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ABSTRACT COMPENDIUM

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ADVANCING MUSCULOSKELETAL HEALTH
THROUGH COLLABORATION AND DISCOVERY.

Does the butterfly fragment of femoral shaft fractures matter for reoperation to promote union, and should it be open reduced? A retrospective review

Anna Zakusylo, MBS¹; Garrett Ball, DO^{1,2}; Brett Biedermann, MD^{1,2}; Oluwatobi Onafowokan, MD^{1,2}; Victoria Kennerly, MS¹; Timothy Domashevich, BS^{1,2}; Adam Schlauch, MD^{1,2}

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OBJECTIVES: To evaluate whether the presence and open reduction of a butterfly fragment in femoral shaft fractures was associated with reoperation to promote union.

METHODS:

Design: Retrospective cohort study

Setting: Single-center, academic Level I trauma center

Patient Selection Criteria: Included were patients who underwent surgical fixation of an acute AO/OTA 32A–C femoral shaft fracture between January 2017 and January 2024. Patients younger than 18 years, nonunion surgeries, <3 months follow-up, periprosthetic fractures, and pathologic fractures were excluded.

Outcome Measures and Comparisons: The primary outcome was reoperation to promote union. Secondary outcomes included fracture-related infection, postoperative alignment, and cortical step sign (CSS). A femoral shaft fracture butterfly fragment was defined as a singular, wedge-shaped segment of comminution from the diaphysis of the femur. Comparisons of primary and secondary outcomes were made between patients with and without a femoral butterfly fragment. A subgroup analysis was performed within the butterfly fragment cohort comparing open versus closed reduction.

RESULTS:

A total of 192 patients were included (mean age 36.5 years, SD = 16.1, mean BMI 27.5 kg/m², SD = 6.58), including 138 without and 54 with a butterfly fragment. A total of 33 patients (17.2%) underwent reoperation to promote union. There was a non-significant trend towards a higher reoperation to promote union in patients with a butterfly fragment versus those without (24.1% vs 14.5%, $p = 0.17$). Fragment size and displacement were not associated with reoperation to promote union. Within the butterfly fragment cohort, open reduction was associated with a higher rate of reoperation to promote union compared with closed reduction (54.5% vs 16.3%, $p = 0.02$). Open reduction was associated with a lower incidence of cortical step sign (0% vs 30.2%, $p = 0.05$). There were no significant differences in fracture-related infection or postoperative alignment between groups.

CONCLUSIONS:

The presence of a femoral butterfly fragment had a non-significant higher rate of reoperation to promote union. Open reduction of the butterfly fragment was associated with a higher rate of reoperation despite reduced CSS. These findings support prioritization of biologic preservation over anatomic reduction in these injuries.

KEY WORDS: Femoral shaft fracture, butterfly fragment, reoperation, nonunion, open reduction

LEVEL OF EVIDENCE: III

Is lateral ankle soft tissue thickness a risk factor for deep surgical site infection in rotation ankle fractures?

Anna Zakusylo, MBS; Brandi A. Krieg MD; Justin Hellwinkel MD; Nathaniel E Schaffer PhD; Adam Schlauch MD; Cyril Mauffrey MD

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Purpose: To determine if soft tissue thickness (STT) was a risk factor for developing deep surgical site infection (SSI) in closed rotational ankle fractures after open reduction and internal fixation (ORIF).

Methods: Adult patients undergoing ORIF for closed rotational ankle fractures (OTA/AO 44A–C) at a single Level I academic trauma center from 2019–2025 were retrospectively reviewed. Exclusion criteria included <6 months of follow-up without radiographic union, absence of preoperative CT imaging, prior ankle surgery, staged external fixation, and open fractures. STT was measured on preoperative post-reduction ankle CT as the distance from the lateral fibula to the dermal surface at the level of the plafond. Deep SSI was defined as infection requiring operative irrigation and debridement. Patients with and without deep SSI were compared. STT was additionally analyzed by stratifying patients into bottom 20%, middle 60%, and top 20% thickness groups.

Results: 116 patients with mean age of 40.7 and 44% male were included, of which 10 (8.6%) developed deep SSI. Patients who developed deep SSI versus those who did not had higher age (49.8 vs. 39.9 years, $p=0.04$). There were no differences between groups for STT, sex, body mass index, ASA class, diabetes, active smoking, peripheral vascular disease, OTA/AO class, or fracture type. There was no correlation between STT and deep SSI (8.7% risk for average soft tissue thickness, OR 0.95 [95% CI: 0.13–4.50] for bottom 20% STT, and OR 1.00 [95% CI: 0.14–4.73] for top 20% STT). Multivariate analysis found increased infection risk of 7% with OR 2.3 (95% CI: 1.2–5.0, $p < 0.03$) per 15 years of age above the sample mean of 41.

Conclusion: STT was not associated with deep SSI in closed rotational ankle fractures following ORIF. Surgeons should focus on risk factors, such as age, when considering a patient's pre-operative risk of infection in these cases.

KEY WORDS:

LEVEL OF EVIDENCE: III

Time to Union is a Flawed Primary Outcome: A Study to Evaluate Time to Union Determined by Interval Radiographic Scores

Adam Schlauch¹, Anna Zakusylo¹, Nathaniel Elliot Schaffer¹, Cyril Mauffrey¹, William M Ricci²

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Purpose: To determine if the observed time to union (TTU) in tibial shaft fractures, as defined as the first post-operative clinical visit where the modified radiographic union score for tibial fractures (mRUST) ≥ 12 , was a reliable way to report TTU in orthopaedic studies. The purpose was to inform orthopaedic surgeons on the potential limitations of using TTU as a method to compare groups when conducting research.

Methods: This was a retrospective cohort study at a Level I academic Trauma Center of adult patients (18 years and older) with a tibial shaft fracture (OTA/AO 42A, 42B, 42C) with index treatment of tibial intramedullary nailing (IMN). Excluded were patients with pathologic fractures, nonunion repairs, and lack of at least a 6 week and 12-week post-operative radiographs. All patients were evaluated for date and mRUST scores of each successive post-operative radiographic evaluation. The cohort's observed TTU (the median time to a post-operative visit with mRUST ≥ 12) was compared to the predicted TTU (the time at which 50% of patients would be expected to achieve mRUST ≥ 12 based on survivorship analysis).

Results: 101 patients with a tibial shaft fracture who underwent tibial IMN were included. Mean age was 43.4 years old (SD = 13.52 years) and 69 (69.0%) were male. 90 patients achieved radiographic union based on mRUST ≥ 12 , and 7 (6.9%) patients required a reoperation to promote union. The median observed versus predicted TTU was 96.5 days (mean 218.3 days, SD 373.32) versus 62.5 days, respectively. The observed TTU over-estimated the predicted TTU by 34 days. At the time of union, the median change in mRUST from the most recent prior clinical contact was 4 (mean 4.4, SD 1.6).

Conclusion: In patients with tibial shaft fractures treated with IMN, the observed TTU (mRUST ≥ 12) over-estimated predicted TTU. The median change in mRUST scores that occurred between a visit with observed union and the most recent clinical contact was high. These results suggest that observed TTU is an imprecise method to compare groups when conducting retrospective research.

Impact of Surgeon Experience on Reduction Quality in Transverse Acetabular Fractures

Anna Zakusylo MBS; Sean Higinbotham PhD; Adam M Schlauch MD; Justin Hellwinkel MD; Nathaniel E Schaffer MD PhD; Cyril Mauffrey MD

OBJECTIVES

To determine whether surgeon experience influences reduction quality in transverse and transverse–posterior wall acetabular fractures after controlling for case complexity.

METHODS

A retrospective review of 49 operative cases in 48 patients with OTA/AO 62-B1 (transverse) or 62-B2 (transverse-posterior wall) fractures treated between 2019 and 2025 at a single Level I trauma center was performed. Bilateral fractures were analyzed as independent cases. The groups compared were surgeons with <10 years versus ≥ 10 years post-fellowship experience. Groups were compared for 1) gap and step displacement and 2) reduction quality, which was graded on post-operative computed tomography (CTs) by the Matta criteria (≤ 1 mm anatomic, 2–3 mm imperfect, >3 mm poor). Case complexity was influenced by the presence of an associated pelvic-ring injury (OTA/AO 61) and transtectal fracture morphology.

RESULTS

Postoperative gap and step displacement was similar across experience levels. Surgeons with ≥ 10 years of post-fellowship experience demonstrated a mean postoperative gap and step of 2.31 ± 1.37 mm and 1.63 ± 0.78 mm, respectively, compared with 2.29 ± 1.41 mm and 1.75 ± 0.80 mm in the <10-year group ($p = 0.96$ and $p = 0.72$, respectively). This study was underpowered to detect differences in experience level at the lower extremes (<1mm) of gap and step displacement. Matta grades for the less experienced versus experienced group were 27.8% vs 46.2% anatomic, 50% vs 38.5% imperfect, and 22.2% vs 15.4% poor, respectively ($p > 0.05$).

CONCLUSIONS

Surgeon experience of ≥ 10 years was not associated with superior reduction quality in transverse-family acetabular fractures. Observed differences in residual displacement were minimal even after adjustment for case complexity. These findings suggest that at a Level I trauma center with structured pelvic and acetabular expertise and mentorship pathways, less experienced surgeons can achieve reductions comparable to those of senior colleagues.

Utility of Routine Post-Anesthesia Care Unit Radiographs Following Operative Fixation of Upper Extremity Fractures

Anna Zakusylo MBS; Hank Weresh BS; Connor Patrick Littlefield MD; Brett McClure Biedermann MD; John W Belk MD; Sean E Higinbotham, PhD, Jessica Churchill MD

INTRODUCTION: Fracture fixation of the clavicle, proximal humerus, and olecranon is commonly followed by routine radiographic evaluation in the post-anesthesia care unit (PACU). These studies are frequently obtained to confirm implant position and reduction quality prior to discharge; however, their impact on immediate postoperative decision-making remains unclear. Routine postoperative imaging increases healthcare costs, resource utilization, and patient radiation exposure. Despite widespread use, limited evidence exists regarding the clinical utility of PACU radiographs following uncomplicated upper extremity fracture fixation. This study evaluated whether routine PACU radiographs following open reduction and internal fixation (ORIF) of clavicle, proximal humerus, and olecranon fractures resulted in changes in immediate postoperative management.

METHODS: A retrospective review was performed at a Level I academic trauma center. Adult patients undergoing ORIF of clavicle, proximal humerus, or olecranon fractures between January 2022 and December 2024 who received routine PACU radiographs were included. Medical records, PACU radiographs, follow-up imaging, operative reports, and radiology interpretations were reviewed. Demographic information, fracture characteristics, postoperative complications, and return to operating room events were collected.

The primary outcome was a change in immediate postoperative management attributable to PACU radiographic findings, including revision surgery, alteration of postoperative restrictions, additional imaging, or other treatment modifications. Secondary outcomes included unexpected radiographic findings, subsequent reoperation, and postoperative complications.

RESULTS: A total of 132 patients met inclusion criteria, including 88 clavicle fractures, 18 proximal humerus fractures, and 26 olecranon fractures. Routine PACU radiographs were obtained in all cases. No PACU radiograph demonstrated an unexpected finding requiring intervention. No patient underwent immediate revision surgery, additional fixation, alteration of postoperative restrictions, additional imaging, or return to the operating room within 24 hours based on PACU radiographic findings. Radiographic findings were uniformly consistent with intraoperative assessment and fluoroscopic imaging.

Subgroup analysis by fracture type similarly demonstrated no management changes attributable to PACU radiographs. Across all fracture groups, routine postoperative imaging provided no clinically actionable information beyond that obtained intraoperatively.

Although five patients subsequently underwent return to the operating room and eight patients experienced postoperative complications, none of these events were identified on or attributable

to findings on PACU radiographs. Patients returning to the operating room did so for symptomatic hardware, loss of reduction secondary to infection, contracture release, hardware removal, or irrigation and debridement, none of which were predicted by immediate postoperative imaging.

DISCUSSION AND CONCLUSION: Routine PACU radiographs following ORIF of clavicle, proximal humerus, and olecranon fractures did not alter immediate postoperative management in this series. No patient underwent revision surgery, experienced a change in treatment plan, or required additional intervention based on PACU imaging findings. Furthermore, PACU radiographs failed to identify any patient who subsequently developed a complication or required reoperation. These findings suggest that routine postoperative radiographs following uncomplicated upper extremity fracture fixation provide little clinically actionable information and may represent a low-value practice. Selective imaging based on intraoperative concerns rather than routine institutional protocols should be considered to reduce unnecessary resource utilization without compromising patient care.

Simultaneous Clavicle and Rib Fracture Fixation in Patients with Severe Chest Wall Injuries is Associated with Improved Outcomes

Adam Schlauch MD, Alexandra C Ferre MD, Angela Sauaia MD, Anna Zakusylo MBS, Ernest E. Moore MD, Fredric Michael Pieracci MD

BACKGROUND

Recent studies demonstrate improved early functional outcomes after operative fixation of clavicle fractures via open reduction and internal fixation (Clavicle-ORIF). This strategy may be particularly advantageous when patients are eligible for early surgical stabilization of rib fractures (SSRF). We compared outcomes between patients undergoing simultaneous Clavicle-ORIF with SSRF (Clavicle-ORIF+SSRF) and those undergoing SSRF alone (SSRF-Alone) for severe chest wall injury in a pilot study to determine if there is benefit for further research on this approach.

METHODS

A prospective, 2016–2025 IRB–approved database of adults (≥ 18 years) undergoing SSRF at a Chest Wall Injury Collaborative Center was queried for patients with displaced clavicle fractures. Patients undergoing Clavicle-ORIF simultaneously with SSRF were compared to patients with displaced clavicle fractures. Outcomes were daily morphine milligram equivalents (MME), mechanical ventilation (MV), intensive care unit (ICU) days, and hospital length of stay (HLOS).

RESULTS

Of 60 consecutive patients with displaced clavicle fractures, 52 (86.7%) had complete data, of whom 17.3% underwent simultaneous Clavicle-ORIF+SSRF. Another 15.4% had Clavicle-ORIF performed later in their admission and were excluded from the study. Operative time was longer for Clavicle-ORIF+SSRF (245 [211–297] vs. 166 [109–219] min, $p=0.01$). The groups were similar in age (52 vs. 57 years) and injury severity (New Injury Severity Score 22 vs. 27; RibScore 4 vs. 3). Mortality was low with only 2 deaths, both in SSRF-Alone. Clavicle-

ORIF+SSRF was associated with significantly fewer ICU days (2 [1–3] vs. 5 [3–11], $p=0.005$), and less MV requirement (0% vs. 42%, $p=0.02$); HLOS was shorter but the difference did not reach significance (6 [4–11] vs. 11 [6–16] days, $p=0.10$). Median and maximum daily MME were lower for Clavicle-ORIF+SSRF, albeit these differences were not statistically significant (38 [30–59] vs. 62 [30–83], $p=0.25$; and 67 [45–155] vs. 112 [61–140], $p=0.61$, respectively).

CONCLUSION

This pilot study demonstrated that in patients with combined rib and clavicle fractures undergoing SSRF, simultaneous clavicle fixation is associated with improved outcomes. This finding justifies further research on the benefits of simultaneous clavicle fixation with SSRF.

Key Words: Surgical stabilization of rib fractures, clavicle, simultaneous, outcomes

Level of Evidence: III

Association of Sacroiliac Joint Anatomical Variants with Quality of Reduction of Isolated Sacroiliac Joint Dislocations

Anna Zakusylo, MBS ; Marie Le Baron, MD; Guillaume David, MD; Brandi Ann Krieg, MD; Nathaniel Elliot Schaffer, MD, PhD; Adam Schlauch, MD; Cyril Mauffrey, MD;

OBJECTIVES: To determine if sacroiliac joint morphology (SIJM) influenced quality of surgical reduction in patients with pelvic ring injuries that had a unilateral sacroiliac joint (SIJ) dislocation.

METHODS:

Design: Retrospective cohort

Setting: Two level I trauma centers

Patient Selection Criteria: Included patients were skeletally mature with Young and Burgess anterior posterior compression (APC) II, APC III and vertical shear (VS) pelvic ring injuries that had a unilateral purely ligamentous SIJ dislocation and underwent operative fixation from March 2016 to April 2025.

Outcome Measures and Comparisons: Groups compared were simple versus complex SIJM for the primary outcomes of quantitative and categorical quality of post-operative reduction. SIJ reduction quality was measured on post-operative CT scans based on cranial diastasis, cranial anterior-posterior (AP) translation, caudal diastasis, caudal AP translation and vertical translation. Quantitative reduction was measured in millimeters and categorical reduction was defined as either acceptable (0-1.9mm displacement) or unacceptable (≥ 2.0 mm displacement)

RESULTS: Fifty-one patients met criteria with 36 being classified as simple SIJM and 15 as complex SIJM. There were no differences in age, sex, or AO/OTA or Young-Burgess classification of injuries between complex and simple SIJM ($p > 0.05$). Categorical reduction quality was not associated with SIJM in any of the measurements ($p > 0.05$ for all). There was

less caudal displacement in the complex group versus the simple group (mean = 1.0 ± 0.9 vs 1.2 ± 1.6 mm respectively, $p = 0.02$). Mean cranial diastasis, cranial AP displacement, caudal diastasis, vertical displacement and cumulative displacement were not statistically significant between groups ($p > 0.05$ for all).

CONCLUSIONS: Simple sacroiliac joint morphology (SIJM) which notably include normal type and semicircular defect from this study's population may be associated with more displaced caudal anterior to posterior translation malreductions in the setting of pure ligamentous sacroiliac joint (SIJ) injuries. There was otherwise no association of SIJM with reduction quality. Surgeons

should not necessarily consider SIJM as a significant inhibitor to the ability to obtain an acceptable reduction.

Patient reported outcomes are less favorable with malreduced SIJ dislocations making ways to improve the reduction quality an important area of investigation; however, SIJ morphology might not make a difference in reduction quality.

KEY WORDS: sacroiliac joint morphology; pelvic ring injury, sacroiliac joint dislocation

LEVEL OF EVIDENCE: Level III

Percutaneous treatment of pelvic metastatic disease: Ablation, Reinforcement and Internal Fixation (AORIF) Technique and Case Series

Anna Zakusylo MBS, William Jiang BS, Sarah Bausano BS, Marie LeBaron MD, Adam Schlauch MD, Francis Lee MD PhD, Cyril Mauffrey MD

Introduction:

Pelvic metastatic disease can cause severe pain, impaired mobility, and pathologic fracture risk. Traditional open reconstruction is associated with substantial morbidity and may delay systemic oncologic treatment. Ablation, osteoplasty, reinforcement, and internal fixation (AORIF) is a minimally invasive technique designed to provide local tumor control, mechanical stabilization, and pain relief while facilitating rapid recovery. The purpose of this study was to describe the AORIF technique and evaluate early clinical outcomes in patients with pelvic metastatic disease.

Methods:

A retrospective review was performed of patients who underwent percutaneous AORIF for osteolytic pelvic metastases at a Level I trauma center between January 2023 and December 2024. The procedure combined radiofrequency ablation, polymethylmethacrylate cement augmentation, and percutaneous pelvic fixation using cannulated screws placed through established pelvic fixation corridors. Demographic data, operative variables, complications, ambulatory status, functional outcomes, and survival were collected.

Results:

Seven patients (mean age 64 years, range 46–84) underwent AORIF for symptomatic pelvic metastatic disease. Primary malignancies included breast carcinoma (n=2), lung carcinoma (n=2), melanoma (n=1), hepatocellular carcinoma (n=1), and cervical carcinoma (n=1). All lesions were osteolytic and involved weight-bearing regions of the pelvis.

Fixation constructs utilized anterior column, posterior column, supra-acetabular, infra-acetabular, and transiliac-transsacral screw corridors. The number of screws ranged from 2 to 7 per patient. Operative time ranged from 60–180 minutes, and estimated blood loss ranged from 10–200 mL.

There were no intraoperative complications. One patient required postoperative blood transfusion. All patients were permitted immediate weight-bearing as tolerated. Six of seven patients demonstrated improvement in pain and ambulatory function at early follow-up, with several progressing from walker-assisted ambulation to cane use or independent ambulation. ECOG performance status improved in most patients. Median postoperative survival was 6 months (range 3 days–18 months). No early mechanical failures were identified on available follow-up imaging.

Conclusion:

Percutaneous AORIF provided reliable pain relief, improved functional status, and immediate

weight-bearing with a low complication profile in patients with pelvic metastatic disease. Although survival remained limited by progression of advanced malignancy, the technique offered meaningful palliation and mechanical stabilization. AORIF represents a safe and reproducible minimally invasive treatment option for symptomatic osteolytic pelvic metastases.

Level of Evidence: IV, Therapeutic Case Series.

Percutaneous Screw Fixation for Traumatic Tile C Pelvic Fractures – Does the Number of Screws Matter? A Review of Clinical and Biomechanical Outcomes

Timothy Domashevich; Anna Filley, MD; Anna Zakusylo, MBS; Sean E. Higinbotham, PhD; Adam M. Schlauch MD, Cyril Mauffrey, MD

Purpose:

This review addresses whether one-screw or two-screw percutaneous constructs offer superior outcomes for Tile C pelvic fractures. It compares biomechanical stability and clinical outcomes, weighing potential gains in stability against increased surgical complexity and complication risk.

Methods:

A systematic search of PubMed, Embase, and Web of Science identified clinical and biomechanical studies on posterior fixation in Tile C fractures. Inclusion criteria required adult traumatic injuries, percutaneous posterior screw fixation, and reported primary outcomes. Two reviewers independently screened and extracted data.

Results:

Thirty biomechanical and seven clinical studies met inclusion. One third of biomechanical studies favored the use of both a S1 and S2 screw for greater rigidity, while others showed benefit. Clinical studies showed mixed results, with some benefit for radiographic reduction and fixation failure in high-risk patterns but no consistent functional advantage. Significant heterogeneity in methodologies limited direct comparisons.

Conclusion:

Biomechanical evidence supports two-screw fixation for increased stability in Tile C fractures, especially unstable patterns. Clinical benefits remain uncertain, emphasizing individualized treatment decisions and the need for standardized future research.

Keywords:

pelvic fractures; percutaneous fixation; iliosacral screws; transsacral screws; biomechanics; clinical outcomes