

A Biomechanical and Clinical Comparison of Midshaft Clavicle Fixation Performed with Either Two or Three Screws on Each Side of the Fracture

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Introduction

Displaced midshaft clavicle fractures are relatively common injuries and studies have shown that surgical plate fixation results in superior patient satisfaction and lower non-union rates than non-operative management.¹ In recent studies, the rate of non-union after plate fixation is 2.2 percent, whereas it is as high as 15.1 percent when treated non-operatively.² Surgical plate fixation with six cortices of purchase (three screws) on each side of the fracture has been the standard of care for plating displaced midshaft clavicle fractures.³ However, the use of locking plates and screws may afford equivalent biomechanical strength and clinical outcomes with only four cortices of purchase (two screws) on each side of the fracture. The purpose of this study is to compare the biomechanical and clinical performance of three-screw versus two-screw constructs for plating displaced midshaft clavicle fractures.

References

- Bernstein J., et al. Nonoperative treatment compared with plate fixation of displaced midshaft clavicular fractures. *J Bone Joint Surg.* 2007; 89(8):1866–1867.
- Zlowodzki M, Zelle BA, et al. Treatment of acute midshaft clavicle fractures: systematic review of 2144 fractures: on behalf of the Evidence-Based Orthopaedic Trauma Working Group. *J Orthop Trauma.* 2005;19:504-7.
- Altamimi, S., McKee, M., Canadian Orthopaedic Trauma Society. Nonoperative treatment compared with plate fixation of displaced midshaft clavicular fractures. *J Bone Joint Surg.* 2008;90-A(Surgical Techniques):1-2, 3, 4, 5, 6, 7, 8.

Methods

After simulating midshaft fractures in 10 pairs of embalmed cadaveric clavicles, the biomechanically inferior lateral fragments were randomly assigned to plate fixation with either three non-locking screws or two locking screws. Cyclic tensile loads (10 N to 75 N in a sinusoidal pattern at a rate of 1 Hz) were applied for 5 minutes along the long axis of the clavicle [Figure 1]. Then, the constructs were loaded to failure at a rate of 0.5 mm/s with pullout forces applied parallel to the long axis of the screws.

Additionally, we retrospectively identified 41 patients who had midshaft clavicle fractures surgically repaired by the senior author (SCC). Initially, three screws on each side of the fracture site and longer contoured plates were used, but following the availability of locking screws, only two screws (at least one locking) on each side of the fracture site and shorter

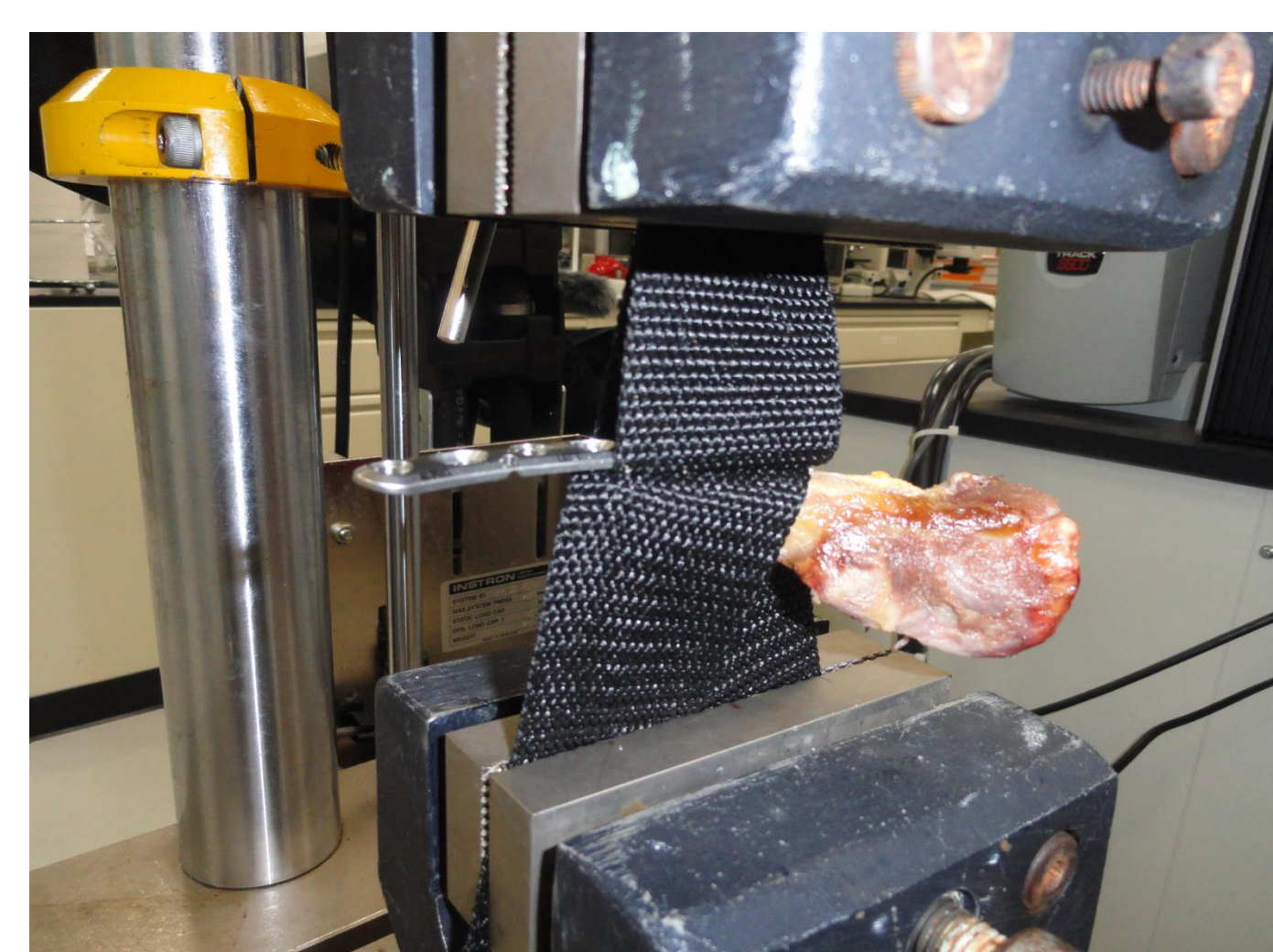
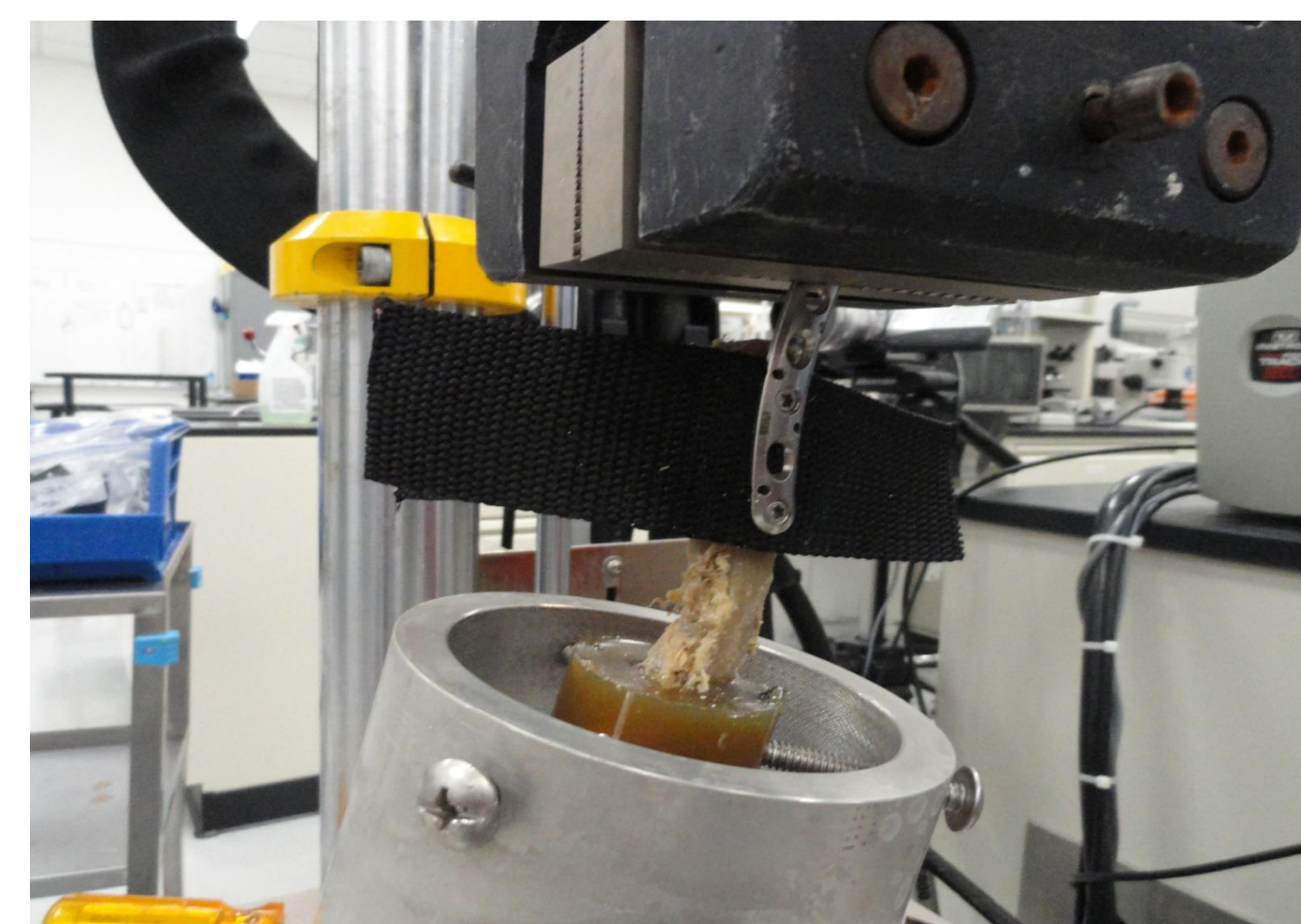


Figure 1: Biomechanical testing apparatus for the cyclic displacement test (top) and the pull-out to failure test (bottom).

straight plates were used. Proper sorting of these patients into the two groups was confirmed by looking at post-operative radiographs on our Picture Archiving and Communication System (PACS) [Figure 2]; 21 patients were treated with three-screw constructs and 20 patients with two-screw constructs. Patient reported outcomes, radiographic time to union, length of plates used, and complication rates were compared. Patients were contacted to participate in the patient-reported outcomes portion of the study. Those who agreed were sent a series of questionnaires via the Outcomes Based Electronic Research Database (OBERD). The questionnaires sent consisted of: American Shoulder and Elbow Surgeons (ASES) shoulder assessment, Constant Score, Visual Analog Scale (VAS) pain score, and the Single Assessment Numeric Evaluation (SANE).



Figure 2: Plain radiographs from patients who received midshaft clavicle ORIF with three screws proximal and distal to the fracture site (top) versus two screws proximal and distal to the fracture site (bottom).

Results

Biomechanically, there were no significant differences in cyclic displacement ($p=0.17$), stiffness ($p=0.94$), yield load ($p=0.65$), or ultimate load ($p=0.622$) between the two groups [Table 1]. Clinically, there were no significant differences in ASES score ($p=0.35$), Constant score ($p=0.34$), VAS pain score ($p=0.34$), SANE score ($p=0.99$), or average time to union ($p=0.74$) [Table 1]. We found that the length of plates used were consistently shorter in the two-screw group overall

($p<0.005$) and when broken down by comminuted ($p<0.005$) and non-comminuted ($p=0.039$) fractures, although for both the two-screw and three-screw groups larger plates were used for fixation of comminuted fractures. Complication rates trended toward being higher in the three-screw group with three cases of painful hardware requiring removal and one case of hardware failure (19%) and two cases of painful hardware requiring removal in the two-screw group (10%) ($p=0.20$).

	Two-Screws	Three-Screws
Biomechanics		
Cyclic Displacement	0.20 ± 0.12 mm	0.12 ± 0.10 mm
Pull-out Stiffness	217 ± 75 N/mm	214 ± 70 N/mm
Pull-out Yield Load	2465 ± 1092 N	2670 ± 1165 N
Pull-out Ultimate Load	2715 ± 1150 N	2496 ± 1102 N
Clinical Outcomes		
ASES	94.3 ± 3.6	98.0 ± 0.8
Constant	33 ± 1.7	30.6 ± 1.7
VAS Pain Score (100 point scale)	3.43 ± 2.2	1.0 ± 1.0
SANE	94.7 ± 3.4	94.7 ± 1.8
Average time to union	11.9 ± 1.0	11.4 ± 1.1
Average plate length		
Overall	7.24 ± 0.30 cm	9.56 ± 0.23 cm
Comminuted Fractures	8.05 ± 0.36 cm	9.86 ± 0.18 cm
Non-comminuted fractures	6.24 ± 0.20 cm	8.30 ± 0.62 cm

Table 1: Summary table of the data collected from the biomechanical and clinical portions of the study.

Conclusion

Plate fixation of displaced midshaft clavicle fractures with four cortices of purchase on each side of the fracture using two screws performs biomechanically and clinically equivalent to fixation with six cortices of purchase using three screws. Potential clinical benefits include decreased surgical exposure, morbidity, time, and cost. Particularly, with regards to midshaft clavicle fractures, the

reduction in the number of required points of cortical fixation from six to four allows the surgeon, in most instances, to use shorter and non-contoured straight plates, eliminating the extra time and technical difficulty associated with matching longer contoured plates to the variable and complex anatomy of the clavicle.