

Intraoperative Clavicle Fracture Characterization And Radiographic Outcomes After Operative Fixation

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BACKGROUND

Clavicle fractures account for **2-5%** and **10-15%** of fractures in the adult and pediatric populations. While the optimal method for surgical treatment is not clear, segmental fracture patterns or significant comminution may require plate fixation instead of intramedullary devices to avoid shortening and loss of fixation.

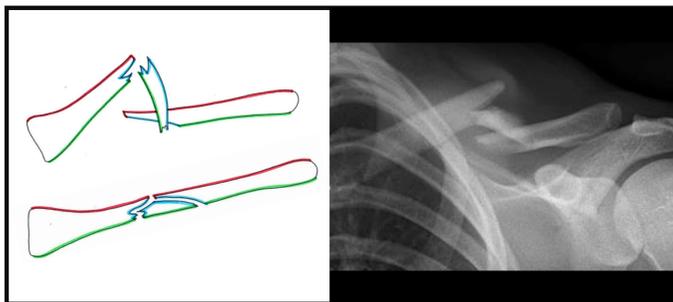


Figure 1. X-ray and diagram of hypothesized 'typical' length-stable clavicle fractures. In red is the posterior-superior cortical surface; green, the anterior-inferior cortical surface. Blue represents the non-cortical edges resulting from (in this case) 1 butterfly fragment.

Note that the butterfly fragment **does not segment the posterior-superior cortical surface** at all; in fact, we can obtain an intact cortical read along the P-S surface, tracing the red edge. Thus, the P-S surface is **length stable**.

No clavicle fracture classification differentiates between **length-stable** and truly **segmental** fracture patterns.

We hypothesize that **virtually all displaced clavicle fractures with butterfly comminution have the same general pattern with 1-3 butterfly fragments** anterior-inferior without segmental comminution, and a length-stable cortical read could be obtained at the posterior-superior diaphyseal region.

Purpose Of study

Characterize the origin, morphology, and size of clavicle fracture fragments

Determine frequency of segmental comminution vs. length-stable patterns.

Analyze butterfly fragment size, number, location of the cortical read.

Determine if pre-op radiographs are predictive of segmental vs. length-stable patterns.

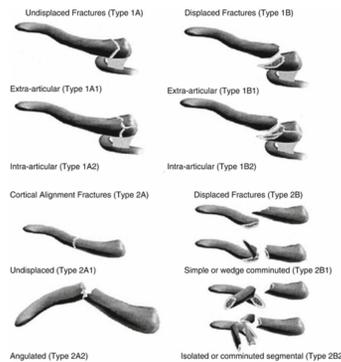


Figure 2. Robinson Classification of clavicle fractures describes "displaced" fractures as Subtype B1 – simple, wedge comminution or Subtype B2 – multifragmentary, segmental. Reproduced from Murray et al (European Surgical Orthopaedics and Traumatology, 2014)

RESULTS

Patient demographic information is outlined in **Table 1**. Mechanism of injury is further delineated in **Figure 3**. Regardless of the various activities during injury **45/53 (84.9%) describe a fall** directly on their shoulder.

Characterization of the fractures is summarized in **Table 2**. In these patients, a constant segment for a read for anatomic reduction was found in **44/53 (83.0%)** even though **54.7% of these patients were Robinson 2B2 fractures** based on pre-operative radiographs.

In those whom an anatomic read was achievable, **43/44 (97.7%)** had a read present in the posterior-superior aspect of the clavicle.

Looking at post-operative shortening we found a mean *lengthening* in the plate fixation group of **1.5 mm** and *shortening* of in the intramedullary pinning group **1.7 mm**, which was statistically significant ($p=0.017$).

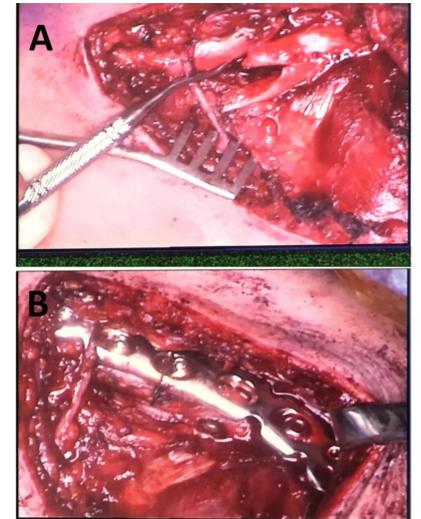


Figure 4: Intraoperative photograph of clavicle fracture with anterior-inferior butterfly fragment (A) and after reduction and plate fixation utilizing posterior superior cortical read (B).

Age [mean(range)]	30 (15-51)		
Gender	47 male	6 female	
Laterality	Right: 26	Left: 27	
Robinson classification	2B1: 24	2B2: 29	
Type of fixation	Plate fixation	Intramedullary pinning	
	34	19	
Mechanism of injury	Direct trauma to shoulder	Axial load through arm	Other
	45	5	3

Table 1: Patient demographic and injury information.

Presence of read	Yes	No	p-values
	44	9	
Location of fracture fragments	Anterior inferior	Circumferential	
	40	9	
Location of read	Posterior superior	Other	
	43	1 (anterior)	
Post-operative Length change (range)	Plate fixation	Intramedullary pinning	
	-1.5 mm (-10.7 to 10.2)	1.7 mm (-7.7 to 10.9)	0.017

Table 2: Characterization of fractures.

METHODS

A prospective descriptive study looked at 53 skeletally mature patients operatively treated for midshaft clavicle fractures at Madigan Army Medical Center and Medical University of South Carolina, Jan. 2014 – Jul. 2018, treated by 10 orthopaedic surgeons. Patient information collected includes:

- ❖ Age;
- ❖ Gender;
- ❖ Laterality of fracture;
- ❖ Robinson classification of fracture;
- ❖ Type of fixation;
- ❖ Mechanism of injury;
- ❖ Bilateral clavicle radiographs.

Post-operative bilateral clavicle x-rays were obtained and shortening measured to determine radiographic reduction. The mean shortening of fractures following fixation was compared by **unpaired, 2 tailed Student's t-test**.

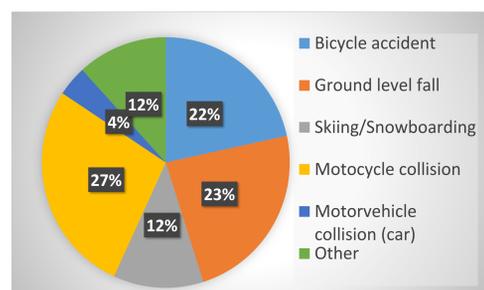


Figure 3: Mode of injury. Other included pedestrian versus car, longboarding, collision sport, direct trauma from falling object, and unknown secondary to intoxication.

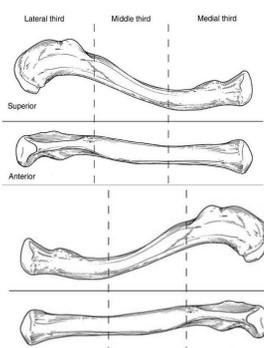
During surgery the surgeon filled out the **Intraoperative Clavicle Fracture Characterization Protocol form**:

INTRAOPERATIVE CLAVICLE FRACTURE CHARACTERIZATION PROTOCOL

NAME:
DATE OF SURGERY:
SURGEON/RESIDENT:

TAKE A PICTURE BEFORE AND AFTER ORIF (You can use the camera in the overhead OR lights. Please confidentially email or physically hand them to Chase Dukes chase.a.dukes.mil@mail.mil).

FRAGMENT NUMBER:
FRAGMENT SIZE (mm):
1) LENGTH WIDTH DEPTH
2) LENGTH WIDTH DEPTH
3) LENGTH WIDTH DEPTH



PLEASE ANSWER

Was the fracture segmental? Yes/No

Could a cortical read be achieved with the intact medial and lateral segments? Yes/No

What location best describes the location of the cortical read for judgement of length with the intact medial and lateral segments? (circle all that apply - e.g. :posterior-superior): posterior; anterior; superior; inferior

What location best describes the origin of the butterfly fragments/comminution?(circle all that apply - e.g. :posterior-superior): posterior; anterior; superior; inferior

CONCLUSION & DISCUSSION

84.9% of patients who could recall their mechanism of injury reported a direct blow to the shoulder.

- It makes sense that fracture occurs in a predictable pattern and has a stable fragments in a predictable location.

54.7% of our patients had Robinson 2B2 fractures radiographically; only 9 were truly segmental.

- Only these 9 fractures were considering length unstable and all required plate fixation.

44/53 (83.0%) had a direct reduction read and it was posterior-superior in 43/44 (97.7%) of cases.

- Even with comminution on the pre-op radiographs, intramedullary pinning is a viable option for most patients.

Understanding clavicle fracture patterns allows surgeons to use the posterior-superior surface to establish and restore pre-injury anatomy during repair and potentially bypass inferior comminution. This reduces need for dissection and stripping of the butterfly fragments, particularly when performing internal fixation.

No previous studies have described this **anatomic fracture pattern**. This is also the first study that shows **radiographic comminution is poorly sensitive** in detecting length unstable fractures.

LIMITATIONS

1. Intra-operative data is only available on patients selected for surgery. This **selection bias** could affect frequency and pattern of fractures observed.
 - ❖ However, it is reasonable to surmise that relatively lower energy injuries and less significant fractures would be treated non-operatively, thus over-estimating the relative rate of length unstable fractures among our population as a whole.
2. The study is only **modestly powered**.
3. Our population was **predominantly young males**, from a military population. However, other studies showed that nearly all clavicle fractures are caused by the same mechanism, so results should be similar in a female population and non-military population.