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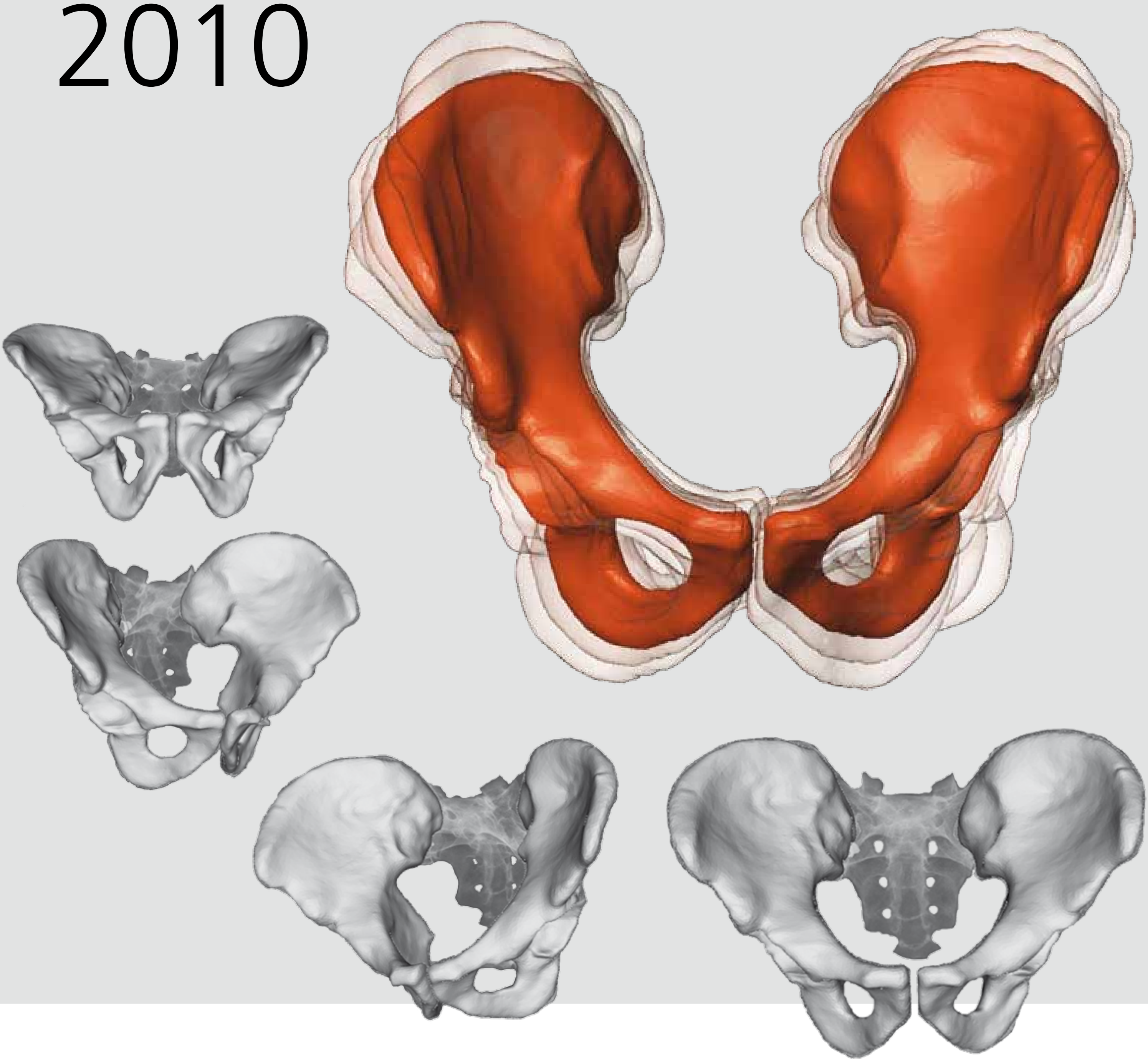
Annual Report 2010



Institute for Surgical Technology & Biomechanics

Contents

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Introduction

2010 in Retrospect

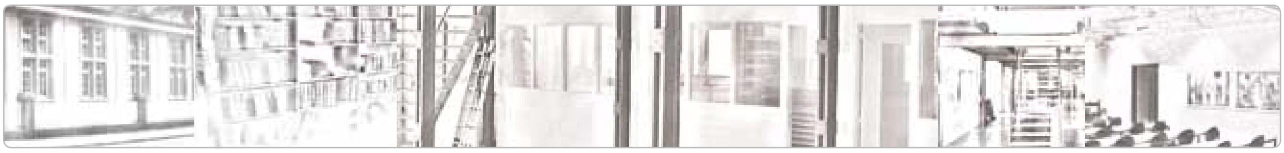
For the research groups of the Institute for Surgical Technology and Biomechanics (ISTB), 2010 was a year of continuous consolidation. Our institute comprises a multidisciplinary team of over 60 co-workers. It is also closely integrated into the Artificial Organ (ARTORG) Center for Biomedical Engineering Research (www.artorg.unibe.ch), with two faculty members cross-appointed between the two institutions. Through participation in national and international research network programs, we have been able to continue research activities in all of our focus areas.

External funding was maintained at a high level through both governmental funding and with major contributions by non-governmental organizations and our industrial partners. The ISTB continues to co-direct the Swiss National Center of Competence in Research CO-ME (www.co-me.ch) and hosts various projects and subprojects that have a primary focus on computer aided medical interventions. This network of excellence has now moved into its tenth year since its inauguration in 2001. Together with other key research groups and industrial partners the collaborative EU Spine FX program was realized in 2010. We were proud to have our research and development efforts recognized by several awards, including Venture Kick Stages I & II and the CTI Label for our start-up company CAScination. The close collaboration with CAScination provides our laboratory direct access to a highly advanced CE marked platform for navigated and robotic surgical planning and assistance. Key collaborative projects with the Swiss MedTech industry continue to be developed through funding from KTI/CTI, which is the Innovation Promotion Agency of the Swiss Federal Office for Professional Education and Technology.

In the past year, the ISTB contributed to the organization of several international scientific meetings, most notably, the annual meeting of the International Society for Computer Assisted Orthopaedic Surgery (CAOS 2010), the Advanced Training High-Tech Course for Paranasal Sinus and Skull Base Surgery (PSSB 2010), the sixth Otological Microsurgery Course with Emphasis on Minimally Invasive Techniques (OMMIT 2010), the BMT 2010 (D-A-CH Societies for Biomedical Engineering), and the 2010 Biomedical Engineering Day.

In 2010 we continued our activities in training undergraduates, graduate students, and postdoctoral fellows for future leadership roles in teaching, research, and industry. Our Master of Science in Biomedical Engineering program (www.BIOENG.Master.unibe.ch) continues to attract students nationally and internationally, the 5th class recently starting with 84 new students. Currently, more than 150 students are enrolled in the program to become specialists in biomedical engineering. The program continues to cover three main focus areas, in collaboration with the Bern University of Applied Sciences and the University of Basel. In addition, about 40 students from the ISTB and the ARTORG Center are currently enrolled in the interdisciplinary biomedical science doctoral program (www.gcb.unibe.ch).

Lutz P. Nolte
Director



Organization

Institute for Surgical Technology & Biomechanics

Management

L. P. Nolte
Director

Central Services

K. Fahnemann-Nolte
Administration

H. Studer
IT-Support

A. Neuenschwander
Administration

H. Lu
IT-Support

B. Schmitter
Administration

Division of Biomechanics

Orthopaedic Biomechanics
S. Ferguson
Division Head

Computational Bioengineering
P. Büchler

Tissue Mechanobiology
B. Gantenbein

Division of Surgical Technologies

Smart Device Technology
S. Weber
Division Head

Computer Assisted Orthopaedic Surgery
G. Zheng

Medical Image Analysis
M. Reyes

Master Biomedical Engineering

U. Jakob
Study Coordinator

Mechanical Design and Production

U. Rohrer

The ISTB conducts basic and applied research for the prevention and treatment of disease, working from the cell level to the whole locomotor system. The focus is on developing solutions that address particular clinical problems or unmet clinical needs. Currently, the institute focuses on two areas defined by its two primary divisions. The efforts of the Division of Surgical Technology are directed towards the development of surgical devices and technologies that provide improved surgical functionality, feedback, and integration, navigation and planning focused on less invasive procedures in various anatomical locations, and methods to process and optimally utilize data from a variety of medical imaging modalities. The focus of the Biomechanics Division is the application of mechanical principles to biological systems, with an emphasis on the musculoskeletal system. In order to improve current diagnostic and treatment methods, a combination of experimental and computational studies is applied. The ISTB brings together scientists from different areas of biomedical research and actively collaborates with other research and development groups nationally and internationally. Through our Center for Competence in Medical Technology, knowledge and technology transfer is promoted by involving partners from the medical technology industry.

Tissue Mechanobiology

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Group Members

      

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Research Profile

The Tissue Mechanobiology Group conducts research leading towards improving the current treatment methods for degenerative disorders and traumatic injuries of the spine. The group focuses its efforts on developing a better understanding of the interaction between living tissues and biomaterials, studying the influence of mechanical and physiological stimuli on tissue repair and development, and evaluating the potential for achieving a successful biological repair to an injury or to degeneration. We employ a variety of cell, tissue and organ level models in the study of normal and compromised intervertebral disc metabolism. A major initiative in our group is the development of appropriate three-dimensional scaffolds for the repair of intervertebral disc defects.

In 2010, we have consolidated our efforts in the Spine Research Center (SRC). The SRC is a joint program of the ISTB and the Department of Spinal Surgery at the Inselspital Bern, within the ARTORG Center for Biomedical Engineering Research. Prof. Benjamin Gantenbein-Ritter holds a cross-appointment between the ISTB and ARTORG and brings a complimentary biological research to our traditional biomechanics program. Details of related spinal research at the ARTORG Research Center can be found in the center's annual report (http://www.artorg.unibe.ch).

Current Research Areas

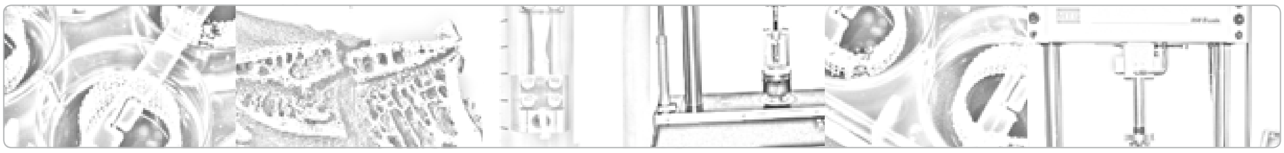
Direct Electrical Stimulation of Disc Cells

In the context of our program to investigate the mechanisms of solute transport in the disc, we have previously investigated the application of electrical fields to disc tissue, as a means to enhance solute transport via electro-osmosis or to enhance tissue permeability via electro-poration. However, the direct effect of electrical fields on cell metabolism is a relevant and little understood issue. The disruption of intradiscal streaming potentials has been proposed to contribute to extracellular matrix (ECM) degradation, e.g. in degenerative disc disease (DDD). In our previous monolayer studies with nucleus pulposus cells, we have identified viable ranges for electrical stimulation, using DC current or bipolar pulses. In a follow-on study, we have investigated the response of nucleus pulposus cells embedded in a 3D culture system to electrical stimulation. The use of a 3D culture system approximates the native extracellular matrix. A comprehensive series of trials was completed evaluating a broad range of electrical field strengths, current densities, pulse characteristics and stimulation duration. Evaluation of cell response was conducted with biochemical and molecular biological assays. A stimulation of disc cell metabolism by electrical field application could be demonstrated. The final goal is to explore the potential of local in situ electrical field application to the whole disc organ, as a means to maintain or restore disc matrix integrity and thus provide an avenue for a minimally invasive therapeutic approach for the treatment of DDD.

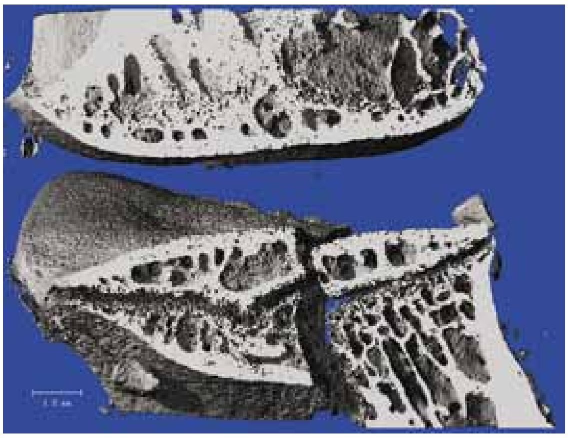
Nucleus pulpous cells embedded in a three-dimensional matrix are exposed to electrical field stimulation.

Post-Traumatic Disc Degeneration

We have previously demonstrated that fractures of the vertebral endplate can trigger a severe cascade of degenerative processes within the intervertebral disc. The cellular response to intervertebral disc trauma is characterized by a strong up-regulation of pro-inflammatory cytokines (IL-6, TNF-α) and chemokines (MCP-1, IL-8). These agents are the hallmark of acute inflammation and stand at the beginning of a sequence of actions that lead to wound healing. In most tissues, this phase is characterized by an infiltration of macrophages and polymorphonuclear cells (PMN). Whereas IL-8 is a potent chemoattractant for PMN, the



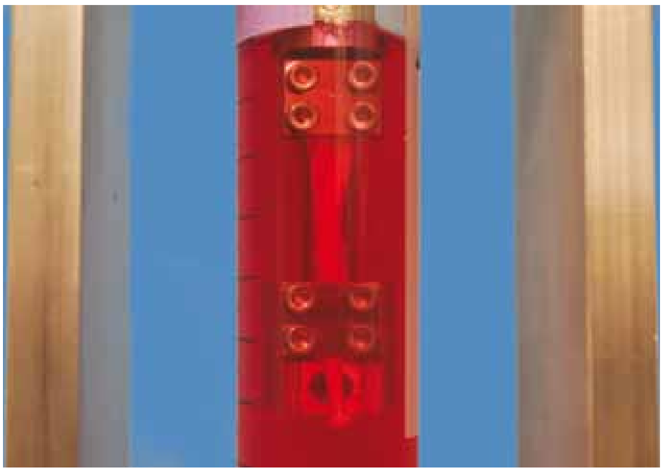
chemotactic effects of TNF-α on PMNs are discussed controversially. Once PMNs are attracted to the site of injury, they release their granules as a consequence of surface receptor activation. Upon trauma of the intervertebral disc, many putative PMN activators (fragments of collagen and hyaluronic acid, heparin sulfate, ATP, HMGB1, HSP, chromosomal DNA) are generated or released from disc cells. They are known as damage associated molecular patterns (DAMPs) and initiate a sterile inflammatory process. Endplate fractures facilitate the contact of disc material with PMNs and their activation. The implication of PMN in post-traumatic intervertebral disc degeneration was never investigated. Therefore we hypothesized that trauma of the intervertebral disc and adjacent endplate trigger PMN recruitment and activation. Preliminary data from our organ culture model showed synthesis of pro-inflammatory cytokines (IL-1, TNF-α) and chemokines (IL-6) by NP cells when co-cultured with disc fragments. However, histological evaluation did not show PMN engraftment in central regions of the organ, although some enrichment of PMNs may be seen in the outer AF and easily accessible regions of the fractured endplate.



Experimentally induced burst fracture of the vertebral endplate in a whole-organ model of post-trauma disc degeneration.

Comparing Stochastic Loading versus Cyclic Loading Regimes in vitro using Rabbit Tendons

It is generally unclear how oriented collagenous tissues such as spinal ligaments respond to mechanical loading and how they contribute to the overall biomechanical behavior of the spine. In the context of our mechano-biology program, we investigated a viscoelastic model of linearly-arranged tissue, i.e. tendon explants. Injuries to soft tissues such as tendons are very frequent and suboptimal healing can result in significant dysfunction and disability. Such injuries, due to repetitive (over-)loading, are a problem especially for workers and athletes. Overuse is thought to be the primary cause of injury, in which forceful or repetitive loading results in an accumulation of micro-tears leading to a maladaptive repair response. From a biological point of view, tendon tissue is avascular and incorporates only few cells that together account for a very low ability for self-renewal and repair, which is a common feature shared with spinal ligaments and the intervertebral disc. Traditional approaches to study the repair or augmentation of tendon strength involve repetitive and cyclic loading of the ruptured tissue. However, such a testing regime does not reflect the natural loading pattern exerted during daily activity. We investigated whether stochastic loading could provoke a more beneficial response than strict symmetric cyclic loading profiles. In this project, we evaluated whether tenocytes (the cells of the tendon) are mechano-sensitive to the mean stretching force over time, independent of the applied shape of the loading regime, i.e. cyclic stretching regimes vs. stochastic loading regimes with an equivalent mean frequency and mean stretching force over time. A further aim of the study was to demonstrate cellular, mechanical and viscoelastic responses of tendons and incorporated tenocytes. A loading device was developed, which allowed the culture of flexor digitorum profundus tendons of rabbits and also allowed at the same time to connect the tendon to a dynamic loading machine. The tendons were randomly assigned into three loading groups: stochastic stretching, sinusoidal cyclic stretching and unloaded controls. Tendons were cultured under standard tissue-culture conditions in an incubator and were removed and uni-axially stretched on a MTS machine for 1h for 7 days.



The response of tenocytes to stochastic and cyclic mechanical loading profiles is compared.

Orthopaedic Biomechanics

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Research Profile

The Orthopaedic Biomechanics Group conducts basic and applied research focused on expanding the knowledge of the mechanisms of musculoskeletal disorders and developing improved strategies for their treatment. A main thematic area of study is the complex relationship between spinal loading, spinal motion, injury or degeneration and alterations to the biochemical and structural properties of the spine.

Work continues on the effective treatment of osteoporotic and traumatic fractures of the spine. In 2010, we continued our activities within the European Union consortium project VPHOP (Osteoporotic Virtual Physiological Human), using computer simulation and experimental methods to improve the diagnosis and treatment of fragility fractures. We also commenced our work in the European Union network project SpineFX, with the scientific goal to better understand the mechanisms of spinal fractures and the broader goal to offer a top-level, collaborative training environment for young researchers.

Our group participates in the CO-ME Research Network of the Swiss National Science Foundation, continuing our project in the area of patient-specific tissue engineered constructs for cartilage repair. We are a member of the AOSpine Research Network and work closely with the Swiss Paraplegic Research in Nottwil. In 2010, Prof. Peter Cripton completed his one-year academic sabbatical from the University of British Columbia and we have defined a new program for the exchange of researchers from the University of Ottawa.

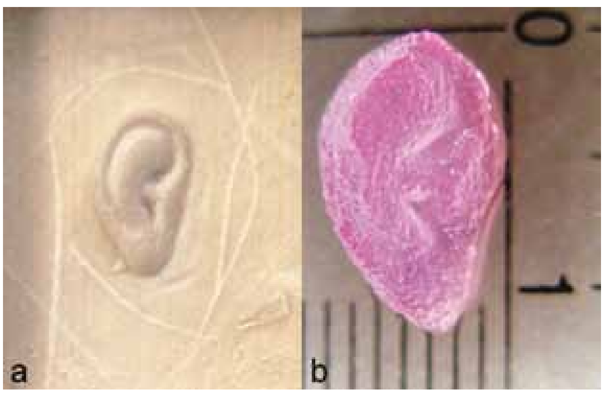
Current Research Areas

Applied Research

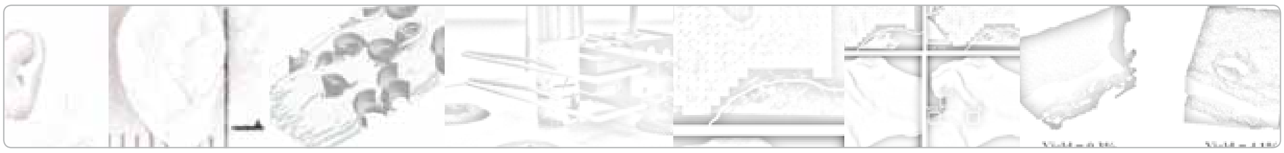
Last year we continued our collaboration with partners in the dental, biomaterials and orthopaedic industries on research activities ranging from simple material tests to complex multidisciplinary in vivo implant studies.
In collaboration with the MSRU of the VetSuisse Faculty of the University of Zürich, we contributed biomechanical testing to a new study investigating the healing performance of critical-sized bone defects, supplemented with next-generation osteoconductive biomaterials. In the field of implantology and osseointegration, we have completed the biomechanical evaluation of a variety of surface-treated metallic implants to improve our understanding of the potential benefits of bioactive coatings for dental and orthopaedic implants. Fracture fixation for small stature animals and the destabilising effects of a hemi-corpectomy in the spine were the topics of in vitro studies completed with the VetSuisse clinic in Bern.

Patient-Specific Scaffolds for Tissue-Engineered Cartilage in ORL Surgery

Cartilage reconstruction in the field of Oto-Rhino-Laryngology (ORL) represents an area of strong demand for viable tissue, which is not met by autologous transplantation. Tissue engineering for the creation of new cartilage would appear a promising direction, however the control of the shape and volume of such constructs is challenging. In order to assess the feasibility of using a plaster/PMMA-based rapid prototyping (RP) machine within the chain of patient-specific cartilage scaffold production, a cell culture study was performed. For this, chondrocytes were cast with agarose into a silicone form produced from a RP printed miniature ear and cultured for 3 weeks. Cell proliferation and the accumulation of the essential extracellular matrix protein glycosaminoglycan (GAG) was measured throughout the culture period. The miniature ear maintained its shape over the full three weeks. The feasibility of using a RP machine for producing complex scaffold shapes was highlighted by a rapid cell proliferation and matrix protein production in the RP tissue engineered constructs.

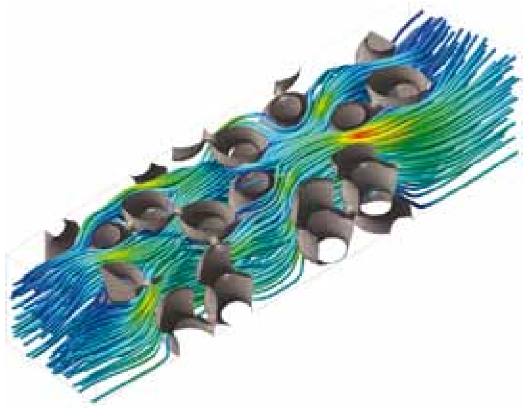


Rapid prototyping negative form (left) for the production of chondrocyte-seeded near-net-shape tissue engineered structures (right).



Bone Augmentation

Percutaneous vertebroplasty is the injection of bone cement into the vertebral body in order to relieve pain and stabilize fractures and/or osteoporotic vertebrae. The aim of this project is to develop a computational model to simulate the flow of two immiscible fluids through porous trabecular bone in order to predict the three-dimensional spreading patterns developing during cement injection and therefore minimize the risk of cement extravazation while maximizing the mechanical effect. Our previous model, based on Darcy's law for flow through porous media, was improved through an extensive computational study of the principal determinants of the intrinsic permeability of trabecular bone. Using a representative three-dimensional model of trabecular bone, in which several micro-architectural parameters could be varied over their typical range of values, we performed thousands of individual simulations of the flow through this porous microstructure. A subsequent statistical regression analysis was performed to determine the net contribution of each morphological parameter to the description of the full variance of permeability values. We have concluded that permeability can be described by only three specific architectural parameters, parameters which can be obtained from conventional clinical CT scans.



Pore-scale flow simulations (>10'000 parameter permutations) used to determine the dependence of bone permeability on micro-architecture.

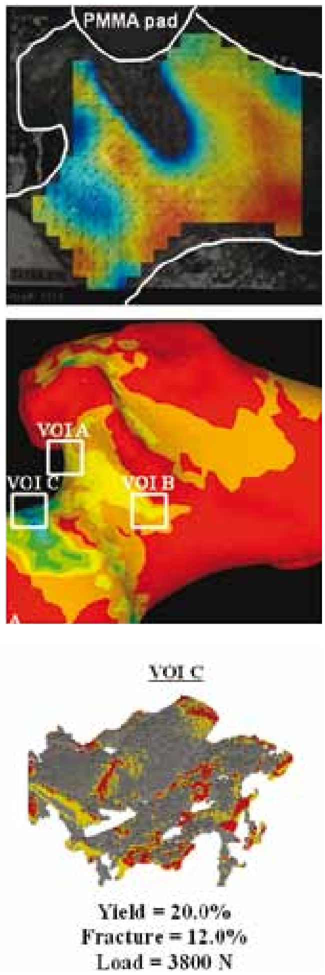
To improve our predictions of the mechanical effect of bone augmentation, we continued to study the complex interaction between reinforcing biomaterials and trabecular bone at the micro-scale. We have completed an extensive series of experiments and voxel-scale micro finite element analyses to demonstrate the influence of cement adhesion on the overall reinforcing potential of injectable biomaterials. This work has shown that the dominant influence on the stiffness and strength of augmented bone is the biomaterial itself; the quality of the host bone contributes little to the mechanical response. With this knowledge, a focus can be placed on the development of new materials.

Experimental validation of microCT-based bone simulation

High Rate Impact and Femoral Neck Fracture

This year we have collaborated with the Orthopaedic and Injury Biomechanics Group of the University of British Columbia on their pioneering study that aims to improve our knowledge of the mechanism of femoral neck fractures, a frequent and serious injury in the elderly. To date, fracture tests in the laboratory have been performed with quasi-static loading and have failed to correctly capture the dynamic nature of fractures due to falls. In the current project, we have contributed organ- and voxel-scale finite element analyses of the femur, and specific focal regions, to provide a mechanical interpretation of the novel experimental data obtained in the labs of our collaborators during high-speed impact testing. Surface strains captured with high-speed video during testing correlated highly with finite element analysis predictions of surface and internal deformation of the femoral neck, opening the door for more extensive simulations covering a broad range of loading conditions.

Image courtesy S. Gilchrist / LaVision



Comparison of organ-scale finite element simulations (middle) with surface strain measurements from in vitro impact experiments (top). Voxel-scale sub modeling (bottom) is used to predict bone failure.

Computational Bioengineering

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Group Members

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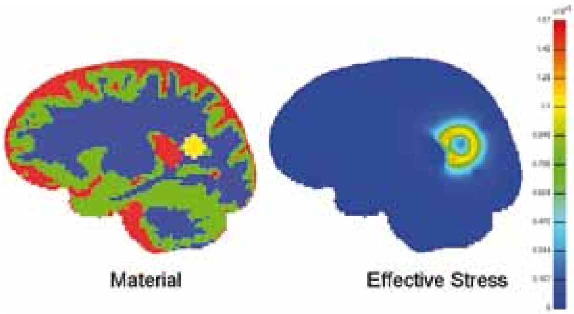
Research Profile

The Computational Bioengineering Group tackles challenges in basic and applied medical research with modern computational simulation tools. Rather than focusing on the computational methods themselves, we are concerned with their appropriate application to resolve practical and fundamental clinical questions. Numerical methods are combined with experimental and clinical research in order to improve the quality and extend the validity of our models.
Together with our collaborators we constitute a strong team covering a wide spectrum of research topics ranging from direct support of surgical patient treatment to basic cell research. Besides our core expertise in applying finite element analysis to study skeletal biomechanics, we are seeking to improve planning of various computer aided interventions by developing and applying refined numerical techniques into the field of computer aided surgery. Another important research focus of the group is the development of novel statistical finite element methods to incorporate uncertainty in bone shape and mechanical properties in the evaluation of bone biomechanics.

Current Research Areas

ContraCancrum

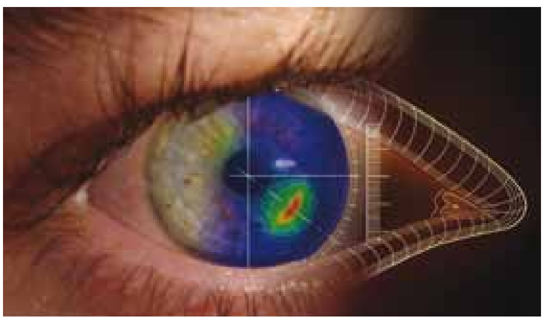
The ContraCancrum (Clinically Oriented Translational Cancer Multilevel Modeling, www.contracancrum.eu) project aims at developing a composite multilevel platform for simulating malignant tumor development as well as the tumor response to therapeutic modalities and treatment schedules. As part of a European network of collaborating institutions, the Computational Bioengineering Group is in charge of the mechanical aspects within this project.
In the spirit of the integrative idea of the ContraCancrum project, the Finite Element based structural mechanics simulation of tumor growth has been successfully coupled with a biological cell simulator in a self-consistent manner, representing a major step towards a multi-scale and multi-physics model of tumor growth. As the standard Finite Element formulation of solid mechanics on a moving grid reaches its limits of applicability under large deformations, we started a project on a novel approach based on a fixed grid. Using this so-called Eulerian approach, discretized volume elements maintain their shape, while material is transported to adjacent elements under deformation. The complete implementation will be a prerequisite for accurate mechanical simulations of large and fast-growing tumors.



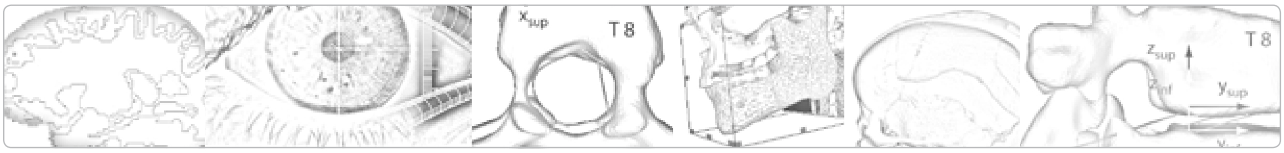
A biomechanical model is combined with a biological cell simulator. Finite element calculations are used to determine geometrical evolution of the tumor in the brain.

Biomechanics of Refractive Surgery

The optical characteristics of the human cornea depend on the mechanical balance between the intra-ocular pressure and intrinsic tissue stiffness. A wide range of ophthalmic surgical procedures alter corneal biomechanics to induce local or global curvature changes for the correction of visual acuity. Due to the large number of surgical interventions performed every day, a deeper understanding of corneal biomechanics is needed to improve the safety of these procedures.
The objective of this project is to develop a biomechanical model of the cornea able to predict patient-specific surgical interventions. The biomechanical behavior of the cornea is mainly driven by stromal collagen fibers distributed in a regular pattern. Our first challenge was to propose a constitutive model of the tissue able to take the stromal microstructure into consideration. During the last



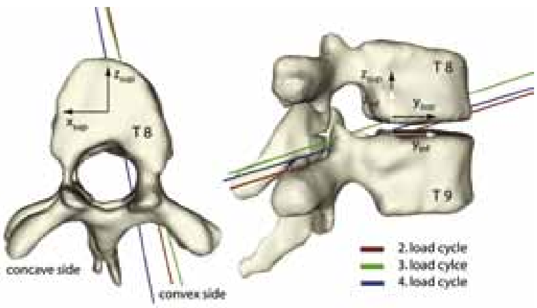
An opto-mechanical tool for planning patient-specific ophthalmic surgical procedures. A biomechanical model based on stromal microstructure has been proposed and used to predict correction of arcuate keratotomy.



year, the focus was to develop a finite element model that includes patient-specific geometrical information and initial tissue pre-stressing.
A frequent procedure aiming at correcting optical aberrations is arcuate keratotomy, where the surgeon places curved incisions in the steep meridian to relax the astigmatism. Our opto-mechanical planning tool has been used to virtually correct astigmatism on patient's data. Results showed that patient-specific models are needed for an accurate prediction of the surgical outcome. The proposed approach has great potential to become an important tool for surgeons in planning and optimizing patient-specific interventions in corneal refractive surgery.

Biomechanics of the Scoliotic Spine

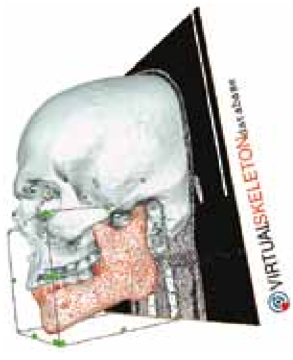
Adolescent Idiopathic Scoliosis is defined as a lateral curvature of the spine, involving a rotation of the vertebrae towards the concavity. Surgical correction of idiopathic scoliosis is required for severe deformities and for crankshaft prevention. Successful intervention requires careful planning, excellent surgical technique and intra-operative monitoring. Selection of appropriate fusion levels, amongst other considerations, will greatly influence the final goal of establishing a mechanically well-balanced spine in both the coronal and sagittal planes Biomechanical models have been proposed in order to simulate the surgical correction of spinal deformities. However, to be a reliable assistance for surgeons, these simulations should be three-dimensional and patient-specific.
The aim of the project is to obtain patient-specific mechanical properties of scoliotic spines. We developed a method for in vivo measurements of the scoliosis stiffness along the curvature in order to evaluate the mechanical properties of the spine and soft tissues. Although extremely important information about the spine biomechanics can be obtained, this information is not directly usable for surgical planning. Therefore, another aspect of the project focuses on determining the mechanical properties of the scoliosis spine based on pre-operative bending films. Based on this non-invasive technique, patient-specific mechanical properties could be included in numerical model of the patients. This work constitutes an important step toward finite element based planning of scoliosis correction.



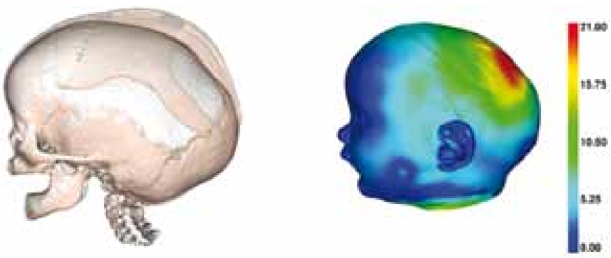
An apparatus has been used to measure spine stiffness in vivo. The axis of rotation for the different load cycles can be determined and enable the calculation of stiffness characteristics of the spine motion segments in vivo.

The Virtual Skeleton Database

The Virtual Skeleton Database is part of the Computer Aided and Image Guided Interventions Network (co-me.ch). During the past years, statistical shape and intensity analysis enjoyed a remarkable popularity within the medical image analysis community. These techniques hold potential for novel approaches in image guided surgery planning, simulation and execution. However, a recurrent problem that is faced when applying these techniques to a specific clinical application is the large amount of data required to build a valid model. The objective of the project is to develop a database system for storing and sharing large amounts of medical images, which enables researchers to quickly develop and test new tools. Special attention is given to also store processed images and statistical shape models together with the raw medical data.
One of objectives of the project is to provide a tool to analyze the statistical variability of bone biomechanics in the population. New techniques have been developed to include bone shape and mechanical properties into statistical models. As a first application, finite element models are being used to evaluate the mechanical performance of orthopedic implants.
Another application concerns craniosynostosis. This condition corresponds to a premature fusion of the sutures in an infant skull, which restricts the skull and brain growth. During the last decades there has been a rapid increase of diverse surgical treatment methods, but no method is currently available to evaluate and compare the different surgical approaches. We developed a method to evaluate the outcomes of craniosynostosis surgery. Initial results achieved with this semi-automatic analysis tool showed that the technique was appropriate to compare different surgical techniques.



Developments of the virtual skeleton database is being designed to stored medical images as well as processed data such as segmentation, deformation fields or 3D models.



Geometrical evolution of an infant skull 9 days after craniosynostosis surgery.

The Center for Computer Assisted Surgery (Part ISTB)

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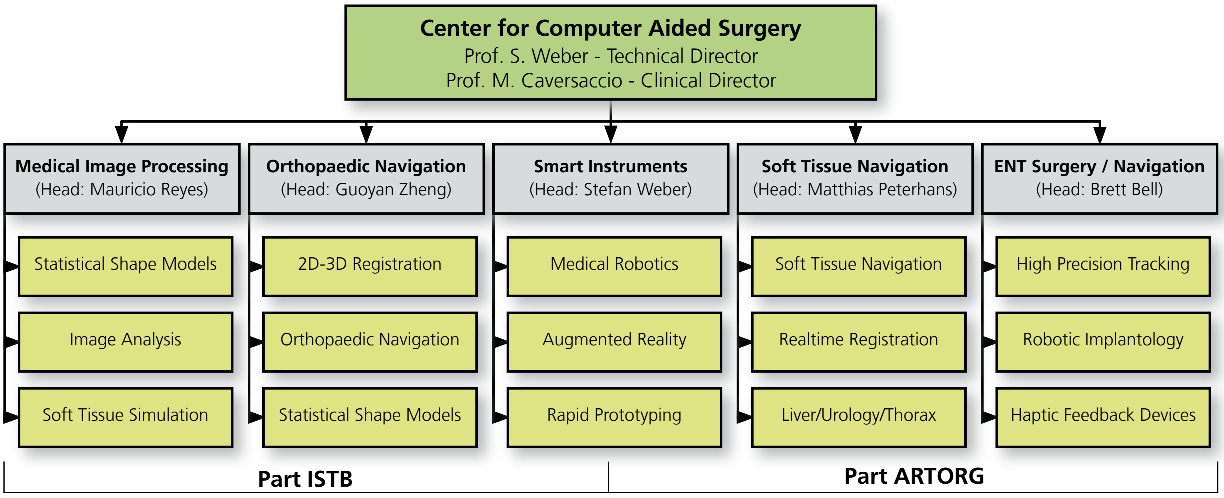
Nathaniel Reynolds, Simon Roder, Vidina Rodriquez, Jonas Salzmann, Tom Williamson

Research Profile

The Center for Computer Aided Surgery (CCAS) is a collaborative effort between the ARTORG Center for Biomedical Engineering Research, the Institute of Surgical Technologies (ISTB) and the Inselspital Bern. This powerful network of scientists, engineers and clinicians enables the creation of novel diagnosis and therapy solutions and aims to demonstrate its clinical evidence. CCAS envisions to support society and its healthcare systems for the challenges to come (demographic, economic, socio-cultural). It aims for the enhancement and integration of novel technology, improving its availability for patients and indications and demonstrating its clinical benefit respectively.

It specifically focuses on clinically related research and development activities in the broad area of computer assisted surgery. It aims at providing novel technologies for diagnostics, therapy and implantation to the interested clinical communities and enabling their evaluation in clinical routine. Our activities are primarily focused on supporting medical image analysis and diagnosis as well as surgical and interventional treatments by improving accuracy and reproducibility. At present, the centre is composed of five different research groups focusing on different aspects of fundamental and translational research.



The centre provides technological expertise in the areas of computer aided surgery, diagnosis, medical image processing and smart instruments based on clinical problems and motivations. The bandwidth of its research ranges from challenging clinical problems to improving existing approaches through medical technology. Competencies range from pure algorithmic research to integrated systems development and to clinical validation (through our clinical network).

Current Research Areas

Computer Assisted Microsurgery for ENT applications

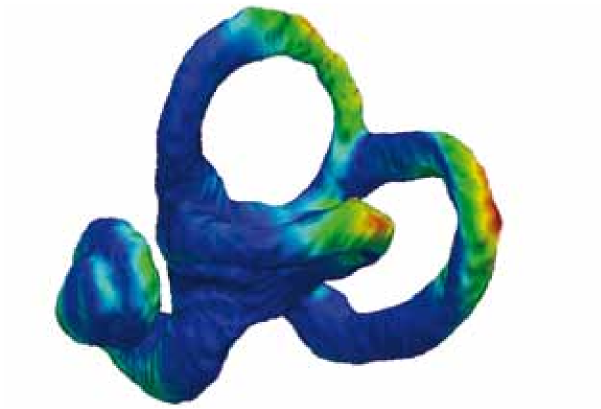
Robot

The overall objective of this project is the development of a robotic instrument guidance system to facilitate microsurgical interventions in the ear. Key components of the work is the development of a robotic device to be integrated in the OR which is scalable for future clinical application, the development of a planning and instrument guidance system and the development of

a high precision optical tracking allowing accurate instrument guidance in the ear. As a target scenario for our research we have chosen the surgical implantation of hearing devices. Here, a maximum allowable tolerance of 0.5 mm is required to safely reach the cochlea through the facial recess.

Computer assisted microsurgery: Validation of the robotic drilling system in a cadaver experiment.

Integrated planning and instrument navigation interface guiding the user through all steps of a robotic assisted intervention.

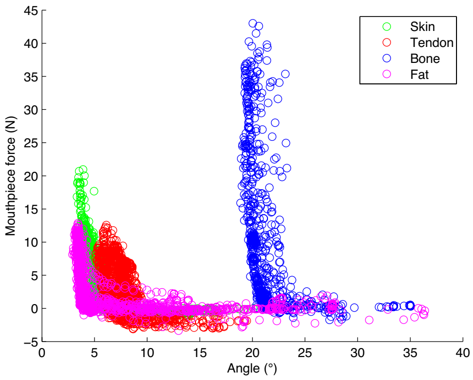


Model based segmentation using statistical shape models (here of the Vestibularis) can optimize computer assisted planning. Picture: Statistical mean shape of the Vestibularis with color coded deviations of the first Eigenmode.

Testing of a haptic feedback system to intuitively control the robot system.

Smart Surgical Instruments

A main objective of our ENT related activities is the development of optical fibre (OF) based 'smart' surgical instruments specific to ORL and CMF surgery. Key aspects of this work are the identification of clinical scenarios in which the provision of additional information is useful for the clinical user, the integration of fibre-based sensors into existing surgical equipment with a focus on clinical applicability and demonstration of effectiveness in ex-vivo scenarios.

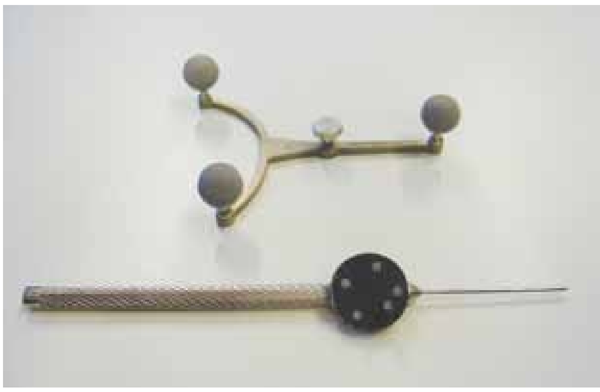


Δx/ΔF response curves for different tissue types

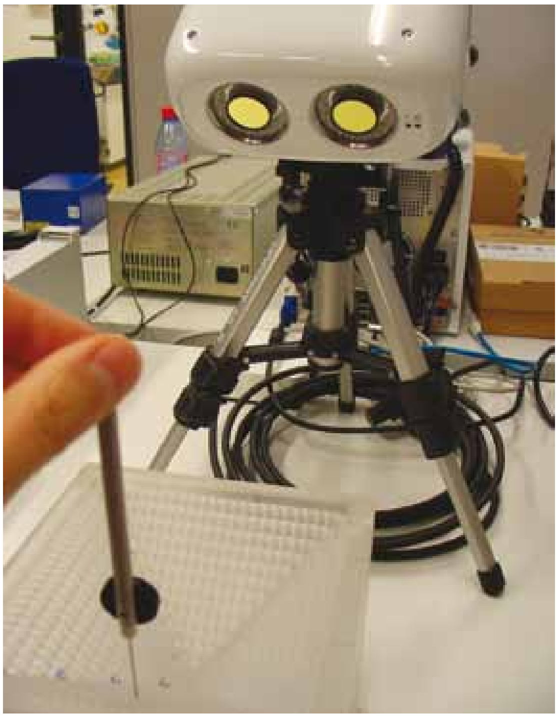
Cadaver experiments to test the reproducibility of a fibre integrated 45° blunt Blakesly for tissue stiffness analysis.

High Precision Tracking

To enable high precision micro surgery, the development of a suitable high precision tracking method was continued. The approach for tracking is based on a new optical tracking sensor (Axios Cambar B2) with precision of 20 microns within a working volume of 200×200×200 mm at a distance of 300 mm from the sensor. This optical sensor can be placed directly near the surgical site. This allows for an integrated solution and avoids line-of-sight problems due to the short measuring distance. The tracking technology is video based, thus suitable tracking references must be developed.



Microtracking probe compared to standard optical tracking reference.



High precision tracking system Cambar B2 (Axios) with a miniature probe and tracking references.

Soft Tissue Navigation

Computer Assisted Liver Surgery

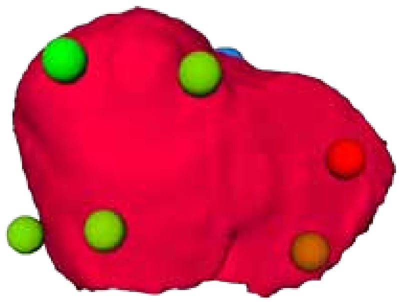
Following the development of the first CE marked navigation system to support open liver surgery, the CAScination AG was founded start commercialization of the technology. In 2010, marketing started with exhibition at major international hepatobiliary congresses and two systems were sold to international customers. CAScination continues to develop its instrument guidance technology together with the division for Surgical Technologies of the Institute. At the end of 2010 a CTI project was launched between the two partners to develop a novel ultrasound based image-to-patient registration scheme.

Preparing for a navigated resection of a HCC liver tumour at the Eastern Hepatobiliary Hospital Shanghai, the worlds largest specialized liver hospital, where University of Bern, together with Fraunhofer MeVis and CAScination AG have engaged in a collaboration to further develop the liver navigation system.

Non-Rigid Tracking of Soft Tissues

Organ motion and deformation are major obstacles in the introduction of image guidance for soft tissue surgery. Due to challenges with detection rate, invasiveness and intra-operative complexity, no clinically established solution for deformation measurements on soft tissues is currently available. We develop a soft tissue tracking approach based on single passive surface markers as part of a navigation system for open liver surgery. Such markers are non-invasive and allow for real-time surface motion acquisition while using available tracking systems. Aspects of the research towards application in open liver surgery include demonstration of reliable motion tracking, deformation detection and respiratory gating.

Silicon phantom of a liver with attached retro- reflective surface markers.



Virtual correspondence of the detected surface markers and their registration with a preoperatively acquired image of the liver.

Ultrasound Based Registration

Intra-operative image-to-physical space registration of surgical planning data is a fundamental component of navigation systems for oncological liver surgery. Within this work, we propose a two stage registration procedure which is fast and requires minimal user interaction. Initial alignment is obtained by using surface landmarks. Then, fine registration follows on the basis of freehand 3D intraoperative ultrasound imaging of vascular structures. Vessels are automatically segmented and aligned with the preoperative graph by means of feature-based ICP. Overall routine is fast and incorporates well in the current clinical workflow. Initial results obtained on patients undergoing oncologic resections are evaluated.

Recording of ultrasound image sequence within the liver after an initial point based registration.

Medical Image Analysis

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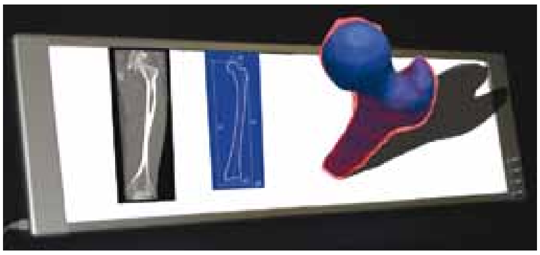
Research Profile

The Medical Image Analysis group conducts basic and applied research in image processing, computer vision, and artificial intelligence for the analysis of medical image datasets. Although particular focus is given to orthopaedic research and applications, the spectrum of topics and research interests is broad and open to other fields where medical image analysis techniques can provide solutions to biomedical-related problems.
All our projects are done in collaboration with internationally outstanding academic, clinical and industrial partners.

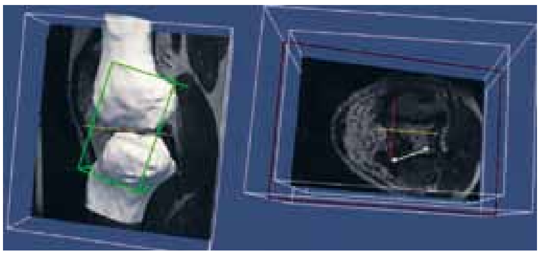
Current Research Areas

Bone Shape Analysis and Statistical Shape and Intensity Modelling using Computational Anatomy Techniques

Computational anatomy enables analysis of biological variability on a population. Using statistical mathematical techniques, models can be built to represent the typical shape of an anatomical structure and the predominant patterns of variability across a given population. These techniques can be used to generate new statistically conforming shapes and to predict, from sparse information, the shape of unknown ones. We are developing methodologies to combine anthropometric and morphometric patient-specific information into the problem of multivariate and high-dimensional regression of medical images, with applications to image-guided minimally invasive augmented bone shape visualization, automated patient-specific and model-based bone segmentation and longitudinal studies of bone anatomy. During 2010, a novel non-rigid registration for bone structures was investigated. The method utilizes a polyaffine model as regularization term that better captures the deformations and therefore provides better prior-knowledge to the non-rigid image registration optimization process.



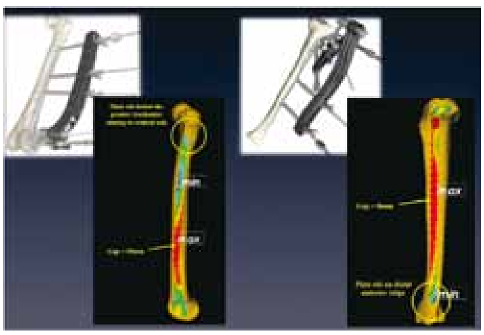
Predicting bone anatomy from sparse information. Computational anatomy based techniques are being used to model the statistical relationships between anthropometric and morphometric patient-specific sparse information and the complete bone anatomy. Applications range from minimally invasive and low-radiation dose bone diagnosis to automated patient-specific model based bone segmentation.



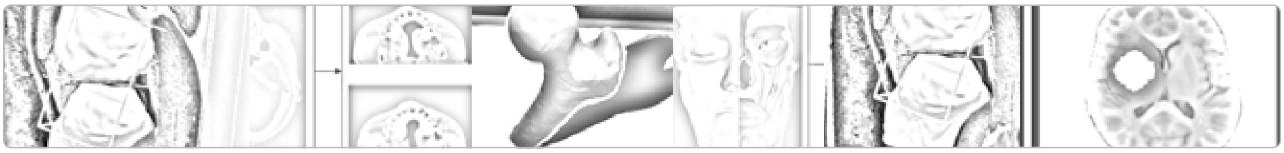
Automatic bone segmentation and localization of menisci-plane based on statistical shape modeling. Left: automatic bone segmentation from MR images. In green color, the best orientation to image both menisci is displayed. Right: cross-sectional view oriented using the sought best orientation plane.

Evidence-Based Implant Design

The methods highlighted above have been applied to the problem of optimization of orthopaedic implants. In collaboration with our industrial partner and through a dedicated SNSF project, we have collected a large research CT data bone database, which allows us to provide significant statistical statements about the appropriateness of proposed implant designs. This methodology was utilized for the first time to perform population-based computer-assisted orthopaedic implant design in collaboration with Stryker Osteosynthesis. The outcome of this project is of great benefit to the implant manufacturing industry, which has been reflected in successful technology transfer with our industrial collaborator. During 2010



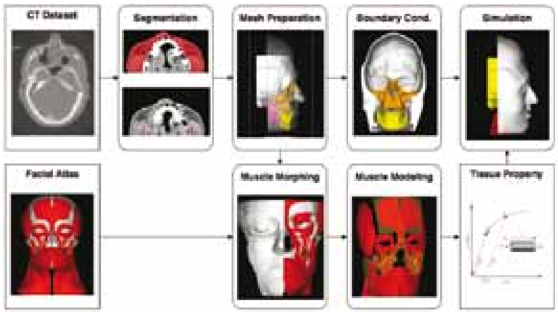
Automatic orthopaedic implant bone fitting. Result examples of implant fitting on different bone anatomies. Colors represent the quality of the fitting, "min" and "max" labels indicate best and worst fitting points. Based on this technique and statistical analysis of an entire selected population, modifications to the implant design can be proposed.
Collaboration and image source: Stryker Osteosynthesis



research efforts have been made to deal with the problem of designing implants that ensure adequate coverage of a given population. In addition, the intra-operative problem of plate bending has been considered in order to design implants that minimize bending and torsional deformation.

Soft Tissue Simulation for Cranio-Maxillofacial (CMF) Surgery

The system developed in the previous years for computer-aided CMF surgery has been developed and introduced into routine clinical practice. It offers a 3D surgical planning environment, which is currently being extended to consider soft tissue deformations to realistically predict realistic facial appearance after surgery. Methodologies have been developed and evaluated on real clinical cases to perform prediction of facial soft tissue deformations for CMF surgery. Special emphasis has been given to maintain the current clinical workflow, as well as avoiding the difficult and time consuming task of muscle tissue segmentation. During 2010 the method was clinically evaluated on several cases using a fast and robust methodology of soft tissue modeling. Our contribution also includes the incorporation of non-homogeneous and anisotropic tissue properties as well as sliding contact considerations.

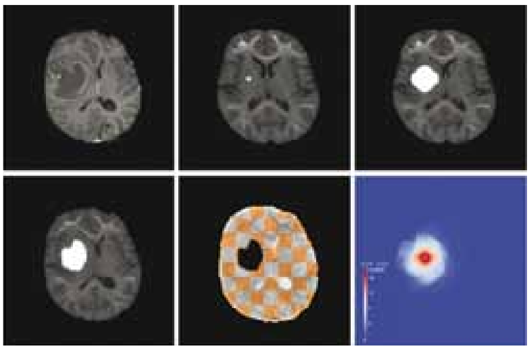


Soft tissue simulations for computer-assisted cranio maxillo facial (CMF) surgery. Workflow of the system used to predict soft tissue deformations after CMF surgery. The system features incorporation of non-homogeneous and anisotropic muscle behavior, slide contact considerations and fully conforms to the clinical workflow.

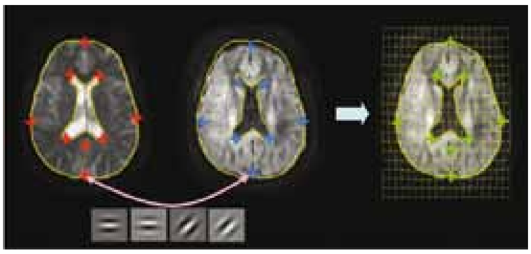
Brain Image and Brain Image Tumour Analysis and Simulations using Highly Efficient Cuda-Enabled Technologies

Magnetic Resonance Imaging (MRI) is a powerful image modality that encompasses rich anatomical and physiological information at a high resolution. This project aims at developing methods to analyze MRI images with focus on image registration, interpretation and pattern recognition. Novel methodologies are being developed to improve non-rigid registration of multimodal brain images. In this sense, a novel multimodal non-rigid registration method has been developed, featuring fast and accurate non-rigid registration. During 2010, this methodology has been extended into a hybrid multimodal non-rigid registration technique that allows the incorporation of anatomical landmarks, which allowed us to improve the accuracy of the registration process on a localized fashion. Further developments include automatic landmark detection in order to make this solution clinically applicable.

Research efforts have been made to employ these methodologies for the task of brain image segmentation in the presence of tumors. In this direction, an atlas-based patient-specific tumor-induced brain image segmentation method has being developed and fully implemented in a CUDA architecture. Furthermore, accurate segmentation of different brain tumor tissue types has been investigated with promising results.



Automatic segmentation of tumor-bearing brain image. The developed method features an intensity-based markov random field tumor growth based model and robust and accurate atlas-based segmentation. A CUDA implementation of this framework is available.



Diffusion weighted image (DWI) distortion is corrected by using a novel landmark-assisted multimodal registration. Anatomically important landmarks are extracted automatically based on Gabor attributes (lower left row) to guide the intensity-based registration algorithm. The combination of landmarks force and intensity-driven force leads to a dense deformation field in diffeomorphic transformation space (right side). A software implementation is available.

Multimodality Image Based Computer Assisted Biopsy

A computer navigated solution for Positron Emission Tomography/Computer Tomography (PET/CT) image based biopsy has been developed. The system aims at assisting radiologists to precisely locate, reach and remove tumors as part of the biopsy procedure with minimal radiation exposure to the radiologist and patient. The project is conducted in collaboration with the Computer-Assisted Surgery Center (CCAS). The support of the Medical Image Analysis group is based on providing expertise in medical image segmentation and registration, as well as simulation of soft tissue deformations for surgical procedures. During 2010, an image-guided method for multimodal target correction was investigated based on localized bone image registration.

Computer Assisted Orthopaedic Surgery (CAOS)

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Weiguo Xie

Research Profile

The Computer Assisted Orthopaedic Surgery (CAOS) group aims at developing state-of-the-art medical image computing technologies to enhance the autonomy and improve the usability of computer assisted interventional systems.
In the past year we have continued our pursuit of novel medical image computing methodologies/systems for various clinical applications. These include the development of various statistically deformable 2D/3D reconstruction algorithms and their applications in computer assisted surgeries, a patient-specific, gravity assisted navigation system for THA operated in lateral approach, a comprehensive software package for surgical treatment of femoroacetabular impingement, a symmetry-based registration method for determination of pelvic orientation from sparse ultrasound data, and a graphical model-based method for automated vertebra identification from X-ray image(s).

Current Research Areas

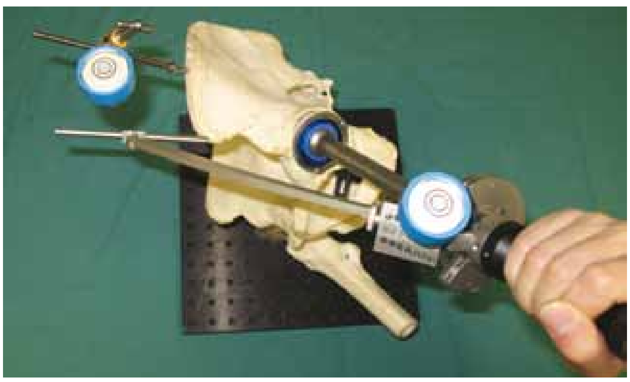
Development of Statistically Deformable 2D/3D Reconstruction Algorithms and their Application in Computer Assisted Surgeries

The applications of two-dimensional (2D) X-ray images in computer assisted surgeries are pervasive, ranging from pre-operative planning, intra-operative intervention, and post-operative treatment evaluation. Although X-ray imaging has an inferior accuracy in comparison to three-dimensional (3D) imaging means such as CT or MRI, it is used routinely because of its simplicity, availability, and minimal expense associated with its acquisition. While 2D X-ray images are easily obtained, their accurate interpretations are subjected to substantial errors. Thus, recently statistically deformable 2D/3D reconstruction has drawn more and more attention due to the fact that it allows one to derive a 3D patient-specific model from 2D X-ray images. We have developed various statistically deformable 2D/3D reconstruction algorithms and applied them to different clinical applications including: (1) reconstructing a patient-specific 3D knee joint (both distal femur and proximal tibia) from a single calibrated knee X-ray radiograph for total knee arthroplasty (TKA) (figure left); and (2) reconstructing a patient-specific 3D pelvic model from a single conventional AP pelvic X-ray radiograph for total hip arthroplasty (THA) planning and for estimating post-operative cup orientation after THA (figure right).

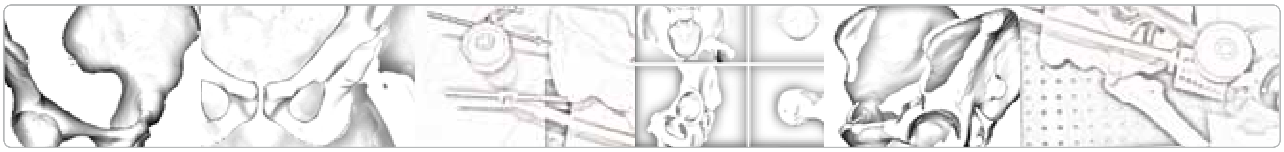
Statistically deformable 2D/3D reconstruction for total knee arthroplasty and total hip arthroplasty.

PS-GANS: a Patient-Specific, Gravity Assisted Navigation System for THA

We developed a new system that allowed reliable acetabular cup placement when a total hip arthroplasty (THA) was operated in lateral approach. Conceptually, it combines the accuracy of computer-generated patient-specific morphology information with an easy-to-use mechanical guide, which effectively uses natural gravity as the angular reference. The former was achieved by using a statistical shape model-based 2D/3D reconstruction technique that can generate a scaled, patient-specific 3D shape model of the pelvis from a single conventional anteroposterior (AP) pelvic X-ray radiograph. The reconstructed 3D shape model facilitates a reliable and accurate co-registration of the mechanical guide with the patient's anatomy in the operating theatre.



A patient-specific, gravity assisted navigation system for THA.



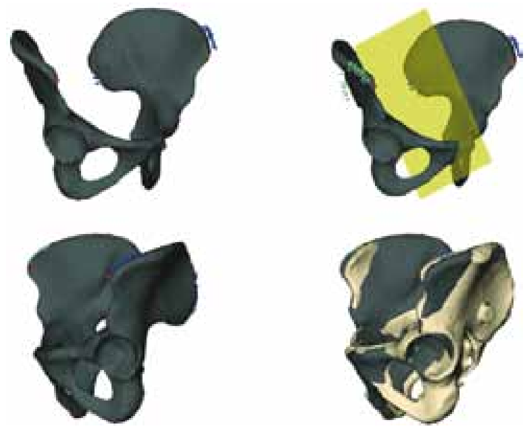
Computer Assisted Diagnosis and Treatment of Femoroacetabular Impingement

The surgical treatment of femoroacetabular impingement (FAI) focuses on joint-preserving surgical interventions. The idea is to resect these bony areas which cause the impingement. However, the treatment of FAI is hampered by the inability to preoperatively localize the impingement areas. Thus, time-consuming and cumbersome impingement tests have to be performed intra-operatively in order to evaluate the impingement situation. We have developed a comprehensive software package to improve and to facilitate the surgical treatment of FAI. This comprehensive software tool covers the whole range of the treatment from pre-operative diagnosis and planning to assistance during surgical intervention. After careful evaluation of the software package, the complete framework has been successfully integrated to the clinical workflow of the surgical treatment of FAI at the Inselspital, University of Bern.

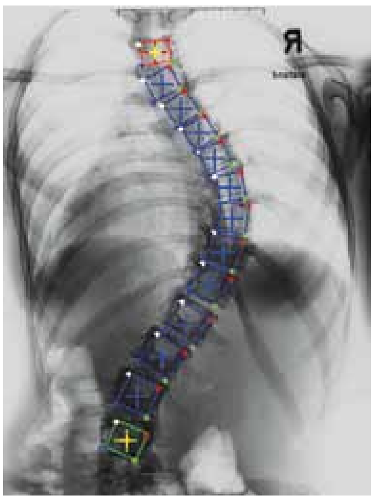
A comprehensive software package for surgical treatment of femoroacetabular impingement.

A Symmetry-Based Registration Method for Determination of Pelvic Orientation from Sparse Ultrasound Images

In the field of computer-assisted orthopaedic surgery, the anterior pelvic plane is commonly used to determine the pelvic orientation. This reference plane is used to precisely place the acetabular cup prosthesis. An accurate cup insertion and therefore a precise detection of this plane are very important for the clinical outcome. B-mode ultrasound potentially provides a precise means to support the surgeon during this step. In order to derive 3D information, the ultrasound probe is tracked by a navigation system. We have developed a symmetry based registration method, which uses statistical shape models of the pelvis to accurately reconstruct the pelvic orientation based on sparse point data, derived from tracked ultrasound images. The image data could be thereby acquired from the pelvis in lateral position, which is most appropriate for the clinical routine. In this lateral position only one side of the pelvis is freely accessible. Based on a symmetry constraint, this data can be reflected to the other side of the pelvis and further be used for the registration of the pelvis statistical shape model. Experimental trials based on plastic and dry cadaveric pelvises together with custom-made soft-tissue simulation phantoms proved the validity of our method.



Different stages of applying the symmetry-based registration method to determine pelvic orientation from sparse ultrasound data.



Automated Vertebra Identification from X-ray Image(s)

Automated identification of vertebra from medical images is important for various image processing tasks. We have developed a graphical model based solution for vertebra identification from X-ray images. Compared with the existing graphical model based methods, our method does not ask for a training process using training data and it has the capability to automatically determine the number of vertebrae visible in the image.

Automated vertebra identification from a X-ray radiograph.

Mechanical Design & Production

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Pascal Aebersold

Sara Corinti

Patrick Moser

Ronald Ramseier

Profile

The primary function of the Mechanical Design and Production (MDP) group is the co-development and manufacturing of mechanical and electro-mechanical components related to the research pursuits of the ISTB. The MDP group supports all levels of the design and manufacturing process from concept to production. This includes computer assisted design (CAD) modelling with SolidWorks®, prototyping and production with technical drawings, standard tooling, computer assisted manufacturing (CAM) with MasterCam® software, and CNC-machines. We also support industrial and academic external research collaborators with their mechanical design and production needs.

The MDP group has a secondary role in training. This training encompasses the skills required to safely and proficiently operate machine shop tools and equipment, the knowledge required to achieve the best results with a variety of materials and the skills needed to efficiently manage the design and production workflow.

Trial apprenticeships are used as a means to evaluate candidates for a full apprenticeship in the MDP group or just to show to young people what we are doing in our profession. This year, we performed three such courses as a contribution to society and to promote Polymechanic apprenticeships.

After a successful completion of his apprenticeship, Ronald Ramseier was employed from August 2010 until the end of February 2011 as a polytechnician in the MDP. We congratulate and thank him for his solid workmanship and wish him all the best for the future.

This year in August, Patrick Moser became our new first year apprentice as a polymechanic. Our apprentice Sara Corinti completed her basic training at the end of the second year with good results. In the coming years her training will focus more on CAD-CAM technologies and the manufacturing of more ambitious parts.

Projects

Research Equipment Design & Manufacturing

As expected, the requirements of a machine shop supporting research in the biomedical engineering field are as diverse as the research field itself. The variety of subjects researched in the ISTB yield a number of diverse design and production requests from prototype clinical and surgical tooling to fixtures for mechanical, biological and kinematic testing, as well as imaging system accessories and calibration equipment. The following illustrations highlight a few of this year's projects

ARTORG Machine Shop

This November, several ARTORG groups were able to move to the new facilities in Murtenstrasse 50 near Inselspital. The infrastructure at this location includes a workshop, which was established under the direction of Urs Rohrer together with Sascha Weidner. As of January 2011, the mechanical needs of all ARTORG research groups will be covered in cooperation with our workshop.


Loading Device IVD

A prototype mechanical testing unit designed specifically for the vertebral disc was initially created for the Mechanobiology group to evaluate its functionality. Due to the positive initial results, the design was improved and three additional units were produced.

HIP Impactor

Proper placement of the accetabular cup in hip surgeries requires the use of an impactor and alignment device. Several prototypes of an alignment device which uses a simple water bubble for correct orientation were created in our workshop during 2006/2007. Because of the success of this simple navigation method, we have undertaken a redesign which includes the professional requirements of a sterilizable surgical instrument.



Three Point Bending Device

The dental clinic of Inselspital requested that we design and build parts for a mechanical test machine. Our design for a 3-point bending attachment allows samples with differing dimesions to be tested without removal of the adpter to change the specimen length.

Revival for PAO Chisel Navigation

Curved chisels are one type of tool used during a periacetabular osteotomy of the pelvis. In collaboration with the Orthopaedic Clinic of Inselspital, the standard chisels were modified so that they can be used with a navigation system during the operation. These modifications were patterned after prototypical parts which were developed for this purpose by our workshop in the 90s.



Housing for Liver Surgery Remote Control

This housing, which holds the electronics for the remote control of the liver navigation system was created on our CNC-milling machine. The creation of these parts was very challenging, as both halfs of the housing are very thin-walled and vibrate easily during the milling process which can lead to a rough surface finish.

Acknowledgments

A research institution such as ours depends significantly on support from a number of bodies including government, industry and other private sponsors. We are indebted to the AO-Foundation for its contributions to our budget. We graciously thank the Swiss National Science Foundation for its support within the Swiss National Center for Competence in Research CO-ME and individual Division III project grants, and the Federal KTI/CTI Innovation Promotion Agency for providing R&D matching funds. Furthermore we are grateful to the European Commission for its support within the Seventh Framework Programme. In addition, support in the form of equipment, donations, or finances for a large number of specific research projects by various foundations and companies is gratefully acknowledged.

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Innovation Promotion Agency CTI

FNSNF
Fonds national suisse
Schweizerischer Nationalfonds
Fondo nazionale svizzero
Swiss National Science Foundation

CO-ME
COMPUTER AIDED AND IMAGE GUIDED MEDICAL INTERVENTIONS

EUROPEAN COMMISSION

AO Foundation

MSc & PhD Degrees at the ISTB

MSc in Biomedical Engineering

In a continuing effort to support Swiss innovation and ensure a critical mass of skilled labor in the field of Bioengineering, the University of Bern's Medical Faculty in collaboration with the University of Applied Sciences Bern are offering a masters degree by coursework. The program is composed of advanced classes covering a wide variety of topics within our current focus areas, which are electronic implants, image-guided therapy, and musculoskeletal system. Students who hold at least a bachelor degree from a regular university or a university of applied sciences (Fachhochschule) in biomedical, mechanical, electrical, systems or civil engineering or in micro technology, mechatronics, computer science, physics, medicine or closely related fields are eligible for the master study course biomedical engineering. For further information visit the program's web site at www.bme.master.unibe.ch.

PhD in Biomedical Engineering

The doctorate degree in biomedical engineering at the ARTORG Center is undertaken within the Graduate School for Cellular and Biomedical Sciences at the University of Bern, which is jointly administered by the Faculties of Medicine, Science and Veterinary Medicine (Vetsuisse). The programme usually lasts three years and offers structured post-graduate training in experimental research. For further information please visit the graduate schools web site at www.gcb.unibe.ch.

Master Theses

Braumann, A.
Human-machine interface for computer-assisted liver surgery

Coigny, F.
MEMS-based laser projection system for computer guided surgery

Hofmann, S.
Liver surface marker tracking

Jäger, M.
Muscle PCSA and composition in the elderly

Lindenmann, P.
Finite element analysis of a prototype disc prosthesis

Seif, M.
Numerical simulation of the cornea capillary forces caused by tear film surface tension

Steiner, T.
Comparing a stochastic loading pattern to cyclic loading in an in vitro testing of rabbit flexor digitorum profundus tendons

Stirnimann, P.
Determinants of the mechanical response of trabecular bone-cement composite

Wüthrich, A.
Evaluation of an ultrasonic deflector

Dissertations

Abouhossein, A.
A dynamic, non-linear multibody model to estimate segmental forces in the lumbar spine

Jünger, S.
Use of intervertebral disc whole organ culture for degenerative and regenerative studies

Peterhans, M.
Ultrasound based non-invasive referencing of anatomical structures for computer assisted surgery

Puls, M.
A comprehensive software tool for the diagnosis, planning and navigation for the minimally-invasive surgical treatment of femoroacetabular impingement

Tasci, A.
Determining appropriate loading patterns for avascular tissue engineering

Editorial & Review Contributions

African Invertebrates
Annals of Biomedical Engineering
Apoptosis
ASME Journal of Biomechanical Engineering
Biomedical Engineering Online
Biomedizinische Technik
BMC Evolution
Clinical Biomechanics
Computerized Medical Imaging and Graphics
European Cells & Materials
European Spine Journal ESJ
HNO
IEEE Transactions on Biomedical Engineering
IEEE Transactions on Medical Imaging
IEEE Transactions on Pattern Analysis and Machine Intelligence

Editorial & Review Contributions

International Journal of Computer Assisted Radiology and Surgery
International Journal for Numerical Methods in Biomedical Engineering
International Journal on Medical Robotics and Computer Aided Surgery IJMRCAS
Journal of Anatomy
Journal of Biomechanics
Journal of Biomedical Materials Research
Journal of Oral and Maxillofacial Pain
Journal of Orthopeadic Research
Journal of the Association for Laboratory Automation
Journal on Computer Aided Radiology and Surgery CARS
Medical Engineering and Physics
Medical Image Analysis MedIA
Medical Physics
Molecular Ecology
Molecular Phylogenetics and Evolution
Neuroradiology
Ostheoarthritis and Cartilage
Pattern Recognition Letters
Spine
Surgical Innovation
Tissue Engineering part A and part C

Editorial Board Member

Clinical Biomechanics
European Spine Journal
Journal on Medical Devices

Review Activities for Funding Agencies

AO Foundation and AO Spine, Switzerland
Austrian Science Fund, Austria
Bundesministerium für Bildung und Forschung, Germany
Deutsche Forschungsgemeinschaft, Germany
Engineering and Physical Sciences Research Council, United Kingdom
Natural Sciences and Engineering Research Council, Canada
Royal National Institute of Deaf People, Great Britain
Swiss National Science Foundation, Switzerland

Review Activities for Academic Institutions

Swiss Federal Institute of Technology, Zurich, Switzerland
Berne University of Applied Sciences, Biel, Switzerland
The University of Tokyo, Tokyo, Japan
University of Leeds, Leeds, Great Britain
University of Hong Kong, Hong Kong
University of Zürich, Zürich, Switzerland
Zurich University of Applied Sciences, Winterthur, Switzerland

Review Activities for Conferences

CAOS Computer Assisted Orthopaedic Surgery
CARS Computer Assisted Radiology and Surgery
CURAC Annual Conference of the German Society for Computer and Robot Assisted Surgery
EuroSpine
ICIAR International Conference on Image Analysis and Recognition
IEEE Annual Conference of the Engineering in Medicine and Biology Society, EMBS
IEEE International Conference Intelligent Robots and Systems, IROS
IEEE International Symposium on Biomedical Imaging, ISBI

IPCAI International Conference on Information Processing in Computer-Assisted Interventions
MIAR International Workshop on Medical Imaging and Augmented Reality
MICCAI Medical Image Computing and Computer Assisted Interventions
MLMI International Workshop on Machine Learning in Medical Imaging
Orthopaedic Research Society

Awards

Ypsomed Innovation Award for Research and Development
Peterhans, M., vom Berg, A., Inderbitzin, D., Candinas, D., Nolte, L.-P., Weber, S.
Entwicklung und klinische Anwendung einer integrierten Navigationsplattform für die computerassistierte Leberchirurgie
Ypsomed Innovationsfonds, Burgdorf, Switzerland

Ypsomed Innovation Award for Research and Development
Zheng, G., Echeverri, S., Nolte, L.-P.
A novel cost-effective system for high-precision placement of acetabular cups in total hip arthroplasty (THA)
Ypsomed Innovationsfonds, Burgdorf, Switzerland

First prize of the "Vereinigung für Kinderorthopädie"
Wietlisbach S, Büchler P, Hasler CC
Objektivierte Tragzeit von dynamischen SpineCor-Korsetten bei adoleszenten Mädchen mit idiopathischer Skoliose
Vereinigung für Kinderorthopädie, Germany

Conference Travel stipend, Annual Conference 2010 of the German Society Computer and Robot Assisted Surgery CURAC
Bell, B.,Salzmann, J., Nielsen, E., Gerber, N., Zheng, G., Nolte, L.-P., Stieger, C., Caversaccio, M., Weber, S.
An Accuracy Approach to Robotic Microsurgery in the Ear

Oliveira-Santos, T., Hofmann, S., Peterhans, M., Weber, S.
Soft Tissue Surface Tracking for Open Liver Surgery

Anderegg, S., Peterhans, M., Weber, S.
Ultrasound Segmentation in Navigated Liver Surgery

Best Poster Award
Oliva, V., Bell, B., Stankowsky, S., Caversaccio, C., Stieger, C., Weber, S.
Advanced surgical instrumentation for ORL and CMF Applications
Biomedical Engineering Day 2010, Bern, Switzerland

Best Poster Award
Chan, S.C.W., Ferguson, S., Wuertz, K., Gantenbein-Ritter, B.
Effect of short term torsion to the intervertebral disc: An organ culture study
Proceedings of eCM XI, Cartilage & Disc: Repair and Regeneration, Davos, Switzerland

Invited Lectures

Büchler, P.
Integration of geometry and material variability in biomechanical simulations
International Society for Computer Assisted Orthopaedic Surgery, Statistical Shape Modeling and 2D-3D Reconstruction pre-congress Educational Workshop, Paris, France

Ferguson, S.
Biomechanics of the Spinal Unit and Fusion
17th Brussels International Spine Symposium, Brussels, Belgium

Ferguson, S.
The Broken Column: Causes, Consequences and Treatment of Spinal Fractures
ETH-Zürich Colloquium on Orthopaedic Technologies, Zürich, Switzerland

Ferguson, S.
Consequences of a Torn Labrum
Bernese Hip Symposium, Bern, Switzerland

Invited Lectures

Ferguson, S.
Geometric Simulation of SCFE
Bernese Hip Symposium, Bern, Switzerland

Ferguson, S.
Stress Distribution in the Hip
Bernese Hip Symposium, Bern, Switzerland

Nolte, L.-P.
Sensors for Orthopaedic Interventions
CMSI Annual Symposium, The University of Tokyo, Tokyo, Japan

Nolte, L.-P.
Bioengineering – Fascination, Challenges and Constraints
Lecture Series - Technology & Computer Science, University of Applied Sciences Bern, Biel, Switzerland

Nolte, L.-P.
Biomedical Engineering – Partnership between Clinicians, Technicians and Industry
Research Day, Pediatric University Hospital Bern, Gerzensee, Switzerland

Nolte, L.-P.
Swiss Medical Technology and Innovation Promotion
16th Swiss Conference on Biomaterials, EMPA Academy, Dübendorf, Switzerland

Nolte, L.-P.
Future of Health Technology
70th Anniversary Symposium, Invalid Foundation, ORTON Hospital, Helsinki, Finland

Nolte, L.-P.
Technological Aspects of ORL Navigation
23rd Congress of the European Rhinologic Society, Geneva, Switzerland

Nolte, L.-P.
CTI - Innovation Partner for the Swiss Medical Technology Industry
Meet the Expert - Medical Manufacturing, Solothurn, Switzerland

Reyes, M.
Computational Anatomy for Bone Analysis and Orthopedic Implant Design
CAOS 2010 Workshop Versailles, France

Reyes, M.
Medical Image Analysis at the Institute for Surgical Technology and Biomechanics
Technology Institute of Buenos Aires, Argentina

Reyes, M.
Medical Image Analysis at the ISTB Showcase of Research activities
Dept. of Magnetic Resonance Spectroscopy and Methodology, Switzerland

Weber, S.
3D-Printing in der computerassistierten Chirurgie
Medical Cluster Meet the Expert in Rapid Prototyping, St. Gallen, Switzerland

Weber, S.
High precision Navigation and Robotics Approach on the Oto-Base
Workshop at CAOS Conference for Computer Aided Orthopaedic Surgery, Paris, France

Weber, S.
Sensors and Smart Devices for Orthopaedic Surgery
Workshop at CAOS Conference for Computer Aided Orthopaedic Surgery, Paris, France

Weber, S., Nolte L.-P.
Technological aspects of ORL Navigation
ERS-ISIAN 2010 Symposium New technology, Tokio, Japan

Weber, S.
Basic challenges in image guided head and neck surgery
PSSB Clinical Course, Bern, Switzerland

Weber, S.
Computer- und roboterassistierte Implantation modernster Hörgerätetechnik
Heinz-Nixdorf Symposium für Bioelektronische Diagnose- und Therapiesysteme, Munich, Germany

Zheng, G.
X-ray image based 2D/3D reconstruction for orthopaedic applications
2010 CAOS workshop on Statistical Shape Modeling and 2D-3D Reconstruction, Paris, France

Keynote Lectures

Ferguson, S.J.
Bone Augmentation
IASTED Biomed, Innsbruck, Austria

Gantenbein-Ritter, B.
Cell Therapy for Intervertebral Disc Degeneration from the Lab-Bench Perspective
Swiss-Japanese Symposium on Disc/Spine Research, Zürich, Switzerland

Nolte, L.-P.
Statistical Shape Model-based 2D/3D Reconstruction for Orthopaedic Interventions
European Orthopaedic Research Society, Davos, Switzerland

Publications - Journal Papers

Ambrosetti-Giudici, S., Gédet, P., Ferguson, S.J., Chegini, S. and Burger, J.
Viscoelastic properties of the ovine posterior spinal ligaments are strain dependent
Clinical Biomechanics, 25(2):97-102

Arbabi, E., Chegini, S., Tannast, M., Boulic, R., Ferguson, S.J. and Thalmann, D.
The penetration depth method – a novel real time strategy for evaluating femoro-acetabular impingement
Journal of Orthopaedic Research, 28(7):880-6

Bardyn, T., Gédet, P., Hallermann, W. and Büchler, P.
Prediction of dental implant torque with a fast and automatic finite element analysis: a pilot study
Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontics, 109:594-603

Bork, T., Hogg, A., Lempen, M., Müller, D., Joss, D., Bardyn, T. Büchler, P., Keppner, H., Braun, S., Tardy Y. and Burger, J.
Development and in-vitro characterization of an implantable flow sensing transducer for hydrocephalus
Biomedical Microdevices, 12(4): 607-18

Cevidanes, L., Tucker, S., Styner, M., Kim, H., Chapuis, J., Reyes, M., Proffit, W., Turvey T. and Jaskolka, M.
Three-dimensional surgical simulation
American Journal of Orthodontics and Dentofacial Orthopedics, 138(3):361-371

Chan, S.C.W., Gantenbein-Ritter, B., Lezuo, P., Cheung, K. and Ito, K.
The fate of mesenchymal stem cells injected into bovine whole organ disc culture
The Spine Journal, 10(6)486-496

Chan, S.C.W., Lam, S.K., Leung, V.Y., Chan, D., Luk, K.D. and Cheung, K.M.
Minimizing cryopreservation-induced loss of disc cell activity for storage of whole intervertebral discs
European Cells and Matererials, 19: 273-283

Chegini, S. and Ferguson, S.J.
Time and depth dependent Poisson's ratio of cartilage explained by an inhomogeneous orthotropic fiber embedded biphasic model
Journal of Biomechanics, 43(9):1660-6

Ebert, LC., Ptacek, W., Naether, S., Fürst, M., Ross, S., Buck, U., Weber, S. and Thali, M.
Virtobot - a multi-functional robotic system for 3D surface scanning and automatic post mortem biopsy
International Journal of Medical Robotics and Computer Assisted Surgery, 6(1):18-27

Franke, J., Zheng, G., Wendl, K., Korber, J., Grützner, P.A. and von Recum, J.
Hüftendoprothetik - Rolle der computergesteuerten Navigation
Trauma und Berufskrankheit, 12:101-106

Publications - Journal Papers

Gantenbein-Ritter, B., Benneker, L.M., Alini, M. and Grad, S.
Differential response of human bone marrow stromal cells to either TGF-ß(1) or rhGDF-5.
European Spine Journal [Epub ahead of print]

Hägi, T.T., Enggist, L., Michel, D., Ferguson, S.J., Liu, Y. and Hunziker, E.B.
Mechanical insertion properties of calcium-phosphate implant coatings
Clinical Oral Implants Research, (11):1214-22

Hasler, C., Wietlisbach, S. and Büchler, P.
Objective compliance of adolescent girls with idiopathic scoliosis in a dynamic SpineCor brace
Journal Of Children's Orthopaedics, 4:211-218

Hasler, C., Hefti, F. and Büchler, P.
Coronal plane segmental flexibility in thoracic adolescent idiopathic scoliosis assessed by fulcrum-bending radiographs
European Spine Journal, 19:732-8

Hasler, C., Büchler, P. and Wietlisbach, S.
Die compliance von adoleszenten Mädchen mit idiopathischer Skoliose in einem dynamischen Korsett
Medizinisch Orthopädische Technik, 130(2): 69-80

Ilien-Jünger, S., Gantenbein-Ritter, B., Grad, S., Lezuo, P., Ferguson, S.J., Alini M. and Ito, K.
The Combined Effects of Limited Nutrition and High Frequency Loading on Intervertebral Discs with Endplates
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Kim, H., Jürgens, P., Weber, S., Nolte, L.-P. and Reyes, M.
A new soft-tissue simulation strategy for cranio-maxillofacial surgery using facial muscle template model
Progress in Biophysics and Molecular Biology. Special Issue on Soft Tissue Modelling, 103(2-3):284-291

Kozic, N., Weber, S., Büchler, P., Lutz, C., Reimers, N., González Ballester, M.A. and Reyes, M.
Optimisation of orthopaedic implant design using statistical shape space analysis based on level sets
Medical Image Analysis, 14(3):265-275

Kozic, N., Weber, S., González-Ballester, M.A., Abdo, G., Rufenacht, D.A., Ferguson, S. and Reyes, M.
Automated cement segmentation in vertebroplasty
Computery Aided Surgery, 15(1-3):49-55

Peterhans, M., vom Berg, A., Dagon, B., Inderbitzin, D., Baur, C., Candinas, D. and Weber, S.
A navigation system for open liver surgery: Design, workflow and first clinical applications
International Journal of Medical Robotics and Computer Assisted Surgery, [epub ahead of print]

Puls, M., Ecker, T.M., Tannast, M., Steppacher, S.D., Siebenrock, K.A. and Kowal, J.
The equidistant method - a novel hip joint simulation algorithm for detection of femoroacetabular impingement
Computer Aided Surgery, 15:75 - 82

Reutlinger, C., Gédet, P., Büchler, P., Kowal, J., Rudolph, T., Burger, J., Scheffler, K. and Hasler, C.
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Validation of statistical shape model based reconstruction of the proximal femur - a morphology study
Medical Engineering & Physics, 32:638-644

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The Journal of Laryngology & Otology, 125:262–270

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Zheng, G.
Assessing the accuracy factors in the determination of postoperative acetabular cup orientation using hybrid 2D-3D registration
Journal of Digital Imaging, 23:769 - 779

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Annals of Biomedical Engineering, 38:2910 - 2927

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Anderegg, S., Peterhans, M., Weber, S.
Ultrasound Segmentation in Navigated Liver Surgery
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Bauer, S., Seiler, C., Bardyn, T., Büchler, P., Reyes, M.
Atlas-based segmentation of brain tumor images using a markov random field-based tumor growth model and non-rigid registration
Proceedings of the 32nd Annual International Conference of the IEEE EMBS Buenos Aires, Argentina, pp. 4080-4083

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Conf Proc IEEE Eng Med Biol Soc, pp. 1848-1851

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Accurate and reliable navigation of a surgical reaming device for femoral head-neck offset improvement
Davies BL, Joskowicz L, Merloz P (eds): Computer Assisted Orthopaedic Surgery. Berlin, Deutschland, pp. 117-120

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Postoperative evaluation of surgery for craniosynostosis based on image registration techniques
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Anatomically-driven soft-tissue simulation strategy for cranio-maxillofacial surgery using facial muscle template model
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