MUSCULOSKELETAL MODELLING OF A PROTHESIZED HIP ALLOWS TO DETERMINE HIP CONTACT LOADS AND LOCATIONS

Giovanni Putame (1,2), Federico A. Bologna (1,2), Alberto L. Audenino (1,2), Mara Terzini (1,2)

1. Polito^{BIO}Med Lab, Politecnico di Torino, Turin, Italy

2. Department of Mechanical and Aerospace Engineering, Politecnico di Torino, Turin, Italy

Introduction

Due to the rising of the average population longevity and the concurrent decrease of the age at which arthroplasty is performed, an important increase in revision surgery for total hip arthroplasty (THA) has been estimated by the year 2030 [1]. Based on these forecasts, a better understanding of the loads to which implants undergone during daily activities, together with insights of how such loads are related to the implant geometrical features, can provide valuable information in order to extend implants lifespan, hence reducing the necessity of revision surgeries. In this context, *in silico* musculoskeletal modeling represents an effective and flexible approach able to estimates articular loads [2]. In this study, a multibody (MB) model of the lower limb, including a parametrized hip prosthesis, is exploited to assess the impact of the implant geometry on hip contact force and contact point location on the femoral head during normal walking activity.

Methods

A MB model of a lower limb (Fig. 1A) was created (Adams View MSC Software, USA) including scaled bony geometries (from pelvis to tibia), main muscles, and a parametrized hip prosthesis (Fig. 1B). Muscle actuators are implemented through a set of feedback controllers having the muscle lengthening as controlled variables. Motion and ground reaction forces for a normal walking activity were derived from the OrthoLoad datasets [3] and used as inputs to perform inverse kinematics followed by muscle-driven forward dynamic simulations for which average external forces and torques were directly applied to the ankle joint while the pelvis kinematics was prescribed. Also, 1 DoF knee joint was considered, beside a contact pair was defined between femoral and acetabular cup. Simulations were repeated by varying the implant geometry. Specifically, the influence of different prosthesis neck lengths (L) was investigated (ref = 38, long = 42, short = 34 mm), thus, the obtained hip contact force, expressed in body weight (BW), and the contact location on the femoral head were compared.

Results

Numerical analyses revealed a contact force variation of roughly ±0.1 BW (Fig. 1C), during mid and terminal stance phases, where the shorter neck length produced the highest force. Looking at the contact location, a negligible alteration in the contact point trajectory was observed among the different configurations. In general, the contact point moves along an arc path located apically on the femoral head (Fig. 1D).

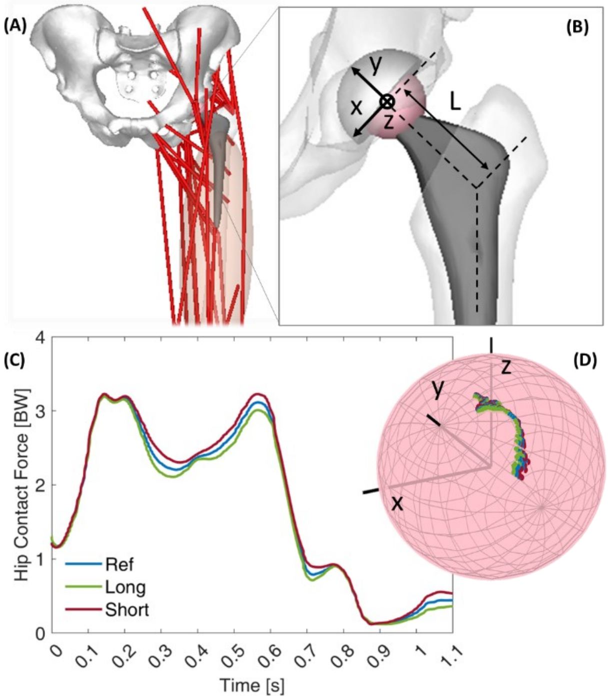

Figure 1: (A) multibody model of the THA; (B) hip prosthesis with the parametrized neck length (L), and the head reference system (x,y,z); Explanatory results showing (C) hip contact force and (D) contact location on the femoral head during walking for different L.

Discussion

The presented musculoskeletal model can find applicability in a variety of outstanding scenarios, spanning from advanced patient-specific preoperative planning to *in silico* testing of novel hip prosthesis designs. Indeed, the outputs attainable from the model, e.g., loads and related points of application, undeniably constitute a plus for more reliable loading conditions in finite element modeling. In the next future, the model capability will be further enhanced by including additional motion activities, e.g., knee bending, and other settable geometrical implant parameters.

References

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