3D KINEMATIC AND KINETIC DATA OF TOTAL KNEE ARHTROPLASTY DURING THE STANCE PHASE OF LEVEL WALKING USING A MOVING VIDEO-FLUOROSCOPE

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INTRODUCTION

Accurate in vivo kinematic and kinetic data of total knee arthroplasties, TKA, are important to understand the complexity of knee joint mechanics after knee joint surgery. This knowledge is crucial to reduce high stresses and strains on the ligamentous structure as well as on the implant parts. A better understanding could lead to better surgical strategies, improved implant designs, and increase patient's satisfactory rate. Video-fluoroscopy is a well established method to get accurate kinematic information of artificial joints by a three-dimensional numeric reconstruction of the single plane projection view of the fluoroscopic images. Until now, this method was limited to kinematic data only. Very accurate in vivo kinematic and kinetic data of TKA can be received by coupling instrumented gait analysis and video-fluoroscopy simultaneously and using a movable fluoroscopic system, proposed by Zihlmann et al. [1]. The goal of the present study was to get kinematic as well as kinetic data of TKA during the stance phase of level walking.

METHODS

One subject with a TKA (balanSys™ fixed bearing, Mathys AG Bettlach, Switzerland) was asked to perform several gait cycles. *Fluoroscopic motion tracking*: The c-arm of the pulsed fluoroscopic unit (Philips Medical Systems, Switzerland) was mounted on a motor driven trolley. The system accelerates and decelerates thereby keeping the knee joint within the field of view of the fluoroscopic image (25frames/s). *Optical tracking*: The subject's condyles and the position of the unit mover were tracked by the optical tracking system VICON (VICON Motion Systems Ltd.) with 100Hz. *Ground reaction forces*: Five force plates (KISTLER AG, Switzerland) were fixed on a basement which was mechanically decoupled from the surrounding ground avoiding an interaction with the unit mover during the level walking tasks. The time of all measurement systems was synchronised. *3D reconstruction of the 2D fluoroscopic images*: Distortion of the fluoroscopic images was corrected by a calibration grid. A full three dimensional analysis of each image was achieved by fitting a synthetic x-ray projection of the tibial and femoral component onto the original in each image [2]. The reconstruction of the implant's position and orientation (6DOFs) was performed relative to the focus of the fluoroscopic image. *Transformation into global coordinate system*: A calibration frame was fixed on one force plate on a defined position. Because the distance of the grid lines were known, the exact position in the global coordinate system of the fluoroscope's focus was calculated.

RESULTS AND DISCUSSION

The fluoroscopic system was able to track the knee joint so that the implant components were in the field of view of the fluoroscope during the stance phase of the gait cycle. During this phase, ground reaction forces were available. Figure 1 shows the finite axis of rotation between femoral and tibial component in the global coordinate system. The force vectors of the third force plate are plotted in the same figure. By reducing the ground reaction force into the axis of rotation the net forces and moments of the TKA can be estimated.

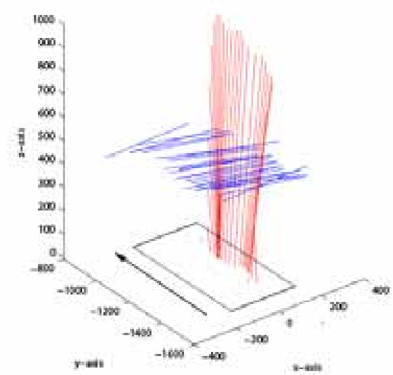

Figure 1: Axis of rotation between tibial and femoral component in the global coordinate system and force vectors of one force plate (4D plot with Δt = 40ms. Y-axis is gait direction)

CONCLUSIONS

This pilot study shows that the presented measuring technique enables the capture of kinematic and kinetic data of the stands phase of level walking simultaneously by coupling instrumented gait analysis and a movable fluoroscopic system.

REFERENCES

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2. Burckhardt KV, *PhD thesis Diss ETH No. 14262* ETH Zurich Switzerland, 2002.

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