How reproducible are classical and new ct-pelvimetry measurements?

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Abstract

Purpose: The objective of this study was to assess the reliability and reproducibility of existing and new computed tomography (CT)-pelvimetry measurements.

Material and methods: A retrospective cohort study of 63 women with a mean age of 33.9±5.2 (DS) years (range: 19–49 years) was conducted. Classical pelvimetry measurements were collected including the obstetric conjugate (OC), median transverse diameter (MTD), and interspinous diameter (ISD). Additionally, we used multiplanar reconstruction (MPR) mode to define two oblique planes: inlet pelvic plane (IPP) and mid-pelvic plane (MPP) and measure newer pelvic parameters, including anteroposterior (APD), transverse diameters and circumference of both IPP and MPP (inletAPD, inletMTD, inletCIRC and midAPD, ISD, midCIRC, respectively). The reproducibility (intra- and inter-observer) of our results were assessed. Multivariate analyses using principal component analysis and clustering methods were conducted to analyze the association between pelvimetry measurements and identify patient sub-groups.

Results: All linear measurements (OC, inletAPD, MTD, inletMTD, midAPD, and ISD) showed statistically "almost perfect" intra- and inter-observer correlation coefficients (range 0.924-0.980). Circumferences (inletCIRC and midCIRC) showed statistically "almost perfect" intra- (range 0.847-0.857) and inter-observer correlation coefficients (range 0.923-0.957). The measurement of 6 pelvimetric parameters allowed determining three groups of pelvis size.

Conclusion: New pelvic measurements have excellent reproducibility and are similar to the classical measurements, based on the MPR analysis of CT planes adjusted to the inner bony pelvis.

Keywords: Pelvimetry; Multidetector computed tomography (MDCT); Pregnancy; Reference values; Reproducibility study

Introduction

In obstetric practice, pelvimetry refers to the measurement of pelvic parameters to assess obstetrical prognosis, in order to prevent mechanical bone dystocia and potential fetal suffering [1]. Fetal-pelvic disproportion (FPD) occurs when the fetus is larger than the maternal pelvis. The prediction of FPD, and consequently, the determination of the most appropriate mode of delivery, remains challenging for obstetricians, especially in cases of breech presentation or twin pregnancies, the two most common indications of pelvimetry [2].

Conventional X-ray pelvimetry was replaced by sequential and helical computed tomography (CT) during the 1980s, which became the gold standard. More recently, magnetic resonance imaging (MRI) or low-dose stereoradiographic imaging (SRI) have emerged as promising alternatives [3–13]. Furthermore, cross-sectional imaging (CT and MRI) allow multiplanar reconstructions (MPR) and measurements on oblique planes, that may be more relevant than measurements on projections to assess cephalo-pelvic disproportion [7,8,10].

In practice, pelvimetry is challenged by inter-observer variability of measures performed on conventional X-ray radiography, and even CT [14]. New MRI and CT measurements for successful vaginal delivery have been identified and recently discussed in the literature [2–4,8]. The obstetric conjugate (OC), median transverse diameter (MTD), and interspinous diameter (ISD) are commonly used and compared with fetal ultrasound biparietal diameter (BIP) to determine the appropriateness of vaginal birth in the case of breech presentation or twin pregnancy [15]. Nonetheless, at the pelvic inlet level, Fremondiere et al. distinguished the "true" inlet pelvic plane (IPP) that includes the sacrum under the promontory level of the first sacral vertebra from the classical obstetric conjugate plane (OCP) [2]. They suggested that the anteroposterior diameter (APD) of the IPP is more relevant in identifying fetal-pelvic disproportion than the obstetric conjugate (OC) of the OCP [2]. In addition, recent studies emphasize the role of mid-pelvic measurements while introducing anteroposterior diameter of the mid-pelvis to supplement the interspinous diameter [3,10,16,17]. Similarly, mid-pelvic circumference could be predictive of vaginal delivery [10,16,17].

The main objective of this study was to assess reliability and reproducibility of CT-pelvimetry measurements, including standard measurements and a set of alternate measurements that may be more clinically relevant, based on the assumptions of the recent literature [2]. A secondary objective was to analyze how these new parameters could be arranged to classify the morphometry of the female pelvis.

Material and Methods

Population

This single-center retrospective study was approved by the local Ethical Committee (CNIL No. DEC16-207). All consecutive CT-pelvimetries performed in a specialized women imaging department between January 1, 2017 and April 30, 2017 were included.

From the Picture Archiving and Communication System (PACS), a total of 63 women with a mean age of 33.9 ± 5.2 (SD) years (range: 19–49 years) were included, with no exclusions. In 44/63 (70%) patients, CT-pelvimetry was performed due to breech presentation of the fetus, in 17/63 (27%) due to twin gestation, and in 2/63 (3%) due to small mother height (1.50m). CT-pelvimetries were performed in the third trimester of pregnancy. Patients demographic data are shown in **Table 1**.

CT-pelvimetry protocol

All examinations were performed using a 64-slice multidetector CT scanner (Somatom Definition AS®, Siemens Healthineers) using routine pelvic protocols, and images reconstructed at a 1.5 mm-slice thickness. The acquisition parameters including dosimetry are show in **Table 2**. Analysis was performed on a three-dimensional (3D) workstation (Intellispace® Portal Multimodality; Philips Healthcare) using multiplanar rendered images with surface shaded display 3D rendering. All measurements were performed on oblique multiplanar reformatted (MPR) images of the pelvis.

Image analysis

Image analysis was performed by two radiologists blinded to each other (C.C. and L.L., having 1- and 2-years of experience in obstetric imaging, respectively) on a dedicated workstation and carried out twice by the first observer (C.C.) to assess intra-observer variability. In addition to the classical OCP, we defined two additional pelvic planes, which included the inlet pelvic plane (IPP), and the mid-pelvic plane (MPP) (**Figure 1**), and collected multiples measurements summarized in **Table 3**.

IPP was obtained by tilting the posterior anchor of the OCP downwards until the entire circumference of the pelvis became bony (**Figure 2**). This operation required visibility of two CT planes on MPR-CT images: sagittal and oblique axial (IPP). IPP remained oblique, but at a variable distance from the first sacral vertebra. On the IPP image, the two observers manually drew the bony pelvic inlet using a Bezier polygon, and collected 3 measurements: automatically calculated circumference (inletCIRC; cm); manually defined anteroposterior diameter (inletAPD; cm) and median transverse diameter (inletMTD; cm) orthogonal and crossing the middle of inletAPD (**Figure 2**).

MPP was obtained by finding both ischial spines on axial CT images, aligning the centerline of rotation, then tilting the anterior anchor of this plane to the lower posterior edge of the pubis (**Figure 3).** Posteriorly, the MPP does not depend on a fixed position on the sacrum and this technique therefore does not consider an anatomically defined anchor point on the sacrum. On the MPP image, the two observers manually delineated the mid-pelvis, by using a Bezier polygon following the bony structures and the pelvic inner and collected 3 measurements: automatically calculated circumference (inletCIRC; cm); manually defined interspinous diameter (ISD; cm) and anteroposterior diameter (midAPD; cm) orthogonal to ISD (**Figure 3**).

The two observers also measured the "classical" median transverse diameter (MTD) as the distance perpendicular to the middle of the OC, and the sagittal outlet diameter (SOD) between the lower border of the pubis and the sacrococcygeal joint, and calculated the sum of OC + MTD (Magnin index or OCP index), the IPP index (sum of inletAPD + inletMTD), and the MPP index (sum of ISD + midAPD) [1,2]. The sacrum measurements were collected once, without variation analysis, because they are not considered in obstetric decision making [15]. The sacrum height differences between the OC and inletAPD (H1), and between the midAPD and SOD (H2), respectively, were measured.

Statistical analysis

Statistical analyses were performed using SAS 9.4 and SPSS 19 software. Descriptive analysis was first performed to verify and summarize the data. The assumption of normality was tested using the Shapiro-Wilk test. Quantitative variables were expressed as mean, standard deviation (SD) and ranges. Qualitative variables were expressed as raw numbers, proportions and percentages. Intra- and inter-observer reproducibility were examined using the intra-class coefficient of correlation (ICC) (Fleiss method). Coefficients of correlation ("R") were considered as "almost perfect" with R between 1.00 and 0.81; "substantial" with R between 0.8 and 0.61; "moderate" with R between 0.6 and 0.41; "fair" with R between 0.4 and 0.21; and "slight" with R between 0.2 and 0.01. After analysis of reproducibility, one value for each parameter was computed using the mean value of the several measurements. For all tests, significance was set at P <0.05.

In order to summarize relationships between the different parameters and select a subset of 6 non-correlated parameters, a principal component analysis and a hierarchical clustering analysis were performed. Finally, a hierarchical clustering analysis was carried out aiming to highlighting different patient subgroups (clusters) based on pelvimetry measurements. The distribution of the 6 parameters were compared between the 3 clusters (Kruskall-Wallis test) and represented, after standardizations (z-scores), on a radar graph.

Results

Reproducibility of classical and new pelvimetry measurements

All linear measurements (OC, inletAPD, MTD, inletMTD, midAPD, and ISD) and circumferences (inletCIRC and midCIRC) showed statistically "almost perfect" intra- and inter-observer correlation coefficients. The value of all intra- and inter-observer correlation coefficients ranged between 0.980 and 0.847 **(Table 4)**.

Comparison of inlet and mid-pelvis dimensions

The mid-pelvis was statistically significantly narrower than the inlet pelvis, with significant differences of circumferences or linear indexes. For circumferences, mean midCIRC was 35.56 ± 2.10 (SD) cm, whereas mean inletCIRC was 40.52 ± 2.55 (SD) cm (P <0.001). Mean MPP index was 22.66 ± 1.43 (SD) cm, mean IPP index was 25.43 ± 1.68 (SD) cm (P < 0.001), and mean Magnin Index was 25.05 ± 1.65 (SD) cm (P < 0.001). The ISD was the narrowest diameter (**Table 4**).

Comparison of classical and new pelvimetry measurements

At the inlet, the mean difference between OC and inletAPD was 0.4 ± 4.4 (SD) mm (P = 0.358). MTD was significantly smaller than inletMTD. Mean difference between MTD and inletMTD was 2.6 ± 2.8 (SD) mm (P < 0.001). At the mid-pelvis, midAPD was significantly larger than SOD with a mean difference of 4.3 ± 3.2 (SD) mm (P < 0.001).

Sagittal projections of the pelvic planes

At the inlet, the cranio-caudal distance between the sacral intersection of the IPP and the promontory (H1) was 22.3 ± 8.4 (SD) mm. At the mid-pelvis, we found that the MPP cut the lower sacrum posteriorly at different levels on each woman between the fourth sacral vertebra and the sacrococcygeal joint; the cranio-caudal distance between the sacrococcygeal joint and sacral position of the MPP (H2) was 10.7 ± 5.5 (SD) mm. Several forms of sacrum were observed. In patient with flat sacrum, unlike curved sacrum (classical morphology), the narrowest anteroposterior distance from the inner pelvis was not at the IPP or MPP **(Figure 4)**.

Clustering analysis

Twelve parameters (OC, inletAPD, MTD, inletMTD, midAPD, ISD, inletCIRC, midCIRC, SOD, Magnin index, IPP index, and MPP index) were first included in the hierarchical clustering analysis, allowing grouping of correlated parameters. Thus, six parameter groups were obtained (**Figure 5**). Then, we arbitrarily selected one variable per group: inletMTD, inletAPD, inletCIRC, midAPD, midCIRC and ISD (**Figure 5**). Based on these 6 parameters, we divided the population into three clusters as follows: Cluster 1 (C1): n=18, narrow pelvis; Cluster 2 (C2): n=28, medium pelvis; and Cluster 3 (C3): n=17, large pelvis (**Table 5**). The average values of each parameter are represented in a standardized way (Z-score) **Figure 6**.

Discussion

Historically, inlet measurements in the classical OCP (OC and MTD) have been considered the most important, and sometimes the only, pelvimetry radiological measurements used to assess the maternal pelvic morphology [7]. However, in a recent publication, Fremondiere et al. argued in favor of distinguishing between the OCP and the IPP, and suggested that the inletAPD was more relevant than the OC in identifying fetal-pelvic disproportion [2]. Our study therefore sought to evaluate the proposal by Fremondiere et al. to use the inletAPD rather than the OC as the best inlet anteroposterior diameter [2]. In our series, the mean difference between OC and inletAPD was not significant; however, in comparison with the OCP, the IPP matches the bone circumference, and instantly defines the inletAPD. This avoids tricky identification of the lumbosacral transitional vertebra when defining the posterior anchor point of the OC in the OCP. A unique feature of our study is the manual contouring of inletCIRC, facilitated by the use of MPR, rather than an estimation of its circumference calculated on the basis of two diameters [17,18].

The mid-pelvic plane has been considered the most critical obstacle in overcoming breech presentation [2,3,11,17]. In this plane, ISD is typically used as the pertinent mid-pelvis measure. The distance between the pelvic symphysis and the sacro-coccygeal joint is another relevant parameter to determine the mid-pelvis aperture. It is important to emphasize that the interspinous plane is defined by three points, namely the lower posterior edge of the pubis and the two ischial spines. This plane is oblique, and it was obtained in our study by using the multiplanar mode on the workstation. The interspinous plane (MPP) joins the lower sacrum posteriorly at different levels, between the fourth and fifth vertebrae, as described on MRI by Korhonen et al. and on CT by Lenhard et al. and Salk et al. [3,4,6]. In our study, the junction with the sacrum was situated on average at 10 mm above the sacrococcygeal joint. This approach differs from descriptions in the literature which refer to S3 or the sacrococcygeal joint for the measurement of the sagittal mid-pelvis, and which have led to confusion with the pelvic outlet in some descriptions [8,17].

In agreement with other authors, we did not assess the reproducibility of pelvic outlet measurements (SOD and intertuberous diameter) [6]. Intertuberous diameter is not considered a useful selection criterion due to its specific lower perineal location and its inaccurate smooth shape, which exposes to important variations [4,8]. Additionally, SOD is considerably mobile during delivery, which decreases the relevance of this parameter to predict the risk of FPD.

The analysis of CT examinations using MPR offers an interesting perspective on pelvic analysis that is not limited to the inlet and mid-pelvic compartments, but also includes sacrum configuration. In cases of atypical sacrum configuration, the narrowest length of inner pelvis may not be at the IPP or MPP. Indeed, it is known that female pelvis can have different shapes (gynecoid, android, anthropoid, platypelloid), that cannot be modelized by simple lengths and circumferences. This opens the discussion of 3D analysis of the inner bony pelvis [19]. Ami et al. evaluated a computer model to detect FPD with simulation of cephalic passage in the pelvic cavity, using MRI data [20]. This approach suggests that the future of pelvimetry might be a “tailored” simulation of the fetal passage through the birth canal. Thus, we believe that circumferences are a first step to 3D modelling, and more relevant than empirical indexes to enrich those models.

Recent single-center studies have found excellent intra- and inter-observer agreements for OC, MTD, and ISD measurements (ICC: 0.812-0.99) on CT or MRI [3,6,8,9] (**Table 6**).

Another study has found excellent reproducibility on CT and SRI for OC (ICC: 0.841-0.996) but moderate to excellent for ISD (ICC: 0.441-0.996) [12]. Reproducibility of newly-designed parameters in our single-center study is excellent (ICC: 0.847-0.980) and similar to those in other studies (ICC: 0.710-0.96) for midAPD and (ICC: 0.852-0.997) inletDTM [3,6,12]. In the sole multi-institutional study published to date, Lockhart et al. found large variations between different readers on all measures except for OC (ICC: 0.64-0.78) (**Table 6**), even though training was provided [21].

Statistical analyses have shown that some of the pelvic parameters we initially identified were redundant, and that only six parameters out of twelve were necessary to assess the size of the pelvis. As we aimed to analyze a set of new pelvimetric parameters, we preferred inletMTD, inletAPD, inletCIRC, midAPD and midCIRC to MTD, OC, IPP index or OCP index, SOD and MPP index, respectively in case of proven redundancy. Moreover, for groups [inletCIRC; IPP index; OCP index] and [midCIRC; MPP index], it was more relevant in our opinion, to select circumferences rather than indexes, first because they were independent measurements (not combined), and second potentially clinically meaningful, in case they could be compared with fetal circumferences. Indeed, in a recent study, De Vries et al. suggested a strong association between neonatal head circumference and caesarean section for failure to progress (CS-FTP). The unadjusted risk of CS-FTP increased from 4.1% in the lowest to 14.3% in the highest quartile [22]. So, inletCIRC and/or midCIRC could be directly compared for more accurate determination of fetal-pelvic disproportion.

Based on the six selected uncorrelated parameters, we clustered our population into 3 distinct groups of different pelvic size: narrow, medium, or large pelvis. This clustering seemed relevant, but the relatively low size of our population (including only 7 CS-FTP) did not allow us to assess a correlation with the delivery outcome.

Our study has some limitations. First, because of its monocentric design and the low number of observers, further research should assess the reproducibility of our measuring methodology across multiple institutions. Second, the clustering technique of the population based on global population data made it difficult to rank a given woman prospectively, unless validated on a larger population. Finally, we chose our new parameters based on previous literature and a potential clinical significance, but did not test other potentially relevant parameters (different or additional obliquities), nor did we assess the pelvis in true 3D mode.

In conclusion, our study provides an update on two pelvic planes (IPP and MPP) depicting newly-designed pelvimetric measurements and notably the pelvic circumferences at these two levels. CT-pelvimetry using MPR analysis allows reproducible measurements of distances and circumferences on these two oblique planes. Consequently, we believe that IPP could be used as a replacement of the classical OCP and that the anteroposterior diameter (midAPD) and the circumference of the mid-pelvis (midCIRC) could describe the mid-pelvis in complement of the ISD in further studies.

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Figure Legends

Figure 1: Schematic representation of sagittal view with inlet and mid-plane of the inner pelvis. (A). Inlet pelvic plane (IPP) extends from the upper edge of the symphysis to a level between the sacral promontory and the first sacral piece. Mid-pelvic plane (MPP) starts from the lower edge of the symphysis, passes through the ischial spines (in red) and usually extends to the fifth sacral vertebra. Schematic representations of the IPP (B) and the MPP (C).

Figure 2: Mutiplanar reconstruction images of the inlet level. (A) oblique axial plane, (B) oblique coronal plane in orthogonal plane, (C) sagittal plane. The blue line represents the sagittal plane, the green line represents the oblique coronal plane, and the red line represents oblique axial plane. OC: Obstetric Conjugate; inletMTD: median transverse diameter of inlet pelvis plane; inletAPD: anteroposterior diameter of inlet pelvis plane; inletCIRC: circumference of inlet pelvis plane; H1: distance between the promontory and sacral position of the inletAPD.

Figure 3: Multiplanar reconstruction images of the mid pelvis level. (A) oblique axial plane, (B) oblique coronal plane in orthogonal plane, (C) sagittal plane. The blue line represents the sagittal plane, the green line represents the oblique coronal plane and the red line represents oblique axial plane. ISD: interspinous diameter; midAPD: anteroposterior diameter of mid pelvis plane; midCIRC: circumference of mid pelvis plane; SOD: sagittal outlet diameter; H2: distance between the sacrococcygeal joint and sacral position of the midAPD.

Figure 4: Two examples of sacrum morphology. The variability of the upper sacral anatomy is illustrated by the two examples with a curved sacrum (A) and flat high sacrum (B). In B the smallest anteroposterior diameter of inner bony pelvis does not correspond to the measured diameters. OC: Obstetric Conjugate; inletAPD: anteroposterior diameter of inlet pelvis plane; midAPD: anteroposterior diameter of mid pelvis plane; SOD: sagittal outlet diameter.

Figure 5: Tree diagram of the 12 parameters after hierarchical clustering. This diagram defines 6 groups of correlated variables. The selected parameter in each group is surrounded. MTD: median transverse diameter; inletMTD: median transverse diameter of inlet pelvis plane; OC: Obstetric Conjugate; inletAPD: anteroposterior diameter of inlet pelvis plane; inletCIRC: circumference of inlet pelvis plane; IPP index: index of inlet pelvis plane; OCP index: index of obstetric conjugate plane; SOD: sagittal outlet diameter; midAPD: anteroposterior diameter of mid pelvis plane; midCIRC: circumference of mid pelvis plane; MPP index: index of mid-pelvis plane; ISD: interspinous diameter.

Figure 6: Radar diagram representing the Z-score of the parameters for the 3 clusters. Orange for Cluster 1 (C1); Blue for Cluster 2 (C2); Green for Cluster 3 (C3). This standardized representation of the 6 parameters clearly shows the differences between the 3 clusters.

Table 1: Demographic data of 63 women who underwent CT pelvimetry.

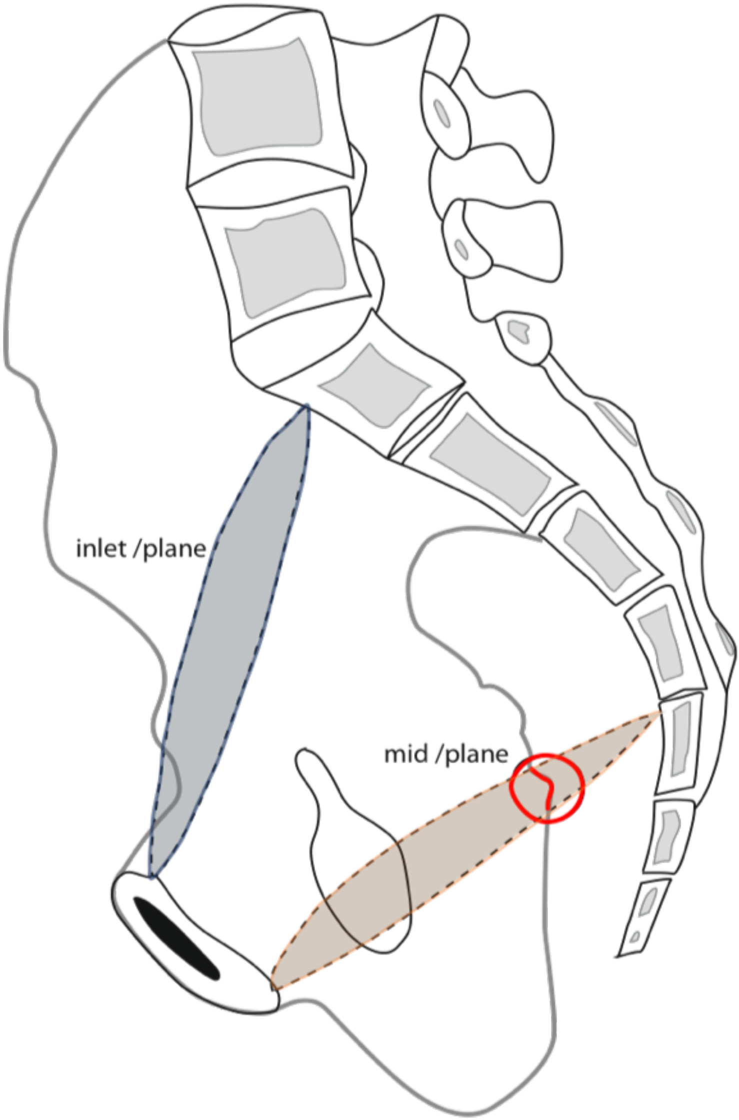
Table 2: CT-pelvimetry acquisition parameters.

Table 3: Definition of classical and new pelvimetry parameters.

Table 4: Pelvimetric data from 63 patients.

Table 5: Description of the three patient groups based on the six uncorrelated parameters, using mean values (cm).

Table 6: Retrospective analysis results compared with results in similar populations in published studies.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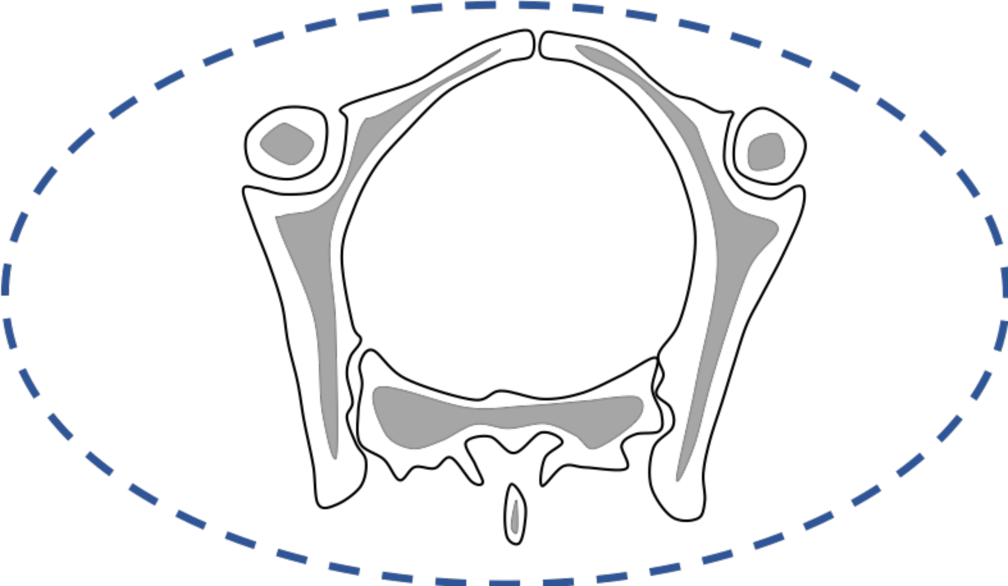

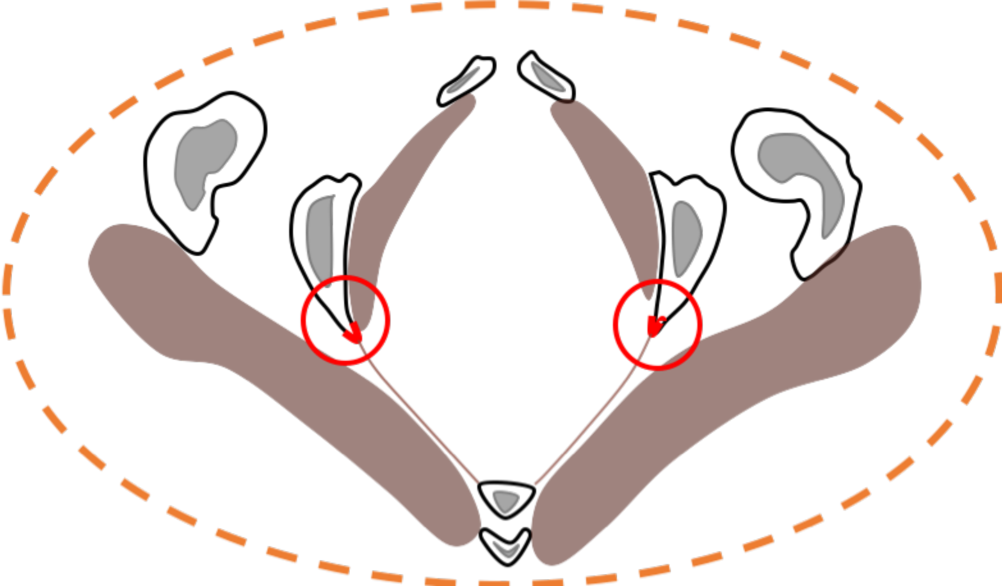

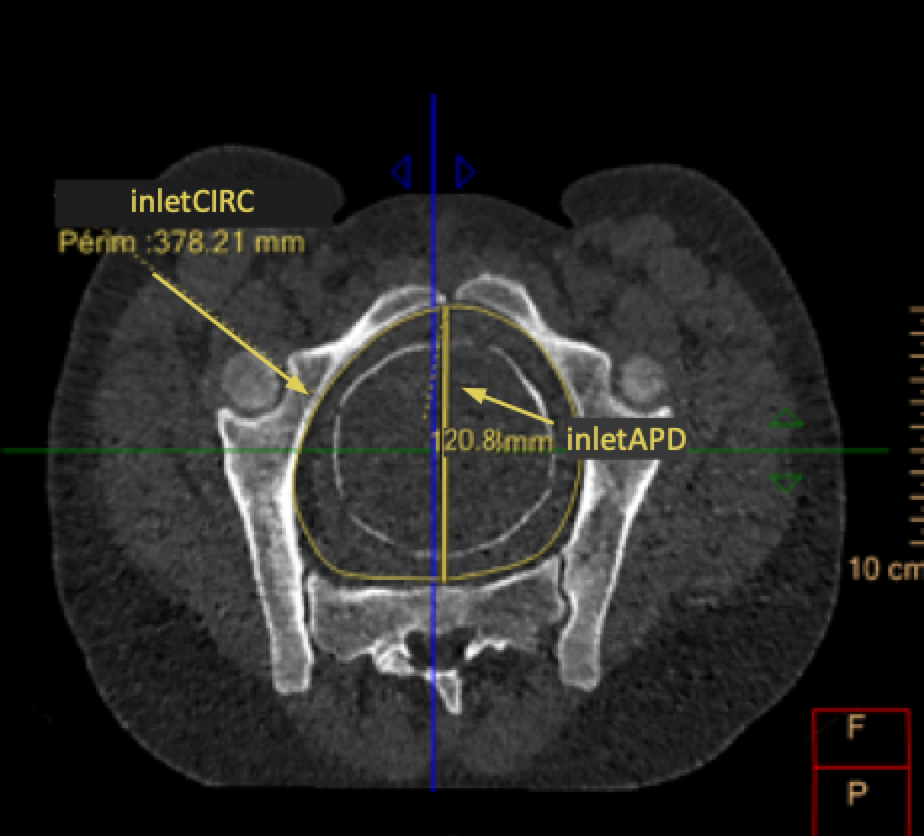
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120.8 mm
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10 cm
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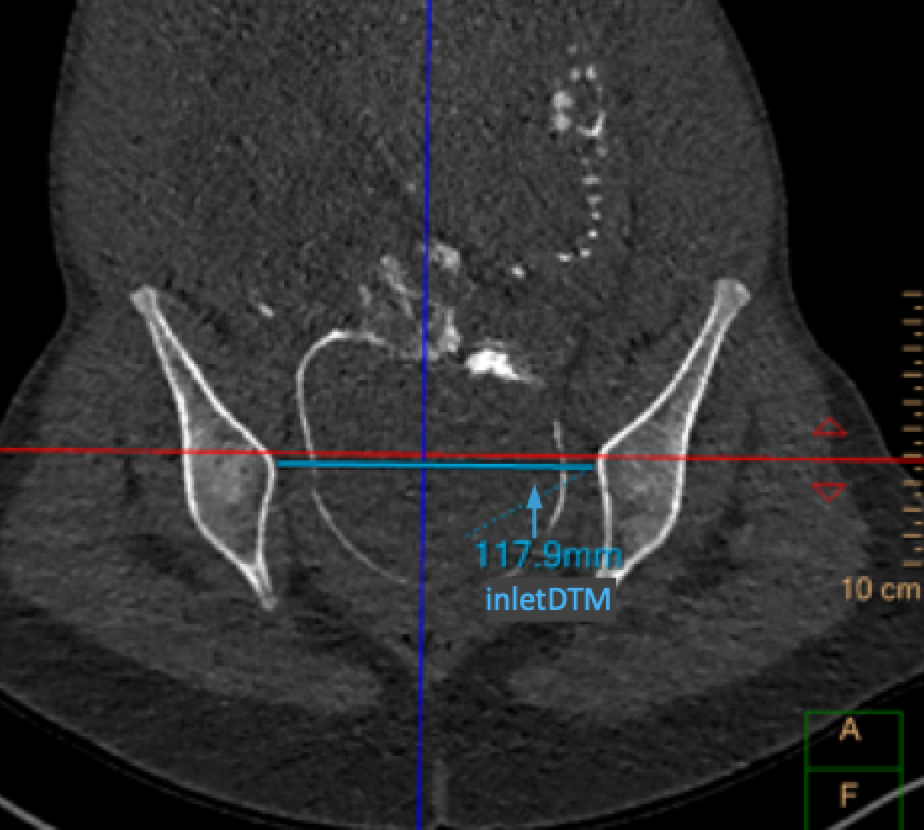
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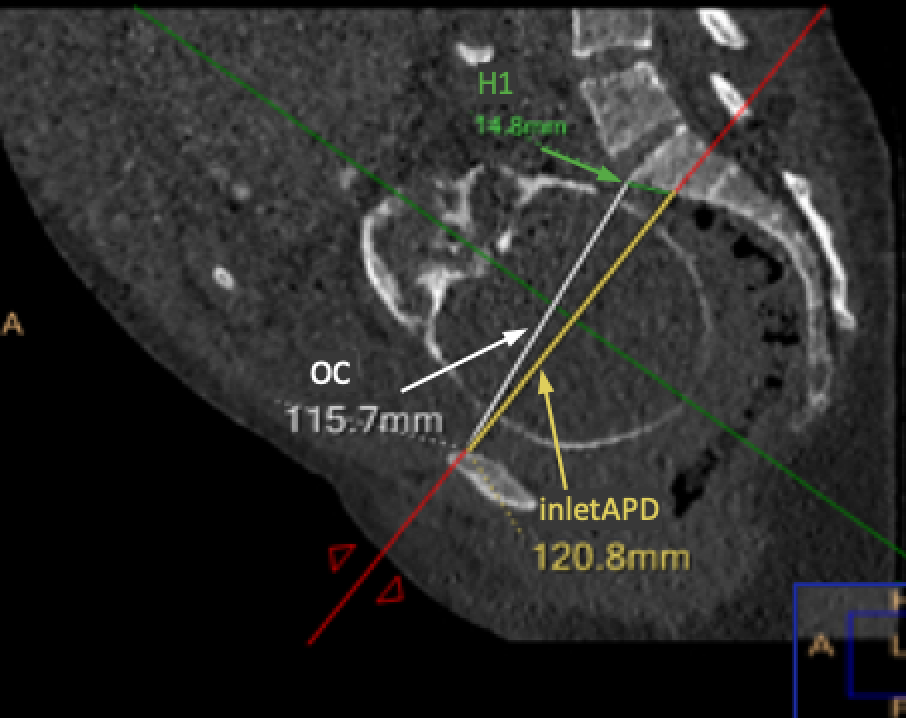

H1
14.8mm
OC
115.7mm
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120.8mm
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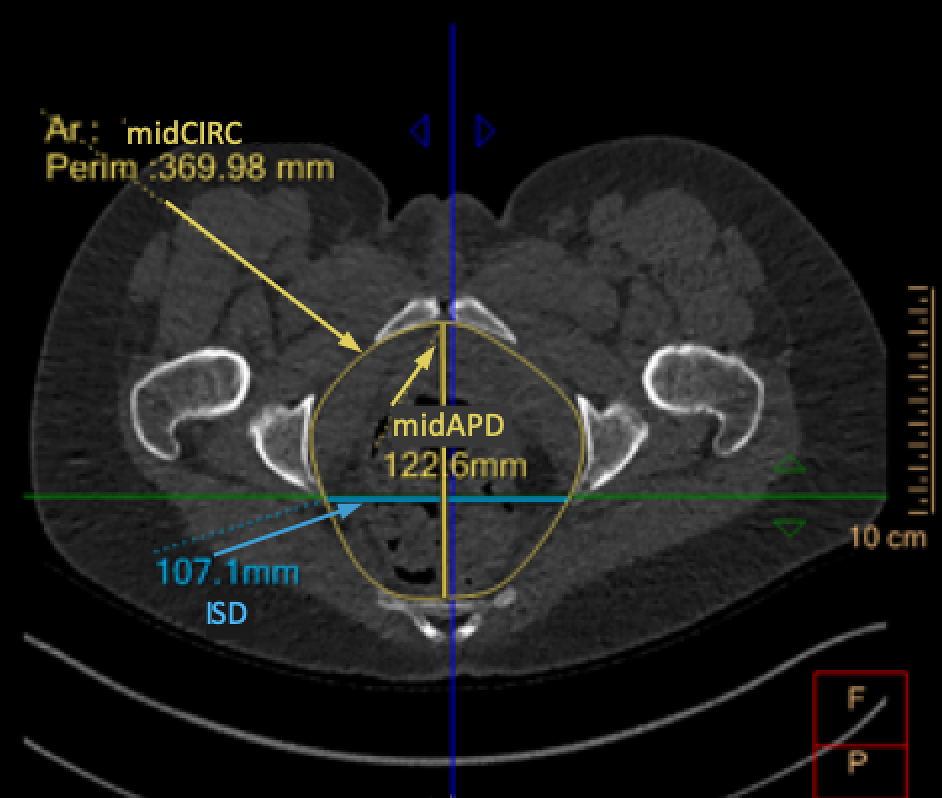
A


Ar.: midCIRC
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ISD
10 cm
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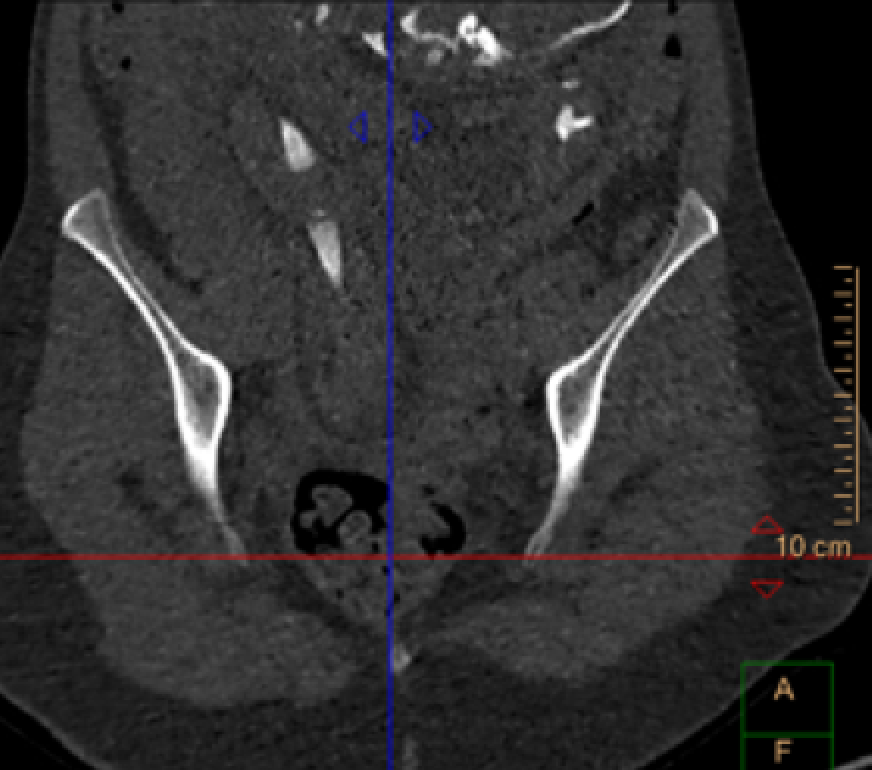
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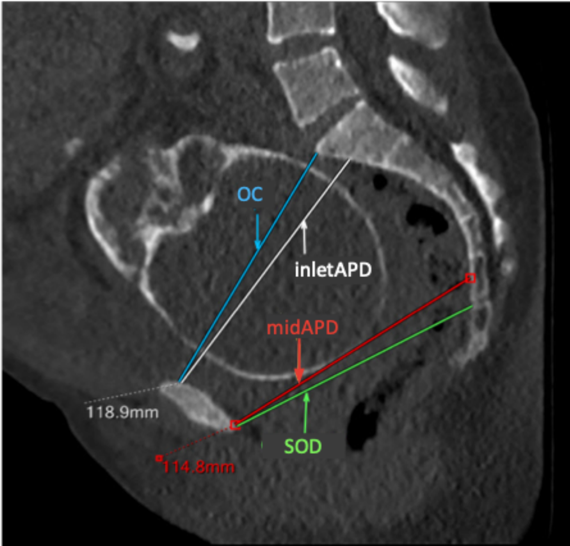
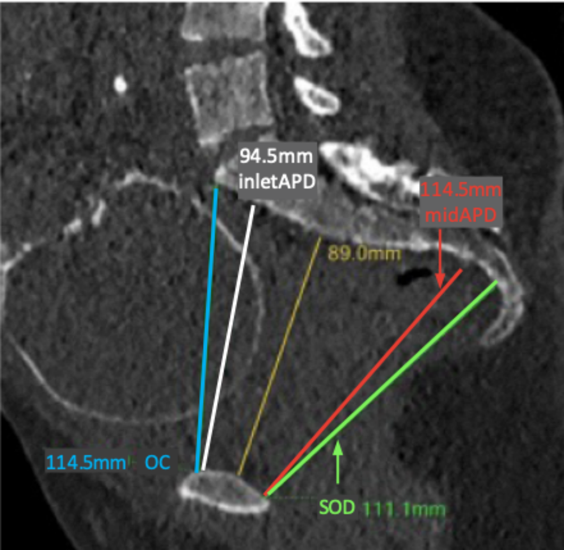
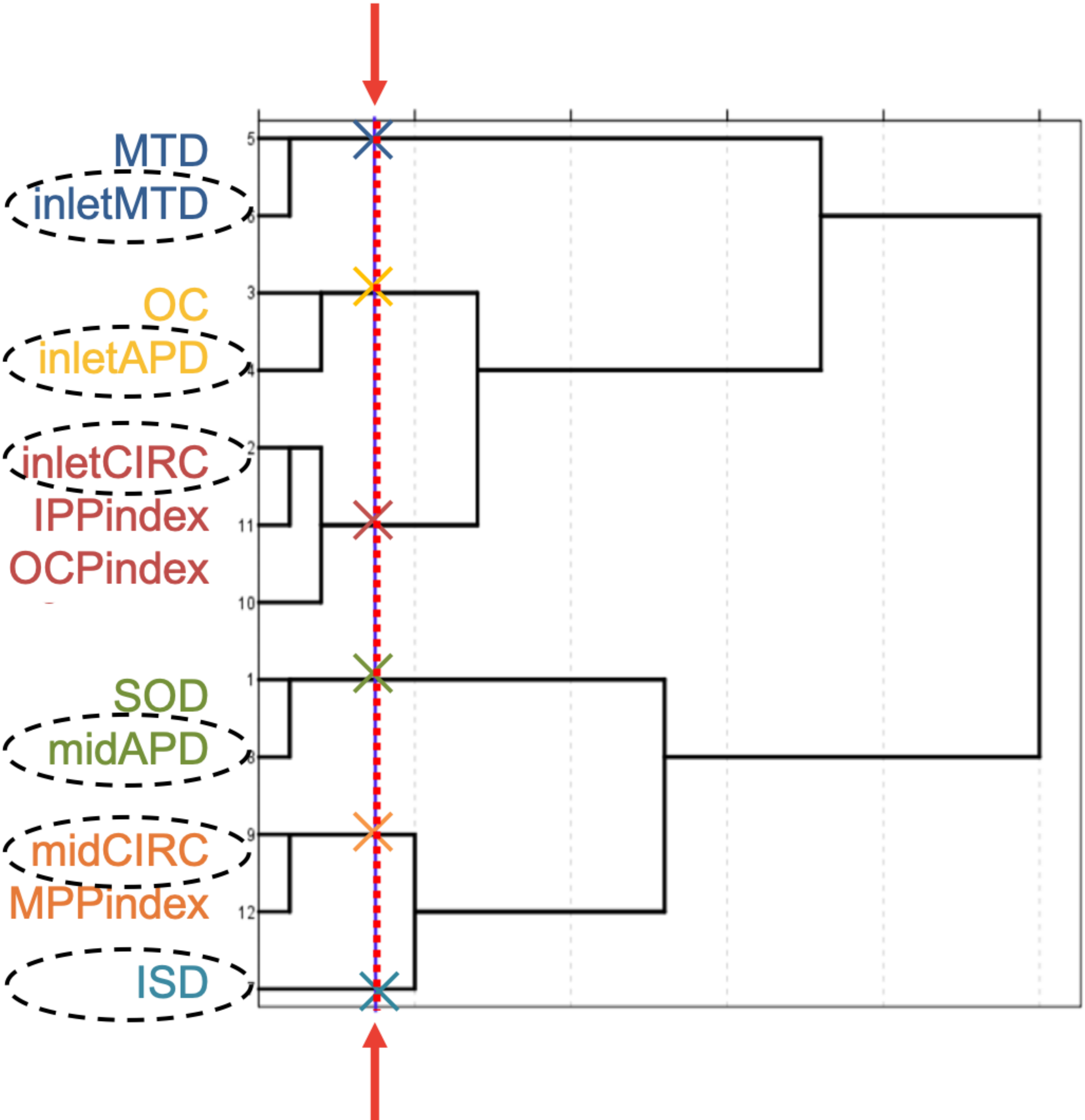
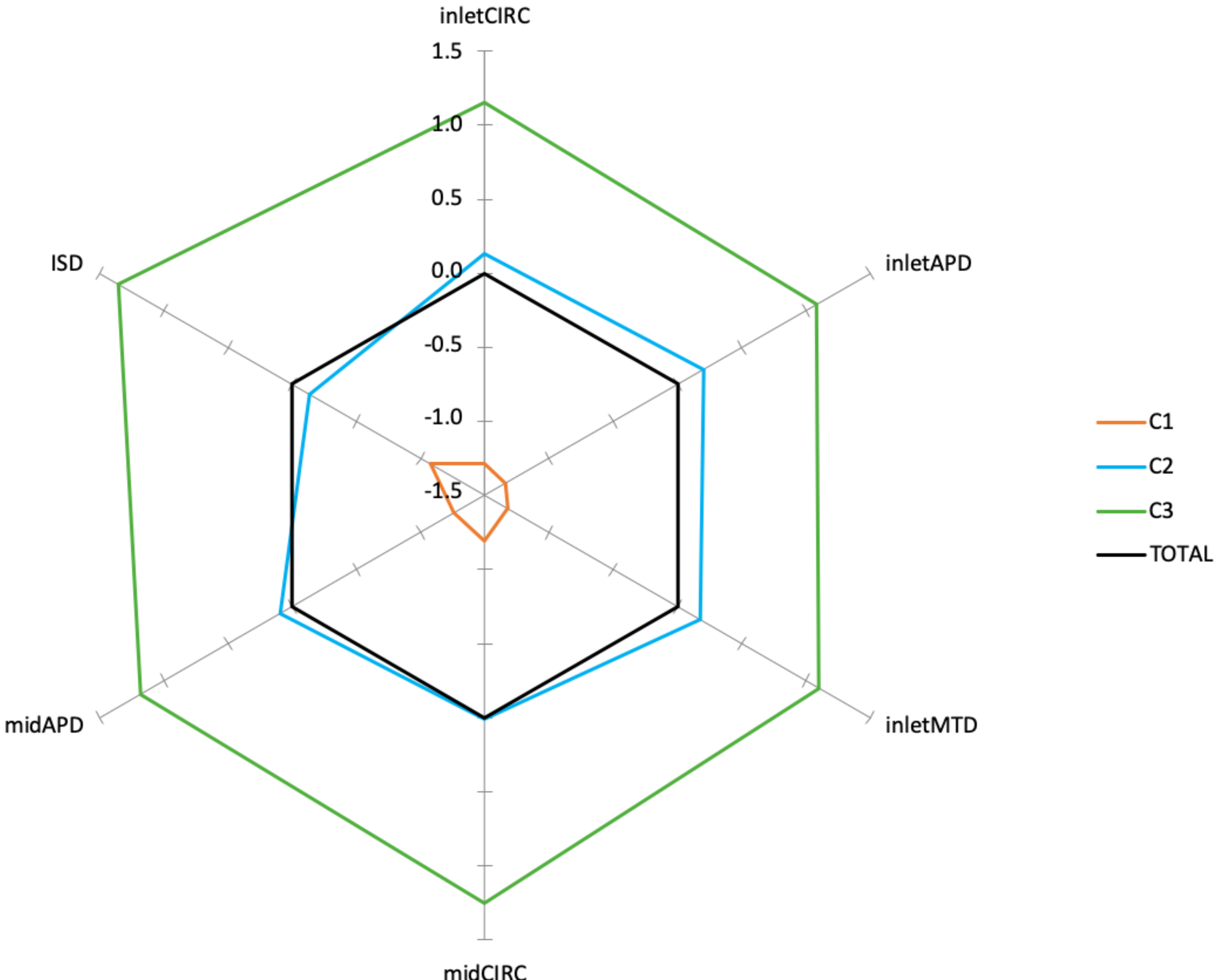
A
F


H2
28.0mm
122.6mm
midAPD
SOD
106.5mm
10 cm
H
A
L
P
F


OC
inletAPD
midAPD
SOD
118.9mm
114.8mm


94.5mm
inletAPD
114.5mm
midAPD
89.0mm
114.5mm OC
SOD 111.1mm


MTD
inletMTD
OC
inletAPD
inletCIRC
IPPindex
OCPindex
SOD
midAPD
midCIRC
MPPindex
ISD
5
6
3
4
2
11
10
1
8
9
12
7



inletCIRC
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
inletAPD
inletMTD
midCIRC
midAPD
ISD
C1
C2
C3
TOTAL

Variables	
Age (years)	33.9 ± 5.2 [19 – 49]
Size (cm)	165 ± 8 [143 – 183]
BMI (kg/m^2)	23.4 ± 4.7 [17.4 - 40.2]
Gestational age at the time of pelvimetry (WG + days)	(36+5) ± (1+4) [(33+4) – (41+2)]
Nulliparity	38/63 (60)
Twin pregnancy	17/63 (27)
Twin pregnancy and nulliparity	12/17 (27)

Quantitative data are expressed as mean ± standard deviation; numbers in brackets are ranges. Qualitative data are expressed as proportions; numbers in parentheses are percentages. N: number of patients; BMI: body mass index; WG: weeks of gestation

Parameters	
Tube voltage (kV)	83.8 ± 7.9 [80 - 100]
Tube current (mAs)	31.6 ± 3.7 [30 - 40]
DLP (mGy.cm)	22.5 ±10.2 [14 - 55]
CTDI vol (mGy)	1.2 ± 0.3 [0.8 - 1.8]
Exploration length (cm)	25.5 ± 3.0 [18.4 - 30.3]

Data are expressed as mean ± standard deviation; numbers in brackets are ranges; DLP: Dose length product; CTDI: Computed tomography dose index

Pelvimetry parameters	Denomination	Definition
Classical parameters	Obstetric conjugate (OC)	Between the promontory and the shortest posterior upper **posterior** margin of the pubis
	Transverse median diameter (MTD)	The transverse diameter obtained from a perpendicular plane to the middle of the OC, on the 3D oblique coronal view between the inner border of iliac bone
	Interspinous diameter (ISD)	The interspinous distance was measured as the shortest distance between both ischial spines in the transverse plane
New parameters	Anteroposterior diameter of the inlet pelvis (inletAPD)	From a plane below the OC plane, with inner pelvis is all surrounded by bone, the anteroposterior diameter of the inlet is measured between the upper posterior pubis and the first sacral vertebrae
	Transverse median of the inlet pelvis (inletMTD)	The transverse diameter of the inner pelvis obtained from a perpendicular plane to the middle of the inletAPD, on the 3D oblique coronal view between the inner border of iliac bone
	Circumference of the inlet pelvis (inletCIRC)	In the inlet plane. Circumference obtained by contouring the inner border of the inlet pelvis
	Anteroposterior diameter of the mid-pelvis (midAPD)	Between the lower border of the pubis to the middle of ISD (from a 3D sagittal view) and joined the sacral vertebra at the 4th or 5th sacral vertebrae
	Circumference of the mid-pelvis (midCIRC)	In the interspinous plane. Circumference obtained by contouring the inner border of the mid-pelvis
Other reference parameter	Sagittal outlet diameter (SOD)	The sagittal outlet as the distance between the inferior inner of the pubis to the sacrococcygeal junction

Parameters	**Mean ± SD** (cm)	**Range** (cm)	**Intra-observer reproducibility**	**Inter-observer reproducibility**
inletCIRC	40.52 ± 2.55	33.24 - 47.22	0.847	0.957
OC	12.46±1.07	9.54 - 14.37	0.967	0.975
inletAPD	12.51±1.09	9.42 - 14.60	0.980	0.968
MTD	12.58±0.92	10.44 - 14.85	0.957	0.932
inletMTD	12.84±0.95	10.52 - 15.37	0.934	0.957
ISD	10.57±0.83	8.81 - 12.42	0.975	0.924
midAPD	12.09±0.91	10.26 - 14.37	0.933	0.953
midCIRC	35.56±2.10	31.03 - 39.75	0.857	0.923
SOD	11.66±0.94	9.53 - 13.74	-	-
Magnin index	25.05±1.65	20.16 - 28.39	-	-
IPP index	25.36±1.68	20.30 - 29.53	-	-
MPP index	22.66±1.43	19.30 - 25.66	-	-

SD: standard deviation; inletCIRC: circumference of inlet pelvis plane; OC: obstetric conjugate; inletAPD: anteroposterior diameter of inlet pelvis plane; MTD: median transverse diameter; inletMTD: median transverse diameter of inlet pelvis plane; ISD: interspinous diameter; midAPD: anteroposterior diameter of mid pelvis plane; midCIRC: circumference of mid pelvis plane; SOD: sagittal outlet diameter; IPPindex: index of inlet pelvis plane; MPPindex: index of mid-pelvis plane.

Cluster	**N**	**inletCIRC (*mean*)**	**inletAPD (*mean*)**	**inletMTD(*mean*)**	**midCIRC (*mean*)**	**midAPD (*mean*)**	**ISD (*mean*)**
1	18	37.7	11.5	11.9	33.1	11.2	10.0
2	28	40.8	12.7	13.0	35.6	12.2	10.5
3	17	43.0	13.3	13.6	38.1	13.0	11.3
Total	**63**	**40.5**	**12.5**	**12.8**	**35.6**	**12.1**	**10.6**

Cluster 1: narrow pelvis; Cluster 2: medium pelvis; Cluster 3: large pelvis; N: Number of patients

	Lenhard et al. [2]	Korhonen et al. [5]		Hoffman et al. [7]		Keller et al. [8]		Lockhart et al. [21]	Aubry et al. [11]				Present study	
Imaging modality	CT	MRI		MRI		MRI		MRI	SRI		CT		CT	
Methodology	Single-center	Single-center		Single-center		Single-center		Multi-center	Single-center				Single-center	
Reproducibility	Inter	Intra	Inter (3 readers)	Intra	Inter (2 readers)	Intra	Inter (5 readers)	Inter center	Intra	Inter (3 readers)	Intra	Inter (3 readers)	Intra	Inter (2 readers)
OC	0.96	0.981	0.950-0.956	0.96	0.97	0.96	0.94	0.93	0.966	0.898	0.996	0.841	0.967	0.975
inletAPD	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	0.980	0.968
MTD	0.99	0.959	0.925-0.953	N.A.	N.A.	0.97	0.95	0.64	N.A.	N.A.	N.A.	N.A.	0.957	0.932
inletMTD	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	0.977	0.967	0.997	0.852	0.934	0.957
ISD	0.91	0.957	0.812-0.873	0.91	0.91	0.94	0.92	0.75	0.533	0.441	0.996	0.739	0.975	0.924
midAPD	0.96	0.956	0.710-0.797	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	0.933	0.953
SOD	0.96	N.A.	N.A.	0.79	0.92	0.83	0.66	0.78	0.809	0.580	0.994	0.512	N.A.	N.A.
ITD	0.91	N.A.	N.A.	0.73	0.74	0.83	0.64	0.73	0.740	0.517	0.984	0.530	N.A.	N.A.
inletCIRC	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	0.847	0.957
midCIRC	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	0.857	0.923

CT: computed tomography; MRI: magnetic resonance imaging; SRI: stereoradiographic imaging; OC: obstetric conjugate; inletAPD: anteroposterior diameter of inlet pelvis plane; MTD: median transverse diameter; inletMTD: median transverse diameter of inlet pelvis plane; ISD: interspinous diameter; midAPD: anteroposterior diameter of mid pelvis plane; SOD: sagittal outlet diameter; ITD: intertuberous diameter; inletCIRC: circumference of inlet pelvis plane; midCIRC: circumference of mid pelvis plane; N.A.: Not analyzed