Design process of cementless femoral stem using a nonlinear three dimensional finite element analysis

Bahrudin, M.Y.1,2, Saleh, S. H.3, Zulkifly, A.H.4, Lee, M.H.4, Noor, A.M.5,6, A-Harris, A.R.5,6, Majid, N.A.5,6, Abd Kader, A.S.5,6

1 Department of Biomedical Engineering, Faculty of Engineering, University of Malaya, Kuala Lumpur, Malaysia
2 Centre for Biomedical Engineering Transportation Research Alliance, UniversitiTeknologiMalaysia, Skudai, Johor, Malaysia
3 Department of Orthopaedic, Traumatology and Rehabilitation, Kulliyyah of Medicine, International Islamic University Malaysia, Kuantan, Pahang, Malaysia

Abstract

Background: Minimal available information concerning hip morphology is the motivation for several researchers to study the difference between Asian and Western populations. Current use of a universal hip stem of variable size is not the best option for all femur types. This present study proposed a new design process of the cementless femoral stem using a three dimensional model which provided more information and accurate analysis compared to conventional methods. Methods: This complete design cycle began with morphological analysis, followed by femoral stem design, fit and fill analysis, and nonlinear finite element analysis (FEA). Various femur parameters for perosteal and endosteal canal diameters are measured from the osteotomy level to 150 mm below to determine the ischium position. Results: The results showed better total fit (33.7%) and fill (76.7%) canal, with more load distributed proximally to prevent stress shielding at calc region. The stem demonstrated lower displacement and micromotion (less than 40 μm) promoting osseointegration between the stem-bone and providing primary fixation stability. Conclusion: This new design process could be used as a preclinical assessment tool and will shorten the design cycle by identifying the major steps which must be taken while designing the femoral stem. © 2014 Bahrudin et al; licensee BioMed Central Ltd.

Author keywords

Cementless hip, Femur, Finite element analysis, Hip replacement, Morphology

Indexed keywords

MeSH:
- Adult
- Arthroplasty, Replacement, Hip
- Computer Simulation
- Computer-Aided Design
- Female
- Femur
- Finite Element Analysis
- Hip Prosthesis
- Humans
- Imaging, Three-Dimensional
- Male
- Multidetector Computed Tomography
- Nonlinear Dynamics
- Prosthesis Design
- Prosthesis Failure
- Radiographic Image Interpretation, Computer-Assisted
- Stress, Mechanical
- Young Adult

ISSN: 1471-2474
Source Type: Journal
Original language: English
PubMed ID: 2484753
Document Type: Article

Cited by 9 documents

The effect of boundary constraints on finite element modelling of the human pelvis


Comparative analysis of the biomechanical behaviour of two cementless short stems for hip replacements: Lines Anatomic and Minihip


The influence of contact ratio and its location on the primary stability of cementless total hip arthroplasty: A finite element analysis