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An Increase in Cranial Acetabular Version With Age: Implications for Femoroacetabular Impingement

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ABSTRACT

This cadaveric study aimed to determine if acetabular retroversion demonstrates predictable changes with age that could inform understanding of factors that may contribute to the pathophysiology of femoroacetabular impingement. Two-hundred forty pelves were divided into young and old groups. Version was measured at the cranial (5 mm below superior rim), central (transverse of acetabulum), and caudal (5 mm above inferior rim) locations. The data showed a significant difference between young ($10 \pm 10°$) and old ($13 \pm 9°$) cranial version ($P = .02$). Cranial retroversion increases with age and may reflect a developmental component in the etiology of the focal rim impingement lesion or ossification of the damaged labrum. Global acetabular retroversion does not appear to change with age and may reflect a congenital etiology.

During infancy, the development of the acetabulum is a product of lateral growth from acetabular cartilage and medial growth from the triradiate cartilage [1,2]. The balanced growth of these two structures and its interaction with the femoral head determine the overall structure and orientation of the acetabulum [3]. The height and width of the acetabulum are controlled by the interstitial growth of the triradiate cartilage [4]. An uncoordinated growth by these two regions can result in morphological abnormalities of the skeletally mature acetabulum. One of the many pathologies resulting from an uncoordinated growth of these two cartilage regions is focal or global change in the abduction and version of the acetabulum.

Cranial retroversion can result in repetitive contact stresses of a normal femoral neck against an abnormal area of focal acetabular “overcoverage.” On an anteroposterior (AP) radiograph, this focal anterosuperior overcoverage is manifest as a "cross-over" sign, which is seen when the anterior rim line extends lateral to the posterior rim in the cranial part of the acetabulum and then crosses over the posterior line to become more medial in the central and caudal acetabulum [5]. This situation results in degeneration and tearing of the anterosuperior labrum and a posteroinferior “contre-coup” pattern of chondral injury to the femoral head and acetabulum. With focal rim impingement, the labrum is primarily injured, resulting in progressive bone apposition on the osseous rim adjacent to the labrum and ultimately ossification of the labrum itself [6].

In contrast, global acetabular retroversion is an often misdiagnosed variety of hip dysplasia that does not present until the second or third decade of life [7]. While it may present with clinical symptoms similar to those of a focal rim lesion, the mechanical problem is distinct and reflects “overcoverage” anteriorly combined with “undercoverage” posteriorly. The diagnosis is preoperatively suspected on plain radiographs by the “posterior wall sign,” or medial passage of the posterior wall relative to the center of the femoral head on an AP view. Computed tomography (CT) scan with axial views clearly demonstrates retroversion of the acetabulum at the cranial (5 mm inferior to the superior border of the acetabulum), central (through the longitudinal center of the acetabulum), and caudal (5 mm superior to inferior border of the acetabulum) locations. Some orthopedists refer to cranial retroversion as simply “retroversion” when in fact that term should be reserved for global retroversion. The posterior femoral head is the site of the highest joint pressure, and any deficiency in support of this area results in large contact stresses and later pathologies [8]. Furthermore, loss of offset anteriorly at the femoral head–neck junction in combination with acetabular retroversion and posterior “undercoverage” may result in posterior instability or dislocation. In certain circumstances, pain with associated symptoms of posterior instability symptoms could be better addressed with a reverse, “anteverting” periacetabular osteotomy to correct the anteversion of the acetabulum and improve mechanics

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between the acetabular rim and the femoral head–neck junction [9]. Therefore, research studies examining the complexity of the pathoanatomy are essential to further understand the appropriate treatment necessary to achieve the best patient outcome.

Studies have suggested a correlation between hip retroversion and a predisposition to develop osteoarthritis in the hip [10,11]. The repetitive impact caused by the decrease in clearance between the femoral head/neck junctions may lead to local cartilage damage and hip pain. This contact may lead to degenerative changes to the acetabular rim and adjacent structures [12–15]. The criterion for a diagnosis of acetabular retroversion was the presence of a so-called crossover sign on the AP radiograph of the pelvis. It has been found that patients with osteoarthritis, developmental dysplasia, or Legg–Calvé–Perthes disease were significantly more likely to have acetabular retroversion than normal subjects ($P < .05$) [16].

Understanding the relationship between changes in focal and global acetabular retroversion and femoroacetabular impingement (FAI) is of paramount importance to the clinical treatment of symptomatic patients. Furthermore, this information could offer novel insight into the developmental or congenital factors that may contribute to the pathophysiology of FAI. The purpose of this study is to measure focal and global acetabular version and to identify potential differences between age groups and racial groups. The hypothesis of our study is that focal (cranial) acetabular retroversion increases with age and may reflect a developmental component in the etiology of rim impingement lesion, potentially secondary to progressive ossification of the damaged labrum.

Methods

Populations

The Hamann–Todd Human Osteological Collection at the Cleveland Museum of Natural History has 2967 skeletal specimens. Measurements were made on 240 randomly chosen pelves between the ages of 14 and 60 years. Specimens younger than 14 years were excluded secondary to skeletal immaturity and specimens over the age of 60 years were excluded due to degenerative changes resulting in osteophyte formation and dysmorphic acetabuli. The specimens were divided into two groups based on specimen age (young: 14–24 years, old: 25–60 years). Cut off ages were chosen to have an equal number of specimens in each group. The groups were normalized by having equal numbers of males and females, as well as equal distribution between Caucasians and African Americans, within each group. All of the specimens were representative of a population from Northern Ohio during the early twentieth century.

Anatomic Measurements

Anatomic measurement techniques were adopted from Jamali et al [11]. Each disarticulated pelvis and sacrum were reconnected using rubber bands and a 5-cm thick foam piece that was compressed to 2 cm in place of the pubis symphysis. The plane formed between the anterior superior iliac spines (ASIS) and the pubic symphysis was used to define the anatomic frontal plane of reference of the pelvis. During normal upright standing and walking, this plane is positioned vertically [17,18]. To stabilize the pelvic specimens while taking measurements, the specimens were set on a flat table with the ASIS and the pubic symphysis rested against the table. Thus, the table represented the anatomic frontal plane (Fig. 1).

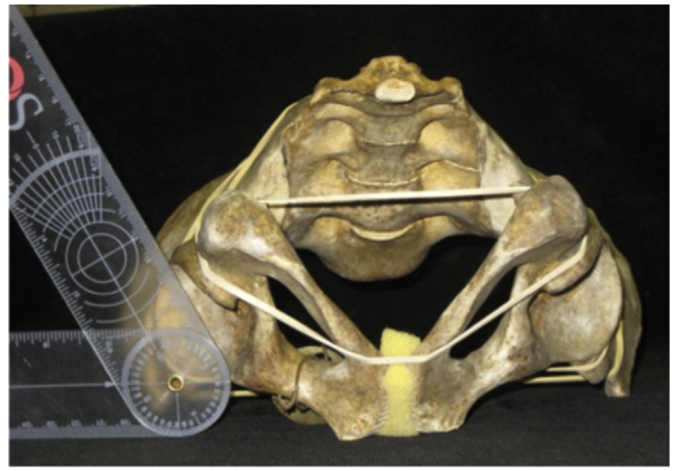

Fig. 1. The pelvis was placed on a flat surface with the anterior superior iliac spine and pubic symphysis in contact with the table. The table served as the frontal plane and the version of the acetabulum was measured at the three acetabular regions (cranial, central, and caudal).

The acetabular version was measured using a goniometer at three separate transverse sections: cranial (5 mm distal to the acetabular roof), central (through the longitudinal center of the acetabulum), and caudal (5 mm proximal from the most inferior edge of the acetabular cavity) (Fig. 2). The average of the three distinct measurement locations was determined and will be referred to as the global version. Since most acetabular chondral damage in FAI occurs anterosuperiorly near the anterior inferior iliac spine, the distance of 5 mm cranially was used.

Statistics

All data are presented as the mean plus/minus the standard deviation, and all statistical analyses were done on SPSS (IBM Corp, Armonk, New York). Significant differences were determined by using two-tailed t-tests and one-way ANOVA tests with an α value of 0.05. Student Newman Keuls post hoc tests were also performed with an α value of 0.05. Data from a pilot cadaveric study of acetabular

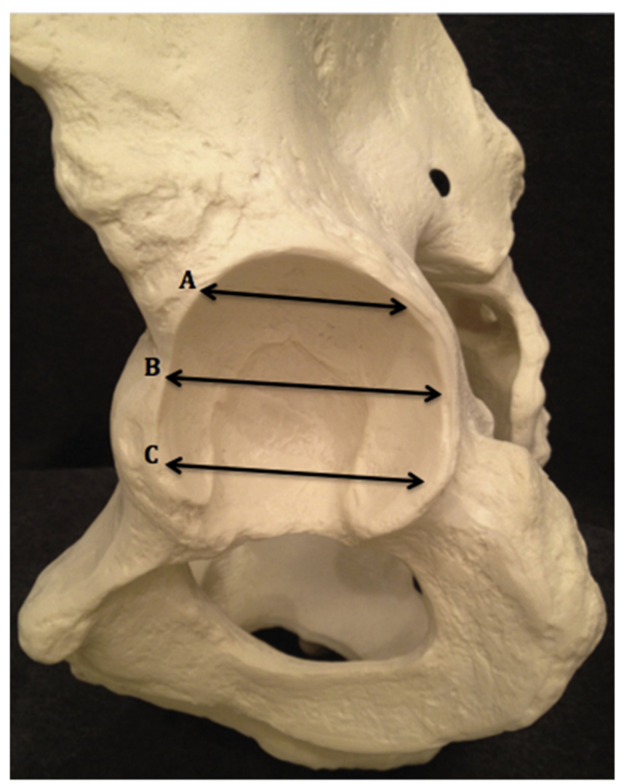

Fig. 2. (A) Cranial version was measured 5 mm distal to the acetabular roof. (B) Central version was measured through the longitudinal center of the acetabulum. (C) Caudal version was measured 5 mm proximal to the most inferior edge of the acetabulum.