PATIENT MUSCULOSKELETAL PHENOTYPES, REAL TIME BIOMECHANICAL MODELING AND PREDICTED INDIVIDUALISED FUNCTIONAL OUTCOMES IN TOTAL KNEE ARTHROPLASTY

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Introduction

Primary total knee arthroplasty (TKA) has been developed to a successful clinical treatment for degenerative osteoarthritis, rheumatoid arthritis and osteonecrosis with comparably low cumulative percentages of revision over a period of 15 to 20 years [Reed 2019, Graves 2019, Evans 2019]. Mechanical axis alignment, especially in combination with navigation allows for a precise component positioning, reduced revision rates [De Steiger 2015] and better functional outcomes [Rebal 2014]. Despite substantial advances in primary TKA, studies suggest only 80 % to 85% of patients are satisfied and Bourne 2010 confirmed in a substantial TKA cohort that one in five (19%) TKA patients were dissatisfied with their outcome. Various approaches in TKA alignment and knee balancing are currently undergone, such as kinematic alignment [Rivière 2018, Calliess 2016], a constitutional varus concept [Bellemans 2012], functional knee phenotypes in coronal lower limb alignment [Hirschmann 2019], and dynamic coronal femoral tibial mechanical angle alignment [Larrainzar-Garijo 2017]. Due to the empirical character of different proposed TKA alignment approaches, the objective of our study was to develop and validate a dynamic biomechanical knee model for pre-operative simulation and intra-operative real-time usage in combination with orthopaedic knee navigation.

Materials & Methods

A knee implant positioning model was created and a dynamic biomechanical FEA simulation was developed, using as input parameters standardised loads and flexion-extension movements measured in vivo [Bergmann 2014]. The hypothesis was that the resulting moments are comparable and would lead to comparable tibio-femoral kinematics (model output).

Results

Using the CAMS-Knee data set with moving fluoroscope and 3D kinematic reconstruction [Taylor 2017, Schuetz 2019] for multiple patients and different activities, the dynamic biomechanical knee model was validated to predict knee reaction moments and tibio-femoral kinematics (AP-translation & IE-rotation).

Discussion

The newly developed dynamic biomechanical knee model allows for the prediction of the implant kinematics based on standardised loads, considers patient-specific parameters (e.g. phenotypes), monitors resultant tibio-femoral contact mechanics and is compatible for various TKA alignment approaches.