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ORIGINAL STUDY

The impact of upright radiographs of midshaft clavicle fractures on treatment recommendations

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Clavicle fractures' treatment recommendations are based on displacement. The goal of this paper is to determine upright clavicle radiographs at initial presentation changes timing and method of treatment. Retrospective study in a level 1 trauma center. 356 patients with clavicle fractures were reviewed. Patients with only supine radiographs (Group 1, 285 patients) were compared to patients with supine and upright radiographs (Group 2, 71 patients). Higher proportion of fractures in the upright vs supine radiographs were displaced 100% or more of the clavicle width, (52.1% vs. 33.5%, p =0.004). Treatment assignment changed from nonoperative to operative treatment more commonly in the Group 2 compared to Group 1 (43.7% vs 21.9%, p =0.019). The most common reason for surgery in Group 1 was presence of continued pain or failure to develop radiographic evidence of callus on serial radiographs (17, 53.1%) as compared to Group 2 (2, 14.2%, p =0.014). In Group 2 the most common cause for treatment change was displacement (12, 85.7%) as compared to Group 1 (15, 46.9%, p =0.014). Patients with upright x-rays are more likely to have a change in treatment because of displacement while patients that had supine x-rays have more delayed/nonunion.

Keywords : midshaft clavicle fractures ; upright x-ray ; nonunion ; displacement.
Level of evidence : 3

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All authors believe that the manuscript represent honest work.

INTRODUCTION

Clavicle fractures are the most common fracture of the upper extremity, with midshaft clavicle fractures accounting for 80% of these injuries [9]. Midshaft clavicle fractures that were once thought to heal uneventfully (1% nonunion) with benign neglect [12] are now recognized to have higher rates of nonunion (15-20%) and functional deficit *(5)*. Specifically non-operative treatment of displaced clavicle fractures is associated with lower shoulder strength and endurance as well as higher incidence of non-union *(2,8)*.

The Canadian Orthopaedic Trauma group identified elder age, female gender, comminution,

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and fracture displacement greater than 100% the width of the bone as risk factors for nonunion *(2)*. Murray et al identified overall fracture displacement, smoking status and comminution as independent risk factors for nonunion *(11)*.

Plocher et al found that 27% of operatively treated fracture initially presented with minimal displacement. Only in outpatient follow-up was fracture displacement identified *(13)*. This series suggests that injury radiographs, alone, are not sufficient to adequately assess fracture displacement. Backus et al studied the effect of upright radiography in clavicle fractures at presentation. The authors showed a 89% increase in fracture displacement with upright radiographs *(1)*. However, they focused on the radiographic implication (fracture displacement) of upright vs supine radiographs without discussion on affect on treatment recommendation.

To date no study, has examined the clinical value of upright clavicle radiographs and the resultant influence on treatment recommendations at the time of injury. The purpose of this study was to determine whether routine upright injury radiographs affect measurement fracture displacement and/or change treatment recommendations. The study hypothesizes that upright radiographs will show greater fracture displacement, which will lead to higher percentage of early operative intervention.

METHODS

Following approval by local Institutional Review Board a retrospective cohort series of midshaft clavicle fractures at a single level I trauma center from January 2008 through February 2012 was conducted. Inclusion criteria included midshaft clavicle fractures in skeletally mature patients. Patients with open fractures and patients younger than 18 years old, were excluded from the study. For the purposes of this study, midshaft was defined as a fracture occurring in the middle 1/3 of the clavicle (AO/OTA 13 B). If there was any question regarding location, the distance from the main fracture line to the lateral edge of the clavicle was taken and compared to the overall length of the clavicle.

From January 2008 to August 2012 all patients with clavicle fractures had initial single supine clavicle series radiographs (AP and Zenca) obtained in the emergency department or trauma recess bay as was standard practice. Our institute has a standardized x-ray protocol for clavicle fractures : anterior-posterior (AP) are taken when the patients back (both scapulae blades), and occiput touch the film board – the tube is centered over the middle of the clavicle and is tangential to the film board – 0 degrees of caudal or cranial angulation. The Zanca view is taken with similar patient position – the tube is tilted cephalad by 30 degrees**.** This can be done in both supine and upright position. Initial treatment recommendations were based upon these, supine radiographs, and subsequent displacement was assess with AP and Zanca radiographs obtained in routine clinic follow-up 2-3 weeks post injury. Beginning in August 2010 a change in clinical practice resulted in all patients with acute midshaft clavicle fractures undergoing standard supine films in the recess bay as well as upright radiographs during the initial hospitalization was adopted by all faculty at the trauma center. Upright radiographs included AP and Zanca views, performed with the patient standing, or seated if the patient was unable to stand. Maximal displacement in either AP or Zanca views was used. Patients were then divided into those without upright clavicle radiographs (Group 1), and those with supine and upright clavicle radiographs (Group 2).

Patient demographics, mechanism of injury, initial treatment recommendations, any change in treatment and reason for the change were recorded. Fractures were classified according to the AO/OTA system by a fellowship trained orthopaedic trauma surgeon (JAL). Initial fracture displacement (supine radiographs) as well as displacement on subsequent radiographs (upright radiographs) was recorded for all patients. Absolute fracture displacement (millimeters) was measured on AP and Zanca films by a single author (RW). In addition percent cortical displacement was calculated (Figure 1). For all patients initial and subsequent displacement was calculated. Initial recommendations for operative intervention and change in treatment from non-operative to operative treatment was at the treating

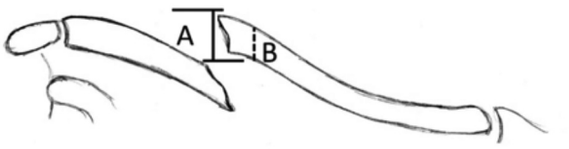

Figure 1. — Fracture displacement was measured as vertical translation and was recorded both as an absolute amount of displacement (mm), line A, and a percent of clavicle diameter, line A/line B.

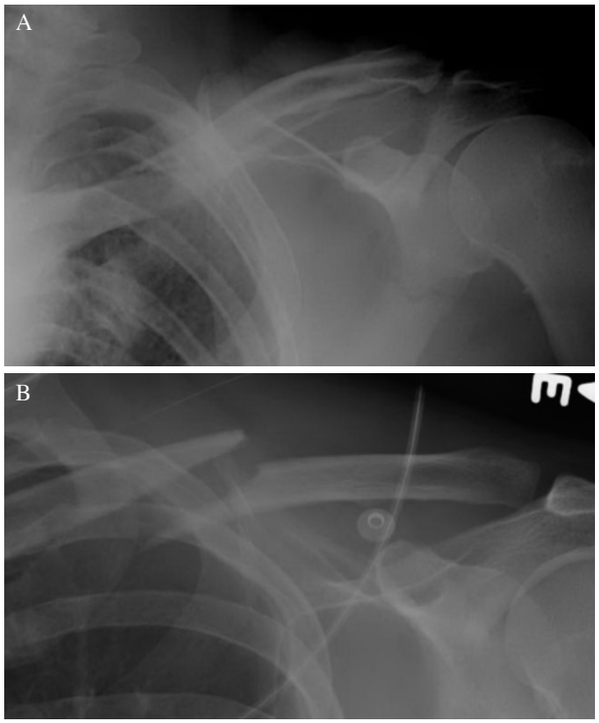

Figure 2 — X-rays of Medial inferior buttress – stable fracture (2A) and Lateral inferior buttress – unstable fracture (2B) buttress diagonal fracture patterns.

surgeon's discretion, and the reason for change in treatment was recorded from the electronic medical record. Method of surgical fixation was at the discretion of the treating trauma surgeon.

During fracture classification the authors observed a difference in direction of fracture obliquity, which is not currently accounted for in the AO/OTA system. A subgroup analysis of fracture displacement was therefore, performed for AO/OTA B1.2 fractures. Fractures were designated as being B1.2 medial inferior buttress or lateral inferior buttress based upon the direction of the fracture obliquity (Figure 2). Fracture displacement was compared between these two groups.

Statistical analysis was performed using SPSS version 16, by an experienced biostatistician (AH). Categorical data were presented by count (percent). Comparisons between the groups of categorical data were performed with a chi-square test $P<0.05$. Continuous data was presented as mean displacement (±standard deviation). Comparisons between groups of continuous data were done by Wilcoxon rank sum test. All reported p values are two-sided. P value below 0.05 was considered to be statistically significant.

RESULTS

Three hundred and fifty six mid-shaft clavicle fractures were identified between 2008-2012. Of these, 97 (27.2%) were females and 259 (72.8%) males. Mean age at the time of fracture was 38.31 (±15.8), with 148 (41.6%) fractures of the right clavicle and 208 (58.4%) of the left clavicle. The mechanism of injury was classified as being high or low energy in 330 (92.7%) and 20 (5.6) fractures, respectively. We were unable to classify the mechanism of injury in 6 patients secondary to inadequate documentation. High-energy mechanisms included motor vehicular collisions, motorcycle collisions, any crush injury, and fall from heights greater than 10 feet. Low energy was considered fall from standing. Using the AO/OTA classification system there were 186 (52.2%) B1, 101 (28.4%) B2 and 69 (19.4%) B3 fractures. There were no open fractures. There was no statistically significant difference between patient group demographic or mechanism of injury (Table 1).

Mean initial displacement in supine radiographs for all the patients was 8.2 (±8.6) mm. The mean initial displacement in supine radiographs was 8.59 mm (±9.0) and 6.64 mm (±6.3) in Groups 1 and 2, respectively (p value=0.228). Maximal displacement (either supine or upright when available) was 8.59 mm (±9.0) and 11.93mm (±8.5) in groups 1 and 2, respectively. This difference was found to be statistically significant (p value=0.001). The percent of patients with greater than 100% of displacement at initial presentation was 33.5%

Table 1 — Demographic data

	Group 1 (supine only x-rays, N=285)	Group 2 (supine and upright x-ray, N=71)	P value
Age	38.3 (15.9)	38.1 (15.2)	0.99
Gender Male Female	 202 (70.9%) 83 (29.1%)	 57 (80.3%) 14 (19.7%)	 0.111
Side Right Left	 115 (40.4%) 170 (59.6%)	 33 (46.5%) 38 (53.5%)	 0.349
Mechanism Low energy High energy Unknown	 20 (7.0%) 260 (91.2%) 5 (1.8%)	 0 (0.0%) 70 (98.6%) 1 (1.4%)	 0.069
Associated injuries Scapula Fx Floating shoulder Scapulothorasic dissociation Vascular injury	 9 (3.2%) 4 (1.5%) 3 (1.1%) 4 (1.5%)	 5 (7.0%) 0 (0%) 0 (0%) 0 (0%)	 0.65
OTA classification 15-B1 15-B2 15-B3	 149 (52.3%) 81 (28.4%) 55 (19.3%)	 37 (52.1%) 20 (28.2%) 14 (19.7%)	 0.992

Table 2. — Fractures and treatments summary

	Group 1 (supine only x-rays, N=285)	Group 2 (supine and upright x-ray, N=71)	P value
Displacement supine at presentation (min)	8.59 (±9.0)	6.64 (±6.3)	0.228
Maximal displacement at presentation (Sup or upright)	8.59 (±9.0)	11.93 (±8.5)	0.001
Displacement percent of clavicle at presentation. Displacement < 100% Displacement ≥ 100%	 187 (66.5%) 94 (33.5%)	 34 (47.9%) 37 (52.1%)	 0.004
Displacement at Follow Up (mm) for patients initially treated non-operatively	10.7 (±8.8)	9.89 (±9.2)	0.428
Displacement percent of clavicle at follow-up. Displacement < 100% Displacement ≥ 100%	 64 (43.8%) 82 (56.2%)	 18 (56.2%) 14 (43.8%)	 0.202
Difference in displacement between presentation and follow-up (mm)	4.33 (±9.7)	0.79 (±11.4)	0.058
Initial treatment Operative Non Operative	 111 (38.9%) 174 (61.1%)	 27 (38.0%) 44 (62.0%)	 0.99
Operative Tx type ORIF by plating IMN	 105 (94.6%) 6 (5.4%)	 22 (81.5%) 5 (18.5%)	 0.024
Treatment changed to operative Tx	32/146 (21.9%)	14/32 (43.7%)	0.019
Reasons for treatment change Displacment Nonunion	N=32 15 (46.9%) 17 (53.1%)	N=14 12 (85.7%) 2 (14.2%)	 0.014
Time to ORIF of patients initially assigned to ORIF (days)	5.59 (±10.2)	4.19 (±4.1)	0.488
Time to ORIF of patients initially assigned to conservative Tx (days)	36.5 (±40.0)	10.29 (±7.2)	0.014

ORIF=Open reduction and internal fixation; IMN = intramedullary nail.

Table 3. — B1 diagonal fractures according to direction

	B1.2 Medial inferior buttress stable (N=31)	B1.2 Lateral inferior buttress unstable (N=72)	P value
Maximal displacement at presentation (Sup or upright)	5.08 (±6.3)	8.80 (±7.4)	0.015
Difference between supine and upright at presentation	2.87 (±6.1, N=14)	4.24 (±5.7, N=10)	0.259
Treatment Operative Nonoperative	 2 (6.5%) 29 (93.5%)	 29 (40.3%) 43 (59.7%)	 0.001
Change in initial treatment	4/29 (13.8%)	9/43 (20.9%)	0.440
Reasons for treatment change Displacement Nonunion	 2 (50%) 2 (50%)	 6 (60%) 4 (40%)	 0.733

and 52.1% in Groups 1 and 2, respectively. This difference was found to be statistically significant (p value=0.004).

Mean displacement at clinic follow-up for all patients initially treated non-operatively was 10.54 mm (±8.9). Upright radiographs obtained in clinic follow up for those fractures initially treated non-operatively showed no statistically significant difference fracture displacement for either group (Table 2). The mean difference in displacement between initial and follow-up x-ray was 4.33 mm (±9.7) and 0.79 mm (±11.4) in Groups 1 and 2, respectively (p value=0.058).

Initial non-operative treatment was recommended for 218 (61.2%) all patients. There was no statistically significant difference between the groups (p value=0.99). Out of the patients that were initially assigned to non-operative treatment follow up was available for 172 patients (81.6%). Of the patients with initial non-operative management, 146 (of 174, 84.8%) patients in Group 1 and 32 (of 44, 72.7%) patients in Group 2 were available for follow-up (p value=0.135). Treatment recommendation was changed in 46 patients, 21 (21.9%) and 14 (43.7%) patients in the Groups 1 and 2, respectively. This difference was found to be statistically significant (p value=0.019). The most common indication for change in treatment was pain in the Group 1 (53.1%), and displacement in Group 2 (85.7%). This difference was statistically significant (p value=0.014). For patients that were initially assigned to non-operative treatment and were operated, the mean time to ORIF for was 36.5 (±40.0) and 10.29 (±7.2) days for the supine and upright groups, respectively. This difference was found to be statistically significant (p value=0.014).

Subgroup analysis of 13 B1.2 fractures showed that fractures with lateral inferior buttress had initial displacement of 8.8 mm (±7.4), while those with a medial inferior buttress demonstrated initial displacement of 5.08 mm (±6.3). This difference was statistically significant (p value=0.015). As a result more fractures with lateral inferior buttress were treated operatively ; 29 (40.3%) and 2 (6.5%) patients in the lateral and medial inferior buttress groups, respectively (p value=0.001, Table 3).

DISCUSSION

This manuscript studied the clinical value of upright x-ray during initial evaluation of mid-shaft clavicle fracture displacement and resultant effect on treatment recommendations. Data presented supports that upright x-rays taken at the time of injury reveal additional fracture displacement compared to supine films (p=0.001), and that this displacement represented a indication of surgery (≥100%) which resulted in a change in treatment recommendation leading to surgery on an average of 10.6 days post injury. It was also observed that injury upright radiographs reveal most displacement as those patients treated non-operatively with upright radiographs had on average 0.79 mm of displacement on follow up x-rays. The importance of this data is in the identification of patients for whom fracture displacement is identified early and allows a change in treatment recommendations affording earlier recovery. In this data it was observed that

there was no difference in the incidence of surgery between groups but that those in Group 1 had surgery based upon persistent pain and on an average of 36 days post injury.

The authors are careful to interpret this data. Clavicle treatment recommendations have shifted from begin neglect, to operative care on many fractures, and is now, arguably, settling into evidence based recommendation for operative treatment of those fractures with high risk of non-union. One such indication is fracture displacement. Robinson et al and Murray et al have reported nonunion rates of 13% *(11,15)* where fracture displacement was a significant risk factor for nonunion in non-operative fractures. Several randomized controlled studies have shown that advantage of operative treatment of displaced clavicle fractures *(2,7,16-18,19,20)*. They have also shown 5-12 point improvement in Constant scores between operative and non-operative care, and fracture nonunion was described as the major complication in non-operated patients where displacement was a risk factor. In a meta-analysis of 6 randomized controlled trials, Mckee et al, reported nonunion rates of 15% and 1% for conservative and operative treatments, respectively *(10)*. It therefore stands to reason that early iden-tification of fracture displacement will improve treatment recommendations and possibly limit nonunions.

Plocher, et al, studied progressive displacement clavicle fractures in the clinic setting for patients initially treated non-operatively. The authors found progressive fracture displacement in 30% of their patients ultimately lead to a change in management from conservative to operative. The average displacement progression was 131% (±63%) of clavicle width. They were unable to find any correlation between patient demographics, mechanism of injury or associated injury that increased the risk of displacement in this cohort *(13)*. In this study fractures upright x-rays showed subsequent displacement. This indicates that displacement can be detected at the time of initial hospital encounter, on upright radiographs. This is important for timely recognition, patient education, and consideration for operative treatment.

The current study also demonstrated a significantly shorter time to surgery in patients that were initially treated non-operatively and were followed with upright radiographs. This is especially important in light of the work by Potter et al, which showed delayed reconstruction of displaced midshaft clavicle fractures have worse Constant Shoulder Scores (89 vs 95) for delayed verses acute reconstruction, respectively *(14)*. Comparing delayed versus acute fixation, George et al showed an improvement of 4.6 (out of 10) in the DASH score in favor of acute operative treatment *(4)*. Jayaseenlan et al reported on 21 patients with brachial injury following delayed operative treatment for clavicular injury *(6)*. While not measured in these studies one must also consider an earlier return to function and potential return to work given the earlier time to surgery in those patients with operative fixation in Group 2.

The authors also observed a difference in fracture displacement between medial or lateral inferior buttress (B1.2 fractures). Fractures with a medial inferior buttress showed less initial displacement and lower operative rates than lateral inferior buttress fractures. We attribute this to the inferior pull of the lateral fragment through the coracoclavicular ligaments, deltoid muscle, and the weight of the upper extremity. The medial fragment is thought to maintain position balanced by the sternoclavicular joint, the sternocleidomastoid muscle and the pectoralis major muscle. The number of B1.2 fractures was too small to evaluate subsequent fracture displacement, however, the obliquity of the AO/OTA 13-B1.2 fracture may affect fracture displacement and treatment recommendations.

A potential limitation to our study is that while Zenca and AP views are standard radiographs of the clavicle x-rays were taken serially and not by the same technician. Therefore variability in technique may have affected measurements between images. Additionally only one author reviewed the fracture films and measured displacement and could not be blinded to the position in which the x-rays were taken based upon radiographic markers and labeling of x-rays at this institution.

Another limitation is the retrospective nature of the study design. One aspect of this was patient follow up. Only 178 of 218 initially non-operatively treated fracture followed up, which may have

altered our results but does represent 80% of the study population, which is considered acceptable. Additionally while performed at a single institution, with agreed upon surgical indications amongst the surgeons, variability in practice habits must be considered. The authors acknowledge that 93% of the patients presented fractured as the result of a high-energy mechanism and that similar results may not be born out in a lower energy group of patients. There were not enough low energy fractures for a direct comparison, which is a limitation of this study.

CONCLUSIONS

Upright, injury, radiographs reveal significant increase in fracture displacement for mid-shaft clavicle fractures. Displacement observed with initial upright radiographs does not progress with time, and therefore ultimate displacement is diagnosed earlier. Identifying early displacement results in earlier operative intervention but does not change the overall incidence of surgery for fractures designated for non-operative treatment based upon supine radiographs. Upright radiographs should be obtained on all mid-shaft clavicle fractures.

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