

## **Quantifying Changes in Acetabular 3D Morphology in Normal Hips Based on the Development of Secondary Ossification Centers**

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### **INTRODUCTION:**

Acetabular development in pediatric hips is driven by growth from the triradiate cartilage (TRC) and secondary ossification centers (SOCs) of the os pubis, os ischium, and os ilium. These SOCs appear and fuse at different ages, with sex-specific differences affecting morphology. This study quantifies the impact of SOCs on acetabular coverage, version, tilt, and surface area during adolescence.

### **METHODS:**

Three-dimensional (3D) surface reconstructions of 540 normal hips (128 males and 142 females) aged 8-19 years with no hip pathology were generated from computed tomography (CT). Acetabular parameters, including coverage angles in pre-defined octants, version, tilt, and surface area, were extracted via a previously published algorithm. The Proximal Femur Maturation Index (PFMI) assessed skeletal maturity. Contributions to acetabular morphology from the three SOCs were analyzed using generalized linear mixed models ( $p < 0.05$ ).

### **RESULTS:**

PFMI scores strongly correlated with chronological age in sex assigned at birth ( $r_s = 0.91$ ,  $p < 0.001$ ). Os ilium ossification was significantly associated with increased superior coverage ( $p < 0.001$ ), while os ischium ossification was correlated with increased posterior coverage ( $p < 0.001$ ). Superior coverage demonstrated a strong correlation with lateral tilt ( $r_s = 0.837$ ,  $p < 0.001$ ), and posterior coverage was strongly correlated with anteversion ( $r_s = 0.788$ ,  $p < 0.001$ ). Females exhibited greater acetabular anteversion ( $17.7^\circ \pm 6.4^\circ$  vs.  $12.2^\circ \pm 6.4^\circ$ ,  $p < 0.001$ ) and lateral tilt ( $38.5^\circ \pm 4.7^\circ$  vs.  $36.6^\circ \pm 5.7^\circ$ ,  $p < 0.001$ ), while males demonstrated larger acetabular surface areas ( $31.9 \text{ cm}^2 \pm 6.4 \text{ cm}^2$  vs.  $28.8 \text{ cm}^2 \pm 4.2 \text{ cm}^2$ ,  $p < 0.001$ ). Os pubis ossification was not found to be associated with increased anterior coverage ( $p = 0.397$ ), nor was anterior coverage correlated with age ( $p = 0.115$ ).

### **DISCUSSION AND CONCLUSION:**

Os ilium and ischium ossification are associated with superior and posterior acetabular coverage during adolescence. In contrast, os pubis ossification was not associated with changes in anterior coverage. The timing of SOC appearance and closure aligns with key developmental changes in acetabular morphology, reinforcing their role in defining hip stability.