Computer-Assisted Hip Osteotomy with Real-Time Biomechanical Guidance System

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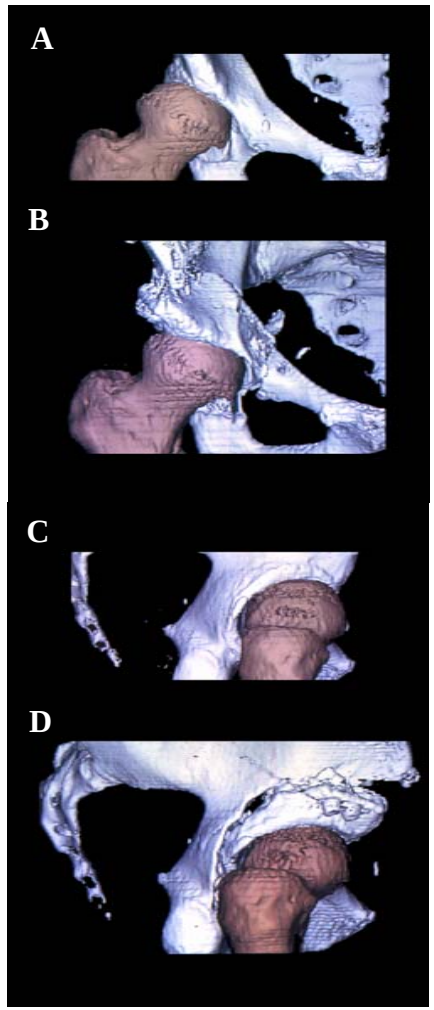
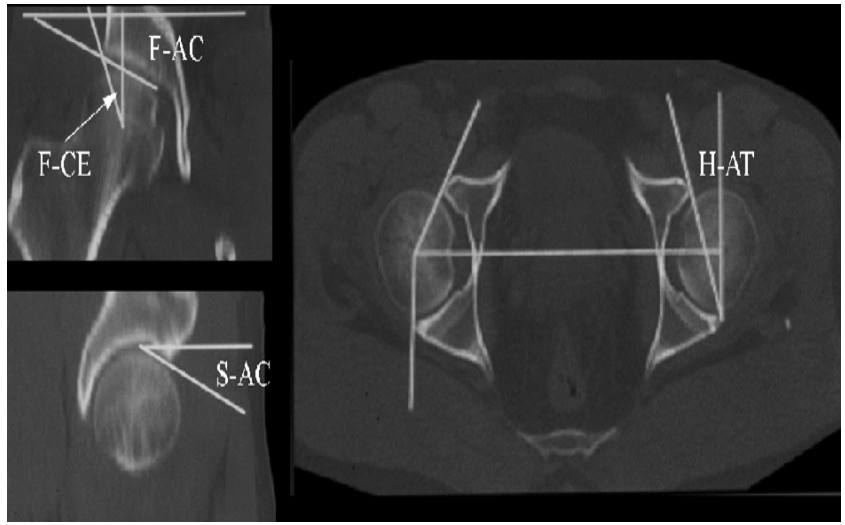
Introduction

- **Objective:**
  - **Demonstrate the feasibility of image-guided joint surgery when near real-time feedback of the biomechanical state of the joint is presented intraoperatively**
- **Hip dysplasia:**
  - **A significant cause of osteoarthritis in young adults**
- **Surgery goals:**
  - **To reduce patient pain**
  - **To reduce joint subluxation by reorienting the acetabulum to contain the femoral head**
- **Bernese Osteotomy:**
  - **Technically challenging procedure**
  - **Can benefit from computer-aided surgery**



Introduction

- **Preoperative Planning:**
  - **Aims at quantifying the abnormal anatomy based on anatomical angles**
  - **Limited biomechanical analysis**



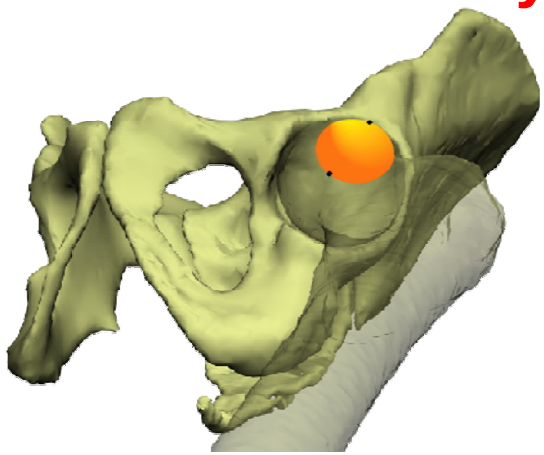
- **Image-guided Osteotomy:**
  - **Langlotz et al. reported the first 12 cases (1997)**
  - **Limited clinical application due to high cost, interface problems, space constraints, additional intervention time**

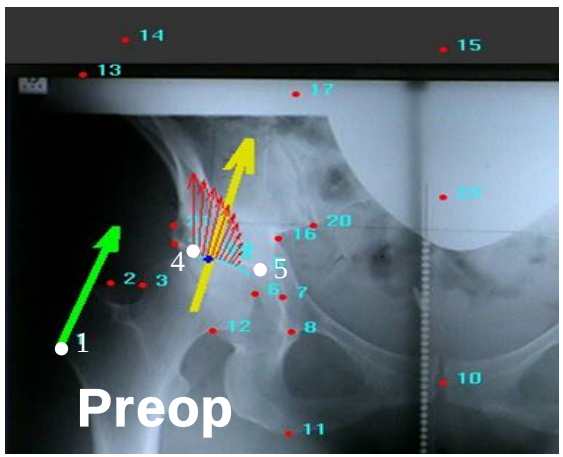
- **Intraoperative Biomechanical Guidance:**
  - **A tool to help the surgeon change the plans when fixation, congruency, impingement, and joint stability problems arise during the surgery**

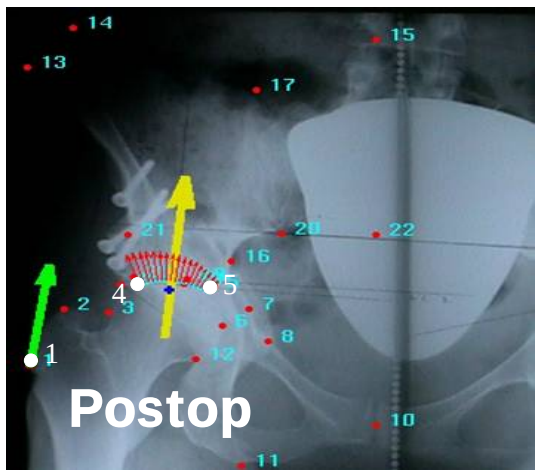
Approach: Analysis Tool

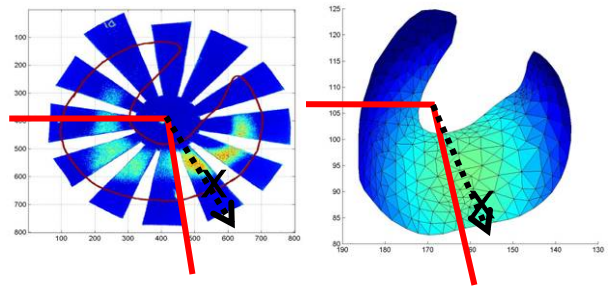
Discrete Element Analysis

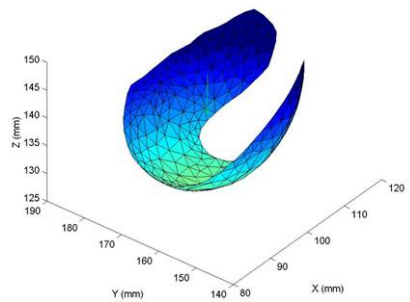
- **Analysis technique requirements:**
  - Relative accuracy
  - Fault-tolerant on the joint geometry
  - Suitable for simulation of individual-based functional data
  - Experimental validation





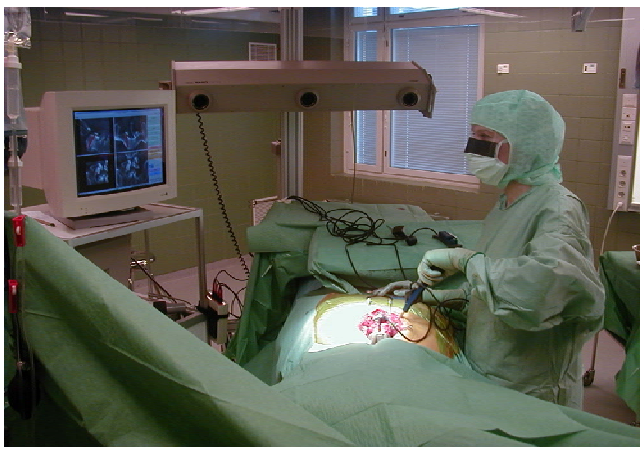


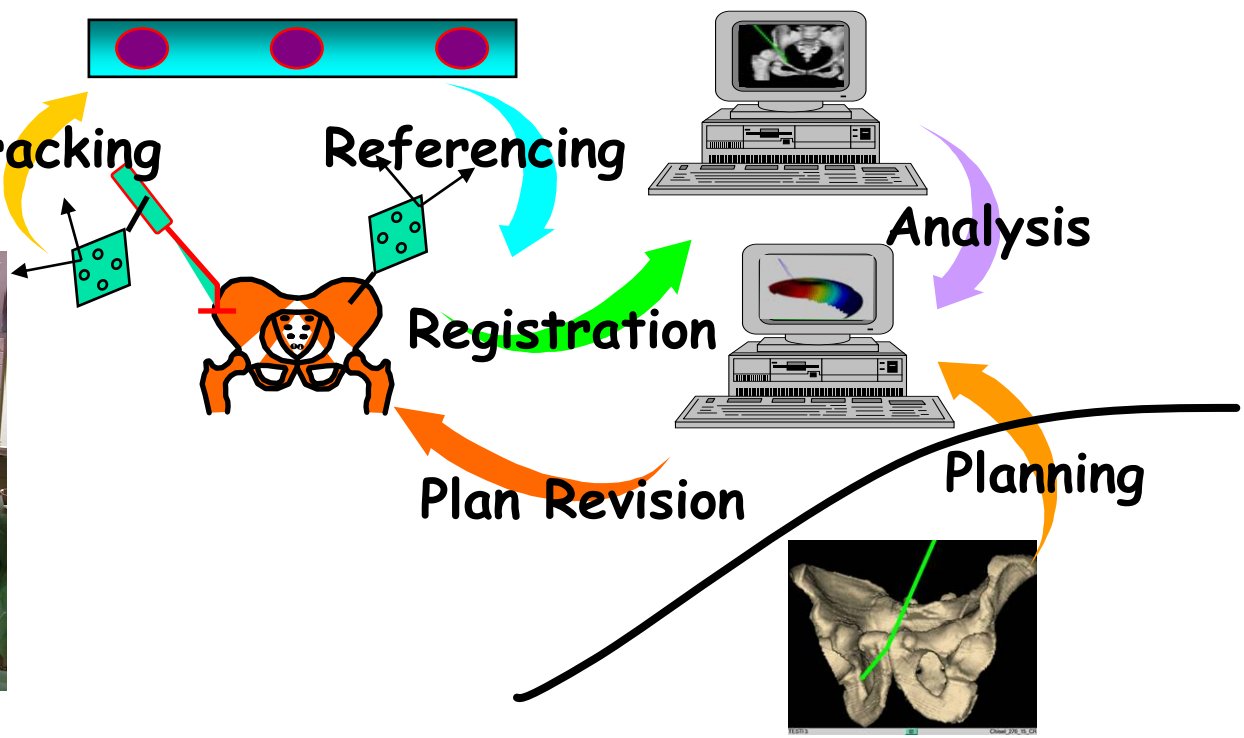




Approach: System architecture

- **System requirements:**
  - **Run independent of imaging system**
  - **Minimal additional effort for registration**
  - **Provide information at request of surgeon in < 1 min**





Study Plan

- BGS Development
  - Preoperative Planning Module
    - Model reconstruction from CT images
    - Surgical planning based on joint kinematics and biomechanics
  - Intraoperative Module
    - Model registration
    - Joint kinematics and biomechanical simulation
- Test of reliability and functionality
  - Cadaver testing
  - Satisfaction of minimal criteria for joint alignments
- Analysis of outcomes
  - Surgeries on 10 patients
  - Clinical follow-up at 6 months
  - Comparison with traditional technique