Effect of Pelvic Tilt on Femoral Head Coverage after Periacetabular Osteotomy

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INTRODUCTION:

Developmental dysplasia of the hip (DDH) leads to early-onset of hip osteoarthritis due to the presence of a shallow acetabula and poor femoral coverage. It causes structural instability, decreased load-transferring area, and abnormal joint stress distribution on articular cartilage. Periacetabular osteotomy (PAO) has been a successful procedure to correct these morphological abnormalities and subsequently improve hip biomechanics, delaying or even preventing the development of osteoarthritis. Success of the operation is dependent on optimal positioning of the acetabular fragment, so surgeons frequently plan for these operations using 2D parameters derived from radiographs to estimate joint coverage, yet it is unclear if these are reliable metrics. Additionally, previous studies investigating hip joint biomechanics evaluated the joints in a standardized position, which does not apply to most patients given the inherent and positional variability of pelvic tilt, which has a significant effect on acetabulum orientation [1-2]. Therefore, the objective of this study was to quantify the effect of pelvic tilt on femoral head coverage after PAO.

METHODS: Hip models of 22 patients (25 hips) with DDH were created using pre-operative CT images. The pelvic tilt was measured in preopeerative standing X-ray using the method proposed by Tannast et al. [3]. Then, each model was positioned in the ISB coordinate system and the pelvic tilt was adjusted to the preoperative neutral position. Next, a simulated PAO was carried out by laterally rotating the acetabular fragment until the lateral center edge angle (LCEA) reached 35°, followed by 10° anterior rotation of the fragment. A custom MATLAB program was built to measure the femoral head coverage under different pelvic tilt conditions (Figure 1). Specifically, the measurements were repeated at 0°, ±5°, ±10°, and ±15° pelvic tilt. At each position, the 2D projection of the lunate surface on the transverse plane was measured and divided into four quadrants. Statistical significance was evaluated through a paired, two-tailed Student's t-test ($p=0.05$).

RESULTS:

As the pelvic tilt increased from neutral (i.e., 0°) to 15° anteriorly, there was a significant increase in the coverage in the anterolateral (AL) quadrant and a significant decrease in the posterolateral (PL) coverage ($p<0.0001$). On the other hand, posterior pelvic tilt led to a significant decrease in total coverage ($p<0.04$). Moreover, there was a significant decrease in the AL coverage ($p<0.0001$) and a significant increase in the PL coverage ($p<0.0001$). No significant differences were detected in the posteromedial (PM) or anteromedial (AM) coverage across all levels of pelvic tilt.

DISCUSSION AND CONCLUSION:

The findings of this study demonstrated the effect of pelvic tilt on femoral head coverage after PAO. More anterior tilt results in increased load-bearing coverage, and more posterior tilt results in decreased load-bearing coverage. These findings indicate that natural pelvic tilt should be considered when planning a PAO.

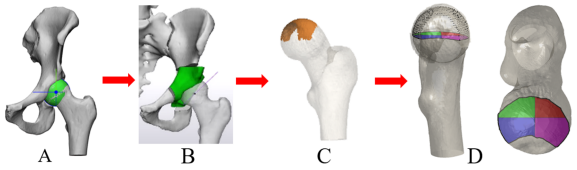

Figure 1 Measurement of load-bearing coverage. A) 3D hip models from CT scans. B) Simulated PAO. C) 3D coverage. D) 2D projection of femoral coverage on the transverse plane.

Table 1: Average coverage area in the four quadrants, and in total, under different levels of pelvic tilt.

	15° Posterior	10° Posterior	5° Posterior	0° (Neutral)	5° Anterior	10° Anterior	15° Anterior
AL	150.85±42.56	167.79±41.00	184.65±39.16	199.65±37.89	212.59±35.05	223.36±32.63	232.77±30.66
PL	220.58±33.85	208.71±37.81	201.02±33.93	188.93±35.87	174.07±35.08	160.39±37.28	145.81±37.85
PM	282.94±70.39	274.90±62.80	290.61±59.99	291.88±61.74	297.82±55.22	301.28±47.86	304.60±50.87
AM	258.49±62.27	259.42±60.88	271.58±61.21	267.82±69.45	266.33±66.71	268.85±60.93	264.09±65.77
Total	912.87±149.68	910.82±147.65	947.86±140.94	948.28±154.73	950.81±145.21	953.88±132.01	947.26±140.37