MXL

Enhanced patient safety by computational modelling from clinically available x-rays to minimise the risk of overload and instability for optimised function and joint longevity

MXL aims to develop an ICT-environment to enable the safer management of joint surgery at all stages of joint degeneration, including replacement, with a focus on minimizing the key risks of failure that result from mechanical overload and instability.

Objectives of the project

It is estimated that over 100,000 joint revision surgeries are performed annually in the EU. Currently, between 5-10% of all surgical interventions to the knee and hip joints, and even up to 44% of shoulders, require revision surgery due to an unsuccessful outcome of the primary surgery, with clear implications to the comfort and wellbeing of the patient concerned. There is evidence to suggest that joint instability, overloading and implant loosening are initiated at the time of surgery or soon after in the immediate post-operative period. For the patient, failure means loss of function and severe pain. The inevitable revision surgery is not only highly stressful for the patient but also costly, with an estimated total socio-economic expense of over € 80,000 for each hip revision. The success rate of revision surgery, whether for loosening or early dislocation, is low.

Currently available planning systems in orthopaedics are limited to application in joint replacement, are typically based on 2D X-rays, and only focus on the determination of the likely size of the prosthesis that could fit the patients' anatomy.
MXL will:

- Identify the imaging techniques and protocols that are required to generate individual patient models of hard and soft tissue for use in the ICT system.
- Develop an ICT system that provides surgeons with quantitative information on the patient's anatomy, the status of the muscles and ligaments, as well as the status of the bone tissue and allows them to manipulate a virtual implant until optimal placement is achieved.
- Validate the developed system using clinical data
- Build the developed system to deliver a Surgical Planning (SP) environment and Surgical Training (ST) environment.

Project description

The MXL collaborators will be using innovative computational techniques to take clinically available X-rays as a basis from which to derive multilevel biomechanical models. These models will be enhanced with musculoskeletal competency data derived from explicit clinical tests that will enable a clinician to simulate the surgery and manipulate the virtual components to assess the mechanical loading conditions resulting from the reconstruction of the joint.

Due to its specialist ICT involvement, the MXL project is both novel and highly innovative; a claim supported by its use of original methodologies to process clinical and research data, as well as the joint involvement of clinical, biomechanical, management and IT specialists to effect the development and validation of a framework to allow accurate prediction of key mechanical parameters related to future clinical outcome.

The overall project is divided into a series of distinct phases. The initial phase will involve collection and management of the necessary medical image data. The second phase, which will occur in parallel with the first, will be research intensive and aimed at developing a variety of technologies (including statistical shape modelling, rapid biomechanical model generation, rapid biomechanical solution methods) to a useable status. The third phase will see their application within the verification phase, through in vitro testing as well as retrospective and prospective clinical trials. The fourth phase will see the development of the end applications, including a pre-operative planning tool, surgeon training tool and a patient recruitment tool. In parallel, additional work plans have been designed to monitor & control the project and to demonstrate the project results to the wider end-user community.

It is expected that IP generated from the MXL project will include;
Methods and algorithms for the automated meshing of finite element (FE) models
Neural networks for the rapid solution of FE models.

CASE STUDY

A 56 year old man is in need of a shoulder replacement due to worn cartilage and inflammation that is causing him pain and restriction of motion. Using the MXL surgical planning environment his surgeon is able to create a patient specific assessment of the risks of mechanical overload and instability for different replacement joint geometries and implantation orientations. This allows delivery of optimal joint function and longevity which, in turn, means our patient is able to return to work pain free.

Expected Results & Impacts & Preliminary results

MXL aims to deliver a descriptive, integrative and predictive ICT-environment that allows the inclusion of essential biomechanical information into the surgical decision making process to enable the identification of a safe route to optimal functional outcome, independent of the surgeon's prior experience and training.

MXL will deliver the technology to efficiently and accurately reconstruct 3D anatomy, assess the internal musculoskeletal loading and dynamic functional conditions, and perform in-depth analyses of the likely risk for joint overloading and joint instability in individual subjects. This methodology will ensure that MXL technology will be successfully translated into routine clinical practice and find a wide acceptance. By providing a complete biomechanical assessment through to patient postoperative function, this project will provide an integrated framework to make the parameters directly linked to the success of joint surgery accessible to the surgeon in clinical routine. MXL will be instrumental in optimizing patient care, reducing the risk of joint failure, and therefore maximizing patient safety in the treatment of degenerative joint disease and reducing health care spending over the coming decades.

Approximately 300,000 hip joint and 250,000 knee joint replacements are performed annually in the EU. Through the MXL project, we estimate that we will reduce the number of revisions necessary for hips, knees and shoulders that are related to mechanical problems by a target of at least 25%, which will result in a net reduction of 26,500 revision operations annually, equating to a total annual saving to EU healthcare providers of €689 million p.a. by 2020, (average cost per corrective procedure is €26k according to a UK survey [National Center for Health Statistics 2001 Nationwide Inpatient Survey]), which will then be available for re-distribution to other healthcare priorities.

improving joint surgery

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Project co-ordinator:
Charité - Universitätsmedizin Berlin

Contact person:
Markus Heller
Tel: +49 30209346128
Fax: +49 30209346001
Email: Markus.Heller@charite.de
Website: www.m-x-l.eu

Partners:

- Charité - Universitätsmedizin Berlin (Germany)
- University of Southampton (United Kingdom) Academisch Ziekenhuis Leiden – Leids Universitair Medisch Centrum (Netherlands)
- Euram Ltd (United Kingdom)
- ESI Group S.A. (France)
- Konrad-Zuse-Zentrum für Informationstechnik Berlin (Germany)
- Technische Universiteit Delft (Netherlands)
- Istituto Ortopedico Rizzoli (Italy)
- SCS SRL (Italy)
- Medis Specials b.v. (Netherlands)

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Biomechanics, Joint replacement, Surgery, Computational Modelling, Functional Assessment