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Understanding the Pincer - The Importance of Reference Plane Orientation on Acetabular Rim Evaluation

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Objectives: Femoroacetabular impingement (FAI) is a common cause of young adult hip pain. FAI can result from an acetabular-sided bony lesion, or “pincer” lesion. A pincer lesion is defined as an area of linear contact between the acetabular rim and the femoral head-neck junction due to general or focal acetabular overcoverage. Three dimensional (3D) analysis of the acetabular rim morphology is essential to understand etiology and aciculate diagnosis of the of the pincer type FAI. A few studies have measured 3D geometry of the acetabular rim; in which the acetabular rim is described as a deviation from a reference plane. Therefore, the definition of the reference plane is critical to determine the acetabular rim geometry. The purpose of this study was to use 3D Computed Tomography (CT) modeling to evaluate the impact of varied acetabular orientation reference planes on the interpretation of acetabular rim abnormalities, with the goal to determine the ideal reference plane for future study use.

Methods: 3D CT modeling was performed on five hip joints of patients who underwent hip arthroscopy with acetabular trimming for a presumed pincer lesion. These models were exported into point-cloud models. An acetabular 3D model was automatically created within 10 mm from the femoral head surface (Fig. 1A,B). The acetabular articular surface and rim were separated with a threshold of 5 mm, which provided an acetabular rim model with a band width of 5 mm (Fig. 1C). A local coordinate system was defined with the acetabular notch midpoint being 6 o’clock. A best-fit plane of the acetabular rim was determined by the least square method using two different acetabular rim models: 1) a model excluding the acetabular notch (plane A) and 2) a model excluding the acetabular notch and superior region from 10:30 to 3:00 (3:00 being anterior) (plane B). The acetabular rim model was transformed into a cylindrical coordinate system with an axis determined by a normal vector of the plane. The final acetabular rim model consisting of 120 points with 3° increments was created by searching the outermost points of the rim. The acetabular center was determined using best-fit sphere of the articular surface model. A reference plane including the center point was determined with orientations determined by normal vectors of the acetabular rim planes (Fig. 1C, yellow line). The 3D geometry of the rim was described by subtended angles from the normal vector of the reference plane.

Results: Three distinct peaks were noted at anteroinferior (AI), anterosuperior (AP) and posteroinferior (PI) regions (Fig. 2 A,B). While the AI and PI peaks measured with the plane A were higher than that measured with plane B, the AP peak measured with plane A was lower than that measured with plane B (Fig. 2C). The angle between the normal vectors of plane A and B was 13.7±3.5°.

Conclusion: The findings demonstrate that the orientation of the reference plane is critical to the 3D measurement of the acetabular rim. Since bony prominence in the anterosuperior region has been considered as the pathogenesis of the impingement, the reference plane including this region may cause underestimation of the bony lesion. An appropriate determination of the reference plane is crucial for evaluation of the bony lesion in the pincer FAI patient.

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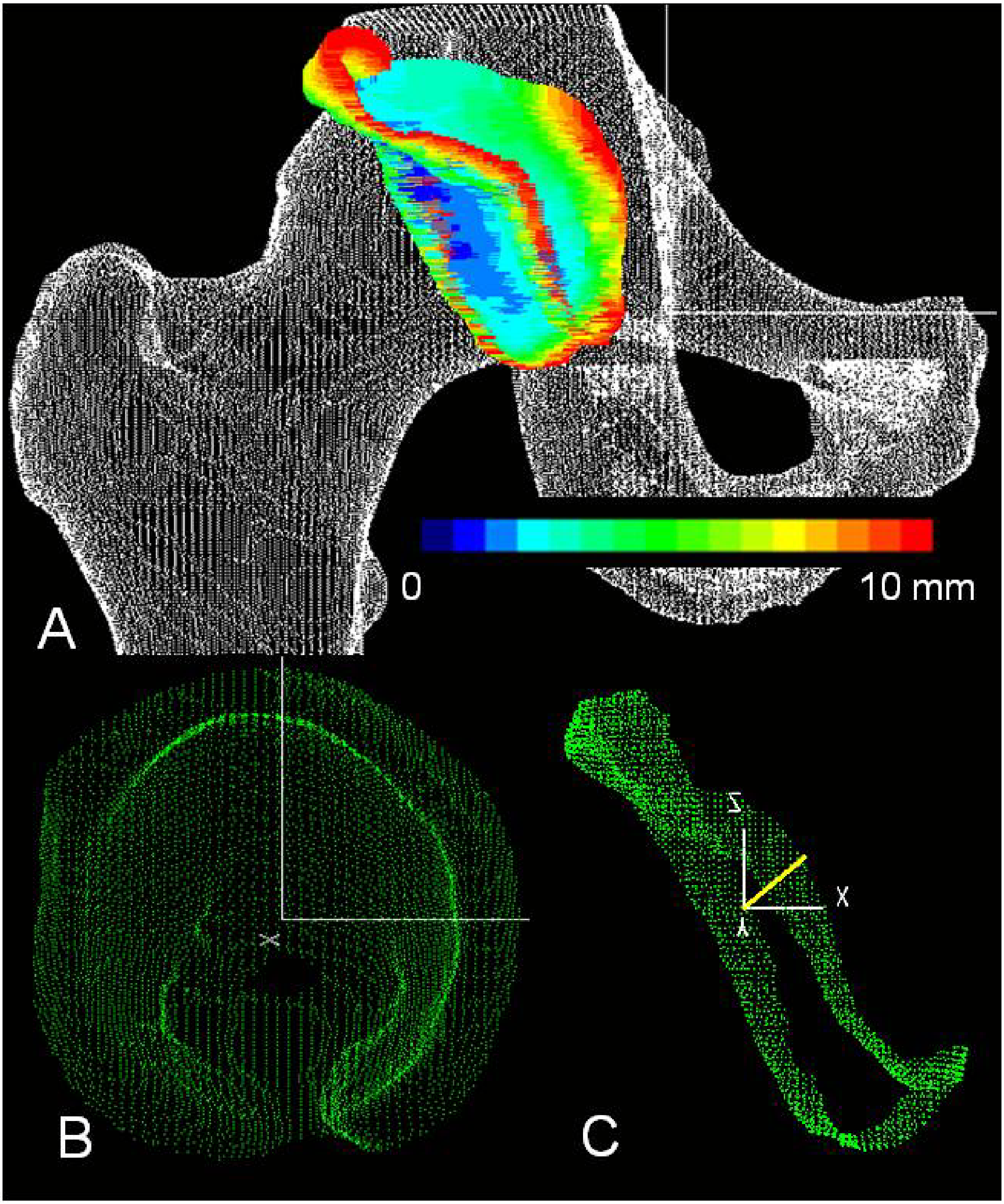
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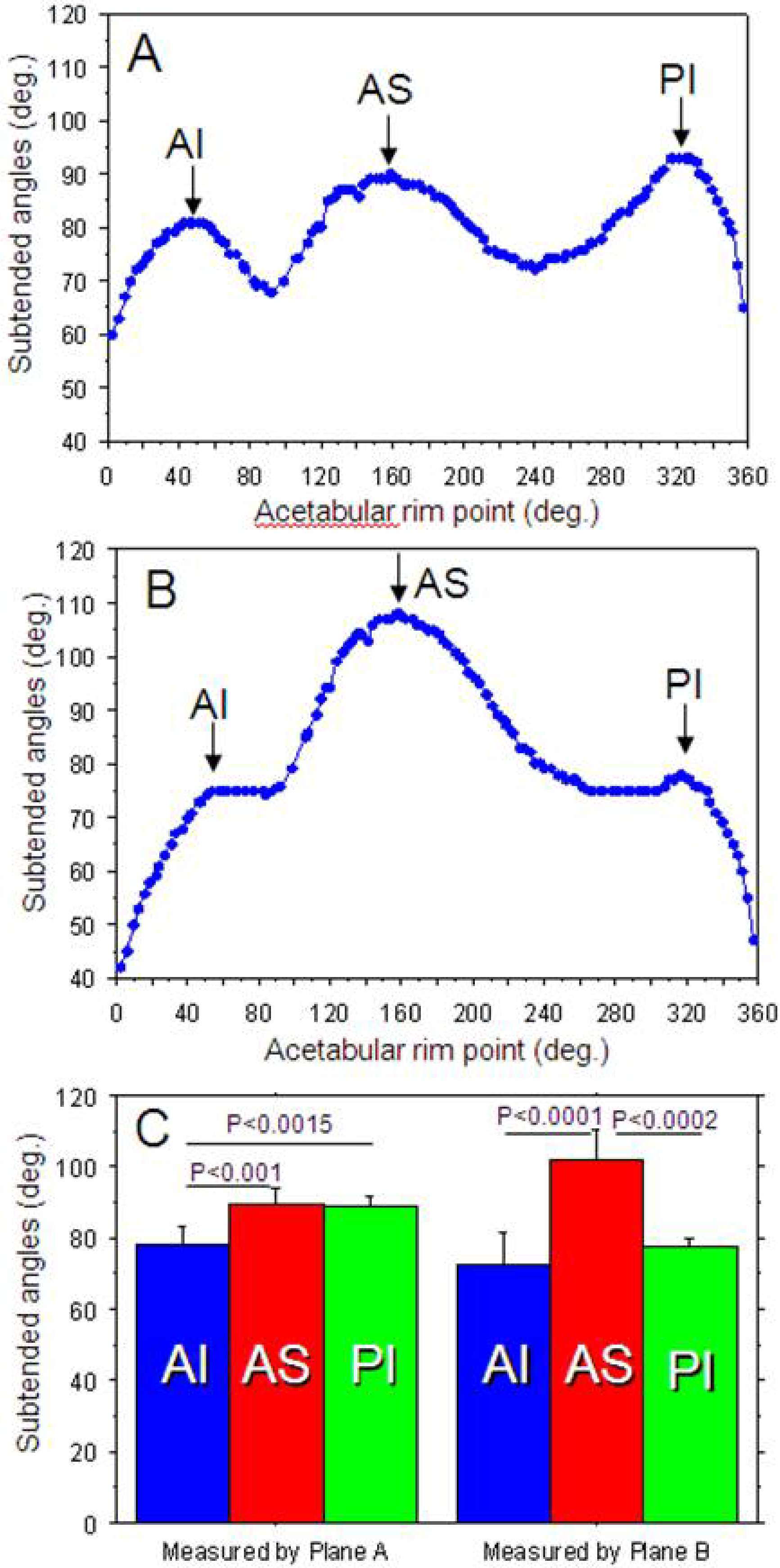
A
AI
AS
PI
Subtended angles (deg.)
Acetabular rim point (deg.)
B
AI
AS
PI
Subtended angles (deg.)
Acetabular rim point (deg.)
C
P<0.0015
P<0.001
P<0.0001
P<0.0002
AI
AS
PI
AI
AS
PI
Subtended angles (deg.)
Measured by Plane A
Measured by Plane B