

## 2014 Scientific Program Abstracts — Friday

(An asterisk (\*) by an author's name indicates the presenter.)

Friday, December 19, 2014

### Concurrent Session 11A: Foot and Ankle (Palomino Ballrooms 8-10)

**Civilian Moderator:** Bruce Cohen, MD  
**Military Moderator:** COL Scott Shawen, MD

0930-0935

### Chronic Latent Syndesmotic Instability: A Surgical Algorithm, Patient Outcomes, And Return To Activity

LTC Paul Ryan, MD  
Ryan M. Rodriguez, PA-C, ATC

**Introduction:** his study is a retrospective review of prospectively gathered data determining the post-operative outcomes of patients who underwent surgical treatment to address chronic syndesmosis instability.

**Methods:** The cohort is comprised of 23 individuals who elected to undergo surgical treatment of chronic syndesmotic instability. The surgical repair consisted of arthroscopic debridement in all cases with suture button fixation of those patients who had greater than 4 mm of syndesmotic diastasis on arthroscopic evaluation. Inclusion criteria includes: greater than 2mm of diastasis at the distal syndesmosis on arthroscopic stress examination and failure of conservative management. All patients had a minimum of 24 months follow-up. This study retrospectively examined the prospectively gathered pre-operative and post-operative outcome scores to include: a Visual Analog Pain Score (VAS), SF 36, and an AOFAS Ankle and Hind foot Scale scores. In addition, patients were questioned on their ability to return to their pre-injury level of activity and their ability to continue running sports.

**Results:** Fourteen patients returned their post-operative surveys. 79% (11 of 14) of patients were able to return to running

and 57% (8/14) were able to continue athletics at their pre-injury level. An AOFAS score was available for 13 patients pre-operatively with an average score of 48.5. Post-operative AOFAS scores were available for 12 patients with an average score of 73.6. This difference was clinically significant ( $p=0.008$ ). A post-operative VAS was obtained for 12 patients with an average score of 1.1. Pre-operative subjective pain scores were determined through chart review and averaged 5.9. This improvement is also clinically significant ( $p<0.001$ ). Preoperative and postoperative weight bearing ankle radiographs were reviewed to evaluate the tibio-fibular clear space and overlap. The clear space measured on AP radiographs decreased from 5.36mm to 4.59mm ( $p=0.005$ ), the clear space evaluated on the mortise radiograph decreased from 4.49 mm to 3.62 mm ( $p=0.006$ ), and the overlap measured on the AP radiograph increased from 5.72 mm to 6.89 mm ( $p=0.019$ ). All radiographs were measured by a board certified musculoskeletal radiologist.

**Discussion:** Chronic syndesmotic instability is a disabling condition that can result in chronic ankle pain. The diagnosis is difficult and arthroscopic evaluation remains the gold standard for diagnosis. This study presents a treatment algorithm that can be instituted at the time of diagnosis. Injuries to the syndesmosis with 2-4 mm of diastasis are treated with debridement alone and those injuries with greater than 4 mm of diastasis are treated with debridement and stabilization. The results of this treatment algorithm are promising with significant improvements in subjective outcome scores. More importantly, 79% of patients were able to return to running sports.

**Conclusion:** Chronic latent syndesmotic instability can be effectively managed through a treatment algorithm wherein patients with mild instability are debrided alone and patients with moderate instability are treated with debridement and percutaneous stabilization.

**Notes:**

0935-0940

## The Effectiveness Of Different Syndesmotic Reduction Techniques

LCDR Colin Crickard, MD  
 John Rodriguez-Feo, MD  
 John Ellington, MD  
 James Toussaint, MD  
 Erica E. Andrews, BS  
 Katherine M. Sample, BBA  
 LTC (Ret) Joseph R. Hsu, MD

**Introduction:** Syndesmotic injuries are very common with rotational ankle injuries. Multiple studies exist that show plain radiographs have a poor ability to detect syndesmotic alignment and that malalignment increases the risk of a bad outcome. Based on this, another method to evaluate and treat syndesmotic injuries could provide significant clinical benefit. Numerous authors have advocated advanced imaging both in and out of the operating room to accomplish this goal. While computed tomography (CT) and magnetic resonance imaging (MRI) are very accurate in the evaluation of syndesmotic injury as well as malreduction they both have the disadvantage of significant increased cost. CT also carries the risk of increased radiation exposure. Arthroscopic reduction has also been supported. Given the current situation, a minimal radiation exposure, real time evaluation of the syndesmosis would provide significant benefit. The purpose of this study is to quantitatively compare the accuracy of fluoroscopic, open, and arthroscopic reduction of the syndesmosis.

**Methods:** Ten fresh frozen cadaveric lower limb pairs were obtained. The demographic data for each of these patients was collected. Cadavers were excluded if they had previous ankle surgery. The cadavers were positioned supine for the reductions. Each reduction was performed under the supervision of the senior author, a fellowship trained orthopedic trauma surgeon. Initially a medial approach to the ankle was used to expose the plafond with sectioning of the deep deltoid, achilles, tibialis anterior, extensor hallucis longus, and extensor digitorum longus tendons. Care was taken to preserve the anterior and posterior inferior tibiofibular ligaments. The talus was then dislocated at this time to allow a calibrated photograph to be taken. This was the intact state. The syndesmosis was then sectioned to include the interosseous membrane from the level of the plafond to 10cm proximal to the ankle joint. The ankle was reduced at this time and reduction was performed under fluoroscopic guidance. The ankle was stabi-

lized with a partially threaded screw 3.5mm in diameter. The ankle was then dislocated and another calibrated photograph was taken to evaluate the fluoroscopic reduction. The cadaver legs were then randomized by odd or even number to undergo reduction with either arthroscopic or open method first, followed by the one remaining reduction technique. The process of reduction, screw placement, and dislocation with calibrated photograph was repeated for both open visualization and for arthroscopic visualization. To ensure distinct reductions from one technique to the next, the syndesmosis screw was placed 1cm proximal to the previous start point each time after initially starting 2cm proximal to the plafond for the first screw. We analyzed each photograph using ImageJ software. This software measures a calibrated digital photo and calculates the two dimensional distances and is useful in quantifying surgical reduction.

**Results:** The average anterior syndesmosis width measured from the anterior border of the fibula was 1.2 +/- 0.61mm for the intact specimens. The posterior width of the syndesmosis was, on average, 3.7 +/- 1.08mm for the intact ankles. The average anterior and posterior syndesmosis widths for reduction under fluoroscopy were 1.2 +/- 0.99mm and 3.6 +/- 1.32mm respectively. Using arthroscopic reduction the anterior widths were 1.3 +/- 0.98mm and the posterior widths were 3.6 +/- 0.95mm. The open reduction yielded anterior widths averaging 1.2 +/- 0.78mm and posterior widths of 3.5 +/- 1.01. None of these differences were statistically significant or clinically relevant. In our study all three of the reduction techniques averaged within 0.2mm of the intact state.

**Conclusion:** Given the available options tested in this study for reduction of the syndesmosis no single method can be recommended over the others based upon our cadaveric study. All three options provided acceptable reduction of the syndesmosis in our model.

**Notes:**

0940-0945

## Comparative Study Of Assisted Ambulation And Perceived Exertion With The Wheeled Knee Walker And Axillary Crutches

MAJ Benjamin Kocher, DSc, PA-C  
MAJ Donna Lopez, MSN  
CPT Matthew Napierala, MD  
LTC (Ret) Kevin Kirk, DO

**Introduction:** Foot and ankle injuries (FAI) are common and a major cause of time lost from military operations. Functional limitations after lower extremity surgery often require the use of an assistive device for ambulation during rehabilitation and recovery. The Wheeled Knee Walker (WKW) has recently gained popularity as an assistive device, but there is no known clinical data evaluating it for protected ambulation. The purpose of this study is to compare ACs and the WKW in healthy volunteers for both clinical and subjective outcomes using the 6 Minute Walk Test (6MWT), Self-Selected Walking Velocity (SSWV) and OMNI Rating of Perceived Exertion (OMNI-RPE). The hypothesis is that the WKW will provide improved assisted ambulation on the 6MWT and SSWV, have lower perceived exertion, and provide high patient satisfaction when compared to ACs.

**Methods:** A prospective, randomized crossover study was performed using 24 healthy volunteers. Each subject performed a Six-Minute Walk Test (6MWT) on each assistive device in a crossover design. Pre-activity and post-activity heart rates were recorded for each device. SSWV was calculated with the 6MWT data and the subject's rating of perceived exertion was recorded using the OMNI Rating of Perceived Exertion (OMNI-RPE). Subject's preference for assistive device was identified using a subjective questionnaire.

**Results:** The 6MWT, SSWV and the Omni-RPE were evaluated using paired t-tests and all determined to be statistically significant (p value less than 0.001) with the comparison of the devices. The 6MWT distances for the WKW was 546.67 meters (351.68-741.65 95% CI) compared to 317.21 meters (125.98-508.44 95% CI) for the AC. The SSWV for the WKW was 1.52 m/s (0.98-2.06 95% CI) compared to 0.88 m/s (0.35-1.41 95% CI) for the AC. Evaluation of the pre-activity and post-activity heart rates demonstrated statistically significant lower post-activity heart rates for participants utilizing the WKW when compared to ACs. Overall, 87.5% of participants preferred the WKW to ACs.

**Discussion and Conclusion:** The WKW provides improved assisted ambulation on the 6MWT and SSWV, has a lower perceived exertion and post-activity heart rate, and is the preferred device for assisted ambulation in healthy patients compared to ACs.

**Notes:**

0945-0950

## Return To Duty And Short Term Outcomes Following Internal Fixation Of Ankle Fractures In Active Duty US Military Personnel

CPT Nicholas Kusnezov, MD  
COL Philip J. Belmont Jr., MD  
CPT David M. Romano, MD  
MAJ Brian R. Waterman, MD  
MAJ Justin D. Orr, MD

**Introduction:** Ankle fractures are common orthopaedic injuries in active duty service members (ADSMs), a population of predominantly young athletic individuals. There are few reports on outcomes of surgical fixation of ankle fractures in such populations. This study sought to determine the military occupational outcomes following open reduction and internal fixation (ORIF) of ankle fractures in a cohort of ADSMs.

**Methods:** The records of all ADSMs who received primary fixation for ankle fractures at William Beaumont Army Medical Center between August 2007 and January 2012 were reviewed to determine the occupational outcomes and complication rates following fixation of ankle fractures. Fracture severity was subcategorized based on unimalleolar pattern, bi/trimalleolar pattern, and presence of syndesmotom injury. Demographic information including age, sex, rank and military operational specialty (MOS) were recorded as well as fracture severity. Outcomes considered included full return to duty, ability to return to running, medical separation and overall complications. Statistical analysis was performed to identify significant risk factors for occupational outcomes.

**Results:** 76 ADSMs met inclusion criteria, of which 88% of patients were male with a mean age of 28.4 years. 70% of patients were junior enlisted (E1-E6), and 61% of patients were either combat arms or combat support branch MOS. Unimalleolar injury was the most common pattern (76%), followed by the more severe bimalleolar (16%) and trimalleolar fractures (7.9%). Syndesmotic fixation was performed in 49% of patients. Demographics were not significantly different between fracture severity groups. Complications included two (2.6%) infections, one (1.3%) nonunion, and six (7.9%) re-operations other than hardware removal. 41% required eventual hardware removal. At a mean follow-up of 2.4 years, 76% of patients remained on full active duty service, and 5.3% of ADSMs were medically separated from the military due to sequelae from ankle fractures. Medical separation was most common in males (83%), patients 20 – 29 years old (50%), isolated lateral malleolar fractures (50%), and junior enlisted ADSMs (100%). Compared to senior enlisted and officers, junior enlisted were significantly younger ( $p < 0.0001$ ) but were significantly more likely to be medically separated due to the ankle fracture ( $p = 0.04$ ). ADSMs with combat arms and support MOS were significantly more likely than those with combat service support MOS to require reoperation other than hardware removal ( $p = 0.04$ ); however, they were significantly more likely to return to running ( $p = 0.03$ ) and less likely to undergo medical separation.

**Discussion and Conclusion:** Young male ADSMs and junior enlisted were most likely to undergo medical separation following ankle fracture fixation. At least one in twenty ADSMs undergoing ankle fracture fixation will be medically separated from the military. Combat arms and combat support MOS service members were significantly more likely to require reoperation; however, they were also significantly more likely to return to running and less likely to undergo medical separation. Overall, more than 40% of patients required hardware removal of some type. These results are important for military orthopaedic surgeons when counseling their patients regarding long-term prognosis following ankle fracture fixation.

**Notes:**

0950-0955

## Ankle Arthroscopy Simulation Improves Basic Skills, Anatomic Recognition And Proficiency During Diagnostic Examination Of Residents In Training

MAJ Kevin D. Martin, DO  
David Patterson, MD  
Phinit Phisitkul, MD  
Kenneth L. Cameron, PhD, MPH, ATC  
John E. Femino, MD  
Annuziatio Amedola, MD

**Introduction:** The purpose of this study was to determine whether low fidelity arthroscopic simulation training improves basic ankle arthroscopy performance and efficiency among orthopaedic trainees.

**Methods:** Thirty orthopaedic surgery trainees with varying levels of ankle arthroscopy experience were randomized into either a simulation or standard practice groups. All subjects were oriented to the arthroscopic Sawbones ankle simulator, a 15-point ankle arthroscopy checklist, and the Arthroscopic Surgery Skill Evaluation Tool (ASSET), a validated metric for assessing technical ability during arthroscopy. Individual surgical case logs were queried to identify cumulative exposure to ankle arthroscopy. At baseline testing, all participants performed simulator-based testing and a cadaveric diagnostic ankle arthroscopy with video recording. The simulation group subsequently received four one-on-one 15 minute training sessions over a four-month period, while the standard practice group received routine arthroscopic exposure without simulator training. After intervention, both groups were re-evaluated with simulator testing and a second recorded cadaveric diagnostic ankle arthroscopy. Two blinded, independent experts evaluated each arthroscopic performance utilizing the 15-point checklist, ASSET score, and total elapsed time, and all outcome measures were compared within and between groups.

**Results:** Baseline arthroscopic experience, simulator task performance measures, and ASSET scores were equivalent between the simulation and standard practice groups. After intervention, the simulation group performed simulator and cadaveric testing significantly faster while simultaneously achieving a higher overall ASSET scores. Further analysis of the ASSET also revealed that the simulation group had significantly higher post-intervention safety scores.



**Conclusion:** These results demonstrate low fidelity ankle arthroscopy simulation training can improve orthopaedic trainees' basic surgical skills and efficiency while decreasing surgical time on a cadaveric model. The results also suggest greater patient safety during ankle arthroscopy following simulation training.

**Notes:**

0955-1000

## Mini-Fragment Internal Fixation Of Distal Fibular Fractures Results In Lower Rates Of Hardware Removal Without Compromising Healing

LT Lauren Ehrlichman, MD  
Eric Bluman, MD  
Wajdi Kanj, MD

**Introduction:** Fractures of the distal fibula are common and in certain situations are optimally treated with operative stabilization. Small-fragment implants that are typically used for internal fixation of these fractures may result in local irritation due to their size and subcutaneous position, which may ultimately necessitate hardware removal. A recent study demonstrated that the mean load at failure of mini-fragment constructs is equivalent to that of small-fragment implants. We describe our single-surgeon experience with the use of mini-fragment constructs in the fixation of ankle fractures involving the lateral malleolus.

**Methods:** A retrospective chart review of 84 ankle fractures involving the lateral malleolus treated by the senior author at our institution between July 2009 and April 2014 was performed. Of these, mini-fragment non-locking constructs were used either independently or in conjunction with other implants to provide internal fixation of the lateral malleolus in 54 cases. In some cases, mini-fragment constructs were also used for stabilization of the medial malleolus, posterior malleolus, talus, or tibial plafond. Only patients with a follow-up time of at least four weeks were included in the analysis (n=52). In total, there were

28 isolated fractures of the lateral malleolus, seven bimalleolar fractures, nine trimalleolar fractures with only the medial and lateral malleolus fixation, three trimalleolar fractures with fixation, two fractures of the lateral and posterior malleoli, one pilon fracture, one lateral malleolus fracture with accompanying distal tibia fracture, and one lateral malleolus nonunion treated with mini fragment internal fixation. The mean time of follow-up was six months (24.3 weeks).

**Results:** Of the 52 ankle fractures involving the distal fibula that were treated with internal fixation using mini-fragment constructs, only three necessitated hardware removal (5.8%). Less than 4% of patients reported lateral ankle pain overlying the hardware. Reasons prompting hardware removal included peroneal tendon irritation in the setting of hardware loosening (n=1), lateral wound dehiscence (n=1), and infection after ORIF of a fracture-dislocation in a diabetic patient (n=1). One patient developed SPN neuritis but did not require hardware removal. All but three patients achieved radiographic union by six weeks, with an average of 6.2 weeks until union. There were no cases of loss of reduction.

**Discussion and Conclusion:** Mini-fragment constructs yielded excellent results for the fixation of ankle fractures involving the distal fibula at a mean follow-up of 6 months. Only 3 cases required hardware removal for local irritation, wound dehiscence, or infection. There were no cases of loss of reduction. Our results lend clinical support to recent findings demonstrating that mini-fragment constructs exhibit similar biomechanical function to small-fragment implants in supination external reduction fractures of the distal fibula. Furthermore, our hardware removal rate of 5.8% is substantially lower than a previously reported rate of 23%.

**Notes:**

1000-1005

## Patient-Based And Surgical Risk Factors For Thirty-Day Post-Operative Complications And Mortality Following Ankle Fracture Fixation

CPT Shaunette Davey, DO  
 COL Philip J. Belmont Jr., MD  
 CPT Nicholas Rensing, MD  
 Julia O. Bader, PhD  
 MAJ Brian R. Waterman, MD  
 MAJ Justin D. Orr, MD

**Introduction:** The purpose of this study was to calculate the incidence rates and determine risk factors for 30-day postoperative mortality and morbidity following ankle fracture open reduction and internal fixation.

**Methods:** The National Surgical Quality Improvement Program (NSQIP) database was queried to identify all patients undergoing ankle fracture open reduction and internal fixation between 2006 and 2011, with extraction of selected patient-based or surgical variables and 30-day clinical course. Bivariate and multivariable logistic regression analysis identified significant risk factors on outcome measures.

**Results:** Mean age was 50.3 (+/-18.2) years, while diabetes mellitus (12.8%) and Body Mass Index (BMI)  $\geq 40$  (9.2%) were documented from 3,328 total patients identified. The 30-day mortality rate was 0.30% and complications occurred in 5.1%. Chronic obstructive pulmonary disease (OR 4.23, 95% CI 1.19, 15.06) and a non-independent functional status prior to surgery (OR 2.25, 95% CI 1.13, 4.51) were the sole independent predictors of mortality and major local complication, respectively. Pulmonary embolism (0.45%) was the most common major systemic complication. Major local complications occurred in 2.2% of patients and the most significant independent risk factors were peripheral vascular disease (OR 6.14; 95% CI 1.95, 19.35), open wound (OR 5.04; 95% CI 2.25, 11.27), non-clean wound classification (OR 3.02; 95% CI 1.31, 6.93) and smoking (OR 2.85; 95% CI 1.42, 5.70). Independent predictors of hospital stay  $>3$  days, in descending order of magnitude, were cardiac disease, age  $\geq 70$  years, open wound, partially/totally dependent functional status, ASA Classification  $\geq 3$ , BMI  $\geq 40$ , bimalleolar or trimalleolar ankle fracture pattern, female sex and diabetes.

**Conclusions:** Chronic obstructive pulmonary disease increased the risk of mortality following ankle fracture fixa-

tion. Predictive factors increasing the risk of postoperative complications included peripheral vascular disease, open wound, non-clean wound classification, age  $\geq 70$  years and ASA Classification  $\geq 3$ . Level of Evidence: II (Prognostic).

Notes:

1015-1020

## Medial Malleolar Screw Hemiepiphysiodesis For Ankle Valgus Revisited

CPT David J. Wilson, MD  
 Sean M. Caskey, MD  
 Glen O. Baird, MD  
 Bryan J. Tompkins, MD  
 Paul M. Caskey, MD

**Purpose:** We reported a large review of complications of medial malleolar screw hemiepiphysiodesis for ankle valgus in 2009 and recommended using fully threaded 4.5 mm screws to avoid hardware complications. The purpose of this study is to report our experience with medial malleolar screw hemiepiphysiodesis after our conversion to fully threaded 4.5 screws exclusively.

**Methods:** A retrospective review of medial malleolar screw hemiepiphysiodesis from 2007 to 2012 was performed. Inclusion criteria; clinical and radiographic evidence of ankle valgus treated with a fully threaded 4.5mm screw, minimum follow up to screw removal or completion of growth. Preoperative, post-operative and follow-up clinical and radiographic data were collected. Measurements of tibial talar angle and complications related to the procedure were collected.

**Results:** Our population who met the inclusion criteria for the study consisted of 54 ankles in 35 patients, 23 males and 12 females. Common underlying diagnoses were clubfoot, multiple hereditary exostosis and neurologic problems. Mean age at screw insertion was 10 years (range of 6.25 to 14.9 years) and mean age of screw removal or maturity of 11.9 years (range of 8.5 to 16.3 years). Mean preoperative tibial talar angle was 11.2 degrees valgus (range 1 to 31 degrees) and mean tibial talar angle at screw removal/maturity was

0.5 degrees valgus (range 32 degrees valgus to 9 degrees varus). The average rate of correction of ankle valgus was 0.72 degrees/month (range 0 to 1.5 degrees/month). We had no major complications, defined as requiring additional surgery. Minor complications occurred in 7.4% of ankles including 2 ankles with temporary pain over incision at first follow up and two screws in one patient that migrated with continued correction.

**Conclusion:** Medial malleolar screw hemiepiphyseodesis is a safe, reliable means of correcting ankle valgus. The average rate of correction of the valgus deformity is comparable to other means of correction using guided growth and the complication rate was low especially when 4.5mm fully threaded screws were used exclusively. We prefer the medial malleolar screw technique for correction of ankle valgus because the insertion and removal of the screw can be performed percutaneously.

**Notes:**

1020-1025

## Microfracture Repair Of Osteochondral Lesions Of The Talus In The Active Duty Population At A Military Medical Center

CPT Andrew Jackson, MD  
CPT Christopher Chen, MD  
CPT Chase A. Dukes, MD

**Introduction:** Osteochondral lesions of the talus are one of the most common talar injuries observed in the active duty military population. Maintaining the integrity of the chondral surface of the talus is critical in preventing the degenerative cascade leading to osteoarthritis. The purpose of this study is to analyze the outcomes of microfracture repair of osteochondral lesions of the talus in the active duty military population, focusing on the soldier's ability to run, resolution of pain, need for revision surgery, and need for medical evaluation board (MEB).

**Methods:** A retrospective review of all osteochondral lesions of the talus treated with microfracture VS OATS performed

on active duty Soldiers at a Military Medical Center from January 2010 to December 2013 was conducted. Data were collected from operative reports, eprofile and the electronic medical record (AHLTA).

**Results:** There were sixty-one microfracture repairs during the study period. Outcomes were characterized as good, fair, or poor. Good being defined as able to run, no MEB, and no revision. Fair being defined as pain, without MEB or revision surgery. Poor being defined as having to have a MEB or revision surgery. Patients with a one year follow up or greater currently demonstrate ten good outcomes, nine fair outcomes, and six poor outcomes.

**Discussion and Conclusion:** In conclusion, microfracture repair of osteochondral lesions of the talus in this active duty population allowed approximately seventy-six percent of soldiers to return to military duties; however, thirty-six percent of those soldiers required a permanent duty restricting profile and experienced pain while running. Twenty-four percent of soldiers in this cohort required medical evaluation board or additional surgery.

**Notes:**

1025-1030

## Tubercle Views Of The Ankle

LCDR Colin Crickard, MD  
LTC (Ret) Joseph R. Hsu, MD

**Introduction:** Syndesmotic injuries are very common with rotational ankle injuries. Evaluation and treatment present numerous challenges to the orthopedic surgeon. Multiple studies exist that show plain radiographs have a poor ability to detect syndesmotic alignment and that malalignment increases the risk of a bad outcome. Based on this, another method of imaging to evaluate and treat syndesmotic injuries could provide significant clinical benefit. Numerous authors have advocated advanced imaging both in and out of the operating room to accomplish this goal. While computed tomography (CT) and magnetic resonance imaging (MRI) are very accurate in

the evaluation of syndesmotic injury as well as malreduction they both have the disadvantage of significant increased cost. CT also carries the risk of increased radiation exposure. Given the current situation, a low cost, minimal radiation exposure, real time evaluation of the syndesmosis would provide significant benefit. Based on both the initial evaluation of malrotated radiographs of the ankle and upon a thorough understanding of the anatomic orientation of the incisura fibularis on the lateral distal tibia, it is our theory that the syndesmosis may be evaluated for reduction and alignment with a variation in the current radiographic technique.

**Methods:** 10 cadaveric lower extremity specimens were evaluated under fluoroscopy to determine the ideal limb position for the ankle to obtain direct views of both the anterior and posterior tubercles of the incisura and the relationship of the fibula to the tubercles. One specimen was also intentionally malreduced to evaluate the effectiveness of reduction assessment with the fluoroscopic evaluation of the tubercle and fibula alignment.

**Results:** To isolate the posterior tubercle in the cadaver an anterior-posterior (AP) projection of the ankle with approximately 25 degrees of external rotation was performed. With this same degree of external rotation the fluoroscopy unit was rotated to the lateral position to obtain the anterior tubercle view. On average, an additional 10 degrees of external rotation helped further delineate the anterior tubercle on the lateral image. Orthogonal positioning of the fluoroscopy unit was very reliable in determining the relationship of the anterior to the posterior tubercle view. Additionally, using the lateral image and having the tibia overlap the posterior quarter of the fibula also assisted in isolating the anterior tubercle.

**Conclusion:** Imaging of the incisura and distal fibula relationship is reproducible using simple anatomic orientation. It may also provide easy to use evaluation of syndesmotic reduction in the operating room.

**Notes:**

1030-1035

## Publication Rates Of Abstracts Presented At The American Orthopaedic Foot And Ankle Society Annual Meeting

Capt Ian Tuznik, MD  
 Capt Andrew J. Sheehan, MD  
 Patrick M. Osborn, MD  
 Thomas C. Dowd, MD

**Introduction:** Annual meetings provide attendees with the opportunity to present original research and share data, ideas, and techniques so as to advance the body of knowledge within a wide array of subspecialty areas. It is not uncommon for conclusions presented in the form of scientific abstracts to be cited by subject matter experts or referenced in orthopaedic textbooks. Several well-designed analyses, however, have scrutinized the rigor of this practice by reporting on the rates of full-text publication in peer reviewed journals among abstracts presented at various national meetings. These studies have reported publication rates of abstracts presented at orthopaedic meetings ranging from 22 to 68%. The purpose of this study was to characterize publication rates for abstracts presented at the Association of Foot and Ankle Surgeons (AOFAS) annual meeting from 2006 to 2010. We hypothesize that the publication rate will be similar to other specialty meetings.

**Methods:** A database was created using all abstracts presented at the AOFAS Annual Meetings from 2006-2010 as listed in the official program books. A computerized PubMed search for the presenting authors and appropriate keywords from the title was conducted to assess whether an abstract resulted in a peer-reviewed, full-text publication.

**Results:** 150 of 329 were published (46%). The number of presentations and frequency of subsequent publication did not vary greatly between AOFAS meetings from year to year. The mean time to publication from initial presentation was 18 months. The 150 published articles were distributed among 25 different peer-reviewed journals. Twenty eight percent of abstracts presented were eventually published in Foot & Ankle International (FAI), which was the most common target journal.

**Discussion and Conclusion:** The 46% publication rate for abstracts presented at the AOFAS meeting from 2006-2010 is comparable to reported publication rates from other orthopaedic subspecialty meetings. In light of this finding, the practice



of citing conference proceedings from the AOFAS Annual Meeting should be discouraged.

**Notes:**

**Friday, December 19, 2014**

**Concurrent Session 11B: Spine**  
*(Palomino Ballrooms 6-7)*

**Civilian Moderator:** R. Douglas Orr, MD  
**Military Moderator:** MAJ Melvin D. Helgeson, MD

0930-0935

**Revision Surgery Rates After Primary Fusion For Adolescent Idiopathic Scoliosis**

CPT Joseph Dannenbaum, MD  
Bryan J. Tomkins, MD  
Paul M. Caskey, MD  
William E. Bronson, MD

**Introduction:** Instrumented fusion remains the standard of care for surgical management of Adolescent Idiopathic Scoliosis (AIS). Specific revision rates vary throughout the literature, however, reasons for and overall revision rates after definitive fusion in this population are still poorly defined. The purpose of this study is to define the revision rates in AIS at a single referral based pediatric center and compare various instrumentation constructs utilized during the initial spinal fusion.

**Methods:** A retrospective chart review was performed of all patients with AIS who underwent instrumented fusion from January 1990 through December 2011 with minimum of 2 year follow up. Demographic information, types of implants, surgical approach and other information concerning the primary surgery and all subsequent revision operations was obtained from medical chart and operative logs. Exclusion criteria included age younger than 10 or 19 and older, diagnosis

of congenital, infantile, or neuromuscular scoliosis, isolated kyphosis and primary surgical fusion performed at an outside facility.

**Results:** Four hundred and eleven patients who underwent instrumented fusion for AIS during the study period met our inclusion criteria. There were 333 posterior spinal fusions, 30 anterior only fusions, and 48 combined anterior and posterior fusions performed. The posterior spinal fusion constructs included 103 pedicle screw constructs, 27 hybrid hook and pedicle screw constructs, 200 all hook constructs and 3 wire only constructs. A total of 66 revision operations were performed in 50 patients (12.2%). Prominent hardware, pseudarthrosis, and infection were the most common indications for revision. Posterior pedicle screw constructs had a lower revision rate (5.8%) compared to the rest of the study population ( $p=0.02$ ). The all hook, hybrid, anterior only and combined fusions had revision rates of 13.0%, 18.5%, 10.0% and 20.8% which were not statistically different. Additionally, when specifically comparing pedicle screw and all hook constructs, there was a statistical difference in pseudarthrosis rates, favoring pedicle screw instrumentation with no difference in the rates of infection or prominent hardware ( $p=0.03$ ).

**Conclusions:** Patients undergoing instrumented fusion for AIS are at some risk for requiring subsequent surgery after their initial procedure. To lessen that risk, pedicle screws constructs should be considered as they show an overall lower revision rate compared to other constructs specifically regarding the rate of pseudarthrosis compared with posterior hook only constructs.

**Notes:**

0935-0940

## Validation Of The Lumbosacral Injury Classification System (LSICS)

LT Scott C. Wagner, MD  
 CPT Gregory S. Van Blarcum, MD  
 LT Benjamin Chi, MD  
 CPT Daniel G. Kang, MD  
 LTC Ronald A. Lehman Jr., MD

**Introduction:** There is currently no universally accepted classification or scoring system for lumbosacral dissociation (LSD) injuries. A new classification system called the lumbosacral injury classification system (LSICS) has been proposed based on three injury characteristics: injury morphology, neurologic status and posterior ligamentous complex (PLC) integrity. This new classification system for LSD injuries has not yet been validated in a systematic and scientific manner. Therefore, we set out to begin pre-clinical validation of the LSICS, and to assess for intra- and inter-observer reliability.

**Methods:** Four orthopedic surgeons performed separate reviews of nineteen LSD injury case examples, including injury mechanism, description of neurologic examination, and pertinent imaging studies. A composite LSICS injury severity score was calculated for each case. The reviews were performed in two rounds one week apart. Statistical analysis was performed to determine intra- and inter-observer reliability for the LSICS.

**Results:** After two rounds of scoring, we found inter-observer reliability values of 0.81, 0.93 and 0.5 for fracture morphology, neurologic status and posterior ligamentous integrity, respectively. Inter-observer reliability for the overall calculated severity score was 0.86. Intra-observer reliability values were 0.76, 0.94 and 0.65 for all variables, respectively. Intra-observer reliability for the overall severity score was 0.87.

**Discussion and Conclusions:** Our results suggest that LSICS is a reliable classification scheme for lumbosacral dissociation injuries, with high reproducibility within and between physicians. We believe that with further analysis and previously described clinical modifiers, LSICS is predictive of injury severity and provides guidance for management of these complex injuries. However, further validation using prospective clinical analysis must be performed.

**Notes:**

0940-0945

## Association Between Hyper Flexibility And Spinal Deformities In A Population Of 1,217,724 Adolescents

Maj. Oded Hershkovich, MD, MHA  
 Alon Friedlander, MD  
 Gabriel Gutman, MD  
 Harel Arzi, MD  
 Barak Gordon, MD  
 Estela Derazne, MSc  
 Dorit Tzur, MBA  
 Arnon Afek, MD, MHA

**Introduction:** The most common spinal deformities among adolescents are adolescent idiopathic scoliosis and Scheuermann's kyphosis. The association between hyper flexibility and its possible association to spinal deformities is unknown and a literature debatable issue.

Our purpose in this study was to examine the prevalence of hyper flexibility and its association to spinal deformities.

**Design and Methods:** The data for this study were derived from a medical database containing records of 17-year-old males and females before their recruitment into mandatory military service. Information on the disability codes associated with spinal deformities and hyper flexibility according to the Regulations of Medical Fitness Determination (RMFD) was retrieved.

**Results:** We calculated the prevalence of hyper flexibility in 1,220,073 young adults and identified 1355 cases (0.0111%). Spinal deformities were identified in 128282 subjects. We had 96,950 subjects with mild spinal deformities, 29,539 subjects with Intermediate spinal deformities and 1793 subjects with severe spinal deformities. When examined the association between hyper flexibility and spinal deformities the Odds Ratios were 2.31 ( $P < 0.001$ , 2.208 - 2.631) for all spinal deformities. Odds ratio calculated for mild, Intermediate and severe spinal deformities were 1.226 ( $P = 0.041$ , 1.012-1.485), 5.783 ( $P < 0.001$ , 4.908-6.813) and 4.01 ( $P = 0.002$ , 1.904-8.445) respectively. We found a strong association between hyper flexibility and spinal deformities, Intermediate and severe spinal deformities were associated more strongly compared to mild spinal deformities.

**Conclusions:** Hyper flexibility is strongly associated to spinal deformities. Better understanding this association might in light our understanding of the development of spinal deformities. Further research in light of our findings is required.

**Notes:**

0945-0950

### Characterization Of Spinal Cord Injuries Sustained During Operation Iraqi Freedom And Operation Enduring Freedom

CPT Joseph Petfield, MD  
 MAJ James A. Blair, MD  
 MAJ Daniel R. Possley, DO, MS  
 MAJ Jessica C. Rivera, MD  
 Andrew J. Schoenfeld, MD  
 LTC Ronald A. Lehman Jr., MD  
 LTC (Ret) Joseph R. Hsu, MD

**Introduction:** Injury to the spinal cord is a potentially devastating wound sustained in combat operations. Not since the Vietnam Conflict has the United States and its allies had to bear the number of casualties with severe, multisystem injuries to include neurologic injury to the spine. The poly-trauma often seen with combat injuries makes recognition and management of spinal cord injury in the field a difficult task. An understanding of the frequency and type of spinal cord injury sustained during modern combat is valuable to forward surgeons to allow them to prepare for proper management of these casualties. To our knowledge, there has not been an adequately sized review of combat related spinal cord injury to date. The goal of this study is to characterize and determine the rates of spinal cord and neurologic injury in the most recent United States military engagements associated with conventional and unconventional warfare.

**Methods:** The Joint Theater Trauma Registry was queried for all American servicemembers sustaining an injury to the

spinal cord while deployed in Iraq or Afghanistan between January 2001 and October 2009. These data were manually reviewed for relevant information regarding demographics, mechanism of injury, surgical intervention, and neurologic injury. Results for this study were part of a larger data set to include pelvic and acetabular injury, as well as spine trauma without neurologic/spinal cord injury. Primary outcome measures included type of spinal cord injury, neurologic injury, and ASIA scoring (unchanged or improved at follow up).

**Results:** A total of 598 servicemembers were identified by the JTTR as having combat related spine injuries during a 6-year period, from 2001 to 2009. Of these patients, 104 (17.4%) were identified as having spinal cord injuries and 19 (3.2%) as having neurologic injury (cauda equina, nerve root injury, conus medullaris syndrome). A blunt mechanism of injury caused 39 (38%) spinal cord injuries whereas a penetrating mechanism was the cause in 63 patients (61%). Of the 104 patients that presented with spinal cord injury, 47 sustained a complete injury, 52 sustained an incomplete injury, and 5 patients were recorded as unknown. Named cord syndromes were also identified in 7 patients – central cord in 2, anterior cord in 1, posterior cord in 3, and Brown-Sequard in 1. Of the 19 patients that presented with neurologic injuries, 9 presented with frank cauda equina syndrome, 8 patients presented with nerve root injuries at varying levels, and 2 patients presented with conus medullaris syndrome. ASIA scoring was carried out in 58 patients with neurologic injuries. Baseline scores were taken and compared to final follow-up. 28 patients (48.3%) were noted to have no change from initial scores at final follow-up, while 30 (51.7%) patients were noted to have improved ASIA scores at their final follow up.

**Conclusions:** This study demonstrates that spinal cord injury occurs in 17% of patients who present with a spinal column injury sustained in combat. Approximately fifty percent of these were found to be complete spinal cord injuries. A significant number of those with recorded ASIA scores demonstrated improvement of at least one ASIA grade at final follow up, indicating that some neurologic recovery is possible in those who sustain a spinal cord injury in combat.

**Notes:**

0950-0955

## The Impact Of Dynamic Alignment, Motion And Center Of Rotation On Myelopathy Grade And Regional Disability In Cervical Spondylotic Myelopathy

Ensign Shian Liu, BS  
 Vincent Challier, MD  
 Virginie Lafage, PhD  
 Michael Fehlings, MD, PhD  
 Justin Smith, MD, PhD  
 Christopher Ames, MD

**Introduction:** Cervical stenosis is a defining feature of cervical spondylotic myelopathy (CSM). Matsunaga et al proposed that elements of stenosis are both static and dynamic, where the dynamic elements magnify the canal deformation of the static state. Degenerative changes, superimposed on congenitally narrow neural spaces, accumulate with age and affects the canal diameter and anterior-posterior mobility of the cervical spine. We hypothesize that dynamic motion may be associated with myelopathy severity and neck disability and present traditional and novel methods of dynamic motion analysis in CSM including range of motion (ROM) and center of rotation (COR).

**Methods:** Post-hoc analysis of a prospective, multicenter database of patients with CSM. 110 patients (34%) met inclusion criteria: symptomatic CSM, age over 18, baseline flexion/extension radiographs, health related quality of life questionnaires (HRQOLs: mJOA, NDI, SF-36) and Nurick grade. The mean age was 57+12 years with 41% female (n=46). Correlations with HRQOLs were analyzed for regional (C2-C7 cervical lordosis, C2-C7 cervical sagittal vertical axis) and focal parameters (olisthesis between each level and number of kyphotic levels) in flexion and extension. Baseline dynamic parameters (Flexion/Extension cone relative to a fixed C7, center of rotation, range of motion arc relative to the COR) were also analyzed for correlations to HRQOLs and Nurick grade.

**Results:** At baseline, the mean HRQOLs demonstrated disability (Nurick grade 4.09+0.9, NDI 42.5+20.7, mJOA 13.0+2.9, SF-36 PCS 34.7+10.1, and SF-36 MCS 41.5+14.1) and the mean radiographic parameters demonstrated sagittal malalignment (Ext: C2-C7 SVA 50.0+13.2mm, C2-C7 lordosis 51.17+11.6°; Flex: C2-C7

SVA 70.1+12.4mm, C2-C7 lordosis 28.8+12.7°). Among regional parameters, there was a significant correlation between increased C2-C7 lordosis in flexion and Nurick grade ( $R=0.189$ ,  $p 0.048$ ) with no significant correlations in extension. Focal parameters including C7 slip (mJOA, Flex  $R=-0.377$ ,  $p 0.003$ ; mJOA, Ext  $R=-0.261$ ,  $p 0.027$ ) and number of kyphotic levels (mJOA, Flex  $R=0.249$ ,  $p 0.009$ ; Nurick, Flex  $R=-0.296$ ,  $p 0.002$ ) were significantly correlated with disease severity. Reduced flexion/extension motion cones (Nurick,  $R=-0.261$ ,  $p 0.041$ ), a more posterior center of rotation (SF-36 PCS,  $R=-0.319$ ,  $p 0.016$ ), and smaller range of motion from COR (Nurick,  $R=-0.266$ ,  $p 0.038$ ) also correlated with worse HRQOLs.

**Discussion and Conclusion:** Dynamic motion analysis may play an important role in understanding CSM. Analysis of regional parameters revealed increased cervical lordosis in flexion correlates with a poor Nurick grade. Furthermore, dynamic motion appears to highlight the role of focal deformities in symptomatology. Focal parameters such as C7 slip in flexion and extension and number of kyphotic levels exacerbated in flexion demonstrated a significant correlation with worse HRQOLs. To better visualize and conceptualize the dynamic aspect of the symptomatic stage of the disease, each patient's cervical motion was represented by both an area (integrated from flexion and extension positions) and an angle (measured from flexion to extension at a fixed C7 position) to define a cone of kinesis. This novel method of motion analysis demonstrated reduced motion cones correlated with worse myelopathy grades. Additionally, a more posterior center of rotation and smaller range of motion were both correlated with worse general health scores (PCS & Nurick).

**Notes:**

0955-1000

## Can Orthopaedic Surgeons Be Trained To Accurately Gauge Tapping Insertional Torque?

LT Scott C. Wagner, MD  
CPT Daniel G. Kang, MD  
LTC Ronald A. Lehman Jr., MD  
Adam J. Bevevino, MD  
CPT John P. Cody, MD  
LCDR Robert W. Tracey, MD  
Paul A. Anderson, MD

**Introduction:** Tapping insertional torque (IT) is a metric used to estimate pedicle screw size. Prior studies have shown that obtaining a tapping IT value of 2.5 in-lbs predicts optimal pedicle fill when selecting screw size intra-operatively. Aside from utilization of an intraoperative torque meter, there are currently no guides to assess tapping IT values. The purpose of this study was to determine if surgeons at all levels (intern to attending) could be trained to assess torque by “feel” to obviate the need for intra-operative gauges.

**Methods:** Ten surgeons at our institution at different levels of training (attending, senior resident, and junior resident) underwent a 30-repetition round of torque training with three separate tap sizes (4.5, 5.5, 6.5mm), followed by a round of testing. Each participant subsequently performed two additional rounds of testing spaced 1-week apart. Testing was performed utilizing polyurethane foam blocks at a density of 10 pounds/ft<sup>3</sup> (pcf), which most closely resembled cancellous bone based on our pilot test. Torque values were recorded utilizing a digital torque gauge meter. Data were then analyzed with an ANOVA test with a post hoc comparison of means for any significant differences.

**Results:** We found no significant difference ( $p > 0.05$ ) between each training level and our “perfect” model. We also found that there was no significant difference between rounds of testing for all participants ( $p > 0.05$ ). Additionally, there was no significant difference between the standard deviations measured between rounds ( $p > 0.05$ ). We determined that junior level residents were not as accurate as either the senior level residents ( $p < 0.05$ ) or the attending surgeons ( $p < 0.05$ ), but there was no difference noted between junior residents and the “perfect” model ( $p > 0.05$ ).

**Discussion and Conclusions:** Our data suggest that surgeons at all levels of training can be taught to accurately gauge 2.5

in-lbs of tapping insertional torque, and that this skill does not regress with subsequent testing at 1-week intervals. Therefore, Resident and Staff surgeons can be easily trained to assess intraoperative IT which obviates the need for an IT screw driver in the operating room.

**Notes:**

1005-1010

## Operative Treatment Of New Onset Radiculopathy And Myelopathy Secondary To Combat Injury

CPT Gregory S. Van Blarcum, MD  
\*CPT Peter Formby, MD  
LT Scott C. Wagner, MD  
CPT Daniel G. Kang, MD  
LTC Ronald A. Lehman Jr., MD

**Introduction:** Several recent studies have examined the rates of combat-related spinal injury sustained in Operations Enduring (OEF) and Iraqi Freedom (OIF) using joint trauma registries. We set out to describe combat-related spine trauma over a 10-year period at three high-volume military treatment facilities, and thereby determine the frequency of new onset myelopathy and radiculopathy secondary to injuries sustained in direct support of combat operations.

**Methods:** We performed a retrospective analysis of a surgical database at three military institutions. Patients undergoing spine surgery following a combat-related injury in Operations Enduring and/or Iraqi Freedom between July 2003 and July 2013 were evaluated. Inclusion criteria consisted of: evidence of myelopathic or radicular symptoms requiring operative treatment following documented trauma sustained in direct relation to combat operations while in theater.

**Results:** Our review found 105 patients with combat-related (OIF/OEF) spine trauma requiring operative intervention. Of these, 15 patients had documented radicular symptoms. There were no documented cases of myelopathy. The average age was 39 years, with 80% injured in Iraq and 20% in Afghanistan. The most common mechanism of injury was mounted



improvised explosive device (IED, 33%). All patients were diagnosed with herniated nucleus pulposus (HNP). The cervical spine was most commonly involved (53%), followed by lumbar (40%), and one patient has a thoracic HNP. Average time from injury to index surgery was 23.4 months. C5-C6 was the most commonly treated level (75% of cervical), and L5-S1 was the second most common (83% of lumbar). 75% of the cervical patients were treated with anterior cervical discectomy and fusion. Average follow-up time was 33.1 months. 62% of patients had continued symptoms following surgery, and two had at least one revision surgery. 85% of patients returned to full active duty. Two patients were medically retired due to their symptoms.

**Discussion and Conclusions:** To our knowledge, this is the largest study evaluating the treatment of traumatic myelopathy or radiculopathy following combat-related trauma. Over half of these patients continued to have symptoms following operative intervention. Our findings suggest that spinal symptoms are a significant source of disability in the military, even in patients sustaining combat-related injuries, and further studies are needed to elucidate the impact these disorders have on military readiness/preparedness.

**Notes:**

1010-1015

## Sacral Screw Strain In A Long Posterior Spinal Fusion Construct With Sacral Alar-Iliac (S2AI) Versus Iliac Fixation

LT Scott C. Wagner, MD  
 CPT Daniel G. Kang, MD  
 LTC Ronald A. Lehman Jr., MD  
 LCDR Robert W. Tracey, MD  
 CPT John P. Cody, MD  
 Lawrence Lenke, MD

**Background:** Long instrumented posterior fusion constructs to the lumbosacral spine have a significant rate of pseudoarthrosis and S1 screw failure. With the increasing popularity of Sacral Alar-Iliac (S2AI) fixation with its purported advantages of 1) decreased implant profile and 2) obviating the need for

a lateral offset connector, the biomechanical properties with respect to S1 screw strain remain unknown. We set out to compare the biomechanical effect of S2AI versus traditional iliac screw fixation on S1 screw strain.

**Methods:** Five fresh-frozen human cadaveric specimens were instrumented from L2-pelvis, maintaining all osteoligamentous structures, with bilateral titanium 6.0x40-mm pedicle screws and 5.5-mm cobalt-chromium rods. Bilateral S1 pedicles were instrumented with 8.0x50-mm screws that were centrally cored out and two uniaxial strain gauges inserted at 0° and 90°. S2AI and/or Iliac fixation with 8.0x80-mm titanium pedicle screws was performed to evaluate four different constructs: (1) Bilateral S1 Screws (control); (2) Bilateral S2AI; (3) Bilateral Iliac; (4) Hybrid (S2AI with contralateral Iliac). Bilateral S1 screw strain was measured (microstrain), and pure moment loads (12.0 Nm) were applied in axial rotation (AR), flexion-extension (FE) and lateral bending (LB). One way repeated measure ANOVA was used to analyze the S1 screw strain data.

**Results:** Compared to S1 screws alone, both S2AI and Iliac fixation significantly reduced sacral screw strain in FE by 58% and 67%, respectively (p<0.05). Hybrid constructs demonstrated a significant reduction in only FE, with reduction in screw strain by 56% for S2AI and 59% for Iliac fixation, with no difference in AR and LB moments. When S2AI and Iliac fixation were compared, there was no significant difference in screw strain for all bending moments (p>0.05). Similarly, hybrid constructs demonstrated no side-to-side significant difference between S2AI and Iliac fixation for all bending moments (p>0.05).

**Conclusion:** Both S2AI and Iliac fixation provide significant reduction in S1 sacral screw strain compared to sacral fixation alone. Bilateral S2AI fixation is a viable and biomechanically comparable alternative to traditional Iliac fixation, and presents another option to achieve protection of the S1 sacral screws for long segment constructs to the pelvis.

**Notes:**

1015-1020

## Chain Of Compensation Related To Spino-Pelvic Mismatch: A Complete Standing Axis Investigation Including The Lower Extremities

Ensign Shian Liu, BS  
Emmanuelle Ferrero, MD  
Renaud Lafage, MS  
Bassel Diebo, MD  
Virginie Lafage, PhD  
Frank Schwab, MD

**Introduction:** Spino-pelvic harmony, radiographically quantified by pelvic incidence minus lumbar lordosis (PI-LL), is one of the key parameters in aligning patients with sagittal spinal deformity (SSD). Patients with SSD recruit compensatory mechanisms to maintain erect posture and align the head over the pelvis. Spino-pelvic mechanisms of compensation involving retroversion of the pelvis have been described. Additionally, knee flexion and pelvic shift have been proposed as limb mechanisms, but how and when these mechanisms contribute is poorly understood. In this study, we propose to determine the percentage of compensatory response based on global spinal deformity.

**Methods:** This is a retrospective review of adults with SSD who underwent head to foot stereoradiography between 2012-2013. Radiographic measurements were performed with dedicated surgical planning software. Patients with a pelvic incidence greater than lumbar lordosis were categorized based on their mismatch and compared in terms of compensatory mechanisms normalized to each patient's PI-LL: pelvic tilt (PT), knee flexion and pelvic shift angle (the angle between the lines formed from the posterior-superior corner of S1 to the anterior distal cortex of the tibia and the vertical).

**Results:** 161 patients with SSD were included with a mean age of 62.93±12.8yrs, mean BMI 27.0, and gender of 80.6% females. At baseline, patients had a mean sagittal vertical axis (SVA) of 62.3±61.5mm, pelvic tilt (PT) of 29.2±8.4°, and PI-LL 21.0±14.9°. Patients were categorized based on their PI-LL in 4 groups of PI-LL by mismatch 10° (Group 1: PI-LL 0-10°, Group 2: PI-LL 10-20°, Group 3: PI-LL 20-30°, and Group 4: PI-LL greater than 40°). There were significant differences between all groups in PT, knee angle, and pelvic shift angle by ANOVA (p 0.000). Specifically, Group 2 had a significantly higher PT with respect to

malalignment but a lower knee angle and pelvic shift angle compared to Group 4 (Group 2 PT/(PI-LL) 196%, Group 4 PT/(PI-LL) 73%, p 0.000; Group 2 knee angle 7.5°, Group 4 knee angle 19.8°, p 0.000; Group 2 pelvic shift angle 0.78°, Group 4 pelvic shift angle 4.8°, p 0.000).

**Discussion and Conclusion:** In less severe mismatch with a PI-LL 10-20° such as in Group 2, PT is the main contributor of compensation. With increasing mismatch between PI and LL, gradually pelvic version becomes exhausted, at which point there appears to be a steady transfer of compensation towards the lower limbs; this is evident with the decrease in pelvic tilt contribution and increase in both knee angle and pelvic shift angle, which are perhaps linked. Consequently, as the PI-LL mismatch increases and pelvic retroversion is maximized, there is a significant trend toward lower limb participation in compensation.

**Notes:**

1020-1025

## Persistent Axial Neck Pain After Cervical Disc Arthroplasty: A Radiographic Analysis

LT Scott C. Wagner, MD  
CPT Daniel G. Kang, MD  
CPT Peter Formby, MD  
LCDR Robert W. Tracey, MD  
CPT John P. Cody, MD  
LTC Ronald A. Lehman Jr., MD

**Introduction:** There are relatively few, non-industry sponsored studies examining the outcomes and complications of cervical disc arthroplasty (CDA). In addition, there is very little literature examining optimal radiographic parameters for placement of CDA. Therefore, we set out to perform a single center evaluation of the radiographic outcomes, including associated complications, of CDA.

**Methods:** We performed a retrospective review of all patients from a single military tertiary medical center from August 2008 to August 2012 undergoing cervical disc arthroplasty. Preoperative, immediate post-operative and final follow up

films were evaluated. The clinical outcomes and complications associated with the procedure were also examined.

**Results:** A total of 312 patients were included in the review, with an average radiographic follow-up of 14 months and a 15.1% rate of persistent axial neck pain. For patients with persistent neck pain, the rates of heterotopic ossification (HO) formation and osteolysis were 27.7% and 14.9%, respectively, while the rates were significantly lower for patients without neck pain (12.8% and 6.2%, respectively,  $p=0.01$ ). There was a significant association between severity of HO and the presence of neck pain ( $p=0.02$ ). There were no differences in pre-operative facet arthrosis, pre- or post-operative disc height, segmental range of motion or placement of the device relative to the posterior edge of the vertebral body. However, patients with implants more centered between the uncovertebral joints were more likely to experience posterior neck pain ( $p=0.028$ ).

**Discussion and Conclusions:** We found that posterior, axial neck pain is relatively frequent after cervical disc arthroplasty, and patients with persistent neck pain were significantly more likely to have developed heterotopic ossification or implant-related osteolysis. The severity of the HO was also significantly associated with neck pain. We also found that patients with implants that were placed off-centered were less likely to also complain of neck pain, though the reasons for this finding are unclear.

**Notes:**

1025-1030

## Characterization And Outcomes Of Combat-Related Spinal Cord Injuries Requiring Operative Treatment

CPT Gregory S. Van Blarcum, MD  
 \*CPT Peter Formby, MD  
 LT Scott C. Wagner, MD  
 CPT Daniel G. Kang, MD  
 LTC Ronald A. Lehman Jr., MD

**Introduction:** Several recent studies have examined the rate of combat-related spinal injury among casualties in

Operations Iraqi and Enduring Freedom. However few have described clinical follow-up after complete and incomplete spinal cord injuries (SCI). We set out to characterize combat-related SCI, and report outcomes following operative treatment.

**Methods:** We performed a retrospective analysis of a surgical database at three military institutions. Patients undergoing spine surgery following a combat-related injury in Operations Enduring and/or Iraqi Freedom between July 2003 and July 2013 were evaluated. Inclusion criteria included trauma sustained in direct relation to combat operations while in theater requiring operative treatment after evacuation to the United States, with a complete or incomplete spinal cord injury. Medical records and radiographic images of identified patients were reviewed for demographic information, mechanism of injury, characterization of spine injuries, neurologic examination, and work/return to duty.

**Results:** Our review identified 105 casualties requiring definitive surgical management for combat-related spine injuries after return to the United States. Thirty-one (29.5%) of these patients sustained complete or incomplete spinal cord injuries, including four patients with injuries isolated to the conus medullaris or cauda equina. 51.6% and 48.4% of SCI occurred in Iraq and Afghanistan, respectively, and the mean age was 26.0 years. 48.4% sustained complete (ASIA A) SCI. The most common mechanism of injury was gunshot wound (45.2%), followed by mounted improvised explosive device (IED, 32.3%). Average length of follow up after injury was 27.8 months. There was no significant recovery of function in the remainder of ASIA A patients. 42.0% of patients had been medically retired at the time of most recent follow up, and the average time from injury to retirement was 20.1 months. One patient died from pulmonary dysfunction while in rehabilitation. 42% of patients were being treated for clinical depression during their recovery.

**Discussion and Conclusions:** To our knowledge, this study is the first and largest series characterizing and reporting outcomes following operative intervention for combat-related spinal cord injuries. We found that ballistic penetrating trauma was the most common mechanism of injury, and no patients sustaining an ASIA A SCI had significant functional recovery after injury. Almost half of all patients sustaining any SCI were unable to return to duty. In conclusion, service members sustaining SCI have a poor prognosis, and functional recovery is minimal after injury.

**Notes:**

1030-1035

## Outcomes Following Complex Combat-Related Lumbosacral Dissociation Injuries

LT Scott C. Wagner, MD  
CPT Gregory S. Van Blarcum, MD  
CPT Daniel G. Kang, MD  
LTC Ronald A. Lehman Jr., MD

**Introduction:** As war injury patterns have changed throughout Operations Iraqi and Enduring Freedom (OIF/OEF), a relative increase in the incidence of complex lumbosacral dissociation (LSD) injuries has been noted. LSD injuries are an anatomic separation of the spinal column from the pelvis, and represent a manifestation of severe, high energy trauma. We assessed the clinical outcomes of combat-related LSD injuries after operative treatment.

**Methods:** We performed a retrospective review of all patients surgically managed for complex LSD injuries since the beginning of current combat operations in the Middle East.

**Results:** Twenty patients met inclusion criteria and were treated as follows: posterior spinal fusion (12), sacroiliac screw fixation (7), and combined anterior-posterior fusion (1). The mean age was 28.2 years old. The most common mechanism of injury was mounted improvised explosive device (IED, 50%). On average, 2.2 spinal regions were injured per patient. Neurologic dysfunction was present in four patients. Three patients underwent operative stabilization of their injuries before evacuation to the United States. Median time to surgery from injury was 12 days (range: 0-111 days). There was a 20% wound infection rate. Median follow up was 45.5 months (range: 23.2-105.3 months), and one-third of all patients were medically retired due to their injuries. At most recent follow up, 45% complained of chronic low back pain and 35% had persistent neurologic deficits; however, 30% were actively engaged in strenuous physical activities, including swimming, distance running and training for Special Forces.

**Conclusion:** This is the largest series of operatively managed lumbosacral dissociation patients currently reported. Our series suggests that combat-related lumbosacral dissociation injuries frequently result in persistent, long-term neurologic dysfunction, disability and chronic pain. Operative management carries a high post-operative risk of infection. However,

two-thirds of patients were able to remain on active duty after their injuries, and two patients were able to complete marathon training.

Notes: