

Paper Session I: Femoral and Pelvic Injuries

8:05 am Paper 1

Outcome of Femoral Fractures in Post-Poliomyelitis Patients

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Background/Purpose: Poliomyelitis (polio) was prevalent in certain parts of the world in the 1950s. As post-polio patients age, low-energy proximal, shaft, and distal femoral fractures are becoming more common in this population. Unique problems include altered bony anatomy affecting reduction and conventional implant placement. Impaired bone quality and muscle strength pose significant challenges in the postoperative rehabilitation in this special population. Very little is known in the existing literature about the outcome of post-polio patients following lower extremity fracture surgery. The aim of the study was to describe the outcome of femoral fractures in post-polio patients.

Methods: A retrospective analysis of all femoral fractures in polio patients between the years 1990 and 2011 was performed. A total of 68 post-polio patients were admitted to our center with femoral fractures involving the affected (paretic) extremity. The patient charts and radiographs were surveyed for demographic information, fracture types, fracture treatment, and functional outcome. Fractures were classified according to the AO/OTA classification. All surgeries were performed by fellowship-trained trauma surgeons.

Results: The female-to-male ratio was 1.7:1. The average age on injury was 59.4 years and the average hospital stay was 11 days. The most common mechanism of injury was low-energy trauma (85%). More than half of the fractures were at the proximal femur (OTA 31A), 30% at the distal metaphysis (OTA 31C) and the rest shaft fractures (OTA 31B). A total of 53 patients underwent operative treatment, while 15 patients were treated nonoperatively. The vast majority of proximal fractures (95%) were operatively treated while 48% of the distal fractures and 36% of the shaft fractures were treated nonoperatively. Operative fixation techniques varied with individual cases and consisted of sliding hip screw systems or cannulated screw fixation for proximal fractures, intramedullary nail and plate fixation for more distal fractures. Five cases of proximal fractures required reoperations due to hardware failure while one shaft and one distal fracture required hardware removal after fracture healing. 23 out of 45 (51%) regained their preoperative ambulatory function at the final follow-up. Almost all patients with either proximal or midshaft femoral fractures who avoided weight bearing on their affected extremity did not regain their preinjury ambulatory status. All patients with distal femur fractures managed to return to the preinjury ambulation. No correlation was found between fracture types to postinjury ambulation.

Conclusion: Femoral fracture management in post-polio patients remains problematic with a high complication rate in proximal fractures. Return to preinjury ambulatory status is guarded in many cases. Postoperative non-weight-bearing status harbors a worse prognosis in post-polio patients with femoral fractures.

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8:13 am Paper 2

Atypical Femoral Fractures Associated with Bisphosphonate Use: A Case Series and Discussion on Surgical Treatment

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Purpose: Atypical fractures of the proximal femur associated with long-term bisphosphonate use are a rare occurrence but are associated with high rates of complications and reoperation. The aim of this study was to review all patients treated for atypical proximal femoral fractures in our unit over a 4-year period and study the time to union and reoperation rate.

Methods: Patients who had suffered an atypical pattern proximal femoral fracture in our unit over a 4-year period (2009-2013) were identified from a prospectively collected database. Radiographs were reviewed to determine the accuracy of reduction, type of fixation, and any augmentation used. Follow-up radiographs and clinical notes were then reviewed to determine progression to bony union (separated to medial and lateral union). Any failure of fixation or revision surgery was also noted.

Results: 18 primary operations were identified in 16 patients. Six procedures were excluded due to the location of the fracture, early death, or prophylactic procedures. Of the 12 remaining procedures (0.38% of proximal femoral fractures in our unit over the same period), only 50% achieved full union at 2 years. Complete union after primary operation took an average of 295 days (range, 82-524) and lateral union took 167 days longer than medial union. Revision surgery was necessary in 42% (n = 5) of patients for nonunion with or without implant failure.

Conclusion: These rare fractures occur in patients with multiple comorbidities and currently have an unacceptably high revision rate. We describe a novel aggressive initial surgical management, excising the nonunited stress fracture via a valgus subtrochanteric osteotomy and fixation with an anterolateral tension band plate over a dynamically locked cephalomedullary nail. This strategy is based on optimizing the biological and mechanical environment to maximize the chance of union following primary surgical intervention.

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8:21 am Paper 3

Periprosthetic Cortical Bone Remodeling in Patients with Osseo-Integrated Leg Prosthesis

Lisanne M. Haket, MSC; Jan Paul M. Frölke, MD, PhD; Nico J.J. Verdonshot, MSC; Pawel K. Tomaszewski, MSc; Henk van der Meent, MD, PhD; Radboud University Medical Center, Nijmegen, The Netherlands

Background/Purpose: Stress shielding in periprosthetic bone may lead to decrease of cortical bone resulting in periprosthetic fractures and insufficient bone stock for future revision surgery when indicated. We sought to quantify the effect of osseointegrated prosthesis on periprosthetic bone changes and skeletal remineralization for safety purposes.

Methods: All consecutive patients from 2009-2012 with transfemoral (1 bilateral) or through-knee amputation who underwent implantation of osseointegrated femoral leg prosthesis (ILP system, Ortho Dynamics GmbH, Lübeck, Germany) were included in this study. Periprosthetic cortical thickness was analyzed from standard AP radiographs taken directly postoperative, and at 12 months and 24 months follow-up. All measurements were performed by one researcher. According to validated methods, the area around the implant was divided into 6 zones of equal length (3 medial and 3 lateral) and the periprosthetic cortical thickness was digitally measured in the middle of each zone and corrected for radiologic distortion. Dual x-ray absorptiometry (DXA) scans were used to measure bone mineral density (BMD) at the femoral neck of healthy and amputated leg before surgery and at 12 and 24 months follow-up. Outcomes were analyzed by the two-sided paired Student *t*-test in SPSS software. This study was approved by the institutional ethical committee.

Results: 27 patients (6 female, 21 male) with 25 transfemoral (1 bilateral) and 2 through-knee amputations with 12 to 24 months follow-up, who underwent implantation of osseointegrated femoral leg prostheses, were eligible to participate in the study. The mean age at ILP implantation was 48 years (range, 23-68). One amputation was caused by infection, four by tumor, and 22 by trauma. The average time between amputation and treatment with ILP was 18 years (range, 2-45). Significant increase of the mean cortical thickness of all 6 zones was found at 12 and 24 months follow-up. The largest increase of cortical thickness, 18.60%, was observed in the distal medial periprosthetic zone ($P = 0.016$) with a mean increase of 9.44% of all 6 zones ($P = 0.001$). There was no significant increase of the BMD of the femoral necks as measured by DXA scans.

Conclusion: Instead of bone resorption, which has been suggested by mathematical model calculations regarding periprosthetic stress shielding, significant periprosthetic cortical bone growth was observed in patients with a femoral osseointegrated leg prosthesis. No additional risk of periprosthetic fractures is to be expected with sufficient bone stock for future revision surgery when indicated.

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8:44 am Paper 4

Predictors of Intraoperative Fractures in Uncemented and Cemented Hip Hemiarthroplasty for the Treatment of Intra Capsular Neck of Femur Fractures

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Background/Purpose: Cemented hemiarthroplasty is the gold standard for treatment of intracapsular hip fractures. Uncemented hemiarthroplasty is considered to be associated with a high rate of intraoperative fracture (IOF) although there is a paucity of information regarding this. Proximal morphological indices such as the Metaphyseal Diaphyseal Index (MDI) and Canal Bone Ratio (CBR) have been implicated as a determinant of IOF. The aim of our study was to evaluate the rate of IOF in uncemented and cemented hemiarthroplasty. We also aim to ascertain preoperative predictors of IOF.

Methods: A retrospective review of intracapsular hip fractures using the National Hip Fracture Database was undertaken in a regional high-volume major trauma center. We identified 626 patients who underwent hemiarthroplasty using either a contemporary hydroxyapatite (HA)-coated uncemented or cemented prosthesis. After exclusion of patients with erroneous and incomplete data, 472 patients were available for analysis. We collected patient demographic data, surgeon grade, time to surgery, and operative duration. Radiographs for all patients were analyzed by three independent assessors to measure the MDI and CBR. Univariate and multivariate analysis was undertaken to identify preoperative predictors of IOF in hemiarthroplasty.

Results: There were 10 (6.7%) and 23 (7.1%) IOFs in cemented and uncemented groups, respectively. There was no statistically significant difference with respect to cement usage, surgeon grade, operative duration, MDI and CBR, and time to surgery between patients with an IOF compared to those that did not. The subsidence rate was 3.4% in the uncemented group. MDI and CBR did not help predict subsidence. Multivariate regression analysis identified age as the strongest predictor of IOF after hemiarthroplasty surgery (overall relative risk [RR] = 1.06; 95% confidence interval [CI] 1.01-1.12). Subgroup analysis of the uncemented cohort alone also revealed age as the strongest predictor (RR = 1.06; 95% CI 1.00-1.13). There was no significant difference in revision ($P = 0.9$), dislocation ($P = 0.058$) and 30-day mortality ($P = 0.8$) between patients receiving an uncemented or cemented hemiarthroplasty.

Conclusion: We found no difference in the rate of IOF between uncemented and cemented hemiarthroplasty. Increasing age is the strongest preoperative risk factor for IOF in hip hemiarthroplasty surgery. The contemporary HA-coated uncemented hemiarthroplasty can be safely used without increasing the risk of IOF in the treatment of fragility hip fractures. Cemented hemiarthroplasties are known to be associated with intraoperative morbidity related to cement insertion in the elderly.

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8:52 am Paper 5

Are Dislocations Following Hip Hemiarthroplasty a Predictor of Increased Mortality?

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Purpose: The aim of our study was to evaluate the incidence, characteristics, and mortality risk of patients sustaining a dislocation of a hip hemiarthroplasty.

Methods: This is a case series of patients who presented in our institution with one or more episodes of hip hemiarthroplasty dislocation within 2 years from the initial hip operation. Patients having their dislocations reduced at the emergency department, dislocations with an associated implant infection, and patients with dislocations following polytrauma were excluded from the study. All primary hemiarthroplasty procedures were performed on a lateral position and through a lateral incision. Implant selection was based on the physiological age of the patient, life expectancy, preexisting disease, quality-of-life demands, anticipated functional demands, psychological/mental status, bone and joint quality, as well as the surgeon's preference. Following reduction of the hip the stability was confirmed and the wound was closed accordingly. Check radiographs were taken 48 hours postoperatively. Dislocations were reduced with a closed reduction in theater and under general anesthetic. Image intensifier was utilized to confirm reduction. Prosthesis stability was checked and documented. The following parameters were collected and evaluated: (1) patient demographics, (2) mechanism of injury, (3) type of implant, (4) type of dislocation, (5) complications, and (6) mortality rate. The patients were followed up only in case of complications or repeated dislocations.

Results: Over a 3-year period, out of 881 hip hemiarthroplasties performed in our institution, 31 patients (10 male) had at least one episode of dislocation. The mean age at time of first dislocation was 81.6 years (median, 81.5 years; range, 65-95). The average time between the hemiarthroplasty and the first dislocation was 32.5 weeks (median, 3.3 weeks). The average number of dislocations was 2.3 per patient (median, 2; range, 1-6 dislocations). All dislocations were a result of a mechanical fall and 16 patients had a background of impaired mental capacity. 15 patients underwent an excision arthroplasty as a result of their repeated dislocations. During the same period of time, we identified the patients who died during their initial hospitalization following the hip hemiarthroplasty operation. Out of a total of 81 patients, 7 had sustained a dislocation. The two groups (dislocation vs. no dislocation) were matched in terms of gender, length of hospital stay, and comorbidities. Age was found to be significantly lower in the dislocation group ($P = 0.02$). Although there was a trend that patients in the dislocation group died closer to their initial hip operation, it was not statistically significant ($P = 0.06$). However, this failure to reach significance might be secondary to a type II statistical error. The risk ratio of mortality following a dislocation while still in hospital was 2.30 (95% confidence interval, 1.14-4.65).

Conclusion: This study demonstrates that dislocations in the immediate postoperative period following a hip hemiarthroplasty represent a predictor of increased mortality. In particular, the inpatient mortality was found increased more than twofold.

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9:00 am Paper 6

The Longevity and the Complication Rates of Proven Cemented Taper-Slip Femoral Stem Hemiarthroplasties in Fracture Neck of Femur Patients: Exeter Trauma Stem as an Example

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Background/Purpose: Hip fractures are a major health problem among the elderly, with Europe and the United States having the highest hip fracture rates globally. Displaced intracapsular fracture is often treated surgically with hemiarthroplasty (HA). Recent guidelines about HA configurations advocate the use of femoral stem designs that are “tested and proven” within total hip replacement configurations. The Exeter Trauma Stem (ETS) HA is based on the well-proven Exeter total hip replacement design. This is a prospective survival analysis study to assess the long-term complication rates of these cemented taper-slip femoral HAs in the management of displaced intracapsular femoral neck fractures.

Methods: At our center, data on all hip fracture patients are prospectively collected by independent audit officers using the Hip Fracture Standardised Audit Proforma in Europe. The database is linked to the Office of National Statistics and includes post discharge mortality. It is cross-matched with independently collected database for periprosthetic fractures and revision hip surgery. There is only one emergency room within a well-defined geographical area ensuring excellent follow-up of complications. In bilateral fractures, overall survival was calculated from the time of the first fracture. Death was considered the only event in overall survival analysis. Deep infection, dislocation, loosening, periprosthetic fracture, and revision were considered implant failure events.

Results: Between 2005 and 2013, 6250 consecutive hip fractures were treated at our institution; 1123 were treated with an ETS (36 patients had bilateral ETS for sequential fractures). Patient characteristics were: mean age 82 years; 70% females, 72% with abbreviated mental test ≥ 7 . Follow-up period ranged between 0 days and 8 years. Median overall patient survival time following the first ETS operation was 4.5 years. Out of the 1123 implanted ETS, only 29 implants failed. All failure events were reported within the first year. The risk of implant failure was 2.8% at year 8. The risk of implant dislocation was 1%, the risk of periprosthetic fracture was 0.5%, and the risk of deep infection was 1.1% for year 1 up to year 8. The number of failures was too small to perform Cox multivariate analysis to identify failure risk factors.

Conclusion: The ETS HA has a low implant failure rate. We conclude that using an HA prosthesis based on proven cemented taper-slip total hip replacement design leads to a low failure rate.

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9:33 am Paper 7

Time to Surgery Is Not a Risk Factor for Complications in Garden 3 and 4 Femoral Neck Fractures Treated With Cannulated Screws

Kodí Kojima, MD, PhD; Jorge Silva, MD, PhD; Marcos Leonhardt, MD, PhD; Fernando Brandão, MD, PhD; Tales Guimaraes, MD; University of São Paulo, São Paulo, Brazil

Purpose: In femoral neck fractures, osteosynthesis is indicated in patients younger than 70 years, where the complications are more related to the fixation than the general systemic condition. In this study the authors have analyzed various factors that would correlate with failure of the fixation or osteonecrosis. The objective was to evaluate the correlation between the time to surgery and the occurrence of complication.

Methods: From January 2009 to December 2010 there were 31 patients with femoral neck fractures Garden types 3 and 4 treated with reduction and fixation with cannulated screws, with minimum follow-up of 2 years. They were analyzed according to the time to surgery, days in the hospital, Pauwels classification, Singh classification for osteoporosis, surgical time, and the Garden index for reduction (considered normal between 155° and 180°). The binary variables (gender, Garden classification, and side) were analyzed with the χ^2 test and odds ratio. The Singh and Pauwels classification were analyzed with χ^2 . The other variables were analyzed with logistic regression and odds ratio (OR). The confidence interval (CI) was 95% ($P < 0.05$). The association between complications and the variables were verified with Fisher test and Pearson coefficient.

Results: The mean age of the population was 64.6 years (range, 46-76 years). There were 20 male patients (64.5%) and 11 female (35.5%). Fifteen fractures (48%) were on the right side and 16 (52%) on the left. 16 patients (52%) were considered as type 3 in Singh classification for osteoporosis, 10 patients (32%) were type 4, and 5 patients (16%) were type 5. In the fracture classification, 20 patients (64.5%) were Garden type 3 and 11 (35.5%) were Garden type 4; according to Pauwels classification there were 3 (10%) type 1, 18 (58%) type 2, and 10 (32%) type 3 fractures. The mean time between fracture and surgery was 8 days (range, 3-18 days). The mean hospitalization time was 13 days (range, 5-23 days). The time of surgery varied from 45 to 220 minutes; the mean time was 100 minutes. Five patients (16%) had unsatisfactory reduction on the AP view and 3 patients (10%) had unsatisfactory reduction on the lateral view after surgery, according to the Garden index. Four patients (13%) had complications on the follow-up period and they were: one infection, one failure, one non-union, and one osteonecrosis. The analysis of the correlation between time to surgery and complication showed no association (OR 1.01, 95% CI 0.76-1.35, $P = 0.931$). The only variable that correlated with complication was varus reduction measured by the Garden index ($P = 0.00016$, Pearson 0.878).

Conclusion: There was association between the time to surgery and complication. The only variable that showed correlation with failure was varus reduction.

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9:41 am Paper 8

Microvascular Function Following Open (DHS) Versus Less Invasive (PCCP) Extramedullary Fixation of Intertrochanteric Hip Fractures

Matthias Knobe, MD, MSc; Gertraud Gradl, MD; Franziska Böhle; Hagen Andruszkow, MD; Klemens Horst, MD; Frank Hildebrand, MD, MSc; Hans-Christoph Pape, MD;

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Background/Purpose: The dynamic hip screw (DHS) is one of the most widely used implants for fixation of intertrochanteric hip fracture and serves as a benchmark in this field. In elderly patients, however, high rates of surgical site infection have been reported due to extensive soft-tissue compromise associated with the open approach. The angular stable percutaneous compression plate (PCCP) may represent a less-invasive alternative. This pilot study aims to evaluate microvascular function and quantify soft-tissue damage in the region of the proximal femur following less invasive and open treatment of intertrochanteric fractures.

Methods: After IRB approval, investigators prospectively investigated local microvascular function in 25 patients (12 DHS, 13 PCCP) prior to and following fixation of an intertrochanteric femoral fracture (8, 24, 48, 96 hours). We used lightguide tissue spectrophotometry, in combination with laser Doppler fluxmetry (O2C, Oxygen to See; LEA Medizintechnik, Giessen, Germany) to determine local blood flow (LF) and oxygen saturation (SO₂) at the proximal femur. Measurements were performed in two different penetration depths at 2 mm as a measure of skin blood flow and oxygenation and at 8 mm as a measure of superficial muscle and adipose tissue blood flow and oxygenation. Differences between groups were analyzed with the Mann-Whitney *U* test. A *P* value <0.05 was considered statistically significant.

Results: We enrolled 25 patients (15 females, 10 males), with an average age of 74 years. Patients in the DHS group showed significantly higher flow values and lower SO₂ values compared with patients in the PCCP group (DHS: flow 30 AU vs. PCCP 21 AU; *P* = 0.049; AU = arbitrary unit). This difference was particularly marked 8 hours after the operation and was maintained until the final measurement after 4 days. Local flow and oxygen saturation were significantly higher in the muscle layer compared with the superficial skin layer in both groups (*P* < 0.001). There was a strong correlation between flow and SO₂ parameters (*P* < 0.001). Age, blood pressure, body mass index, and sex showed no correlation with flow or SO₂.

Conclusion: There is a significant difference in local microvascular function following an open versus a less invasive approach to the proximal femur. Less invasive percutaneous compression plating seems to be advantageous in terms of soft-tissue compromise. O2C spectrophotometry is a reliable tool for simultaneous evaluation of microvascular skin blood flow and oxygenation and might allow new insights into the pathophysiology of tissue breakdown associated with different surgical approaches.

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9:49 am Paper 9

Low-Energy Pelvic Fractures of the Elderly Population: Clinical/Radiological Outcome and Associated Prognostic Factors

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Background/Purpose: The incidence of low-energy pelvic fractures in the elderly population increases, and their treatment can be challenging. Comorbidities, decreased bone quality, fracture fixation limitations, and often poor compliance to mobilization restrictions represent some of the specific difficulties in their management. Early multidisciplinary input, focused rehabilitation, as well as recent evidence of fracture healing enhancement due to the use of antiosteoporosis medication, have been investigated in similar fragility fracture cohorts. Our objective was to compare the impact of: the use of different antiosteoporotic drug therapies over the period of fracture healing (clinical and radiological), the utilization of a specific clinical pathway (SOP [standard operating procedure] protocol), and different combinations of pelvic ring disruptions to the clinical and radiological outcome of a group of elderly patients with low-energy pelvic fractures.

Methods: A retrospective cohort study of elderly patients (>65 years) referred to and/or admitted to a large trauma center during the period 2010-2012 with fragility pelvic fractures was performed. High-energy fractures, pure acetabular fractures, associated trauma affecting mobility, pathological pelvic lesions, and incomplete documentation were used as exclusion criteria. Patient characteristics (demographics, comorbidities/Charlson index, drug history, and anatomic classification of pelvic fractures [Nakatani, Hannover, Dennis, Rommens/Hofmann FPF systems]) were collected. Primary end point was the time to healing, both radiological and clinical. Secondary end points included length of stay, return to preinjury mobility, union status, mortality, and complications. Patient outcomes were analyzed between groups based on use of antiosteoporotic medication and groups based on following or not the SOP. Multivariate regression analysis was used to determine prognostic factors.

Results: The study cohort (132/209) included 108 females (108/132; 81.8%) and 24 males (18.2%) with a mean age of 85.8 years (SD 7.9; range, 67-108). Under the SOP there were 67, 51% of the whole group, and 108 (82%) were under some form of antiosteoporotic treatment during their healing phase. In-hospital early deaths were recorded in 9% and overall mortality within 6 months was 33%. Use of antiosteoporotic medication was significantly associated with a shorter time of healing ($P = 0.036$). Patients who followed the protocol showed a significant protection against malunion ($P < 0.001$), which was consistent when looking at overall radiological union outcome ($P = 0.039$). Also, patients following the SOP were more likely to return to their preinjury mobility status with a large variety in combinations of anterior and posterior pelvic ring fractures (missed on plain imaging by 67%), identified via CT/MRI scan (performed in 124, 94%).

Conclusion: The use of antiosteoporotic medication in elderly patients with fragility pelvic fractures was associated with faster healing, while the adherence to a structured clinical pathway with less malunion/nonunion and return to preinjury mobility state. An accurate diagnosis via early imaging (CT scan) can direct clinicians on decision-making and guide rehabilitation of these patients.

Paper Session I: Femoral and Pelvic Injuries

9:57 am Paper 10

Outcome Following Fixation of Comminuted Quadrilateral Plate Fracture: Single Surgeon's Experience

Theodoris Tosounidis; Suribabu Gudipati, MBBS, MRCS; Nikolaos Kanakaris, MD; Peter V. Giannoudis, MD; University of Leeds, Leeds, United Kingdom

Purpose: The aim of the current study was to assess the functional outcome following fixation using a spring plate in a cohort of consecutive patients treated in our institution.

Methods: This is a retrospective review of data inserted prospectively to the departmental database of pelvic and acetabular reconstruction cases over an 8-year period. Inclusion criteria were adult (>16 years) patients with quadrilateral plate fractures and a minimum follow-up of 2 years. Open fractures, pathological lesions, fractures with associated metabolic bone diseases, and also cases with incomplete data were excluded. Patients' characteristics, fracture pattern (Judet and Letournel classification), associated injuries, operative details, complications both intra- and postoperatively, regular follow-up with both radiological and functional assessment using Harris hip scores and Matta's radiological grading of arthritis were collected at the latest follow-up.

Results: Overall 35 patients were eligible for the study (28 males) with a mean age of 50.1 years (range, 16-79). 45.8% of patients had an isolated acetabular fracture, while the rest had one or more associated injuries. Most common fracture pattern was the associated both-column in 40%, followed by equal distribution of anterior column-hemitransverse and T-shaped fractures (20% each). The most common mechanism of injury was road traffic accident (54%), followed by fall from height (31.4%). The mean period of time from the accident to surgery was 8 days (range, 0-24 days). Patients with associated severe head trauma waited the longest. All fractures were treated operatively via an ilioinguinal approach using spring plates. The mean duration of the surgical procedures was 2 hours and 15 minutes (range, 2-4.5 hours). All patients were mobilized as toe-touch weight bearing for 8-12 weeks following the surgical fixation of the acetabulum. The mean duration of follow-up was 38 months (range, 24-87 months). At the final follow-up 3 patients (8.5%) had undergone a total hip arthroplasty (THA) after a minimum period of 1 year follow-up. Two patients died from causes unrelated to the acetabular trauma. The mean Harris hip score at the final follow up was 89.2. (range, 57.9-100). Matta grading was excellent in 31.4%, good in 45.7%, fair in 2.85%, and poor in 14.3%. Of the 5 patients who had poor Matta grading, 3 were converted to a THA and the other 2 are mobilizing with walking aids and minimal pain. The patient who scored the minimum also had associated severe spinal trauma. All of them were able to perform normal activities without difficulty and 3 patients over 60 continue to ride their pushbikes.

Conclusion: Open reduction and internal fixation of acetabular fractures with involvement of the quadrilateral plate/medial wall using a spring plate has been found to be effective in reducing the risk of posttraumatic arthritis and maintaining the joint congruity.

Symposium II: Orthopaedic Care Overseas: Get Involved!

10:10 am - 10:30 am

Moderators: *Amir M. Matityahu, MD*

Panelists: *Christopher T. Born, MD*

Hilario (Larry) Diaz, MD, Philippines

Henry Ndasi, MD, Cameroon

Lewis G. Zirkle Jr, MD

Humanitarian Efforts Abroad: Pearls and Pitfalls of Getting Involved in Humanitarian Orthopaedic Care Overseas

Paper Session II: Lower Extremity and Foot and Ankle Injuries

10:30 am Paper 11

The Perceptions of Kenyan Orthopaedic Surgeons Regarding the Role of Visiting Foreign Orthopaedic Surgeons: A Qualitative Study

Luke Harmer, MD, MPH¹; Jeff Mailu, MB ChB²; Rachel Seymour, PhD¹;

¹Carolinas Medical Center, Charlotte, North Carolina, USA;

²CURE Hospital, Kijabe, Kenya

Purpose: Orthopaedic trauma surgeons from high-income countries are increasingly choosing to visit low- and middle-income countries to teach and deliver clinical care. To our knowledge, little is understood about how these well-meaning visitors affect or are regarded by the surgeons in the host country. The purpose of this study is to understand the perceptions of Kenyan orthopaedic surgeons toward visiting orthopaedic surgeons and surgical trainees.

Methods: A questionnaire was designed using the themes identified in our literature review. This questionnaire was piloted by two Kenyan orthopaedic residents and two Kenyan orthopaedic surgeons. The questions where there was uncertainty about the meaning were edited for clarity. The length of the questionnaire was decreased following this process. The questionnaire was designed and administered in English, which is one of the official languages in Kenya. The survey asked three sets of questions. The first captured participants' demographics, training, and current practice environment. The second documented their experience and view toward international surgeons who visit their hospital. The third asked about their experience and views toward visiting international trainees. Each surgeon attending the 2012 Kenya Orthopaedic Association Annual Meeting in Malindi, Kenya was invited to complete the survey in paper format. Informed consent was obtained from each respondent and no compensation for completing the survey was offered. The data were collected and tabulated. Differences between surgeon groups were compared.

Results: 23 orthopaedic surgeons and 15 orthopaedic residents responded to the survey. Most respondents worked at the large teaching hospitals in Nairobi or the surrounding area (33/38). 70% of the surgeons had mixed private and public practices. All surgeons completed some training in Kenya with 35% (8/23) also having training abroad. Only one resident had received training outside East Africa. Kenyan surgeons and trainees hosted a median of 3.5 visiting surgeons and 1 visiting trainee each year. The surgeons stayed for a median of 2 weeks while the trainees stayed for a median of 4 weeks. Visiting surgeons were involved in a wide variety of activities, including performing common and novel operations and teaching in both the clinic and operating room settings. Visiting trainees were mostly involved with performing common operations and assessing patients in clinic. 100% of respondents felt that there was value in having surgeons visit their hospitals with 46% feeling the most valuable part of the visit was their "knowledge". Respondents felt that visiting surgeons were a more valuable resource for themselves, the hospital staff, and patients than were visiting trainees ($P < 0.001$), but even so 81% of respondents felt that there was value in having trainees visit from abroad. The most commonly identified benefit was trainee education. The perception of Kenyan orthopaedic surgeons toward visiting surgeons did not correlate to the number of visiting surgeons they had hosted ($P > 0.05$). Kenyan surgeons and residents did not have significant differences in their responses ($P > 0.05$).

Conclusion: Visiting orthopaedic surgeons are perceived as a valuable resource by Kenyan orthopaedic surgeons. Knowledge transfer and education was cited as the primary benefit of having visiting surgeons. As orthopaedic trauma surgery becomes more globalized, further research is needed to understand how to design international relationships to best serve surgeons and patients around the world. Focusing on educational opportunities and the impact of learning new techniques and advances in evidence-based medicine will improve care for patients in the host countries.

Paper Session II: Lower Extremity and Foot and Ankle Injuries

10:38 am Paper 12

Characterization of Lower Extremity Fracture Patients in Uganda

Nathan O'Hara, MHA²; Jeffrey M. Potter, MD¹; Rodney Mugarura, MBChB, MMed²; Trina V. Stephens, MSc¹; Piotr A. Blachut, MD¹; Gerard Slobogean, MD, MPH, FRCSC¹;

¹University of British Columbia, Vancouver, British Columbia, Canada;

²Mulago University, Kampala, Uganda

Background/Purpose: Orthopaedic trauma is a common cause of disability in low-income countries, and is thought to disproportionately affect working-age populations. These patients often have a network of dependent individuals indirectly affected by their injury via reduced economic stability. We sought to define the socioeconomic status of patients presenting with long bone fractures of the lower extremity in Uganda, and to define the economic impact of these fractures on the individual and their dependents.

Methods: Patients admitted to Mulago Hospital over 1 month (October 2013) with long bone fractures of the lower extremities were invited to participate. This hospital is the sole tertiary care facility servicing the population of Uganda (population 34,758,809). Participants completed a questionnaire describing their socioeconomic characteristics, and injury information was collected from medical charts. Follow-up assessment was performed 6 months later (April 2014), with a repeat questionnaire. The EuroQol EQ-5D was used to estimate participants' health status immediately prior to injury, and again at the time of follow-up.

Results: 74 patients with lower extremity long bone fractures were admitted during the study period. The majority (84%) of patients were male, ages 20-34 (43%), and in otherwise excellent health prior to injury (74% with an EQ-5D score of 1.00). On average these patients lived in a household with 4.6 other individuals, with 2.72 school-aged children per household. The most common injury was femur fracture (76%) sustained in a traffic accident (77%). 30% of fractures were open injuries. 86% of subjects were available for 6-month follow-up (2 deaths, 8 lost to follow-up). 58% had been treated operatively. There were significant changes in average EQ-5D score (0.908 vs. 0.375, $P < 0.05$), and the number of subjects with active employment (86% vs. 24%, $P < 0.05$). 93% of school-aged children missed school during their parent's injury, with an average of 2.7 months missed.

Conclusion: The vast majority of lower extremity fractures in Uganda affect working-age men involved in traffic accidents. These men are responsible for the financial security of several household dependents, including school-aged children. They rely on labor-intensive employment for their livelihood, but lack financial security factors such as formal terms of employment and external sources of income. This study demonstrates that orthopaedic injury has a significant impact on the earning potential of the individual, as well as the financial health of the family unit. The findings of this study corroborate concerns highlighted in the 2004 World Health Organization report on road traffic injury prevention, and warrant further investigation.

Paper Session II: Lower Extremity and Foot and Ankle Injuries

10:46 am Paper 13

Knee Fusion Using the SIGN Nail for Internal Fixation: Experience in Soddo, Ethiopia

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Background/Purpose: Knee fusion is an uncommon operative procedure, although a very useful procedure when other surgical procedures are contraindicated. Serious bacterial infections with bone destruction, advanced tuberculosis of the knee, polio with flexion contracture, and severe contractures from other causes are indications for knee fusion. Complicated two-part intramedullary nails are used in the developed world for knee fusion as well as plates and external fixators. The SIGN (Surgical Implant Generation Network) nail is a simple, stable, and inexpensive implant that can be used for knee fusion and is available in many institutions in the third world.

Methods: This was a retrospective study of all patients undergoing knee fusion with a SIGN nail at our institution. In all, 6 consecutive patients (3 males, 7 knees) with an average age of 30.5 years (range, 18-50 years) underwent a fusion by the described method at our institution. Diagnoses included tuberculosis of the knee in two patients, congenital knee dislocation in two knees (one patient), and two knees with end-stage bacterial septic arthritis, and one patient with severe gout and a 90° flexion contracture. A final radiograph demonstrating intact hardware and fusion in each patient was obtained as well as a physical examination. Our surgical technique utilized a straight anterior knee incision with bone cuts made perpendicular to the axis of the knee joint. Additional bone was removed to allow the knee to approach full extension. Care was taken to avoid removing too much bone as well as avoiding the natural bone compression from a tight joint. A posterior soft-tissue release was also used to avoid excessive shortening of the bone and resulting limb-length inequality. Knees were placed in 10° of flexion and neutral coronal alignment. An entrance point 12 cm above the joint line was made on the anterior medial aspect of the femur and carefully enlarged. The canals of the tibia and femur were reamed with hand reamers. The nail was inserted, locked distally, reverse-impacted, and proximally locked. Knee immobilizers were used when there was poor bone quality and/or fixation. Weight bearing as tolerated was immediately permitted.

Results: Two of 7 patients ambulated without an aid and all knees had clinical and radiographic evidence of fusion at an average 10.7 months follow-up (range, 8-14). All patients reported improved overall physical function. There were no infections, nerve injuries, or nonunions.

Conclusion: We found in our small series with short-term follow-up that the SIGN nail is a safe and effective device for internal fixation for the purpose of knee fusion.

Microcirculation of the Healthy Hindfoot. A Proband-Study from the Perspective of the Surgical Approach

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Background/Purpose: The choice of the optimal surgical technique of intra-articular calcaneal fractures represents a surgical challenge. Despite the establishment of minimally invasive techniques and possibilities of conservative treatment, surgical treatment using the extended lateral approach represents the gold standard. In combination with a plate osteosynthesis this leads to wound complications in up to 20% of cases impairing the outcome significantly. The literature suggests a multifactorial etiology, characterized by individual patient factors. The intact dermal microcirculation is essential for wound healing without complications. The aim of this study is to detect microcirculatory parameters of the soft tissue in a healthy volunteer collective to identify the optimal approach and factors predicting microcirculation.

Methods: 125 study participants (age, 30.7 years; 76 males, 49 females; BMI [body mass index] 22.3 kg/m²; blood pressure, 124/79 mm Hg; 32 smokers, 93 nonsmokers) were included in the study and underwent analysis of the soft-tissue microperfusion of the right hindfoot in supine position using the O₂C (oxygen to see, laser-Doppler/ultrafast laser spectroscopy, LEA-Medzintechnik GmbH, Giessen, Germany). Using a standardized measurement plan, 10 measurement-points were laterally and medially recorded in a penetration depth of 2 mm and 8 mm each, analyzing the blood flow and the capillary venous O₂ saturation in the blood vessels up to 100 µm.

Results: Demographic and individual variables (gender, age, systolic and diastolic blood pressure, BMI, smoking pack-years) did not show a statistically relevant prediction of microcirculation. The comparison of the superficial (2 mm) and deep (8 mm) measurements showed significant differences in favor of the deep values (SO₂ 57% vs. 42% $P < 0.001$; flow 122 AU vs. 25 AU $P < 0.001$). Both the analysis of the superficial (2 mm) and deep (8 mm) measurements and the statistical correlation analysis between SO₂ and blood flow values showed a close correlation ($P < 0.001$). When comparing the medial approaches the McReynolds approach was found to have significantly higher values (SO₂ and flow, $P < 0.001$) in both 2 mm and 8 mm depth, whereas the descending sustentaculum approach had the lowest values ($P < 0.001$). On lateral hindfoot the extended lateral approach showed significantly higher SO₂ values (2 mm and 8 mm) compared to the Palmer approach showing the lowest values ($P < 0.001$). Focusing on the blood flow, however, the Palmer approach provided the highest values ($P < 0.001$). The clinically critical tissue zone connecting the vertical and horizontal part of the extended lateral approach showed significantly superior microcirculatory values ($P < 0.001$) in comparison to surrounding area.

Conclusion: Soft-tissue measurements of the hindfoot microcirculation show significant regional differences. The McReynolds approach provides high parameters in microcirculatory criteria on the medial hindfoot. The extended lateral approach, gold standard in the treatment of calcaneal fractures, does not show lower microcirculatory values in healthy feet despite high infectious complication rates in fracture cases. Clear factors influencing the microcirculation could not be detected. The analysis of all results shows a relevant correlation of the values for blood flow and SO₂ as well as for the superficial and deep measurements. Microcirculatory measurements in patients with calcaneal fractures are mandatory.

Paper Session II: Lower Extremity and Foot and Ankle Injuries

11:07 am Paper 15

Inhaled and Oral Corticosteroids in Chronic Lung Disease Patients with Ankle Fractures: Effect on Fracture and Wound Healing

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Background/Purpose: Inhaled corticosteroids are commonly prescribed for patients with chronic lung disease. Long-term use of these agents leads to decrease in bone mineral density. On the other hand, the use of oral corticosteroids can, in theory, have detrimental effect on bone leading to increased fracture risk, delayed fracture healing, as well as poor wound healing. We aimed through our retrospective comparative analysis to assess the effect of inhaled and oral corticosteroids on fracture healing in patients suffering from asthma and chronic obstructive pulmonary disease (COPD).

Methods: Out of 2436 patients, 88 patients met the inclusion criteria (closed ankle fracture, surgical fixation, and known to have asthma or COPD, being treated with corticosteroids). 21 patients were asthmatic and the rest (n = 67) suffered from COPD. Oral corticosteroids were used by 12 patients, 6 of whom suffered from COPD. The rest of the cohort (n = 76) used corticosteroid inhalers. An age- and sex-matched control group (n = 88) were randomly identified and confirmed not to suffer from chronic lung disease, hormonal disorders, or on any medication that may affect bone metabolism. Both groups were also matched to their Lauge-Hansen fracture classification and surgical fixation requirements. Primary outcome factors studied were time to fracture union and wound healing. Secondary outcome factors analyzed included duration of postoperative pain, bleeding, swelling, infection, delayed union and nonunion, neurovascular impairment, and compartment syndrome. All patients were followed up for a minimum period of 24 months.

Results: The mean age of the chronic lung disease group (46 males, 42 females) was 56 years. In the control group (49 males, 39 females), the mean age was 59 years. There was significant difference in time to fracture union between the oral corticosteroid group (mean, 14 weeks; range, 13-16) when compared to both inhaled corticosteroid group (mean, 10 weeks; range, 8-10) and control group (mean, 9 weeks; range, 8-11). Inhaled corticosteroids, regardless of the dose, were not associated with delayed union or nonunion as well as delayed or poor wound healing. Asthmatic and COPD patients on oral corticosteroids suffered from delayed union when compared to both inhaled corticosteroid patients ($P < 0.001$) and the control group ($P < 0.001$). Assessment of secondary outcome factors revealed that the oral corticosteroid group had slight increase in time to wound healing, wound infections, and postoperative pain when compared to inhaled corticosteroid group ($P = 0.012$, 0.042 , and 0.021) and the control group ($P = 0.013$, 0.023 , and 0.021), respectively.

Conclusion: Inhaled corticosteroids for asthma and COPD could not be linked to any adverse event affecting fracture union and wound healing. Oral corticosteroids were associated with an increased time to fracture union, poor wound healing, postoperative pain (registered at 4 weeks), and surgical site infection.

Paper Session II: Lower Extremity and Foot and Ankle Injuries

11:15 am Paper 16

Posterior Malleolar Fracture Patterns

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Background/Purpose: Quantification of three-dimensional CT (Q3DCT) is a reliable and reproducible technique to quantify and characterize ankle fractures with a posterior malleolar fragment (www.traumaplatform.org). This technique could be useful to characterize posterior malleolar fragments associated with specific ankle fracture patterns. Fixation of posterior malleolar fractures of the ankle is subject of ongoing debate. Fracture fixation is recommended for fragments involving 25%-30% of articular surface. However, these measurements—and this recommendation—are based on plain lateral radiographs only. A reliable and reproducible method for measurements of fragment size and articular involvement of posterior malleolar fractures has not been described. The aim of this study is to assess the interobserver reliability of Q3DCT modeling for fragment size and articular involvement of posterior malleolar fractures. We hypothesize that Q3DCT modeling for posterior malleolar fractures has good to excellent reliability.

Methods: To evaluate interobserver reliability of Q3DCT modeling, we included a consecutive series of 43 patients with an ankle fracture involving the posterior malleolus and a complete radiographic documentation (radiographs and CT). Fractures of the tibial plafond (pilon type fractures) were excluded. These 43 patients were divided in 3 different types (Type I, II or III) as described by Haraguchi. Five patients of each type were randomly selected for an equal distribution of articular fragment sizes. 3D models were reconstructed by (1) creating a mask for every respective slice, (2) select the appropriate dots that separate fracture from tibial shaft, (3) connect masks of each respective slice, and (4) reconstruct a 3D mesh. After reconstruction of 3D models, (1) fragment volume, (2) articular surface of the posterior malleolar fragment, (3) articular surface of intact tibia, and (4) articular surface of the medial malleolus were calculated by all three observers. A summary of this technique is shown on www.traumaplatform.org. The interobserver reliability of these measurements was calculated using the intraclass correlation coefficient (ICC), which can be interpreted as the kappa coefficient.

Results: Measurements of the volume of posterior malleolar fracture fragments ranged from 357 to 2904 mm³ with an ICC of 1.00 (confidence interval [CI] 0.999-1.000). Measurements of the articular surface of the posterior malleolar fracture fragment ranged from 25 to 252 mm² with an ICC of 0.998 (CI 0.996-0.999); the articular surface of the intact tibia plafond ranged from 375 to 1124 mm² (ICC 0.998, CI 0.996-0.999); and the articular surface of the medial malleolus ranged from 79 to 149 mm² (ICC 0.978, CI 0.978-0.911). The categorical ratings for all ICCs were defined as almost perfect according to the system of Landis.

Conclusion: This study showed that our Q3DCT modeling technique is reliable and reproducible to reconstruct ankle fractures, in order to assess fracture characteristics of posterior malleolar fracture fragments. Future research will focus on the association between overall ankle fracture patterns according to Lauge-Hansen, and characterization of posterior malleolar fragment morphology. We hypothesize that supination-exorotation type fractures are associated with smaller (in volume and involved articular surface) “pull-off” fragments, while pronation-exorotation type ankle fractures are associated with larger (in volume and involved articular surface) “push-off” fragments. The clinical relevance might be that smaller “pull-off” type fractures benefit from positioning screws, while larger “push-off” type fractures require direct open reduction and internal fixation of the posterior malleolar fragment.

Paper Session II: Lower Extremity and Foot and Ankle Injuries

11:23 am Paper 17

Treatment of Deltoid Ligament Injuries in Ankle Fracture: Should it Be Repaired or Not?

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Background/Purpose: 20 years ago, it was common for surgeons to repair the injured deltoid ligaments at the time of fibular osteosynthesis. Then, anatomic restoration of the fibular fracture and the medial clear space without direct surgical intervention of the injured deltoid ligaments grew common. However, it was supported mostly by case series reports. The controversy has never ended. This study compared the clinical outcomes in patients with repairing the injured deltoid ligaments and patients without direct surgical intervention after anatomic restoration of the fibular fracture and the medial clear space.

Methods: 71 patients were followed up for average 31 months, who were diagnosed as ankle fractures associated with deltoid ligament rupture and later dislocation of talus. Among them, 33 patients were treated by deltoid ligament repairing at the time of fibular (and posterior malleolus, sometimes) osteosynthesis; 38 patients accepted no direct surgical intervention to the deltoid ligaments after anatomic restoration of the fibular fracture and the medial clear space. All the patients were evaluated with stress views intraoperatively. The outcomes were evaluated with Philips and Schwartz clinical scoring system of ankle.

Results: All fractures were healed without pain. In the repairing group, the mean degree of plantar flexion was 50°, with 2.5° (range, 0°-10°) less than the normal side, the mean degree of dorsiflexion was 14.5°, with 7° (range, 0°-20°) less than the normal side. In the non-repairing group, the mean degree of plantar flexion was 48.8°, with 2.8° (range, 0°-10°) less than the normal side, the mean degree of dorsiflexion was 15.4°, with 6.6° (range, 0°-20°) less than the normal side. There were no degenerative changes in all ankles. The mean Philips and Schwartz score was 92.5 (range, 80-100) in the repairing group versus 93.4 (range, 85-100) in the non-repairing group. According to the intraoperative stress views, we found that repairing of injured deltoid ligaments can reduce the talus tilt under valgus and lateral rotational stress. However, no statistically significant intergroup differences were evident in terms of clinical outcomes.

Conclusion: This study did not support regularly exposing and repairing the injured deltoid ligaments, since both repairing and non-repairing achieved similar results. Repairing injured deltoid ligaments may be helpful to early talus stability postoperatively.

Paper Session III: Basic Science and Fracture Healing Complications

12:30 pm Paper 18

What is the Cell Composition and Characteristics of Fibrous Tissue Harvested from the Nonunion Site of Long Bone Atrophic Nonunions?

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Background/Purpose: In a proportion of fractures, adequate stabilization is not sufficient to bring about union. Mesenchymal stromal cells (MSCs) are widely accepted as being key contributors to new bone formation following fracture and are often taken from bone marrow (BM) and used as components of autologous grafts. However, the local microenvironment of the nonunion site is poorly understood and the prevalence of MSCs at these sites is unknown. We examined material taken directly from the nonunion site in order to gain a better understanding of its cellular composition.

Methods: Patients undergoing long bone nonunion revision surgery were invited to participate (n = 8; 5 male, 3 female; mean age, 51 years; range, 22-72 years). The mean time from original fracture fixation to nonunion treatment was 14 months (range, 9-18 months). Following debridement, fibrous tissue removed from the fracture side was enzymatically digested into a single cell suspension. Flow cytometry was next used to quantify cell subsets whereas a colony forming unit fibroblast (CFU-F) assay was employed to detect MSCs. Adherent cells were also expanded in MSC culture conditions and their differentiation potential following exposure to osteogenic, adipogenic, and chondrogenic stimuli was compared to standard BM-derived MSCs. Osteogenesis was assessed by alkaline phosphatase activity and calcium accumulation, adipogenesis by oil red uptake, and chondrogenesis was measured by glycosaminoglycan (GAG) content of resulting pellets.

Results: A substantial percentage of enzymatically released cells (40%) expressed cell surface markers consistent with BM MSCs (CD90⁺CD73⁺CD45^{low}); additionally 22% and 20% of cells expressed markers consistent with pericytes (CD45⁻CD34⁺CD146⁺) and endothelial cells (CD45⁻CD31⁺), respectively. Adherent cells from digested extracts readily formed CFU-F colonies morphologically identical to MSCs. Culture expanded cells were able to undergo trilineage differentiation and showed parity with BM MSCs with regards to calcium accumulation and GAG content.

Conclusion: Analysis of the cellular content of nonunion tissue suggests a bioactive environment, not only containing MSCs but also cells essential for blood vessel formation and maturation. The ability of enzymatically released cells to readily form CFU-F colonies in vitro and undergo trilineage differentiation confirms the presence of MSCs. The fact that the presence of these cells at the fracture site is not sufficient to induce full healing is intriguing; manipulation of the local microenvironment to maximize cell potential may reduce the need for revision surgery.

Paper Session III: Basic Science and Fracture Healing Complications

12:38 pm Paper 19

Predictors for Nonunion, Reoperation and Infection after Surgical Fixation of Patellar Fracture

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Purpose: The most common major complications following surgical fixation of patellar fractures are infection, nonunion, and reoperation. In this study, we sought to define the predisposing factors to the development of these complications.

Methods: Open reduction and internal fixation surgeries for patellar fractures that were performed in a single institution between 2006 and 2011 were retrospectively reviewed. Patient demographic data (age, gender, comorbidities), injury and fracture data (associated injuries, type of fracture, open or closed fracture), surgical data (type of surgery and interval between fracture occurrence and surgery), and major postoperative complications (infection, nonunion, symptomatic hardware, and revision surgery) were collected from the medical records and verified by a telephone survey. Correlation analysis identified the major variables influencing the development of these complications.

Results: The cohort of 188 patients had an average follow-up of 908 days. 13 patients (6.9%) developed infection, 3 (1.6%) had fracture nonunion, and 42 (22.3%) required a second operation. A history of CVA (cerebrovascular accident) correlated significantly with the development of infection (OR (odds ratio) = 6.18, CI (confidence interval): 1.1-35.6, $P = 0.041$) and nonunion (OR = 14.9, CI: 1.2-188.1; $P = 0.037$). A history of diabetes significantly increased the risk of a second operation (OR = 8.69, 95% CI: 1.8-41.9, $P = 0.007$). Open fracture did not increase the risk of any of these complications:

Conclusion: A history of CVA and diabetes mellitus significantly increased the risk of complications following patellar fracture fixation. Patients with these comorbidities should be informed of their increased risk of these complications and be followed up more rigorously.

Paper Session III: Basic Science and Fracture Healing Complications

12:46 pm Paper 20

Multipotential Stromal Cell Abundance in Cellular Bone Allograft: Comparison with Fresh Age-Matched Iliac Crest Bone and Bone Marrow Aspirate

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Purpose: Autograft bone remains the “gold standard” for bone replacement following trauma, but it has known disadvantages associated with additional surgery. In contrast to traditional allografts totally devoid of cells, “viable” cellular bone allografts such as Osteocele (used clinically since 2005) are characterized by the selective removal of the immune cell component from the graft while preserving the osteogenic, non-immune cells. The purpose of this work was to enumerate and characterize multipotential stromal cells (MSCs) in a cellular bone allograft material, as it is used clinically, and compare with fresh age-matched iliac crest (IC) bone and bone marrow (BM) aspirate.

Methods: After IRB approval, BM aspirates (n = 16) and IC bone (n = 14) were collected from patients undergoing orthopaedic surgery and used as controls. Six Osteocele lots were used for whole genome array and 10 for other assays. MSC characterization used in vitro functional assays of differentiation and immunomodulation, confocal/scanning electron microscopy, and cell phenotyping. Native MSCs resident in Osteocele and control IC bone were enumerated by flow cytometry for the CD45⁻CD271⁺ phenotype following enzymatic extraction using collagenase.

Results: Cellular allograft material contained live osteocytes and proliferative bone-lining cells defined as MSCs by phenotypic, functional, and immunoregulation capacities. Without cultivation/expansion, the allograft displayed an “osteoinductive” molecular signature, with high-level expression of MSC- and osteoblast-specific transcripts such as osterix, osteocalcin, osteopontin, and alkaline phosphatase. The allograft material contained CD45⁻CD271⁺MSCs that were also positive for CD73⁺CD90⁺CD105⁺ and similar in numbers to IC bone; however, their purity was over 100-fold higher due to the effective removal of hematopoietic cells, HLCs. In comparison to BM, MSC numbers enzymatically released from 1 g of cellular allograft were equivalent to ~45mL of BM aspirate.

Conclusion: Cellular bone allograft represents a unique non-immune material rich in MSCs and osteocytes. This osteoinductive graft therefore represents an attractive alternative to autograft bone or composite/synthetic grafts in orthopaedic trauma and broader orthopaedic settings.

Paper Session III: Basic Science and Fracture Healing Complications

12:59 pm Paper 21

The Free Vascularized Medial Femoral Condyle Corticocancellous Flap for Treatment of Challenging Upper Extremity Nonunions

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Background/Purpose: Numerous methods have been used to address fracture nonunions. Microsurgical techniques have evolved tissue management largely by applying free vascularized bone grafts.

Methods: In a retrospective study, we reviewed patients with upper limb nonunion who had undergone vascularized corticocancellous flap from the medial femoral condyle. Patient demographics, surgical technique, and outcome measurements were evaluated.

Results: 15 patients with nonunion of upper extremity underwent free vascularized corticocancellous flap reconstruction. Two patients were lost to follow-up. The other 13 patients healed in an average of 15 weeks (range, 8-22 weeks). Only one patient required additional surgery. On average 1.5 surgeries were performed prior to this last surgery. The length of bone defect ranged from 0.8-3 cm. Functional outcome measures such as Mayo, DASH (Disabilities of the Arm, Shoulder and Hand) and Constant Murley scores were all improved.

Conclusion: Free vascularized medial femoral condyle corticocancellous flap is a reliable option in tissue reconstruction over recalcitrant nonunions and small bone defects.

Paper Session III: Basic Science and Fracture Healing Complications

1:07 pm Paper 22

Long Bone Defects Managed with the Induced Membrane Technique: Treatment Protocol and Clinical Outcomes

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Purpose: This study was conducted to present our institutional experience in a cohort of patients with bone defects who were treated with the use of the induced membrane technique.

Methods: This prospective study was undertaken at a regional tertiary referral centre from January 2008-December 2012. Inclusion criteria were septic nonunion, acute fracture with bone loss, and chronic osteomyelitis treated with the induced membrane technique. Pathological fractures with bone loss were excluded. Data collection included patient demographics, pathology, previous surgical intervention, size of bone defect, time to union, and complications. The minimum follow-up was 12 months.

Results: 18 patients (15 males) with bone loss after debridement of a septic nonunion or an acute fracture met the inclusion criteria. The mean age was 50 years (range, 18-80). In 7 patients the above technique was applied following an acute fracture with bone defect while in the remaining 11 cases for management of septic nonunion. Anatomically, radius was involved in 6 patients, femur in 5 patients, tibia in 4 patients, metatarsal in 2 patients, and humerus was involved in 1 patient. All patient except one sustained grade 2 or 3 open fractures. One had chronic osteomyelitis following fracture fixation 20 years previously. The mean length of the bone defect was 5 cm (range, 2-12 cm). Two patients required additional soft-tissue coverage. In all patients both clinical and radiological healing was evident at an average of 8 months (range, 2-20 months). Functionally all of them were able to perform their daily living activities with upper limb injuries recovering to almost near normal range of motion. Two patients had 1-1.5 cm leg-length discrepancy. No evidence of reoccurrence was observed.

Conclusion: The induced membrane technique appears to be a good alternative for the management of large bone defects secondary to acute bone loss or as a result of chronic infected nonunions as seen in this series of patients. It should be considered in the surgeon's armamentarium as it is effective and is associated with a low incidence of complications.

Paper Session III: Basic Science and Fracture Healing Complications

1:15 pm Paper 23

Tibial Plateau Fractures: Will I Need a Knee Replacement?

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Purpose: Tibial plateau fractures are common intra-articular fractures. The principal long-term complication is posttraumatic osteoarthritis (PTOA) with the usual salvage procedure being total knee arthroplasty (TKA). Our aim was to define the incidence of PTOA requiring TKA following tibial plateau fractures and identify the risk factors.

Methods: We looked at all tibial plateau fractures in our catchment area between 1995 and 2008. There were 888 tibial plateau fractures. 23% were Schatzker I, 25% II, 14% III, 22% IV, 8% V, and 8% VI. To date, 25 have undergone TKA (2.8%). The mean time from fracture to arthroplasty was 27 months. 56% of the arthroplasty implants were primary, 28% complex tibial components, and 8% full revision arthroplasty.

Results: The mean age of patients at time of fracture was 56 years in the overall cohort and 65 in those requiring TKA; this was statistically significant ($P = 0.04$). 4% of females with tibial plateau fractures required TKA in comparison to 2% of males. The Schatzker I fractures were the least likely to require TKA at 1% with the most likely requiring arthroplasty surgery being type II at 6%. Only 1% of the patients treated nonoperatively later underwent TKA.

Conclusion: The overall incidence of TKA after tibial plateau fractures was 3%. For displaced fractures requiring internal fixation this rose to 4%. Risk factors were increasing age, split depression fractures, and female gender. Although tibial plateau fractures are commonly associated with degenerative radiographic changes, we concluded that the incidence of symptomatic osteoarthritis severe enough to require TKA is low.

Paper Session III: Basic Science and Fracture Healing Complications

1:23 pm Paper 24

Hormone Replacement Therapy in Proximal Humerus Fracture Patients: Effect on Fracture Severity and Fracture Healing

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Background/Purpose: The incidence of proximal humerus fractures is rising and they are mostly linked to osteoporosis in the elderly. In general, they result from low-energy trauma following a mechanical fall, and are more predominant in females. This retrospective comparative study examines the relationship between hormone replacement therapy (HRT) and severity of proximal humerus fracture among women >45 years as well as fracture healing.

Methods: Over a 5-year period, 2317 patients were treated with humerus fractures. The inclusion criteria included females of >45 years of age with good health status and no balance or mental health issues, not diabetic or suffering from neuromuscular weakness, not requiring a walking aid, and no history of falls or previous fractures. Fractures were classified as per the Neer classification system: one-part, two-part, three-part, or four-part fracture and their displacements (>1 cm or >45°). 822 patients met the inclusion criteria and mechanism of injury was a mechanical fall in 92% of the patients. 82 patients underwent surgical fixation and the rest were treated conservatively. The cohort (n = 822) was divided according to whether or not they received HRT. This was compared to the severity of the fracture and outcome of fracture and soft-tissue healing. All patients were followed up for a minimum period of 24 months.

Results:

	1-Part Fracture	2-Part Fracture	3-Part Fracture	4-Part Fracture
Never received HRT (n = 134)	5	28	28	73
Receiving HRT (n = 67)	6	20	36	5
Received HRT for <3 years (n = 155)	15	68	43	29
Received HRT for ≥3 years (n = 466)	40	236	122	68

Patients who never used HRT were more likely to sustain 4-part proximal humerus fracture with >1 cm displacement when compared to patients who are receiving HRT ($P = 0.002$) or have received HRT for <3 years ($P = 0.003$) or ≥3 years ($P < 0.001$). The surgical fixation group of patients who never received HRT (8 3-part and 39 4-part fractures) had an increased delay in fracture healing (mean 15 weeks [range, 12-15]) when compared to the surgical fixation group of patients receiving or who have received HRT (7 3-part and 28 4-part fractures) (mean 11 weeks [range, 9-12]), ($P = 0.002$). Further analysis revealed a significant correlation when it comes to postoperative delayed wound healing ($P = 0.032$), duration of postoperative pain ($P = 0.03$), and surgical site infections ($P = 0.05$). The conservatively managed group of patients who never received HRT (15 3-part and 67 4-part fractures) had an increase delay in fracture healing (mean 13 weeks [range, 9-15]) when compared to the conservatively managed group of patients receiving or who have received HRT (213 3-part and 109 4-part fractures) (mean 10 weeks [range, 8-12]; $P = 0.021$). Further analysis revealed a significant correlation when it comes to soft-tissue healing ($P = 0.042$) and duration of postoperative pain ($P = 0.01$).

Conclusion: Current and past use of HRT for more than 3 years appears to be associated with a reduced severity of fracture at the proximal humerus. Furthermore, these patients were less likely to suffer from delayed union and other soft-tissue problems.

Are Individuals with TNF- β NCO1 Polymorphism at a Higher Risk of Developing Postoperative Sepsis?

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Background/Purpose: Postoperative sepsis remains a challenge for surgeons and clinicians as it is a significant cause of morbidity and mortality following major surgeries. Tumor necrosis factor (TNF) is believed to be a cytokine central to pathogenesis of sepsis and the TNF- β NcoI polymorphism has been found to be associated with increased mortality rate in severe sepsis. We therefore postulated that NcoI polymorphism may be associated with clinical findings and that despite comparable risk factors, postoperative sepsis develop in some patients but not in others. It has been postulated that genetic factors may have a role in etiopathogenesis of sepsis. The accurate identification of such risk factors may develop strategies to prevent these potentially devastating catastrophes. If specific diagnostic markers could be identified, surgeons may be able to predict which patient is prone to develop post operative sepsis.

Methods: The study group consisted of 153 patients undergoing major spinal surgeries. Blood samples were obtained for genomic DNA isolation. Genotyping of each patient for TNF- β polymorphism was performed by analyzing restriction fragments of an NcoI-digested DNA fragment obtained using polymerase chain reaction. All the patients were followed for 1 month following surgery for any evidence of sepsis as determined by guidelines from Bone et al.

Results: The overall allele frequency for TNF- β genotype was 0.32 for TNFB1 and 0.68 for TNFB2. In TNF- β genotype, homozygous recessive TNFB1 were 17 (11.1%), heterozygous TNFB1/TNFB2 were 63 (41.2%), and homozygous dominant TNFB2 were 73 (47.7%). 125 patients showed an uncomplicated postoperative recovery, while sepsis developed in 28 patients. Genotype distribution in patients with an uncomplicated clinical course was significantly different from that in patients with postoperative sepsis. Development of postoperative sepsis was significantly higher in patients homozygous for the allele TNFB2. When compared with patients carrying at least one TNFB1 allele, the TNFB2 homozygous genotype was associated with an odds ratio (OR) of 3.39 ($P = 0.005$; 95% confidence interval [CI] 1.4 to 8.3) for the development of severe sepsis. Compared with the heterozygous genotype, the OR for the homozygous TNFB2 genotype was 5.5 ($P = 0.001$; 95% CI 1.78 to 17.33). Although the small number of TNFB1 homozygous surgical patients makes their risk estimate less accurate, the data indicate that both homozygous genotypes possess a significantly increased susceptibility for the development of postoperative sepsis compared with the heterozygous genotype.

Conclusion: The NcoI polymorphism within the TNF- β gene influences the development of postoperative sepsis. This suggests a genetic determination of the individual inflammatory response, which significantly influences susceptibility to postoperative sepsis.

Paper Session III: Basic Science and Fracture Healing Complications

1:39 pm Paper 26

A Simple Technique for the Correction of Coxa Vara Deformity With the Use of a SIGN Intramedullary Locking Nail

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Background/Purpose: Coxa vara deformity has many causes but the treatment is essentially the same. This involves the use of a subtrochanteric osteotomy and fixation with a blade plate or screw and plate combination under real-time fluoroscopic or radiographic guidance. This equipment is expensive and not affordable in resource-limited hospitals in developing countries. The aim of this study is to demonstrate a safe, simple, effective, and affordable technique for the correction of coxa vara deformity using a SIGN (Surgical Implant Generation Network) intramedullary locking nail.

Methods: We operated seven consecutive patients presenting with coxa vara deformity using a subtrochanteric valgus osteotomy and stabilization with an intramedullary SIGN nail with image intensifier or intraoperative radiographs.

Results: All patient achieved correction of the deformity and had a neck-shaft angle $>110^\circ$, and gain in leg length. One patient had a second surgery to improve on the neck-shaft angle and increase limb length. There were no complications.

Conclusion: An intramedullary locking nail can be used in the correction of coxa vara deformity to a desired angle without the need for expensive intraoperative image intensifier or radiographs. Long-term follow-up and a bigger sample size will be necessary to confirm the efficacy of this technique.