

# **A study of the errors associated with measuring knee kinematics using marker based motion capture and imaging**

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Accurate measurement of knee kinematics is essential for monitoring joint degeneration and evaluating total knee replacement (TKR) function. Motion analysis techniques are commonly used to generate in-vivo TKR kinematics. This method provides useful information on patient outcomes; however, errors are introduced due to soft tissue artifact when markers are attached to the skin. Image registration methods more accurately measure knee kinematics by registering 3D bone models or 3D CAD implant models to 2D fluoroscopic images. This study investigates the errors associated with marker based motion capture by comparing 3D in-vivo kinematics of the knee quantified using non-simultaneous motion analysis and image registration.

5 healthy knees and 5 TKR knees were examined for a step up/down task using dynamic fluoroscopy and motion capture. MRI scans of the knee, femur and tibia were performed on the 5 healthy subjects using a 3T GE scanner (General Electric Company). These were subsequently segmented using ScanIP (Simpleware Ltd) to produce subject specific 3D bone models. Registration of models produced from fine and coarse scan data was used to produce bony axes for the femoral and tibial models. Tibial and femoral component CAD models were obtained for the 5 TKR patients.

The 3D knee models and TKR CAD models were registered to a series of frames from the 2D fluoroscopic image data obtained for the 10 subjects, using KneeTrack (S. Banks, Florida) to produce kinematic waveforms. The same subjects were also recorded whilst performing the same action using the same step, using a Qualisys (Sweden) motion capture system with a pointer and marker cluster - based technique developed to quantify knee kinematics.

Range of motion, peak and minimum values were determined for the six degrees of freedom at the knee. One-way ANOVA was used to detect significant differences ( $P < 0.05$ ) between the measurements using motion analysis and image registration for the NP and TKR cohorts. The motion analysis method measured significantly larger frontal and transverse rotations and significantly smaller translations in three planes than the image registration method.

This work demonstrates that MRI can be used as a non-invasive tool for producing 3D bone models, thus avoiding the highly invasive effects of CT scanning on healthy volunteers. Good segmentation was achieved from MRI data using ScanIP (Simpleware Ltd.). It describes an application of combining fine and coarse scan models to establish anatomical or mechanical axes within bone models for use with kinematic modeling software.

This study outlines a method of investigating errors associated with measuring knee kinematics using marker-based motion capture. An appreciation of the errors is important for future data interpretation and classification of function.