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Evaluating *in vivo* bone motion of hip joints under weight-bearing condition using open MRI

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INTRODUCTION

Femoroacetabular impingement (FAI) is a mechanical hip disorder that is believed to be caused by abnormal bony contact between the femur and acetabulum. FAI leads to pain and reduced range of motion. Evaluating *in vivo* hip motions are important in better understanding the FAI mechanism [1]. This study aimed to estimate the repeatability of bone motions in sitting postures under weight-bearing condition from *in vivo* MRI images.

MATERIAL AND METHODS

We scanned three healthy subjects to obtain the high resolution (HR) MRI images of the pelvis, hip and knee at supine position in two cycles on a 3T MRI scanner; and low resolution (LR) MRI images of hip at sitting position in four cycles on the o.5T Open MRI scanner - MrOpen (Paramed Medical Systems).

Volumetric models of the femur and acetabulum were manually segmented from the HR and LR MRI images. Anatomical landmarks on pelvis and femur were used to build the hip joint coordinate system (see Figure 1). The LR (sitting) models were registered to the HR (supine) models using an intensity-based rigid registration method. The relative femoropelvic joint angles were computed (see Figure 2).

Bone Motion Repeatability in sitting postures

The variation of sitting postures may be affected by the MRI scanning setup and personal consistency. To test the repeatability of the sitting postures under the same placement configurations, the hip joint angles

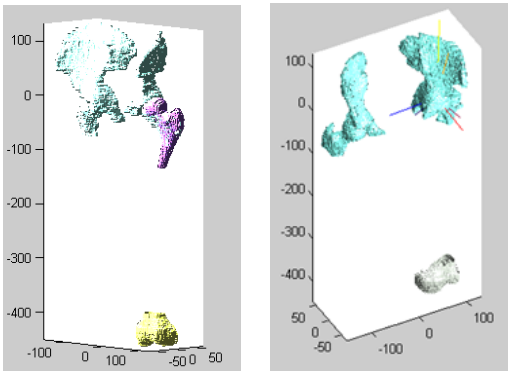

Figure 1: The pelvis, hip, and knee models from 3 HR scans (left); the hip joint coordinate system based on the landmarks (right).

were calculated by registering the LR bone models to the HR1 bone models for the four repeated sitting cycles which consists of an 'up' and a 'down' posture per cycle. The intra-subject variance was determined by the grand mean of the variance of the three hip joint angles from three subjects. The equation for a subject can be written as:

$$\sigma = \sqrt{\Sigma\left(x_{ij} - \bar{x}_i\right)^2/(n-1)} \qquad (1)$$

where i=1(up), 2(down), j=cycle 1-4, n=24.

Bone Motion Repeatability in supine positions

The static positioning at lying postures for obtaining HR images may affect the assignment of coordinate system and the HR-LR registration leading to variation of hip joint angles. To test the effect of subject static positioning on the hip joint angle measurement, the hip joint angles were calculated by registering the LR bone models to the HR1 and HR2 bone model, respectively. The intra-

subject variance was determined by the grand mean of the variance of three hip joint angles from three subjects. The equation for a subject can be written as:

$$\sigma = \sqrt{\Sigma(x_{ij} - \bar{x}_i)^2/(n-1)} \qquad (2)$$

where i=LR1,…, 8, j=HR 1, 2, n=48.

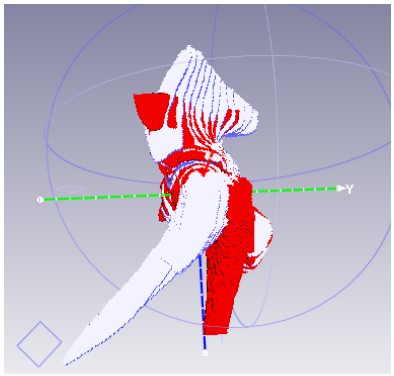

Figure 2: The relative position of HR (red) and LR (blue) femur after registering HR and LR acetabulum bones.

RESULTS

The femoral flexion angle relative to the scanner is quite repeatable (SD<0.9°). The mean femoral flexion angle change was also consistent (SDs<2°), but abduction, external rotation angles were more variable (SDs<~5.7°).

The repeatability of *in vivo* bone motions during repeated sitting was good to excellent, with mean and standard deviation of 0±2.1, 0±2.2, 0±1.4 for 3 subjects (see Figure 3). The intra-subject repeatability (grand mean of 3 STDs) for sitting posture is 1.9 degree.

The repeatability of bone motions during repeated lying postures was excellent, with mean and standard deviation of 0±1.1, 0±0.4, 0±1.1 for 3 subjects (see Figure 4). The intra-subject repeatability (grand mean of 3 STDs) for lying position is 0.8 degree.

CONCLUSION

This paper presented a repeatability study of measuring the bone motions under sitting postures. The results are similar to that presented in [2]. It indicated that the supine positioning has limited effect on evaluating bone motions. It is more challenging for subjects to reproduce the sitting position.

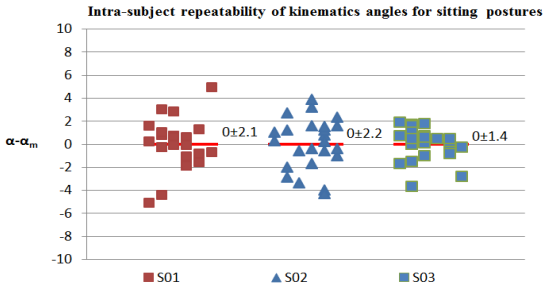

Figure 3: Intra-subject repeatability of kinematics angles (flexion, adduction and Internal rotation in degree) obtained from four repeated cycles (8 postures) of 3 subjects.

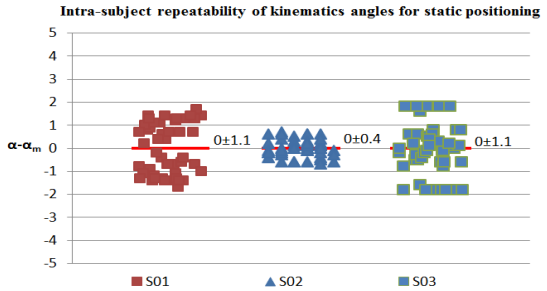

Figure 4: Intra-subject repeatability of kinematics angles obtained from repeated static lying position of 3 subjects.

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REFERENCES

[1] G.A. Turley, M.A. Williams, R.M. Wellings, D.R. Griffin, "Evaluation of range of motion restriction within the hip joint," Med Biol Eng Comput. 51(4), pp.467-77, 2013

[2] R.A. Fellows, N.A. Hill, N.J. MacIntyre, M.M. Harrison, R.E. Ellis, D.R. Willson, "Repeatability of a novel technique for in vivo measurement of three-dimensional patellar tracking using magnetic resonance imaging," J Magn Reson Imaging. 22(1), pp.145-53, 2005.