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What is the most reliable ultrasound parameter for assessment of fetal head descent?

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ABSTRACT

Objectives *The aims of this study were, first, to establish the agreement between digital and ultrasound assessment of occipital position and, second, to evaluate the repeatability of the measurements of head direction, angle of the middle line, progression distance and angle of progression in women in the second stage of labor.*

Methods *Digital examination and then transabdominal ultrasound examination was performed on 50 women in the second stage of labor to determine the fetal occipital position. We also obtained three-dimensional (3D) blocks of the fetal head by transperineal sonography, and two experts in 3D ultrasound measured head direction, angle of the middle line, progression distance and angle of progression. Intraclass correlation coefficients with 95% CIs, and Bland–Altman analysis, were used to evaluate intraobserver and interobserver repeatability of measurements.*

Results *The fetal head position, determined by ultrasound examination, was occiput anterior in 33 (66%) cases and occiput lateral in 17 (34%) cases. Vaginal digital examination failed to identify the correct fetal head position by more than 45° in 33 (66%) cases. All four 3D ultrasound measurements were reproducible but the progression angle had the highest intraclass correlation coefficient for the same observer (0.94; 95% CI, 0.90–0.97) and for two different operators (0.84; 95% CI, 0.73–0.91). The progression angle was also the measurement for which smaller limits of agreement (LOA) were found in the Bland–Altman test, performed to calculate the intraobserver (bias 0.9; LOA, −9.2 to 11.1%) and interobserver (bias 1.5; LOA, −15.4 to 18.3%) variability.*

Conclusions *Digital pelvic examination for determining the fetal head position during labor is not accurate. The most reproducible of the 3D measurements for progression of the fetal head in labor is the progression angle. Copyright © 2010 ISUOG. Published by John Wiley & Sons, Ltd.*

INTRODUCTION

Extensive evidence indicates that digital pelvic examination for the determination of fetal head position during labor is not accurate and this can have major implications in deciding the mode of delivery[1–6]. Recent studies suggest that the use of ultrasound can overcome these problems by providing a series of objective measurements for progression of the fetal head in labor and prediction of successful instrumental vaginal delivery[7–11]. These measurements, including head direction[7], angle of the middle line[8], progression distance[9] and angle of progression[10,11], have been incorporated into three-dimensional (3D) ultrasound software called Sonography-based Volume Computer Aided Display labor (SonoVCAD™ *labor*, Voluson i; GE Medical Systems, Milwaukee, WI, USA).

The aim of SonoVCAD*labor* is to provide an objective measure of progression of the fetal head during labor. However, there are no prospective studies using this tool to establish which of the measurements is more reliable and accurate in the prediction of vaginal delivery. The objective of this study was to evaluate the clinical applicability of the SonoVCAD*labor* and the repeatability of the four different measurements in women in the second stage of labor.

METHODS

The study population included 50 women with singleton pregnancies in the second stage of labor, with the fetal

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occiput thought, during digital examination, to be in the anterior or lateral position. Obstetricians, who had experience in obstetric ultrasound and had attended a 1-day practical session in the 3D collection of blocks in labor, performed a vaginal digital evaluation to assess the position of the occiput in the pelvis and then confirmed this position by placing the ultrasound probe transversely above the maternal pubic bone. Subsequently, 3D volumes of the fetal head were obtained by placing the ultrasound probe between the labia below the pubic symphysis and taking care to obtain a sagittal view with the maximum contour of the fetal head and the pubic bone as a reference of the maternal pelvis (RAB 4-8L probe, Voluson i; GE Medical Systems). All women provided written informed consent to participate in the study, which was approved by the hospital Ethics Committee.

Accuracy of digital examination during assessment of fetal head position

In the transabdominal scan, the fetal head position was defined by visualizing the fetal orbits, midline cerebral echo and cerebellum or occiput. The clinical and ultrasound findings of the fetal position were recorded on a data sheet depicting a circle that was divided into 24 sections, each of 15°. Direct occiput anterior, posterior and right transverse positions were recorded as 0, 180 and 270°, respectively. The digital examination was considered to be correct if the fetal head position was within ±45° of the ultrasound finding. We studied the percentage agreement between occipital position assessed digitally and using ultrasound examination.

Measurements for progression of the fetal head in labor

The 3D volumes were examined offline, using the multiplanar mode of the SonoVCAD*labor* software, by two experts in 3D ultrasound. The facilities of the software allowed us to standardize the pubic bone as a reference in the sagittal and transverse planes for the subsequent measurements (Figure 1). The first measurement, i.e. head direction, which was defined as the angle between a line perpendicular to the longer diameter of the pubis starting from the inferior border and another line drawn perpendicular to the widest diameter of the fetal head, was made in Plane A. The contour of the fetal head was drawn manually and the software then calculated the maximum diameter of the head and the head direction, which is a line to the most distal point of the head contour orthogonal to the head diameter (Figure 2). The second measurement, i.e. the middle line angle of the head with the vertical, was obtained automatically by clicking in Plane B on the occipital and frontal points of the fetal head (Figure 3). The third measurement, i.e. progression distance, which is the shortest distance between the leading edge of the fetal skull and an imaginary line perpendicular to the pubis from its anterior edge, was displayed automatically after clicking in Plane A on the most distal point of the head contour (Figure 4). The fourth measurement, i.e. the angle of progression of the fetal head, which is the angle between a line through the midline of the pubic bone and a line from the anterior edge of the pubis to the leading edge of fetal head, was also obtained in Plane A (Figure 5).

In order to determine the intraobserver and interobserver concordance in measurements, two experts in 3D ultrasound made each of the four measurements in each case and one of the examiners subsequently repeated all the measurements.

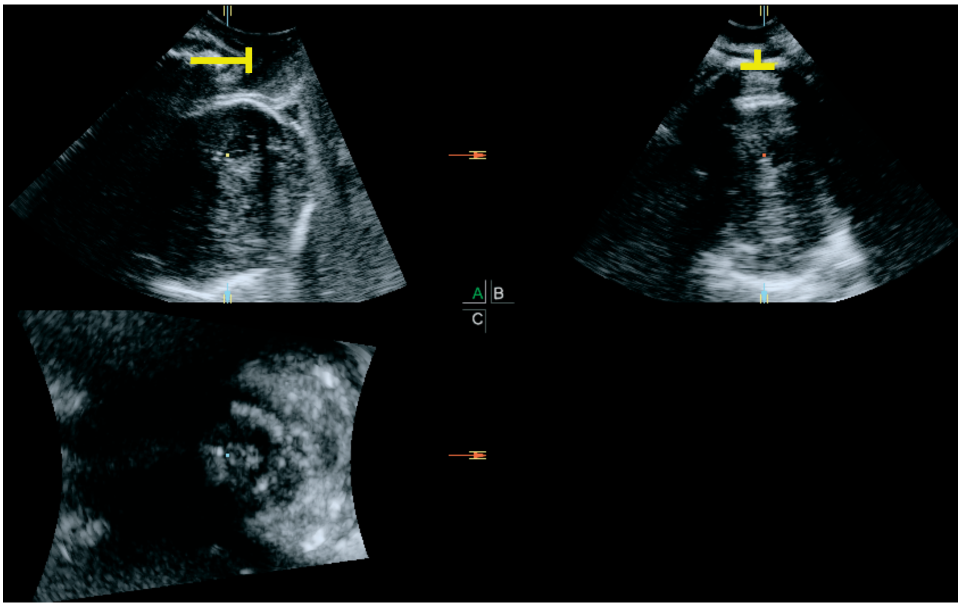

Figure 1 Multiplanar mode of the SonoVCAD™ *labor* software. The yellow mark was placed to standardize the pubis before the measurements were made. In Plane A, the horizontal part of the mark should be placed along the longer diameter of the pubis and the vertical part of the mark at the edge of the pubis. In Plane B, the horizontal part of the mark should be in line with the two pubic rami and the vertical part of the mark in the space of the symphysis pubis.

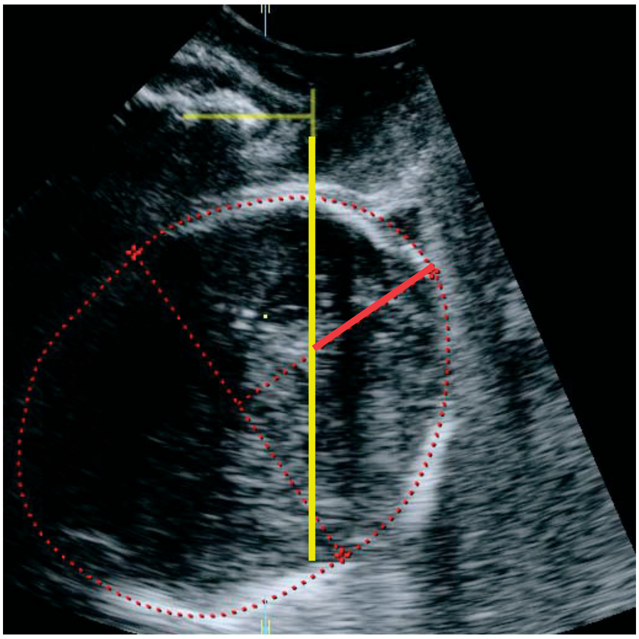

Figure 2 The head direction is the angle between a vertical line from the inferior apex of the symphysis (yellow line) and another line drawn perpendicular to the widest diameter of the fetal head (red line).

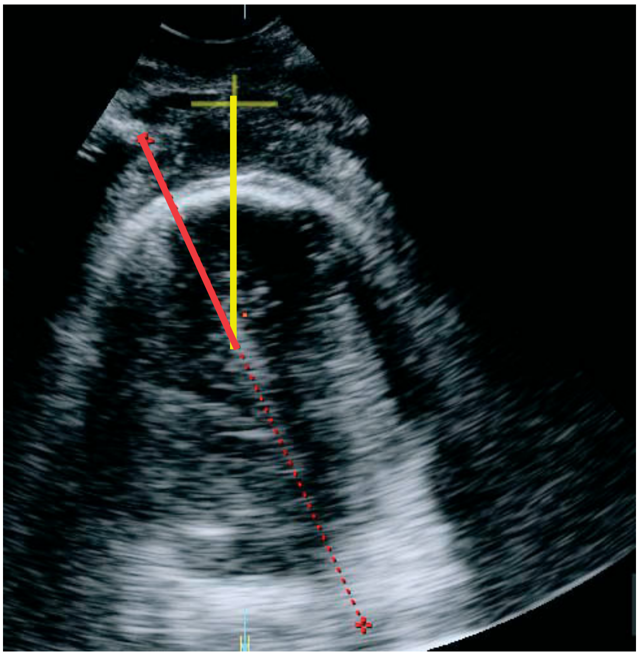

Figure 3 The angle of the middle line of the head is the angle between the head midline (red line) and the vertical line (yellow line).

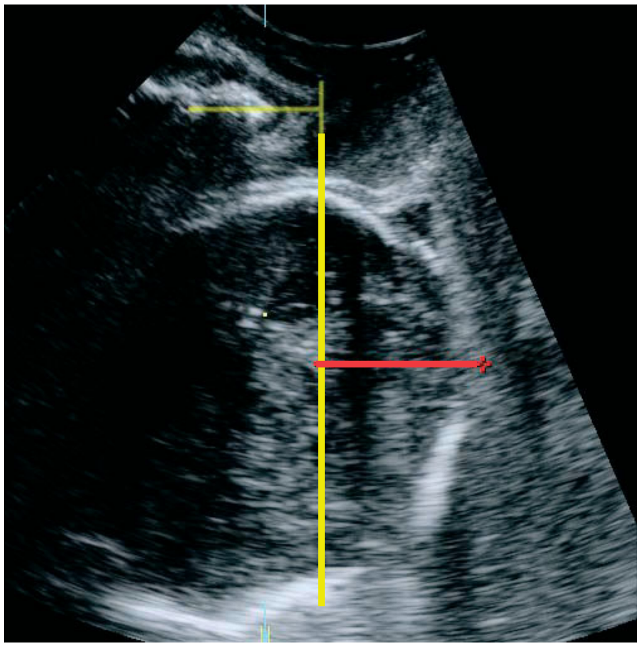

Figure 4 The progression distance (red line) is the minimum distance between the leading edge of the fetal skull and an imaginary line perpendicular to the pubis from its anterior edge (yellow line).

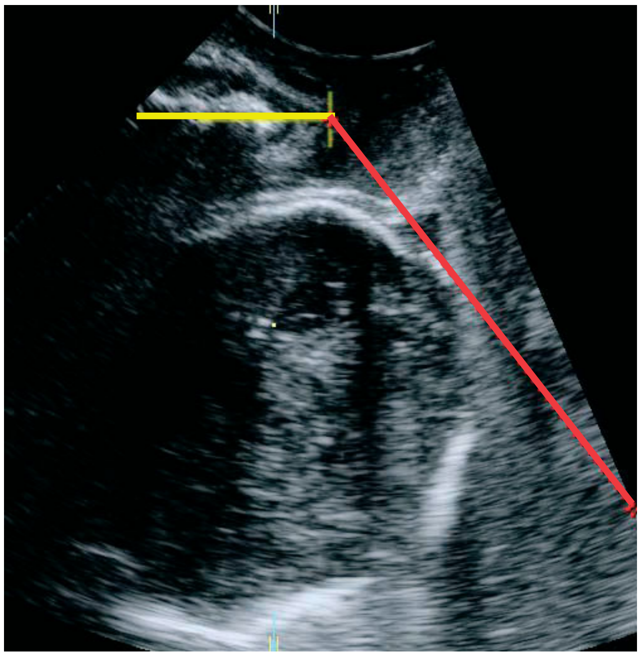

Figure 5 The angle of progression is the angle between a line through the midline of the pubic bone (yellow line) and a line from the anterior edge of the pubis to the leading edge of the fetal head (red line).

Statistical analysis

The percentage agreement in assessing occipital position digitally with the findings of transabdominal ultrasound examination was determined using descriptive statistics. The reproducibility of intraobserver and interobserver measurements was examined by calculating intraclass correlation coefficients and their 95% CIs[12,13]. The overlap between the 95% CIs of two intraclass correlation coefficients was indicative of no significant difference between them. The Bland–Altman plot[14] of the average measurement against the percentage of the differences between the two measurements was produced and the 95% limits of agreement (LOA) were calculated for each measurement to examine the agreement and bias for a single examiner and between two examiners in each measurement. The optimal measurement is the one where, first, the intraclass correlation coefficients are large and the SD of the differences between measurements is small and, second, there is no bias and the LOA are smaller in the Bland–Altman plot.

Data were analyzed using the statistical software MedCal® Version 9.3.7.0 (Mariakerke, Belgium) and SPSS 17.0 software (SPSS Inc., Chicago, IL, USA)

RESULTS

In the 50 cases included in the study the mean maternal age was 30.9 (range 17.5–42.7) years and the mean gestational age was 39.9 (range 37.1–41.9) weeks. The maternal demographic and delivery characteristics are summarized in Table 1.

Accuracy of digital examination in the assessment of head position

Assessment of the fetal head position by ultrasound examination took less than 3 min to complete; it was occiput anterior in 33 (66%) cases and occiput lateral in 17 (34%) cases. Vaginal digital examination failed to identify the correct fetal head position by more than 45° in 33 (66%) cases, including seven (14%) in which the difference from the ultrasound finding was more than 90° (Table 2).

Table 1 Maternal and pregnancy characteristics of the study population

Characteristic	*Mean (95% CI) or n (%)*
Gestational age (weeks)	39.9 (37.1–41.9)
Maternal age	
< 20 years	4 (8)
20–35 years	33 (66)
> 35 years	13 (26)
Parity	
Nulliparous	31 (62)
Parous	19 (38)
Body mass index	
20–25 kg/m²	17 (34)
26–30 kg/m²	29 (58)
> 30 kg/m²	4 (8)
Onset of labor	
Spontaneous	34(68)
Induced	16 (32)
Mode of delivery	
Spontaneous	37 (74)
Instrumental	11 (22)
Cesarean section	2 (4)
Fetal weight (g)	3330 (2730–4660)

Comparison of measurements for progression of the fetal head in labor

The results of the studies carried out to determine intraobserver and interobserver reproducibility for the various 3D measurements are summarized in Table 3. There was an overlap between the 95% CIs of two intraclass correlation coefficients for both the intraobserver and interobserver results, indicating no significant difference for any of the 3D measurements. The most reproducible results were obtained for the progression angle because it demonstrated the largest intraclass correlation coefficients and the smallest 95% CIs and SD of the differences between measurements.

The Bland–Altman plots, demonstrating the degree of concordance between pairs of measurements made by the same observer and by the two different observers, are illustrated in Figure 6 and the data are presented in Table 4. In all cases there was no bias because the difference between measurements remained stable as the

Table 3 Intraclass correlation coefficients for measurement of fetal head position in labor to determine intraobserver and interobserver reproducibility

Measurement	*Intraclass correlation coefficient*	*95% CI*	*SD of the differences (%)*	P
Head direction				
Same observer	0.85	0.75–0.91	8.89	< 0.001
Two observers	0.69	0.52–0.82	11.53	< 0.001
Middle line				
Same observer	0.78	0.65–0.87	26.07	< 0.001
Two observers	0.67	0.48–0.79	44.83	< 0.001
Progression distance				
Same observer	0.93	0.87–0.96	23.18	< 0.001
Two observers	0.85	0.74–0.91	32.12	< 0.001
Progression angle				
Same observer	0.94	0.90–0.97	5.18	< 0.001
Two observers	0.84	0.73–0.91	8.59	< 0.001

Table 2 Agreement between ultrasound and vaginal digital examination in determining fetal head position in labor

Head position on ultrasound	*Total (n (%))*	*Digital vaginal examination (n (%))*		
		Agreement	*Difference from ultrasound by 45–90°*	*Difference from ultrasound by 90–180°*
Direct occiput anterior	14 (28.0)	3 (21.4)	10 (71.4)	1 (7.2)
Right occiput anterior	9 (18.0)	4 (44.4)	4 (44.4)	1 (11.2)
Left occiput anterior	10 (20.0)	7 (70.0)	3 (30.0)	—
Left occiput lateral	11 (22.0)	2 (18.2)	6 (54.5)	3 (27.3)
Right occiput lateral	6 (12.0)	1 (16.7)	3 (50.0)	2 (33.3)

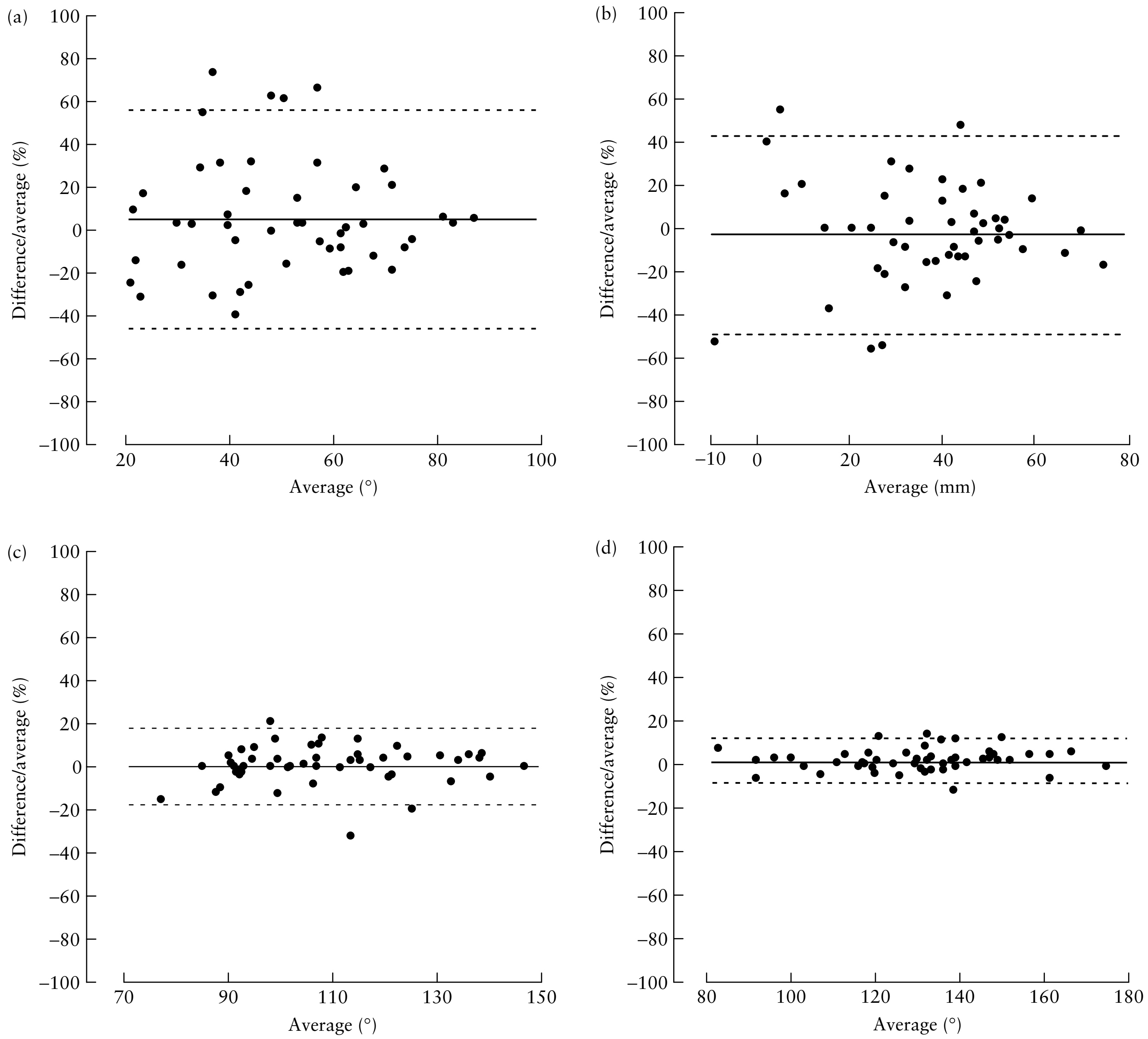

Figure 6 Bland–Altman plots demonstrating the degree of concordance between pairs of measurements of fetal head position obtained by the same observer in women in the second stage of labor: middle line angle (a), progression distance (b), head direction (c) and angle of progression (d). Solid lines represent the mean and dotted lines represent ± 1.96 SD.

average increased. The most reproducible measurements were obtained for angle of progression.

DISCUSSION

The findings of this study confirm that digital pelvic examination for determining the fetal head position during labor is not accurate and demonstrate that the most reproducible of the 3D objective measurements for progression of the fetal head in labor is the progression angle.

In our study, vaginal digital examination failed to identify the correct fetal head position by more than 45° in two-thirds of the cases. Akmal *et al.*[4] reported that the use of digital pelvic examination failed to determine the fetal head position in 34% of women in labor and, of those in whom the position was determined, the findings of the digital and sonographic examinations were in agreement in only 49.4% of cases. The rate of correct identification of the fetal head position by digital examination increased with cervical dilatation increase, from 20.5% at 3–4 cm to 44.2% at 8–10 cm. Similarly, Souka *el al.*[5] showed that it was not possible to assess the fetal head position by digital examination in 61% of cases in the first stage of labor and in 31% of cases in the second stage of labor. Difficulty in assessing the head position was more likely if the occiput was posterior in comparison to anterior. In the cases where assessment by vaginal examination was possible, assessment of the fetal head position by digital examination was accurate in 31% of the cases in the first stage of labor and in 66% of cases in the second stage of labor. Akmal *et al.*[15] assessed the fetal head position immediately before instrumental delivery and reported

Table 4 Degree of concordance between pairs of measurements of fetal head position in labor made by the same observer and by two different observers

Measurement	Difference between measurements (%)	
	Same observer	*Two observers*
Head direction	0.2 (−17.3 to 17.6)	0.4 (−22.2 to 23.0)
Middle line	5.8 (−45.3 to 56.9)	16.8 (−71.1 to 104.6)
Progression distance	−3.0 (−48.4 to 42.5)	−7.5 (−70.4 to 55.5)
Progression angle	0.9 (−9.2 to 11.1)	1.5 (−15.4 to 18.3)

Difference between measurements is expressed as a percentage of the average of two measurements taken by the same observer or by two different observers. Data are bias (limits of agreement).

that in 27% of the cases vaginal digital examination failed to identify the correct fetal head position by more than 45°. These results demonstrate that ultrasound examination is needed in labor to objectively determine head position, and in particular before instrumental vaginal delivery.

The inaccuracy of clinical examination during labor has also been demonstrated in assessing the descent of the head over the different planes of the maternal pelvis. A study using a birth simulator reported the alarming results that at the point where a consultant in obstetrics should decide if the delivery would be safer vaginally or abdominally, 67% of the mistakes were caused by misdiagnosing a true high-pelvic station as a mid-pelvic station[6]. Recent studies have attempted to provide a series of measurements obtained by two-dimensional (2D) ultrasound as an objective way of assessing progression of the fetal head in labor[7–11]. Our study, which compared each of the previously suggested measurements, demonstrated that the one with the highest repeatability is the progression angle. We used 3D ultrasound rather than 2D ultrasound, because the multiplanar mode allows standardization of the measurements by ensuring that the pubis ramus can be identified and used as the reference point. Although the measurements were made offline after delivery, they could also be made prospectively during labor because all four measurements of each block were obtained within 3 min.

The objective measurements incorporated into the 3D software to determine progression of the fetal head in labor were head direction[7], angle of the middle line[8], progression distance[9] and angle of progression[10,11]. Assessment of head direction necessitates manual tracing of the contour of the fetal head, and assessment of angle of the middle line requires accurate definition of the middle line of the fetal head. Consequently, these measurements are not reliable in all cases because of shadowing of the fetal head by the maternal pelvic bones, especially when the fetal head is deep in the pelvis. By contrast, the measurements of progression distance and angle of progression rely on assessment of the leading part of the fetal head, which is easy to identify using transperineal ultrasound scanning.

The results of repeatability of measurements in our study were very similar to those in a recent study by Dückelmann *et al.*[16]. They examined the angle of progression in 24 women experiencing a prolonged second stage of labor and reported that the intraclass correlation coefficient of separate images acquired by two experienced operators was 0.86 (95% CI, 0.70–0.93). They also studied the repeatability in the measurement of the angle by different observers with different ultrasound experience in 44 still pictures, obtained by one experienced obstetrician, in women undergoing a prolonged second stage of labor. The intraclass correlation coefficients were 0.82 (95% CI, 0.70–0.89), 0.81 (95% CI, 0.71–0.88) and 0.61 (95% CI, 0.43–074) for observers with more than 10 years of experience, less than 5 years of experience and no experience, respectively. Bland–Altman analysis indicated reasonable agreement between measurements obtained by two different operators with more than 10 years and less than 5 years of ultrasound experience (bias, −1.09°; 95% LOA, −8.76 to 6.58°), which was very similar to our LOA in intraobserver variability. The finding that our results are similar to those of Dückelmann *et al.*,[16] who used a 2D ultrasound system, implies that the angle of progression is not only reliable regardless of fetal head station and ultrasound experience but also of the technique used to acquire the images.

The results of our study indicate that the progression angle is a reproducible measurement for assessing progression of the fetal head in labor. Future studies incorporating the progression angle in the management of labor should investigate the role of this measurement in the prediction of outcome.

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