INTRODUCTION: The orientation of the acetabulum is a key clinical measure as abnormalities can adversely affect normal hip biomechanics, leading to complications such as osteoarthritis and subluxation.1 3-D imaging has been used to better characterize acetabular orientation but has remained dependent on a coordinate system established from the entire pelvis where possible bilateral asymmetry is not accounted for.2,4 The objective of this research is threefold: 1. Utilize a specially developed methodology to quantify accepted measures of inclination and version by fitting planes to selected points and point clouds. 2. Establish a new “hemi-pelvis coordinate system” and set of measures intrinsic to each innominate bone to evaluate acetabular orientation. 3. Characterize the relationship between the acetabulum and both the true and false pelvic regions within the new hemi-pelvis coordinate system.

METHODS: With institutional review board approval, CT scans of normal human pelvises were acquired. Stereolithography (*stl) 3-D bodies were generated from scan data using Mimics® (Materialise, Leuven, Belgium). Typical bony landmarks were identified and located. Point clouds containing vertices of the acetabular rim (AR), obturator foramen, and flat interior face of the symphyseal pubis were extracted. A specially developed MATLAB® program (MathWorks, Inc., Natick, MA) used the collected data sets to calculate measures of interest.

Acetabular Plane: Starting with points on both sides of the acetabular notch and one on the superior portion of the AR (Fig. 1A), the true plane of the AR was determined by the program using a least squares fit of vertices (average of 25 points per cup) on the peak of the rim(s). The vector normal to the AR plane, referred to as the acetabular axis (AX), was used to define the opening direction of the acetabulum (Fig. 1A).

Standard Measures: To establish a 3-D pelvic coordinate system common in literature, the anterior pelvic plane (APP), used as a coronal plane, was established by a line in the APP that was perpendicular to both the anterior ASIS and AIIS (Fig. 2). To determine angles of version and inclination, vectors normal to the APP and FPP, as well as the AX, were projected onto the anterior and coronal planes. Version was measured in the axial plane and inclination in the coronal plane from the angles formed between the projected AX and FPP/TTP vectors (Fig. 3).

RESULTS: Data from 7 subjects (14 acetabula) was collected. For the radiographic measures, the mean radiographic inclination (RI) was 53.8°±3.0° (range 59.2°-48.4°) and anteverision (RA) was 19.1°±3.2° (range 22.9°-12.0°). The mean anatomic inclination (AI) was 56.2°±3.2° (range 61.4°-59.0°) and anteverision (AA) was 23.2°±3.4° (range 28.2°-15.2°). For the hemi-pelvis measures, mean anteverision angles of 25.0°±6.2° and 26.6°±5.9° were observed for the left and right sides, respectively, with a total bilateral range of 39.0°-15.0°. Inclination angles measured 50.9°±5.4° for the left and 50.3°±5.3° for the right with a total bilateral range of 41.3°-55.9°. The relationship between the AX and true pelvis showed an inclination (TI) of -2.5°±6.6° and version (TV) of 18.9°±3.4°. For the AX and false pelvis the inclination angle (FI) was 20.7°±8.6° and version (FV) 54°±5.5°.

DISCUSSION: Results for radiographic and anatomic inclination and anteverision were similar to other researchers’ findings.2,4 Angles from the hemi-pelvis analysis suggest that a bilateral correlation in symmetry exists; however, interpatient bilateral differences of 16.4° in inclination and 12.9° in anteverision were observed. Radiographic measures, determined using the full pelvis coordinate system, showed notably less bilateral discrepancy. Using the same subjects for the hemi-pelvis analysis, APP based radiographic bilateral differences of 3.2° for inclination and 4.5° for anteverision were observed. During development, the true and false pelvic regions are separated by growth plates of the triradiate cartilage which meet at the center of the acetabulum. The new hemi-pelvis coordinate system characterizes the relationship of the acetabulum to these different portions of the innominate bone.

SIGNIFICANCE: Improved methods to quantify acetabular orientation were developed. With our novel hemi-pelvis coordinate system and corresponding measures, pelvic symmetry can be better understood, allowing for advancements in both surgical planning and implant design.

ACKNOWLEDGEMENTS:

Thanks to the VCU Department of Radiology for providing scans.