RANGE OF MOTION SIMULATION FOR DIAGNOSIS OF FEMOROACETABULAR IMPINGEMENT

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INTRODUCTION

In femoroacetabular impingement (FAI), deformations of the femoral head or the acetabular rim lead to bony impingement, resulting in limited hip motion, pain and progressive damage to the labrum. Recent work suggests that FAI may lead to osteoarthritis (OA) [2]. Although the etiology of FAI is still unclear, a variety of possible causes are described, such as excessive sporting activities and posttraumatic deformities (e.g. acetabular dysplasia).

When the acetabular rim shows deformations, this is referred to as Pincer FAI. Cam type FAI occurs when the femoral head has deformed. The two types sometimes occur simultaneously. However, each individually reduces the head-neck offset and leads to FAI symptoms.

Various imaging modalities are used for the diagnosis of FAI, none being conclusive. The spatial relationship of the pelvis and femur plays an important part in this, and as such more complex measurements are required to properly diagnose and assess FAI.

In previous work, a range of motion (RoM) simulation system for shoulder replacement surgery was presented [3]. The system loads patient-specific CT-data of the shoulder and simulates bone-constrained RoM. For the experiment described herein, we adapted the simulator to the hip joint to evaluate its applicability for the diagnosis of FAI.

METHODS

An MRI-scan of the hip joints of a FAI patient was segmented and converted to surface models. The bone models of the healthy (left) side were mirrored and the positions were matched with the positions of the bone models of the pathological side using the iterative closest point algorithm. To quantify morphological geometric differences between the bones, we calculated the closest point distance for each of the models using Mesh1.13 [1].

The bone models were loaded into the RoM simulator. The simulator automatically detects the centre of rotation of the femoral head by applying a Hough transform. It then uses a simplified kinematic model to systematically reorient the bone in multiple directions, whilst using a collision detection algorithm to detect whether further motion is possible. The RoM simulation results were compared to detect RoM differences of the affected hip joint.

The patient was surgically treated. Successful pain relief and increased function indicate that the patient was correctly diagnosed with FAI.

RESULTS AND DISCUSSION

The closest point distances of the two femora ranged from 0 to ~3.5 mm, showing a pronounced deformation of the proximal femur at the femoral head (see Figure 1). The closest point distances of the acetabula showed deformations with a thickness of up to ~7.1 mm.

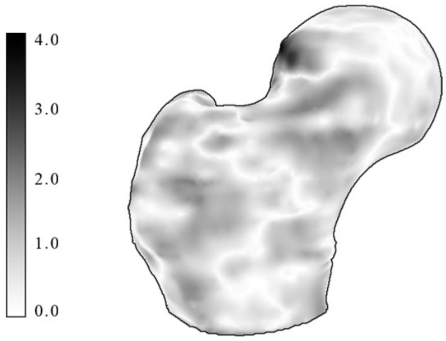

Figure 1: Closest point distances in mm between the two femora. The pathological femoral head shows deformations.

Our RoM simulations show that the bone-constrained RoM of the pathological side is substantially more limited than the healthy side (see Figure 2). The difference in abduction ranges to ~22°. This is a strong indication that the pain experienced by the patient when abducting is due to FAI.

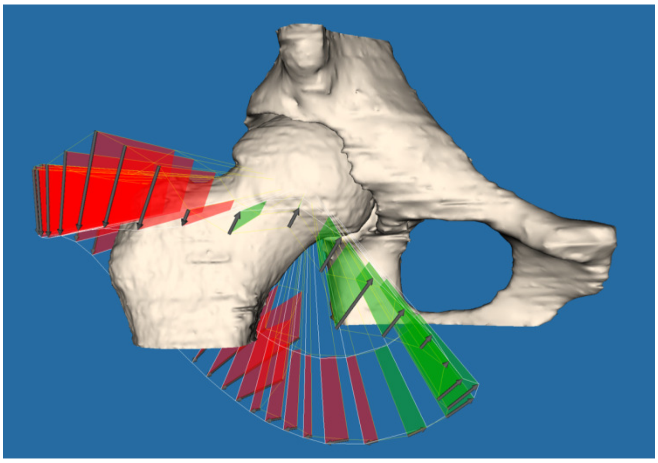

Figure 2: RoM comparison of pathological and healthy side. The red surfaces indicate a RoM deficiency that can be ascribed to FAI.

CONCLUSIONS

Our methodology was successfully applied to diagnose this specific case of FAI. By visualising how the deformation affects RoM, helpful hints are given on how the deformation may be treated. In future, the effectiveness of surgical treatment may increase by combining this technique with computer navigation. This demonstration suggests that our methodology is a useful addition to the traditional means of diagnosis.

REFERENCES

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