

Finite Element Analysis in Orthopedic Biomechanics

Abstract:

In this work a literature review has been carried out to identify current trends of research in orthopedic biomechanics with emphasis on significance and challenges involved in finite element analysis of musculoskeleton implant structures. The finite element analysis was introduced in field of orthopedic biomechanics in 1972 to quantify and predict stresses in human bones, deformations of musculoskeletal structures and to estimate the impact of biomechanical stimuli at microscopic cellular level. In particular this method is popularly used for structural analysis of bones, implants, prosthesis structures. Moreover, performing prototyping of such structures in virtual environment provides a nondestructive way of analyzing musculoskeleton structures and reduces the reliance on clinical trials and animal experimentation.

The aim of this investigation is to identify popular research areas within orthopedic biomechanics especially in design and developments of musculoskeletal implants. From the investigation, following research trends have been identified within the area of orthopedic biomechanics. 1- Musculoskeleton injury and repair following a fracture and role of biomechanical stimuli in healing procedure. 2- Constitutive model of soft tissues composing cartilage, tendons and bones. 3- Framing finite element analysis as a methodology which creates clinically relevant results. 4- Design and development of dental and musculoskeletal implants using finite element analysis. Furthermore a detailed study development of implants has revealed main challenges of virtual prototyping of musculoskeleton implants i.e. 1- Three dimensional detailed reconstruction of bone morphology using CT scans 2- Mapping of inhomogeneous material data on finite element mesh. 3- Estimating three dimensional mechanical loading on joints 4- Predicting the mechanics of bonding between implant and bone interface. 5- Production of implants by additive manufacturing techniques.

Literature has extensively pointed out finite element method as an important research tool in field of biomechanics that has triggered potential new lines of research in science of orthopedics.