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Musculoskeletal finite element model of the foot. Loading and direct dynamic validation

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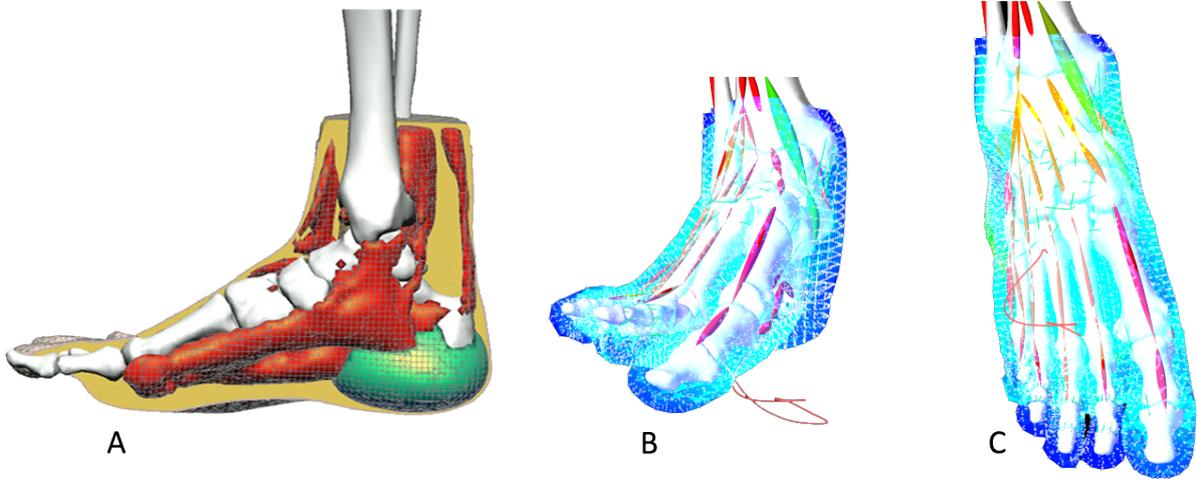
Introduction: The foot is one of the most complex structures of the human body with 28 bones, 33 joints and a hundred ligament structures. Foot plantar ulcer often appears when some deformities occur in a neuropathy context. Predicting foot adaptation of a structural, neurological or functional, and tissue modification is an important issue in estimating the risk lesion.

Methods: We designed a biomechanical model of the human foot. The anatomy was reconstructed from Ct-Scan and MRI. The multi-articulated foot joint constraints were obtained by ligaments and bone contact. Muscles have been implemented to control the model in direct dynamic. Finally, the soft tissues such as muscle, fat and skin were meshed into finite elements. The validation was performed using foot plantar pressure and motion analysis coupled with EMG exploration.

Results: Adapting the foot on the ground in standing position was evaluated by comparing the actual loading pressure map of the subject to a simulated one. The mean pressure difference was 1.9 N/cm² and 1.6N/cm² for the peak pressure. The motor control of foot in opened chain by activation of the extrinsic muscles was assessed by comparing the kinematics of the biomechanical model piloted by electromyography to kinematics captured in the laboratory on a movement of abduction - adduction. The 3D range of motion difference was 3.9%.

Discussions: This model is validated and will allow through mesh-matching tool to obtain specific patient models. The fields of application will focus on assisted surgery and prevention of ulceration.

Clinical relevance: A realistic anatomical foot model can predict foot pressure et foot motion under muscle activation. It could be helpful for educational purpose and physio pathological understanding.



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