2014 Scientific Program
Abstracts — Thursday

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

Thursday, December 18, 2014

Concurrent Session 10A: Basic Science/Tumor
(Palomino Ballrooms 8-10)

Civilian Moderator: **Regis J. O'Keefe, MD**
Military Moderator: **LTC Benjamin K. Potter, MD**

0915-0920

Evaluation Of The Skin-Implant Interface And Possible Osseointegration Implant Surface Solutions In A Porcine Model

CPT Donald Hope, MD
*CPT Gabriel J. Pavey, MD
CPT Elizabeth M. Polfer, MD
Dana M. Golden, BS
Thomas A. Davis, PhD
LTC Benjamin K. Potter, MD
CDR Jonathan A. Forsberg, MD

Introduction: Osseointegration provides a means of direct prosthetic skeletal attachment, thus eliminating the need for a socket and obviating the numerous potential socket-related complications. While osseointegration has been used for amputations, the technique includes its own complications, largely related to the skin-implant interface. Minimizing motion at the skin-implant interface, while allowing soft tissue and vascular ingrowth, is critical towards mitigating these complications. With this in mind, we studied the implant surface and coating that would allow for the best vascular and soft tissue ingrowth in Hanford miniature swine.

Methods: We implanted porous titanium discs with large (400μm) pore size, directly under the dermal layer into the backs of six pigs. Each pig had eight discs inserted with a combination of porous titanium alone and porous titanium coated in either alginate, platelet rich plasma, or both. We euthanized two pigs each at 5 weeks, 8 weeks, and 12 weeks post-implantation, respectively. Discs were removed and the strength of the skin-implant interface was assessed with a skin pull off test performed with the MTS Mini-Bionix 858, a 100 N load cell, displacement rate of 5mm/min, and data collection rate of 100 Hz. Additionally, the skin-implant interface was evaluated for dermal and vascular ingrowth on histology.

Results: Histology demonstrated considerable fibrous and vascular ingrowth in all samples. On skin pull off test porous titanium with platelet rich plasma coating had the highest average pull off force required at 25.31 N. The porous titanium alone, porous titanium + alginate + platelet rich plasma, and porous titanium + alginate groups had average pull off test forces of 20.94 N, 9.29 N, and 5.61 N, respectively.

Discussion and Conclusion: We observed robust, early, soft tissue and vascular ingrowth with a porous titanium implant coated in platelet rich plasma. There appears to be less ingrowth to those coated with alginate. These results will support future efforts geared towards optimizing the transdermal portion of osseointegrated implants.

Notes:

0920-0925

Adhesion Of Mesenchymal Progenitor Cells To A Traumatized Muscle Biomimetic Environment Is Mediated By α2β1 Integrin

LT Patrick E. Jones, MD
CPT Ronald Goodlett, MD
Gregory Christopherson, PhD
David Hall, PhD
LTC Leon J. Nesti, MD, PhD

Introduction: The phenomenon of post traumatic heterotopic ossification (HO) remains an area of intense study in the field

of musculoskeletal research. A proposed mechanism for HO formation is that multipotential progenitor cells within the wounded environment form bone instead of regenerating muscle tissue. These progenitor cells are mesenchymal in origin and have been demonstrated to undergo enhanced ossification when cultured on a traumatized muscle biomimetic nanofiber scaffold. The purpose of this study was to investigate what integrin pathways are involved in the adhesion of these cells to the nanofiber scaffold.

Methods: Integrin Profile MPCs were isolated using an established lab protocol from human tissue discarded during surgical debridements of combat wounded. The MPCs were then cultured on either a tissue culture plastic or a 3D collagen nanofiber scaffold, the latter created by electrospinning a 2.5% bovine collagen solution. The MPCs were assayed after two weeks culture time for integrin protein expression using a commercially available α/β Integrin-mediated Cell Adhesion Array Combo Kit. Blocking of Adhesion MPCs were isolated on tissue culture plastic then plated on nanofiber scaffolds. An antibody to alpha 2 Beta 1 was introduced at the time of plating. After 2 hours the aspirate was removed and the cells were fixed and stained. The cells were counted per four high powered fields at three sequentially increasing concentrations of antibody. Imaging MPCs were cultured on nanofiber scaffold and stained for α2β1 integrin with nuclear counterstaining. Images were obtained using a Zeiss ApoTome fluorescent microscope

Results: Integrin profile: MPCs cultured on nanofiber demonstrated a relative up-regulation of alpha2beta1 heterodimer when compared to the MPCs cultured on tissue culture plastic or 2D collagen. This correlated with RT/PCR data demonstrating a fourfold up-regulation of α2integrin with a threefold down-regulation of α1integrin when MPCs were cultured on nanofiber. Using alpha2beta1 as a probable target we attempted to block MPC adhesion to nanofiber scaffolds. We used 3 separate antibody concentrations of 3%, 7% and 15%. We observed a stepwise decrease in the amount of bound MPCs with the highest concentration able to block MPC adhesion by 70%. MPCs also demonstrated a co-localization of alpha2beta1 integrin with the nanofiber suggesting they are involved in binding.

Discussion: We have previously described the similarities between the physical microstructure of wounded muscle and our generated nanofiber scaffold. The ability of this nanofiber to enhance osteogenesis would support the hypothesis that the microstructure plays a role in the differentiation of MPCs. This study serves to highlight the mechanism these MPCs use to adhere to the nanofiber and likely to traumatized muscle within a wound environment. Further investigation will focus on the role of alpha2beta1 signaling in differentiation of MPCs, which may lead to a possible therapeutic target in HO prevention.

Notes:

0925-0930

The Effect Of Slip Severity On Construct Stiffness In A Spondylolisthesis Model

MAJ Jason M. Cage, DO
Bryan M. Armitage, MD, MSc
MAJ Jeff Knox, MD
COL Joseph R. Orchowski, MD

Introduction: Increased spondylolisthesis has been associated with increased rates of pseudoarthrosis. This study used established synthetic spine models to compare the effect of progressive slip on the biomechanical stiffness of a transforaminal fusion construct with posterior stabilization.

Methods: Four models were made with four polypropylene vertebral blocks separated with isoprene elastomer intervertebral spacers and a nylon mesh to recreate the PLL. A slip was created between the middle two vertebral blocks and set to 0%, 25%, 50%, and 75% offsets. Interbody cages were placed in all models and stabilized with pedicle screws and rods. The models were then tested in a 858 Mini Bionix II MTS machine and subjected to cyclic loading. Loading was applied from 100N to 1000N in 100N increments with 100 cycles at each step. Force and displacement during axial compression were recorded to determine construct stiffness.

Results: Overall displacement measurements at 0% and 25% were significantly less when compared to 50% and 75% ($p<.05$). Average maximum displacement at the 1000N load step was increased by 25.3% and 17.8% when comparing 0% (2.72mm) slip with both 50% (3.64mm) and 75% (3.58mm) respectively. At the 1000N loading increment the 25% slip, 50% slip and 75% slip showed decreased stiffnesses of 11.4%, 25.3% and 17.8% respectively when compared to the

0 slip model. There was no significant differences in average maximum displacement or stiffness when comparisons were drawn between the 0% and 25% groups or between 50% and 75% groups.

Conclusion: Slips of greater than 50% showed significantly higher displacement at maximal loading. Our data supports that there is no significant difference in construct in slips of up to 25%.

Notes:

0930-0935

Electrospun Collagen Nanofiber Increases The Isolation And Proliferation Of Mesenchymal Progenitor Cells Following Orthopaedic Trauma

LT Patrick E. Jones, MD
Gregory Christopherson, PhD
CPT Ronald Goodlett, MD
CPT Husain Bharmal, MD
Youngmi Ji, PhD

Introduction: The role of the mesenchymal multipotential cells has been the subject of intense research over the past years. Previous research has suggested that traumatized muscle, such as that encountered in high energy blast wounds from the global war on terror or the Boston Marathon bombing, becomes populated with a high concentration of mesenchymal progenitor cells (MPCs). These MPCs play a role in wound healing and have been demonstrated to have the capability to undergo osteogenic, chondrogenic or adipogenic differentiation. We demonstrate in this study that a biomimetic electrospun collagen scaffold that mimics the structure and composition of traumatized muscle can be used to increase isolation and proliferation of MPCs from tissue.

Material and Methods: Human tissue was obtained from surgical waste tissue taken from patients undergoing wound debridement from Afghanistan theatre of operations. Nanofiber matrix: A 2.5% collagen solution was prepared from commercially available collagen type 1. Fibers were then cross-linked by glutaraldyhyde vapor treatment. Osteogenic assay: MPCs isolated by standard plastic adherence were cultured in osteogenic media for two weeks prior to staining and western blot analysis. MPC isolation: An established two hour adherence protocol for MPCs was used on various substrates. Flow cytometry was used to confirm known markers of MPCs on the isolated cells. MPC proliferation: MPCs were isolated from tissue on tissue culture plastic. They were then cultured on different scaffolds for 1 week. The cells were then counted per four high powered fields.

Results: Electrospun collagen nanofiber has a similar morphological appearance to decellularized traumatized muscle tissue with a similar fiber diameter and disorganized nature to the fibers. Electrospun collagen nanofiber has an increased ability to isolate mesenchymal progenitor cells from traumatized tissue compared to plastic, 2D collagen or alternative nanofiber substrates. MPCs isolated in the traditional manner utilizing plastic adherence proliferate at a higher rate on nanofiber scaffolds than 2d substrates. MPCs on nanofiber had higher total cell counts and increased rates of cumulative cell division.

Discussion: This study demonstrates that a biomimetic culture environment similar to that found in traumatized muscle can be created using electrospun collagen. That this collagen matrix not only appears similar to traumatized muscle in its disorganized appearance but can increase MPC osteogenesis and isolation of MPCs from traumatized tissue. Additionally this collagen nanofiber matrix not only has the ability to isolate more MPCs from traumatized muscle than traditional methods but it can allow more rapid expansion of those isolated cells in culture.

Significance: The ability to harvest a multipotential cell from traumatized tissue that can differentiate into osteoid or chondral tissue has significant regenerative medicine implications. Rapid isolation and expansion of MPCs with directed differentiation could allow for new treatments for trauma related bone loss and cartilage loss.

Notes:

0945-0950

Variance Of Matrix Metalloproteinases (MMP) And Tissue Inhibitor Of Metalloproteinases (TIMP) Concentrations In Activated, Concentrated Platelets From Healthy Male Donors

CPT Justin M. Hire, MD
J. Lee Evanson, DO
CPT Peter C. Johnson, MD
Steven D. Zumbrun, PhD
M. Kelly Guyton, PhD
John A. Bosjescul, MD

Introduction: The use of autologous blood concentrates, such as activated, concentrated platelets, in orthopaedic clinical applications has had mixed results. Research on this topic has focused on growth factors and cytokines, with little directed towards matrix metalloproteinases (MMPs) which are involved in post-wound tissue remodeling.

Methods: In this study, the authors measured the levels of MMP-2, MMP-9 and ADAMTS13 in activated platelets derived from blood of healthy, male volunteers (n=92), 19 to 60 years old. The levels of the pharmacological inhibitors of these proteases, tissue inhibitor of metalloproteinase 1 (TIMP-1), TIMP-2 and TIMP-4 were also assessed.

Results: Notably, there was no significant change in concentration with age in four of six targets tested. However, TIMP-2 and TIMP-4 demonstrated a statistically significant increase in concentration for subjects older than 30 years of age compared to those 30 years and younger (P=0.03, P=0.04 respectively).

Discussion and Conclusion: TIMP-2 and TIMP-4 are global inhibitors of MMPs, including MMP-2 (Gelatinase A). MMP-2 targets native collagens, gelatin and elastin to remodel the extracellular matrix during wound healing. A decreased availability of pharmacologically active MMP-2 may diminish the effectiveness of the use of activated, concentrated platelets from older patients, and may also contribute to longer healing times in this population.

Notes:

0950-0955

TGF-β2 Gene Expression At The Time Of Injury May Be Predictive Of The Severity Of Heterotopic Ossification Development

LT Patrick E. Jones, MD
*CPT Ronald Goodlett, MD
Youngmi Ji, PhD
CPT Hussain Bharmal, MD
LTC Leon J. Nesti, MD, PhD

Introduction: Heterotopic Ossification (HO) remains a significant problem for our wounded warriors. As many as 60% of extremity injuries resulting from high energy blasts will result in HO formation. Heterotopic ossification can cause skin breakdown, complicate prosthetic fitting and limit joint range of motion. Although there have been many studies into the etiology of HO formation there remains no way to determine which patients will develop significant HO and which patients will not. In this regard not all patients that develop HO will have symptomatic HO that requires reoperation. The purpose of this study was to correlate severity of HO formation with gene expression levels at the time of injury.

Methods: We retrospectively reviewed 175 patients who had tissue collected during surgical debridements following combat injury. Patients were identified who positively developing heterotopic ossification with adequate radiographic evidence between 2-9 months post injury. Patients were excluded who had not had tissue samples obtained within 2 weeks of injury. Additionally patients were excluded who did not have adequate sample for RNA isolation. The included patients had their HO graded using the Walter Reed HO scoring system developed by Potter et al. Patients were stratified into mild, moderate or severe HO. QTPCR was used to identify significant changes in gene expression between the groups.

Results: We identified thirteen patients who meet the criteria for inclusion. All patients were male with an average age of 28 (range 23-39). Tissue was collected on average 10 days from injury (5-16 days). All patients were injured as a result of IED blast. Three patients were identified as having trans-tibial amputations, three had open femur fractures and seven patients had trans-femoral amputations. Following stratification of HO severity four patients were identified as severe HO, four as moderate, and five as mild HO. There were several genes that demonstrated up-regulation from mild to severe HO. Patients classified as moderate or severe HO had

significant up-regulation of collagen 3α1 and β2 microglobulin expression. However there were only slight differences in expression between moderate and severe. Transforming Growth Factor 2 (TGFβ-2), however demonstrated a twenty fold up-regulation in mild compared to moderate HO and a sixty fold up-regulation in mild to severe which correlated to a 3 fold up-regulation from moderate to severe HO.

Discussion: The ability to predict which patients will develop severe HO compared to those that will develop mild would allow clinicians to counsel patients about this possible need for reoperation and provide them closer follow-up. TGβ-2 expression as a marker may have predictive value for severity of later HO development. This known mediator of fibrotic tissue development is increasingly up-regulated in the patient developing mild, moderate or severe HO. Additionally COL3A1 demonstrated significant up-regulation in moderate and severe heterotopic HO compared to mild HO formation and control tissue. These markers may indicate patients at risk of developing severe HO and may be used to play a predictive role for patients who will develop severe HO.

Notes:

0955-1000

The Validity Of A Rat Model For Analyzing Mirna In Chondrosarcoma

Col (Ret) Theodore W. Parsons III, MD, FACS
Nicholas B. Frisch, MD, MBA
Gary Gibson, PhD
Christopher Dodson, BS
Michael P. Mott, MD

Introduction: MicroRNA (miRNA) expression has been previously shown to be linked to tumor growth and progression. Analysis of miRNA expression has also provided biomarkers that define tumor type and stage. Several studies have looked at miRNA expression in human sarcomas but no studies have been reported the use of miRNAs signatures to define chondrosarcoma stage or to distinguish enchondroma from chondrosarcoma. The Swarm rat chondrosarcoma has for many years provided a resource for studying cartilage biochemistry and chondrosarcoma development. To validate the use of the rat chondrosarcoma for studies of miRNA function in the development of the chondrosarcoma we have compared the expression of miRNAs in the rat chondrosarcoma relative to normal rat cartilage with miRNA expression in human chondrosarcoma relative to normal human cartilage.

Methods: Twenty healthy Sprague-Dawley rats age 10-15 weeks were sacrificed, sterna and rib cartilage were collected and RNA extracted. 380 miRNAs were analyzed by Taqman low-density arrays from the rib and the sternum samples. The results were then directly compared to an array analysis of chondrosarcoma dissected from a tumor in a rat swarm chondrosarcoma cell line. Normal human tissue was similarly compared with human chondrosarcoma tissue. CT values of miRNA in each sample were normalized by the loess method. MiRNAs were then selected that showed differences between normal human cartilage and fresh chondrosarcoma, and between normal rat cartilage and rat chondrosarcoma.

Results: The analysis was carried out for differentially expressed miRNA on 219 matched miRNA between human and rat. Several miRNA that showed a difference between normal human cartilage and fresh chondrosarcoma showed similar difference between normal rat cartilage and rat chondrosarcoma. 60 percent (68/114) of the sternum tissue miRNAs and 54 percent (53/99) of the rib miRNAs analyzed showed a similar pattern of expression (positive or negative). Of particular interest during preliminary analysis were: miR-181a, miR-145, miR-143, miR-21, miR-138, miR-489 and miR-320. More extensive analysis is currently underway in human tissues and the rat model, but at present time it appears that miRNA expression in the rat chondrosarcoma closely resembles that human chondrosarcomas.

Discussion/Conclusion: At present time, the similarities in miRNA between normal human and rat samples, and human and rat chondrosarcoma samples suggest that the rat model is a viable model for further study of chondrosarcoma and will enable us to determine the role of miRNAs in chondrosarcoma development and progression. We anticipate that these studies will provide rational new targets for the development of much needed therapeutic intervention.

Notes:

1000-1005

Femoral Head Anteversion Relative To The Linea Aspera: Axial CT For Orientation Of Endoprosthetic Reconstruction

Capt Brad Hyatt, MD
MAJ Daniel R. Possley, DO, MS
Capt Taara S. Hassan, MD
Lt Col Seth O'Brien, MD
LTC Joseph F. Alderete, MD

Introduction: We set out to define femoral anteversion relative to the linea aspera, guiding optimal positioning of femoral endoprostheses when rotational landmarks are eliminated.

Methods: Axial CT scans from 68 patients were examined independently by a team of physicians including a musculoskeletal radiologist and residents from radiology and orthopaedics. The angle between the linea aspera and the horizon was added to the angle between the femoral neck and the horizon to yield anteversion relative to the linea aspera.

Results: The average angle between the linea aspera and the femoral neck was 87.6° (standard deviation = 9.3°). Inter-rater reliability was R2 = 0.87.

Conclusion: The angle between the linea aspera and the femoral neck averaged 87.6°. This method of determining femoral anteversion relative to the linea aspera had a high inter-rater reliability.

Notes:

Thursday, December 18, 2014

Concurrent Session 10B: Pediatrics
(Palomino Ballrooms 8-10)

Civilian Moderator: **Anthony Riccio, MD**
Military Moderator: **LCDR Terrance D. Anderson, MD**

1040-1045

Functional Outcomes Following Operative Treatment Of Tibial Tubercle Fractures

Anthony Riccio, MD
*Robert L. Wimberly, MD
Grant D. Hogue, MD
Corey S. Gill, MD
Lori A. Karol, MD
DeRaan Collins, BA

Purpose: Though operative treatment for displaced tibial tubercle avulsion fractures is widely considered to be the standard of care, the functional outcomes of patients undergoing surgical management for this injury are not well understood. The purpose of this study is to evaluate the functional results of surgically managed tibial tubercle fractures in adolescent patients.

Methods: A retrospective review of all patients treated surgically for unilateral tibial tubercle fractures at a single institution from 2007-2011 was performed. Fractures were classified using the Ogden system. Knee extension torque strength was assessed using a Biodex© dynamometer, knee range of motion was recorded, and thigh circumference was measured. All testing was performed on each patient's involved and uninvolved extremity. Torque deficit was calculated using the subject's unaffected limb as a control. The Pediatric-International Knee Documentation Committee Subjective Knee Form (IKDC), Tegner-Lysholm Knee Scoring Scale, and Visual Analog Pain Scale (VAS) were completed. Post-operative protocols were reviewed to include the use of physical therapy and protected weight-bearing. Functional parameters were compared between the involved and uninvolved extremities using the Student's t-test. Regression analysis was performed to identify any relationships between peri-operative factors, functional parameters and subjective outcomes.

Results: 19 of 42 patients completed biometric testing and outcome surveys. Average age at injury was 13.9 years (range

10-17 years) and average follow-up was 2.9 years (range 1.2-6.1 years). No statistical difference in extension torque, flexion torque or range of motion was identified between the involved and uninjured sides. A 1.3 cm decrease in thigh circumference at 15cm above the patella and a 1.2cm decrease at 50% the length of the thigh was noted ($p<0.05$). No association between functional parameters or outcome scores was indentified with regard to body mass index, postoperative weight bearing status, Ogden classification, or enrollment in postoperative physical therapy. The mean VAS for affected limbs was 13.4/100 and for unaffected limbs was 5.2/100 ($p=0.016$). The Tegner-Lysholm Scale revealed 9 excellent results, 5 good, 4 fair, and 1 poor (average 87/100). Results of the Pediatric-IKDC were 11 excellent, 3 good, 2 fair, and 3 poor results (average 84/100). Linear regression analysis suggested a weak but significant correlation between greater extension torque deficit, higher VAS scores and lower pediatric-IKDC scores.

Conclusion: Patients can expect a decrease in thigh circumference after fracture union and clinical recovery. Analysis suggests that a decrease in quadriceps strength increases the likelihood of pain in the affected knee and poorer results as determined by validated outcome measures. Despite promising objective results, clinical outcomes measured by subjective validated surveys are not all excellent.

Notes:

1045-1050

All Lateral Versus Medial And Lateral Retrograde Flexible Intramedullary Nails For The Treatment Of Pediatric Femoral Shaft Fractures

MAJ Jason M. Cage, DO
Sheena Black, MD
CPT Jay B. Cook, MD
Robert L. Wimberly, MD
Anthony Riccio, MD

Introduction: Multiple techniques for flexible intramedullary fixation of pediatric femur fractures have been described. To our knowledge, no study comparing medial and lateral entry versus all lateral entry retrograde nails has been reported. The purpose of this study is to compare surgical and radiographic outcomes and rates of symptomatic hardware removal between these techniques.

Methods: An IRB approved, retrospective review of patients who sustained a femoral shaft fracture treated by retrograde, flexible intramedullary fixation was performed at a pediatric hospital between the years 2005-2012. Demographics, blood loss, operative time, and complications were collected from the medical and surgical record. We assessed radiographs for fracture pattern, location, canal fill, shortening and angulation. Data was compared between patients treated with all lateral entry nailing and those treated with medial and lateral entry nailing.

Results: 274 children with femoral shaft fractures were treated with retrograde flexible intramedullary fixation using Ender's stainless steel nails (Richards). 109 were treated with two lateral entry nails and 165 were treated with one medial and one lateral entry nail according to surgeon preference. Average age between the two groups differed by 0.6 years (8.1 years versus 8.7); there were no statistical differences in regard to gender, weight, body mass index, and blood loss. The average total anesthesia time was 29 minutes faster in the all lateral group ($p<0.0001$). There was no statistical difference between the two techniques in regard to shortening, coronal angulation, and sagittal angulation at union, regardless of fracture location or stability, and patient age or BMI. In the lateral group, there was a correlation between fill of the canal and reduced shortening at union. There was no difference between the two groups regarding rates of symptomatic hardware removal. There was one superficial infection in the all lateral group and none in the medial-lateral entry group. There were no iatrogenic neurologic injuries, clinically significant malunions, non-unions or refracture.

Discussion: Medial and lateral versus all lateral retrograde flexible nails in femoral shaft fractures demonstrate comparable fracture stability and safety. The all lateral technique is potentially a faster procedure. Overall, neither technique demonstrated a clinically significant difference in rates of shortening, angulation, or symptomatic hardware.

Significance: Final fracture alignment, surgical complications and rates of symptomatic hardware are clinically comparable between pediatric femur fractures treated with all lateral entry flexible nailing and those treated with medial and lateral flexible nailing.

Notes:

1050-1055

Bone Behavior With Limb Length Discrepancy Treated With Guided Growth Plates

COL (Ret) Kathleen McHale, MD
LTC Jefferson Jex, MD
Christopher P. A. McIlvaine

Introduction: Guided growth technique has resulted in excellent outcomes in the treatment of angular deformities in skeletally immature patients. There are few reports of the use of this technique for limb length discrepancy (LLD). This series illustrates the application of the guided growth technique for equalization of moderate limb length differences.

Materials and Methods: Fifty-two patients were treated with guided growth technique. Of these, twenty patients (37%) had limb length discrepancy as the indication for surgery; three of these patients also had angular deformities. The underlying etiologies for the inequality was: hemihypertrophy syndrome, 6; idiopathic, 4; clubfoot, 3; fibular hemimelia, 2; myelodysplasia, 1; trauma, 1; Chondrodysplasia punctata, 1; and Klinefelter's Syndrome, 1. The age ranged from 8 to 15 years old; 13 were girls, and 7 were boys. The limb discrepancy was moderate but dysfunctional to the patient and ranged from1.5 to 4.5 cm at the time of the index surgery. Guided growth plates were applied to the both medial and lateral sides of the physis. Sites were: both distal femoral and proximal tibia, 8; distal femur, 11; and proximal tibia, 1.

Results: Patients have been followed for up to 6 years (average 3). They can be divided into three groups in order to describe the behavior of the technique on the bone physiology: 1. Undergoing treatment, limbs not yet equalized, 5 patients; 2. Completed treatment for LLD, need further angular or other deformity correction, 4 patients; and 3. Completed all treatment, 12 patients. In Group 1, keeping the plate in place effectively has slowed growth towards equalization of the limb length; the physes are open without damage radiographically. In Group 2, after equalization and plate removal, the operated physis continued to grow. In Group 3, 7 patients reached full equalization (0.5 to 1 cm); plates were removed. Four other Group 3 patients did not correct fully; these patients were close to skeletal maturity. Patients from all three Groups who had hemihypertrophy syndrome have responded well to treatment. One in this group that was uncorrected required an ipsilateral shortening and contralateral lengthening. Although desired limb length equalization did not occur in some patients, true complications were few. All patients experienced initial stiffness after surgery especially those who had plated on both the femur and tibia at the knee. Two patients in Group 1 and one in Group 2 have had plates that backed out and required reapplication. One patient in Group 3 had limb equalization, but developed genu varum.

Discussion: Guided growth technique for limb equalization may be ideal in situations where the end LLD is difficult to predict such as in hemihypertrophy although there may be a tendency for the plates to back out with growth. It allows for resumption of growth after plate removal unlike permanent epiphysiseodesis. Although the incision for plates is larger than with traditional epiphysiseodesis, guided growth eliminates the guess work. The technique works best if done when there is sufficient growth remaining. However, in a mobile population of people, assessment of growth and prediction of total limb length discrepancy may need to done on at a single encounter. The technique appears to work well with limb length inequalities that are associated with angular or other deformities.

Conclusion: Guided growth plating is a useful technique for treatment of limb length discrepancy particularly with hemihypertrophy syndrome.

Notes:

1055-1100

Treatment Of Blount's Disease In Obese Adolescents

CAPT William Hennrikus, MD
Alex T. Burton, MD

Introduction: Treatment of Blount's disease in adolescents can be daunting due to the patient's obesity. The goal of an osteotomy for Blount's disease should be to correct the deformity, restore joint alignment, preserve leg length, and avoid complications such as neurovascular injury, nonunion, infection, and recurrent deformity. The purpose of the pres-

ent study is to report the outcomes when treating adolescent Blount's disease using a complete closing wedge metaphyseal tibial osteotomy and oblique fibular osteotomy.

Methods: From 2009 to 2012, 10 complete oblique proximal tibial lateral closing wedge osteotomies were performed on nine patients with Blount's Disease. There were 3 females and 6 male patients. Mean age at operation was 15 years (age range 10 to 17). The average preoperative weight was 199.4 pounds (range 62.5 to 317 pounds). The average Body Mass Index (BMI) was 36 (range 18 to 48). The mean preoperative varus angulation was 22° (range 10° to 36°). Preoperatively, the size of the osteotomy wedge to remove was templated with paper cutouts. Fixation of the osteotomy was done with a large 4.5 millimeter plate and screws. An additional screw was placed obliquely from the medial side across the osteotomy site for additional stability. An oblique fibula osteotomy was done at the mid shaft via a separate incision. Prophylactic fasciotomies were performed and a drain was placed for 24 hours. Lastly, to prevent possible plate failure, an external fixator was added for patients that weighed over 250 pounds.

Results: The average postoperative femoral-tibial angle was 4° with an average correction of 24° (range 17° to 37°). The average tourniquet time was 88 minutes (range 50 minutes to 119 minutes). The ave BMI was 36. Six patients were obese a BMI greater than 30. Two patients were overweight, with a BMI between 25 and 30. Only one patient was normal weight with a BMI of 18. We report no neurovascular complications, nonunions, or infections. Nine of ten cases were corrected into valgus; one case, the first in the series, sustained a fractured plate and healed in 8 degrees of varus (pre op 25 degrees varus, 252 pounds). This patient was not treated with a medial screw or an external fixator. All subsequent patients received a medial screw and 2 patients with body weight of > 250 pounds also received an external fixator.

Conclusions: The reported technique of an oblique metaphyseal closing wedge osteotomy, internal fixation, and in very obese patients, an external fixator is practical, safe, and reliable in this population of patients. To prevent plate failure, we recommend and additional oblique screw in all patients as well as consideration for an additional external fixator for patients that weigh over 250 pounds.

Notes:

1100-1105

Acquired Upper Extremity Growth Arrest

CPT Erich Gauger, MD
Lauren Smith, BS
Deborah C. Bohn, MD
Ann Van Heest, MD

Introduction: Acquired upper extremity growth arrest leading to limb deformity is a well-recognized phenomenon with multiple etiologies including trauma and infection. The majority of the literature consists of case reports and small case series with a focus on distal radius physeal arrest after trauma. The goal of this study is to evaluate the clinical history and management of all acquired causes and anatomic sites of upper extremity growth arrest in pediatric patients.

Methods: A retrospective review of all patients presenting to a single institution from 1996 to 2014 with radiographically proven acquired growth arrest was completed. Records were reviewed to determine the cause and site of growth arrest as well as management and complications. Patients with tumors or hereditary etiology were excluded.

Results: Forty-three patients (21 boys, 22 girls) with a total of 59 physeal growth arrests presented at a mean age of 10 years old (0.8-17.3) with an estimated mean age at the time of physeal insult of 6.5 years old (0-15.8). The distal radius was the most common site of arrest (n=19) followed by metacarpal (n=17), distal humerus (n=8), distal ulna (n=5), proximal humerus (n=4), radial head (n=3), phalanx (n=2), and olecranon (n=1). Physician referral was the reason for presentation in 19 cases followed by parent (n=9) or patient (n=3) recognition of limb length discrepancy or functional limitation. Eight patients presented primarily for pain and two for routine surveillance for potential growth arrest after fracture. Growth arrest was secondary to trauma (n=17), infection (n=11), idiopathic (n=10), inflammatory (n=2) compartment syndrome (n=2) and avascular necrosis (n=1). Twenty-two patients (51%) had surgery to address the limb length, alignment or rotation caused by physeal arrest with 5 patients having multiple surgeries, not including removal of implants. Thirteen out of 19 patients (68%) with distal radius growth arrest underwent a surgical procedure to correct for abnormal ulnar variance. Additionally, 3 out of 5 patients with physeal arrest of the distal ulna, 3 out of 8 distal humerus, 2 out of 17 metacarpal, 1 out of 4 proximal humerus and 1 out of 3 radial head were treated operatively. Operative intervention included

epiphysiodesis (n=27), lengthening osteotomy (n=8), shortening osteotomy (n=4), other osteotomy (n=2), excision physeal bar/bone fragment (n=2), and creation of single bone forearm (n=1). There were three complications, one deep infection requiring multiple irrigation and debridements, removal of implants and placement of external fixator, one loss of ulnar staple fixation requiring revision and one failure of distal ulna physeal arrest after epiphysiodesis.

Discussion and Conclusion: Acquired upper extremity growth arrest was most commonly caused by trauma or infection. The most frequent site of growth arrest in the upper extremity is the distal radius followed by the metacarpal, distal humerus, distal ulna, proximal humerus, radial head, phalanx, and olecranon. Growth disturbances due to premature arrest can effectively be treated by epiphysiodesis or osteotomy. Periodic monitoring after injury or infection is recommended to evaluate for growth arrest.

Notes:

1105-1110

Outcomes Of Unstable Pelvic Fractures Managed With Percutaneous Iliosacral Screws In A Pediatric Population

CPT Shaunette Davey, DO
Jordan Salmon, BS
Preet Gurusamy, BS
Enes M. Kanlic, MD, PhD
Amr A. Abdelgawad, MD

Introduction: Percutaneous iliosacral screws has become a more popular treatment option for sacroiliac joint (SIJ) disruption and sacral fractures. There however, has been a paucity of literature that describes the outcomes in a pediatric population.

Methods: In this retrospective chart review, we identified 11 patients who had sacral fracture or SIJ disruption treated with iliosacral screw fixation at a single institution. The patients were assessed for the following: age, sex, type of injury, associated injuries, surgery, complications, and postoperative return of function.

Results: We identified six males and five females with an average age of 14years (range 6-17 years). Six patients had SIJ disruption, while five patients sustained sacral fracture. All patients had associated injuries, nine of whom required orthopedic surgeries for these injuries. Eight patients went on to union. Two patients developed complications: one had failure of fixation and one had postoperative neurological deficit. Three patients were lost to follow up.

Conclusion: Iliosacral screws provide minimally invasive percutaneous posterior stabilization and can be safely used in a pediatric population and is feasible in children as young as 6 years old.

Notes:

1110-1115

Pediatric Musculoskeletal Injuries Associated With Recreational Motorized Vehicle Use: Do More Wheels Mean A Safer Ride?

Anthony Riccio, MD
*Ryan D. Rose, MD
Grant D. Hogue, MD
Robert L. Wimberly, MD

Introduction: Children comprise a disproportionately high percentage of emergency department visits for off-road motorized vehicle related trauma. The purpose of this study is to identify differences in musculoskeletal injury location, severity, and associated trauma between pediatric operators of all-terrain (ATV) and motorized two-wheel (motor-bike) vehicles.

Methods: An IRB approved retrospective review of all four-wheeled ATV and two-wheeled motor-bike related emergency department (ED) visits to a single level 1 trauma center over a 6 year period was performed. Details of all musculoskeletal injuries were documented. Isolated soft tissue injuries and strains were excluded. The use of protective equipment,

injury severity score (ISS), length of hospital stay (LOS), associated injuries and demographic data were noted. Statistical analysis using the Student's t-test was performed to identify differences in injury characteristics between ATV and motor-bike riders.

Results: 334 ED visits resulted from ATV related trauma with 156 orthopaedic injuries identified in this cohort. 170 ED visits resulted from motor-bike related trauma, accounting for 123 orthopaedic injuries. The percentage of musculoskeletal injuries associated with motor-bike related ED visits (72%) was significantly higher than that associated with ATV related visits (47%) [p<0.001]. While lower extremity injuries predominated over upper extremity trauma in both groups, motor-bike riders sustained a significantly higher rate of lower extremity injuries than ATV riders (p=0.0003). Furthermore, motor-bike riders sustained a significantly greater number of tibia/fibula (p=0.03) and wrist (p=0.03) injuries. While a greater proportion of motor-bike riders used protective equipment (p<0.0001), this did not result in a lower ISS, LOS or a diminished incidence of extremity trauma.

Discussion and Conclusion: As musculoskeletal trauma is exceedingly common in children injured while operating recreational motorized vehicles, orthopaedic surgeons should be aware that injury characteristics vary with vehicle type. Children injured while riding motor-bikes are more likely to sustain musculoskeletal trauma than their counterparts using all terrain vehicles, despite a higher rate of protective equipment use. Lower extremity injuries and fractures about the leg and wrist occur with greater frequency in pediatric motor-bike riders.

Notes:

Thursday, December 18, 2014

Concurrent Session 10C: Hand and Education
(Palomino Ballrooms 6-7)

Civilian Moderator: **Alexander Y. Shin, MD**
Military Moderator: **MAJ Mathew L. Drake, MD**

0915-0920

Epidemiology Of Ligamentous Wrist Injuries At The United States Military Academy

LT Patrick E. Jones, MD
* CPT Ronald Goodlett, MD
2d Lt Kenneth Tanyi, BS
Kenneth L. Cameron, PhD, MPH, ATC
LTC Brett D. Owens, MD
LTC Leon J. Nesti, MD, PhD

Introduction: Non-osseous injuries of the wrist are a common but poorly understood condition among athletic populations. They remain a significant cause of training time lost and can limit activity for many years. These injuries include but are not limited to ligamentous injuries, tendon injuries, muscle strains and damage to the triangular fibrocartilage complex. Active populations, such as cadets in training to become military officers are at high risk to not only develop non-osseous wrist injuries but to have activity limited by those injuries.

Methods: A longitudinal cohort study was performed to determine risk factors for closed soft tissue injuries of the wrist at the United States Military Academy between 2005 and 2009.

Results: A total of 220 cadets sustained new wrist injuries without acute osseous abnormalities on initial radiographic evaluation during 2329 person- years at risk, resulting in an overall IR of 48.0 per 1000 person-years. The average patient age was 21 years. 112 patients reported participation in organized activity during injury, of those 15 were female and 97 male. The most common activity at time of injury was combatives to include boxing, martial arts and grappling, this accounted for 23% of the injuries. Other common causes of non-osseous wrist injury were weightlifting and intercollegiate sports with football and gymnastics being the most common of these activities. The average length of activity restriction was 23 days with a range of 0 to 291 days. Nine-

teen percent of the cohort had persistent symptoms after initial immobilization requiring advanced imaging, of which 19 % required surgical intervention.

Conclusion: Non-osseous injuries to the wrist are common in the young, active, military population and can interrupt training and mission readiness. Activities that place the patient at high risk for these injuries include combatives and predictably sports that place a high demand on the wrist such as gymnastics or football. The majority of non-osseous wrist injuries can be reliably treated with a brief period of immobilization; however, a significant percentage will have a protracted recovery period requiring advanced imaging and surgical intervention. Further investigation is needed identify which injuries will be refractory to immobilization and may require more aggressive intervention.

Notes:

0920-0925

Incidence Of Metacarpal Fractures In A Military Population

Captain Robert Dichiera, MPAS
CPT E'Stephan J. Garcia, MD
COL Mark P. Pallis, DO
MAJ Jamie Bulken-Hoover, MD
MAJ Justin J. Mitchell, MD

Introduction: Hand injuries are among the most common musculoskeletal complaints seen by military healthcare providers. Non-accidental or intentional metacarpal injuries are usually self-inflicted and can be related to age, alcohol, aggression, and brawling. These injuries impact the unit medical readiness.

Methods: This study will be a retrospective records-based review to evaluate the incidence by type of metacarpal fractures over a 5-year period in a specified U.S. Military population. Multiple investigators will conduct data collection utilizing the Armed Forces Health Longitudinal Technology Application (AHLTA) and e-profile databases. Data will be collected from the investigators' local medical treatment facility and will include demographic information, military occupational specialty (MOS), mechanism of injury (MOI), nature of injury, total number of visits, estimated cost of treatment, and estimated time on profile.

Preliminary Results: A preliminary analysis of the data from the local military treatment facility demonstrated over 650 metacarpal fractures for the specified timeframe. Among these metacarpal fractures, small finger metacarpal fractures are the most common type. There are as many aggression-related or intentional small finger metacarpal fractures as there are accidental or unintentional small finger metacarpal fractures. The typical patient that sustains a small finger metacarpal fracture is usually a young male, in a combat arms occupation, and the injury is usually associated with aggression or an aggressive act. On average for all metacarpal fractures there were 6.99 encounter visits, 26.13 days on a limited duty profile that placed the Service Member on a Medically Non-deployable status, and 37.87 total days on a limited duty profile.

Discussion and Conclusion: Active Duty Army personnel are required to perform Army-specific as well as military occupational specialty (MOS) specific duties. These duties include, but are not limited to, handling personal weapons, operating vehicles, and performing physical fitness activities both in Garrison and in deployed or austere environments. While most hand injuries do not require surgery, these injuries still impact the unit medical readiness. This is a result of the number of multiple medical and rehabilitation appointments the Soldiers must attend, as well as the restricted duties placed on the Soldiers via the standard physical profiling system. As a result, metacarpal fractures account for time lost at work and reduced job performance. This directly affects the unit medical readiness in regards to the unit mission and projected deployments. There is currently very little published work associated with isolated hand injuries that occur in a military population. This study will serve to establish a baseline for productivity lost to treatment, treatment follow up and rehabilitation; assess the impact on unit medical readiness; and potentially develop a method that allows for identification of at risk Soldiers based on age, military occupation specialty to assist in the development of intervention and prevention strategies.

Notes:

0925-0930

MRI-Based Classification System For Ulnar Collateral Ligament Injuries

LCDR Patrick Joyner, MD, MS
Jeremy Bruce, MD
Ryan Hess, MD
Aaron K. Mates, MD
James R. Andrews, MD

Background: Currently there is no widely accepted classification system for ulnar collateral ligament (UCL) injuries. We present a MRI based classification for UCL injuries.

Materials & Methods: A total of 240 elbow MRI's from athletes that had undergone UCL reconstruction were reviewed. The UCL injuries were classified as follows; Type I were low-grade partial tears, Type II were high grade partial tears, Type III were complete tears in one location (ulna sided, humeral sided or midsubstance) and Type IV were tears in more than one location. The tears were further sub-classified by location of injury as follows; U-ulna, H-humerus, M-midsubstance. Secondary parameters investigated included; the presence of a T-sign on MRI, and the presence of a vacuum sign on stress radiograph.

Results: The MRI classification found 22/240 (9.1%) were Type I, 139/240 (58%) were Type II, 66/240 (27.5%) were Type III, and 13/240 (5.4%) were Type IV. Injury location was noted on the ulna 90/240 (37.5%) of the time, the humerus 107/240 (44.6%) of the time and midsubstance pathology was present in 30/240 (12.5%). T sign on the ulna was noted in 94/240 (39%) of the cases. The vacuum sign was found in 39/240 (16%) of the cases of which 1/39 (2.6%) was a Type I UCL injury and 38/39 (97.4%) were a Type II, III, or IV.

Conclusion: We present a MRI based classification system that helps to separate low from high grade partial UCL injuries as well as complete tears. The vacuum sign being present almost exclusively in Type II injuries or worse, confirms this radiographic finding as a marker of severity. As a result, we feel this classification will not only help with communication, but may also help to direct care.

Notes:

0930-0935

Treatment And Outcomes Of Isolated Metacarpal Shaft Fractures In An Active Duty Military Population

CPT Emily Morgan, MD
LTC Nicholas Noce, MD

Introduction: Metacarpal shaft fractures are common injuries in the military population. We hypothesized that the majority of isolated metacarpal shaft fractures would be amenable to non-operative treatment and would not result in functional limitations in these high demand patients.

Methods: A retrospective review was performed of all active duty soldiers who were treated at our institution for an isolated metacarpal shaft fractures from 2009-2011. Patients were excluded if they had received initial treatment at an outside facility, were noncompliant with treatment, sustained their injury in combat, if the fracture was open, and if sufficient radiographs were not available.

Results: Forty-two patients were identified. Two patients required operative treatment of their fractures, one for shortening > 4 mm and one for 100% translation at the fracture site following initial reduction. The metacarpal fractures which required operative fixation included one spiral and one oblique fracture, representing 4.8% (2/42) of the study population. Fracture pattern was not found to be statistically significant for requiring operative fixation, with p=0.14. Patients required 66 days on average of limited duty related to their injury. Only one patient required permanent duty modifications related to his injury, this patient sustained a spiral metacarpal fracture which had been treated operatively.

Conclusion: The majority of metacarpal shaft fractures can be treated non-operatively with excellent functional results for young high demand patients, with the rare exception of spiral and oblique fractures which may require operative fixation.

Notes:

0935-0940

Digital Tomography For Detection Of Acute Occult Scaphoid Fractures

CPT Anthony Barcia, MD
CPT Liang Zhou, MD
CPT Jay B. Cook, MD
COL Kenneth Lindell, MD
MAJ Aaron Dykstra, MD
CPT Robert Lachky, MD
Steven H. Shaha, PhD
COL (Ret) Kenneth Taylor, MD

Introduction: Diagnosis of occult scaphoid fractures remains a challenge with various modalities advocated. One of the proposed imaging techniques to assess for scaphoid fractures when there is high clinical suspicion but initial radiographs are negative is the digital tomogram. This modality quickly provides fine-cut visualization of the carpus with minimal radiation exposure. Our study set out to determine the ability of digital tomography to detect acute occult scaphoid fractures and to compare this modality against MRI, a much more expensive, but well-established technique.

Methods: This was an IRB approved, prospective series. All patients age 18 years and older with clinical suspicion for acute scaphoid fracture and negative initial radiographs were included. Patients had to be within 96 hours of the acute trauma and all were evaluated by orthopedic surgeons. Both the digital tomogram and a wrist MRI were obtained. The wrists were then immobilized and re-evaluated at 10-14 days with repeat radiographs as per standard of care. The studies were interpreted by a musculoskeletal radiologist in a blinded fashion. Repeat radiographs and clinical follow up were used as a control to compare the efficacy of both digital tomogram and MRI.

Results: There were 40 extremities in 39 patients included in the study. Six of the 40 scaphoids (15%) were determined to be fractured as determined by repeat radiographs and clinical follow up. Digital tomogram was positive in 4 of the 40 extremities (10%). MRI was positive in 8 of the 40 extremities (20%). The sensitivities were 67% and 100% for digital tomogram and MRI respectively (p=0.14). The positive predictive value (PPV) was 100% for tomogram and 75% for MRI (p=0.15).

Discussion and Conclusion: The optimal algorithm for diagnosing occult scaphoid fractures has yet to be determined. Traditional management of two weeks immobilization and repeat radiographs is often inconvenient for the patient and results in unnecessary immobilization of many patients without fracture. MRI has been shown to be very sensitive in the acute setting and is also capable of detecting ligamentous injury, but it is an expensive test and difficult to obtain in many centers. While very sensitive, the MRI may over-call some contusion injuries as fracture, a finding reported previously by other authors. Digital tomography has been proposed for this use but has never been compared to MRI. Our findings indicate that digital tomography will detect most scaphoid fractures not seen on initial radiographs but may miss some entirely non-displaced fractures. Our study shows that digital tomography is less sensitive than MRI for detecting occult scaphoid fractures.

Notes:

0940-0945

Flexor Tendon Repair In An Ex-Vivo Model: An Established Knotless Bidirectional Barbed Suture Technique Does Not Withstand Cyclic Loading Necessary For Early Rehabilitation

MAJ Fred O'Brien, MD
Kenneth R. Means Jr., MD
Brent G. Parks, MD

Introduction/Hypothesis: In an ex-vivo model, a zone II flexor tendon laceration repaired with knotless, bidirectional barbed suture, as previously tested in a tensile load-to-failure model, would provide equivalent resistance to gap formation during cyclic loading as a repair using conventional locking four-strand technique with braided suture of similar strength.

Methods: Flexor digitorum profundus tendons from fifteen fresh frozen cadaver hands were randomly assigned to one of three repair techniques: locking cruciate four-strand repair using braided suture (LC), three-strand repair with transverse passes using braided suture (TS), or three-strand repair with transverse passes using bidirectional barbed suture (BB). Epi-

tendinous repairs were not performed. Flexor and corresponding extensor tendons were attached to a load generator. The fingers were brought through a range of motion at 5N per finger, simulating a minimal estimated force transmitted across a repair site during early rehabilitation. Gap formation was assessed and recorded every ten cycles through 100 cycles, and at 100 cycle intervals through 1,000 cycles. Failure of repair was defined as gap formation of greater than 2mm. Tensile loading to catastrophic failure was performed on each tendon, and required force was recorded.

Results: The BB and TS groups developed an average gap of 2.43 mm (SD 3.29) after 20 cycles, and 2.22 mm (SD 0.85) after 10 cycles, respectively. Over 1,000 cycles, the LC group demonstrated an average gap of 3.21mm (SD 1.51) compared with 9.12 mm (SD 2.80) in the BB group. Due to the consistently wide discrepancy between the cycles to failure between the BB and LC groups, the experiment was terminated at seven tendons per group. Using one-way ANOVA with Fisher LSD, post-hoc analysis was performed to determine if any observed differences were significant. We observed a significant difference in number of cycles until failure ($p<0.001$) between the LC and BB groups. There was no significant difference in force (N) required to induce catastrophic failure between the LC and BB groups, and all repairs in this portion of the study failed by suture pullout.

Discussion and Conclusion: The BB group developed gapping early in the testing process, with significant differences compared to the LC group at 1,000 cycles.

Notes:

0945-0950

Distal Humeral Hemiarthroplasty: Indications, Results, And Complications. A Systematic Review

CPT John Dunn, MD
CPT Nicholas Kusnezov, MD
MAJ Justin J. Mitchell, DO
LTC Miguel Pirela-Cruz, MD

Introduction: Distal Humeral Hemiarthroplasty (DHH) is an infrequently utilized treatment for comminuted intra-articular fractures of the distal humerus. DHH has specific advantages over other, more common, treatment modalities of unreconstructible distal humerus fractures: Total Elbow Arthroplasty (TEA) and Open Reduction Internal Fixation (ORIF). Preservation of bone stock, lower rates of loosening, and less postoperative restrictions make DHH a reasonable option in these difficult cases. The reported cases of DHH are few in number. We present the first systematic review of DHH and describe the indications, results, and complications of this uncommon procedure.

Methods: A literature search yielded 13 primary articles with 116 elbows that underwent DHH for fractures and 4 papers with 17 elbows that underwent DHH for non-fracture causes. A systematic review was generated; patient indications, outcomes, and complications were recorded.

Results: For fractures; good to excellent results were achieved in 67.4% of patients with a mean arc of motion of 98° at mean follow up of 42 months. 28% of patients experienced a complication, and only 1.7% of patients experienced loosening of the prosthesis. For non-fracture indications; good to excellent results were achieved in 76.5% of patients with a mean arc of motion of 62° at mean follow up of 46 months. Half of patients experienced a complication; most commonly stiffness. Loosening of the prosthesis was not noted in any patient.

Conclusion: Here we present the first review of the indications, outcomes, and complications for DHH. DHH is a reasonable treatment option for young patients with unreconstructible intra-articular distal humerus fractures, especially with specific comorbidities to include rheumatoid arthritis, tumor, bone loss, or osteomyelitis.

Notes:

1000-1005

Positional Tension Of The Ulnar Nerve After Decompression Procedures

CPT John Dunn, MD
CPT Nicholas Kusnezov, MD
MAJ Justin J. Mitchell, DO
LTC Derek F. Ipsen, DO
MAJ Aaron Dykstra, MD

Introduction: The elbow is the most common site of ulnar nerve compression, likely due to the superficial location and inherent compressive anatomy of the ulnar nerve. While biomechanical studies have analyzed the effect of strain on nerve conduction, few have applied these principles to the various techniques of ulnar nerve decompression. The purpose of this study is to determine the amount of strain on the ulnar nerve in full flexion and extension of the elbow and determine if tension in full extension is increased after anterior transposition of the nerve.

Methods: Fifteen fresh cadaver upper extremities with intact shoulder girdles were tested. A differential variable reluctance transducer (DVRT) was placed in the ulnar nerve just proximal to the medial epicondyle and the distance between the mounting pins was measured and used as the initial gauge length. The strain was measured in full elbow flexion and extension. An in situ release, a sub-cutaneous transposition, and a submuscular transposition were performed sequentially with the strain being measured after each procedure in the full elbow flexion and extension positions. The strain was then averaged and compared for each procedure. A one-way analysis of variance was used to determine if any observed differences were significant ($p \leq 0.05$).

Results: After the in situ release there was no statistically significant change in strain in either flexion or extension. After a subcutaneous transposition there was a statistically significant decrease in strain in full elbow flexion but not in extension. Similarly after a submuscular transposition there was a statistically significant decrease in strain in full flexion but not in extension. There was not a statistically significant change in strain with medial epicondylectomy.

Conclusion: An in-situ release of the ulnar nerve at the elbow may relieve pressure on the nerve but does not address the problem of strain which may be the underlying pathology in many cases of ulnar neuropathy at the elbow (UNE). Transposition of the ulnar nerve anterior to the medial epicondyle addresses the problem of strain on the ulnar nerve. In addition it does not create increased strain on the ulnar nerve with elbow extension.

Notes:

1005-1010

A Vascularized Elbow Allotransplantation Model In The Rat

LCDR Scott M. Tintle, MD
Juyu Tang, MD
L. Scott Levin, MD, FACS

Introduction: There is no durable solution for end stage elbow arthritis in the young active patient population. Potential surgical solutions to include elbow debridement, resurfacing arthroplasty, non-vascularized allograft elbow transplantation, and total elbow replacement have not proven to be the successful long term solution to this problem. In the current patient with end stage elbow arthritis or elbow destruction as a result of injury, infection or failed arthroplasty, the only viable solution is often surgical arthrodesis, or resection arthroplasty leaving a patient with a minimally useful extremity with minimal to no motion. An ideal replacement for these patients with elbow joint destruction would be a living joint allogeneic transplant that exactly matches the dimensions and structural properties of the missing joint.

Methods: We developed an animal model for composite tissue allotransplantation (CTA) of the elbow joint in rats. Microvascular elbow CTA was performed in 9 rats across a major histocompatibility barrier. 3 rats were treated with full dose Immunosupression consisting of cyclosporine until sacrifice. 3 rats were provided with 10 days of immunosuprresion and then the cyslosporine was stopped. This group was termed the cyclosporine taper group. Finally, 3 rats were utilized as a control and were given no immunsuppression. Joint mobility and weight-bearing capability were assessed throughout 90 days of life. Pedicle patency, bone blood flow, and histologic analysis were performed at the time of sacrifice.

Results: In the cyclosporine group, forelimb activity was gradually recovered over the postoperative 90 days. The operated extremity was utilized in daily activities such as ambulating and eating. There was little to no range of motion or utilization of the limb in the cyclosporine taper or the control groups. The vascular pedicles were patent at the time of sacrifice in the cyclosporine treated group, but not in the remaining groups. Micro CT scan performed 3 months following the transplants revealed union at the bone junctions and the elbow joint appeared grossly normal upon sacrifice in the cyclosporine treatment group only. Incomplete healing was observed in the other two groups, and the elbow joints were grossly destroyed. Flow Cytometry of blood samples obtained on days 14, 30, 60 and 90 showed no recipient cell chimerism in any of the groups. Histologic examination of the elbow joints is currently being performed.

Conclusion: We have provided the first animal model for elbow CTA. In our cyclosporine treated rats we have shown that animals regain near normal function of their forelimbs after bone union and maintain grossly normal elbow cartilage. Without cyslosporine treatment, both our control groups and the cyclosporine taper group rejected their allotransplants.

Notes:

1010-1015

The Effect Of Below-Elbow Immobilization On Driving Performances

Capt Aaron Barrow, MD
Maj Evan Jones, MD
Capt Nic J. Skordas, MD
Lt Col Mickey S. Cho, MD

Introduction: This study evaluated the effect of various below-elbow immobilization devices on driving performance.

Methods: 20 healthy subjects completed 10 runs through a closed, cone-marked driving course while wearing a randomized sequence of left and right-sided below-elbow fiberglass casts and removable splints (short arm cast, spica cast, wrist splint, and spica splint). The first and last driving runs were without immobilization and served as controls. Performance was measured based on evaluation by a certified driving instructor (pass/fail scoring), cones hit, run time, and subject-perceived driving difficulty (1-10 analogue scoring).

Results: The greatest number of instructor-scored failures occurred while immobilized in right spica casts (n=6; p=0.02) and left spica casts (n=5; p=0.049). The right spica cast had the highest subject-perceived difficulty (5.2 ± 1.9; p0.05). There was no significant difference for cones hit or driving time between control runs and any type of immobilization.

Conclusions: Driving performance was significantly decreased by immobilization in a below-elbow spica cast. All other forms of immobilization tested, except the left removable splint, also caused some amount of driving impairment. This information can help surgeons counsel patients on the appropriate time to return to driving while undergoing treatment that requires below-elbow immobilization.

Notes:

1015-1020

Dorsal Screw Penetration With The Use Of Volar Plating Of Distal Radius Fractures: How Can You Best Detect?

CAPT Irshad Shakir, MD
Brian W. Hill, MD
Lisa K. Cannada, MD

Purpose: The valley between the sigmoid notch and Listers' tubercle make evaluation of screw prominence difficult with conventional fluoroscopic images. Various projections have

been described to detect dorsal cortex screw penetration. This cadaveric study is designed to evaluate which described fluoroscopic images are useful to detect dorsal cortex penetration with the use of volar locking plates.

Methods: Twenty-one embalmed forearm cadaveric specimens were used. Volar locking plates were secured in position proximally. Four 2.5 mm locking screws were inserted distally using 18 mm, 20 mm and 22 mm screws in 7 specimens for each length. The specimen was evaluated to count the number of screws breaching the dorsal cortex. Four fluoroscopic images (lateral, 45° supination, 45° pronation, dorsal tangential view) were taken of each wrist. A group of 63 orthopaedic surgeons with different levels of experience were then asked to evaluate if the screws penetrated the dorsal cortex after viewing each image. The data was analyzed for sensitivity and specificity in the evaluation of dorsal screw penetration and interobserver reliability using the interclass correlation coefficient.

Results: The 21 cadaveric specimens had an average age of 78 (range, 25-91 years). Dorsal cortex screw penetration of at least one screw occurred in 14% (1/7) of specimens with 18mm screw, 57% (4/7) of specimens with 20 mm screw and 86% (6/7) specimens with 22 mm screws. The sensitivity of the lateral view was 64.1%, 90.3% on the 45° supination view, 63.9% on the 45° pronation view, and 73.2% on the dorsal tangential view. An increase in the number of years of orthopaedic experience demonstrated an inverse relationship with respect to sensitivity/specificity.

Conclusion: Dorsal cortex screw penetration can lead to tendon irritation and rupture. This can occur especially with penetration of the third dorsal compartment due to its relationship to Lister's tubercle. This cadaveric study gave us direct visualization of screw penetration to accurately determine which fluoroscopic images detected this breach. The lateral and 45 degree pronation views detected screw penetration about two-thirds of the time. The sensitivity increased with dorsal tangential views to 73% and the 45° supination view to 90%. Clinicians should consider use of these views to diagnose dorsal screw penetration after volar plating.

Notes:

1020-1025

Biomechanical Study Of Olecranon Plate Fixation In Comminuted Osteoporotic Fracture Model: Locking Compression Plates Vs. Dynamic Compression Plates

CAPT Irshad Shakir, MD
Heidi Israel, NP, PhD
Lisa K. Cannada, MD
Gary Bledsoe, PhD

Background: The purpose of this cadaveric biomechanical study is to compare locking compression plate (LCP) fixation to dynamic compression plate (DCP) fixation in a comminuted olecranon fracture using cyclic loading to measure fragment displacement and maximal failure load.

Methods: Eight paired human osteoporotic or osteopenic cadaver elbows were used. One paired half of the specimens randomly received fixation with a locking compression plates and the other paired half received fixation with dynamic compression plates. Both implants were first secured to the intact ulna prior to creating and osteotomy. Two vertical osteotomies were created to simulate a fracture gap of approximately 5mm and then the plates were replaced through the same screw holes. Biomechanical parameters were compared between two groups. Saw-toothed cyclic loading was applied and force and gap displacement was measured. Failure was defined as the fracture gap increasing greater than 2 mm or catastrophic failure, of the bone or construct.

Results: The average force for a DCP plate was 22.12 N compared to the LCP plate as 33.40 N ($p< 0.05$). The average gap for a DCP plate was 7.32mm compared to the LCP plate of 6.40mm ($p< 0.05$). The force measure was statistically significant at 60, 70, 80, 90, and 100 mm of displacement ($p<0.05$). This implies that the LCP was able to withstand higher force than compared to DCP. The gap displacement was statistically significant at 60, 70, 80, 90, and 100 mm of displacement ($p<0.05$). This implies that the LCP maintained the reduction better than compared to DCP. There is no difference in force or gap when comparing to gender, right versus left forearm, osteoporotic versus osteopenic bone. There was also no difference in when failure occurred between the DCP and LCP groups.

Conclusions: Our study compared a locking plate versus a dynamic compression plate for a comminuted olecranon frac-

ture. Our biomechanical study found that the LCP was able to withstand higher force than the DCP and there was less displacement of the fracture with biomechanical testing in the LCP compared to DCP. Both plates could be appropriate surgical techniques for fixation of selected olecranon fractures, particularly comminuted and osteoporotic fractures. Further studies would be needed to compare these two plates clinically.

Notes:

1035-1040

Can An Arthroscopic Training Course Really Improve Your Residents Arthroscopic Basic Skills? Yes, Based On Pre And Post Simulation Testing

MAJ Kevin D. Martin, DO
David Patterson, MD
Kenneth L. Cameron, PhD, MPH, ATC

Introduction: Resident education continues to progress towards a proficiency based curriculum that can be standardized and reproduced. In order to create such a curriculum educators must critically evaluate their training methods and provide objective evidence of benefit. Arthroscopy education has been a major focus due to its popularity and reproducibility but it has lacked a validated standardized curriculum. Many organizations and private industry host multi day arthroscopic educational course and none have objectively evaluated there outcomes nor standardized their curriculums. Our goal was to evaluate the correlation between timed task performance on an arthroscopic shoulder simulator and participation in a well-established standardized arthroscopic educational course.

Methods: Forty-eight orthopaedic residents were voluntarily recruited from over 20 residency programs throughout the United States and Canada. Each subject was tested upon arrival at the North American Arthroscopic Association (AANA) orthopaedic learning center on an previously validated virtual reality arthroscopic shoulder simulator and objectively scored. Each subjects total number of shoulder arthroscopies and PGY were also evaluated to establish surgical experience using each subjects mandated ACGME or equivalent case log system. Following the intense 4 day training curriculum which consisted of lecture and cadaveric didactics each resident was reevaluated on the same simulator. A multivariate regression analysis was performed to determine the correlation between simulator performance and participation in the training program.

Results: After completing the four day standardized arthroscopic curriculum subjects demonstrated significant improvements in all dimensions measured by the simulator. The subjects significantly decreased there probe distance traveled representing improved instrument handling. The subjects all significantly decreased camera distance traveled representing improved anatomic recognition and familiarization. Finally subjects time to completion also significantly improved, time alone does not represent improvement in skill but when combined with the other outcome measures it does reflect improved overall proficiency.

Conclusion: This study establishes objective improvement in orthopaedic trainee's basic arthroscopic skills following a standardized 4 day arthroscopic training curriculum. This data also objectively validates the North American Association of Arthroscopy resident training course and curriculum.

Notes:

1040-1045

The Effectiveness Of Tiered Research Teams Within An Orthopaedic Surgery Residency

CPT Chad A. Krueger, MD
MAJ Daniel J. Stinner, MD
LTC (Ret) Joseph R. Hsu, MD

Introduction: All residents must participate in at least 1 research project during residency and many residencies offer extended periods of research for residents. Yet, it is largely unknown how to best create a productive research environment within residencies. Mentor models (one faculty and one resident) are common for clinical research. Other models involve simply passing projects from one resident to another as residents progress or graduate. This study examined the productivity of a research team that was based on a tiered team structure (ie a faculty member, middle to senior resident and junior resident).

Methods: Tiered team research was instituted beginning in 2008 at a single Orthopaedic Surgery Residency. Research mentoring focused on self-selected PGY 1 and 2 level residents as well as research residents (between PGY 2 and 3 years). Weekly research meetings were mandated as well as monthly updates for the entire department. Initial education focused on data collection and research design. As these junior residents progressed through the Orthopaedic Surgery program to become mid-level and senior residents, they were expected to serve as near-peer mentors and co-authors for new PGY 1 and 2 residents. At this point, the faculty mentor focused on teaching the mid and senior level residents how to manage small research teams and conduct multiple complementary studies from the large database each had created earlier during residency. This single institution study examined publications that were produced by members of this tiered team research. A PubMed search was conducted for publications produced by each member of this team from 2009 through 2013. Software was then used to determine the research connections and individual research pyramids that each member the research team developed over each year to graphically demonstrate the growth in research capability. None of the residents were in the same year group and one of them did not complete a dedicated research year.

Results: The three residents and one staff examined in this study published a total of 99 individual articles, representing 50% of all articles published within the 60+ person orthopaedic surgery department during that timeframe (99/197). Each member of the pyramid-research team was able to increase their research connections in a predictable fashion and developed their own, small research teams using a pyramid model over time. The residents averaged 1 publication during their first year as part of the tiered research team and 7 publications per year in each subsequent year. The staff had 1 publication in his first year after creating the tiered structure and an average of 15 publications per year each subsequent year.

Discussion: This project demonstrates the results of a tiered team research strategy that focused on creating near-peer research mentors as residents progressed though Orthopaedic surgery training. A tiered team research model seems to be an effective, predictable, and sustainable way to promote research within a residency.

Notes:

1045-1050

Are Cell Phones A Potential Source Of Bacterial Contamination In The Operating Room?

CAPT Irshad Shakir, MD
Nirav H. Patel, MD
Robin R. Chamberland, PhD
Scott G. Kaar, MD

Background: Cell phone use has become common in all areas of the hospital, in particular the operating room. Prior studies demonstrated bacterial contamination of cell phones with bacterial growth. The purpose of this study was to document the frequency of cell phone bacterial contamination on attending and resident orthopaedic surgeon cell phones in the operating room and to determine whether a standardized disinfecting protocol decreases the rate of bacterial contamination and amount of organic material on a cell phone.

Methods: Orthopaedic attending and resident cell phones were swabbed in the operating room front and back with

adenosine triphosphate (ATP) bioluminescence to quantify organic material contamination and culture swabs to evaluate bacterial contamination. The phones were then cleaned with a proprietary electronic device cleaning wipe and re-tested. One week later a final set of studies were obtained.

Results: 83% of cell phones tested had pathogenic bacteria at initial testing, only 8% had pathogenic bacteria after disinfection; however, 75% had pathogenic bacteria 1 week later. The average relative light unit at initial testing was 3488, reduced to 200 after disinfection, indicating a cleaned surface. However, it increased to 1825, indicative of a poorly cleaned surface, at final testing one week later.

Conclusions: Cell phones of orthopaedic surgeons have a high rate of pathogenic bacteria and organic material contamination. Both are decreased after a single disinfecting process. However, recontamination can be expected. While the risk of the cell phone as a source of surgical site infection is unknown, it seems prudent for surgeons to routinely disinfect them. Clinical Relevance: Healthcare workers cell phones have been shown to be contaminated with bacteria that can cause nosocomial infections. Proper care and practice should be implemented in the operating room to decrease cell phone associated bacterial contamination.

Notes:

1050-1055

Validity Of Computed Tomography In Predicting Scaphoid Screw Prominence: A Cadaveric Study

LT Clare Griffis, MD
CAPT Patricia L. McKay, MD
Cara Olsen, MS, DrPH
Michael Frew, MD
C. Frank Gould, MD
LTC Leon J. Nesti, MD, PhD

Introduction: Studies of hardware protrusion into joint spaces following fracture fixation have been performed for other bones to address whether or not there is discrepancy between the true and radiographic appearance of screw prominence. We present a cross-sectional study examining the headless compression screw prominence in the scaphoid.

Methods: Forty two cadaveric wrists were separated into four allotted groups with 21 control specimens and 21 study specimen in divided groups of 1-3 mm screw head prominence. All specimens were radiographically screened to exclude those with inherent carpal abnormalities. Headless compression screws were placed into all specimens using an open dorsal approach. With the open incisions, the screw depth at 0mm, 1mm, 2mm and 3mm was observed directly using a digital calipers at the convex surface of the scaphoid proximal pole. Computed tomography, with direct sagittal acquisition and metal suppression technique was performed on all specimens following screw placement. The images were interpreted by two staff radiologists blinded to the study groups.

Results: Results were compared using descriptive statistical methods with the assistance of a biostatistician. Inter-rater reliability was assessed using intra-class correlation (ICC) between the two interpreters and was 0.990 (95% CI, 0.981 to 0.995, $p<0.001$) indicating excellent agreement. The ICC between the average of the two interpreters and measured prominence for intra-rater reliability was 0.740 (95% CI, 0.520 to 0.833, $p<0.001$) indicating good agreement.

Using the Fisher exact test ($P<0.001$) to analyze the interpreted results in relationship to prominence, only one of twenty one (5%) control specimens was interpreted as prominent. This is compared to five of seven (71%) in the 1mm prominent group; seven of seven (100%) in the 2mm prominent group and seven of seven (100%) in the 3mm prominent group. Furthermore, Bland-Altman 95% limits of agreement were -1.431 to 2.202 indicating that it is not uncommon to observe a difference between the radiographic and direct prominence as large as 2mm for an individual specimen. For the 21 control specimens, the average interpretation was 1.755mm below the subchondral surface (95% CI, 1.279 to 2.231). Bland-Altman 95% limits of agreement were -3.846 to 0.337 indicating that raters were unlikely to interpret prominence as greater than 0.3mm higher than actual measurements.

Discussion: Results revealed that only one out of twenty one control specimens was interpreted as prominent. Comparatively, in the studied groups, only two out of twenty one were not interpreted as prominent when in fact there was actual prominence. These results reveal that CT provides an accurate assessment of screw prominence in this model.

When a screw appears prominent by CT scan it is likely to be truly prominent with minimal metal artifact, producing a measurement approximately 0.3mm greater than the direct measurement.

Conclusion: In summary, hardware prominence is a common concern with orthopaedic implants. Internal fixation of the scaphoid is no exception. Our results indicate that a screw that appears prominent by CT scan is likely to be truly prominent and that the degree of metal artifact with headless titanium screws imaged in the direct sagittal plane with metal suppression technique is minimal, producing a measurement approximately 0.3mm greater than the direct measurement.

Notes: