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Letter to the Editor

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Letter to the Editor: The Effect of Postural Pelvic Dynamics on the Three-dimensional Orientation of the Acetabular Cup in THA Is Patient Specific

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To the Editor,

The recent study by Snijders et al. [13] provides an excellent description of THA acetabular component orientation and functional dynamics with respect to the coronal, sagittal, and transverse planes. As noted by the authors, in order to better understand, prevent, and remedy total hip instability, acetabular component positioning should be thought of as a range of acetabular orientations occurring throughout a patient's functional changes in pelvic tilt.

Although the interaction between pelvic motion and acetabular component orientation is a topic that is gaining attention, there has been limited study of the sinusoidal relationship between changes in pelvic tilt and the associated changes in acetabular component orientation. In their article in *Clinical Orthopaedics and Related Research*®, Snijders et al. [13] propose a useful mathematical model for considering changes in pelvic tilt as rotations about a transverse axis, resulting in a change in sagittal orientation equivalent to the change in pelvic tilt. They also provide a free and easy-to-use online tool to calculate expected component orientation after a change in pelvic tilt from the initial orientation as measured in the coronal and sagittal planes. The authors should be commended for this clinical application of a trigonometric algorithm for describing acetabular component orientation in all three planes.

We wanted to highlight the importance of consistent and explicit definitions for the historically ambiguous terminology commonly used to describe pelvic and acetabular orientation. As noted previously [4, 14], there are a variety of definitions of acetabular component anteversion with associated measurements in the transverse or sagittal planes, or oblique projections between these planes. Given this disagreement about the definition of anteversion, we shouldn't be surprised to see that there are methodological limitations to meaningful meta-analysis [14]. Moreover, the various definitions of acetabular anteversion should be considered with respect to an associated sagittal pelvic orientation, given the fluidity of acetabular orientation during sagittal pelvic rotation [4, 13, 15]. This further muddies the body of evidence on acetabular orientation, as pelvic orientation in the sagittal plane often is described by the ambiguous term "pelvic tilt," a concept discussed in arthroplasty [15], spine [7], and hip preservation [3, 5] papers, and may be defined in reference to the plane between the anterior superior iliac spines and the pubic symphysis (the

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anterior pelvic plane) [4, 9, 15], or in reference to the bicoxofemoral axis and the center of the first sacral (S1) endplate [3-5].

Therefore, the authors [13] have proposed adopting a three-dimensional (3-D) characterization of acetabular component orientation, which is dynamic, allows for changes in associated sagittal pelvic orientation, and would provide systematic evaluation of component orientation and better communication among surgeons and between studies [12].

For the purposes of generating greater consensus regarding the ambiguous term "anteversion," it is worth comparing and contrasting the current descriptive terms advanced by Snijders et al. [13]—"sagittal tilt," "transverse version," and "coronal inclination"—with historical definitions of acetabular component orientation. Although the "safe zone" of Lewinnek is often discussed [1], studies frequently use alternate methods for calculating anteversion [2], and equivalence between methods cannot be assumed [11]. In Lewinnek's equation $\tan\alpha = \tan\phi * \cos\theta$ [8], θ represents the "lateral opening angle," measured as the angle between the transverse anatomical axis and the long axis of the ellipse formed by the cup on a "precisely oriented" AP pelvis radiograph taken orthogonal to the anterior pelvic plane. This plane is positioned parallel to the ground via use of a spirit level across the anterior superior iliac spine and the pubis symphysis [8]. Subsequently, Murray referred to this "lateral opening angle" as "radiographic inclination" [10]. Lewinnek's α is described simply as the angle of anteversion and is calculated from the major and minor diameters of the ellipse projected onto the coronal plane radiograph due to the hemispherical rim of the cup [8]. Murray [10] refers to this angle as "radiographic anteversion" and notes that the calculation described by Lewinnek based on ellipse diameter ratio results in the angle between the coronal plane and the acetabular axis. Finally, Lewinnek defines ϕ as rotation about the anatomical transverse axis according to the typical use of an Aufranc-Turner cup positioner, which references the angle between the longitudinal axis of the patient in the lateral decubitus position and the acetabular axis for estimation of sagittal plane rotation [8]. Murray refers to rotation about this transverse axis as "operative anteversion," which is measured as the angle between the longitudinal axis of the patient and acetabular axis projected onto the sagittal plane [10].

In Murray's description of acetabular orientation [10], understanding the "plane of projection" for each of angle is essential for understanding the connections between the trigonometric relationships proposed by Lewinnek [8], Murray [10], and Snijders et al. [13]. Because of Lewinnek's method of patient positioning for AP radiographs, the anterior pelvic plane is parallel to the plane of projection (the coronal plane), and the radiographic inclination of Lewinnek and Murray coincides with the coronal inclination of Snijders. Moreover, the trigonometric models proposed by Murray and Snijders both describe measurements obtained in sagittal (tilt versus operative anteversion) and transverse (version versus anatomic anteversion) planes of projection [10, 13]. It is important to note that the radiographic landmarks used to obtain these measurements in the sagittal and transverse planes are different between the definitions. Murray relies on the "acetabular axis which passes through the center of the socket and is perpendicular to the plane of the socket face" [10], and Snijders et al. [13] use the plane of projection of the rim of the acetabular component at the center of the femoral head (the face of the cup) [13]. These two lines of reference are orthogonal to each other within the associated planes of projection. Because the associated anatomic lines of reference of Murray versus Snijders are also orthogonal to each other, the angles themselves are identical in magnitude.

Given these similarities of the anatomic description of these angles, it is worth comparing the associated trigonometric functions. Starting with the equation from Lewineek, $\tan\alpha = \tan\phi * \cos\theta$, replacing the Greek symbols with Murray's terminology gives us the equation:

$$\tan \textit{radiographic anteversion} = \tan \textit{operative anteversion} * \cos \textit{radiographic inclination}$$

Substitution into another Murray trigonometric equation, $\tan$*radiographic anteversion* = $\tan$*anatomic anteversion* * $\sin$*radiographic inclination*, yields the following: $\tan$ *operative anteversion* * $\cos$*radiographic inclination* = $\tan$*anatomic anteversion* * $\sin$*radiographic inclination*. This may be solved for the tangent of operative anteversion:
$\tan$ *operative anteversion* = $\tan$ *anatomic anteversion* * $\sin$ *radiographic inclination* / $\cos$ *radiographic* * *inclination*

Or more simply:
$\tan$*operative anteversion* = $\tan$*anatomic anteversion* * $\tan$*radiographic inclination*

The similarities in anatomic descriptions of relative acetabular orientation are mirrored by similarity in the trigonometric functions previously espoused by Murray and more recently published Snijders et al. [13].

Letter to the Editor

To better understand the relationship between pelvic motion, functional acetabular orientation, and postoperative instability, it is important to consider the effect of dynamic pelvic tilt on the range of possible component orientations and the associated potential for prosthetic impingement or instability. Given the complexity of the topic, it is also important to consider how current research may build upon and incorporate previous findings.

Given that trigonometry dates back several thousand years, the development of a truly novel algorithm seems less important than understanding how modern cross-sectional imaging and digital simulations of pelvic motion can be used to better understand the interaction between the 3-D nature of commonplace yet ambiguous terms such as "inclination" and "anteversion." Working toward a common consensus for objective descriptors of dynamic acetabular orientation is an important goal toward fostering collaboration and further understanding. If possible, authors should seek to express their findings via terminology already established in the literature or at the very least define new terms in the context of old. Using commonly understood descriptive terms in a systematic manner may be beneficial. In a previous publication, Snijders et al. [11] use the more descriptive terminology "transverse-CT anteversion" and "sagittal-CT anteversion" instead of "transverse version" and "sagittal tilt." The latter terms seem to prioritize brevity at the cost of clarity. Further discussion in the literature and at the relevant society meetings is warranted. If the community of stakeholders can agree upon a common language to describe cup orientation in a functional manner that incorporates patient-specific pelvic dynamics, it would be an important step toward future consensus regarding optimal acetabular component orientation. We would advocate for the use of commonly understood, descriptive terms in a systematic manner. A structured, systematic approach— similar to Ilizarov's descriptive terminology for limb lengthening [6]—would allow for more reliable communication between authors.

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