Abstract

Skeleton is a basic supporting system of the human body and a passive substrate for any possible movement, while the shape and mechanical properties of a single bone are given both by the embryological origin and its function. The bone can transfer mechanical load with an optimal amount of energy, and this power flow can be documented by mechanical testing or computational modelling. The author decided on the latter and tried to define the main stiffnesses as one of the most important internal modalities to determine overall bone quality.

Stiffness is a widely used biomechanical measure reflecting geometric, topologic and material properties of a given bone. It is defined as a resistance of a bone against deformation in response to an applied force. This thesis aims to study and describe a characteristic bone stiffness of a CT based virtual models using the spectral decomposition of a stiffness matrix. The characteristic stiffness as a brand-new descriptor of bone tissue will be further correlated with the bone density spatial distribution and matched against a set of chosen anthropometric measurements to test its sex-specificity. Additionally, an automatic system capable of recognising and generating anthropometric landmarks on a bone will be developed as a side result.

The localisation of the smallest stiffnesses and their directions has a significant practical output. As bone quality directly influences patients' lives, novel methods for predicting bone mechanics are of high interest in various medical fields. With proper modelling, one can model the fracture risk (side-falls, car accidents), skeletal adaptation in response to specific loading (implants) or mechanical changes based on different diseases (osteoporosis). Ideally, non-invasively and based on actual patient examinations.

In this thesis, the author focused on finding these stiffnesses to better understand the complex anatomy and physiology of the human pelvic bone. As the bones are different in size and shape, connected to muscles and neighbouring body parts, all these aspects affect bone stiffness's spatial distribution. Here, the combined anatomical and bio-mechanical input is essential.