and of the 28 patients observed, 5 patients showed displacement (18%) which they defined as more than 100% translation (8). In a second study that evaluated all clavicle fractures between 1997 and 2001, Robinson et al observed 24 patients with 8 showing displacement (33%, more than 100% translation) (9). In the study of Postacchini et al, 8 of 11 patients (72%) showed displacement (>3 mm). Nordqvist and Petersson found the overall incidence of medial displaced fractures was 20% (5). Throckmorton et al. evaluated 57 fractures and 25 (44%) showed no displacement (11). Thirteen (23%) fractures were categorized as moderately displaced, that is, those with 2 to 10 mm of gapping between fragments. Finally, those fractures with more than 10 mm between fragments were classified as severely displaced. Nineteen (33%) were classified as such. In our study, we only defined displacement if there is no bony contact. In our follow-up study 50 % (19 of 38 patients) showed displacement.

When evaluating the frequency of non-union of medial clavicle fractures, several different rates can be found in the literature. In the first study of Robinson et al., all medial clavicle fractures (displaced and undisplaced) healed uneventfully (28 patients) (8). In the second study, Robinson et al described a risk of 8.3% of non-union of medial clavicle fractures (20 patients) (9). Although the rate of non-union following displaced fractures (14.3%) was higher than that of non-displaced fracture (6.7%), this difference was not significant because of the small number of patients. In Nowak et al., two patients with medial clavicle fracture were followed for six months and one had a non-union, but no information on displacement of the fractures was described (6).

Throckmorton et al could not show a correlation between fracture comminution nor the amount of displacement and associated death. He did not evaluate the correlation between displacement and clinical outcome. When evaluating all fractures in our study, symptomatic non-union requiring surgery is only seen in displaced fractures. Also the clinical outcome of displaced medial clavicle

fracture Type 1B is significantly lower compared to nondisplaced fractures. Future research is necessary to evaluate if operative reduction and fixation in the acute setting would give a better outcome than nonoperative treatment.

An important limitation of this study is the lack of radiographic control of union of the medial clavicle fracture. Because of its location, the best investigation to evaluate union is a CT, but due to the lack of symptoms, no CTs were undertaken. Another limitation is the fact that this classification is based on CT scan and not on standard radiographic Xray. This means it can be less useful in situations where the use of a CT-scan is limited

### CONCLUSION

This study is the largest series on imaging of medial clavicular fractures and enabled the authors to elaborate a new classification system based on anatomical specificities (ligaments and bones). This classification is simple and shows a high inter- and intra-observer reliability. Moreover this classification has clinical implications because in case of Type 1B fractures (displaced fracture with the fracture line medial to the costoclavicular ligament) the prognosis is worse.

*Conflicts of Interest: No conflicts declared..*

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