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The anterior center edge angle in Lequesne's false profile view: interrater correlation, dependence on pelvic tilt and correlation to anterior acetabular coverage in the sagital plane. A cadaver study

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Abstract
Introduction Lequesne's vertical-center-anterior margin (VCA) angle measured on the false profile view of the pelvis aims at quantifying the anterior acetabular coverage of the femoral head. The anterior delimitation of the acetabular roof is often defined on the false profile view but there are no data on its interrater reliability. Additionally, it is not known how pelvic tilt may influence this angle. Finally, the plane in which this angle is measured lies at an angle of 65° to the sagittal plane and we wondered if this angle would be transposable to the anterior acetabular coverage measured in the sagittal plane.
Methods Eight hips from four cadaver pelvises were investigated by means of a total of 72 false profile views, each taken in defined pelvic inclinations at 5° increments ranging from −20° to +20°, and the VCA angle measured by three independent raters. A computed tomography (CT) of each hip was performed in a neutral pelvic tilt position and a sagittal 2D reconstruction calculated in order to measure anterior coverage in the sagittal plane. The interrater reliability of the VCA angles was assessed using the intraclass correlation coefficient (ICC). The dependence of the VCA angle on pelvic tilt was assessed by regression analysis. The Correlation between the VCA angle and anterior coverage in the sagittal plane of the CT was analyzed using a simple linear regression model.
Results The interrater reliability for measurements of the VCA angle was almost perfect (ICC:0.97). Regression analysis showed that each degree of pelvic tilt was accompanied by a change of the VCA angle by a value of 0.63° ($P < 0.001$). A low correlation between the VCA angle measured in the false profile view and the anterior coverage in the sagittal plane was statistically not significant ($r = 0.667$, $P = 0.06$).
Conclusions Lequesne's VCA angle has an excellent interrater reliability and represents a reliable measure of acetabular dysplasia for comparisons with published data. Lequesne's VCA angle is influenced by pelvic tilt in a linear manner. Performing the false profile view in a standing position may reduce the clinical relevance of this dependency on pelvic tilt. The correlation of Lequesne's VCA angle to anterior acetabular coverage in the sagittal plane is low and therefore unsuitable to be transposed into the sagittal plane.

Keywords Hip · LEQUESNE's false profile view · Pelvic tilt · Anterior acetabular coverage

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Introduction

Acetabular dysplasia can be quantified by measuring the amount of femoral head coverage by the acetabulum [6, 9]. Lateral coverage is measured using Wiberg's center edge (CE) angle on an AP pelvic X-ray [6]. Because of the superposition of both hips on a true profile view of the pelvis, Lequesne [6] proposed to measure anterior acetabular coverage on a false profile view using the

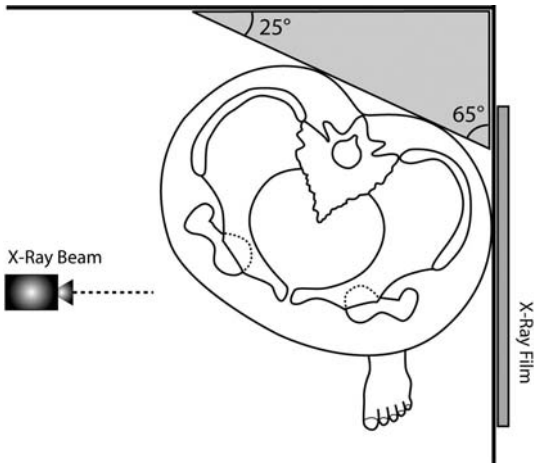

Fig. 1 Schematic drawing of patient positioning according the Lequesne [6] projection: the hip of interest is facing the detector while the pelvis is rotated by 65° in the axial plane. The axis of the ipsilateral foot has to be parallel to the radiographic plate

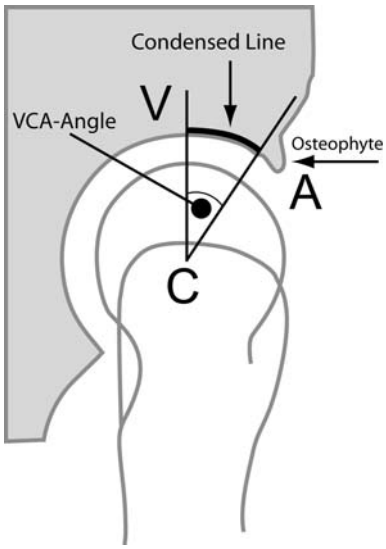

Fig. 2 The VCA angle measured on the false profile view of Lequesne [6] is suggested to correspond to anterior coverage of the femoral head. The VCA angle is measured between the vertical and the line extending from the centre *C* of the head to the most anterior point of the acetabulum *A*. Normal values are greater than 25° [6]

vertical-center-anterior margin (VCA) angle (Fig. 1). This VCA angle is composed of a vertical line (parallel to the border of the film) through the center of the femoral head and a second line through the center of the hip and the foremost aspect of the condensed line of the acetabulum [6] (Fig. 2). A VCA angle greater than 25° is widely accepted to be normal, whereas less than 20° abnormal [6], corresponding to acetabular dysplasia. Other investigators have disagreed on these normal values [2, 7]. However, they did not use exactly the same imaging protocol. In Lequesne's original description, the sclerotic zone of the acetabulum only (i.e., without marginal osteophytes) is taken into consideration for VCA angle measurements. This was not the case in Milcan's [7] and Crockarell's [2] study and may be an explanation for this discrepancy. Nevertheless, the normal values proposed by Milcan and Crockarrell differed significantly from each other (17.7° vs. 24.75°) despite using an identical technique. We wondered if these discrepancies were due to a lack of inter-observer reliability due to difficulties in defining the anterior delimitation of the acetabulum or to differing patient positions during X-ray acquisition, especially varying pelvic inclinations. The aim of the present study was, therefore, to analyze the interrater reliability of measuring the VCA angle on identical false profile views, and to correlate VCA angle values with differing pelvic inclinations.

The VCA angle may additionally be used for the preoperative planning of reorienting procedures of the acetabulum [1, 4], especially as far as the anterior coverage is concerned. However, the false profile view is taken at an angle of 65° to the sagittal plane, whereas surgeons prefer to orient themselves in sagittal and frontal planes. Therefore, an additional aim of the present study was to correlate the VCA angle of Lequesne with the acetabular coverage determined in the sagittal plane of a CT scan.

Materials and methods

Cadaver specimens

The responsible investigational review board did not require a formal approval of this study. The cadaver pelvises were obtained and utilized according to the institutional guidelines and with informed consent of the donors prior to death or appropriate family members.

Eight formalin fixed hips in four cadaver specimens including the pelvis and the proximal parts of the thighs were available from the anatomic department for this investigation.

Before inclusion in to the study, absence of osteoarthritis of the hip was confirmed by an AP pelvic X-ray.

Each specimen was fixed to a frame in a standardized pelvic tilt position; in analogy to Legaye et al. [5] 0° pelvic tilt position in this study was assumed when the line connecting the promotorium and the center of the hip joint was parallel to the frame on a true profile view. Each specimen was positioned in this standardized position using fluoroscopy.

Image acquisition

In a first step, the frame together with the fixed specimen was positioned on the horizontal table of an Angio-C-Fluoroscope.

False profile views were acquired for each hip separately. According to Lequesne's description, the X-ray beam was perpendicular to the longitudinal axis of the specimen and rotated by 65° around its longitudinal axis and centered exactly between the two rotational centers of both hips.

In order to imitate varying pelvic tilts the X-ray beam was rotated stepwise by 5° increments around the transverse axis through the rotational centers of the hip joints while leaving the fixed specimen in an unchanged position, and the false profile view repeated. This was performed for +5°, +10°, +15° +20° (inclination) and −5°, −10°, −15°, −20° (reclination). The same procedure was performed for all 4 cadaver specimens and resulted in 36 false profile views of a right and 36 false profile views of a left hip with defined pelvic inclinations.

In a second step the fixation frame together with the specimen was positioned on the horizontal table of a CT scanner (Siemens Somatom plus 4, Siemens Medical Solution, Erlangen) in the supine position and 2-mm thick axial images were acquired. In order to imitate various pelvic tilts secondary 2-D sagittal reconstructions were calculated through the center of the femoral head.

Measurements

All images were transferred to a dedicated workstation (Advantage Windows Workstation, Version 4.1; General Electrics Medical Systems Europe, Buc, France) equipped with an electronic caliper allowing precise measurements on the digital images.

The center of the femoral head was identified on both the sagittal plane CT reformations through the center of the femoral head and false profile views, by superimposing a circle of the same radius as the femoral head contour onto the femoral head.

On the false profile views, the VCA angles were measured drawing a line parallel to the border of the film though the center of the femoral head, i.e., the vertical line, and a line connecting the center of the femoral head with the most anterior delimitation of the acetabular dome sclerotic line (Fig. 3). These measurements were carried out by three independent observers on different days. All observers were blinded for each others measurements and the inter-rater reliability calculated.

On the 2-D sagittal plane CT reformations the angle between the border of the film (i.e., the vertical line) and the line connecting the center of the femoral head and the most anterior bony end of the acetabular roof was measured (Fig. 4). These measurements were performed by means of consensus of the three investigators.

Fig. 3 X-ray measurement of VCA angle. The geometric center of the femoral head was determined by superimposing a circle of the same radius as the articular surface. Then a parallel line to the film margin was drawn though the center of the femoral head, i.e. representing the vertical. Finally, the angle between the vertical and the anterior border of the sclerotic line was measured

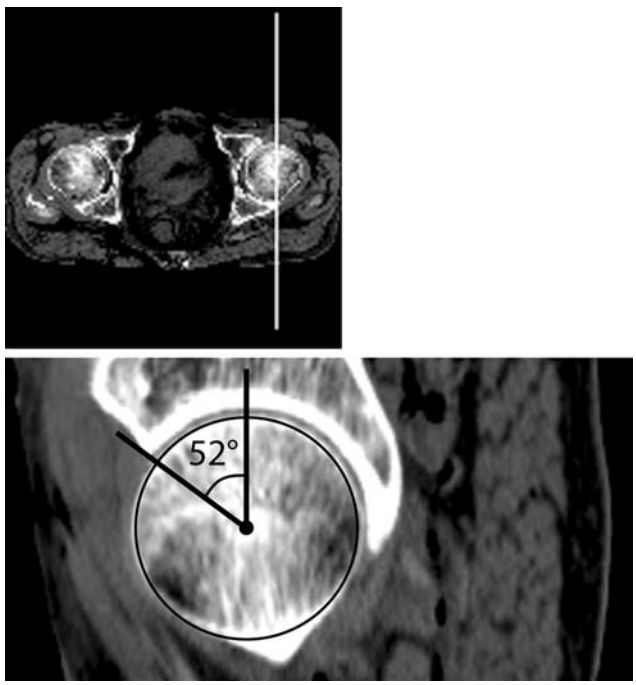

Fig. 4 CT measurement of anterior acetabular coverage in the sagittal plane. Measurements of the anterior acetabular coverage on CT scans, was performed by using a sagittal plane CT reformations through the center of the femoral head

Statistical analysis

Statistical analysis was performed by a statistical consultant from the Department of Biostatistics (SB).

Interrater reliability of the measured VCA angle was assessed in a four-way random ANOVA using the factors rater, side, cadaver, and pelvic tilt. Restricted maximum likelihood estimation was used to calculate variance components of the different sources of variation. Interrater reliability was defined as the part of variation not influenced by the rater. Thus, the interrater reliability is a direct generalization of the intra-class correlation coefficient (ICC) to this complex design. ICC values were interpreted as follows: ICC < 0.20 = slight agreement; 0.21–0.40 = fair agreement; 0.41–0.60 = moderate agreement; 0.61–0.80 = substantial agreement; and >0.80 = almost perfect agreement [8].

The dependence of VCA angle measurements on pelvic tilt was assessed in a three-way mixed ANCOVA (analysis of covariance) using the random factors rater, cadaver and fixed factor side. Pelvic tilt was included as a covariate. Thus, the ANCOVA is a regression analysis addressing the correlation of measurements within the same pelvis and those performed by the same rater.

The correlation between the VCA angle and anterior coverage in the sagittal CT plane was analyzed using a simple linear regression model.

All statistical analyses were performed using SPSS 13.0 for MacIntosh OS X. The significance level was set at $P < 0.05$.

Results

All of the four specimens available (8 hips) could be included in the analysis since none of the 4 cadavers (2 males and 2 females) had radiological evidence of osteoarthritis. Table 1 summarizes the VCA angles of all hips in neutral pelvic tilt position. In 2 hips the VCA angle indicated acetabular dysplasia according to Lequesne's criteria.

Variance components of the factors rater, side, cadaver and pelvic tilt as well as their interactions are summarized in Table 2. An almost perfect interrater reliability was found for measurements of the VCA angle (ICC = 0.97).

Table 1 VCA angles of all hips in neutral pelvic tilt position

Cadaver	1		2		3		4	
Hip	1	2	3	4	5	6	7	8
VCA angle	13[a]	32	29	41	16[a]	36	30	29

[a] Acetabular dysplasia according to Lequesne's criteria

Table 2 Variances of VCA angle measurements

Source of variation	Variance[a]	Interrater reliability of VCA angles
Cadaver	13.86	= intra-class correlation coefficient (ICC)
Side	38.29	= 0.97
Rater	0.52	
Tilt	72.75	
Cadaver[a] side	54.20	
Cadaver[a] rater	0	
Cadaver[a] tilt	6.43	
Side[a] rater	0	
Side[a] tilt	0	
Rater[a] tilt	1.11	
Cadaver[a] side[a] rater	1.04	
Cadaver[a] side[a] tilt	7.47	
Cadaver[a] rater[a] tilt	0.96	
Side[a] rater[a] tilt	0.13	
Error	3.25	

Covariance analysis illustrating the different variances of the factors rater, side, cadaver and pelvic tilt as well as their interactions. Since statistical tests applied are covariance analyses the variance data have no units

[a] No units

Analysis of covariance showed that each degree of pelvic tilt was accompanied by a linear change of the VCA angle by a value of 0.63° ($P < 0.001$) (Fig. 5).

The correlation between the VCA angle of Lequesne and the corresponding angle measured in the sagittal plane of the CT was low and did not reach the significance level of 5% with the numbers analyzed in the present study ($r = 0.667$, $P = 0.06$).

Discussion

The present study reveals a high interrater reliability for measurements of the VCA angle of Lequesne. Difficulties in defining the anterior delimitation of the acetabulum in the false profile view seems not to be an issue. Thus, Lequesne's angle gives a reproducible measure of acetabular coverage in the anterolateral region of the joint. Together with normal values published in the literature it is a reliable measure of acetabular dysplasia and its improvement after reorientation procedures.

As expected, pelvic tilt does have an influence on the values of the measured VCA angles. Fortunately this influence is linear. Every 1° of pelvic tilt increases the measured VCA angle by 0.63°. Two out of eight evaluated hips had a dysplastic anterior coverage and showed to have the same relationship between VCA angle and pelvic tilt. We therefore

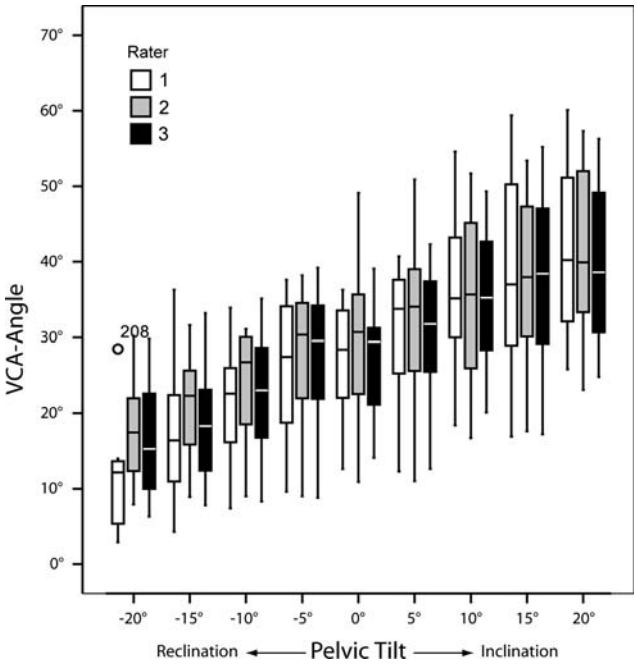

Fig. 5 *Box-plots* demonstrating the dependence of VCA angle measured on false profile view on pelvic tilt and the excellent interrater reliability (ICC = 0.97) of VCA angle measurements. Analysis of covariance showed that each degree of pelvic tilt was accompanied by a linear change of the VCA angle by a value of 0.63° ($P < 0.001$)

conclude that measurements of normal and dysplastic hips are equally affected by changes in pelvic inclination. This dependency on pelvic tilt should be kept in mind when using this angle to measure the degree of acetabular dysplasia. One measure to reduce this confounding factor is to perform the false profile view in the standing and not in the lying position, expecting that the standing position would correspond to a more functional position of the pelvis.

However, the VCA angle of Lequesne had a low and nonsignificant correlation with the anterior acetabular coverage in the sagittal plane. This is in line with the anatomical and radiological investigation of Fabeck et al. [3] demonstrating that the VCA angle does not correspond to a real anatomical structure. However, the fact that only four whole body specimens (eight hips) were available in the present study may limit this finding and a greater number of specimens might have rendered this correlation significant. Nevertheless, even if significant with a higher number of specimens, the low correlation would be unlikely to have increased with higher numbers and we estimate the VCA angle of Lequesne unsuitable to be transposed into the sagittal plane and therefore unsuitable for guiding the surgeon during reorientation procedures. Sagittal reconstruction of CT scans would be more appropriate for guiding reorientation procedures with respect to anterior acetabular coverage. However, CT scans are rarely used for the primary diagnosis of acetabular dysplasia. One reason might be the higher dose of radiation and the lack of normal values for anterior coverage in the sagittal plane. In addition CT scans would face the same positional problems of pelvic tilt.

In conclusion, Lequesne's VCA angle measured on a false profile view has an excellent intra- and inter-rater reliability and represents a reliable measure of acetabular dysplasia when a comparison to published data needs to be made. However, Lequesne's VCA angle is influenced by pelvic tilt. This influence is linear: 3° of pelvic tilt results in increasing the VCA angle by approximately 2°. Performing the false profile view in a standing position may reduce the clinical relevance of this dependency on pelvic tilt. Unfortunately the correlation of Lequesne's VCA angle to anterior acetabular coverage in the sagittal plane is low and therefore not very helpful in guiding the surgeon during reorientation procedures.

References

1. Crockarell J Jr, Trousdale RT, Cabanela ME, Berry DJ (1999) Early experience and results with the periacetabular osteotomy. The Mayo Clinic experience. Clin Orthop Relat Res (363):45–53
2. Crockarell JR Jr, Trousdale RT, Guyton JL (2000) The anterior centre-edge angle. A cadaver study. J Bone Joint Surg Br 82(4):532–534. doi:10.1302/0301-620X.82B4.10063
3. Fabeck L, Farrokh D, Behets C, Delince P (2002) Anatomical and radiological correlation of Lequesne's "false profile". Surg Radiol Anat 24(3–4):212–216. doi:10.1007/s00276-002-0038-1
4. Ganz R, Klaue K, Vinh TS, Mast JW (1988) A new periacetabular osteotomy for the treatment of hip dysplasias. Technique and preliminary results. Clin Orthop Relat Res (232):26–36
5. Legaye J, Duval-Beaupere G, Hecquet J, Marty C (1998) Pelvic incidence: a fundamental pelvic parameter for three-dimensional regulation of spinal sagittal curves. Eur Spine J 7(2):99–103. doi:10.1007/s005860050038
6. Lequesne M, de Seze S (1961) False profile of the pelvis. A new radiographic incidence for the study of the hip. Its use in dysplasias and different coxopathies. Rev Rhum Mal Osteoartic 28:643–652
7. Milcan A, Yildiz A, Oztuna V, Eskandari MM, Sahin G, Kuyurtar F (2004) The anterior center edge angle: a study of 102 volunteers. Joint Bone Spine 71(3):221–223. doi:10.1016/S1297-319X(03)00121-0
8. Montgomery AA, Graham A, Evans PH, Fahey T (2002) Inter-rater agreement in the scoring of abstracts submitted to a primary care research conference. BMC Health Serv Res 2(1):8. doi:10.1186/1472-6963-2-8
9. Wiberg G (1939) Studies on dysplastic acetabula and congenital subluxation of the hip joint with special reference to the complication of osteoarthritis. Acta Chir Scand Suppl (83):1–130