

# Unlocking the Relationship Between Pelvic Tilt and Acetabular Orientation in 3D: Role of Pelvic Morphology

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**INTRODUCTION:** Patients with adult spinal deformity (ASD) undergoing total hip arthroplasty (THA) have a higher risk of THA dislocation than the general population. Published reports have suggested that acetabular anteversion and inclination increase linearly with pelvic tilt (PT), with 1° increase in PT leading to 0.7 to 0.9° increase in acetabular anteversion and 0.3° increase in acetabular inclination. However, those studies assumed linearity between the two parameters without accounting for patient-specific pelvic morphology. The aim of this study was to describe the 3D geometric relationships between positional acetabular orientation and morphologic pelvic parameters.

**METHODS:** Parameters of interest (Figure 1) were defined. These included the acetabular morphological angle (AMA), defined as the angle between the acetabular axis and the hip axis, and the sagittal acetabular inclination (SAI), defined as the angle between the acetabular axis projected on the sagittal plane and the horizontal axis. While AMA is a morphological patient-specific angle, SAI increases incrementally with PT (i.e. a 1° increase in SAI corresponds to a 1° increase in PT). The 3D geometrical relationships between AMA, SAI, and acetabular parameters (abduction and anteversion) were examined. A mathematical formula to calculate acetabular abduction and anteversion using AMA and SAI was described and then graphically represented.

**RESULTS:** The mathematical formulas and graphical representation demonstrate that acetabular abduction and anteversion exhibit a non-linear relationship with SAI and is impacted by the acetabular morphology (AMA). As illustrated in figure 2, acetabular abduction and anteversion can be directly calculated from the AMA and SAI angles. Specifically, for a given decrease in pelvic retroversion (SAI), changes in abduction and anteversion vary significantly depending on pelvic morphology (AMA). Case examples (Figure 3) highlight this non-linearity: two ASD patients with similar SAI variations (i.e. similar decrease in pelvic retroversion) exhibited markedly different changes in acetabular abduction (-14° for case 1 vs. -3° for case 2) and anteversion (-10° vs. -2°).

**DISCUSSION AND CONCLUSION:** This study establishes that changes in functional acetabular abduction and anteversion in relationship to changes in PT is dependent on actual 3D pelvic morphology, exhibiting a non-linear relationship between PT and acetabular orientation. This has major implications in both total hip arthroplasty and spinal realignment surgeries, where it enables surgeons to accurately predict the effect of changing pelvic tilt (during spinal realignment) or the AMA (during total hip) on functional acetabular orientation. Using this information, future research should aim at establishing new patient-specific hip "safe zones" to minimize THA dislocation risk, specifically in patients with ASD.

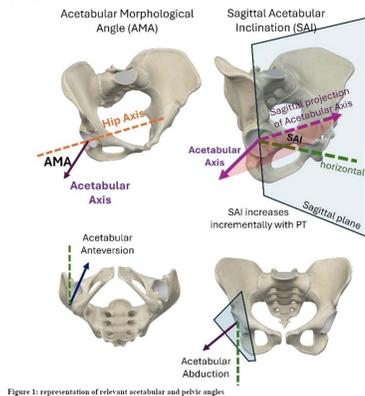


Figure 1: representation of relevant acetabular and pelvic angles

$$\text{Acet. Abduction} = \cos^{-1}(\sin(\text{AMA}) + \cos(\text{SAI}))$$

$$\text{Acet. Anteversion} = \tan^{-1}(\tan(\text{AMA}) * \sin(\text{SAI}))$$

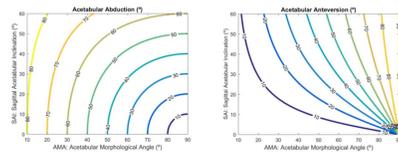


Figure 2: non-linear transformation of acetabular abduction and anteversion with sagittal acetabular inclination (SAI) based on patient-specific acetabular morphological angle (AMA)

Similar decrease in PT: 16°

	Case 1 pre	Case 1 post	Case 2 pre	Case 2 post
AMA (°)	40	26	23	10
SAI (°)	50	34	26	10
PT (°)	49	33	46	30
Acet. Abduction (°)	66	52	69	66
Acet. Anteversion (°)	32	22	11	9

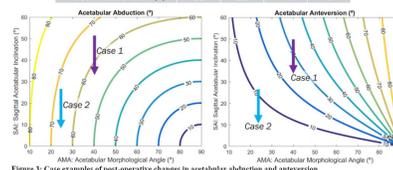


Figure 3: Case examples of post-operative changes in acetabular abduction and anteversion