Time to Definitive Operative Treatment Following Open Fracture Does Not Impact Development of Deep Infection: A Prospective Cohort Study of 736 Subjects

Donald Weber, MD[1]*; Sukhdeep K. Dulai, MD, MSc, FRCS(C)*[1]*; Joseph Bergman, MD*[1]*; Richard E. Buckley, MD*[2]*; Lauren A. Beaupre*[1]*;*
[1]*University of Alberta, Edmonton, Alberta, Canada;*
[2]*University of Calgary, Calgary, Alberta, Canada*

Purpose: The primary study objective was to evaluate the relationship between time to definitive orthopaedic surgical management and development of deep infection in open long bone fractures (humerus, radius/ulna, femur, tibia/fibula). Secondarily, we examined the association of Gustilo grade and fracture location with development of deep infection.

Methods: Between 2001 and 2008, 736 subjects with 791 open fractures were enrolled in a prospective cohort study undertaken at three Level I trauma centers. Demographics, injury information (Gustilo grade, fracture site), and time from injury to definitive surgical management were recorded. Subjects were evaluated at outpatient clinics using standardized data forms until the fracture healed. Phone interviews were undertaken at 1 year postfracture to confirm outcomes. Deep infection was defined as purulent drainage or osteomyelitis presenting after wound closure. Descriptive analyses were initially undertaken on time from injury to definitive surgical management calculated in hours, Gustilo grade, and fracture location (upper extremity, femur, tibia/fibula). Multivariate logistic regression was undertaken on time from injury to surgery, Gustilo grade and fracture location with deep infection (yes/no) as the dependent variable.

Results: Most subjects were male (n = 530 [72%]) and the mean age was 41.5 ± 17.1 years. Almost half (n = 359 [49%]) of injuries occurred in motor vehicle accidents; falls (n = 230 [31%]), crush injuries (n = 131 [18%]) and assaults (n=16 [2%]) were other mechanisms of injury. Tibial/fibular fractures were most common (n = 413 [52%]), followed by upper extremity (n = 285 [36%]) and femoral (n = 93 [12%]) fractures. Overall, 636 (86%) subjects (685 fractures) completed the 1-year interview; only 39 (5%) subjects (43 fractures) did not complete either clinic visits or the 1-year interview. Of 753 fractures with outcomes, 46 (6%) developed deep infections. The mean time to surgery was 10.9 ± 10.6 hours for those without and 8.7 ± 4.4 hours for those with deep infection ($P = 0.17$). Of those with infection, 9 (21%) underwent surgery within 6 hours, 28 (65%) between 6 and 12 hours, and 6 (14%) after 12 hours of injury. In general, time to operating room (OR) decreased as Gustilo grade increased ($P < 0.001$) while infections increased with increasing Gustilo grade ($P < 0.001$).

Gustilo Grade	Mean Time to OR ± SD*	Deep Infection	No Infection
Grade 1 (n = 220)	13.6 ±16.8 hours	2 (1%)	210 (99%)
Grade 2 (n = 284)	9.9 ± 5.3 hours	12 (4%)	265 (96%)
Grade 3A (n = 159)	10.0 ± 6.1hours	15 (10%)	143 (90%)
Grade 3B (n = 92)	8.7 ± 3.8hours	16 (17%)	76 (83%)
Grade 3C (n = 7)	9.9 ± 4.3 hours	1 (17%)	5 (83%)

*SD = standard deviation.

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Four (1.5%) upper extremity, seven (8%) femoral, and 34 (9%) tibial/fibular fractures developed deep infections ($P = 0.001$). Multivariate logistic regression showed no significant association between developing deep infection and mean hours to operative management (odds ratio [OR] 0.97; 95% confidence intervals [95% CI] 0.90, 1.1) while Grades 3A (OR 6.6; 95%CI 1.5, 30.2) and 3B (OR 13.4; 95%CI 2.9, 61.9) relative to Grade 1 injuries and tibia/fibular (OR 4.0; 95%CI 1.4, 11.8) relative to upper extremity fractures were significantly associated with developing deep infection.

Conclusion: Development of deep infection after open fracture was not associated with time to surgery; instead increasing Gustilo grade or tibial/fibular fractures were associated with developing a deep infection. With the low number of infections seen in Grade 1 and 2, and all upper extremity open fractures, there may be clinical implications for determining if an open fracture requires surgery in the middle of the night, especially if a trauma room is available in the morning.

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Pain and PTSD Following Major Extremity Trauma: Results from the METALS Study

Renan C. Castillo, PhD*; Anthony R. Carlini, MS; Ellen J. MacKenzie, PhD;*
for the METALS Study Group;
Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland, USA

Background/Purpose: Soldiers injured in Iraq and Afghanistan experience significant rates of chronic pain and posttraumatic stress disorder (PTSD), and major limb injuries are a primary cause of disability in this population. However, the extent to which pain and PTSD drive disability among veterans who have experienced major limb injuries is not known. This study was undertaken to assess the burden and co-occurrence of pain and PTSD among service members who sustained a major limb injury while serving in Afghanistan or Iraq, and examine the extent to which these conditions are associated with functional outcomes.

Methods: METALS (Military Extremity Trauma Amputation/Limb Salvage) is a retrospective cohort study of 429 United States service members who sustained major limb injuries (defined as one or more of the following: traumatic amputation, revascularization, bone graft or transport, local or free flap coverage, complete deficit of a major nerve, or compartment syndrome) while serving in Afghanistan or Iraq. Outcomes assessed by telephone interview (mean 38 months postinjury) were: function using the Short Musculoskeletal Functional Assessment (SMFA); PTSD using the PTSD Checklist (PCL) and Diagnostic and Statistical Manual (DSM) criteria; and pain using the Chronic Pain Grade Scale.

Results: As previously reported, significant long-term pain was observed in this population (mean pain: 49.8 ± 22.8), as well as a high prevalence of PTSD (25% met both the PCL and DSM criteria). As shown in the table below, there was a marked relationship between report of pain and PTSD and functional outcome. The age- and gender-adjusted population norm for SMFA dysfunction is 5.4 ± 9.8 and the proposed minimally clinically important difference (MCID) for this measure is 6. The results suggest METALS patients without pain or PTSD were, on average, about one MCID from age- and gender-adjusted population norms. In contrast, METALS patients with low levels of pain and no PTSD were, on average, two MCIDs from population norms. METALS patients with either greater levels of pain, PTSD, or both, were three to four MCIDs from population norms. Regression analyses adjusted for injury type, age, time to interview, military rank, social support, mild TBI (traumatic brain injury)/concussion, and combat experiences showed large, significant effects for both pain and PTSD on 1-year functional outcomes.

Conclusion: Major limb trauma sustained in the military results in significant long-term pain and PTSD. Overall, the results are consistent with the hypothesis that pain and PTSD are major drivers of disability in this population. The correlational nature of the data does not permit ruling out the alternative hypothesis, that function is driving PTSD and pain. However, prior analyses and theory suggest this alternative hypothesis is less likely.

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SMFA Dysfunction [n, mean (95% confidence interval)] by PTSD status and Chronic Pain Grade

	No Pain	Low Pain (<50) Intensity, No Interference	High Pain (≥50) Intensity, No Interference	Low Pain (<50) Intensity, High Interference	High Pain (≥50) Intensity & Interference
No PTSD	n = 31 10.6 (7.3, 13.9)	n = 141 16.8 (14.9, 18.7)	n = 127 25.1 (22.9, 27.3)	n = 39 35.5 (32.0, 39.0)	n = 5 40.9 (27.3, 54.5)
PTSD	n = 1 41.9 (N/A)	n = 8 33.9 (24.4, 43.4)	n = 31 33.2 (27.7, 38.6)	n = 26 42.7 (38.3, 47.1)	n = 15 55.6 (50.9, 60.2)

The Effectiveness of an Osseointegrated Prosthesis Compared With Socket Prosthesis After Transfemoral Amputation

Henk van de Meent, MD, PhD; Maria Hopman, PhD; ***Jan Paul M Frölke, MD, PhD****; Radboud University Nijmegen Medical Center, Nijmegen, The Netherlands*

Purpose: The purpose of this study is to evaluate the functional efficacy of an osseointegrated leg prosthesis (ILP) as compared to conventional sleeve prosthesis.

Methods: In this prospective case-control study, 22 consecutive patients were included after transfemoral amputation (one bilateral) with demonstrable socket-related skin and stump problems resulting in limited prosthetic use. The mean age was 46.5 years (range, 23-67 years) and the mean time after the amputation was 16.4 years (range, 2-45). The cause of amputation was traumatic in 20 and a malignancy in 2 cases. All patients underwent surgical treatment with implantation of an osseointegrated prosthesis (ILP; Ortho Dynamics GmbH, Lubeck, Germany) in two sessions. The primary outcome measure was the validated questionnaire for persons with a transfemoral amputation (Q-TFA) after 1 year. Secondary outcome measures were prosthetic use, 6-minute walking test, timed stand up and go test, and oxygen consumption on the treadmill measured after 1 year.

Results: With a socket prosthesis the Q-TFA showed a mean global score of 38.5 points (standard deviation [SD] 4.7). One year after implantation of the ILP this was 62.6 (SD 5.3). Prosthetic use, the 6-minute walking test, the timed stand up and go test, and oxygen consumption were 55.7 hours per week (SD 7.9), 321 m (SD 28), 15.1 sec (SD 2.1), and 1330 mL/min/kg (SD 310). One year after implantation of the ILP, a significant improvement was registered on all these parameters respectively: 100.9 hours per week (SD 2.4), 423 m (SD 21), 8.1 sec (SD 0.7), and 1093 mL/min/kg (SD 361).

Conclusion: Osseointegration is an effective concept for patients after transfemoral amputation who have complaints from the stump and skin problems. Implantation of an ILP improves their function and quality of life.

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Multiple Orthopaedic Procedures in the Initial Surgical Setting: When Do the Benefits Outweigh the Risks in Patients With Multiple System Trauma?

Benjamin R. Childs, BS*; Nickolas J. Nahm, MD; Timothy A. Moore, MD; Heather A. Vallier, MD;*
MetroHealth Medical Center, Cleveland, Ohio, USA

Purpose: The objective of this study is to compare the risk of performing orthopaedic procedures in the same setting as other procedures, with the risk of performing an orthopaedic procedure alone, in patients with unstable fractures and multiple system injury. We hypothesized that in resuscitated patients the complication rates would be no different, and that length of hospital stay would be shorter in patients undergoing multiple procedures.

Methods: Patients with high-energy, mechanically unstable fractures of the femur, pelvis, acetabulum, and spine and ISS >16 were prospectively identified over 30 months at a Level I trauma center. A standard protocol for resuscitation was followed to recommend definitive fixation of these fractures once a patient was hemodynamically stable and acidosis had improved to lactate <4.0 mmol/L, pH ≥7.25, or base excess (BE) ≥–5.5 mmol/L. Patient demographic, physiological, and laboratory data were collected, and musculoskeletal and other system injuries and treatment provided were recorded. Surgical duration, fluid, and blood product administration were included. Complications were adjudicated, including pneumonia, ARDS (acute respiratory distress syndrome, infections, DVT (deep vein thrombosis), PE (pulmontary embolism), sepsis, multiple organ failure, and death.

Results: 370 patients were included with fractures of the femur (n = 166), pelvis (n = 70), acetabulum (n = 57), and spine (n = 108). 147 (39.7%) underwent multiple procedures in the initial surgical setting, including definitive stabilization of the aforementioned fractures. Multiple procedure patients had significantly greater ISS (29.4 ± 12.3 vd 24.6 ± 10.2, P <0.01), more transfusions (8.86 ± 13.5 U vs 3.55 ± 5.7 U, P <0.01), greater estimated blood loss (773 ± 1370 mL vs 443 ± 555 mL, P <0.01), and longer surgical duration (4:22 ± 2:07 vs 2:41 ± 1:39, P <0.01). In spite of these differences, once adequate resuscitation was provided, no significant differences between groups with multiple versus single procedures were found in pulmonary complications (10.2% vs 14.8%, P = 0.50), pneumonia (7.48% vs 12.1%, P =0.15), infection (7.48% vs 8.52%, P = 0.72), sepsis (6.85% vs 5.38%, P = 0.56), mortality (3.40% vs 2.69%, P = 0.69), or overall complication rate (33.3% vs 30.0%, P = 0.50). Contrary to our hypothesis, multiple procedure patients had greater length of stay (12.4 ± 9.3 days vs 10.0 ± 9.0, P = 0.018) spending a mean of 1.41 additional days on the floor (5.97 ± 4.0 days vs 4.56 ± 4.3, P <0.01), although no more time in the ICU (6.38 ± 8.5 days vs 5.77 ± 9.3, P = 0.51).

Conclusion: Prior work has shown benefits of resuscitation in normalizing acidosis associated with severe trauma. A standardized protocol to measure the adequacy of resuscitation and to determine readiness for orthopaedic surgery results in an acceptable risk of complications. Multiple procedures did not increase the frequency of pulmonary or other complications versus patients who had a single procedure, despite greater ISS, more transfusions, and longer surgical duration in the multiple procedure group. Performing multiple procedures in the same setting likely reduces treatment expenses and risk associated with additional

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surgeries on other days. Additional study to characterize these two groups and to minimize risk will be helpful before making broad treatment recommendations.

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Early Appropriate Care: A Protocol to Standardize Resuscitation Assessment and to Expedite Fracture Care Reduces Hospital Stay and Enhances Revenue

Heather A. Vallier, MD*; Andrea Dolenc, BS; Timothy A. Moore, MD;*
MetroHealth Medical Center, Cleveland, Ohio, USA

Purpose: Previous study has demonstrated a substantial multiplier effect for professional activity related to care of polytraumatized patients, such that the trauma center collects revenue several times larger than that of the surgical providers. We hypothesized that our trauma service line would have a favorable payer mix within our hospital and would be the beneficiary of a large multiplier effect. We further hypothesized that a standardized protocol for trauma care would enhance revenue by decreasing length of stay, reducing complications, and thus generating a larger percentage of collections for care of a given type of injury.

Methods: Financial records were obtained for patients prospectively treated with a standardized protocol for resuscitation after multiple system trauma. 253 consecutive adult patients with mean age of 40.7 years and mean ISS of 26.0 (all >16) who were treated surgically during 18 months for fractures of the femur, pelvis, or spine were included. The trauma center is a large urban, public hospital, and the physicians are hospital employees. Hospital facility charges and collections and professional charges and collections for the injury inpatient and related outpatient care for 6 months were analyzed. Timing of fracture fixation was defined as early (within 36 hours after injury) or delayed. Complications were recorded and hospital stay was characterized.

Results: Mean facility charges were $142,533 with mean $59,882 in collections (42%). Mean professional charges were $37,612 with mean $6989 in collections (19%). Mean total facility charges were $180,145 with mean $66,871 in collections (37%). The revenue multiplier effect was $59,882/$6989 (8.57), indicating a hospital collection of $8.57 for every dollar of professional collections, less than half of which went to orthopaedic surgeons. The trauma payer mix was favorable compared to the hospital with over three times as much Workers' Compensation (BWC) and less than half as much Medicare in the trauma group. Commercial and BWC were the best payers with 58.5% and 59.3% collected, respectively, on facility charges. When fracture care was delayed, mean ICU days increased from 4.5 to 9.4 days, and the total hospital stay increased from 9.4 to 15.3 days. Mean loss of revenue based on actual hospital costs for the increased length of stay alone was $6380 per patient delayed (n = 47). Interestingly, professional collection percentages increased by 4.3% in patients with delayed care, with more total episodes of surgical care on different days, likely due to limited discounting for multiple procedures in the same surgical setting. Complications were associated with the largest treatment expenses: mean $291,846 charges and $101,005 collections (35%). Facility collections decreased by 5% when a complication occurred. In contrast, an uncomplicated course of care was associated with the most favorable total collections: ($54,213/$140,797 = 38.5%) and the shortest mean total stay (8.0 days).

Conclusion: The trauma service line appears favorable in terms of payer mix. Facility collections were nearly 9 times those of the providers. An uncomplicated course of care resulted in the greatest total percent collections. Delays in fracture care were associated

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with more complications and longer hospital stays. Facility collections decreased by 5% when a complication occurred. Furthermore, delayed fracture care significantly increased hospital stay, accounting for ~$300K more in actual hospital costs alone over the course of the study. A standardized protocol to expedite definitive fracture fixation when patients are physiologically optimized appears efficacious in enhancing the profitability of the trauma service line.

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The Effect of Surgical Treatment on Mortality After Acetabular Fracture in the Elderly: A Multicenter Study of 454 Patients

Joshua L. Gary, MD[1]*; Ebrahim Paryavi, MD, MPH*[2]*; Steven D. Gibbons*[3]*; Michael J. Weaver, MD*[4]*; Jordan H. Morgan, BS*[4]*; Scott P. Ryan*[5]*, Adam J. Starr, MD*[3]*; Robert V. O'Toole, MD*[2]*;*
[1]*University of Texas Health Science Center, Houston, Texas, USA;*
[2]*University of Maryland School of Medicine, Baltimore, Maryland, USA;*
[3]*University of Texas Southwestern Medical Center, Dallas, Texas, USA;*
[4]*Brigham and Women's Hospital & Massachusetts General Hospital, Boston, Massachusetts, USA;*
[5]*Tufts Medical Center, Boston, Massachusetts, USA*

Purpose: Controversy exists regarding the effect of surgical treatment on mortality after acetabular fracture in elderly patients. Our hypothesis was that surgical treatment would confer a mortality benefit compared to nonsurgical treatment even after adjusting for comorbidities associated with death.

Methods: Institutional trauma databases were searched for all patients age 60 years and older who had been treated for acetabular fractures (62-A, B, C) at 3 academic Level-I trauma centers between 2002 and 2009. Medical records were reviewed to determine demographic characteristics, comorbidities, fracture patterns, dates of treatment, and method of treatment as nonsurgical versus surgical. Surgical treatment was further classified into three groups: traditional open reduction and internal fixation, percutaneous fixation, or acute arthroplasty. Our study sample consisted of 454 patients with a average age of 74 years. Mortality was determined using the social security death index. Kaplan-Meier survival curves were created and Cox proportional hazards models were used to calculate unadjusted and adjusted hazard ratios for covariates of interest.

Results: In contrast to previous smaller studies, the overall mortality was relatively low at 16% at 1 year (95% confidence interval [CI] 13%-19%). Unadjusted survivorship curves suggested higher mortality rates for nonsurgically treated patients (P <0.001); however, the treatment decision for nonsurgical treatment was associated with other factors associated with higher mortality. Our final multivariate model of survival demonstrated no significant difference in hazard of death for nonsurgical treatment (P >0.10), nor for any of the surgical treatment subgroups (P >0.10). As expected we did find a significantly increased hazard for factors such as the Charlson comorbidity index (per point), age (hazard ratio was 1.09 [95% CI 1.06-1.12]) per year of age over 70), and length of stay (per day) (all P <0.05). In addition associated fracture patterns (compared to elementary patterns) significantly increased the hazard of death with a ratio of 1.46 (95% CI 1.07-2.00).

Conclusion: In contrast to the rationale for surgical treatment of hip fractures, the surgical treatment of acetabular fractures does not appear to convey a mortality benefit once comorbidities are taken into account. The reason for this is unknown, but might be related to greater limitations in postoperative weight-bearing status compared to those after hip fracture surgery. Regardless of the cause, it does not appear that surgical treatment of geriatric acetabular fractures can be justified based on mortality benefit alone.

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Acute Total Hip Arthroplasty Versus Open Reduction and Internal Fixation for Acetabular Fractures Involving the Posterior Wall in Patients <65 Years Old: A Matched Cohort Analysis

***Carol A. Lin, MD, MA**; Jerald Westberg, BA; Andrew H. Schmidt, MD;*
Hennepin County Medical Center, Minneapolis, Minnesota, USA

Purpose: Acute total hip arthroplasty (THA) has been advocated for acetabular fractures in elderly patients; however, its usage in younger patients with fractures at high risk for reoperation, such as those involving the posterior wall, has rarely been studied. We hypothesized that patients <65 years old who underwent acute THA would have lower rates of reoperation and similar functional outcomes compared those underwent open reduction and internal fixation (ORIF).

Methods: We retrospectively reviewed consecutive patients under the age of 65 with acetabular fractures involving the posterior wall (62A1, 62A2 + posterior wall, 62B1 + posterior wall) treated at a Level I trauma center from 1996 to 2011. Operatively treated patients were grouped by acute THA or ORIF and were matched by fracture pattern and age at a 2:1 ratio within blocks of 5 years. Patients without a minimum of 1-year follow-up were excluded. The modified Oxford Hip Score* was used to assess functional outcome. Rates of reoperation and referral for THA were recorded. A P <0.05 was considered significant.

Results: 16 THA patients and 32 ORIF patients were evaluated at an average follow-up of 6.2 years (range, 1-15.2) with an average age of 56.4 versus 54.3 years (P = 0.163). There was no difference in the proportion of high-energy mechanisms of injury (100% vs 75%, P = 0.154) or ISS (11.7 vs 13.5, P p = 0.525). There were significant differences in the rates of marginal impaction (94% THA vs 41% ORIF, p < 0.001), full thickness cartilage injury to the femoral head (69% THA v 19% ORIF, P = 0.001), and involvement of the weight-bearing dome (44% THA vs 13% ORIF, P = 0.027). At last follow-up, 12 hips (37.5%) in the ORIF group had undergone THA or been referred for THA; 75% of these occurred within 1 year, and 83% were within 2 years. This was compared to 2 revisions (12.5%, P = 0.312) in the THA group: one loose cup at 2 months and one infection at 14 years. There was no difference in surgical time, blood loss, or the number of postoperative complications. The average time to full weight bearing was 98 days in the ORIF group compared to 71 days in the acute THA group (P = 0.045). The average Oxford Hip Score in the acute THA group was 44 compared to 40 in the ORIF group (P = 0.048) and there was no difference in the number of good-excellent results (93% vs 85%, P = 0.636).

Conclusion: Both ORIF and acute THA for high-energy acetabular fractures involving the posterior wall in middle-aged patients can provide excellent results. Acute THA may be more appropriate for those with femoral head involvement, articular comminution, or marginal impaction. Acute THA patients had better functional scores and earlier weight bearing. The indications for and utility of acute THA in this group warrant further investigation.

*Oxford Hip Score: range 0-48; >41 = excellent, 34-41 = good, 27-33 = fair, <27 = poor.

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Patient-Reported Health After Surgically Treated Displaced Sacral Fractures: A 10-Year Follow-up

Aron Adelved, MD[1,2]*; Anna Tötterman, MD, PhD*[3]*; Thomas Glott, MD*[4]*; Helene Søberg, PT, PhD*[5]*; Jan Erik Madsen, MD, PhD*[2]*; Olav Røise, MD, PhD*[2]*;*
[1]*Orthopaedic Department, Akershus University Hospital, Lørenskog, Norway;*
[2]*Orthopaedic Department, Oslo University Hospital, Olso, Norway;*
[3]*Orthopaedic Department, Karolinska University Hospital, Stockholm, Sweden;*
[4]*Department for Spinal Cord Injury and Multitrauma, Sunnaas Hospital, Nesodden, Norway;*
[5]*Department of Physical Medicine and Rehabilitation, Oslo University Hospital, Oslo, Norway*

Purpose: Displaced sacral fractures are associated with considerable morbidity. The aim of this study was to assess the long-term patient-reported health after surgically treated displaced sacral fractures, its association with clinical outcomes, and changes over time

Methods: Between 1996 and 2001, 32 consecutive patients with surgically treated displaced sacral fractures were included in a 1-year clinical outcome study, the results of which have been previously published. In the present study, 28 of these patients were available for follow-up, mean 10.7 years (range, 8.1-13.4) postinjury. Collected data included patient-reported health with Short Form-36 (SF-36), pain (visual analog scale), neurologic deficits in the lower extremities, and urinary, bowel, and sexual function. The SF-36 scores were compared to the Norwegian general population scores (NBS) and the previously published 1-year scores.

Results: At 10 years, the SF-36 scores were significantly lower than the NBS in all subscales. No significant changes were found between 1- and 10-year scores. We found significant correlations between pain and poor Physical Functioning ($P = 0.05$), Role Physical ($P = 0.01$), Bodily Pain (BP) ($P = 0.003$), General Health ($P = 0.007$), and Role Emotional (RE) ($P = 0.006$). Sexual dysfunction was significantly correlated with poor Social Functioning ($P = 0.013$) and RE ($P = 0.04$), and bowel dysfunctions with BP ($P = 0.02$) and poor RE ($P = 0.03$). No correlations were found between SF-36 and urinary dysfunction or neurologic deficits in the lower extremities.

Conclusion: Patients with displaced sacral fractures reported poor health at 10 years, compared to the general population, with no significant improvement between 1 and 10 years. Poor self-reported health was associated with pain and sexual and bowel dysfunctions. The strongest association was found between pain and patient-reported health, suggesting a special attention to pain treatment, in order to improve quality of life in these patients.

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•Recombinant Human Morphogenetic Protein-2 (rhBMP-2) Versus Iliac Crest Autograft to Treat Tibia Nonunion: A Retrospective Multicenter Study

Southeast Fracture Consortium; ***William T. Obremskey, MD, MPH;***
Vanderbilt University Medical Center, Nashville, Tennessee, USA

Background/Purpose: There is no consensus opinion on the use of recombinant human morphogenetic protein (rhBMP) in the treatment of tibia fracture nonunions. Avoidance of complications associated with iliac crest autograft harvesting has led to a high level of off-label rhBMP-2 use to treat fracture nonunions. Complications with the use of off-label rhBMP-2 in cervical fusion have raised interest in the off-label use of rhBMP-2 in orthopaedic trauma. The purpose of this study was to retrospectively examine the union rate and adverse events associated with the use of rhBMP-2 compared to iliac crest autograft for the treatment of tibia nonunions.

Methods: We retrospectively reviewed the management of all consecutive tibia nonunions in patients who were treated with either rhBMP-2 (n = 33) or iliac crest autograft (n = 132) between January 1, 2002 and December 31, 2008 at five Level I orthopaedic trauma centers. Clinical records and radiographs were reviewed to determine the rate of fracture union and incidence of adverse events.

Results: The two intervention groups were statistically similar. The healing rates were 84.9% and 74.2% for the rhBMP-2 and iliac crest autograft groups respectively ($P = 0.20$). Bivariate logistic regression analysis comparing rhBMP-2 and iliac crest autograft with fracture union revealed an odds ratio (OR) of 1.94 favoring rhBMP-2, but this was not statistically significant (95% confidence interval [CI]: 0.69-5.43, $P = 0.21$). While controlling for age, gender, prior infection, and intramedullary fixation, the OR comparing rhBMP-2 and iliac crest was 2.01 (95% CI: 0.70-5.82, $P = 0.20$). The length of stay was statistically significant favoring the rhBMP-2 group (2.7 days vs 3.6 days, $P = 0.005$).

Conclusion: In a retrospective, multicenter study, rhBMP-2 appears to have similar union rates compared to iliac crest autograft in the treatment of atrophic or oligotrophic tibia nonunions. Our data revealed a statistically significant shorter length of stay for patients treated with rhBMP-2 compared to iliac crest autograft.

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The Reamer Irrigator Aspirator (RIA) as a Device for Harvesting Bone Graft Compared With Iliac Crest Bone Graft: Union Rates and Complications

*Peter J. Nowotarski, MD; **John Dawson, MD**; Dirk Kiner, MD; Warren Gardner II, MD; Rachel Swafford, MS;*
University of Tennessee College of Medicine – Chattanooga, Chattanooga, Tennessee, USA

Purpose: This study was performed to determine if patient outcomes after reamer irrigator aspirator (RIA)–harvested bone grafting are inferior, equivalent, or better than outcomes for patients treated with the current gold standard, either anterior or posterior iliac crest graft (ICG).

Methods: 133 patients with nonunion or posttraumatic segmental bone defect requiring surgical intervention were prospectively randomized to receive ICG or RIA autograft. Supplemental internal fixation was performed per surgeon preference. Surgical data included amount of graft, time of harvest, and associated surgical costs. The Short Musculoskeletal Functional Assessment (SMFA) and the visual analog scale (VAS) were used to document baseline and postoperative function and pain. Clinical and radiographic union was the defined end point; patients developing infection or nonunion requiring reoperation on the grafted extremity were considered to have failed the index treatment.

Results: 113 of 133 enrolled patients were followed until union and included in the final analysis. Intraoperative data showed anterior ICG to yield 20.7 ± 12.8 cc (range, 5-60) of autograft with an average harvest time of 33.2 ± 16.2 minutes; posterior ICG yielded 36.1 ± 21.3 cc (range, 20-100) of autograft in 40.6 ± 11.2 minutes; and RIA yielded 37.7 ± 12.9 cc (range, 5-90) in 29.4 ± 15.1 minutes. Anterior ICG produced significantly less bone graft than either RIA or posterior ICG (P <0.001). The RIA harvest took a significantly shorter duration of operative time compared to posterior ICG (P = 0.005). Anterior ICG did not differ in duration of harvest from either RIA or posterior ICG. At $738, the RIA setup was considerably more expensive than the $100 cost of a bone graft tray; however, when compared to posterior ICG, the longer operative time required for a posterior harvest came at an additional incremental cost of $1780, making RIA the less expensive option. Patients were followed for an average of 56.9 ± 42.1 (range, 11-250) weeks. 49 of 57 patients (86.0%) who received ICG united in an average of 22.5 ± 13.2 weeks; 46 of 56 patients (82.1%) who received RIA healed in an average of 25.8 ± 17.0 weeks. Union rates and time to union were equivalent comparing both procedures. There was no difference in complications requiring reoperation for persistent nonunion or infection. Postoperative follow-up showed that RIA patients had significantly lower donor site pain scores throughout follow-up. There was no difference in donor site complications.

Conclusion: When compared to autograft obtained from the iliac crest, autograft harvested using the RIA technique achieves similar union rates with significantly less donor site pain. RIA also yields a greater volume of graft compared to anterior ICG and has a shorter harvest time compared to posterior ICG. For larger-volume harvests, cost analysis favors using RIA.

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Dynamizations and Exchange Nailing: Success Rates and Indications

Jody Litrenta, MD[1]*; Paul Tornetta, III, MD*[1]*; Cory A. Collinge, MD*[2]*; Heather A. Vallier, MD*[3]*; Clifford B. Jones, MD*[4]*; Christiane G. Kruppa, MD*[4]*; Reza Firoozabadi, MD*[5]*; Kenneth A. Egol, MD*[6]*; Ross K. Leighton, MD*[7]*; Mohit Bhandari, MD*[8]*; Emil H. Schemitsch, MD*[9]*; David W. Sanders, MD*[10]*;*
[1]*Boston University Medical Center, Boston, Massachusetts, USA;*
[2]*Texas Health, Fort Worth, Texas, USA;*
[3]*MetroHealth Medical Center, Cleveland, Ohio, USA;*
[4]*Orthopaedic Associates of Michigan, Grand Rapids, Michigan, USA;*
[5]*University of Washington, Seattle, Washington, USA;*
[6]*NYU – Hospital for Joint Diseases, New York, New York, USA;*
[7]*Dalhousie University, Halifax, Nova Scotia, Canada;*
[8]*McMaster University, Hamilton, Ontario, Canada;*
[9]*St. Michael's Hospital, Toronto, Ontario, Canada;*
[10]*London Health Science Centre, London, Ontario, Canada*

Background/Purpose: Tibial nailing is an accepted and successful treatment for tibia fractures; however, the secondary intervention rate for tibia fractures in large trials has been reported to be >15%. When nailed fractures go on to delayed or nonunion, exchange nailing and dynamization are two common secondary interventions. There are no data comparing union rates in like patients and little data available at all regarding dynamization. The purpose of this study is to report on the timing, indications, and success rates of dynamization and exchange nailing in a multicenter study and to compare these two techniques where appropriate.

Methods: The records and radiographs of 183 tibia fractures in multiple centers that had dynamization or exchange nailing for delayed/nonunion were reviewed. Delayed/nonunion was defined as at least 3 months postsurgery with no progression. Demographic data, fracture type, cortical contact/gap, timing of and success rates of the secondary intervention, and RUST (Radiographic Union Score for Tibial fractures) scores at intervention and follow-up were recorded. Success was defined as obtaining union while nonunion or additional intervention defined failure. Two-tailed *t* tests and Fisher exact or χ^2 with *P* set at <0.05 for significance were used as indicated.

Results: A total of 183 tibia fractures underwent dynamization (92) or exchange nailing (91). The average age was 39 years (range, 16-81). There were 141 men and 42 women. Mechanisms of injury were motor vehicle accident (MVA) (53), motorcycle accident (MCA) (47), pedestrian struck (26), falls (28), direct blow (16), and other (13). There were 112 open (50% grade III) and 71 closed fractures in the proximal (21%), midshaft (30%), or distal (49%) tibia. No statistical differences were found between the dynamization and exchange nailing groups with respect to demographics or fracture characteristics, although a gap or bone defect was more common in the exchange group (20% vs 34%, $P = 0.06$). The success rates of the interventions were not different for exchange nails ($P = 0.3$) or dynamizations ($P = 0.75$) performed early versus after 6 months nor were the RUST scores for successful versus failed procedures ($P = 0.96$ and 0.43) allowing for pooling of the data. 14 patients were lost or are currently in follow-up, leaving 169 fractures followed to union or failure.

See pages 91 - 132 for financial disclosure information.

Table 1 details the primary results:

Table 1: Results

Intervention	N	Median Days to Surgery (days)	RUST Preop	Union n (%)	Median Time to Union (mos)	RUST Union
Dynamization	83	166	7.1	70 (84%)	10.8	10.0
Exchange	86	194	6.7	79 (92%)	13.2	10.3
P value	NA	NA	0.06	0.16	NA	0.4

The RUST scores at the time of intervention were not different for successful or failed dynamizations (7.02 vs 7.0, $P = 0.96$) or exchanges (6.5 vs 7.2, $P = 0.43$). Likewise, the time to successful versus failed dynamization (170 vs 169 days, $P = 0.97$) or exchange nailing (231 vs 191 days, $P = 0.33$) was not different. However, no cortical contact or a gap was a statistically negative factor for both exchange nails ($P = 0.09$) and dynamizations ($P = 0.06$). When combined, the success in the face of a gap was 78% versus 92% when no gap was present ($P = 0.03$).

Conclusion: Prior literature has few reports of the success rates of distant site interventions for tibial nonunions. The indications for dynamization and exchange were similar with RUST scores of 6.7 versus 7.1 and the median time to intervention close to 6 months in both groups. Having no cortical contact or gap favored having an exchange nail performed, and was a negative prognostic factor for both procedures. The current study demonstrates high rates of union for both dynamization and exchange nailing making both viable options.

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