SIMULATION OF A VOLUNTEER-SPECIFIC PATELLOFEMORAL JOINT

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INTRODUCTION

Biomechanical modeling plays an important role in biomedical engineering research studies. It provides a way of obtaining useful information which would be difficult to obtain experimentally. It presents unique challenges: e.g. the verification of model results are often problematic. A method is described by which patellofemoral kinematics can be modeled and validated. The model results can be used as input for further modeling, and for the interpretation of treatment techniques.

METHODS

A volunteer-specific model (male, age = 51) from the iliac spine down to the feet is constructed by means of Computer Aided Design (CAD) models in the LifeMOD environment. LifeMOD is a human biomechanics simulation tool (LifeModeler Inc., San Clemente, California, USA). The CAD models are generated from Computed Tomography (CT) and Magnetic Resonance Image (MRI) scans with the aid of commercial segmentation software (Mimics 12.01, Materialise, Leuven, Belgium). These models are supplemented with muscle-tendon elements, and the patellofemoral ligaments (Lateral retinaculum and medial patellofemoral ligament).

The hip, ankle and tibiofemoral parts of the knee joint are modeled as tri-axial rotational elements. The three principle joint rotations are replicated by means of volunteer-specific motion data as recorded with the Moven motion capture system while the volunteer takes a seat (by Xsens Technologies BV, Enschede The Netherlands). The stiffnesses of the ligaments and tendons as well as the quadriceps' muscle tensile forces are based on published experimental data [1, 2]. Placement of the ligament and tendon implant locations are based on values found in the literature [3, 4], values calculated from the volunteer's MRI scan, and lastly from a cadaveric anatomical study.

RESULTS AND DISCUSSION

The predictions of the right patellar kinematics (Figure 1) have been compared to the *in-vitro* findings of a cadaver study, as well as published results from a finite element model study [5], and results from an *in-vitro* study [6] (Table 1). The comparison of the results between different studies is dependent on the chosen measurement reference frame [7]. Keeping this in mind, the LifeMOD predictions are similar to the in-vitro results of the cadaver study and [5]. The patella shifts laterally while it tilts laterally and flexes from full extension to 90° knee flexion.

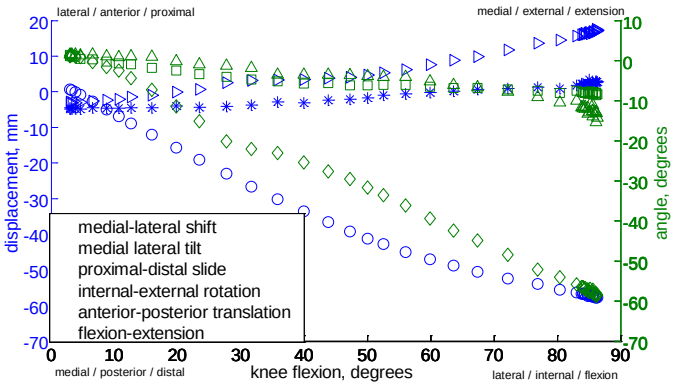

Figure 1: Right patellar kinematic predictions

CONCLUSIONS

The described procedure provides a means by which patellofemoral kinematics can be investigated. A volunteer-specific model is generated and manipulated based on volunteer-specific motion recordings. The model predictions have been compared to results of different studies, and found to produce similar trends for patellofemoral kinematics.

ACKNOWLEDGEMENTS

A special word of thanks to Dr. Van Wagening and Partners for their assistance with the MRI and CT scans and to the volunteer for being willing to take part in the study.

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Table 1: Right patellar kinematics predictions compared to published results and the results of a cadaver study

Source	Mediolateral	Anteroposterior	Proximal-distal	Mediolateral tilt	Flexion- extension	Internal-external
LifeModeler	7 mm lateral	17 mm anterior	55 mm distal	7° lateral	60° flexion	10° internal
Cadaver study	Not measured	Not measured	Not measured	7° lateral	60° flexion	Erratic
[1]	2 mm medial	60 mm posterior	60 mm distal	10° lateral	50° flexion	10° internal
[2]	5 mm lateral	Not measured	Not measured	7° lateral	42° flexion	Erratic