EVALUATION OF LAXITY TESTS WITH A MUSCULOSKELETAL MODEL OF TOTAL KNEE ARTHROPLASTY

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INTRODUCTION

Musculoskeletal models are emerging as potential tools for the use in many clinical applications. One important example is aid to the clinical decision in the orthopaedic field. Recently, a patient-specific model of Cruciate-Retaining Total Knee Arthroplasty (CR-TKA) was presented and validated with respect to knee joint forces and kinematics [Marra, 2015]. However, the ligament restraints were not calibrated and inaccuracies in knee kinematic predictions were present. The objective of this study was to evaluate the effect of ligament calibration on the performance of simulated laxity tests.

METHODS

A musculoskeletal model of CR-TKA was previously described [Marra, 2015]. The model comprised the musculoskeletal architecture of a TKA patient and a force-dependent model of the prosthetic knee and patellofemoral joint. Ligament restraints were modelled using non-linear springs and contact was solved using a rigid formulation. To calibrate the ligament parameters we simulated anterior/ /posterior, valgus/varus and endo-/exorotation laxity tests. Each test was performed at four different knee flexion angles (0, 30, 60, 90 deg). The anterior (respectively posterior) laxity load consisted of a 35 N force applied on the tibia at a distance of approximately 15 cm from the surface of the tibial component, pointing anteriorly (respectively posteriorly). Valgus (respectively varus) test was simulated by applying a force on the tibia at a distance of approximately 15 cm from the ankle joint, pointing laterally (respectively medially) so that the resulting moment was equal to 10 Nm. For the endo- (respectively exo-) rotation a 1.5 Nm torque was applied to the longitudinal axis of the tibia. Laxity envelopes for each test were calculated as the difference between the values obtained in the two opposite directions of the test. Manual changes to ligament insertion site, stiffness, and reference strain were made iteratively in order to obtain laxity envelopes close to those reported in the literature for cadaveric tests on a CR-TKA [Saeki, 2001]. All the laxity tests were eventually simulated with the same ligament configuration.

RESULTS

The results for all simulated laxity tests and the reference values from the literature are summarized in Table 1.

	0°	**30°**	**60°**	**90°**
AP (M)	3.5 mm	4.2 mm	1.0 mm	1.0 mm
AP (L)	1.5 mm	5 mm	4 mm	4.5 mm
VV (M)	0.9°	4.3°	2.6°	1.5°
VV (L)	3.0°	6.0°	7.0°	7.0°
EE (M)	7.0°	16.5°	4.0°	5.5°
EE (L)	6.5°	22.0°	21.0°	23.0°

Table 1: AP: Anterior/Posterior, VV: Valgus/Varus, EE: Endo-/Exorotation, M: Model prediction, L: Literature value

DISCUSSION

The laxity envelopes predicted by the model were in partial agreement with those reported in the literature. The largest differences were noted for 60–90 degrees of knee flexion for all laxity tests, where the model showed considerably less laxity. These deviations may be attributable to actual differences between the implant design and subject geometry currently simulated and those used in the cadaveric tests. In future studies we aim to simulate surgical variations such as implant size and positioning, joint line elevation and ligament restraint. This musculoskeletal model of TKA has potential as a pre-operative planning tool for orthopaedic interventions.

REFERENCES

- *Marra et al, J Biomech Eng, 137, 2015*
- *Saeki et al, Clin Orthop Relat Res, 392:184–189, 2001*