

## **Anterior-Inferior Plating Results in Fewer Secondary Interventions Compared to Superior Plating for Acute Displaced Midshaft Clavicle Fractures**

*Rafael Serrano-Riera, MD<sup>1</sup>; H Claude Sagi, MD<sup>2</sup>; Roy Sanders, MD<sup>2</sup>;*

*<sup>1</sup>FOI Tampa, Florida, USA; <sup>2</sup>Orthopaedic Trauma Service, Tampa, Florida, USA*

**Purpose:** We sought to determine if a difference in plate position for fixation of acute, displaced, midshaft clavicle fractures affects the rate of secondary intervention. Our null hypothesis was that there would be no difference.

**Methods:** After IRB approval, 266 patients treated surgically for an acutely displaced midshaft clavicle fracture between 2000-2012 were identified and reviewed retrospectively at a minimum of 24 months follow-up (F/U). Fractures were divided into two cohorts, according to plate position: anterior-inferior (AI) or superior (S). Exclusion criteria included age <16 years, incomplete data records, and loss to F/U. Group analysis included demographics (age, gender, BMI [body mass index]), fracture characteristics (mechanism of injury, open or closed), hand dominance, ipsilateral injuries, time between injury and surgery, time to radiographic union, length of F/U, and frequency of secondary procedures. Fisher exact test, t test and odds ratio were used for statistical analysis.

**Results:** Final analysis included 174 fractures / 173 patients. 111 (64%) were in group AI, and 63 (36%) were in group S. No differences in demographics, fracture characteristics, time to surgery, time to union, or length of F/U existed between groups. Six patients / six fractures (5.2%) in Group AI underwent a secondary surgery (4 patients had the plate removed due to irritation, 1 developed an infected nonunion, and another fell, refracturing the clavicle) whereas 14 patients / 14 fractures (21.8%) in group S required a secondary surgery (12 due to irritation from the plate, 1 developed a nonunion, and 1 presented with a fractured implant). An additional intervention secondary to superior plate placement was highly statistically significant ( $P = 0.002$ ). Furthermore, because 80% of these subsequent interventions were a result of plate irritation with patient discomfort, the odds ratio for a second procedure was 5 times greater in those fractures treated with a superior plate.

**Conclusion:** This Level III therapeutic retrospective comparative study indicates that when all other variables are held equal, an anterior-inferior plate appears to lessen clinical irritation and results in significantly fewer secondary operations. Considering patient satisfaction and a reduced financial burden to the health care system, we recommend routine anterior-inferior plate application when open reduction and internal fixation of the clavicle is required.

## Introducing the Surgical Therapeutic Index in Trauma Surgery: An Assessment Tool for the Benefits and Risks of Different Operative Fracture Treatment Strategies

*Olivier Van Der Meijden, MD, PhD<sup>1</sup>; Marijn Houwert, MD, PhD<sup>1</sup>;*

*Frans-Jasper Wijdicks, MD, PhD<sup>1</sup>; Marcel Dijkgraaf, PhD<sup>2</sup>; Luke Leenen, Prof. dr. <sup>3</sup>;*

*Michael Verhofstad, MD, PhD<sup>4</sup>; Egbert JMM Verleisdonk, MD, PhD<sup>1</sup>;*

<sup>1</sup>*Diakonessenhuis Utrecht, THE NETHERLANDS;*

<sup>2</sup>*Academic Medical Center, Amsterdam, THE NETHERLANDS;*

<sup>3</sup>*University Medical Center, Utrecht, THE NETHERLANDS;*

<sup>4</sup>*Eramus Medical Center, Zuid-Holland, THE NETHERLANDS*

**Background/Purpose:** The concept of the Surgical Therapeutic Index (STI) has been described as an indicator of the benefits and risks of surgical treatment in other fields of surgery. The index is calculated by dividing the cure rate of an operative treatment by the complication rate and should be interpreted as expressing a certain level of safety; the higher a procedure's STI, the safer the procedure. The STI introduces a concept to critically evaluate the pros and cons of surgical fracture treatment in general. The optimal treatment of clavicle fractures has been a topic of debate for many years. Although many of these fractures may be treated successfully without surgery, displaced midshaft clavicle fractures (DMCFs) are often treated surgically. This study compares the indices for surgical plate fixation (PF) and intramedullary fixation (IMF) for the treatment of DMCF. The purpose of this study is to introduce the concept and philosophy of the STI into fracture treatment by using operative clavicle fracture fixation as an example.

**Methods:** In a randomized controlled fashion 120 patients were assigned to either PF (n = 58) or IMF (n = 62) with follow-up at 6 weeks, 3 months, 6 months, and 1 year after surgery. Cure was defined by a Disabilities of Arm, Shoulder and Hand (DASH) score of 8 or less. Complications were noted as present or not present for each follow up moment. In addition, a panel of experts provided weights to encountered complications in order to correct for the gravity of their consequences, resulting in unweighted and weighted STIs. After bias correction and using nonparametric bootstrapping, STIs were reported along with their 95% confidence intervals. The higher a procedure's STI, the higher the benefit/risk balance of that procedure.

**Results:** One year after surgery 50 patients (86%) in the PF group and 55 patients in the IMF group (89%) were considered cured (P = 0.67). Superficial infection occurred in 3 (5%) patients in the PF group and 4 patients (7%) suffered from a complication requiring major surgical revision. The IMF failed in 2 patients (3%) and the rate of implant-related soft-tissue irritation was 55%. The nonweighted STI after 6 weeks was significantly higher in the PF group. During further follow-up the differences leveled out and turned nonsignificant. When weighing the complications the indices decrease but are significantly in favor of the PF group at 6 weeks and 6 months after surgery. At 1 year postoperatively, differences are not significant.

**Conclusion:** The STI may be a reliable tool to assess the benefits and risks of operative fracture treatment. Further studies on clavicle and other fractures with consistent results of this new scoring system are needed, before conclusions can be generalized. When de-

terminating the indices of PF and IMF, a significant difference in favor of PF was observed during the early phase of recovery, which was prolonged when correcting for the gravity of consequences of complications by using severity weights. One year postoperatively, the STI for PF and IMF were similar.

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**Effects of Injury and Social Factors on Functional Outcomes after Clavicle Fracture**

*Joshua Napora, MD; Dominic Grimberg, BS; Benjamin Childs, BS; Heather Vallier, MD; MetroHealth System, Cleveland, Ohio, USA*

**Purpose:** Controversy exists regarding surgical indications for clavicle fractures. Practice patterns have shifted toward more operative care in recent years. The purpose of the study is to evaluate effects of patient demographic, injury, and social characteristics on functional outcomes of clavicle fractures.

**Methods:** 739 skeletally mature patients with clavicle fractures over a 14-year period were identified. At a mean of 56 months follow-up 214 patients completed the American Shoulder and Elbow Surgeons (ASES) survey. It is a 20-item questionnaire with scores up to 100 points, higher scores indicating better function. Effects of age, gender, fracture location, open fracture, associated injuries, tobacco or alcohol use, employment status, and type and timing of treatment were assessed.

**Results:** The mean ASES score for the entire group was 81.7. The study group was 73% male, with mean age 45.3 years (range, 16 to 89). Fractures were classified as medial (OTA 15-A, n = 15), midshaft (15-B, n = 157), and lateral (15-C, n = 39). 4% were open fractures. 77 (36.0%) were treated with plate fixation (ORIF [open reduction and internal fixation]), while 137 had nonoperative management; mean scores were 84.0 versus 78.5, respectively,  $P = 0.054$ . Further investigation revealed better ASES scores in surgical patients with lateral (88.8 vs 73.2,  $P = 0.04$ ) and isolated (85.0 vs 69.6,  $P = 0.02$ ) fractures compared to nonoperative patients. Those with clavicle fracture with concurrent head injury had better functional outcomes than isolated clavicle fractures when treated nonoperatively (84.6 vs 71.8,  $P = 0.033$ ). Smokers (75.0 vs 82.9,  $P = 0.003$ ) and unemployed (72.3 vs 84.6,  $P < 0.001$ ) had the lowest ASES scores. With the numbers available, ASES scores were not associated with age, gender, or open fracture, with the exception of better ASES scores in 30-40 year olds with operative treatment versus nonoperative (90.9 vs 65.7,  $P = 0.0008$ ). Surgical timing was not related to outcome for patients treated <10 weeks versus >10 weeks, and <20 weeks versus >20 weeks after injury (both  $P > 0.36$ ).

**Conclusion:** Mean ASES scores showed good shoulder function in most patients. Indications for surgical care for clavicle fractures have been a topic of recent debate. This study provides insight for counseling patients on outcome expectations and highlights anatomical and social factors to be considered before determining a treatment plan. Additionally, initial nonoperative management for clavicle fractures may be a reasonable treatment plan with delay in surgical treatment showing no difference in ultimate outcomes.

	ORIF (n=77)	Non-operative (n=137)	All patients (n=214)
Men	85.1	79.3	81.6
Women	79.7	76.7	77.5
Smokers*	76.3	74.4	75.0
Non-Smokers <sup>∞*</sup>	86.8	80.7	82.9
Employed <sup>∞ †</sup>	88.5	81.8	84.6
Unemployed †	69.5	73.3	72.3
Isolated <sup>∞</sup>	85.0	69.6	80.3
Chest trauma	81.3	78.8	79.4
Multiple trauma	83.3	79.7	80.6
p<0.05: *all smokers v non-smokers; † all employed v unemployed; <sup>∞</sup> ORIF v non-operative			

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## Results and Outcomes after Midshaft Clavicle Fracture: Matched Pair Analysis of Operative Versus Nonoperative Management

Joshua Napora, MD; **Dominic Grimberg, BS**; Benjamin Childs, BS; Heather Vallier, MD; MetroHealth System, Cleveland, Ohio, USA

**Purpose:** Traditional conservative treatment of midshaft clavicle fractures has recently transitioned toward an operative approach in many patients. However, this is not a consensus practice in the orthopaedic community. Prior studies have not well defined those patients who benefit most from surgery, maintaining acceptable risk of complications and reasonable cost of care. This study evaluates clinical results and functional outcomes of closed, midshaft clavicle fractures for patients treated surgically matched with patients treated nonoperatively.

**Methods:** Closed, midshaft clavicle fractures in skeletally mature patients were identified from a Level I trauma center registry between 2002 and 2013. Eighty patients were treated primarily with open reduction and internal fixation with plating (ORIF), and 491 patients were treated nonoperatively. 71 matched pairs were generated based on age, gender, and fracture pattern (OTA 15B-1,2,3). Seven patients had inadequate radiographic follow-up after ORIF; although they had no known adverse events, they were excluded, leaving 64 pairs. Charts and radiographs were reviewed, and the American Shoulder and Elbow Surgeons (ASES) survey was administered. A poor outcome was defined as a treatment complication or ASES score <60.

**Results:** The study group consisted of 106 men and 22 women with mean age of 38.5 years (range, 16 to 71) and fracture patterns of 15B-1 (n = 76), 15B-2 (n = 44), and 15B-3 (n = 8). 38% of patients were tobacco smokers, with 22 in the operative group and 26 in the nonoperative group. Ten (15.6%) initial nonoperative patients underwent ORIF at a mean of 26 weeks (range, 7 to 48) due to persistent pain and motion at the fracture site, and 2 of these had elective implant removal after healing following ORIF. 14 of the 64 patients (21.9%) treated acutely with ORIF had 15 complications including: 1 deep infection, 2 nonunions, 1 malunion, 8 painful implants, and 3 implant failures, resulting in secondary procedures in 10 patients (15.6%). 35 patients with acute ORIF completed ASES surveys with mean score 81.7, while 64 initial nonoperative patients had mean ASES of 80.8. Seven patients (20.0%) after ORIF had ASES <60 (mean 40.5), while the initial nonoperative group had 9 patients (14.1%) with ASES <60 (mean 43.1, P = 0.84). Overall, the rate of poor outcomes was 20 of 64 in the operative group (31.3%) and 18 of 64 (28.1%) in the nonoperative group. Unemployment (P = 0.023) was associated with poor outcome, irrespective of type of treatment, while smoking (P = 0.13) and alcohol abuse (P = 0.29) were not significant with the numbers available.

**Conclusion:** Patient selection is an important factor in achieving good surgical outcomes. For patients matched in age, gender, and fracture pattern, initial surgical versus nonsurgical treatment resulted in similar total complication rates and no difference in functional outcomes. Social factors may prove to be greater predictors of outcomes. We support consideration of initial nonoperative management in closed midshaft clavicle fractures in patients with social risk factors for poor outcome.

## Scapular Dyskinesia Following Displaced Fractures of the Middle Clavicle

*Edward Shields, MD<sup>1</sup>; Caleb Behrend, MD<sup>2</sup>; Tanya Beiswenger, DPT<sup>1</sup>;*

*Benjamin Strong, MD<sup>1</sup>; Michael Maloney, MD<sup>1</sup>; Ilya Voloshin, MD<sup>1</sup>;*

*<sup>1</sup>University of Rochester, Rochester, New York, USA;*

*<sup>2</sup>Virginia Tech and arilion Clinic, Roanoke, Virginia, USA*

**Purpose:** This study was conducted to evaluate the rate of scapular dyskinesia and resulting patient outcomes following treatment of displaced, midshaft clavicle fractures.

**Methods:** Skeletally mature patients who sustained isolated, displaced midshaft clavicle fractures treated with or without surgery over a 16-month period were recruited. The minimum follow-up at study examination was 12 months. Patients were excluded with age less than 21 or over 80 years of age at the time of injury, and if they had concurrent traumatic injuries, prior fractures on the injured side, neurological injury (peripheral or spinal cord), frozen shoulder, shoulder replacement, and patients who were nonambulatory or not living independently. Based on these criteria, 32 patients were eligible for enrollment. Patient outcomes were documented using the SICK (Scapular malposition, Inferior medial border prominence, Coracoid pain and malposition, and dysKinesia of scapular movement) Scapula Rating Scale, Simple Shoulder Test (SST), three visual analog scale (VAS) pain scales, shoulder range of motion (ROM), and strength measurements. Scapular dyskinesia was defined as winging of the scapula at rest or with active abduction and at least a 1.5 cm or 5° difference in the resting position of the affected scapula compared to the unaffected. 24 patients (75%; 24 of 32) were successfully recruited.

**Results:** Average study participant age was  $46 \pm 17$  years with a mean follow-up at time of study evaluation of  $1.7 \pm 1$  years. Twelve (50%) underwent surgical fixation. Scapular dyskinesia was present in 37.5% ( $n = 9$ ) of patients, and only 1 (11%;  $n = 1$  of 9) of these patients had SICK scapula syndrome. The patients with scapular dyskinesia were similar regarding age, body mass index, psychiatric comorbidity, smoking status, initial fracture displacement, and length of time from injury or surgery to study examination compared to patients without dyskinesia. The patients with scapular dyskinesia had worse SICK scapula scores ( $5.8 \pm 2.2$  vs  $3.1 \pm 2.4$ ;  $P = 0.01$ ), worse SST scores ( $10.5 \pm 1.6$  vs  $11.7 \pm 0.8$ ;  $P = 0.029$ ), and worse average VAS pain scores in the week prior to examination ( $2.7 \pm 2.5$  vs  $0.2 \pm 0.4$ ;  $P < 0.001$ ) compared to patients without dyskinesia. ROM and abduction strength measures did not differ between groups. Only 1 patient treated with surgery (8%;  $n = 1$  of 12) developed scapular dyskinesia, compared to 8 of 12 patients (67%) treated nonoperatively ( $P = 0.009$ ).

**Conclusion:** Scapular dyskinesia is common after displaced, midshaft clavicle fractures and these patients experience more pain and have worse functional outcomes compared to patients who do not develop scapular dyskinesia. Surgical treatment of this injury may reduce a patient's risk for developing scapular dyskinesia and improve short-term outcomes.



**Proximal Humerus Fracture Fixation with Locking Plate: Screws with a Length of 45 mm or Longer Are Related to Increased Risk of Cutout**

*Julien Goulet, MD; Jérémie Ménard, Ing; Julien Chapleau, MD, MSc; Georges-Yves Laflamme, MD, FRCSC; Dominique Rouleau, MD, MSc, FRCSC; Université de Montréal, Hôpital du Sacré-Cœur de Montréal, Quebec, CANADA*

**Purpose:** The arrival of locking plate systems for the fixation of proximal humerus fractures (PHFs) has changed the treatment for this condition, but also exposed patients and physicians to new complications. One of the complications most often reported in the literature is intra-articular screw perforation (cutout). Factors related to screw cutout are not known. Since there are no clear guidelines regarding the maximal screw length, our study focuses on assessing the screw length associated with postoperative complications. Our hypothesis is that patients sustaining a PHF treated with screws  $P > 45$  mm are subjected to more cutout and reoperations.

**Methods:** We retrospectively analyzed the radiographic and demographic data from cases of PHF treated with the Synthes Philos locking plate. All patients were operated at our institution between 2007 and 2013 with a mean follow-up of 12 months. Charts were reviewed for postoperative complications. A validation study was conducted in which a synthetic humerus fixated with screws of predetermined lengths underwent radiographs at variable angles. This allowed us to identify screws  $> 45$  mm on follow-up images with a level of confidence of 99%. Measurements were made with the SliceOMatic software and adjusted using the size of the plate to calculate a scaling ratio. We also measured the mediolateral head impaction, neck angulation, and height change between the first and last follow-up.

**Results:** We identified 171 cases with a mean age of 62 years (range, 17 to 94) and 116 females. A total of 80 complications were reported in 58 patients. 34 patients had cutout (20%) and of these, 14 (41%) were reoperated due to this complication. 81 patients (46%) had at least one screw  $> 45$  mm. Patients with screws  $> 45$  mm had a 2.5 risk of cutout ( $P = 0.016$ ) and 37% increased risk of reoperation. The presence of cutout was significantly associated with more complex fracture (Neer I-II = 17% vs Neer III-IV = 33%,  $P = 0.017$ ), initial varus deformity (34% vs 15%,  $P = 0.05$ ), osteonecrosis (55% vs 21%,  $P = 0.003$ ) and longer OR (operating room) time ( $P = 0.019$ ). Age, gender, diabetes and smoking did not correlate with cutout.

**Conclusion:** Incidence of screw cutout is associated with the length of screws and the fracture characteristics rather than patient's demographics or past-medical history. Our study points out the dramatic aspect of screw cutout and the subsequent risk of reoperation. It highlights the importance of avoiding the use of locking screws  $> 45$  mm when treating PHF.



## The Impact of Residual Angulation on Patient-Reported Functional Outcome Scores after Nonoperative Treatment for Humeral Shaft Fractures

*Edward Shields, MD; Leigh Sundem, BS; Sean Childs, BS; Michael Maceroli, MD; Catherine Humphrey, MD; John Ketz, MD; Gillian Soles, MD; John Gorczyca, MD; University of Rochester Medical Center, Rochester, New York, USA*

**Purpose:** Data looking at the magnitude of residual angulation in the healed humeral diaphysis and its relationship to patient reported outcomes are lacking. The purpose of this study was to identify if correlation exists between residual angular deformity after nonoperative treatment for humeral diaphyseal fractures and patient-reported outcome measures, including patient satisfaction.

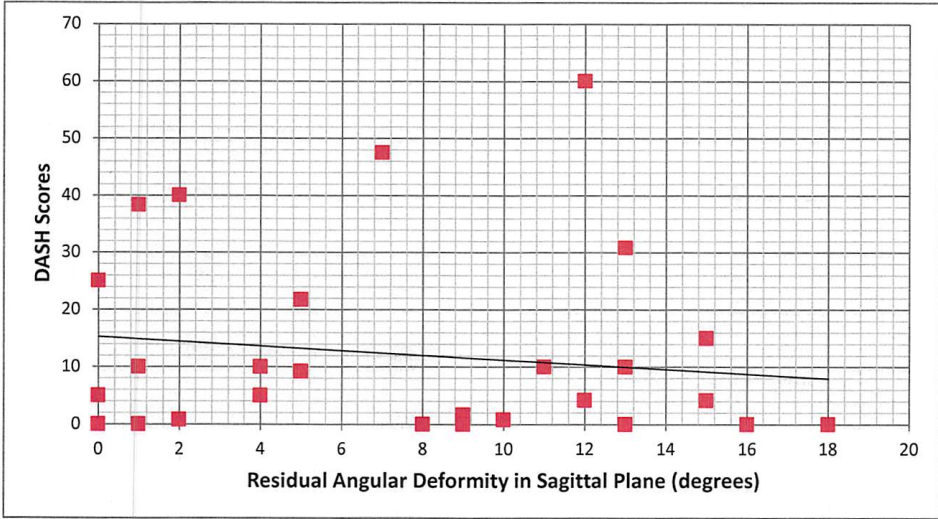
**Methods:** Patients treated from 2004-2011 for humeral shaft fractures were retrospectively identified for 3 surgeons at a single institution. All skeletally mature patients at least 1 year post-injury at the time of study participation were included in the study. Patients were excluded if they were treated surgically, were deceased, did not have available contact information, diagnosed with dementia, had subsequent but unrelated trauma or surgery to the injured extremity, and non-English speaking. 42 patients met criteria and were recruited by telephone to obtain the following outcome scores: Disabilities of the Arm, Shoulder, and Hand (DASH), the Simple Shoulder Test (SST), and general health questionnaire Short Form-12 physical component summary (SF-12 PCS) and mental component summary (SF-12 MCS). The patient chart was reviewed to analyze most recent radiographs to obtain residual diaphyseal angulation in the sagittal and coronal planes. Pearson correlation coefficients and Student t tests were calculated with IBM SPSS v19, with significance set at  $P < 0.05$ . All values are average  $\pm$  standard deviation.

**Results:** 32 patients were successfully recruited with an average age  $45 \pm 22$  years, and average time from injury to study follow-up being  $47 \pm 29$  months. The average outcome scores were DASH  $12 \pm 16$ , SST  $10 \pm 2.7$ , SF-12 PCS  $50 \pm 7.9$ , and SF-12 MCS  $54 \pm 8.8$ . Healed angular deformity in the sagittal plane measured on average  $8^\circ \pm 5.7^\circ$  (range, 0-18), and  $15^\circ \pm 7.9^\circ$  (range, 2-27) in the coronal plane. There was no significant correlation between residual sagittal plane angular deformity and outcome scores (DASH score  $r = -0.14$ ,  $P = 0.47$ ; SST  $r = 0.22$ ,  $P = 0.25$ ). There was no significant correlation between residual coronal plane angular deformity and outcome scores (DASH score  $r = -0.17$ ,  $P = 0.38$ ; SST  $r = 0.28$ ,  $P = 0.14$ ). All patients had less than  $20^\circ$  of residual sagittal plane deformity. Seven patients (22%) had residual coronal plane deformity of at least  $20^\circ$ . These 7 patients had similar DASH scores ( $13.2 \pm 18.7$  vs  $11.7 \pm 16.1$ ;  $P = 0.83$ ), SST scores ( $10.3 \pm 2$  vs  $10.0 \pm 2.9$ ;  $P = 0.81$ ), and overall satisfaction with their treatment ( $P = 0.08$ ) and cosmesis ( $P = 0.44$ ) compared to the rest of the cohort. Higher SF-12 PCS scores correlated with better DASH ( $r = -0.49$ ,  $P = 0.007$ ) and SST scores ( $r = 0.52$ ,  $P = 0.004$ ). Similarly, higher SF-12 MCS scores also correlated with better DASH ( $r = -0.41$ ,  $P = 0.03$ ) and SST scores ( $r = 0.47$ ,  $P = 0.01$ ). There was no significant correlation between outcome and age for either measure ( $P = 0.41$  for DASH and SST).

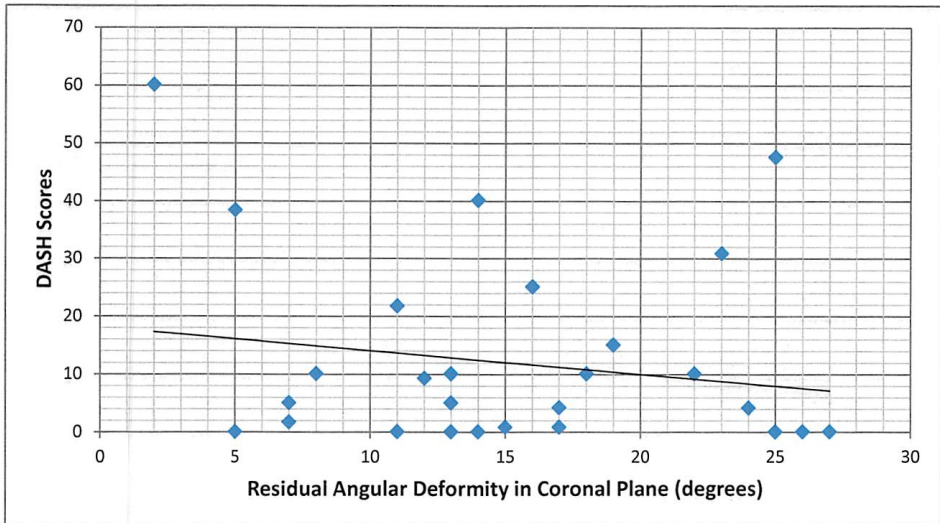
**Conclusion:** Residual angular deformity ranging from 0-18° in the sagittal plane and from 2-27° in the coronal plane after nonoperative treatment for humeral shaft fractures had no

correlation with patient reported DASH scores, SST scores, or patient satisfaction. Instead, overall physical and mental health status as measured by the SF-12 significantly correlated with patient-reported outcomes.

**Figure 1.** Scatter plots with best fit line for angular deformity in the sagittal and coronal planes after humeral shaft fractures and resulting DASH scores.

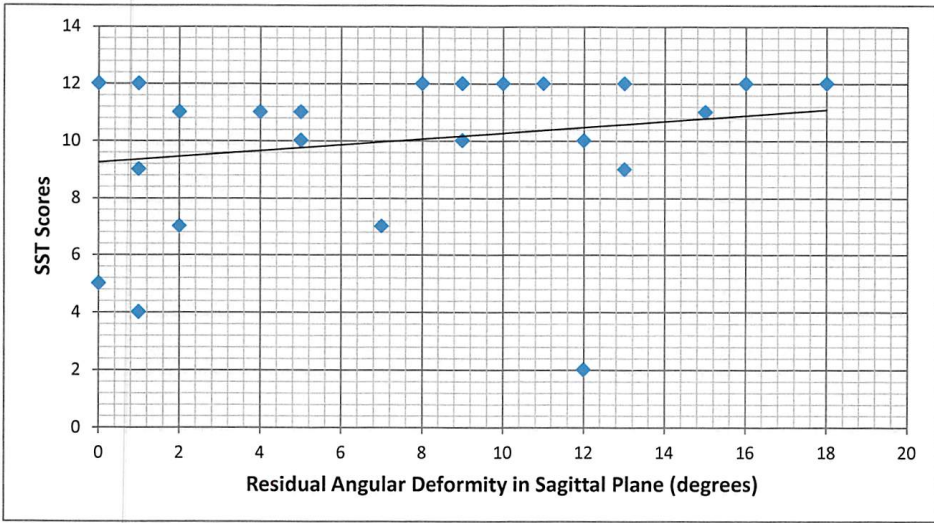


**A.** There was no correlation between residual angular deformity of the humeral shaft in the sagittal plane and resulting DASH scores ( $r=-0.14$ ;  $P=0.47$ ).

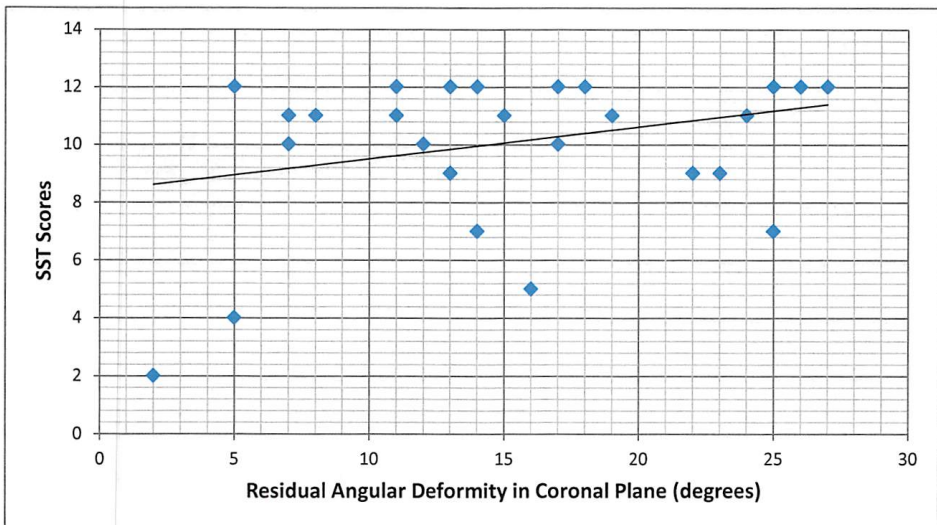


**B.** There was no correlation between residual angular deformity of the humeral shaft in the coronal plane and resulting DASH scores ( $r=-0.17$ ;  $P=0.38$ ).

**Figure 2.** Scatter plots with best fit line for angular deformity in the sagittal and coronal planes after humeral shaft fractures and resulting Simple Shoulder Test (SST) scores.



**A.** There was no correlation between residual angular deformity of the humeral shaft in the sagittal plane and resulting Simple Shoulder Test (SST) scores ( $r=0.22$ ;  $P=0.25$ ).



**B.** There was no correlation between residual angular deformity of the humeral shaft in the coronal plane and resulting Simple Shoulder Test (SST) scores ( $r=0.28$ ;  $P=0.14$ ).

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## Scoring Cortical Healing of Humeral Shaft Fractures Improves Interobserver Reliability

*Anthony Christiano, BA; Abraham Goch, BS; Christopher Burke, MD; Philipp Leucht, MD, PhD; Kenneth Egol, MD; Sanjit Konda, MD; New York University Hospital for Joint Diseases, New York, New York, USA*

**Purpose:** Determining when a fracture of a long bone is united can be difficult. Scoring systems such as the radiographic union score for tibial fractures (RUST) and the radiographic union score for hip (RUSH) have improved interobserver reliability in determining the degree of healing of long bone fractures. The purpose of this study is to determine if a modified RUST score applied to nonoperatively treated humeral shaft fractures can increase interobserver reliability in determining degree of fracture healing.

**Methods:** Three fellowship-trained orthopaedic traumatologists and one fellowship-trained musculoskeletal radiologist scored 50 cases (100 radiographs) of humeral shaft fractures in various stages of healing using a modified RUST scoring system called the Radiologic Humerus Union Measurement (RHUM). All observers were blinded to time from injury. After a 4-week washout period, observers again scored the same cases. Cases were presented in random order with each attempt. Observers classified each fracture as either healed or not healed based on the combination of the two radiographs for the case. Inter- and intraobserver reliability of the RHUM scoring system applied to humeral shaft fractures were determined using an intraclass correlation coefficient (ICC). Interobserver reliability of determining if a fracture is healed was calculated using Cohen's kappa ( $\kappa$ ) statistics.

**Results:** ICC showed almost perfect interobserver reliability (ICC 0.838, ICC 95% confidence interval [CI] 0.765 to 0.896) and intraobserver reliability (ICC range 0.822 to 0.948) with applying the RHUM scoring system to humeral shaft fractures. Cohen's kappa showed substantial agreement between observers in determining fracture healing ( $\kappa = 0.647$ ).

**Conclusion:** The RHUM score applied to humeral shaft fractures showed greater interobserver reliability than overall perception of healing. This is the first time that a cortical scoring system has been shown to have excellent interobserver reliability in a long bone fracture that was not treated operatively. The RUST score applied to the humerus may allow for orthopaedic surgeons to predict healing of humeral shaft fractures, as has been shown for the RUST score in the tibia.

**Optional Follow-up Visits for Common, Low-Risk Arm Fractures**

*Abigail Finger, BA; Teun Teunis, MD; Michiel Hageman, MD; Emily Thornton, BS; Valentin Neuhaus, MD, PhD; David Ring, MD, PhD; Massachusetts General Hospital, Boston, Massachusetts, USA*

**Purpose:** Many common arm fractures have an excellent prognosis with little more than symptomatic treatment, and an additional follow-up visit after diagnosis might not always be necessary. This study tested the primary null hypothesis that there is no difference in disability (QuickDASH [an abbreviated version of the Disabilities of the Arm, Shoulder and Hand]) 2 to 6 months after injury between patients with and without an additional follow-up visit. Secondarily we assessed (1) differences in pain, satisfaction, and return to work at 2 to 6 months after injury; (2) differences between patients choosing an optional or scheduled follow-up; and (3) factors associated with returning after initially choosing not to schedule a follow-up visit.

**Methods:** We prospectively enrolled 120 patients with well-aligned single metacarpal fractures ( $n = 63$ ), non- or minimally displaced distal radius fractures ( $n = 39$ ), and isolated non- or minimally displaced radial head fractures ( $n = 18$ ). 56 (47%) subjects chose to schedule an additional appointment for evaluation of their fracture and 64 (53%) did not. At enrollment we recorded patient demographics, depression (Patient Health Questionnaire-2), Pain Self-Efficacy Questionnaire, disability (QuickDASH), a 0-10 ordinal rating of pain intensity, and satisfaction rated on an 11-point ordinal scale. 82 subjects (68%) were available when contacted by phone or email 2-6 months after injury at which time we measured disability, numerical rating scale for pain and satisfaction, and employment. 11 of 64 subjects (17%) who chose an optional follow-up returned for a follow-up visit. 9 of 56 subjects (16%) who scheduled a follow-up visit did not return. There were no adverse events in either group.

**Results:** Multivariable analysis accounting for difference in baseline characteristics showed no difference in QuickDASH between 2 and 6 months after fracture between patients with and without an additional visit (optional follow-up:  $\beta -0.53$ , 95% confidence interval [CI] -7.4 to 6.4, standard error [SE] = 3.5,  $P = 0.88$ ). There were no differences in pain, satisfaction, or return to work. On multivariable logistic regression analysis, no variables were independently associated with choosing optional or scheduled follow-up. The only factor independently associated with returning after not initially scheduling a follow-up visit was a higher QuickDASH score (odds ratio [OR] 1.05, 95% CI 1.0 to 1.1, SE 0.024,  $P = 0.029$ ). In other words, on average patients returning after initially choosing not to had 1.05 point greater disability.

**Conclusion:** In an urban academic hand surgery office, more patients prefer optional follow-up for simple upper extremity fractures with a good prognosis. There were no adverse events and there were equal outcomes and satisfaction among patients who did and did not return. Hand surgeons can safely consider offering patients with low-risk hand fractures an optional of a scheduled second visit, avoiding unnecessary waiting, travel, inconvenience, time, tests, and costs.

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## Impact of Olecranon Fracture Malunion: Study on the Importance of PUDA (Proximal Ulna Dorsal Angulation)

Julien Chapleau, MD, MSc<sup>1</sup>; Frédéric Balg, MD, FRCSC<sup>2</sup>;

Edward Harvey, MD, MSc, FRCSC<sup>3</sup>; Jérémie Ménard, Ing<sup>4</sup>; Frédéric Vaclair, MD<sup>5</sup>;

George Laflamme, MD<sup>1</sup>; Dominique Rouleau, MD, MSc, FRCSC<sup>4</sup>;

<sup>1</sup>Université de Montréal, Quebec, CANADA; <sup>2</sup>Université de Sherbrooke, Quebec, CANADA;

<sup>3</sup>McGill University, Quebec, CANADA;

<sup>4</sup>Hôpital du Sacré-Coeur de Montréal, Quebec, CANADA; <sup>5</sup>CHU Vaudois, SWITZERLAND

**Background/Purpose:** Olecranon fractures are associated with permanent and significant decrease of range of motion (ROM) in 30% of the patients. The PUDA is the physiologic dorsal bow of the proximal ulna (mean 6°, range 0-140) that is symmetrical from the right and left elbow. A previous biomechanical study showed impaired elbow alignment with a PUDA malunion of 5° or more. The goal of this study is to evaluate the impact of a PUDA malunion on elbow ROM and function 1 year or more after olecranon open reduction and internal fixation (ORIF).

**Methods:** The radiological and surgical database of three trauma centers were reviewed and all adults who underwent ORIF for olecranon fracture were invited to join the study. Bilateral elbow radiographs, radiographic ROM measurement, PUDA malunion, demographic data, and quality of life questionnaires were recorded (PREE [Patient-Rated Elbow Evaluation, Q-DASH [an abbreviated version of the Disabilities of the Arm, Shoulder and Hand], SF [Short Form]-12, VAS [visual analog scale]). ROM and PUDA were measured using Slice-o-Matic software and following a validated method. In this case control study, patients were classified according to the difference of the PUDA between the fracture side and the normal side. Patients were categorized as "PUDA malunion" when the PUDA difference was 5° or more. Our hypothesis was that 50% of patients would present a PUDA malunion and subsequently affect their ROM and function.

**Results:** 49 patients entered the study; 28 of them were females. Mean age was 54 years (range, 21-76). The mean follow-up was 3 years and 9 months (range, 1-7 years). ORIF method was tension band in 23 cases and plate-screws in 26. There was no difference in terms of outcome, quality of reduction, or ROM between those two methods. The mean ROM on the fracture side was 122° compared to 135° on normal side ( $P < 0.001$ ). The mean PUDA on the fracture side was different from the normal side (3.0 vs 4.20,  $P = 0.013$ ). Twelve patients (25%) presented PUDA malunion. Those patients had decreased elbow flexion of 8° ( $P = 0.05$ ) as opposed to the control group. Decrease elbow flexion was the strongest predictor of functional outcome and showed moderate correlation with Q-DASH ( $r = -0.3$ ,  $P = 0.025$ ), MEPS (Mayo Elbow Performance Score ( $r = 0.4$ ,  $p = 0.007$ )) and PREE ( $r = -0.3$ ,  $P = 0.019$ ).

**Conclusion:** PUDA malunion was present in 25% of patients and was associated with decreased elbow flexion. Flexion loss has a greater impact than extension on functional outcome. Tension band and plate fixation can maintain good reduction in terms of PUDA and are not influencing outcome.

## **Surgical Treatment of Chronic Elbow Dislocation Allowing Early Range of Motion: Operative Technique and Early Clinical Results**

*Justin Haller, MD<sup>1</sup>; Lucas Anderson, MD<sup>1</sup>; Duane Anderson, MD<sup>2</sup>;*

*<sup>1</sup>University of Utah, Salt Lake City, Utah, USA;*

*<sup>2</sup>Soddo Christian Hospital, Soddo, Ethiopia, Coeur D'Alene, Idaho, USA*

**Background/Purpose:** Management for a chronic elbow dislocation is a difficult problem. Historically, results have been suboptimal due to elbow stiffness, recurrent instability, and dysfunction of the triceps extensor complex. Postoperative complications have led some surgeons to recommend against surgical procedures for older patients and patients who are greater than 3 months out from initial injury. We report on an operative technique we have developed that allows early range of motion with little risk of dislocation. Our hypothesis is that our surgical technique and postoperative protocol allows for good patient outcome regardless of injury duration.

**Methods:** We performed a retrospective review of clinical and radiographic records of patients who had undergone surgical treatment for chronic elbow dislocation. We excluded patients with associated fracture. Physical examination, the Mayo Elbow Performance Index (MEPI), and radiographs were obtained on all patients. Operative technique involved both medial and lateral approaches to the elbow while sparing the triceps. The ulnar nerve was transposed anteriorly. All soft tissues are dissected off of the distal humerus. The distal humerus was delivered out of either incision depending on ease of delivery. The olecranon fossa and coronoid fossa were cleared of soft tissue and the elbow was reduced after transposition of the ulnar nerve anteriorly. While there was no attempt to individually reconstruct the elbow ligaments, the soft-tissue envelope was repaired around the elbow as sleeves. Physical therapy for range of motion (0-90°) was initiated two days after surgery. Prophylactic indomethacin was given immediately to prevent heterotopic ossification.

**Results:** 25 patients (20 males) with a mean age of 25 years (range, 7-56 years) met inclusion criteria for this study. The mean patient follow-up was 5 months (range, 1-15 months). Duration of dislocation averaged 6 months (range, 1-34 months, standard deviation [SD] 7 months). Mean preoperative range of motion (ROM) was 7° (range, 0-30°). Mean ROM at final follow-up was 94° (range, 55-125°, SD 24°). The mean postoperative MEPI was 88 (range, 80-100). All patients had improvement in elbow motion. There were no infections or recurrent dislocations. There was one patient who developed transient ulnar nerve palsy postoperatively.

**Conclusion:** This is one of the largest case series of surgically treated patients with chronic elbow dislocation. All patients had improved elbow function and there were few complications. Open reduction of chronic elbow dislocation can be accomplished while permitting early motion and with little risk of dislocation. Long-term follow-up will be required to determine if these early clinical results continue.



**Posttraumatic Elbow Arthrofibrosis Incidence and Risk Factors:****A Retrospective Review**

*Lucas Marchand, MD; Zachary Working, MD; J Williams, MD; Iain Elliott, MD; Ami Stuart, PhD; David Rothberg, MD; Thomas Higgins, MD; Erik Kubiak, MD; University of Utah, Department of Orthopaedics, Salt Lake City, Utah, USA*

**Purpose:** Loss of elbow range of motion can significantly decrease patient quality of life and have marked affect on outcomes. Posttraumatic arthrofibrosis is a common cause of decreased elbow range of motion (ROM) in adults. A loss of 50% of elbow motion has been found to compromise 80% of upper extremity function. Although arthrofibrosis has been extensively studied in the lower extremity, sparse data exist concerning this problem in the upper extremity. The aim of this study is to examine the incidence and risk factors of post-traumatic elbow arthrofibrosis.

**Methods:** We conducted a retrospective chart review of intra-articular elbow fracture patients seen at our trauma Level I hospital from March 2004 to January 2014. Demographic information, final range of motion, duration of immobilization, fracture pattern, injury mechanism, additional surgery, postoperative deep infection, and medical comorbidity data were recorded. Patients were included in the study if they had a minimum of 3 months follow-up or return to functional arc ROM (defined as a flexion/extension arc of at least 100° in the absence of an elbow flexion contracture greater than 45°) prior to 3 months. Pearson chi-squared and Student t test were used to evaluate categorical and continuous variables, respectively. A logistic multivariate regression model was used to predict arthrofibrosis risk factors. Statistical significance was set at a P value of <0.05.

**Results:** 470 consecutive patients with intra-articular elbow fractures were identified. 390 patients (83%) were included in the study. 80 patients were excluded from the study because of inadequate follow-up or ROM documentation. 302 patients had documented return to a functional arc range of motion; 88 (23%) patients developed elbow arthrofibrosis. There were no statistically significant differences between the two groups in terms of age, gender, or medical comorbidities. Duration of immobilization, fracture pattern, and energy were all statistically significant predictors of arthrofibrosis. Average time of immobilization was 19 days in patients who developed arthrofibrosis as compared to 13 days of immobilization in patients who recovered a functional arc ROM ( $P < 0.001$ ). High-energy mechanism increased the risk of arthrofibrosis with 44 of 126 (35%) high-energy injuries developing arthrofibrosis as compared to 44 of 264 (17%) low-energy injuries ( $P < 0.001$ ). 7 of 16 (44%) patients with deep postoperative infection developed arthrofibrosis as compared to 81 of 374 (22%) noninfected patients ( $P = 0.038$ ). Elbow fracture dislocations and distal humerus fractures demonstrated statistically significant increased rates of arthrofibrosis with 24 of 67 (36%) patients with elbow fracture dislocations and 27 of 99 (27%) of distal humerus fractures developing arthrofibrosis ( $P = 0.005$ ,  $P = 0.027$ , respectively). Only 22 of 136 (16%) olecranon and 15 of 88 (17%) radial head fractures went on to develop arthrofibrosis ( $P = 0.194$ ,  $P = 0.159$ , respectively). Average follow-up was noted to be 242 days.

**Conclusion:** The functional sequelae of posttraumatic elbow arthrofibrosis can be extraordinarily disabling. Understanding the rate at which this process affects patients and the

predictive risk factors associated with its development is critical. To our knowledge, this study is the first to demonstrate that 23% of patients with intra-articular elbow fractures go on to develop posttraumatic elbow arthrofibrosis. Additionally, duration of immobilization, fracture pattern, and energy were predictive risk factors for the development of elbow arthrofibrosis. Although fracture pattern and injury are nonmodifiable predictors of arthrofibrosis, duration of immobilization proves to be an important modifiable predictor of arthrofibrosis.

**Table 1. Results of Multivariate Logistic Regression Evaluating Predictors of Elbow Arthrofibrosis**

<i>Variable</i>	<i>p-value</i>
Age	0.94
Alcohol	0.480
Days of Immobilization	<.001
Deep Infection	0.038
Diabetes	0.095
Distal Humerus Fracture	0.027
Elbow Fracture-Dislocation	0.005
Olecranon Fracture	0.159
Radial Head Fracture	0.194
Sex	0.963
Tobacco	0.856

The FDA has stated that it is the responsibility of the physician to determine the FDA clearance status of each drug or medical device he or she wishes to use in clinical practice.

**Early Mobilization Versus Plaster Immobilization of Simple Elbow Dislocations:  
A Cost Analysis of the FuncSiE Multicenter Randomized Clinical Trial**

*GIT Iordens, MD<sup>1</sup>; Esther Van Lieshout, PhD, MSc<sup>1</sup>; Suzanne Polinder, PhD<sup>1</sup>;*

*Denise Eygendaal, MD, PhD<sup>2</sup>; Michael Verhofstad, MD, PhD<sup>1</sup>; Niels Schep, MD, MSc, PhD<sup>3</sup>;*

*Dennis Den Hartog, MD, PhD<sup>1</sup>;*

<sup>1</sup>*Erasmus MC Zuid-Holland, THE NETHERLANDS;*

<sup>2</sup>*Erasmus MC, Brabant, THE NETHERLANDS;*

<sup>3</sup>*AMC Amsterdam, Noord-Holland, THE NETHERLANDS*

**Background/Purpose:** To our best knowledge no studies have reported the burden of simple elbow dislocations on health care costs. It is unknown whether or not early mobilization after reduction might play a role in reducing these costs. The primary aim of this study was to assess and compare the total costs (direct health care costs and indirect costs due to loss of production) after early mobilization versus plaster immobilization in patients with a simple elbow dislocation. The secondary aim was to evaluate cost-effectiveness. It was hypothesized that early mobilization would not lead to higher direct and indirect costs than plaster immobilization.

**Methods:** This cost-effectiveness study used data of a multicenter randomized clinical trial comparing early functional treatment with plaster immobilization in patients after simple elbow dislocations (blinded trial). From August 25, 2009 until September 18, 2012, patients aged 18 years or older with a simple elbow dislocation from 3 academic and 19 nonacademic hospitals were recruited and randomized to early mobilization (immediate motion exercises; n = 48) or 3 weeks plaster immobilization (n = 52). Follow-up was 1 year. Primary outcome were the total costs at 1 year. Analysis was by intention to treat.

**Results:** 100 patients were included; one patient was lost to follow-up after 6 months. QuickDASH (an abbreviated version of the Disabilities of the Arm, Shoulder and Hand) was lower in the early mobilization group at 6 weeks, but not at later time points. There were no significant differences in health-related quality of life measured with the EuroQol EQ-5D, Short Form (SF)-36 PCS (physical component summary), and SF-36 MCS (mental component summary) between the two groups throughout the 1-year follow-up. Mean total costs per patient were €3624 in the early mobilization group versus €7072 in the plaster group (P = 0.094). Shorter work absenteeism in the early mobilization group (10 vs 18 days; P = 0.027) did not lead to significantly lower costs for productivity loss (€1719 in the early mobilization group vs €4589; P = 0.120).

**Conclusion:** From a clinical as well as a socioeconomic point of view, early mobilization should be the treatment of choice for a simple elbow dislocation. Plaster immobilization has inferior results at almost double costs, and should therefore be abandoned.

## **Dorsal Tangential View: A Useful Tool for Assessment of Dorsal Screw Penetration in Distal Radius Fracture Fixation?**

*Devin Ganesh, MD<sup>1</sup>; Ben Service, MD<sup>2</sup>; Brian Zirgibel, MD<sup>3</sup>; Kenneth Koval, MD<sup>4</sup>;*

*<sup>1</sup>Orlando Health, Gulfstream, Florida, USA; <sup>2</sup>Orlando Health, Orlando, Florida, USA;*

*<sup>3</sup>Orlando Health, Green Lake, Wisconsin, USA; <sup>4</sup>Orlando Health, Belle Isle, Florida, USA*

**Background/Purpose:** The dorsal tangential view (DTV) provides unique perspective to the topography of the dorsal cortex of the distal radius. It is taken with the wrist hyperflexed and the fluoroscopic beam aimed tangential to the dorsal surface of the radius. Although studies have reported the utility of this view as an adjunct to traditional fluoroscopy, no studies have evaluated its value in detecting dorsal screw penetration compared to CT scan. This study was performed to assess the DTV utility in detecting intraoperative dorsal screw penetration in distal radius fractures treated with volar plating, compared to CT scan.

**Methods:** We prospectively collected data on 30 consecutive distal radius fractures in 25 patients treated with volar locked plating. Intraoperative AP, lateral, and 20° tilted lateral and dorsal tangential views were obtained via fluoroscopy in all wrists. A postoperative CT scan was obtained prior to patient discharge to assess fracture and implant position. We recorded the number and location of screws with dorsal penetration identified by each radiographic view and CT scan. Metaphyseal dorsal screw penetration was recorded as >1 mm of penetration. Statistical analyses were performed to assess the utility of the DTV in identifying dorsal screw penetration, compared to CT scan.

**Results:** 175 metaphyseal screws were assessed. Eight patients out of twenty-five (32.0%) had prominent screws evident on the DTV but not seen on standard fluoroscopic analysis; seven of eight patients underwent screw exchange for a shorter screw. The radial styloid screw was the most common position exchanged. CT scan identified five additional screws with >1 mm dorsal penetration not identified by the DTV. All but one of these were in the second dorsal wrist compartment. The DTV was 66.7% sensitive with a negative predictive value of 97.0% for screws >1 mm of dorsal cortex penetration. The DTV was least sensitive in detecting dorsal penetration in the second dorsal compartment, failing to detect four screws in this compartment. The DTV failed to detect one prominent screw placed in the fourth dorsal compartment as well.

**Conclusion:** The dorsal tangential view is an economic alternative to CT scan to ensure proper screw depth, reducing the risk of extensor tendon irritation and possible tendon rupture in most wrist compartments. We advocate the routine use of this view to help prevent prominent dorsal screws with volar locked plating of the distal radius and suggest caution when using this view to verify acceptable placement of screws in proximity to the second dorsal compartment.

## Timing of Treatment of Open Distal Radial Fractures in Adults

Jarid Tareen, MD<sup>1</sup>; Adam Kaufman, MD<sup>2</sup>; Raymond Pensy, MD<sup>3</sup>;

Robert O'Toole, MD<sup>4</sup>; W Andrew Eglseder, MD<sup>4</sup>;

<sup>1</sup>University of Maryland Medical Center, Gaithersburg, Maryland, USA;

<sup>2</sup>Biltmore Lake, North Carolina, USA;

<sup>3</sup>University of Maryland Medical Center, Brinklow, Maryland, USA;

<sup>4</sup>Shock Trauma Center, Baltimore, Maryland, USA

**Purpose:** Controversy exists regarding the ideal timing of the treatment of open distal radial fracture (DRFs). Two options exist after initial irrigation and debridement: (1) immediate, definitive open reduction and internal fixation (ORIF) or (2) external fixation and delayed ORIF. We hypothesized that there would be increased infection rate in group 1.

**Methods:** We retrospectively reviewed 7 years (2005-2012) of our prospectively collected database to identify all patients 16-65 years old with open DRFs and >3 months of clinical follow-up consistent for CDC (Centers for Disease Control and Prevention) definition of acute surgical site infection. The study group included 92 patients (94 fractures) with an average follow-up of 30 months. All patients were classified as either (1) immediate ORIF (n = 64) or (2) delayed ORIF (n = 32). The decision treatment was made based on the preference of the attending surgeon on the on-call night. Demographics, injury characteristics, and associated injuries were similar in the two study groups (P >0.20). The primary outcome measure was return to the operating room for surgical site infection. The secondary outcome was unplanned reoperation.

**Results:** In contrast to our hypothesis, 23% of patients (n = 7) in the staged group had infections requiring surgery compared to only 11% (n = 7) in the immediate ORIF group (P = 0.13, Pearson chi-square two-tailed). There was a trend toward increased reoperation rate in the staged group (50%) versus the unstaged group (33%) (P = 0.11). Both groups had similar functional outcomes as judged by range of motion and QuickDASH (an abbreviated version of the Disabilities of the Arm, Shoulder and Hand).

**Conclusion:** This relatively large case series on this topic demonstrates that fractures treated with immediate ORIF yield infection and reoperation rates similar to those fractures that are treated in a staged fashion. As a result, we conclude that initial debridement and internal fixation in these high-energy fractures is safe and has the potential benefit of sparing the patients an additional procedure that would otherwise be needed if treated in a staged fashion.