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Comparison between birth canal size and external pelvimetry: implications for clinical practice

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ABSTRACT

INTRODUCTION: Investigating the correlations between the external pelvimetry variables and the birth canal has important implications for clinical practice as well as for the prediction of dystocia. This study aimed to analyze the correlations between several variables of the external and internal pelvimetry.

METHODS : In this single-centered retrospective study, 142 women with a computed tomography pelvimetry were recruited. Four variables of the birth canal (obstetric conjugate, transverse diameters of inlet, midplane and outlet) and five variables of the false pelvis (intertrochanteric, inter antero-superior iliac spines, external conjugate, transverse diagonal, prepubic) were considered in simple and multiple regression models, after adjustment with BMI.

RESULTS : As expected, the external conjugate moderately correlates with obstetric conjugate ($B = 0,65$; $p=0.01$) and weakly correlates with transverse outlet ($B=0,21$; $p=0.03$). In simple model, transverse diagonal weakly correlates with transverse inlet ($B=0,29$; $p=0.01$). In multiple models, intertrochanteric correlates with transverse inlet ($B=0,36$; $p=0.01$), midplane ($B=0,31$; $p=0.01$) and outlet ($B=0,37$; $p=0.01$) while transverse diagonal weakly correlates with transverse inlet ($B=0,27$; $p=0.01$). Prepubic is not a predictor of birth canal dimensions in simple or multiple models.

CONCLUSION: Our study confirm that external conjugate is a predictor of obstetric conjugate. The correlation between transverse diagonal and transverse inlet explains that transverse diagonal helps predict cephalopelvic disproportion, while intertrochanteric could be used as a proxy of the transverse diameters. Our data further confirm that birth canal size cannot be inferred from the prepubic diameter.

Keywords: Pelvis, Cephalopelvic disproportion, Birth canal, Labor.

INTRODUCTION

Obstetrical mechanism and difficulties during childbirth largely results from the pelvic anatomy and the interaction between birth canal and the presenting part of the fetus. The fetal-pelvic interaction derives from complex evolutionary processes and results to a unique fetal-pelvic tight fit (Frémondrière et al., 2022). Accordingly, childbirth is remarkably difficult compared with other primates (Rosenberg and Trevathan, 2002), and obstructed labor is thought to be responsible for 2,8 % of all maternal deaths worldwide (Say et al., 2014) as well as obstetric fistula formation.

The management of dystocia is based on the recognition of its different etiological factors. Dystocia can result from a mismatch between the size of the fetal head and the maternal pelvis (i.e. cephalo-pelvic disproportion), malposition of the fetal head or ineffective uterine propulsive forces. These are summarized as the three “Ps” of labor (Maharaj, 2010): the Passageway represents the maternal pelvic anatomy, the Passenger corresponds to the fetal anatomy, and Powers are defined by the primary and secondary forces of labor. Among these three “Ps”, effective uterine forces are identifiable with a tocograph and ultrasound can determine fetal head size, station, or position (Ghi et al., 2018). However, the pelvic dimensions are rarely available except in the few cases where an MRI or CT scan has been performed (Jaufuraully et al., 2022).

The cephalo-pelvic disproportion is an important issue in developing regions (Say et al., 2014). The prolonged labor resulting from a cephalo-pelvic disproportion could be a cause of uterine rupture, haemorrhage, maternal sepsis, neonatal asphyxia and septicaemia (Say et al., 2014; Liselele et al., 2000). To prevent the prolonged labor, some authors reported that the transverse diagonal, an external pelvimetry measurement, could increase the sensitivity in predicting dystocia, in addition to the maternal height (Liselele et al., 2000). In this context,

the identification of correlations between external and internal pelvic dimensions could represent an important contribution to the prediction of dystocia.

The diagonal transverse is the distance between the two depressions on the skin over the sacrum. It is a proxy of the sacral breadth and the transverse diameter of the inlet, and belongs to the “Mickaelis’ quadrilateral” first described by Mickaelis and Litzmann (1865). During the same period, Cazeaux (1856), described the external conjugate (measured with a calliper such as a pelvimeter, Figure 1), as a proxy of the obstetric conjugate. The inter antero-superior iliac spines and intertrochanteric would be proxies of the transverse diameter of the inlet (Cazeaux, 1856). Trillat and Notter (1948) described the most recent external pelvimetric measurement (the prepubic diameter of Trillat). It corresponds to the distance between the inguinal folds, above the supra-pubic line, and is supposed to be a proxy of the transverse diameter of the inlet.

Exactly how these external pelvimetry diameters are sufficiently reliable to assess bony birth canal dimensions remains a key question. Modern imaging techniques offer the possibility to assess whether external and internal pelvimetry are really correlated. In this study, two thresholds of the computed tomography segmentation are used to model both the soft tissue and skin surface, but also the bone birth canal. The aim of this work is to find out if external pelvimetries are reliable predictors of internal pelvimetries

MATERIALS AND METHODS

A total of one hundred and forty-one women at Lapeyronie Hospital (Montpellier, France) recruited from January 01, 2015 to October 01, 2016 were included in this single-centered study. Inclusion criteria was singleton birth at term with a computed tomography pelvimetry prior to labor. Body Mass Index (BMI) and birth order were collected from the medical records. Computed tomography pelvimetry was performed with a scanner located in the

Medical Imaging Department of the hospital with low-level irradiation in the range of 15–35 mGy/cm. The intersection gap was 0.6–1.0 mm. The study protocol was approved by our institutional review board. As a strict retrospective study, consent to participate in an anonymous retrospective study was not required.

Pelvises were reconstructed and measured using Amira 5.0.0 software (FEI Visualization Sciences Group/Zuse Institute Berlin). Two thresholds of segmentation were used to reconstruct the pelvis (threshold of between 210 and 250 Hounsfield units) and the skin (-610 and -660 Hounsfield units). Figure 2 shows the procedure followed to obtain the external and internal pelvimetry data.

Figure 3 shows the internal and external pelvimetry variables. The four variables of the birth canal (i.e. internal pelvimetry) were the antero-posterior inlet (obstetric conjugate or APi), transverse inlet (TRi), transverse midplane (interspinous or TRm) and transverse outlet (TRo). The external pelvimetry variables were the intertrochanteric, the inter antero-superior iliac spines (interASIS), the external conjugate, the transverse diagonal and the prepubic. Measurements were performed with manual placement of callipers following the variable definition (Figure 3). The same operator (ES) measured all the external and internal pelvic variables.

Correlation analyses were performed with SPSS Statistics 17.0. A correlation was significant with a p -value <0.05 . The correlations were weak, moderate or strongly positive for a B value (coefficient of correlation) between 0-0.2, 0.2-0.5 and 0.5-0.8 respectively (Zhou et al., 2003). For statistics, we used the following method: (1) A simple correlation analysis using the Pearson correlation coefficient permitted investigation of the association between birth canal and external pelvimetry variables. (2) Potential confounding effect of birth order and BMI in the association of birth canal and external pelvimetry variables were tested by ANOVA. (3)

Multiple regression models were used to find associations between birth canal and external pelvimetry variables. (4) Mediation of these associations was investigated following this process: first, we added one by one the external pelvimetry variables in the models, and then we included all the five external pelvic dimensions. All models were adjusted where relevant for BMI and birth order.

RESULTS

Table 1 shows the descriptive results of our sample. Among these diameters, TRm exhibits the lower range of variation (SD=7,9 mm) while interASIS has the higher range of variation (SD=16,8 mm). External conjugate and prepubic exhibit an important variation, ranged between 166,7mm-256,6mm and 100,4mm-171,6mm respectively.

Table 2 reports correlation coefficients across external and internal pelvimetry variables. Among the variables of the birth canal, TRi significantly correlates with TRm (B=0.565) and TRo (B=0.468). Among external pelvimetry variables, intertrochanteric significantly correlates with all birth canal variables (B=0.225-0.672) as well as external conjugate (B=0.187-0.655). InterASIS correlates with all birth canal variables (B=0.327-0.461) except for TRm and TRo. Transverse diagonal correlates with intertrochanteric and all birth canal variables except APi (B=0.285-0.343). Prepubic is not correlated with birth canal variables, but correlates with interASIS (B=0.192).

There were significant associations revealed by ANOVA regarding BMI but not birth order with transverse diagonal. Women with moderate obesity ($30 < \text{BMI} < 35$) had a transverse diagonal 1.7 cm higher than women with severe obesity ($35 < \text{BMI} < 40$) (95% CI 0.16–34.91). Thus, in the next part of the statistical analysis, we considered BMI in the multiple regression models.

Table 3 provides multiple regression models for the prediction of birth canal variables with external pelvimetry variables. When adjusted for BMI, external conjugate was associated with APi ($B=0.45$, $p=0.01$). This association remained when all external pelvimetry variables were added to the model ($B=0.44$ $p=0.01$). In simple model, external conjugate is weakly associated with TRo ($B=0.15$, $p=0.03$). Transverse diagonal appears to predict TRi ($B=0.27$, $p=0.01$) in simple model. InterASIS was associated to TRi($B=0.22$, $p=0.01$) and APi ($B=0.19$, $p=0.01$) in simple models, while this variable is a predictor of TRm in the multiple model ($B=-0.15$, $p=0.01$). Intertrochanteric was associated with all the transverse diameters of the birth canal : TRi($B=0.36$, $p=0.01$), TRm($B=0.31$, $p=0.01$) and TRo ($B=0.37$, $p=0.01$) in simple and multiple models. Prepubic was not correlated with any variable of the birth canal in simple or multiple models.

DISCUSSION

Association between external and internal pelvimetry variables

In this study, External conjugate correlates with APi. These two variables have the highest coefficient of correlation in this sample. This is in accordance with the initial description of Cazeaux (1856). This author suggested that APi can easily be determined by the following formula: $APi = \text{external conjugate} - 8 \text{ cm}$. Intertrochanteric is highly correlated with TRo. This is in good agreement with previous anthropological studies, where an important covariation between bitrochanteric and Tri, TRm and TRo has been described (Ruff, 1995). Transverse diagonal shows a moderate but significant correlation with TRo. This correlation may explain why transverse diagonal measurement is able to predict one out of two cases of cephalopelvic disproportion in nulliparous women (Liselele et al., 2000). However, this analysis does not show any significant correlation between prepubic and internal pelvimetry variables. This is in contradiction with the study of Kakoma et al., (2000) where prepubic is a significant

predictor of caesarean section. In this study, four women had a prepubic of less than 11 cm and none have had a vaginal delivery, whereas 148 women had a prepubic of at least 11 cm and only 28 (19%) have had a caesarean section (Kakoma et al., 2000). Since prepubic is not correlated with internal pelvimetry variables (i.e. the “size”), it could be associated instead with morphological features of the inlet (i.e. the “shape”), which may also be a risk factor for dystocia (Fischer and Mitteroecker, 2015: but see Starrach et al., 2023).

Postural adjustment for a narrowed pelvis

Studies have shown that certain birthing positions can change the dimensions of the bony birth canal (Michel et al., 2002; Rietter et al., 2014). It would therefore be possible to compensate for the reduction of some diameters of a narrowed pelvis by encouraging the women to assume different birthing positions. Squatting position is supposed to increase TRm and TRo (Michel et al., 2002) as well as the antero-posterior mid pelvic and anteroposterior outlet (Rietter et al., 2014). However, assuming a supine position would increase the APi (Michel et al., 2002; Rietter et al., 2014). Michel et al., (2002) found that APi is significantly larger the supine position than in the upright squatting position, but the difference is only 2 ± 4 mm. These studies show that changes in a woman’s position led to changes in pelvic diameters (Michel et al., 2002; Rietter et al., 2014). However, these changes in pelvic diameters are moderate (Rietter et al., 2014), suggesting that the change in birthing position may facilitate delivery, but cannot compensate for major pelvic contraction.

Limitations and perspectives

We are aware that our research may have some limitations. In practice, external pelvimetry variables are measured with anthropometric instruments (such as a pelvimeter, or a tape measure). In our study, measurements are performed by choosing the placement of landmark points along the surface of the pelvis. These two methods of measurement are not similar.

185 However, external pelvimetry variables have an unvarying definition, based on anatomical
186 markers (i.e. landmarks). In our opinion, a very close covariation exists between virtual
187 measurements (our study) and measurements with anthropometric tools (in clinical practice).

188 Some studies investigated the variation of the external pelvimetry variables in relation to the
189 postural change (Siccardi et al., 2019). However, it is unclear whether this variation is similar
190 to the variation of internal pelvimetry variables. Further studies should investigate if the
191 changes in external and internal pelvimetry variables are correlated when the change in
192 birthing position is controlled.

193 **CONCLUSION**

194 The aim of this study is to identify accurate predictor of birth canal variables with external
195 pelvimetry variables. Among these external variables, prepubic is not a predictor of any birth
196 canal variables. Intertrochanteric is a good predictor of transverse diameters of the birth canal
197 while transverse diagonal only predicts the TRi. External conjugate is a predictor of APi.
198 These correlations may have important clinical implications for enhancing the prediction of
199 bony dystocia.

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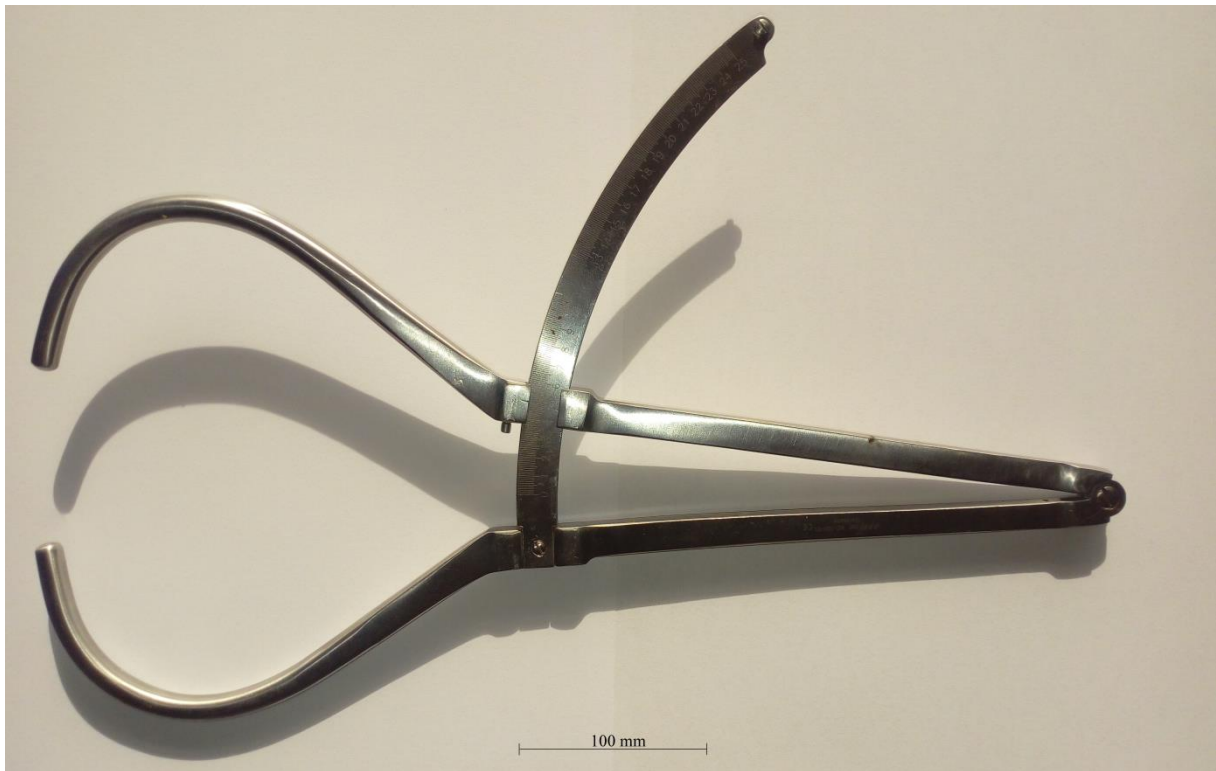
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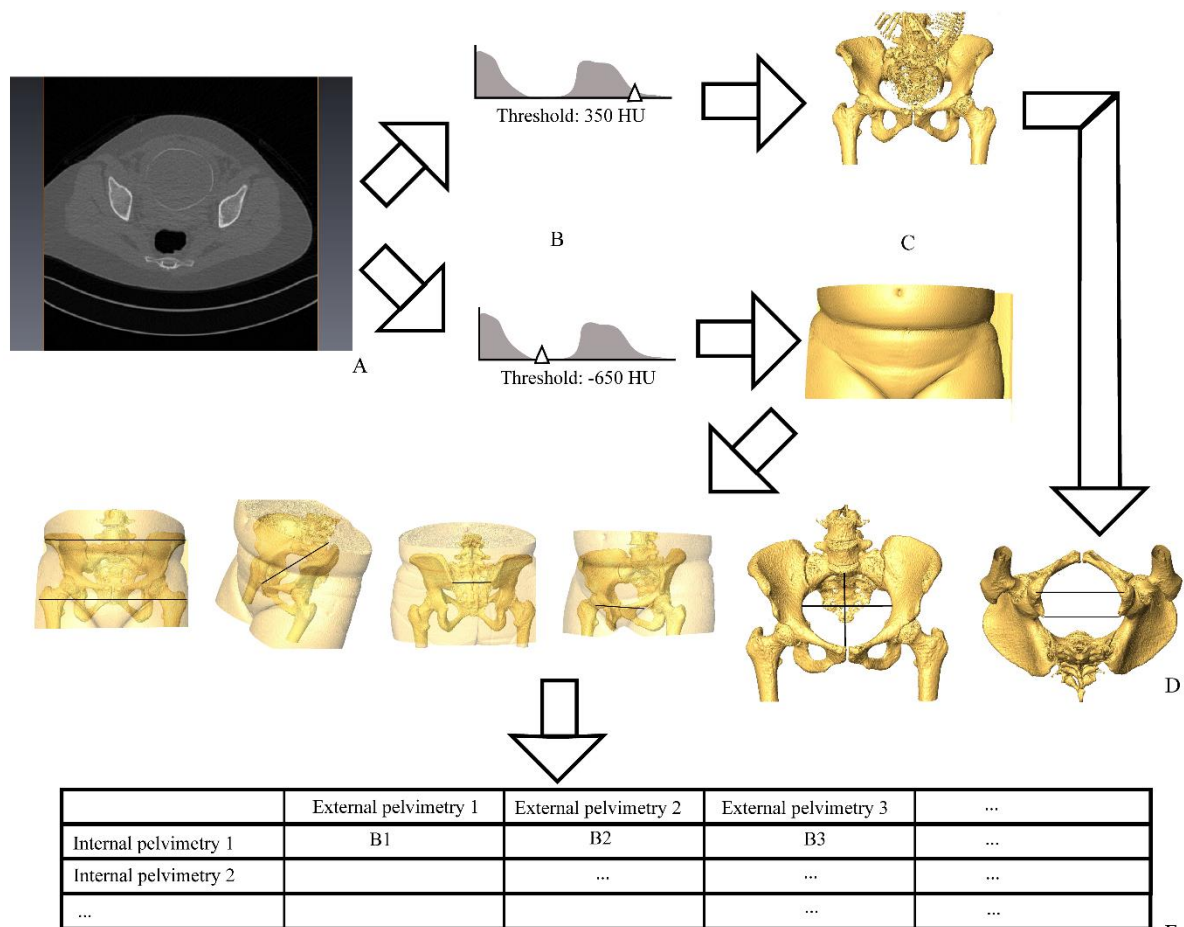
249 **FIGURE 1.** Photograph of a calliper that can be used as a Pelvimeter



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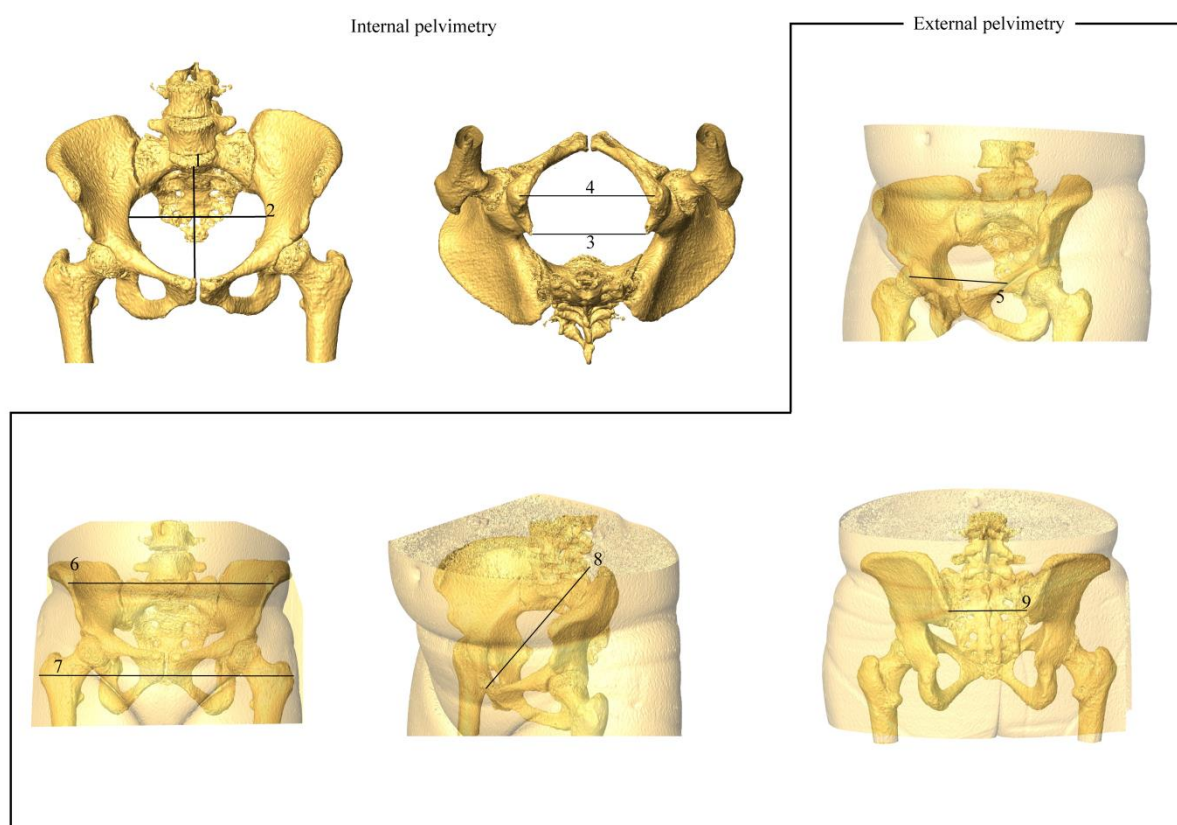
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FIGURE 2. Workflow for modelling the soft tissues and the bony birth canal.



A DICOM images were collected and processed in Amira 5.0.0 software. B two thresholds were used to model both skin surface (-650 Hounsfield units) and the bony birth canal (350 Hounsfield units). C Automatic segmentation process produced the body surface and the surface of the bony birth canal. D Nine measurements were taken by positioning the callipers. E Crude associations and correlations between internal and external pelvimetries are investigated with ANOVA.

260 **FIGURE 3.** Internal and external pelvimetry variables



261

262 1 *antero-posterior inlet* (obstetric conjugate): between the promontory and the pubic

263 symphysis, 2 *transverse inlet*: between the most lateral points of the arcuate lines, 3

264 *transverse midplane* (interspinous): between the right and left sciatic spines, 4 *transverse*

265 *outlet*: between the right and left ischiatic tuberosities 5 *prepubic*: between the right and left

266 inguinal folds, 6 *inter antero superior iliac spines*: between the right and the left antero-

267 superior iliac spines, 7 *bi-trochanteric*: between the most lateral points of the femoral heads, 8

268 *external conjugate* : between the pubic symphysis and the most posterior point of the spinous

269 process of the first sacral vertebra, 9 *transverse diagonal*: between the right and the left

270 postero-superior iliac spines.

271

272 **TABLE 1 Description of the pelvimetric variables.**

DIAMETER (MM)	MEAN (SD)	MINIMUM- MAXIMUM
APi	124,2 (9,3)	97,2-156,5
TRo	120,5 (9,4)	101,7-139,9
TRi	125,8 (8,6)	108,6-148,2
TRm	108,5 (7,9)	94,8-128,3
Intertrochanteric	258,7 (14,8)	213,4-290,1
InterASIS	221,1 (16,8)	184,8-261,0
External conjugate	207,5 (14,5)	166,7-256,6
Transverse diagonal	92,5 (10,2)	73,0-128,0
Prepubic	118,1 (12,1)	100,4-171,6

273 MM: millimetre; SD: Standard Deviation; TR: Transverse; AP: Antero-posterior; ASIS: Antero
274 superior iliac spines

275

276

277 **TABLE 2. Crude correlations among internal and external pelvimetry.**

	T R I	95 % CI	T R M	95% CI	T R O		INTERT ROCHA NTERIC	95% CI	IN T E R A S I S	95% CI	EXT ERN AL CON JUG ATE	95% CI	TRA NSV ERS E DIA GON AL	95% CI	P R E- P U BI C	95% CI
AP ^{inlet}	0,124	[-0,48;0,315]	-0,015	[-0,235;0,198]	0,111	[-0,062;0,284]	0,225**	[0,037;0,246]	0,327**	[0,92;0,270]	0,655**	[0,357;0,549]	0,106	[-0,061;0,253]	-0,075	[-0,199;0,081]
TR ^{inlet}	1		0,565*	[0,446;0,756]	0,468*	[0,288;0,564]	0,672**	[0,317;0,463]	0,461**	[0,160;0,313]	0,408**	[0,147;0,349]	0,289**	[0,107;0,389]	0,160	[-0,011;0,243]
TR ^{mid plane}			1		0,783*	[0,574;0,763]	0,584**	[0,234;0,388]	0,061	[-0,054;0,110]	0,187*	[0,001;0,202]	0,336**	[0,132;0,401]	-0,042	[-0,150;0,095]
TR ^{outlet}					1		0,542**	[0,252;0,436]	0,018	[-0,086;0,106]	0,209*	[0,017;0,250]	0,343**	[0,158;0,450]	-0,111	[-0,220;0,052]
Intert rocha nteric							1		0,369**	[0,186;0,463]	0,435**	[0,286;0,636]	0,285**	[0,169;0,641]	0,014	[-0,203;0,238]
Inter ASIS									1		0,446**	[0,337;0,725]	0,065	[-0,175;0,390]	0,192*	[0,025;0,511]
Exter nal conju gate											1		0,061	[-0,192;0,379]	0,035	[-0,196;0,283]
Trans verse diago nal													1		-0,063	[-0,204;0,098]

278

279 TR:Transverse; AP: Antero-posterior; ASIS:Antero-superior-iliac-spines; *p < .05; **p < .01.CI: Confident Interval

280

281 **TABLE 3. Multiple regression models of internal pelvimetry on external pelvimetry**

PREDICTOR	API				TRI				TRM				TRO			
	Beta	SE	p	r ²	Beta	SE	p	r ²	Beta	SE	p	r ²	Beta	SE	p	r ²
Constant	119.20	4.58	0.01	0.010	120.44	4.07	0.01	0.018	108.80	3.96	0.01	0.01	120.04	4.55	0.01	0.001
BMI	0.20	0.20	0.32		0.24	0.17	0.17		0.01	0.17	0.99		0.02	0.20	0.90	
Constant	91.25	16.46	0.01	0.041	27.39	11.18	0.02	0.440	28.87	11.80	0.02	0.344	24.55	13.01	0.06	0.376
BMI	0.16	0.21	0.46		0.24	0.14	0.10		-0.07	0.15	0.65		-0.04	0.17	0.83	
Intertrochanteric	0.11	0.06	0.07		0.36	0.04	0.01		0.31	0.04	0.01		0.37	0.05	0.01	
Constant	79.65	12.28	0.01	0.120	73.47	10.45	0.01	0.185	103.07	11.2	0.01	0.03	113.37	12.80	0.01	0.003
BMI	0.15	0.19	0.44		0.19	0.15	0.24		-0.01	0.17	0.97		0.02	0.19	0.94	
Inter ASIS	0.19	0.05	0.01		0.22	0.04	0.01		0.03	0.05	0.59		0.03	0.06	0.56	
Constant	25.28	12.79	0.05	0.423	71.88	12.76	0.01	0.178	86.29	13.13	0.01	0.038	87.48	14.78	0.01	0.060
BMI	0.22	0.16	0.19		0.21	0.17	0.21		0.02	0.17	0.92		0.06	0.20	0.78	
External conjugate	0.45	0.06	0.01		0.24	0.06	0.01		0.11	0.06	0.08		0.15	0.07	0.03	
Constant	109.40	10.31	0.01	0.024	93.85	9.17	0.01	0.113	82.84	8.64	0.01	0.1	94.48	9.72	0.01	0.073
BMI	0.20	0.19	0.31		0.29	0.17	0.09		0.10	0.16	0.53		0.15	0.19	0.43	
Transverse diagonal	0.11	0.09	0.25		0.27	0.09	0.01		0.25	0.08	0.01		0.24	0.09	0.01	
Constant	129.56	10.70	0.01	0.024	106.10	9.38	0.01	0.048	108.34	9.23	0.01	0.01	121.59	10.34	0.01	0.006
BMI	0.24	0.21	0.25		0.17	0.18	0.35		0.03	0.18	0.86		0.13	0.21	0.54	
Prepubic	-0.09	0.08	0.30		0.14	0.07	0.07		-0.01	0.07	0.96		-0.04	0.08	0.65	
Constant	49.51	20.91	0.02	0.444	-8.32	16.76	0.62	0.542	39.51	17.17	0.02	0.454	37.54	19.17	0.06	0.445
BMI	0.29	0.19	0.12		0.12	0.15	0.48		-0.01	0.16	0.96		0.19	0.18	0.29	
Intertrochanteric	-0.13	0.07	0.08		0.34	0.06	0.01		0.36	0.07	0.01		0.39	0.07	0.01	
Inter ASIS	0.07	0.06	0.23		0.05	0.05	0.28		-0.15	0.05	0.01		-0.10	0.05	0.06	
External conjugate	0.44	0.07	0.01		0.03	0.06	0.61		-0.03	0.06	0.66		0.03	0.07	0.61	
Transverse diagonal	0.14	0.11	0.21		0.16	0.09	0.08		0.20	0.09	0.03		0.04	0.09	0.69	
Prepubic	-0.16	0.08	0.07		0.10	0.07	0.12		-0.02	0.07	0.73		-0.08	0.08	0.30	

283 TRI: Transverse inlet; TRM: Transverse midplane; TRO: Transverse outlet; AP: Antero-posterior; ASIS: Antero-superior-iliac-spines; BMI: 284 Body Mass Index