

Introduction

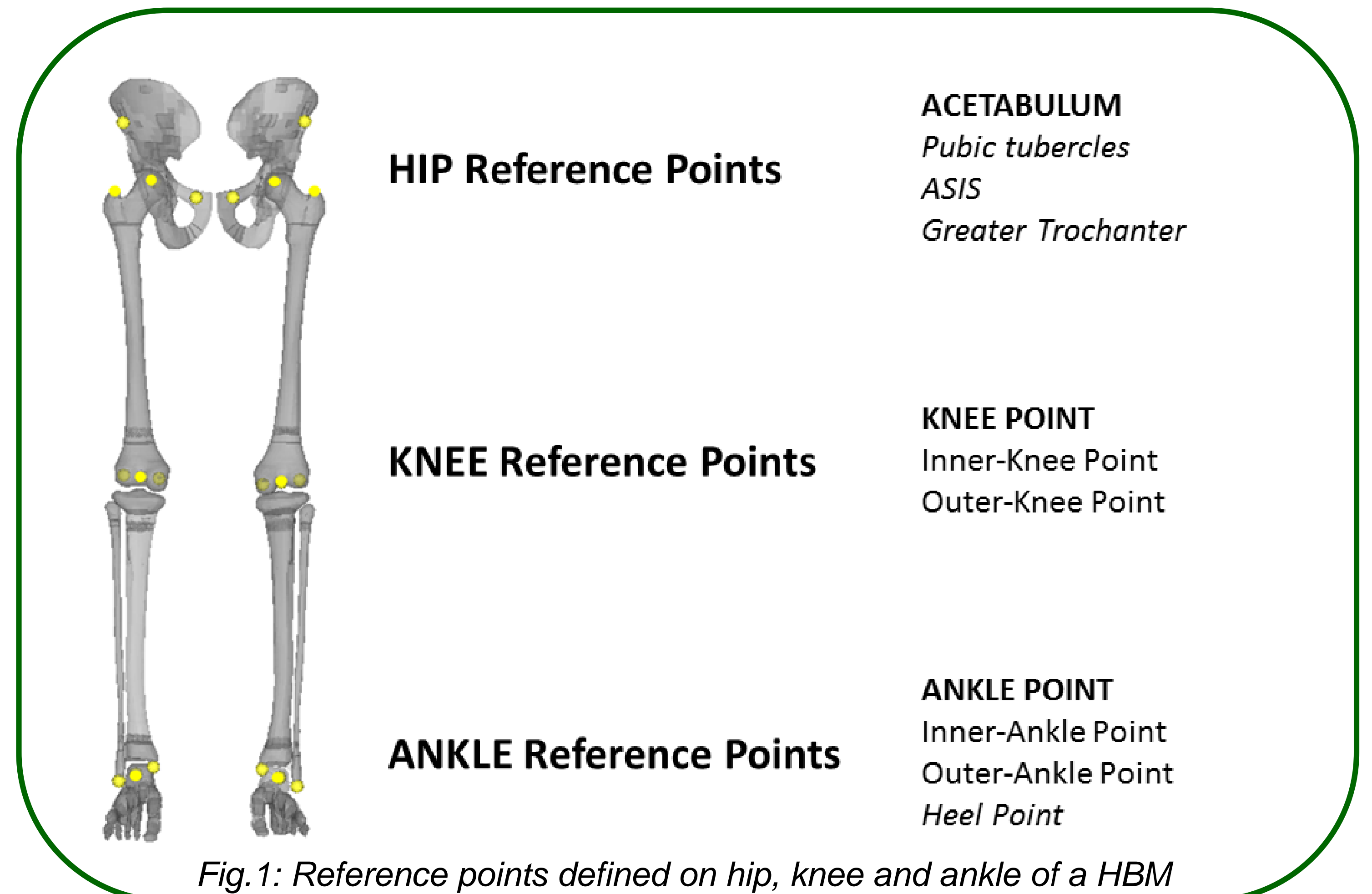
Finite-Element (FE) Human Body Models (HBMs) are broadly used in the automotive field for investigating injury mechanisms in different impact scenarios. Several pre- and post-processing tools for HBMs have been recently developed, such as the PIPER tools to position or scale a HBM. The accuracy of such tools highly depends on the quality of input data, such as metadata describing a HBM's joint rotation centres needed for an anatomically correct positioning. Such data might exist for several HBMs nowadays available. However, there is currently no agreed methodology for defining anatomically meaningful reference points in an HBM which is obligatory for almost any pre- and post-processing procedure. Objective of this study was to define reference points needed to non-ambiguously describe the position of a HBM in the global Coordinate System.

Methods

Any anatomical point needed to obtain and describe anatomically meaningful postures of the HBM was added to the list of reference points. The definitions comprise points located in joint rotation centres building rotation axes and therefore needed to constitute the kinematic chain of a HBM as well as points at other bony landmarks needed to describe commonly used anatomical definitions, e.g. the Frankfurt Plane. The points were defined mesh-independent so that they are not subject to model changes as HBMs are continuously updated by model developers. The definition of the points was based on literature publishing biomechanical methods determining joint rotation centres, axes or bony landmarks in the human anatomy. These procedures were then applied to HBMs and transferred into clear instructions and distinct methodologies of how to define the according reference point in a HBM.

Results

Based on data from literature, instructions for deriving reference points of the lower extremities (hip, knee, ankle) (Fig1), pelvis, upper extremities (shoulder, elbow, wrist) and the thorax were defined. As a showcase, the hip reference point was defined in the rotation centre of the joint and is to be found following the instruction [1], [2]: *“to define the hip reference points (left and right) all nodes, belonging to the hemi-sphere's surface of the acetabulum, are to be selected and the point equidistant from the selected nodes calculated.”*



Discussions

Reference points are needed to establish harmonised pre- and post-processing procedures, to safeguard credible results of HBM simulations and to consequently qualify the models as reliable tools in the safety divisions of automotive companies. Within this study, a set of reference points was developed aiming to be used by a broad community when applying different pre- and post-processing to HBMs in order to safeguard a standardised application of the models.

Acknowledgements

The study was conducted within the THUMS User Community, a project of LMU in cooperation with AUDI AG, Autoliv, BMW AG, Daimler AG, Dr. Ing. h.c.F. Porsche AG, Toyota Motor Corporation, Volkswagen AG and ZF TRW.

Literature

- [1] Kapandji A. (1985). *Ferdinand Enke Verlag*.
 [2] Adam F. (2005). *Georg Thieme Verlag*.