

TOTAL HIP REPLACEMENT: EFFECTS OF BODY MASS INDEX, ACETABULAR MORPHOLOGY, AND BONE QUALITY ON STRESSES DEVELOPED IN CEMENT MANTLES

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Cemented total hip replacements (THR) are widely used and are still recognised as the gold standard by which all other methods of hip replacements are compared. [1]. Long-term results of cemented total hip replacements show that the revision rate due to aseptic loosening could be as high as 75.4% [2]. Moreover, high stresses developed in the cement mantle of reconstructed hips can lead to premature failure of the constructs [3]. Surgical fixation techniques vary considerably [4]. The aim of this study was to investigate the performances of different surgical fixation techniques of hip implants for patients with different body mass indices, bone morphology and bone quality, using finite element (FE) methods.

Anatomically correct reconstructed hemi-pelves were created, using CT-Scan data of the Visible Human Data set, downloaded to Mimics V8.1 software, where polylines of cancellous and cortical bones were created, and exported to I-Deas 11.0 FE package, where the reconstructed hemi-pelvis was simulated. Accurate 3D model of the hemi-pelvis was scaled up and down to create hemi-pelves of acetabular sizes of the following diameters: 46 mm, 52 mm, and 58 mm. Following sensitivity analyses, element sizes ranging from 1-3 mm were used. Material properties of the bones, implants and cement were taken from literature [5-7]. Bones of poor quality were simulated by a reduction in the elastic moduli of the cortical bone by 50%, the cancellous bone by 10 % and the subchondral bone by 50% [5]. The nodes at the sacro-iliac joint areas and the pubic support areas were fixed. A compressive force of 3 times body weight was simulated at the hip joint. The nodes between the cancellous and subchondral bones were merged. Contact elements were used at the subchondral bone and cement mantle interface and between the femoral head implant and acetabular component. Dynamic in vitro tests, simulating forces acting on a hip joint during a gait cycle, were carried out on reconstructed synthetic bones, positioned on an Instron 8874 hydraulic machine, to verify the FE models.

The volume of cement stressed at different levels in groups of 0-1 MPa, 1-2 MPa and up to 11 and above MPa were calculated. Results of FE analyses showed that (1) an increase in the body mass index from 20 to 30 generated an increase in the tensile stress level in the cement mantle; (2) lower tensile and shear stresses developed in thicker cement mantles. For a 46mm acetabular size, peak tensile stresses decreased from 10.32MPa to 8.14MPa and peak shear stresses decreased from 5.36MPa to 3.67MPa when cement mantle thickness increased from 1mm to 4mm. (3) A reduction in the bone quality would result in an increase of approximately 45% in the cement mantle stresses. Results of in-vitro tests show that an increase in the cement mantle thickness improved fixation, corroborating with the FE results.

Performances of fixation techniques depend on the patient's bone mass index, bone quality, bone morphology.

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