FM69 Laparoscopic assisted resection of an ileosacral chondrosarcoma

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Rationale: According to contributions of Yonamine we have begun to resect sacral tumors with video-laparascopic exposure of the anterior structures.

Patient: A 33-year-old woman 6 weeks after her second normal vaginal delivery complained of lumbosacral dysesthesia. Imaging showed a mass of the sacrum crossing the ileosacral joint suggestive of a chondrosarcoma, after biopsy graded G1, calculated volume 700 cc.

Technique: The procedure was performed in an unstable lateral decubitus starting with the anterior laparascopic exposure of the os sacrum and the right pelvic sidewall by passing through right pararectal space and full mobilization of the rectum from the promontorium downwards to the pelvic floor. After transection of the sacral hypogastric fascia, the medial and caudal limits of the tumor and as well as the SNR were identified. While the sacral nerve roots L5 - S2 attached on the tumor, while S3 and S4 were free. Full exposure of the pelvic ureter followed by the coagulation and transection of the internal iliac and the lateral sacral vessels. All cardinal vessels below the tumor were also transected including the pudendal and inferior gluteal vessels. The dissection of the lumbosacral space enabled the exposure of the lateral limits of the tumor and identification of both the obturator nerve and the sciatic just before it entry through the great sciatic foramen. 2 Gigli saws were inserted from anterior to posteriorly, one through foramina L5 and S1, the other through S1 and S4 for transection of the sacrum under visual endoscopic control. The resection of the ilium was performed in analogy to a Judet approach externally.

For reconstruction the defect was replaced with a massive allograft and stabilisation performed by lumbo-ischial screw and rod fixation.

The total blood loss was judged to be about 1000 cc; the total replacement were 2 units of blood.

Results: Pathologic examination showed uncontaminated margins.

Conclusion: We have got the impression, that the anterior video-laparascopic approach presents several advantages by giving a superior view, higher precision and decreased blood loss for tumors in this anatomical difficult location of tumors.
In vivo monitoring of osteosarcoma primary tumor growth using fluorescent and Luciferent imaging

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Introduction: In osteosarcoma (OS), monitoring of metastases is very important, as this is the most important prognostic determinant of patient death. In our laboratory, we study OS in several mouse models. Using our lacZ tagging technique (Arlt et al., J Vis Exp. 2012) we can monitor metastases formation, but only ex vivo. Also, necrosis inside the primary tumor can overestimate tumor volume and the true amount of living tumor cells. We therefore looked into additional techniques to monitor primary tumor growth and metastasis formation in vivo. Here we present results of an experiment where OS tumor cells were tagged with the light-producing enzyme Luciferase (Luc), or the fluorescent proteins mCherry (mCh) or dsRed (dsR), in addition to our lacZ tag.

Methods: Female SCID mice were intratibially injected with either Luc/lacZ, dsR/lacZ, or mCh/lacZ tagged osteolytic 143B OS cells. Mice were scanned every week in the IVIS Lumina XR to monitor Luc, dsR and mCh presence, and primary tumor sizes were measured using caliper and micro-CT. To monitor Luc presence, mice were injected with substrate (Luciferin) immediately prior to measuring. For mCh and dsR monitoring, excitation wavelengths were 557 nm for dsR, and 587 nm for mCh. Scans took between 10-15 min, with two mice scanned simultaneously. After 28 days the animals were sacrificed, lungs were excised, stained for lacZ presence, and both macro (>0.1 mm) and micro metastases (<0.1 mm) were counted.

Results: Already 24 hrs after injection of the Luc tagged tumor cells a clear Luc signal was obtained in the hind limb, which increased further over time and peaked 28 days after tumor cell injection, at which time point lung metastases could also be detected. The dsR signal could only be detected after 28 days due to a high unspecific autofluorescent signal. mCh tagged tumors had an intermediate sensitivity. Unexpectedly, tumor sizes were significantly smaller in Luc tagged tumors compared to dsR and mCh tagged tumors, and mice injected with dsR tagged tumor cells had a larger amount of macrometastases. We found a strong correlation between caliper-measured and micro-CT measured tumor volumes.

Conclusions: Luciferase tagging is a very sensitive technique to monitor living tumor cells. Fluorescent mCherry tagging yielded the most consistent signal during primary tumor growth, whereas dsRed tagging was found to be unsuitable. These techniques allow us to monitor primary tumor growth and metastasis formation in vivo.
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FM71 Computer-aided matching of multimodal tomographic data for improved diagnostics and more accurate osteotomy planning in the oncological pelvic surgery

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Introduction: Planning of tumor resection in the oncological pelvic surgery involves usually multimodal tomographic imaging data. For pelvic osteotomy planning in case of pelvic bone tumors or soft tissue tumors infiltrating bones the computed tomography (CT) and the magnetic resonance imaging (MRI) data are principally used. In the context of diagnostics the nuclear medicine imaging methods like SPECT or PET play also an important role. Magnetic resonance angiography (MRA) could be helpful for evaluating the proximity of bone tumors to vascular structures. All these medical imaging modalities deliver complementary but uncorrelated diagnostic information. For its optimal use at the diagnostics stage and in the surgery planning, it is necessary to align and to correlate all the acquired imaging data. Up to now the correlation of the multimodal information is performed by the surgeons mainly mentally. The objective of this study is to investigate if and how the computer-aided matching of multimodal tomographic data can improve the diagnostics and the oncological pelvic osteotomy planning.

Methods: For computer-based correlation of the multimodal tomographic data several numerical matching methods have been developed and implemented. Two main classes of 3D data matching procedures have been applied in our study: voxel-based methods (based on the mutual information function) and surface-based methods (surfaces of anatomical structures have to be segmented in the data pre-processing phase). For an effective evaluation of the diagnostic-relevant matching results and an optimal osteotomy planning numerous advanced data visualization methods have been applied. A similar data processing pipeline has been performed in 8 oncological pelvic osteotomy planning cases.

Results: For each of these 8 cases at least one pair of multimodal tomographic data has been matched. In the majority of cases the multimodal data pair consisted of CT and MRI data. The matched datasets have been inspected and analyzed by the 2D and 3D visualization methods. For instance, 2D slice-view of one modality with free-movable small inspection window inside, showing the correlated grey-value information from the second modality. Other example is 3D volume rendering of one modality showing the tumor and the soft tissue information mixed with the 3D surface rendering of osseous structures segmented in the aligned second modality. In addition, the implemented virtual cutting tools allow performing more accurate osteotomy planning on the segmented 3D surface models due to numerical, not mental, data correlation. All this can be controlled in a full interactive way. The advantages of the proposed osteotomy planning method over the traditional approach have been confirmed in all 8 cases.
Conclusion: In all tested cases the new system demonstrated significant superiority over the traditional pelvic osteotomy planning based on the mental tomographic data correlation and 2D slice viewing. The proposed oncological pelvic osteotomy planning method has potential to become the method of choice for this class of surgery planning approaches.
**FM72** Biomechanical comparison of five different external fixation configurations for pelvic ring instability

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**Objective:** External fixation is useful in the primary treatment of pelvic ring injuries. The present study compared the biomechanical stability of five different configurations of an external pelvic ring fixation system.

**Methods:** Five configurations of the same anterior external pelvic ring fixation system were tested on pairs of Polyoxymethylene testing cylinders using a universal testing machine with \( n = 3 \) for each sample group. One single connecting rod was used in group SINGLE, two parallel connecting rods in group DOUBLE, two and four rods, respectively, in a tent-like configuration in groups SINGLE TENT and DOUBLE TENT and four rods in a rhomboid-like configuration in group RHOMBOID. Each specimen was subjected to a total of 2000 consecutive cyclic loadings at 1 Hz with sinusoidal lateral compression/distraction (+/- 50 N) and torque (+/- 0.5 Nm) loading alternating every 200 cycles. Translational and rotational stiffness were determined at 100, 300, 500, 700 and 900 cycles.

**Results:** The SINGLE TENT and RHOMBOID configurations already failed with a preloading of 50 N compression. The DOUBLE configuration had around twice the translational stability at 100, 300, 500, 700 and 900 cycles when compared with the SINGLE (\( p=.002, .003, .005, .000, \) and .000) and DOUBLE TENT (\( p=.001, .001, .001, .000, \) and .000) configurations. Rotational stiffness observed for the DOUBLE and DOUBLE TENT configurations was about 50 % higher when compared with the SINGLE configuration at 100 (\( p=.024/.012 \)), 300 (\( p=.019/.074 \)), 500 (\( p=.031/.011 \)), 700 (\( p=.003/.005 \)) and 900 cycles (\( p=.004/.006 \)).

**Conclusion:** Using two parallel connecting rods for external pelvic ring fixation provides the highest translational (lateral compression/distraction) and rotational (bending of the hip) stability.
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FM73 Return to sport after hip arthroplasty - an EMG study

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Introduction: An increasing number of patients suffering from osteoarthritis are young and expect from a hip arthroplasty not only to regain a complete pain relieve but also to return to a normal sport activity including running. Most surgeons allow their patients to start running 5 to 6 month after the operation. Is this period long enough to allow sufficient hip muscle recuperation?

Methods: Twelve patients between 55 and 65 years with a mean follow up of 4 years (6 months to 8 years) after hip arthroplasty were included in this study. All had been practicing running regularly before having developed osteoarthritis and all had continued after the operation. Spatio-temporale parameters were extracted at different velocity with 3-dimensional accelerometers and gyroscopes on the feet. Simultaneously the muscle activity of the gluteus maximus, the gluteus medius and the rectus femoris of both sides were recorded with EMG sensors. The parameters were validated with 4 healthy control subjects.

Results: All participants had started again to run regularly six months after the operation. Six to twelve months after the operation, the EMG signal shows a high variability and the eccentric contraction of the hip muscles were not clearly perceivable. At 12 months, the EMG-signal of the gluteus maximus becomes progressively more regular and between 1 and 2 year, the one of the gluteus medius. 2 to 3 years postoperative the peaks of the eccentric contraction of the three hip muscles are again attained simultaneously.

Conclusion: The simultaneous measurement of the EMG of the three main hip muscles allows to detect the stepwise normalization of their function after hip arthroplasty. A well coordinated eccentric contraction of the extensor muscles reduces the transmission of excessive forces up to the hip joint during running. An intensive reinforcement of the hip muscles is mandatory after hip arthroplasty. Before starting to run again, at least the eccentric contraction of the gluteus maximus should be normalized.
Range of Motion Analysis for the Design Optimization of a Bi-Directional Total Hip Endoprosthesis

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Introduction: After total hip arthroplasty, dislocation is one of the most frequent serious early complications. This occurs in part due to impingement (catching and leverage of the neck-cup on the inlay/cup border). Impingement may also negatively impact long-term outcomes.

Materials and Methods: A preliminary model for an optimized hip endoprosthesys system was developed to offer a mechanical solution to avoid impingement and dislocation. A computer-supported range of motion simulation using parameters of cup anteversion and inclination as well as torsion and CCD shaft angle was then performed to localize areas of anterior and posterior impingement of typical acetabular cups.

Results: Through isolation of the two main trajectories of motion, and modifications with corresponding gaps to the inlay/cup areas as well as oppositional banking in the abduction/adduction plane, the combination of a snap-fit acetabular cup with reduced cup profile was the result: the "bidirectional total hip prosthesis."

Under standardized parameters, the ranges of impingement for typical implants are not directly opposite one another (at 180°), but are found instead at an angle of 108.3°.

Conclusion: Complications such as dislocation and impingement may possibly be avoided with the bidirectional total hip prosthesis. Typical implantation parameters yield an implant design with rotational asymmetry.
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**FM75 The Fifth Muscle of the Quadriceps Muscle Group.**

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**Introduction:** The quadriceps femoris (Q) is traditionally described as a muscle group composed of the rectus femoris (R) and the three vasti (lateralis, intermedius and medialis). However, clinical experience and investigations of anatomical specimens are not consistent and do not reflect accurately the description of anatomy textbooks. Following careful exposure of the muscle bellies we found an intervening muscle belly (IM) between the vastus lateralis (VL) and the vastus intermedius (VI). The aim of this anatomical study was to clarify, with regards to muscle innervation, whether the intervening muscle we observed was a variation of the VL, the VI, or a separate head of the extensor apparatus.

**Methods:** Twenty-six cadaveric lower limbs from sixteen specimens were investigated using macro dissection techniques. The limbs of four specimens were cut transversely in the middle third of the thigh. With special attention to the innervation and vascularisation pattern, the architecture of the quadriceps was examined to confirm its anatomy. Additional muscle bellies were sought; all muscle bellies of the Q were traced from their origin to their insertion, and their affiliation was determined.

**Results:** In all dissections, an intervening muscle (IM) was found between the muscle bellies of the VL and the VI. Similar to the VL and VI, the IM was innervated by independent muscular branches of the femoral nerve and vascularised through separate muscle branches of the lateral femoral circumflex artery. In the proximal aspect this muscle could always be separated easily from the VI. Further distally, at the junction into the tendinous portion, the A of the IM was adjacent to the lateral fasciae of the VI. Before entering the quadriceps tendon (QT), the layers of VL, VI and the IM could be clearly separated. Four morphological types of IM were divided: Independent Type, VI-Type, VL-Type and Combined Type.

**Conclusion:** This study demonstrated a different architecture of the Q as compared to previous descriptions. There is an additional muscle belly between the VI and VL, which cannot be clearly assigned to the former or the latter. Distal exposure shows that this muscle belly becomes its own aponeurosis (A), which continues distally as part of the QT. To our knowledge, the IM has not been previously described or illustrated in any textbook of anatomy.
Muscle Imbalance of the Knee Extensors does not affect Patellar Tracking in the ACL Deficient Knee

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Introduction: Aberrant patellar tracking is known to be an important risk factor in the pathogenesis of patellofemoral pain syndrome (PFPS) and patellofemoral osteoarthritis (OA). Although the etiology is still unclear and multifactorial, abnormal tracking of the patella caused by muscular imbalance of the quadriceps muscle is considered to be an important contributing factor [1]. Especially after knee injuries, weakness and atrophy of the knee extensor muscles followed by altered patellar tracking are commonly seen [2]. Quadriceps strengthening exercises focusing on the vastus medialis muscle (VM) have been suggested as a therapeutic approach to retain knee extensor strength balance. However, results of these studies are not consistent. Moreover, data from in vivo experiments looking at dynamic patellar joint kinematics and muscle force are scarce. Therefore the purpose of this study was to evaluate the influence of the loss of the vastus medialis muscle force on patellar tracking in the intact and anterior cruciate ligament (ACL) deficient knee.

Methods: Eight skeletally mature New Zealand White Rabbits, weighing 6.0kg ± 0.6 (mean ± SD) were used. The animals were placed in a custom built stereotactic frame rigidly fixed at the hips and the distal femur by bone pins. The experimental trial consisted of active, concentric (con) and eccentric (ecc) movements of the knee joint, ranging from 30 to 90° of flexion (eleven limbs, n=11). Measurements were first performed with the knee fully intact (intact control); then, the ACL was transected through a medial arthrotomy, and last, the VM was transected to produce a vast muscle force imbalance. Knee extensor forces for all control, ACL and VM transected trials were matched (≤ 5% difference of peak force) as force is known to affect patellar tracking [3]. For muscle stimulation, a custom made femoral nerve cuff electrode was used. Patellofemoral kinematics (lateral shift, rotation and patellar tilt) were quantified from high speed video (200Hz, optical resolution 0.08mm) which measured the displacement of bone pins imbedded rigidly in the patella relative to bone pins in the distal femur. Statistical analysis was performed using a one way repeated measures ANOVA and Fisher’s post hoc analysis. Statistical significance was set at p<0.05. Intraobserver repeatability was assessed by analyzing selected trials three times and calculating the associated variance. The study was approved by the Institutional Review Board for Animal Care at the University of Calgary.

Results: VM transection did not alter the patellar tracking, tilting or rotation significantly for any of the force-matched experimental conditions. After ACL transection, patellar tracking occurred more laterally for the concentric and eccentric contractions (p<0.001, mean shift 0.3mm (± 0.48mm), and 0.3mm (±0.51mm), respectively (Figure 1a,b), and caused a significant lateral rotation of the patella (p<0.001, mean rotation 1.8° (±2.2°) and, 2.3° (±1.7°), respectively (table 1). No changes in patellar tilt were seen. In all trials, force-matched contractions were
accomplished within 5% of each other. Eccentric contractions resulted in higher force production than concentric, 388 ±83 Ncm, and 252 ±78 Ncm, respectively. Mean intraobserver repeatability was 0.1 ±0.02 mm.

**Discussion:** Our results suggest that the isolated loss of vastus medialis muscle force does not affect patellar tracking, rotation or tilting compared to force-matched concentric and eccentric movements in the ACL deficient knee. These results concur with previous findings where we analyzed patellar pressure distribution and patellar tracking in the intact and VM transected animal model, but contradict some results in the literature [3-5]. It is not clear if the results obtained here in a rabbit model can be directly translated to the human knee. However, the VM has a similar insertion into the human and rabbit patellae, and the fiber direction of the distal VM is virtually the same (about 45° from the femoral axis) in humans and rabbits, suggesting that the current results should be considered carefully in future interpretations of knee extensor imbalance in humans.

**Significance:** Our study is the first to investigate patellar tracking in vivo in the ACL deficient knee superimposed with a selective and controlled muscle imbalance. The findings of this study suggest that muscle imbalance in the ACL-deficient knee does not affect patellar tracking, as has been found previously in the intact, stable knee of rabbits. Therefore, strengthening of the VM in patients with patellar mal-tracking might not restore normal tracking patterns, as has been suggested in the past.

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**Increased macrophage infiltration and trap activity characterize subchondral bone sclerosis in knee osteoarthritis**

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**Background:** Recent investigations have provided substantial evidence that distinct molecular and morphological changes in subchondral bone tissue, most notably sclerosis, play an active and important role in the pathogenesis of OA. The cellular and molecular regulation of this pathological process remains poorly understood.

**Objectives:** We investigated whether osteoimmunology, the reciprocal signaling between cells from the immune and bone system, is involved in OA subchondral bone sclerosis.

**Methods:** Tibial plateaus and informed consent were obtained from patients undergoing total knee arthroplasty due to end-stage OA. Subchondral bone mineralization distribution was analyzed using computed tomography osteoabsoptometry (CT-OAM) and standardized cryosections of low (non-sclerotic) and high (sclerotic) bone mineralization were prepared (n=18 each). Cartilage degeneration was graded in Safranin-O-stained sections using the Mankin scoring system. The presence of T-lymphocytes, B-cells and macrophages was assessed using immunohistochemical staining of their respective surface markers CD3, CD20 and CD68. Osteoclast activity was visualized by staining of the enzyme marker tartrate-resistant acid phosphatase (TRAP). Cellular characterization of ex vivo subchondral bone outgrowth cultures was performed using alkaline phosphatase (ALP), TRAP staining. Correlation between histologic parameters was assessed using Spearman’s rank correlation. Statistical differences were calculated using Wilcoxon signed rank test or paired t-test, where appropriate.

**Results:** CT-OAM revealed a heterogeneous distribution of subchondral bone mineralization in OA tibial plateaus, displaying focal areas of sclerosis that overlapped macroscopically with areas of cartilage damage. These data were confirmed at the histological level by a strong correlation between Mankin score and grade of sclerosis (r=0.7, p<0.001). Immunohistochemistry showed that CD20⁺, but not CD3⁺, lymphocytes and CD68⁺ mononuclear (macrophage) and multinucleated (osteoclast) cells were present in subchondral marrow spaces. Notably, the number of CD20⁺ lymphocytes and CD68⁺ cells was significantly (p<0.05) increased in sclerotic subchondral bone. Enhanced osteoclast activity was confirmed by a significantly increased (p<0.05) number of multinucleated and mononuclear TRAP⁺ cells in sclerotic bone. Finally, the number of CD68⁺ cells was strongly correlated (p<0.001) with Mankin score (r=0.7), grade of sclerosis (r=0.8), CD20⁺ lymphocytes (r=0.8), and TRAP-positive cells (r=0.9).

Outgrowth cultures of subchondral bone showed cells of different morphologies including fibroblast-shaped osteoblasts and macrophage-like cells. Expression of ALP was detected in the
prior, while TRAP expression was evident in the latter. Corresponding with histological analyses, the number of TRAP$^+$ cells was increased in vivo outgrowth cultures of sclerotic compared to non-sclerotic subchondral bone.

**Conclusions:** Together, our data suggest that osteoimmunological mechanisms, specifically the interaction of CD68$^+$ macrophages with bone-resident cells, play a previously unknown role in regulating subchondral bone sclerosis in progressive OA. Targeting osteoimmunology might hold potential as a disease-modifying treatment for OA.
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**FM78 Histological Evaluation of SPECT-CT Imaging in End-stage Ankle Osteoarthritis**

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**Objective:** Single photon emission computed tomography (SPECT)-CT is an emerging diagnostic imaging tool for osteoarthritis (OA). While subchondral bone sclerosis is a hallmark of end-stage OA, the cellular and molecular mechanisms of increased bone turnover in OA remain elusive. In this study, we investigated the cellular mechanisms of increased bone remodeling, defined by SPECT-CT, in patients suffering from end-stage ankle OA.

**Methods:** Pre-operative SPECT-CT imaging, using $^{99m}$Tc-dicaproylphosphonate ($^{99m}$Tc-DPD), was performed in six consecutive OA patients (mean age 63, range 52-72) undergoing total ankle replacement. AOFAS score and VAS were used for clinical evaluation in this study group. Intra-operative distal tibial and talar resections were obtained and standardized samples (5x5 mm) were divided into four categories according to subchondral bone density (low or high) and $^{99m}$Tc-DPD uptake (negative or positive). For histological analyses, tissue sections (10 mm) were stained with haematoxylin and eosin (H&E) and van Gieson’s stain to evaluate cellular morphology and extracellular connective tissue, respectively.

**Results:** Preoperative AOFAS score and VAS were 40±15 (range 20-56) and 7.5±0.84 (range 7-9), respectively. The spatial distribution of SPECT-CT-positive lesions was heterogeneous, with hotspots located in four tibial and two talar resections. $^{99m}$Tc-DPD uptake was found exclusively in areas of increased bone density (sclerotic) as defined by CT scans, while $^{99m}$Tc-DPD tracer-negative areas were both of low and high bone density. H&E staining revealed marked infiltration of subchondral bone marrow spaces by a fibrovascular tissue in SPECT-CT-positive regions. Bone-lining osteoblasts were specifically present in these regions, while they were absent from SPECT-CT-negative subchondral bone. Van Gieson’s staining showed a massive increase of collagen deposition into randomly organized fibers, which is typical for formation of woven bone as a result of rapid osteoblast-mediated osteoid production.

**Conclusion:** In end-stage ankle OA, increased $^{99m}$Tc-DPD tracer uptake in subchondral bone tissue corresponds with fibrovascular marrow infiltration and osteoblast-mediated woven bone formation. These findings indicate that extensive subchondral bone remodeling plays an important role in the development and progression of OA in SPECT-CT positive areas of the ankle.
A comparative study of growth factor release from L-PRF and L-PRP and their effect on migration of mesenchymal stem cells and endothelial cells

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Objective: The aim of this in vitro study was to investigate the release of growth factors from L-PRP and L-PRF during 28 days of culture and their influence on the migration of MSC and endothelial cells, two cell types with an important role in the healing process.

Study design: Blood samples were collected from 11 young healthy male volunteers, and L-PRP and L-PRF were prepared using standard protocols. Platelet-rich concentrates were placed in culture media and incubated at 37°C in CO₂ incubator for 28 days. Media was collected with new media addition after 8h, 1, 3, 7, 14 and 28 days. The levels of vascular endothelial growth factor (VEGF), platelet derived growth factor AB (PDGF), insulin-like growth factor-1 (IGF-1), transforming growth factor β1 (TGFβ1), and interleukin 1β (IL-1β) were quantified using ELISA. A cell migration assay using MSC and endothelial cells in a Boyden Chamber was performed with media samples collected at all time points.

Results: When compared to L-PRF, L-PRP released higher amounts of VEGF, PDGF, IGF-1 and TGFβ1 within the first 8 hours. In contrast, L-PRF released significantly more PDGF and IGF-1 from 1 to 3 days, significantly more VEGF and TGFβ1 from 3 to 7 days while only release of TGFβ1 was significantly increased from 7 to 14 and from 14 to 28 days when compared to L-PRP. Release of VEGF and TGFβ1 from L-PRF was constant for the first 7 days, followed by a decrease until the end of the culturing period; in contrast, it peaked from 3 to 7 days from L-PRF. PDGF and IGF-1 release was continuous from L-PRF for the first 3 days, followed by a decrease, while it decreased already after 8 hours and remained low from L-PRP. IL-1β release was similarly low in both platelet concentrates.

The chemoattractants released from L-PRF within the first 8 hours, and from 1 to 3, 3 to 7 and 7 to 14 days induced significant migration of endothelial cells in comparison to L-PRP. Similarly, L-PRF chemoattractants released from 1 to 3 and 3 to 7 days resulted in a significantly higher migration of MSC compared to L-PRP.

Conclusion: The release of growth factors from the L-PRP peaked at the onset of culture, while being continuously release from L-PRF over a period of 28 days. Moreover, L-PRF demonstrated better chemoattractant properties with endothelial cells and MSC compared to L-PRP. Depending on whether a boost or a constant release of growth factors is desired for the healing process, L-PRP or L-PRF would be employed in clinics.
Gain of length - loss of strength? - Alteration in muscle strength after femoral leg lengthening with a motorized intramedullary nail

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Introduction: Intramedullary leg lengthening with a motorized nail can reduce the complications which are associated with leg lengthening by external fixation. The data on the recovery of muscle strength after leg lengthening is very limited. This prospective observational study was designed to investigate the alteration in muscle strength in patients with a femoral leg lengthening with a motorized intramedullary nail.

Methods: Thirty patients with a median leg length discrepancy of 3.0 cm (range 2.4-8.0 cm) underwent femoral limb-lengthening with an intramedullary motorized device. Maximum isokinetic, concentric muscle strength of the extensors and flexors of the knee as well as range of motion were measured before (n=30) and a median of 2.0 years after the operation (n=21). The investigated parameters were analysed for any alterations before and after the procedure.

Results: Preoperatively there was a significant difference in median isokinetic muscle strength between the shorter and the normal leg in the extensor muscles (15%, p=0.01)). There was no significant difference in the flexors (3%). With increasing leg length discrepancy this effect also increased in the extensors. The etiology of the LLD had no effect on muscle strength. Postoperatively there remained a difference of muscle force of the extensors (22%) between the lengthened and the normal leg. There was no alteration in the flexors. There was no significant loss of muscle force in the lengthened leg.

Conclusion: There is no significant loss of muscle strength in the treated leg after the lengthening procedure with a tendency to a loss of strength in the extensors (7%). However we think that the remaining postoperative difference of muscle strength has no clinical significance. We infer that physical therapy should especially focus on the training of the extensors to diminish this effect.
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FM81 Treatment options in tendon healing following natural growth factor expression

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Introduction: Tendon ruptures recover slowly and the healing of injuries can be devastating. Growth factors are known to influence tendon healing. However, only little is understood about growth factors in a healing tendon. Aim of this study was to investigate the influence of growth factors on tendon healing of rats following their natural expression.

Methods: The Achilles tendon of rats were transected and resutured. First the expression of bFGF, BMP-12, VEGF and TGF-b1 was assessed by immunohistochemical analysis 1 to 8 weeks after surgery. Second the maximal failure load of healed Achilles tendons was measured dependent on the external application of bFGF, TGF-b1 and BMP-12.

Results: The natural expression of bFGF, BMP-12 and VEGF was highest 1 week after transection. VEGF expression persisted during the remaining period whereas bFGF and BMP-12 declined. TGF-b1 expression peaked again after 8 weeks. A combined application of bFGF, TGF-b1 and BMP-12 resulted in a 4fold greater load to failure after 1 week, whereas a sequential treatment of these growth factors increased the load to failure even 5.5fold.

Conclusion: During tendon healing, bFGF, BMP-12, VEGF and TGF-b1 are differentially expressed. Additional administration of growth factors can improve the load to failure in the early healing phase of rat Achilles tendons.
FM82 Nociception of Pain in Osteoarthritis May Be Triggered Through Intraosseous Nerve Fibers

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Background: The mechanism causing pain in osteoarthritis is not well understood. A connection between the presence of intraosseous sensory nerves and pain in osteoarthritis has not yet been established. We hypothesized, that in patients with severe joint pain and radiographically isolated, focal osteoarthritic cartilage degeneration, the source of pain may be exclusively localized within the subchondral bone.

Methods: This retrospective analysis includes five patients with isolated patellofemoral osteoarthritis confirmed by X-ray and MRI, with typical pain provocation upon compression of the patella against the femur. During a diagnostic knee arthroscopy two (lateral and medial) temporary intraosseous catheters were inserted under fluoroscopy into the patella through drill holes from anteroinferiorly. On the first postoperative day both catheters were sequentially injected with 0.5ml NaCl followed with up to 5ml of local anesthetic (ropivacaine0.5%). Pain (Visual Analog Scale=VAS 1-10) at rest and with patella compression before, during and after infiltration was documented.

Results: During instillation through the medial and lateral catheter into bone, the pain at rest shortly bursts from a mean of VAS 1.7 (range 0 to 4) to 8.3 (range 7 to 10) and 5.4 (range 0 to 10), respectively being very similar to the pain the patients had during previous axial patella compression. Pain upon patellar compression decreased from 5.5 (range 3 to 8) to 1.2 (range 0 to 3). Pain during ambulation decreased 100% in 3 patients, 75% in two patients and 50% in one patient during the effect of local anesthesia intraosseously.

Conclusion: The instillation of liquid volume (0.5ml saline) into bone provokes a short burst of severe pain, which resembles the pain felt preoperatively and the intraosseous local anesthetic did eliminate all pain upon patellar compression and was associated with a pain relief during ambulation. Therefore, we conclude that osteoarthritic pain may at least in part be sensed and transmitted through intraosseous nerves. The mechanism of pain triggering is most likely not a direct provocation of nerve endings but elicited through an increase of intraosseous pressure, either through deformation of bone or through inflow of joint fluid. These new findings may allow to explore new surgical or pharmacological approaches to understand, diagnose or treat osteoarthritic pain.
FM83  Does the Gamma 3 need to be distally locked for stable intertrochanteric fracture? A Finite Element Analysis

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Introduction: We could observe sometime a lack of the distal locking for gamma 3 short nail. This fact is mainly due to technical error. Nevertheless, some stable fracture heals without any displacement or complication.
The aim of our study is to simulate such cases based on finite element analysis.

Method: A finite element analysis was carried out to study implant behavior in cases of stable intertrochanteric fractures. A digital model of femur (Digital 3D Femur, ref. Sawbone 3908) corresponding to the medium left composite 4th generation Sawbone was used. Geometries of femur and implant are discretized in Abaqus software. A vertical load of 3000 N is progressively applied to the femoral head through a ball joint. Elastic behaviour laws are implemented for cortical bone (E = 16.35 GPa, v = 0.26), trabecular bone (E = 0.155 GPa et v = 0.3) and stainless steel implant (E = 200 GPa, v = 0.3). Stress distributions in bone and implant are calculated. Interfragmentary motions are described by normal an tangential components.

Result: The simulation demonstrates that the nail does not move longitudinally during vertical load corresponding to a full bearing step. The forces are transmitted to the fracture mainly through the cephalic screw. They are no traction or distraction on the distal locking screw.

Conclusion: This study demonstrates that the distal screw has probably no mechanical effect for stable intertrochanteric fracture treated by intramedullary short nail. Few clinical cases corresponding to such technical mistakes seem to confirm this fact. One could ask if such « technical mistake » could lead to change our procedure.
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(FM 69 – FM 85)

**FM84 Proximal femoral fractures : a new concept of implant, stress and interfragmentary compression analysis.**

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**Introduction:** This paper concerns a new concept of implant for fixing proximal femoral fractures. The solution lies in the adaptability of the implant to different morphologies. The implant has intramedullary and extramedullary parts. These elements are linked with a thin curved blade, allowing the deformation of the implant during insertion. An external device allows the adjustment of the relative position of these two parts leading to a possible adjustment of the angular orientation of the cephalic screw ranging from 115° to 135°. The support points of the cephalic screw on the two rigid parts are spaced apart, thereby limiting stress in implant. Moreover, the blade partially protects the greater trochanter and maintains the gluteus medius muscles.

**Method:** A finite element analysis was carried out to study implant behaviour in cases of stable intertrochanteric and unstable reverse obliquity fractures. A digital model of femur (Digital 3D Femur, ref. 3908) corresponding to the medium left composite Sawbone is used in this study. Geometries of femur and implant are discretized in Abaqus software. A vertical load of 3000 N is progressively applied to the femoral head through a ball joint. Elastic behaviour laws are implemented for cortical bone (E = 16.35 GPa, ν = 0.26), trabecular bone (E = 0.155 GPa, ν = 0.3) and stainless steel implant (E = 200 GPa, ν = 0.3).

**Results:** Stress distributions in bone and implant are calculated. Interfragmentary motions are described by normal and tangential components. Stresses in the new implant are of lower values (400 MPa) compared to yield stress material (800 MPa). Data are finally compared to those obtained by the numerical analysis of intramedullary nail and compression hip screw (similar to Gamma nail and DHS). Results show that the new implant is more suitable in terms of stress state. Data show a decrease of relative motions of fracture lips in the case of fractured femur fitted with the new implant regardless of fracture type.

**Conclusion:** A new implant for treating proximal femoral fractures is proposed in this study. The angulation of the cephalic screw can be adjusted by the surgeon according to the patient’s anatomy. No part of the femur is completely stiffened allowing the bone to follow its natural development. This type of implant could significantly reduce implants stocks in hospitals.
FM85  Impact of a Co-managed Hip Fracture Program on Treatment Process and Patient’s Outcome. A Prospective Quality Assurance Survey

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Objective: Dedicated hip fracture programs are increasingly implemented because of the impact of these fractures. Our objective was to quantify the impact of such a program in multiple dimensions and on different time scales by comparing it with usual care.

Design: Prospective longitudinal cohort quality assurance survey with two observation periods.

Patients: Included were hip fracture patients aged 65 years or older who were treated by our trauma service because of a hip fracture. The first “Usual care” group covers 272 patients who were admitted prior to the start of the hip fracture program. The second “co-managed” group covers 229 patients admitted subsequent to full implementation of the program.

Variables: Quality of treatment process was measured: Time to surgery, length of hospital stay, completeness of documentation. Patient’s outcomes were measured: Mortality rates (in-hospital, 30-days, and 1-year), readmission rates (30-days and 1-year) as well as long-term change from prefracture baseline in ambulatory- or residential status. Short-term data were acquired in person. Long-term follow up data were captured by means of telephone interview.

Results: We did not find statistical significant difference in basic data (age, gender distribution, frequency of fracture type, cognitive status), or prefracture ambulatory status between the two groups. Patients included in the second, co-managed sample were less likely to reside in the community (64% versus 70%), suffered from more preexisting comorbidities (CCI 2.5 versus 2.1; p=0.029), were more dependent when performing ADL (49% versus 27%; p<0.001), and finally suffered from a significantly higher 1-year mortality rate (30.6% versus 20.9%; p<0.01).

The results obtained are conflicting: Length of stay was statistically significant shorter in the co-managed group (12.3 days versus 9.6 days; P<.001). There were non-significant trends towards increased “Time to surgery”, and towards increased 30-day-readmission rate (9/272 versus 16/229; P=0.09) in the co-managed group. There were no significant differences between the two groups concerning in-hospital or 30-days mortality rates or 1-year readmission rates. We did not find significant differences in the frequency of change in ambulatory status or in residential status.

Conclusions: Despite of our efforts to create two equal groups we have to conclude that patients covered by the second sample were somewhat frailer than those covered by the first sample. The co-managed hip fracture program allowed decreased length of stay without adversely affecting...
long-term patient’s outcomes. The interdisciplinary care provided with the program did not alter patient’s short-term outcomes.