Virtual planning and personalised surgical guides for juvenile femoral osteotomies

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INTRODUCTION

Hip deformities in juvenile patients are subsequent to Perthes’ disease, slipped capital femoral epiphysis or neuromuscular diseases¹.

Proximal femoral osteotomy is a complex corrective surgical procedure involving multi-plane corrections.

Traditional surgical pre-planning is informed by static two-dimensional images.

Minimal objective understanding of:
• How the deformity affects pre-operative hip joint kinematics
• How the surgery might affect hip joint & muscular function

AIMS

Perform virtual surgical simulations to restore normal hip joint anatomy & muscle function.

Design & manufacture personalised surgical cutting guides to streamline translation of virtual plan.

METHODS

(1) Ten participants (age: 12.2±3.3 years) with proximal femoral deformity were prospectively recruited and had CT and MRI scans acquired.

(2) Three-dimensional pelvis, femurs and glutei muscles were reconstructed (Mimics 21.0, Materialise). The 3D femoral anatomy was assessed to determine the required rotational corrections.

(3) To examine the effect of the virtual osteotomies on hip joint function, pre-operative and virtually corrected subject-specific musculoskeletal models were created of each participant’s hip. Hip joint range of motion and glutei moment arms were computed in OpenSim².

(4) Adhering to quality control guidelines³, personalised surgical guides were designed, and 3D printed in biocompatible Nylon (Formiga P110, EOS).

(5) The virtual plan and surgical guides were used in surgery to perform the bony correction and guide the fixation of the implant.

(6) Post-operative hip CT scans were acquired, and 3D femurs were reconstructed to compare planned and achieved corrections.

RESULTS

For all the participants, compared to the pre-operative models, the virtually corrected models had increased impingement-free range of motion and glutei muscle moment arms.

Compared to six similar procedures performed with traditional planning, virtual planning cases had, on average:

56% decrease in radiation dose
45% decrease in radiation time
27% decrease in surgical time

DISCUSSION

The proposed virtual surgery workflow can improve proximal femoral osteotomy pre-planning.

The use of personalised surgical guides considerably reduced radiation dose and time, and surgery time.

REFERENCES:

2. Modenese L et al., J Biomech, 73:108-18, 2018

For more information: