Development of a non-contact real-time method of tracking position and orientation of total hip replacement components

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Introduction

Background Impingement, subluxation and edge loading can lead to Total Hip Replacement (THR) failure

Problem In-vitro experimental methods cannot identify these adverse mechanical events

Need Integrated sensors tracking femoral head component position within the acetabular component would be beneficial

Solution Magnetic sensing technology can provide a contact free method of position and angle measurement

Aims

To characterize the viability of a magnetic position & orientation system to measure position & orientation of THR components.

Methods

A tri-axis magnetometer[1] & a disc magnet[2] were integrated into clinically available implants

A Robot Arm[3] was used to move the components through representative motion profiles. The experimental set up is shown in Figure 1.

1) mlx90393, Melexis. 2) N42 Neodymium, Magnet Experts Ltd.
3) UR3, Universal Robots.

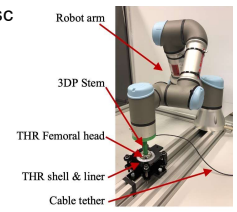

Figure 1 – Annotated photo of the experimental setup

Scan for a video demonstration

Results

The results of two motions studies where predicted stem angle and femoral head position was compared to the the ground truth (actual stem angle and head position of the robot arm) are shown in Figures 2 & 3.

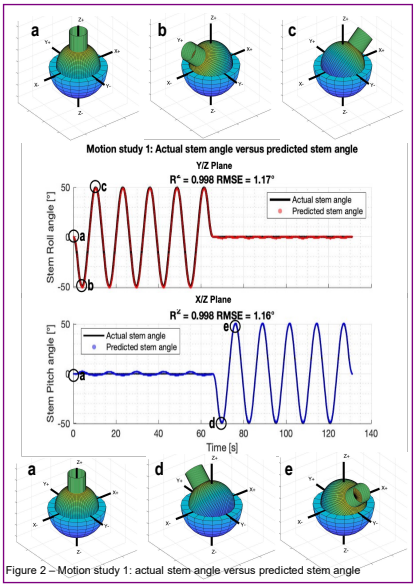

Figure 2 – Motion study 1: actual stem angle versus predicted stem angle

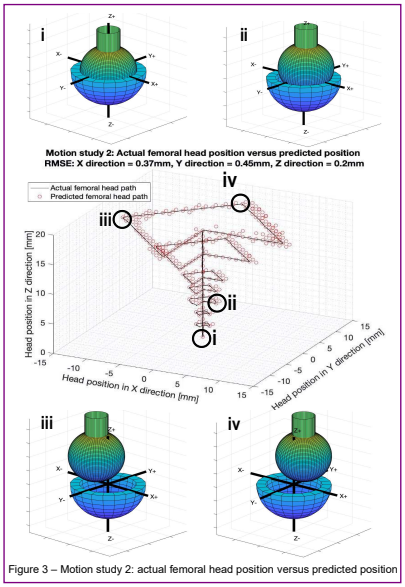

Figure 3 – Motion study 2: actual femoral head position versus predicted position

Discussion

- Addition of the magnetic sensing system required no changes to the implant geometries thus not impacting the function of the bearing
- Close agreement was shown between the output of the magnetic sensing system and the actual stem angle and head position of the robot arm
- At present, the magnetic sensing system can only measure orientation in two degrees of freedom and position of the head can only be determined when the stem is perpendicular to the face of the cup

Future Work

Future work will extend these sensing capabilities to tracking orientation in three degrees of freedom and measuring the position of the head during adverse motions such as subluxation caused by the stem levering out the head.

Significance

- This study has shown that a magnetic sensing system can be used to track the position and orientation of THR components.
- This method could be used as a research tool to better understand the function of a THR

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