DIRECT AND INDIRECT MEASUREMENT OF FEMORAL ANTEVERSION

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Relevance to Musculoskeletal Conditions: Assessment of femoral anteversion is an important consideration in total hip arthroplasty and corrective hip osteotomy. Additionally, this parameter is important for understanding the biomechanics of the normal and pathologic hip.

Introduction: The anteversion angle of the proximal femur has not been given an universally accepted definition (1,2). Therefore, a direct measurement method with specific anatomic criteria has not been established for validating the accuracy and reliability of commonly used indirect methods of femoral anteversion measurement [i.e., computed tomography (CT) and biplane radiography] (3,4,5). Additionally, no study to date has rigorously validated the CT method (3) as the "gold standard" for determining femoral anteversion in clinical and experimental settings. In the present study, anteversion angles of human and canine femora were used to compare measurements made using these direct and indirect methods. Projected anteversion angles from biplanar radiographic and CT determinations, and true anteversion angles from direct osteometric measurements, were compared using data collected from ten adult cadaveric human and ten adult greyhound femora. Interobserver and intraobserver error analyses were also conducted for each method.

Methods: Projected anteversion angles were measured using common computed tomographic (CT) (3) and common biplanar radiographic methods specific for human (4) and canine femora (5), respectively. True (nonprojected) anteversion angles were determined using the direct osteometric method of Ruff and Hayes (6). All measurements were made on ten adult cadaveric human femora (10 males: 6 right, 4 left; all skeletally mature; mean age 47 years, range 20-64 years) and ten adult greyhound femora (3 males, 7 females: 8 right, 2 left; all skeletally mature; mean age 3 years, range 1-10 years). Equipment used included a standard hospital X-ray machine and a second-generation Picker 1200 SZ body CT scanner. Mean differences in magnitudes of projected and true anteversion angles, and between interobserver errors, were evaluated using a nonparametric Mann-Whitney test with statistical significance set at $p < .05$. Mean differences in intraobserver errors were evaluated using a nonparametric Wilcoxon Signed Rank test with statistical significance set at $p < .05$.

Results: Means, standard deviations, standard errors, and interobserver and intraobserver errors are listed in Table I for each method. On average, the projected femoral anteversion angle measured using biplane radiography was significantly greater ($p < .05$) than the corresponding angle using computed tomography (CT) and the true angle using direct osteometric method. In human bones, biplane radiography, on average, exaggerated femoral anteversion angles by 12.0° (2 times greater) and 14.8° (2.5 times greater) when compared to CT and direct osteometric methods, respectively. Similarly, in canine bones, biplane radiography exaggerated femoral anteversion angles by 15.0° (2.3 times greater) and 12.9° (2 times greater) when compared to CT and direct osteometric methods, respectively. The discrepancies between CT and osteometric methods were relatively smaller (within 2.8°).

Table I: Femoral Anteversion Angle Data. The following parameters were evaluated: anteversion angle (AV); standard deviation (Std. Dev.); standard error (Std. Err.), interobserver and intraobserver errors (Interobs. & Intraobs. Err.) and mean differences in magnitude between anteversion angles of different methods (Mean Diff.).

Methods	Mean AV	Std. Dev.	Std. Err.	Intraobs. Err.	Interobs. Err.
Direct:					
Osteometric					
(H)	9.6°	3.3°	1.0	±0.8°	±2.2°
(G)	14.1°	3.4°	1.1	±2.2°	±2.3°
Indirect:					
CT					
(H)	12.4°	1.5°	1.2	±1.5°	±2.9°
(G)	12.0°	2.2°	0.9	±1.7°	±3.7°
Biplane					
(H)	24.4°	4.2°	2.9	±2.1°	±5.1°
(G)	27.0°	4.5°	1.1	±3.9°	±5.5°
Mean Diff.	**Osteometric vs. CT**			**Biplane vs. CT**	
(H)	-2.8°			+12.0°* (73% diff.)	
(G)	+2.1°			+15.0°* (90% diff.)	
Mean Diff.	**Biplane vs. Osteometric**				
(H)	+14.8°* (107% diff.)				
(G)	+12.9°* (70% diff.)				

H = human; G = greyhound; Biplane = biplane radiography; diff. = % difference between two measured means. "+" or "-" are defined as: larger or smaller, respectively, than the second method being compared. For example, in Biplane vs. CT, +12.0° indicates that biplane radiography measured a 12.0° larger mean anteversion angle than CT. ***p < .05.**

Discussion: These data validate the accuracy and reliability of the CT method (3) as the "gold standard" for determining true anteversion angles in both human and canine femora. Although past studies (1,2) have suggested that interobserver and intraobserver errors may have caused the marked discrepancies between biplane radiography and CT and direct osteometric methods (shown in Table I), data from the present study do not support this argument. These data suggest that differences in anatomical criteria used in biplanar radiographic methods account for these marked discrepancies (Table I). Consequently, CT determination of femoral anteversion angle should be considered the primary method of choice for both clinical and research purposes.

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