The Determination of Three-dimensional Acetabular Orientation in Different Coordinate Systems

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Materials and Methods

• Three-dimensional (3D) computed tomographic (CT) images of 56 subjects (28 males and 28 females) in supine position were obtained.
• 3D solid models of pelvis and spine were generated from the CT images.
• The acetabular orientations and coordinate systems were determined using a custom-written MATLAB program.

Pelvic coordinate system
• Four bony landmarks on the pelvis, the right and left anterior superior iliac spines (RASIS and LASIS), the right and left pubic tubercles (RPT and LPT) were determined (Fig. 1a and 1b).
• The coordinate system was established based on the bony landmarks (Fig.1c).

Global body coordinate system
• The bony landmarks on the spine including the geometric centers of five lumbar vertebrae bodies (L1, L2, L3, L4, L5), the most dorsal points on the five corresponding spinous processes (S1, S2, S3, S4, S5) and the anterior sacral promontory were determined (Fig. 2a and 2b).
• The coordinate system was created based on the landmarks (Fig. 2c).

Acetabular rim plane
• A set of points along the acetabular rim were determined (Fig. 3a and 3b).
• The points were fitted to a plane using least squares method (Fig. 3c).
• The acetabular orientation was characterized using three components (x-, y-, z-) of the unit normal vector of the acetabular rim plane in the coordinate system.

Results

• The scatter plots and magnitudes of the three components (x-, y-, z-) of the unit normal vector for the acetabular rim plane in two coordinate systems are shown in Fig. 4 and Table 1.
• Statistically significant differences of y- and z- components of the unit normal vector were observed between the measurements in the two coordinate systems (p<0.05).
• No difference of x- component were found (p=0.22). The best-fit line of x- components for the measurements in the two coordinate systems was not statistically different from the line y=x (pelvic measurement=global body measurement) (R²=0.69, p<0.05).

Discussion

• Different variations of acetabular orientations in natural hip were measured in the two coordinate systems.
• There were larger variations of acetabular orientations in the global body coordinate system compared to those in the pelvic coordinate system.
• The different variations of the acetabular orientation relative to the two coordinate systems were mainly attributed to the tilt of the pelvis relative to the human body in the sagittal plane.
• It is suggested that a global body coordinate system considering the tilt of pelvis is necessarily required to define the acetabular orientation in order to achieve a correct positioning of THR component in clinical practice.

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References