PhD Doctoral Project

Pr D’AGOSTINO, MD and JP MOERMANS, MD, PhD
Clinique du Parc Léopold, Centre de Chirurgie de la Main, SOS Main Bruxelles

E VEREECKE, PhD and F STOCKMANS, PhD
Anatomy, Subfaculty Medicine, Kulak, K.U.Leuven
INTRODUCTION

PhD Thesis Research Project

- KUL PhD International Doctoral School in Biomedical Sciences Admission 12-2010
- Study:
  Does the trapeziometacarpal joint function as a saddle joint? Biomechanical analysis of the trapeziometacarpal joint and the impact of total replacement arthroplasty.
- Prospective and Multicentric
- Connections/ Collaboration: KUL - ULB - UCL
INTRODUCTION
INTRODUCTION

Connections - Collaboration

KUL PhD Doctoral School
Dr Pr D'AGOSTINO
PhD Dr JP MOERMANS
Co-Promotor

mercredi 25 avril 2012
Lack of profound understanding

Literature TMC J models:
Descriptive or quantitative models
Thumb ROM focused

Fundamental joint: Thumb opposition
Prehension component +++
OA > disabling impact +++
Armstrong et al. 1994

Interest?

Arthrokinematics of the thumb ??

Biomechanical factors contributing to OA ??

Prevalence rates < human population ageing
INTRODUCTION

利率？

- **Crucial to better understand the biomechanics of the normal TMC J**
- Saddle joint, bi-axial concept  
  - Eaton et al. 1973
  - Kuhlmann et al. 2001

But … Thumb opposition and circumduction

- movement such as hip and shoulder
- ball-and-socket joints

TMC joint replacement arthroplasty > reasonable medium and long-term results

- H0: normal TMC joint does not function as a saddle joint
Aims of the project

- (1) to develop a musculoskeletal model of the thumb that accurately describes normal TMC joint function in terms of the arthrokinematics

- (2) to obtain an insight in the biomechanical effect of geometrical and ligamentous changes of the diseased TMC joint

- (3) to investigate to what extent a total TMC ball-and-socket arthroplasty is able to restore the arthrokinematics of the healthy joint during standardized prehension tasks during activities of daily living
In vitro, In vivo and In silico Study

- **In vitro**
  - Fresh-frozen human hand cadavers (n = 3-4), no signs of OA on X-ray
  - Anatomical data acquisition (e.g. material properties of ligaments and tendons)
  - Carpal bones 3D modeling using CT and MRI
    - Generic musculoskeletal model of the healthy thumb (OpenSim software)
    - Experimental test conditions and arthrokinematic data collection for the in vivo study using cone-beam CT

Ethical Committee of the K.U.Leuven approval
In vivo

- Non OA, OA and post-implant surgery patients
- 4D dynamic visualization of bone motion < cone-beam CT method

Carelsen et al. 2005, 2009

⇒ In vivo bone geometry and arthrokinematics
METHODOLOGY

- **In silico**
  - Build a realistic musculoskeletal model of the thumb
    - understand the biomechanics of the TMC joint
    - linkage between motion at the STT, TMC and MCPI joints
  - Create a patient-specific model
    - explore biomechanical/anatomical changes
  - Assess the functional outcome of total joint arthroplasty
  - Introduce particular constraints
    - effect on the arthrokinematics
CONCLUSION

- **Study contribution**
  - better understanding of thumb OA and predisposing anatomical factors
  - better understanding of the biomechanics of the normal and implant TMC joint
  - highlight the biomechanical effects on joint function
  - give insight in the failure reasons of total TMC joint implant reconstruction

Ultimately improve the current designs of total joint arthroplasties
Implant concept more closely aligned to the normal TMC joint kinematics
Perspectives and expected benefits

International level:
Scientific and therapeutic major impact

National level:
Hand Surgery practice major impact
PROJECT IMPACT

- **International level**
  - In vivo 4D thumb biomechanical modelization
  - Implant design improvement or new implant concept development
  - Congress communications
  - Publications in International Peer-reviewed Journals
  - Fellowships and Visitors

INTERNATIONAL INFLUENCE and VISIBILITY
PROJECT IMPACT

- National level
  - Hand Surgeon with a PhD academic degree
  - Patients recruitment - Quality of care
  - Inter-University collaboration

FINANCIAL and HEALTH BENEFITS