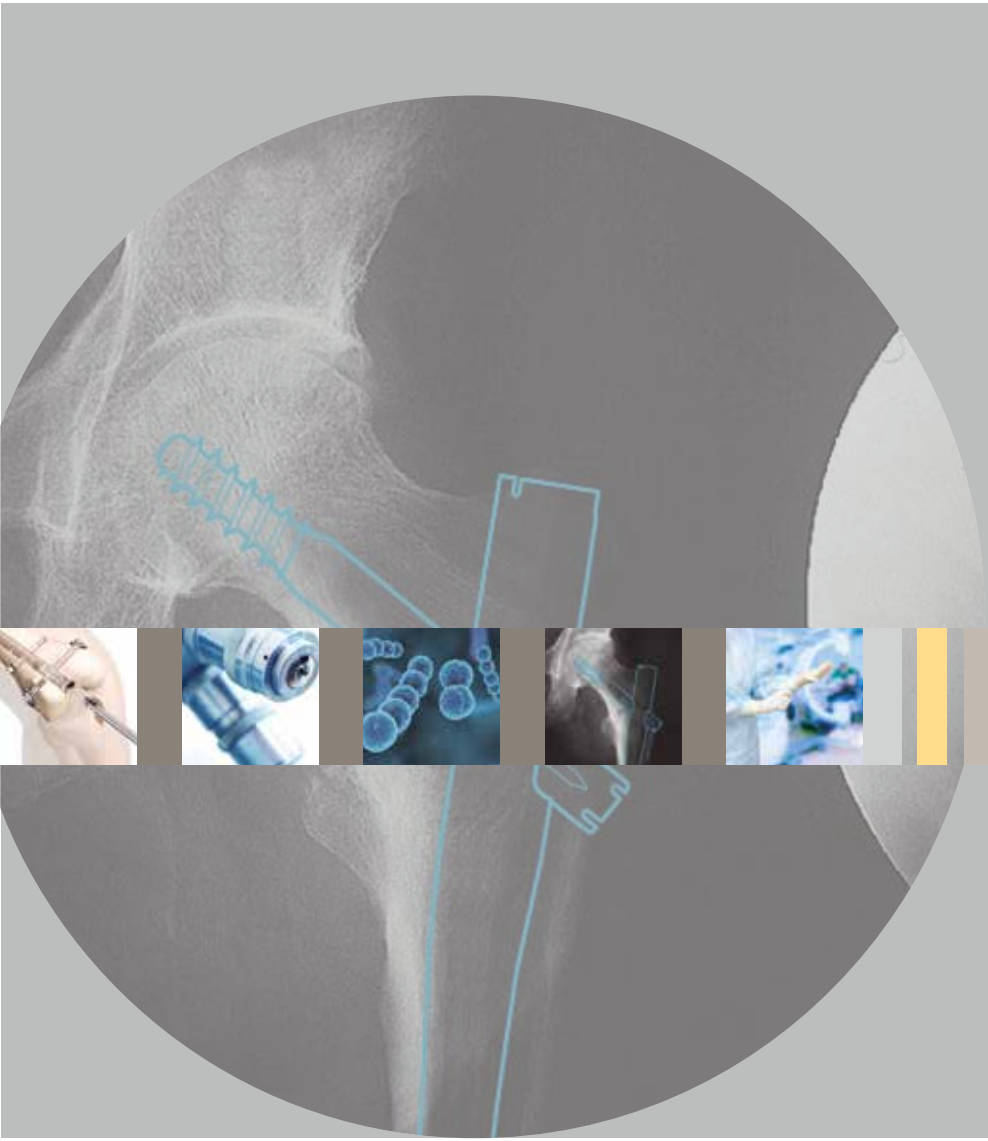
OTC
Osteosynthesis & Trauma Care Foundation



OTC RESEARCH PROGRAM

2009 - 2010

OTC Research Program 2009/10

PRESIDENT'S INTRODUCTION

The Osteosynthesis and Trauma Care Foundation is an educational and scientific professional organization dedicated to the advancement of musculoskeletal trauma treatment.

The OTC Foundation recognizes the importance of scientific discovery and has committed funding to promising research projects since its inception. In particular, the organization has supported the work of young and less experienced investigators, who represent the future of orthopaedic surgery.

This book presents highlights of the basic and clinical research supported by the OTC Foundation over the last two years. Many of these research projects have gone on to garner additional funding from other private and public agencies, and have resulted in multiple presentations and publications. We expect that the results of this research will stimulate future discoveries, and we look forward to the further dissemination of this interesting work.

PETER PATKA

THEODORE MICLAU

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OTC RESEARCH PROGRAM 2009/10

Research Program History

The objective of Research Grants is to encourage investigators by providing seed and start-up funding for promising research projects in the field of orthopaedic trauma surgery through Grants of up to US$ 50,000 for a research project extending over a maximum of two years.

The **Mission of OTC** is to foster evidence-based research that increases knowledge to solve clinical problems and improve orthopaedic trauma care. Through the OTC Research Grant Program, funding support is provided on topics such as:

- Promotion of fracture healing, including treatment and enhancement of fracture repair
- Treatment of fractures in osteoporotic bone
- New technologies in fracture fixation, including computer-assisted surgery
- Prophylaxis and treatment of infections in fracture
- Prospective clinical trials in fracture care
- Numerical methods in trauma surgery

The target groups addressed through the program are investigators performing relevant research projects who are eligible to apply for grants up to $50,000, and also young investigators who can obtain grants of up to US$ 10,000.
The evaluation and selection of grant projects is strictly based upon blinded proposals submitted by applicants, in accordance with OTA criteria.

The OTC Research Committee, currently composed of nine members of high academic standing, oversees and directs the program. This committee identifies research topics to be covered, develops the procedures for reviewing proposals, and establishes the criteria for approving proposals and awarding grants.

Further information on the OTC Research Grant Program can be obtained under
www.otcfoundation.org
by clicking on ‘Research Grants’.

The budget for OTC Grants is limited and the number of applications is generally three times greater than the awards granted. The number of funded proposals varies from year-to-year, depending on available funds.

During the years 2005, 2006 and 2007, the Research Grants were administered by the AIOD. With the transition from AIOD to the OTC Foundation at the beginning of 2008, such grants are provided as OTC Research Grants. The essence of the program has been maintained, including the Research Committee.

Research Committee Members 2010

PETER PATKA, MD PHD, THE NETHERLANDS (CHAIR)
Rotterdam University Chair in Trauma Surgery (Dept. of Surgery-Traumatology, Erasmus MC, University Medical Center Rotterdam, Rotterdam, the Netherlands)

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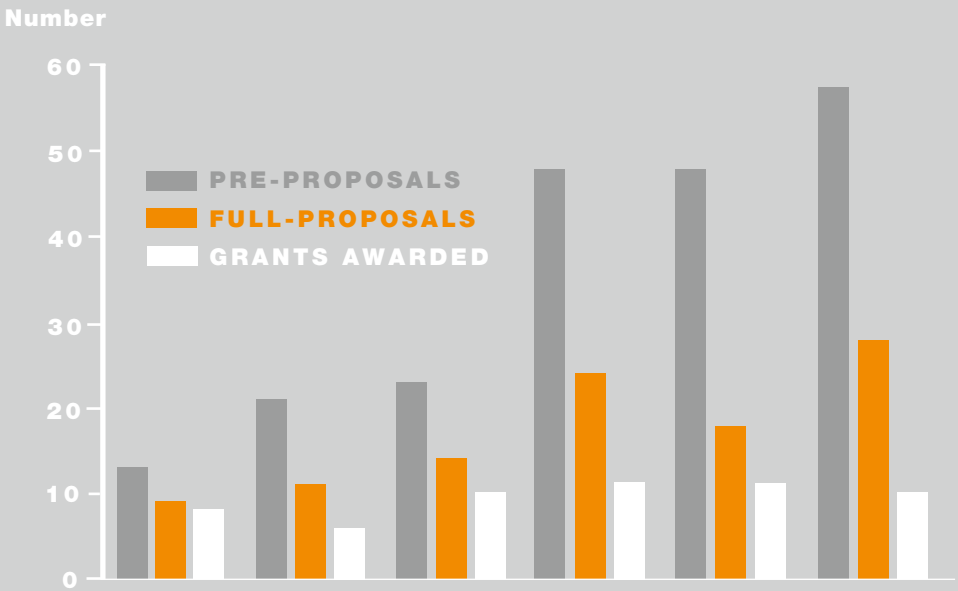
ESTHER M.M. VAN LIESHOUT, PHD, THE NETHERLANDS (SCIENTIFIC COORDINATOR)
Research Coordinator in Trauma Surgery (Dept. of Surgery-Traumatology, Erasmus MC, University Medical Center Rotterdam, Rotterdam, the Netherlands)

Supporting Promising Researchers

Through a Young Investigator Grant or a Research Grant, OTC supports researchers active in areas related to trauma care. For the 2010 grants, 55 Pre-proposal applications were received and 27 were invited to submit a Full-length proposal. Of these, ten were accepted, following a well-defined review and selection process. The approval rate was 46% for the 2008 grants, 61% for the 2009 grants, and 37% for the 2010 grants. Currently, OTC supports 56 projects with a total sum of US$ 1,949,987. Biological research in areas like bone healing and clinical research account for the majority of projects. The number of biomechanical research grants is also increasing.

NUMBER OF PROJECTS SUPPORTED BY OTC



Year	2005	2006	2007	2008	2009	2010
Amount granted	$ 145,000	$ 300,000	$ 365,200	$ 386,965	$ 421,089	$ 331,733
Percentage granted	62%	29%	43%	23%	23%	18%

Review Process

Basic requirements for applicants:

- The (co)-principal investigator should be a trauma or orthopaedic surgeon
- Non-trauma/orthopaedic surgeons may serve as Principal Investigator if affiliated with a trauma/ orthopaedic department and with an orthopaedic surgeon as co-PI
- Candidates may receive only one OTC Research Grant per institution in each category and in each year

Both laboratories and clinical projects are suitable, and relevance must be clearly described.

Pre-proposal applications:

Preliminary screening of applications is based on a pre-proposal application, containing a brief (maximum of three pages) description of the research idea. Pre-proposals are reviewed in a blinded fashion by all research committee members, and are rated and ranked based on scientific merit and orthopaedic trauma impact. Those proposals receiving an average rate of three or higher (on a scale of 1 to 5) are invited to submit a full-length proposal. Applicants or proposals that do not meet this threshold receive feedback on their proposal.

Full-length proposals:

Full-length proposals are evaluated in a non-blinded fashion for their scientific merit, orthopaedic trauma impact, methodology, feasibility, experience of the research team, and the budget requirements. For each application, three appointed reviewers provide an in-depth review, which is discussed with all research committee members. Committee members are absent during discussion or projects in which they have a conflict of interest. The best-rated applications are offered a Grant contract. Applicants of unsuccessful applications receive feedback on their proposal, which may help them improve the quality of their proposal or the design of their study.

Young Investigator Grants 2010

BIOMECHANICAL TESTING OF THE SUBCRISTAL PELVIC EXTERNAL FIXATOR; A COMPARISON WITH THE SLATIS AND SUPRAACETABULAR FRAME CONSTRUCTS

DR. R. BAIRD
Principal Investigator
Royal Adelaide Hospital, Adelaide, Australia

Abstract: External fixation is an important tool in the treatment of anterior pelvic complex injuries.
Pelvic external fixators can be built with different complexities starting from three basic frames: a) anterosuperior, with pins inserted perpendicular to the iliac crest in a superior to inferior direction; b) anteroinferior, with supraacetabular pins inserted in an anterior to posterior direction; and c) subcristal, with pins inserted from the anterior superior iliac spine in the subcortical bone of the iliac crest and parallel with the crest. To date, most pelvic external fixators have been built around anterosuperior or anteroinferior pins. The reported complication rates associated with these fixators, as a definitive form of fixation, is up to 62%. In contrast, a study on subcristal pelvic external fixators used as a difinitive form of fixation has reported a complication rate of 20%. To date, biomechanical testing of the stability provided by the different types of pelvic external fixators has been done only on anterosuperior and anteroinferior types of frames and no information exists on the subcristal types of frames. If pelvic external fixators built on subcristal placed pins can be proven to provide similar or better stability to the disrupted anterior pelvic ring, when compared with the anterosuperior and anteroinferior build fixators, this, in conjunction with the reported reduced complications, will justify the further development and popularization of this technique for the improved management of these severely injured
patients. Therefore the aim of this study is to compare the stability provided by the subcristal pelvic external fixator to the anterior pelvic ring complex when compared with the anteroinferior and anterosuperior pelvic external fixators. This will be done on simulated type C pelvic ring disruptions in both sawbones and cadaveric pelves. The posterior pelvic complex will be stabilised with one screw while the anterior pelvic complex will be stabilised with either an anterosuperior, anteroinferior or a subcristal pelvic external fixator. After preparation and mounting, all specimens will be loaded in a Hounsfield mechanical testing unit as described in previous experiments and tested to cyclic loading followed by loading to failure.
In addition to the Hounsfield testing we will also use radiostereometric analysis to precisely measure the three dimensional movement across the anterior disruption during mechanical loading and after load.

SAME LEVEL FIBULAR PLATING VERSUS NOT PLATING IN DISTAL METAPHYSEAL TIBIA FRACTURES TREATED WITH INTRAMEDULLARY NAILS: A RANDOMIZED TRIAL

DR. R. BUCKLEY
Principal Investigator
University of Calgary, Foothills Medical Centre, Calgary, Canada

Abstract: *Background:* Some historic cohort studies of nailing for distal tibia fractures reported that concurrent fibula fixation results in less malalignment of the tibia. This may prove beneficial because malalignment can impair functional outcome. Distal tibial malalignment also leads to inappropriate pressure increase on tibia-talar cartilage and may cause joint degeneration in the long-term. On the other hand, an increased potential for delayed healing of the tibia may be seen when the distal fibula is additionally stabilized. One study, however, found no significant differences in healing rates. The optimal treatment for combined same level displaced distal tibia and fibula fractures remains unclear.
Research design: We designed a prospective multicenter randomized controlled clinical trial comparing two strategies of patients treatment with distal same level metaphyseal tibia and fibula fractures, in participating medical centers in Canada and Europe.
Methods: The surgeon will either apply a plate to the distal fibula using a separate incision and then proceed with tibia nailing (index group) or start with tibia nailing without applying a fibular plate (control group). For a 2x7 fixed effects, non-directional (two-tailed) analysis of variance, with the criterion for significance (alpha) set at 0.05, and a large effect size estimated (0.40), a total of 70 cases are required, yielding power of .85 for Factor A and 0.59 for Factor B and the interaction. On the assumption of 10% rate of loss of follow-up we need to include 77 patients in the study.
Long-term objective: Two years after surgery, tibia malalignment will be used as our primary outcome because it is a credible, responsive and clinically relevant outcome. Functional outcome scores (VAS, SF-36 short form, HSS knee score, AOFAS ankle score), and bony healing will be used as secondary outcome measurements. We expect significant better distal tibia alignment and better functional outcomes for the index group. However, we expect no difference in bony healing between both groups.
Specfic aims: To our knowledge no randomized trials have been reported on additional fibular plating, and the outcome of this study may define the standard of orthopedic trauma care for distal same level metaphyseal tibia and fibula fractures.

Young Investigator Grants 2010

ENDOTHELIAL PROGENITOR CELLS FOR HEALING AND ANGIOGENESIS IN A SEGMENTAL BONE DEFECT MODEL: A COMPARISON WITH MESENCHYMAL STEM CELLS

DR. A. NAUTH
Principal Investigator
St. Michael's Hospital - University of Toronto, Toronto, Canada

Abstract: Bone regeneration is required to heal bone defects caused by trauma and non or delayed-union of fractures. The proposed study seeks to add to a growing body of research that employs cell-based therapies for the enhancement of fracture healing. Endothelial progenitor cells (EPCs) represent progenitor cells with the capacity for angiogenesis and osteogenesis, whose application to orthopaedics is relatively novel. The proposed research will compare the osteogenic and angiogenic effects of EPCs to mesenchymal stem cells (MSCs) using a segmental bone defect model in the rat. The aim of the proposed work is to prove the hypothesis that EPCs cause a superior fracture healing response compared to MSCs, primarily due to their effects on angiogenesis at the fracture site. Healing of the segmental defect will be assessed using radiography, MicroCT, and biomechanical testing. Angiogenesis at the bone defect site will be assessed using histology, fluorescent microangiography, and Laser Doppler to provide a physiologic appraisal. The successful demonstration that EPCs are more effective than MSCs in this model would have important implications for future research in cell-based strategies of bone regeneration. Further, with continued success, there is significant potential to lead to clinical trials of autologous EPC therapy for bone defects. This could lead to significant reduction in morbidity for many orthopaedic trauma patients.

COMPLEX ELBOW DISLOCATIONS: FUNCTIONAL RECOVERY AND QUALITY OF LIFE IN PATIENTS TREATED WITH A HINGED EXTERNAL FIXATOR AFTER RESIDUAL INSTABILITY – A PROSPECTIVE COHORT STUDY

DR. N.W.L. SCHEP
Principal Investigator
Erasmus MC, Rotterdam, The Netherlands

Abstract: Complex elbow dislocations are associated with fractures of the radial head, olecranon process, and coronoid process. Most patients require open reposition and internal fixation (ORIF) and/or arthroplasty of the radial head to restore the osseous-articular restraints. Complex elbow dislocations are at risk of persistent instability due to disruption of the collateral ligaments. In most cases persistent instability after ORIF or arthroplasty can be treated with a hinged external elbow fixator. Such a fixator provides sufficient stability to allow early mobilization following surgery.
Our hypothesis is that early mobilization will prevent the loss of flexion and extension that is frequently observed after plaster immobilization.

The primary objective of this study is to assess the Quick-DASH (Disabilities of the Arm, Shoulder, and Hand; primary outcome) score in a cohort of patients treated with a hinged external fixator for persistent instability after ORIF and/or arthroplasty of the radial head. Secondary outcomes include the Mayo Elbow Performance Index, Oxford Elbow Score, pain (VAS), range of motion, rate of secondary interventions and postoperative complications, time to radiographic healing, and quality of life (Short Form-36). The proposed study will be a multi-center cohort study (30 patients). Adults (18 years or older) who sustained a complex elbow dislocation, and were treated with a hinged external elbow fixator for residual instability after ORIF and/or arthroplasty are considered eligible for inclusion.

Patients with pathologic or pre-existent injuries in the affected arm, cognitive problems or with expected problems in maintaining follow-up will be excluded to ensure reliability of recordings. The operative technique for applying the elbow fixator and after-treatment will be standardized. Clinical assessments will occur at time of hospital admission, 2 and 6 weeks, and 3, 6 and 12 months after surgery. Outcome data will be recorded at each visit. Multivariate linear regression analysis of the data will be performed to model the
relation between different covariates and the outcome measures.

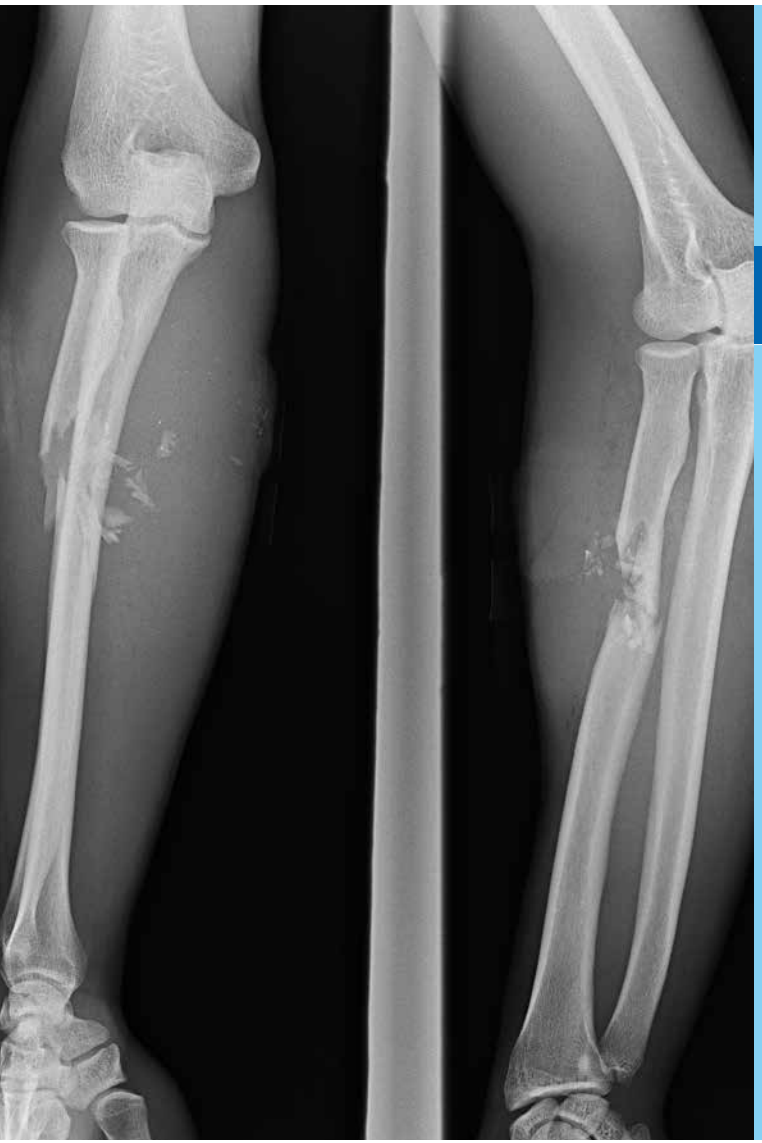
Research Grants 2010

DETERMINANTS OF INTERNAL FIXATION STABILITY AND HEALING OUTCOME

DR. D. EPARI
Principal Investigator
Queensland University of Technology, Kelvin Grove, Queensland, Australia

Abstract: The surgical treatment of bony fractures using fracture fixation plates (or internal fixators) is well established in the clinic. The degree of mechanical fixation stability is known to influence the healing outcome. The stability of fixation is determined by the stiffness of the fracture fixation device, which is in turn determined by its configuration. In the case of an internal fixation device, one of the main determinants of fixator stiffness is the number of screws and the configuration in which they are applied to affix the plate to the fractured bone. Currently, surgeons rely on clinical experience when determining an appropriate configuration when using internal fixation devices. In a recent experimental study, the stiffness of external fixators and intramedullary nailing devices were investigated and the optimal stiffness characteristics for timely healing were determined. There is however, a gap in the knowledge concerning the stiffness characteristics of internal plate fixation devices. Furthermore, it is unknown how modifying the fixator configuration influences its stiffness characteristics.

The goal of this project is to determine the stiffness characteristics of a commonly used internal plate fixator and optimize its screw configuration to promote timely healing. The project is divided into three components. In the first part, computer simulation will be performed to investigate the influence of a wide range of design parameters on the stiffness characteristics of an internal fixator. Next, biomechanical testing will be performed to determine the stiffness characteristics of the internal fixator configured according to current best clinical practise and its stiffness characteristics will be compared with previously defined optimum stiffness values. The screw configuration will then be modified, guided by the results of computer simulation, until optimum stiffness characteristics are reached for the internal fixator. In the final part of the project, the optimized internal plate fixator will be compared with the device configured according to standard clinical practise in a large animal model. The findings of this study will provide guide-lines to aid surgeons in determining appropriate internal fixator configurations to assure timely healing.



IDENTIFICATION OF ATYPICAL DIAPHYSEAL FRACTURE SUBGROUP IN PATIENTS WITH LONG-TERM BISPHOPHONATE TREATMENT – STUDY OF THE CHANGES IN BIOCHEMICAL MARKERS IN BONE METABOLISM

DR. W.H. CHEUNG
Principal Investigator
The Chinese University of Hong Kong, Hong Kong, China

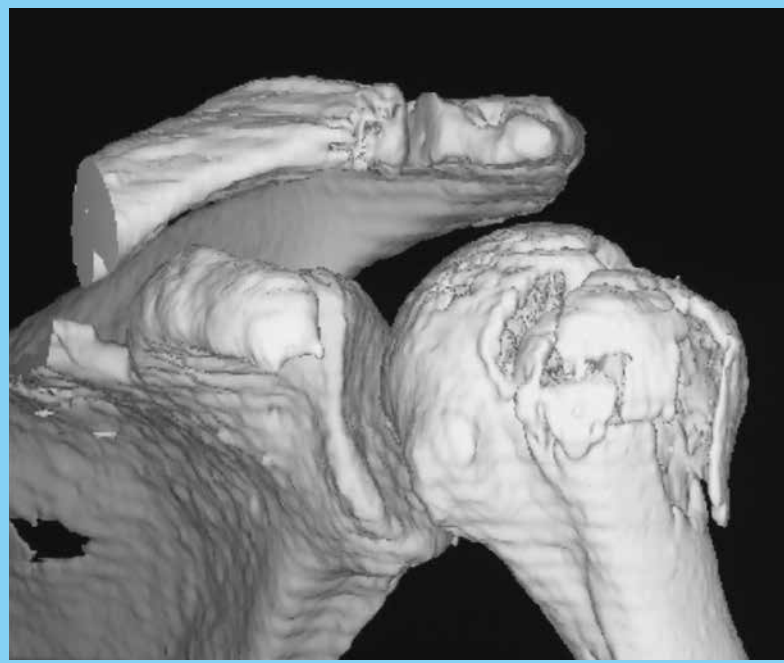
Abstract: Bisphosphonates are a class of drugs that inhibit osteoclast action and the resorption of bone. This is currently one of the commonest first-line prescriptions for patients with known or high risk of osteoporosis. It is therefore generally believed to reduce osteoporotic fractures with no doubt. However, several recent reports challenged that long-term bisphosphonate intake might cause atypical low-energy fractures. The long-term safety of bisphosphonate becomes a cricial issue. In authors' institute, a pilot study was conducted, which also demonstrated that the cortical bone density of long-term bisphosphonate subjects were significiantly lower than those of control by 5-7% but not in trabecular bone. It is therefore believed that long-term bisphosphonate may highly suppress both bone resorption and bone formation due to the re-modelling coupling of osteoblasts and osteoclasts, finally leading to atypical fractures in long bones. In the present study, we hypothesize that there is difference in biochemical markers of bone turnover between long-term bisphosphonate subjects and the controls. Bone mineral density, serum content of RANKL, OPG, NTx and ALP will be measured between long-term bisphosphonate and control groups. The findings of this study may help to identify a subset of patients who could be predisposed to atypical fractures.

Research Grants 2010

PRIMARY HEMIARTHROPLASTY VERSUS CONSERVATIVE TREATMENT FOR COMMINUTED FRACTURES OF THE PROXIMAL HUMERUS IN THE ELDERLY (PROCON); A MULTICENTER RANDOMIZED TRIAL

DR. D. DEN HARTOG
Principal Investigator
Erasmus MC, Rotterdam, The Netherlands

Abstract: Fractures of the proximal humerus are associated with a profound temporary, and sometimes permanent, impairment of independence and quality of life. These fractures represent common injuries in the elderly; the incidence is approximately 66 per 10,000 person years. The treatment of comminuted proximal humeral fractures , like selected three- or four-part fractures and split humeral head fractures, is a demanding and unresolved problem. Locking plates appear to give sufficient fixation, but are contraindicated for use in the elderly due to high screw cut-out rates. Therefore current opinion is to use either a primary hemiarthroplasty (HA) or a conservative approach in the elderly. Results from case series and a small RCT suggest improved function and less pain after primary hemiarthroplasty; however these studies flawed methodologically and an RCT is needed.
The primary aim of this study is to compare the Constant scores (reflecting functional outcome and pain) at one year after primary HA versus non-operative treatment in patients (65+) who sustained a comminuted proximal humeral fracture. Secondary aims include effects on functional outcome, pain, complications, quality of life, and cost-effectiveness. The main study hypothesis is that HA will result in higher Constant scores (reflecting better functional outcome with less pain) at 1 year.
The proposed study will be a multi-center RCT of 80 patients who have sustained a comminuted proximal humeral fracture. At least 8 Dutch and one Belgian centre will participate. Patients will be randomized between HA and conservative treatment. The primary outcome is the Constant score; secondary outcomes include clinical function (DASH), pain (VAS), radiographic healing, health-related quality of life (SF-36, EQ-5D) and cost-effectiveness. Outcome will be monitored at regular intervals over the subsequent 24 months (1, 3 and 6 weeks, and 3, 6, 12, 18, and 24 months). Data will be analyzed on an intention to treat basis, using univariate and multivariable analyses.



A PROSPECTIVE, RANDOMISED MULTICENTER CONTROLLED TRIAL ON THE TREATMENT OF DISPLACED INTRA-ARTICULAR DISTAL RADIUS FRACTURES IN AN ELDERLY POPULATION; MINIMAL INVASIVE VS VOLAR LOCKING PLATING

DR. S. MEYLAERTS
Principal Investigator
Medical Centre Haaglanden, The Hague, The Netherlands

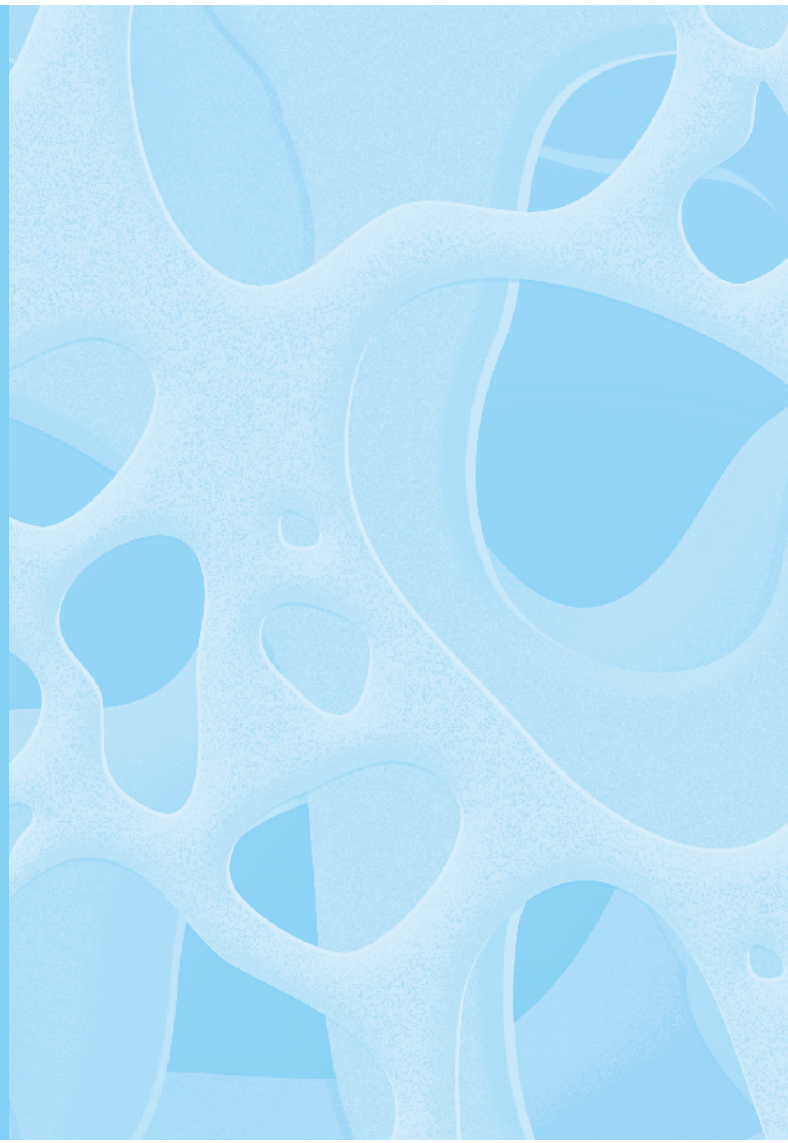
Abstract: Fractures of the distal radius are frequently seen on the emergency department and approximately 60% of all these fractures involve the articular surface. The incidence of these fractures in the elderly population will increase further due to aging and an increase of incidence of osteoporosis. Currently there is no consensus regarding the management of these fractures in this specific population.
A well-accepted approach for treating intra-articular distal radius fractures has been external fixation and percutaneous pinning and showed reasonable radiographic and functional results. Recently the interest for open reduction and internal fixation (ORIF) has grown and great new advances are made in plate technology. Volar plating constructs provide fixed angle fixation in the distal fracture fragment, supplying fracture stability even in osteoporotic bone while allowing early wrist motion. Because the high incidence and impact of distal radius fractures on older patients, the aim of this pospective multicenter randomised controlled trial is to determine a functional benefit and an increase in patient satisfaction after open reduction and internal fixation (ORIF) by volar approach using volar locking plates versus minimal invasive surgery with closed reduction, external fixation and percutaneous pinning. We hypothesize that patients after volar plating will experience better outcomes than those treated with minimal invasive surgery after one year follow-up.
One hundred and forty-eight patients with a displaced intra-articular fracture of the distal radius will be enrolled upon given informed consent. Five Dutch Teaching Hospitals will participate in this study. Patient age should be above fifty and computer randomization will allocate patients between the two surgical treatment options (intention-to-treat). Both techniques persue maximal fracture stability after surgery. Patient follow-up period extends to one year, after initial follow-up at one,6 and 12 weeks, and 6 months. During follow-up, radiologic follow-up, wrist function and movements/strength will be measured. Primary study outcome includes functional disease-related outcome score DASH and MAYO wrist score. Secondary study outcome includes patient satisfactory score SF-36, pain sensation (VAS score), stan-dardized wrist function, radiological parameters and complications.

Research Grants 2010

NOTCH SIGNALING IN BONE REGENERATION

DR. K. HANKENSON
Principal Investigator
University of Pennsylvania, Philadelphia, USA

Abstract: The purpose of this research is to demonstrate the importance of Notch signaling in fracture healing. While many biological factors that are involved in fracture healing are well-described, the role of Notch signaling in bone regeneration has been understudied. Notch regulates maintenance and differentiation of stem cells and influences both wound healing and angiogenesis. Recent evidence shows that Notch activation promotes bone formation in young mice by increasing the number of osteoblast progenitors. Fracture healing has parallels with skin wound healing, and is influenced by both rate and extent of angiogenesis and by the mesenchymal progenitors that proliferate and differentiate to become chondrocytes and bone forming osteoblasts. For this study, we hypothesize that Notch signaling regulates bone regeneration, and can be manipulated to enhance bone healing. To address this hypothesis, we propose two specific aims. In the first aim we will systematically examine Notch signaling in murine fractures. For the second aim, we will manipulate Notch signaling (both increased and decreased) in mice and examine healing. Fracture tissue will be assessed using a combination of quantitative real-time PCR, immunohistochemistry, microcomputed tomography, histomorphometry, and biomechanical testing. When completed this will be the first research to describe Notch signaling during fracture healing. We believe that activation of Notch in a temporally regulated manner may represent a clinically viable methodology to promote fracture healing.



MEASUREMENT OF CONTINUOUS TISSUE OXYGENATION DURING ACUTE COMPARTMENT SYNDROME IN A DOG MODEL

DR. U. KANDEMIR
Principal Investigator
University of California, San Francisco, San Francisco, CA

Abstract: Acute compartment syndrome is a potentially devastating complication of extremity trauma that can result in a functionless limb if treatment by fasciotomy is delayed. It remains a problematic area of orthopaedic surgery due to the difficulty of diagnosis, which currently relies on clinical suspicion and measurement of compartment pressure. Continuous pressure monitoring is not practiced by most clinicians due to concern about the morbidity of unnecessary fasciotomy. Therefore, a clear need exists for a rapid, reliable, objective, and physiologic method for diagnosis of compartment syndrome. The pathophysiology of compartment syndrome is pressure-induced muscle ischemia. Use of tissue oxygenation is an attractive strategy because it is a direct measure of the underlying pathophysiology. We are investigating continuous measurement of intramuscular tissue oxygenation as a novel approach to the diagnosis of compartment syndrome. We have established the feasibility of its use in humans using a minimally invasive polarographic probe. However, controlled study is necessary to observe tissue oxygenation during known compartment syndrome and determine thresholds of reversible or irreversible muscle ischemia. In this non-survival animal study, we plan to perform continuous measurement of tissue oxygenation during induced compartment syndrome in dogs and after treatment with fasciotomy. The dog is a well established model for compartment syndrome. Continuous measurement of tissue oxygenation will be performed during compartment syndrome of varying severity (based on pressure). We will then correlate values of tissue oxygenation with histologic analysis and a tissue viability test of muscle biopsy specimens. On the contralateral extremity, we will study the effects of pure ischemia of varying duration with use of a tourniquet. The goal is to characterize the values and behavior of tissue oxygenation during reversible and irreversible muscle ischemia due to compartment syndrome. The results of this study may have immediate clinically translatable implications for this common problem in orthopaedic trauma.

OTC Research Symposium 2010

ROLE OF BMP-2 IN STEM CELL RECRUITMENT AND DIFFERENTIATION DURING FRACTURE REPAIR

YAN YIU YU, SHIRLEY LIEU, CHUANYONG LU, THEODORE MICLAU, RALPH S. MARCUCIO, CÉLINE COLNOT

University of California, San Francisco, San Francisco, CA

Bone Morphogenetic Proteins (BMPs) are secreted molecules that play a role in the development of multiple organs in the body including the skeleton [1]. BMPs have the ability to induce bone and cartilage, which make them candidates for treating skeletal diseases and injuries [2, 3]. Numerous animal studies have illustrated their ability to improve bone repair in vivo with or without combination with various bio-materials [4, 5]. BMP-2 and -7 are now used clinically to treat delayed-unions and non-unions; however, the cost is high and the efficacy is sometimes limited [7]. The goal of the present study was to better understand the role of BMP-2 during the early stages of bone repair.

First, we analyzed via immunohistochemistry the expression patterns of BMP-2 and its receptors and effectors during fracture repair [8]. During healing of non-stabilized fractures, which occurs via endochondral ossification, BMP-2, BMPRIA, BMPRII, and pSmad 1/5/8 were immunolocalized in the activated periosteum as early as 3 days post-fracture. BMP-2 was also found in isolated inflammatory cells, but not BMP-2 receptors and effectors. During the soft callus phase of repair, BMP-2 and its receptors and effectors were detected in chondrocytes with the strongest staining reported in hypertrophic chondrocytes and decreasing intensity observed during the hard callus phase of repair. BMP-2 and its receptors and effectors were detected in osteoblasts and osteocytes within new bone, with the strongest intensity of immunoreaction reported during the early soft callus phase followed by decreasing intensity during the hard callus phase of repair. In stabilized fractures that heal strictly via intramembranous ossification, BMP-2 and its signaling components were detected in isolated inflammatory cells, but not in periosteum and new bone. These results suggested that the BMP pathway influences the mode of healing during the recruitment of skeletal progenitors. Next we examined the extent to which exogenous BMP-2 enhances fracture repair via direct effects on skeletal progenitors and indirect effects on angiogenesis [6]. rhBMP-2 increased the deposition and resorption of cartilage and bone, which was correlated with a stimulation of osteoclastogenesis but not angiogenesis in the early phase of non-stabilized fracture healing. During healing of stabilized fractures, rhBMP-2 was found to induce cartilage formation suggesting a role in regulating cell fate decisions. Using cell lineage analyses, we further showed that BMP2 can directly affect cell differentiation towards the chondrogenic lineage specifically within the periosteum but not the endosteum, indicating that skeletal progenitors within periosteum and endosteum respond differently to BMP signals (Fig. 1). Thus, BMP2 plays an important role in the early stages of repair by recruiting local sources of skeletal progenitors within periosteum and endosteum and by determining their differentiation towards the chondrogenic and osteogenic lineages.

June 23, 2010; Amsterdam, The Netherlands

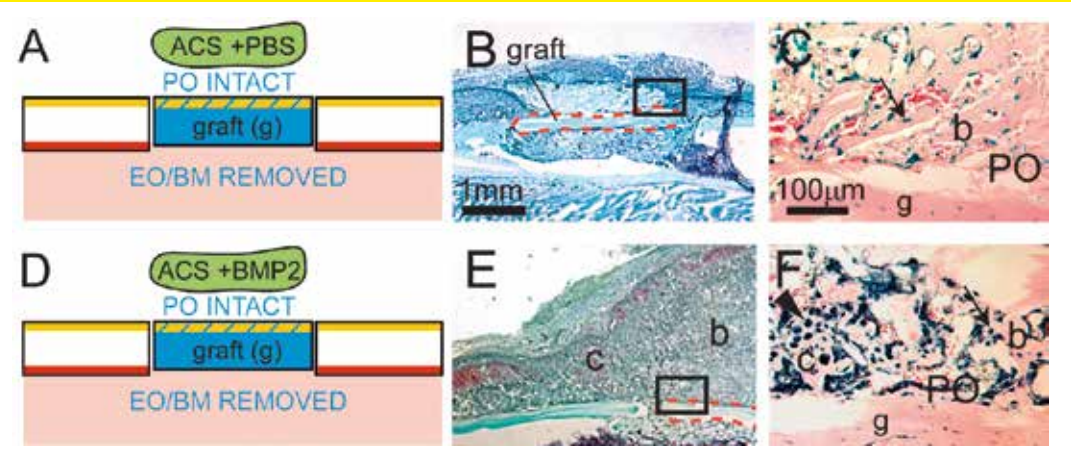


Fig. 1: BMP2 stimulates cartilage formation within periosteum. (left column) Schematic representation of bone grafts (g) isolated from Rosa26 mice after removal of endosteum (EO) and bone marrow (BM). Grafts were treated with (A) PBS or (D) BMP2. (middle, right columns) Adjacent sections through the bone grafts (dotted line) stained with (B, E) SO and (C, F) X-gal. (C) In control samples treated with PBS, new bone contains periosteum (PO)-derived osteocytes (arrow). (F) In BMP2-treated samples, a large periosteal
response is observed containing PO-derived osteoblasts/ osteocytes (arrow) and chondrocytes (arrowhead) [6].

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OTC Research Symposium 2010

BONE REGENERATION IN CRITICAL-SIZE GAP INDUCED BY ENDOTHELIAL PROGENITOR CELLS

D. LEVINSON AND PROF. MICHAEL SOUDRY
Rambam Health Care Campus, Haifa, Israel

Human endothelial progenitor cells (EPC) where isolated from peripheral blood of young volunteers. Two cell populations could be identified: a) „early“ EPC – these are slender cells that adhere to fibronectin and survive in culture for about 7 days. They have very limited proliferation capacity and therefore cannot be expanded in culture. They can be used for transplantation as is. Their characterization by FACS analysis shows them to be positive for CD14 and CD31, but negative for Tie-2 and CD34. They are considered to be of monocytic origin with some endothelial characteristics. b) „late“ EPC – colonies of cells of cobblestone morphology start to appear 8-21 days after seeding. These cells are positive for CD34, CD105, CD 146, CD31 and Tie-2, but negative for CD14. These cells are probably from angioblastic origin. During the first year of the granted project we followed the bone regeneration potential of „early“ EPC. First we followed the vitality of cells in the regenerating tissue in the gap after transplantation into a critical-size gap created in the tibiae of nude rats. This was done by labeling the cells by the fluorescent dye Qtracker 655 (cell labeling kit Quantum Dot Corp.) A defect of 0.5 cm was created in the midshaft of nude rats‘ (males 250-300 g body weight, Hsd: RH-FoxN1RNU, Harlan, IN, USA) tibiae. Rats were anesthetized with im injections of ketalar (10 mg/100 g bw) and xylasine (0.5 mg/100 g bw). Antibiotics (Cephoral 4 mg/100 g bw) were applied before operating the tibiae and for 3 days thereafter. Labeled 105 „early“ EPC were applied into the gap mixed with a novel hyaluronic acid-fibrinogen hydrogel scaffold in a volume of 75 µl before polymerization. Polymerized hydrogel without cells served as control. Two weeks later, rats were euthenized by CO2 and frozen sections were prepared from OCT-embedded regenerating gap tissue and from several other organs. Fluorescent-labeled cells were observed in the frozen sections of the regenerating tissue in the critical gap but not in other organs such as liver, heart, lung and spleen. No fluorescent cells were noted in control gaps that were transplanted only with hydrogels without cells. Three experiments followed the bone regeneration capacity of different concentrations of cells mixed with different volumes of scaffold. Bone regeneration was evaluated either 6 or 10 weeks post transplantation by X-rays radiography on the day of sacrifice, scanned by micro computed tomography and by histology. It became apparent that limited enhanced bone regeneration was observed by all methods of analysis when compared with non-transplanted gaps. In and all, the results showed great variability.

We concluded that the cell population defined as „early“ EPC isolated from human peripheral blood has limited bone regeneration capacity. Consequently we will in the future follow the bone regenerating

potential of „late“ EPC. Based on our encouraging results from the studies of bone regeneration using autologous sheep „late“ EPC (Rozen et al., Bone 2009;45:918), we expect that a „late“ EPC preparation isolated from human blood will be successful.

BMP-7 stimulates early fracture healing in estrogen deficient rats

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[2] Department of Orthopaedics, Radboud University Medical Centre Nijmegen, NL
[3] Department of Nuclear Medicine, Radboud University Medical Centre Nijmegen, NL
[4] Department of Surgery, Radboud University Medical Centre Nijmegen, NL

The influence of osteoporosis, often caused by estrogen deficiency, on the fracture healing process is unclear, but could provide an explanation for the high failure rate in osteoporotic fracture treatment. Intervention, either with anti-resorptive agents or with anabolic agents, such as BMPs, may limit the negative outcome of these fractures. Their effectiveness yet remains to be determined. An experimental study was performed to assess the influence of estrogen deficiency on fracture healing, as well as the effects of anti-resorptive agents and a BMP. Forty adult female wistar rats underwent ovarectomy (OVX) followed by a low calcium diet (LCD). Ten additional rats underwent a sham operation, followed by a normal diet. After six weeks, a closed midshaft femoral fracture was induced in all animals. Ten animals received a single injection of bisphosphonates, ten received an injection of BMP-7 in the fracture, and ten received a combination of these. After fracture induction, normal diet was given. After two weeks fracture healing was evaluated using plain radiographs, callus volume, biomechanical testing, and histology.
Radiographic evaluation showed significant increase of bridging in the groups treated with BMP-7 compared to sham, OVX, and bisphosphonates. Callus volume was significantly higher in these groups as well. Synergy between bisphosphonates and BMP-7 was only seen in this endpoint. Bending stiffness and bending strength were not different between OVX and sham, and were not influenced by bisphosphonates, but a significant increase was seen in the groups treated with BMP-7. The histological evaluation was in accordance with the other endpoints.
The early stage of fracture healing was not affected by estrogen deficiency in the present study. No beneficiary effect of bisphosphonate treatment could be determined, but injection of BMP-7 in the fracture stimulated healing significantly.

OTC Research Symposium 2010

OPTIMIZATION OF LOCKED SCREW DEVICES

DR. T. WEHNER
Ulm University, Ulm, Germany

Introduction of principal investigator / scientific focus:
The institute of orthopaedic research and biomechanics in the center of musculoskeletal research at Ulm University focuses on research in the fields of fracture healing, osteoporosis, tissue engineering, cell biology as well as knee and spine biomechanics.

Abstract:
Conventional implants have a critical primary stability in weak, osteoporotic bone which leads to a large number of complications. Locked plate fixations help to improve this stability but there is still a need for optimization. We developed idealized nonlinear 3D finite element models, which could be used to determine the ultimate loading capability of both (i) conventional non-locked and (ii) locked plate fixations at the proximal humerus **(Fig. 1)**. Therefore, it was possible to directly compare both fixation systems under physiological loading conditions. By changing the mechanical properties of the bone material in relation to the bone mineral density, it was possible to determine the influence of the bone quality on the ultimate load of the bone-implant complex **(Fig. 2)**. The ultimate load of the locked plate fixation was greater than for the non-locked fixation, which could be confirmed by in vitro tests with human cadaver specimens.
With these finite element models, it was possible to vary the design parameters for optimizing the locked plate fixation. The strength of the screw-bone interface and therefore the ultimate loading capability of the bone-implant complex could be increased by enlarging the thread depth and increasing the stiffness of the screw **(Fig. 3)**.

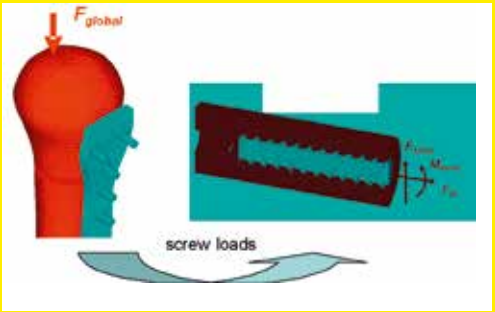

Fig. 1: Global nonlinear FE model (left) for determing the screw loads as boundary conditions for a nonlinear elastoplastic micro FE model (right) of the bone-screw interface.

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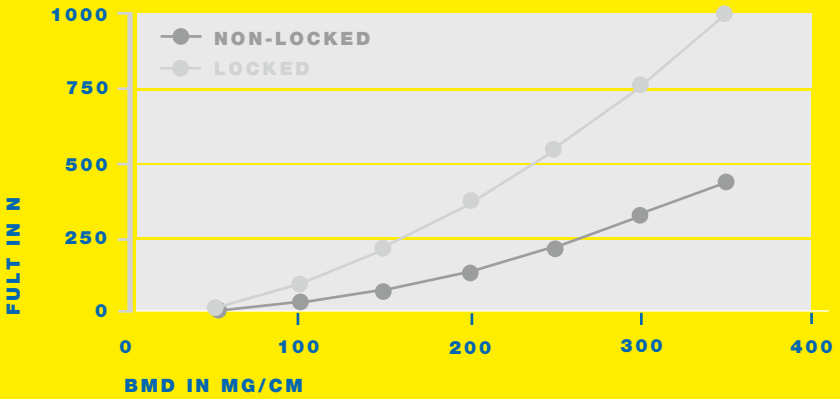


Fig. 2: Ultimate load (Fult) of the bone-implant complex in relation to the bone mineral density (BMD)

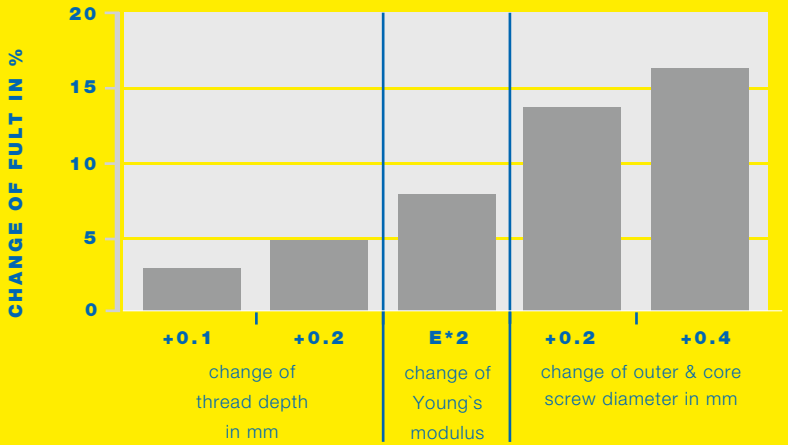


Fig. 3: Change of the ultimate load (Fult) of the bone-implant complex related to variations of the screw design.

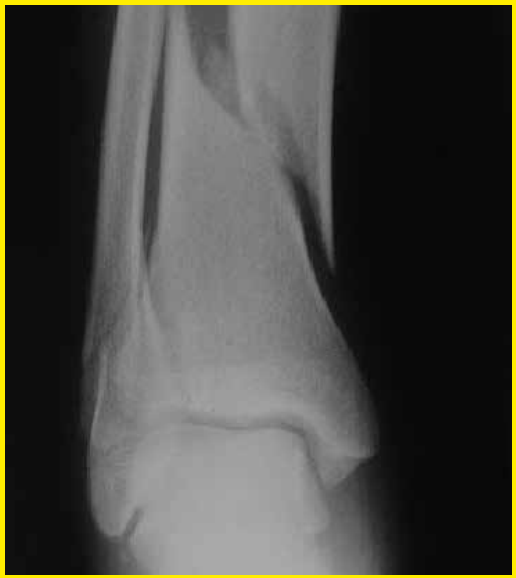
OTC Research Symposium 2010

SAME LEVEL FIBULAR PLATING VERSUS NOT PLATING IN DISTAL METAPHYSEAL TIBIA FRACTURES TREATED WITH INTRAMEDULLARY NAILS: A RANDOMIZED TRIAL

DR. RICHARD BUCKLEY, Department of Surgery, University of Calgary, Canada;
DR. TOM VAN RAAIJ, Department of Orthopaedics, Martini Hospital Groningen, the Netherlands
Principal investigators

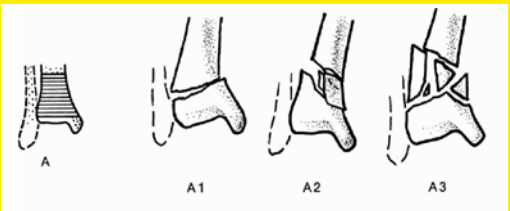
Intramedullary nailing has become the standard of care for the majority of displaced midshaft tibial fractures. The optimal treatment for combined displaced distal tibia and fibula fractures (OTA type 42 and 43) remains unclear.

Because of the lack of interference fit it can be difficult to reduce and control distal tibia fractures with an intramedullary device alone, and malalignment rates of 20% to 50% have been reported. We hypothesize that pre-emptive fibular plating would be beneficial to obtain and maintain optimal distal tibia fracture reduction. Therefore, we designed a prospective transatlantic (Canada, UK and Holland) multicenter open-label parallel randomized controlled clinical trial to answer the following questions: (1) Does additional fibular plating lower the incidence of malalignment after surgical treatment of distal metaphyseal tibia and fibula fractures treated with locked intramedullary nailing? (2) Does fixation of the fibula lead to higher rates of non-union of the distal tibia? We hypothesize that additional fibular plating would be beneficial to obtain and maintain optimal distal tibia fracture reduction, which may lead to a better functional outcome after 2-years follow-up.
Based on a recent retrospective article looking at malalignment in distal tibial fractures treated with an IM nail, using a 2x2 independent samples Chi-Squared or Fisher‘s Exact Statistical test and comparing IM nail alone (29% malaligned) versus IM nail + fibular plate (approximately 5% malaligned), gives us a requirement of 38 pts per group or n=76 with power set to 81% and an alpha of .05 (two-tailed). On the assumption of 10% rate of loss of follow-up we need to include 84 patients in the study.
We will use tibia malalignment as our primary outcome because it is a credible, responsive and



June 23, 2010; Amsterdam, The Netherlands

clinically relevant outcome. Functional scores (VAS, SF-36, HSS knee, AOFAS ankle-hindfoot) and bony healing will be used as secondary outcomes. Each facility estimates to include 1-2 patients per month. This would result in 18 patients per year per site, and 84 patients could be enrolled after 1.5 years.






Research team (left to right):
RICK BUCKLEY, CANADA; TOM VAN RAAIJ AND LARS VAN ROZEN, THE NETHERLANDS; ANDY GRAY, UK.

OTC Research Symposium 2010

SUMMARY OF DISCUSSION

The Research Symposium included a discussion with all attendees regarding future directions of the OTC Research Grant Program. This discussion is summarized below.

In general, the Research Program is highly valued, and the attendees are positive that it provides key funding for orthopaedic traume research. A wide variety is needed in order to remain attractive for a target group of orthopedic trauma surgeons. There was consensus that the three central themes in research should remain in the program, i.e., clinical research, basic or translational research and biomechanical research.

The best way to promote the grant program and to secure good quality research is to include a broad variety of research topics. Identifying one or two hot topics each year may help in attracting specific groups of surgeons or scientists, but restricting to only those hot topics should be discouraged. The method of selecting hot topics is currently employed in the Biomechanical Program, where it functions well.

When identifying (hot) topics, it is crucial that a relation to clinical questions is always present. OTCF is a foundation for clinicians; therefore the grant program should be aimed at serving their needs.

The following items are currently considered to be relevant to orthopedic trauma surgery:

1. Aging: due to current trends in aging worldwide, the number of elderly will increase. Hence the number of elderly sustaining trauma and living with disability will increase. Future research should focus on management of osteoporotic fractures in the elderly, especially of the wrist, shoulder and hip. Optimizing or developing novel treatment options for osteoporosis are also relevant topics.
2. Implants and their application in the young and the elderly.
3. Replacement versus osteosynthesis: for many indications there is no fixed guideline when to perform osteosynthesis and when to do a (hemi-)arthroplasty. Most surgeons first strive to retain a joint and use arthroplasty as a second-stage treatment. Whether or not that is best approached from a patient's perspective is not yet sufficiently investigated. More outcome-oriented clinical research is needed on this topic.
4. Numerical methodology and models: the way the Biomechanical Program is positioning its research, i.e., by selecting a hot topic during a symposium, works well. This directed approach of addressing clinical problems should be maintained in the future.
5. Conservative treatment: there is a general lack of insight into outcome after conservative treatment. For many clinical indications, surgical treatments may not be needed. There is interest in well-designed studies (either cohort or randomized) with major focus on outcome in relation to stability and mobility of patients.
6. Functional assessment: in previous fracture studies, research was primarily focused on radiographic healing or adverse event rates (including revision surgery rates). From a patient perspective, functional recovery may be much more valued. Therefore, functional tests and patient reported outcome measurements are included in most if not all of the current trials. There is a growing need for sensitive and validated tests, both functional tests and questionnaires.
7. Rehabilitation: In addition to (non-)operative approaches, the rehabilitation protocol may also have a critical effect on outcome. This receives too little attention in most research.

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8. Health economics: current economic crises have an adverse effect on the available national healthcare budgets. Therefore, showing favorable outcome following treatment no longer suffices. In order for new treatments taken into the insurance systems it is necessary to also show their cost-effectiveness.
9. Bone healing: Bone healing is a central theme of the OTC research grant program, and can be studied through both basic scientific and clinical approaches. In order to improve healing potential of fractures, there is a continuous need for good research projects related to tissue engineering, bone biology, and effects of implants versus biology. The number of studies using mesenchymal stem cells and endothelial progenitor cells is growing, and application of these cells (either as such or following engineering) is promising.
10. Infection: infection following surgery can be a devastating complication. Current technological developments include coating of implants with different compounds, and there is a need for non-pharmacological means for the treatment of infection. More research on these topics is needed.

Outcome of the projects should be carefully monitored in order to be able to judge if there has been good value given the level of support provided. Although numbers of publication and their impact factors are generally accepted as determinants of success of a project, they should be carefully judged. For example, large numbers of publications should not be expected following a grant for a startup project, rather, the long-term impact of the grant in obtaining additional full funding is much more relevant. The research committee currently monitors the outcome (i.e., publications, presentations, and successful additional grant awards) for two years after completion of the projects, which is considered adequate.

The symposium attendees appreciate the flexibility of the grant size. The available Young Investigator grants (maximum $10,000) and Research Grants (maximum $50,000) provide adequate flexibility. Larger grants would be welcome, but should not be at the expense of the overall number of grants awarded. Given the current budget, increasing the amounts of individual grants is not feasible.

Regarding funding, the following items were considered relevant:

1. The aim of research grant funding (50k-grants) is to provide seed or start-up money for new projects.
   - The grant amount is sufficient to cover all costs of small projects
   - For larger projects, start-up money is crucial for obtaining preliminary results through pilot studies or for showing feasibility of the project. These results may be critical for obtaining future grants for a full study through national agencies.
2. The aim of young investigator grants are to provide young colleagues the opportunity to become member of a research team and to develop their skills. It is a stimulation award, and a gateway to join the scientific community.
3. The grant program may be attractive to other grantors as well.

The symposium chair thanked all attendees for their input in a very fruitful discussion.

OTC Biomechanical Research Fellowship Reports

PATIENT SPECIFIC QUANTITATIVE ANALYSIS OF FRACTURE FIXATION IN THE PROXIMAL FEMUR IMPLEMENTING PRINCIPAL STRAIN RATIOS. METHOD AND EXPERIMENTAL VALIDATION

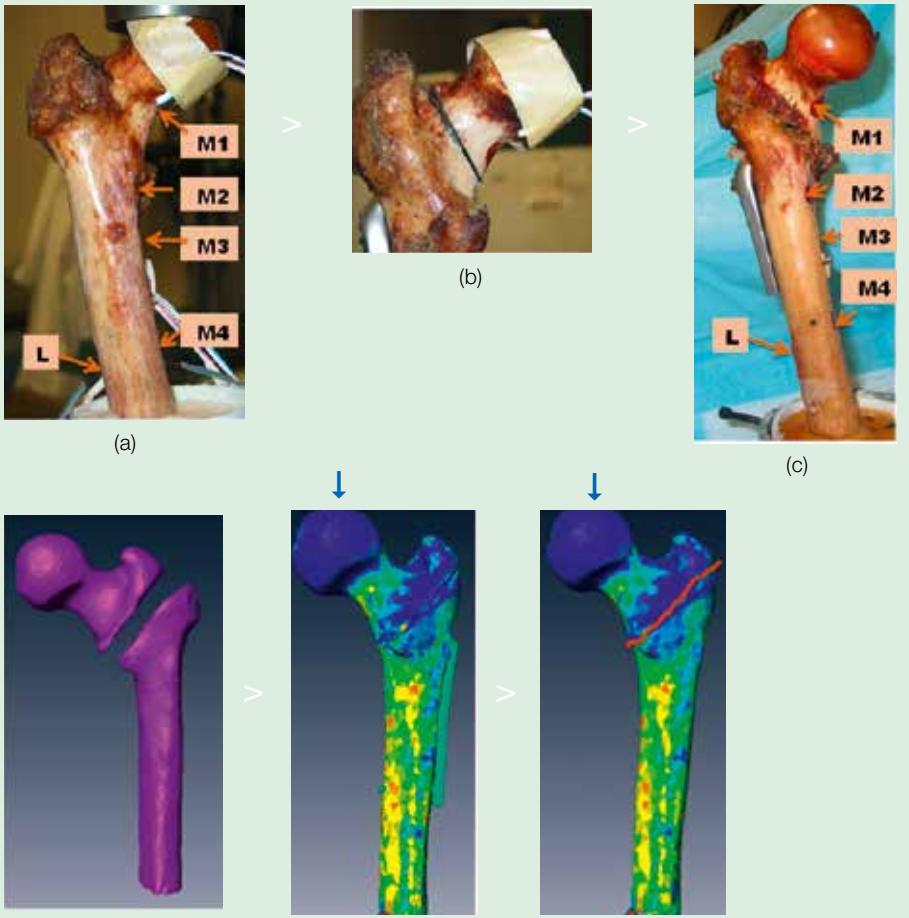
DR. E. PELEG
Fellow
Dept. of Biomedical Engineering, Hadassah University Medical Center, Hadassah, Israel
Host Location: Orthopaedic Biomechanics Laboratory, Sunnybrook Health Centre, Toronto, ON, Canada

Abstract: Computational patient-specific modeling has the potential to yield powerful information for selection and planning of fracture treatments if it can be developed to yield results that are rapid, focused and coherent from a clinical perspective. In this study we introduce the utilization of a principal strain fixation ratio measure (SR) defined as the ratio of principal strains that develop in a fixated bone relative to the principal strains that develop in the same bone in an intact state. The SR field output variable is theoretically independent of load amplitude and also has a direct clinical interpretation with SR<1 representing stress shielding and SR >1 representing overstressed bone. A combined experimental and numerical study was performed with cadaveric proximal femora (n=6) intact and following fracture fixation to quantify the performance of the SR variable in terms of accuracy and sensitivity to uncertainties in density-elasticity relationships and load amplitude as model input variables. For a given axial compressive force the SR field output variable was found to be less sensitive to changes in density-elasticity relationships and the response function to be more accurate than strain values themselves; errors were reduced by 44% comparing SR to strain in the fixated model. In addition, the experimental data confirmed the assumption that the SR values behave independent to load amplitude. The load independent behaviour of SR and its direct clinical interpretation may ultimately provide an appropriate and easily understood comparative computational measure to choose between patient specific fracture fixation alternatives.

DR. E. PELEG
Fellow

OTC
Biomechanical Research Fellowship Reports

Publication:
Peleg E, Beek M, Joskowicz L, Liebergall M, Mosheiff, iWhyne C. Patient specific quantitative analysis of fracture fixation in the proximal femur implementing principal strain ratios. Method and experimental validation. J Biomech 2010;43(14):2684-2688.



OTC Biomechanical Research Fellowship Reports

THE ROLE OF ANGIOGENESIS AND HYPOXIA ON BONE HEALING AND BONE DEVELOPMENT. DOES LACTATE INFLUENCE ANGIOGENESIS?

DR. S. DECKER
Fellow
University of Hamburg, Hamburg, Germany, Fellowship period: 01.01.2010 to 03.31.2010
Host Location: Laboratory for Skeletal Regeneration,
Orthopaedic Trauma Institute, San Francisco General Hospital, San Francisco, USA

Abstract: The main purpose of this research fellowship was to study the role of angiogenesis and hypoxia on both fracture healing and skeletal development. Even though the current dogma is that hypoxia stimulates angiogenesis, convincing studies are still missing. An alternate hypothesis is that lactate stimulates angiogenesis in oxygenated environments, but this idea has received little attention.
To analyze the effect of hypoxia on fracture healing, externally stabilized tibiae fractures were created in 10 mice. The mice were kept in normoxic (21% O2) or hypoxic (13% O2) conditions for 10 days (n=5/environment). Mice were euthanized on d10 and tibiae were fixed, embedded in paraffin, sectioned and stained with the Hall Bryant Quadruple stain.
Analysis of stained sections clearly showed little or no callus formation in the hypoxia treated group **(Fig. 1)** compared to control **(Fig. 2)**.
To analyze the effect of hypoxia on angiogenesis and skeletal development, fertilized chicken eggs were incubated at 39°C in normoxic conditions. On d10 some were put into hypoxia. Embryos were euthanized on d17 followed by bone-cartilage staining with Alcian Blue and Alizarin Red.
No significant difference on relative proportions of bone and cartilage could be detected in long bones. Additionally, 17d old chicken embryos were injected with a rhodamine-labeled lectin before being euthanized. After fixation, embedding and sectioning, a fluorescent analysis clearly illustrated blood vessels and endothelial cells in all parts of the lower leg **(Fig. 3 & 4)**.
A quantification of endothelial cells will be done soon to evaluate whether there is a significant difference in bones of hypoxic treated chicken embryos compared to control or not.

Fellow:
DR. S. DECKER

Fig. 1: No or little callus formation could be seen in stabilized tibiae fractures of mice being kept in hypoxia for 10d.

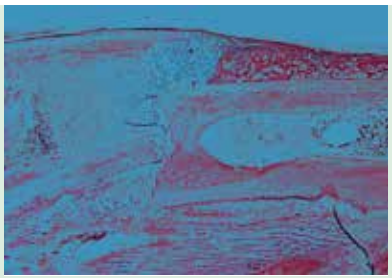


Fig. 2: Much callus formation could be seen in stabilized tibiae fractures of mice being kept in normoxia for 10d.

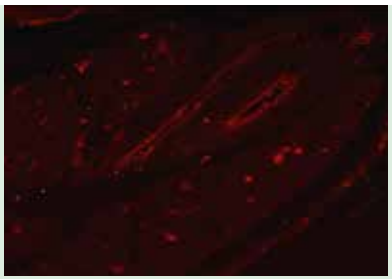


Fig. 3: Leg of a chicken embryo being incubated in normoxic conditions from d10-d17.

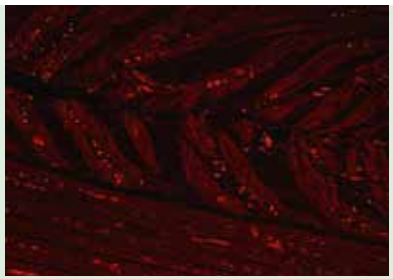


Fig. 4: Leg of a chicken embryo being incubated in normoxic conditions from d10-d17.

Since there is a lack of information regarding the role of lactate for angiogenesis we did in vitro and in vivo experiments. In vitro we performed proliferation assays with a mouse endothelial cell line (C166). Analysis was done after 24h, 48h, 72h and 96h. Evaluation showed a significant decrease of proliferating cells in lactate concentrations of 5mM and higher after 24h compared to control. We also observed a decrease in the absolute cell number. So far no further analysis was done on lactate´s effect on C166. An analysis of apoptosis needs to be done to fully assess this outcome.
In vivo assays were done on the chicken chorioallantoic membrane (CAM). 1mm² pieces of filter paper were soaked in a 30mM lactate solution and put on CAMs of 8d normoxiatreated chicken embryos. After 4d of incubation vessels growing radially towards the filter paper were counted. Evaluation showed a decrease of vessels compared to control. However, even though the CAM assay has been used to study angiogenesis in vivo, there are significant problems associated with quantitative analysis using this method. Therefore, the results of these analyses must be interpreted conservatively and with caution.

Conclusion:
Oxygenation and it´s role for fracture healing and bone development is of great interest for orthopaedic surgeons. Angiogenesis is a key-mechanism to regulate oxygen levels during bone repair and development. Therefore, trying to understand the role of the blood supply during healing and development is important and will provide insight into novel mechanisms that influence the skeleton. Contrary to popular dogma, hypoxia does not appear to affect chondrogenesis or angiogenesis during skeletal repair or development. Lactate has been suggested as a key mediator of angiogenesis in vivo. Our preliminary data do not support a role for lactate, but this statement requires much more extensive analysis before a definitive conclusion can be reached.

OTC Research Courses

Athens, March 28, 2009: Principles and Practice of Clinical Research
Organized jointly with OTC Hellas
Four international faculty members
More than 100 national participants

Toronto, September 16-18, 2009: Principles and Practice of Surgical Research
Organized by Canadian OTC members
Eighteen faculty members and two guest lecturers
More than 100 participants

Havana, June 2-3, 2010: Forum Internacional de Investigaciones Clinicas en Ortopedia
Organized jointly with Centro de Investigaciones Medico Quirurgicas (CIMEQ)
Five international faculty members
More than 140 national participants

London, September 23-25, 2010: Principles of Clinical and Experimental Research
Organized jointly with British Orthopaedic Trainee Association (BOTA)
Nineteen international and national faculty members
Twenty-eight national and international participants

Puerto Vallarta, November 1-2, 2010: Seminario de Investigaciones Clinicas
Organized jointly with Associación Mexicana de Ortopedia y Traumatologia (AMOT)
Five international faculty members
More than 75 national participants

OTC Biomechanical Research Workshops

Cambridge, June 14-16, 2009: Numerical Modeling and Trauma Care Workshop
Organized under the OTC Biomechanics Research Program
Twenty-five participants

Murnau, June 17-18, 2010: Workshop on Assessment and Monitoring of Healing in Orthopaedics and Traumatology
Organized jointly with Institute for Biomechanics, BGU Murnau
Forty-three participants

Boston, December 5-6, 2010: Numerical Modeling Workshop
Organized under the OTC Biomechanics Research Program
Nineteen participants

Participants of the Boston Numerical Modeling Workshop 2010

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Presentations

Atesok K, Li R, Schemitsch EH. The Use of Endothelial Progenitor Cells to Promote Bone Healing: A Defect Model in the Rat Femur. 55th Annual Meeting of the Orthopaedic Research Society (Feb. 2009, Las Vegas, USA). Oral Presentation.

Atesok K, Li R, Schemitsch EH. The Use of Endothelial Progenitor Cells to Promote Bone Healing: A Rat Model Study. American Academy of Orthopaedic Surgeons – AAOS 2009 Las Vegas. Poster Presentation.

Atesok K, Li R, Schemitsch EH. The Use of Endothelial Progenitor Cells to Promote Bone Healing: A Defect Model in the Rat Femur. Canadian Orthopaedic Association/Canadian Orthopaedic Research Society COA/CORS 2009 Annual Meeting in Whistler. Poster Presentation.

Atesok K, Li R, Schemitsch EH. The Use of Endothelial Progenitor Cells to Promote Bone Healing: Preliminary Results From a Rat Model Study. American Society for Bone and Mineral Research, ASBMR – September 12-16, 2008 Montreal. Poster presentation.

Atesok K, Li R, Schemitsch EH. The Use of Endothelial Progenitor Cells to Promote Bone Healing: A Rat Model Study. American Academy of Orthopaedic Surgeons – AAOS 2010. New Orleans, LA. Poster Presentation.

Atesok K, Li R, Schemitsch EH. The Use of Endothelial Progenitor Cells to Promote Bone Healing: A Rat Model Study. Orthopaedic Trauma Association, San Diego, CA 2009. Oral Presentation.

Atesok K, Li R, Schemitsch EH. Endothelial Progenitor Cells of a Segmental Bone Defect. 2010 annual meeting of the American Academy of Orthopaedic Surgeons, March 2010, New Orleans, LA (Oral Presentation).

Badhwar A. A Novel Animal Model for Compartment Syndrome: Pathophysiology and Therapeutics. OTC Research Symposium (June 2010, Amsterdam, the Netherlands). Oral Presentation.

Berry GK. Prospective Randomized Trial Comparing Open Reduction & Internal Fixation, Non-spanning External Fixation and Closed Reduction with Percutaneous Fixation in Displaced Distal Radius Fractures. Canadian Orthopaedic Trauma Society bi-annual conferences, Quebec City, Quebec, Canada, July 2008. Oral Presentation.

Berry GK. Prospective Randomized Trial Comparing Open Reduction & Internal Fixation, Non-spanning External Fixation and Closed Reduction with Percutaneous Fixation in Displaced Distal Radius Fractures. Orthopaedic Trauma Association Annual Meeting, Denver, CO, USA, July 2008. Oral Presentation.

Blokhuis TJ. Fracture healing in osteoporosis. 6th Bone biology congress, Amsterdam. Sept. 3-5 2009. Oral Presentation.

Blokhuis TJ. Fracture healing in osteoporosis. OTC Research Symposium (June 2010, Amsterdam, the Netherlands). Oral Presentation.

Boyce B, Lindsey B, Clovis NB, Smith ES, Hubbard D, Li B. Synergetic effects of exogenous IL-12 supplementation and antibiotic treatment in prophylaxis of implant-associated infection. Orthopaedic Research Society (ORS) Annual Meeting, Long Beach, California, January 2011. Oral presentation.

Bronkhorst MWGA, Patka P, van Lieshout EMM. Single Nucleotide Polymorphisms in MBL2 predispose to infectious complications in polytrauma patients. 29th Annual Meeting of the European Bone and Joint Infection Society, EBJIS (Heidelberg, Germany, September 2-4, 2010). Oral Presentation.

Bronkhorst MWGA, Patka P, van Lieshout EMM. Single Nucleotide Polymorphisms in MBL2 predispose to infectious complications in polytrauma patients. 69th Annual Meeting of the American Association of the Surgery of Trauma, AAST (Boston, September 22-25, 2010). Poster Presentation.

Bronkhorst MWGA, Patka P, van Lieshout EMM. Single Nucleotide Polymorphisms in MBL2 predispose to infectious complications in polytrauma patients. Deutscher Kongress für Orthopädie und Unfallchirurgie (Berlin, October 26-29, 2010). Oral Presentation.

Cheung WH, Shi HF, Qin L, Leung KS. Augmentation of callus formation and mechanical properties of fracture healing in ovariectomized rats by low-magnitude high-frequency vibration treatment. 55rd Annual Meeting of Orthopaedic Research Society (February 2009, Las Vegas, USA). Oral presentation.

Chow DHK, Cheung WH, Qin L, Leung KS. A mechanistic study on the enhanced bone remodeling in fracture healing by vibration treatment. 4th International Congress of Chinese Orthopaedic Association, Xiamen, China. Nov 18-19, 2009. Oral Presentation.

Chow DHK, Cheung WH, Qin L, Leung KS. Investigation of the enhanced bone remodeling mechanism in fracture healing by vibration treatment. 29th Annual Congress of the Hong Kong Orthopaedic Association. Hong Kong, China. Nov 28-29, 2009. Poster Presentation.

Chow DHK, Cheung WH, Qin L, Leung KS. Enhanced bone remodeling mechanism in fracture healing by low-magnitude high-frequency vibration treatment. 56th Annual Meeting of the Orthopaedic Research Society. New Orleans, Louisiana. March 6-9, 2010. Poster Presentation (#1700).

Colnot C. Role of BMP-2 in stem cell recruitment and differentiation during fracture repair. OTC Research Symposium (June 2010, Amsterdam, the Netherlands). Oral Presentation.

Diachkova GV, Stepanov RV, Samusenko DV, Matsukatov FA. Diagnostic CT Criteria on Contact Regenerate Formation in Tibial Fracture Repair. Multiple and associated trauma. Organisational, tactical and technological issues.

Presentations

High technology medical assistance for locomotor injuries and diseases" (Tyumen, Russia, March 30, 2010). Oral Presentation.

Diachkova GV, Stepanov RV, Sukhodolova LV, Diachkov KA. Quantitative assessment of reparative bone formation in treatment of patients with tibial fractures using the method of transosseous osteosynthesis. 5th meeting of ASAMI International (Saint Petersburg, Russia, 28-30 May 2008). Oral
Presentation.

Diachkova GV, Stepanov RV, Diachkov KA, Korabelnikov MA. MRI Characteristics of Lower Leg Vessels and Muscles in Patients that Underwent Treatment with the Method of Transosseous Osteosynthsis for Closed Diaphyseal Tibial Fractures. Genij Ortopedii (Russia, 2010). Oral Presentation.

Fajardo M. Quantitative Assessment of the Bone Morphogenetic Protein Expression from Alternate Bone-Graft Harvesting Sites. Orthopaedic Trauma Association Annual Meeting 2009 (San Diego, CA USA). Oral presentation.

Fajardo M. Quantitative Assessment of the Bone Morphogenetic Protein Expression from Alternate Bone-Graft Harvesting Sites. AAOS Annual Meeting 2010 (New Orleans, LA USA). Poster Presentation.

FLOW Investigators. Fluid Lavage of Open Wounds (FLOW): A Multicenter, Blinded, Factorial Pilot Trial Comparing Alternative Irrigating Solutions and Pressures in Patients with Open Fractures. American Academy of Orthopaedic Surgeons Annual Meeting, March 2010. Oral Presentation.

FLOW Investigators. Fluid Lavage of Open Wounds (FLOW): A Multicenter, Blinded, Factorial Pilot Trial Comparing Alternative Irrigating Solutions and Pressures in Patients with Open Fractures. Canadian Orthopaedic Association Annual Meeting, June 2010. Oral Presentation.

FLOW Investigators. Fluid Lavage of Open Wounds (FLOW): A Multicenter, Blinded, Factorial Pilot Trial Comparing Alternative Irrigating Solutions and Pressures in Patients with Open Fractures. Australia Orthopaedic Association Annual Meeting, October 2010. Oral Presentation.

Hamza T, Pham D, Dietz M, Tidwell J, Jones A, Clovis N, Smith S, Li B. Intracellular Staphylococcus aureus infection: In vivo evidence for chronic osteomyelitis disease. Orthopaedic Research Society (ORS) Annual Meeting, Long Beach, California, January 2011. Poster presentation.

Kreder M, Wright D, Whyne C, Kreder H, Kiss A, Lubovsky O. Prognosticating Acetabular Fractures Using CT Analysis. 56thAnnual Meeting of the Orthopaedic Research Society, March 6-9, 2010, New Orleans, Louisiana. Poster presentations (Poster 1863).

Kuzyk PR, Davies JE, Schemitsch EH. The Effect of Intramedullary Reaming on a Diaphyseal Bone Defect of the Tibia. 55th Annual Meeting of the Orthopaedic Research Society (February 2009, Las Vegas, USA). Poster Presentation.

Kuzyk PR, Davies JE, Schemitsch EH. The Effect of Intramedullary Reaming on a Diaphyseal Bone Defect of the Tibia. British Trauma Society Annual Clinical Meeting (May 2009, Newcastle, UK). Oral Presentation.

Kuzyk PR, Davies JE, Schemitsch EH. The Effect of Intramedullary Reaming on a Diaphyseal Bone Defect of the Tibia. Canadian Orthopaedic Association Annual Meeting (July 2009, Whistler, Canada). Oral Presentation.

Kuzyk PR, Schemitsch EH, Davies JE. A Biodegradable Scaffold for the Treatment of a Diaphyseal Bone Defect of the Tibia. 55th Annual Meeting of the Orthopaedic Research Society (February 2009, Las Vegas, USA). Poster Presentation.

Kuzyk PR, Schemitsch EH, Davies JE. A Biodegradable Scaffold for the Treatment of a Diaphyseal Bone Defect of the Tibia. British Trauma Society Annual Clinical Meeting (May 2009, Newcastle, UK). Oral Presentation.

Kuzyk PR, Schemitsch EH, Davies JE. A Biodegradable Scaffold for the Treatment of a Diaphyseal Bone Defect of the Tibia. Canadian Orthopaedic Association Annual Meeting (July 2009, Whistler, Canada). Oral Presentation.

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Lawendy A, Manjoo A, Bihari A, Sanders DW, Parry NG, Gray DK, Badhwar A. Inflammation causes muscle injury in compartment syndrome: A leukocyte deplete rodent model. Combined Australasian Trauma Society and Trauma Association of Canada Annual Scientific Meeting, Auckland, New Zealand, 2009.

Lawendy, A, McGarr, G, Phillips, JT, Sanders, DW, Parry, NG, Gray, DK, and Badhwar, A. Comparment syndrome causes a systemic inflammatory response and remote organ injury. Combined Australasian Trauma Society and Trauma Association of Canada Annual Scientific Meeting, Auckland, New Zealand, 2009. (NB: received the award for Best Scientific Paper presented by a resident).

Lawendy, A, Sanders, DW, Bihari, A and Badhwar, A. Inflammation causes muscle injury in compartment syndrome: An experimental study. Canadian Orthopaedic Association Annual Meeting, Whistler, British Columbia, 2009.

Lawendy, A, McGarr, G, Sanders, DW, Bihari, A, and Badhwar, A. Compartment syndrome causes a systemic inflammatory response and remote organ injury. Canadian Orthopaedic Association Annual Meeting, Whistler, British Columbia, 2009.

Leung KS, Mok HW, Cheung WH, Liu PL, Chan TJ, Chan SY, Mak WY. ehabilitation and physical therapy in

osteoporosis fracture healing. International Osteoporosis Foundation (IOF)-China Health Promotion Foundation (CHPF) Asia Osteoprosis Conference. Beijing, China. 25-27 Sept, 2009. Oral Presentation.

Levinson D. Bone Regeneration in Critical-size Gap induced by Endothelial Progenitor Cells. OTC Research Symposium (June 2010, Amsterdam, the Netherlands). Oral Presentation.

Li R, Atesok K, Nauth A, Wright D, Qamirani E, Whyne CM, Schemitsch EH. Effect of EPC-based therapy on fracture healing: a Radiographic, MicroCT and Biomechanical study in rats. ISFR, September 2010, London, UK. Oral Presentation.

Li R, Qamirani E, Atesok K, Aaron A, Wang X, Schemitsch EH. Endothelial Progenitor Cells for Fracture Healing: Expression of VEGF mRNA ISFR, September 2010, London, UK. Oral Presentation.

Li R, Li C, Nauth A, McKee M, Schemitsch E: Effect of the hVEGF transfer on endogenous VEGF mRNA expression in a rat osteoblast or fibroblast culture model OTA 25th A nnual Meeting - October 7-10, 2009 - San Diego (Oral Presentation).

Li R, Atesok K, Nauth A, Qamirani E, Wright D, Whyne CM, Schemitsch EH. Endothelial Progenitor Cells for Healing of Segmental Bone Defects: A Biomechanical and MicroCT Analysis. 2010 annual meeting of the Orthopaedic Trauma Society, Oct 2010, Baltimore, MD (Oral Presentation).

Li R, Nauth A, Qamirani E, Atesok K, Schemitsch EH. Endothelial Progenitor Cell Characterization and Growth Factor Expression in a Bone Defect Model. 2010 annual meeting of the International Society for Fracture Repair, Sept 2010, London, England (Oral Presentation).

Li R, Atesok K, Nauth A, Qamirani E, Wright D, Whyne CM, Schemitsch EH. Endothelial Progenitor Cells for Healing of Segmental Bone Defects: A Radiographic, Biomechanical, and MicroCT Analysis. 2010 annual meeting of the International Society for Fracture Repair, Sept 2010, London, England (Oral Presentation).

Manjoo, A, Sanders, D, Lawendy, A, and Badhwar, A. Indomethacin Decreases Cell Damage Due to Elevated Compartment Pressure: An Experimental Study in Rats. Canadian Orthopaedic Association Annual Meeting, Quebec City, Quebec, 2008.

Manjoo, A, Sanders, DW, Lawendy, A, and Badhwar, A. Indomethacin: Shedding new light on compartment syndrome. Orthopedic Trauma Association Annual Meeting, San Diego, California, 2009.

Manjoo, A, Lawendy, A, Sanders, DW, Gray, DK, Parry, NG, and Badhwar, A. Indomethacin intervention may preserve muscular integrity during compartment syndrome. Combined Australasian Trauma Society and Trauma Association of Canada Annual Scientific Meeting, Auckland, New Zealand, 2009.

McGarr, GW, Sanders, DW, and Badhwar, A. The molecular mechanisms of compartment syndrome. Canadian Orthopaedic Association Annual Meeting, Whistler, British Columbia, 2009.

Morshed S. Femoral nailing in bicarbonate-defined hypoperfused trauma patients predicts pulmonary dysfunction. American Academy of Orthopedic Surgeons (March 2008, San Francisco, CA, USA). Oral Presentation.

Morshed S, Miclau T, Bembom O. Delayed femoral shaft fracture internal fixation in multi-system trauma patients decreases mortality in the National Trauma Data Bank. Orthopedic Trauma Association Meeting (October 2007, Boston, MA, USA). Oral Presentation.

Nauth A, Li R, Schemitsch EH. Endothelial Progenitor Cells for Healing and Angiogenesis in a Segmental Bone Defect Model: A Comparison With Mesenchymal Stem Cells. Poster presentation at the 5th annual meeting of the Canadian Society for Clinical Investigation, Sept 2009, Ottawa, ON.

Nauth A, Li R, Schemitsch EH. Endothelial Progenitor Cells for Healing and Angiogenesis in a Segmental Bone Defect Model. Oral presentation at the Orthopaedic Research and Education Foundation Resident Research Symposium, May 2009, Rochester, NY (Winner of Best Resident Research Presentation).

Nauth A, Li R, Schemitsch EH. Endothelial Progenitor Cells for Healing and Angiogenesis in a Segmental Bone Defect Model: A Comparison With Mesenchymal Stem Cells. Paper presentation at the 2010 annual meeting of the Orthopaedic Trauma Society, October 2010, Baltimore, MD.

Nauth A, Li R, Schemitsch EH. Endothelial Progenitor Cells for Healing and Angiogenesis in a Segmental Bone Defect Model: A Comparison With Mesenchymal Stem Cells. Paper presentation at the 2010 annual meeting of the International Society for Fracture Repair and Winner of Best Scientific Paper, Sept 2010, London, England.

Nauth A, Li R, Schemitsch EH. Endothelial Progenitor Cells for Healing and Angiogenesis in a Segmental Bone Defect Model: A Comparison With Mesenchymal Stem Cells. Poster presentation and New Investigator Recognition Award Finalist at the 56th annual meeting of the Orthopaedic Research Society, March 2010, New Orleans, LA.

Nauth A, Li R, Schemistsch EH. Endothelial Progenitor Cells for Healing and Angiogenesis in a Segmental Bone Defect Model: A Comparison With Mesenchymal Stem Cells. Paper presentation at the 2010 annual meeting of the American Academy of Orthopaedic Surgeons, March 2010, New Orleans, LA.

Peeters J, Gotthardt, M, Verdonschot N, Blokhuis TJ. Osteoporosis in fracture healing in rats. Dutch Annual

Presentations

Trauma Society Meeting 2009. Oral Presentation.
Petrisor B, Jeray K, Schemitsch E, Hanson B, Sprague S, **Sanders D, Bhandari M, FLOW investigators.** Fluid Lavage of Open Fracture Wounds (FLOW): A survey of 984 surgeons. Orthopaedic Trauma Association (October 2007, Boston, MA, USA). Poster Presentation.
Petrisor B, Jeray K, Schemitsch EH, Hanson B, Sprague S, Sanders D, Bhandari M Fluid Lavage in Open Fracture Wounds (FLOW): An International Survey. International society for fracture repair (July 14-16, 2009, Lake Tahoe, Nevada, USA). Poster Presentation.
Petrisor B, Jeray K, Schemitsch E, Hanson B, Sprague S, Sanders D, Bhandari M. Fluid Lavage in Open Fracture Wounds (FLOW): An International Survey. Canadian Orthopaedic Associtation (June 4-8, 2008, Quebec City, Canada). Oral Presentation.
Poeze M. Effect of NO metabolism on bone metabolism in non-union. Research Meeting University Hospital Maastricht September 2007, Maastricht, the Netherlands.
Sampson HW. Perturbation of the miRNA Regulation of the Inflammatory Stage of Fracture Healing by Alcohol Consumption. Research Society on Alcoholism. June 20 – 24, 2009. San Diego, US (Oral presentation).
Sampson HW, Li H, Zeitouni S, Gregory S. MicroRNA Regulation in Bone Tissue is Affected by Alcohol Consumption. 39th International Bone and Mineral Society Workshop on Musculoskeletal Biology. August 9-12, 2009, Sun Valley, Idaho, US. Poster presentation.
Sanders, D, Lawendy, A, Bihari, A, and Badhwar, A. Inflammation Causes Cellular Damage in Compartment Syndrome: An Experimental Study. Canadian Orthopaedic Association Annual Meeting, Quebec City, Quebec, 2008.
Sanders, DW, Manjoo, A, Lawendy, A, and Badhwar, A. Indomethacin: Shedding new light on compartment syndrome. Canadian Orthopaedic Association Annual Meeting, Whistler, British Columbia, 2009.
Sanders, DW, Chan, G, and Badhwar, A. Hypothermia in compartment syndrome. Canadian Orthopaedic Association Annual Meeting, Whistler, British Columbia, 2009.
Savaridas T, Muir AY, Gaston MS, Noble BS, Simpson AHRW. A Murine Model of Internal Plate Fixation. British Orthopaedic Research Society (BORS), Manchester, UK. Jun 2008. Poster Presentation.
Shi HF, Cheung WH, Qin L, Lee KM, Leung KS. Low-magnitude High-frequency Vibration Accelerates Fracture Healing in Rats. 16th IAA Human In Space Symposium (May 2007, Beijing, China). P65 Oral presentation.
Shi HF, Cheung WH, Qin L, Lee KM, Leung KS. Effect of Low-magnitude, High-frequency Vibration Therapy on Fracture Healing in Rats. 53rd Annual Meeting of Orthopaedic Research Society (February 2007, San Diego, USA). Poster presentation.
Shi HF, Cheung WH, Qin L, Lee KM, Chan KW, Leung KS. Expression of type I/II collagen and BMP-2 gene in low-magnitude high-frequency vibration treated rat fracture healing. 2nd International Congress of Chinese Orthopaedic Association (CORS) (November 2007, Zhengzhou, China). Poster presentation. P55 (PS1-08-090).
Shi HF, Cheung WH, Qin L, Lee KM, Chan KW, Leung KS. Regulation of Type I/II Collagen and BMP-2 in Low-magnitude High-frequency Vibration Treatment on Fracture Healing – A Rat Study. 27th Annual Congress of The Hong Kong Orthopaedic Association (November 2007, Hong Kong, China). Oral presentation.
Slobogean GP, Sanders D. When is Plate Fixation for Undisplaced, Unstable Fibular fractures Cost Effective? Results from a Multicentre Randomized Control Trial. Orthopedic Trauma Association Meeting, Baltimore, MD USA. October 2010 (Poster Presentation).
The Canadian Orthopedic Trauma Society (COTS). Operative vs Nonoperative Treatment of Unstable Lateral Malleolar Fractures: A Randomized, Multi-Centre TrialOrthopedic Trauma Association Meeting, Baltimore, MD, USA. October 2010. (Podium Presentation).
Van Raaij T. Same level fibular plating versus not plating in distal metaphyseal tibia fractures treated with intramedullary nails: a randomized trial OTC Research Symposium (June 2010, Amsterdam, the Netherlands). Oral Presentation.
Wehner T. Optimization of locked srew devices. OTC Research Symposium (June 2010, Amsterdam, the Netherlands). Oral Presentation.
Yu YY, Lieu S, Colnot C. Distinct effects of BMP-2 on cell differentiation in periosteum and endosteum during bone healing. 54th Annual Meeting of the Orthopaedic Research Society (May 2008, San Francisco, USA). Poster Presentation.
Yu, YY, Miclau, T, Marcucio, RS, and Colnot, C. Expression of bone morphogenetic proteins activation pathway and its antagonists during tibial fracture healing. 55th Annual Meeting of the Orthopaedic Research Society (February 2009, Las Vegas, USA). Poster Presentation.

Announcement Research Grants 2012

Hot topics

- Treatment of fractures in osteoporotic bone
- Assessment of fracture repair in patients

General Topics

- Promotion of fracture healing
- New technologies in fracture fixation, including computer-assisted surgery
- Prophylaxis and treatment of post-traumatic infections
- Prospective clinical trials in fracture care
- Numerical methods in trauma surgery

Timelines

- Pre-proposal submission deadline **October 15, 2011**
- Pre-proposal review: **November 2011**
- Full-length proposal invitation: **December 15, 2011**
- Full-length grant application deadline **January 31, 2012**
- Full-proposal review: **March 2012**
- Grant Award notification **April 2012**
- Grant transfer: **July 1, 2012**

For more information on the application process please consult the OTCF website at **www.otcfoundation.org.**
Questions can also be addressed to **research.grants@otcfoundation.org.**

OTC Foundation at a Glance

The backbone of the Foundation consists of an interactive global network of surgeons and scientists, dedicated to the advancement of osteosynthesis and trauma care through education, research and humanitarian activities. The goal is to attract both younger and experienced professionals and strives to be competent also in the fields of fragility fractures and osteoporosis.

Founded in 2007 by Stryker Trauma SA, the Swiss OTC Foundation (OTCF) consists of:

- A purely Scientific Body which includes Executive, Education and Research Committees, all composed of global leaders;
- A Board of Trustees that assures and enforces legal requirements; and
- A supportive administrative team in Bern, Switzerland.

Education is based upon worldwide CME accredited courses, forums and fellowships. Research is supported with grants, publications and symposia through knowledge sharing and wisdom.

The OTCF Education Committee (EDCO) organizes advanced level, indication-related courses that last two days for approximately 40 surgeons: an annual triple wet-lab-course for a specific indication (Americas, Europe, Asia), a triple course on fragility fractures, and one for emerging markets. The courses take place worldwide at local educational centers.

Other activities include Leadership and Regional Forums and more than a dozen international Fellowships (lasting two or four weeks) held at one of our OTCF Host Centers.

The Research Committee (RECO) guides the significant global research grants, research courses and international symposia regarding osteosynthesis and trauma care. Other research activities cover publications such as books, yearly supplements to the international Journal of Orthopaedic Trauma and some research fellowships.

Humanitarian activities include cooperation with proven international organizations: Active surgeons showing an interest may be invited to short-term assignments, retired surgeons may be invited to longer assignments. Additional projects are subject to internal evaluation.

The Global OTC Alliance is made up of the Foundation and 18 independent OTC Chapters located around the world. The OTC Country Chapters are mainly locally-funded entities that focus on education, with regular local courses. Services are offered to these Chapters, by interlinking them through common meetings and addressing them and their members directly via a global OTC web platform.

The OTC Foundation differentiates itself from similar organizations by providing transparent structures and bylaws that foster and encourage openness and debate. Committees, also in the fully adhered Chapters, adhere to term limits that offer interesting perspectives to younger members.

For more information visit our website at www.otcfoundation.org or contact us at info@otcfoundation.org.

OTC Osteosynthesis & Trauma Care Foundation

www.otcfoundation.org

The OTC Research Program is supported by a grant from Stryker Osteosynthesis