Published in final edited form as:
Int Urogynecol J Pelvic Floor Dysfunct. 2009 February ; 20(2): 133–139. doi:10.1007/s00192-008-0736-2.

Magnetic Resonance Assessment of Pelvic Anatomy and Pelvic Floor Disorders after Childbirth

Victoria L. Handa, MD[a], **Mark E. Lockhart, MD, M.P.H**[b], **Kimberly S. Kenton, MD**[c], **Catherine S. Bradley, MD, MSCE**[d], **Julia R. Fielding, MD**[e], **Geoffrey W. Cundiff, MD**[f], **Caryl G. Salomon, MD**[g], **Christiane Hakim, MD**[h], **Wen Ye, PhD**[i], and **Holly E. Richter, PhD, MD**[j]

[a] Department of Gynecology and Obstetrics, Johns Hopkins School of Medicine, Baltimore, MD

[b] Department of Radiology, University of Alabama at Birmingham, Birmingham, AL

[c] Department of Obstetrics & Gynecology and Urology, Loyola University Medical Center, Maywood, IL

[d] Department of Obstetrics and Gynecology, University of Iowa Carver College of Medicine, Iowa City, IA

[e] Department of Radiology, University of North Carolina, Chapel Hill, NC

[f] University of British Columbia, Vancouver, British Columbia, Canada

[g] Department of Diagnostic Radiology, Edward V. Hines, Jr. Veterans' Administration Hospital, Hines, IL

[h] Department of Radiology, Magee Women's Hospital, University of Pittsburgh Medical Center, Pittsburgh, PA

[i] Department of Biostatistics, University of Michigan, Ann Arbor, MI

[j] Department of Obstetrics and Gynecology, University of Alabama at Birmingham, Birmingham, AL

Corresponding Author: Victoria L. Handa, MD, Johns Hopkins Bayview Medical Center, 4940 Eastern Avenue, Baltimore, MD 21224, (410) 550-0335, Fax (410) 550-0196, Vhanda1@jhmi.edu.
Reprints will not be available.

Pelvic Floor Disorders Network Members: University of Alabama at Birmingham - Holly E. Richter, PhD, MD, Principal Investigator; Kathryn Burgio, PhD, Co-Principal Investigator; Patricia Goode, MD, Co-Investigator; R. Edward Varner, MD, Co-Investigator; Gregg Shore, MD, Co-Investigator; Franklin Tessler, MD, Co-Investigator; Mark Lockhart, MD, MPH, Co-Investigator; Velria Willis, RN, BSN, Research Coordinator. **University of Pittsburgh/Magee—Womens Hospitals** - Halina Zyczynski, MD, Principal Investigator; Diane Borello-France, PhD, Co-Investigator; Christiane Hakim, MD, Co-Investigator; Arnold Wald, MD, Co-Investigator; Judy A. Gruss, BS, MS, Research Coordinator; Wendy Leng, MD, Co-Investigator; Pamela A. Moalli, MD, PhD, Co-Investigator. **Baylor College of Medicine** - Paul M. Fine, MD, Principal Investigator; Rodney A. Appell, MD, Co-Principal Investigator; Peter K. Thompson, MD, Co-Investigator; Peter M. Lotze, MD, Co-Investigator; Naomi Frierson, Research Coordinator. **University of Iowa** - Ingrid Nygaard, MD, Principal Investigator; Debra Brandt, RN, Denise Haury, RN, Research Coordinators; Karl Kreder, MD, Co-Investigator; Catherine S. Bradley, MD, Co-Investigator; Satish Rao, MD, Co-Investigator. **Johns Hopkins Medical Institutes** - Geoffrey Cundiff, MD, Principal Investigator; Victoria Handa, MD, Co-Investigator; Mary Elizabeth Sauter, NP, Research Coordinator; Jamie Wright, MD, Co-Investigator. **University of Michigan** - Morton B. Brown, PhD, Principal Investigator; John T. Wei, MD, MS, Co-Principal Investigator; Beverly Marchant, RN, BS, Project Manager; John O.L. DeLancey, MD, Co-Investigator; Nancy K. Janz, PhD, Co-Investigator; Dean G. Smith, PhD, Co-Investigator; Patricia A. Wren, PhD, Co-Investigator; Wei Wei, PhD, Statistician; Wen Ye, PhD, Statistician; James Imus, MS, Statistician; Yang Wang Casher, MS, Database Programmer. **University of North Carolina at Chapel Hill** - Anthony G. Visco, MD, Principal Investigator; AnnaMarie Connolly, MD, Co-Investigator; John Lavelle, MD, Co-Investigator; Mary J. Loomis, RN, Research Coordinator; Anita K. Murphy, NP, Research Coordinator; Ellen C. Wells, MD, Co-Investigator; William Whitehead, PhD, Co-Investigator; Julia Fielding, MD, Co-Investigator. **Loyola University, Chicago** - Linda Brubaker, MD, Principal Investigator; Mary Pat FitzGerald, MD, Co-Principal Investigator; Kimberly Kenton, MD, Co-Investigator; Dorothea Koch, RN, Research Coordinator; Charity Ball, RN, Research Coordinator. **Steering Committee Chairman** - Robert Park, MD NICHD. **Project Scientist** - Anne M. Weber, MD, MS.

Abstract

Introduction and Hypothesis—To compare pelvic anatomy, using magnetic resonance imaging (MRI), between women with or without pelvic floor disorders 6-12 months after a first delivery.

Methods—We measured postpartum bony and soft tissue pelvic dimensions in 246 primiparas. Pelvic anatomy was compared between women with and without urinary or fecal incontinence, pelvic organ prolapse, and obstetrical anal sphincter lacerations. Because of multiple comparisons, P<0.01 was considered statistically significant.

Results—A deeper sacral hollow was significantly associated with fecal incontinence (p=0.005). We identified trends between urinary incontinence and a wider intertuberous diameter (p=0.017) and a wider pelvic arch (p=0.017). We also noted a trend in increasing transverse inlet diameter with increasing prolapse (p=0.034). A shorter anterioposterior outlet was marginally associated with obstetrical sphincter laceration (p=0.020). None of these latter associations were statistically significant.

Conclusions—MR assessment of pelvic anatomy did not reliably distinguish postpartum women with uterovaginal prolapse or symptoms of urinary or fecal incontinence.

Keywords

magnetic resonance imaging; urinary incontinence; fecal incontinence; pelvic organ prolapse; anal sphincter laceration

Introduction

Magnetic resonance imaging (MRI) is increasingly used to assess pelvic anatomy in women with pelvic floor disorders [1]. While techniques have evolved to identify pelvic support defects [2], MRI does not yet have an established role in the clinical management of pelvic floor disorders. Several research studies have suggested variations in the underlying shape and contour of the pelvic floor between women with and without certain pelvic floor disorders [3-7], but the accuracy and utility of these assessments remain uncertain.

Another possible role for pelvic MRI is the identification of women at risk for pelvic floor disorders. Variations in the shape and dimensions of the bony pelvis may be associated with pelvic organ prolapse, urinary incontinence, and anal incontinence [8-11]. The available evidence suggests that a wide pelvic inlet, a wide midpelvis, and a shallow pelvic outlet are all more common in women with pelvic floor disorders.

MRI pelvimetry has also been used to identify women at risk for labor dystocia [12]. While differences have been observed between women with and without dystocia, it is not clear whether MRI pelvimetry can be used to identify women at highest risk of birth trauma. Maternal and neonatal trauma could theoretically be reduced through the identification of accurate predictors of clinical events such as shoulder dystocia and anal sphincter laceration.

The objective of this study was to compare MRI dimensions of the bony pelvis and soft tissue structures in a large cohort of well-characterized primiparous women with and without pelvic floor disorders. The aims of this study were to investigate differences in: 1) the bony pelvic dimensions of women with and without pelvic floor disorders (urinary incontinence, fecal incontinence, and pelvic organ prolapse), 2) the soft tissue dimensions of women with and without these pelvic floor disorders and 3) the bony pelvic dimensions of women with and without a history of anal sphincter laceration.

Materials and Methods

Study population

The Childbirth and Pelvic Symptoms study (CAPS) [13] was performed by the Pelvic Floor Disorders Network, a multicenter network supported by the National Institutes of Child Health and Human Development. The CAPS study was a prospective cohort study of primiparous women. The goal of CAPS was to study the relationship between obstetrical sphincter laceration and subsequent incontinence. CAPS compared three cohorts: (1) women with anal sphincter disruption, (2) women who delivered vaginally without clinically recognized anal sphincter disruptions, and (3) women who underwent cesarean delivery without labor. CAPS participants were approached to join the supplementary CAPS Imaging Study [14], which correlated standardized imaging (MR and endoanal ultrasound), physical examination findings, and symptom assessment 6-12 months after delivery.

Magnetic resonance imaging

This research protocol was approved at all clinical sites and the central data coordinating center. All women provided written and verbal informed consent for participation. MRI images were obtained 6-12 months after delivery.

Before imaging, all subjects were asked to void. Images were obtained using a 1.5T magnet. Participants were imaged in a supine position and a surface phased array coil wrapped around the pelvis and ultrasound gel (60cc) in the rectum. After localizer images, the protocol consisted of ultra-fast T2-weighted sagittal images (rest and strain), and transverse and coronal T2-weighted images (rest). For straining images, participants were coached to strain without elevating the lumbosacral spine or thighs. Each dynamic image required 2 seconds for acquisition.

On mid-sagittal images, the pubococcygeal line was utilized to represent the normal location of the pelvic floor. Rest and maximal strain images were obtained to evaluate the descent of the bladder and anorectal junction, the anterioposterior length of the levator hiatus and angle of the levator plate with the pubococcygeal line. The angle of the posterior rectal wall relative to the pubococcygeal line was measured at rest and during Valsalva. The H-line, a measure of the genital hiatus, was the distance from the inferior posterior aspect of the symphysis to the posterior rectal wall at the anorectal junction. The distance from the posterior end of the H-line to the pubococcygeal line (at an angle perpendicular to the pubococcygeal line) represented the M-line. The mid-sagittal image was also used to obtain the following bony measurements [9]: sacral length and depth, the obstetric conjugate (from the sacral promontory to the superior aspect of the symphysis) and the anterioposterior outlet (from the last vertical joint of the coccyx to the inferior aspect of the symphysis).

Axial measurements of levator muscle thickness were obtained at the level of the constrictor urethrae muscle. The width of the genital hiatus was obtained at the cranial-most image that included the symphysis. Bony measurements obtained on axial images [9] included the angle of the pubic arch (in degrees, with the symphysis as the apex), the intertuberous diameter (measured from the posterior and medial cortex of the ischial tuberosities) and the interspinous diameter (measured from the posterior aspect of the ischial spines).

Using the coronal image that included the femoral heads and fovea, we measured the transverse inlet (from the inner aspect of the ischial cortex at the level of the fovea on each side). The maximum transverse inlet diameter was also measured on oblique coronal images obtained in the plane of the sacrum.

Standardized images were obtained at six clinical sites. Images were reviewed by the site radiologist and a central reader. Image interpretation was standardized through a full day of in-person training for research radiologists. The radiology investigators were masked to the subjects' obstetric characteristics and clinical findings. Our prior research using these data suggested high variability among readers of pelvic MRI measurements, particularly with respect to soft-tissue parameters [personal communication: Mark E. Lockhart, Julia R. Fielding, Holly E. Richter, Linda Brubaker, Caryl G. Salomon, Wen Ye, Christiane M. Hakim, Clifford Y. Wai, Alan Stolpen, Anne M.Weber. Reproducibility of Dynamic MRI pelvic measures: a multi-site study. Submitted to *Radiology*, 2007]. As a result, this research used only the measures obtained by the central reader in all cases.

Assessment of pelvic floor disorders

Between 6 and 12 after delivery, each subject was interviewed and underwent a structured gynecologic examination. Prolapse was categorized according to the Pelvic Organ Prolapse Quantification (POP-Q) [15] system. The structured telephone interview included validated questionnaires. The Medical Epidemiological, and Social Aspects of Aging Questionnaire [16,17] was used to assess urinary continence and the Fecal Incontinence Severity Index [18] was used to assess fecal continence.

For this research, we considered four separate outcomes. *Urinary incontinence* was defined by a response of “sometimes” or “often” to any of the Medical, Epidemiological, and Social Aspects of Aging Questionnaire questions [13]. *Pelvic organ prolapse* was defined according to the ICS staging system [15]. *Fecal incontinence* was defined as any involuntary leakage of mucous, liquid stool, or solid stool on the Fecal Incontinence Severity Index; the loss of gas only was not considered fecal incontinence [13]. *Anal sphincter laceration* was defined as any 3rd or 4th degree perineal tear that was clinically recognized and documented at the time of childbirth [13].

Analysis

For each clinical outcome, we investigated the hypothesis that dimensions of the bony pelvis would differ between women with and without the outcome of interest. As our prior research did not suggest an association between either sphincter laceration or cesarean delivery and urinary incontinence 6 months from childbirth [13], we pooled the three cohorts to investigate the differences in bony pelvic dimensions among women with and without urinary incontinence. We also pooled the three cohorts to investigate the differences across prolapse stage. For fecal incontinence, we limited our analysis to women in the sphincter tear group because sphincter laceration is a strong risk factor for fecal incontinence, and we sought to eliminate the confounding effect of sphincter laceration. Thus, the comparison allowed us to investigate whether pelvimetry measures are associated with fecal incontinence among women with a known anal sphincter laceration. We were unable to investigate whether measures are associated with fecal incontinence in the absence of a sphincter laceration because only 13 women without a sphincter laceration reported fecal incontinence [14]. Finally, we compared the bony dimensions of women in the sphincter tear group with women in the vaginal control group. Women in the cesarean control group were not considered to be at risk of anal sphincter laceration and were therefore excluded from this comparison.

Analysis of variance was used to test the hypothesis that dimensions of the bony pelvis differ between women with and without each outcome of interest. To adjust for potential confounding, race was included as a covariate in all analyses. Race was self-reported by each subject. In addition, the proportion of races varied among sites, with some sites recruiting a high proportion of Caucasian subjects. Therefore to further adjust for the confounding effect of site, all analyses were conducted with and without site as a covariate. Secondary to multiple comparisons, $p \le 0.01$ considered significant; $p \le 0.05$ to $p > 0.01$ considered marginally significant or showing a trend.

When comparing those with urinary incontinence (N=73) to those without (N=167), our sample provided 80% power to identify a difference of 0.5 standard deviations (i.e., an effect size of 0.5) at a 1% level of significance. When comparing those with fecal incontinence (N=26) to those without (N=80), we attained 80% power to identify a difference of 0.8 standard deviations at a 1% level of significance. The detectable effect size for prolapse was intermediate to these two (~0.65 SD).

Results

The study population included 109 women with clinically apparent obstetrical sphincter lacerations, 100 vaginal controls (women who delivered vaginally without a clinically diagnosed sphincter laceration) and 37 women who underwent cesarean delivery before labor. The demographic characteristics of the groups have been previously reported [14] and are summarized in table I.

Pelvimetry dimensions were compared between women with and without pelvic floor disorders and are described in Table 2. Some trends were noted in bony pelvic dimensions, as follows: women with urinary incontinence had a wider intertuberous diameter and a wider pelvic arch than women without urinary incontinence. With increasing prolapse stage, the diameter of the transverse inlet increased. Women with symptoms of fecal incontinence had a deeper sacral hollow than those who did not report fecal incontinence. Women with a sphincter laceration had a shorter mean anterioposterior outlet compared to those without a recognized laceration (10.9±0.91cm versus 11.3±1.26cm, p=0.020). With the exception of an association between fecal incontinence and sacral hollow depth, none of the comparisons met our a priori level of statistical significance.

We did not observe differences in soft tissue dimensions between women with and without the conditions considered. Specifically, there were no differences in descent of the bladder at rest and with strain, the length and width of the genital hiatus, levator muscle thickness, the angle of the levator plate, the H-line at rest and with strain, or the M-line at rest and with strain.

Discussion

Our findings are qualitatively similar to published case-control studies reporting that women with urinary incontinence demonstrate a wider midpelvis (wider subpubic arch, wider intertuberous diameter) and women with pelvic organ prolapse demonstrate a wider transverse pelvic inlet [8-10]. However, none of these findings reached statistical significance in our study. We could not confirm previously reported associations between pelvic organ prolapse stage and a wider midpelvis or shallower anterioposterior outlet [9,10]. We also could not confirm an association between a narrow subpubic arch and postpartum fecal incontinence [11]. However, we had limited power to detect effect sizes smaller than 50% to 80% of the standard deviation for each measure.

We found an association between the depth of the sacral hollow and fecal incontinence. It is unclear why a deep sacral hollow, as an isolated difference between groups, would predispose to fecal incontinence. Differences in the depth of the sacral hollow may result in a different vector force of the head on the perineum during the final cardinal movements of labor, with resultant trauma to soft tissues. Alternatively, this finding may be the result of a type I statistical error.

We are not aware of prior research investigating the bony pelvic features associated with anal sphincter laceration. In this research, women in the sphincter tear group had a marginally shorter anterioposterior outlet than women who delivered vaginally without a sphincter tear. The magnitude of this difference was small (on average 3 mm) and did not reach our a priori level of statistical significance. It is biologically plausible that a shallow outlet might increase the risk of trauma to the rectum during delivery. Women with a shorter anteroposterior dimension might have less distance between the anus and the symphysis, exposing the anal canal to trauma during delivery. To our knowledge, this association has not been previously reported and our data suggest only a marginal association. Further research is needed to clarify whether a narrow anterioposterior outlet is a risk factor for anal sphincter trauma.

With respect to the soft tissues of the pelvis, we were surprised to find that soft tissue dimensions did not differ between women with and without the pelvic floor disorders considered. Prior single-center research [6] suggested that MRI soft tissue measures correlate with prolapse and urinary incontinence [19]. However, other researchers have not found a strong correlation between MRI soft tissue findings and the presence or severity of prolapse [20]. This variability in results may be due to differences in techniques and lack of uniformly accepted definitions of MRI thresholds currently noted in the literature for diagnosis of abnormalities such as anterior vaginal prolapse [21]. Although we had hoped that a prospective standardized evaluation with a larger sample size would better detect significant differences, the measured soft tissue parameters did not correlate with pelvic floor symptoms or prolapse on standardized physical examination. It is possible that variability in the acquisition of the studies (despite standardized protocol and radiologist training) may impact results even when there is a single expert reader. The predominance of relatively mild prolapse and incontinence in this population may have limited our power to detect an association in some measures.

All research using MR measures, including ours, is limited by the potential inaccuracy of MRI. In prior analyses of these data [personal communication: Lockhart et al, 2007], we found that some MRI measurements had poor reproducibility and inter-rater reliability. This was particularly true for the soft tissue measures. In the current study, we used only measurements provided by an experienced central radiologist, who was masked to study group. Future studies that rely on MRI measures should plan for additional standardized central training of readers and should develop quality-control processes to address possible problems with reliability. Nevertheless, even with enhanced training, some measures may be insufficiently reliable for use in either the research setting or clinical practice.

In this analysis, we considered only individual diameters of the pelvis, but, in reality, these diameters are interrelated. We believe that future research on the relationship between bony pelvimetry and pelvic floor disorders should consider a more comprehensive, 3-dimensional characterization of pelvic shape. The small differences observed in this study may underlie a more profound difference in the spatial configuration of the pelvis, but our methods do not allow us to address these complex 3-dimensional relationships. Further research with geometric morphometrics [22] may reveal 3-dimensional differences in the pelvic shape of women with or without pelvic floor disorders.

Our study used participants' responses to validated questionnaires and findings from a structured physical examination as surrogate markers for clinical disorders. Prior studies of pelvimetry and pelvic floor disorders have considered women who were actively seeking care for incontinence or prolapse [9,10]. Thus, our results may be influenced by spectrum bias, because the pelvic floor disorders identified in our research are probably less severe than clinical disorders considered in prior case-control studies. The differences observed in prior studies may be characteristic of women with severe pelvic floor disorders. This distinction may explain why we failed to observe statistically significant differences in this study.

In summary, we observed only small differences in bony pelvic dimensions between women with and without pelvic floor disorders. Given this observation and the variability of pelvimetry measures, we conclude that MR pelvimetry does not reliably identify women with postpartum symptoms of incontinence or with postpartum support defects. We conclude that MR pelvimetry cannot be used clinically at this juncture to identify individual women at “high risk” for developing pelvic floor disorders after a first delivery.

Acknowledgments

Supported by grants from the National Institute of Child Health and Human Development (U01 HD41249, U10 HD41268, U10 HD41248, U10 HD41250, U10 HD41261, U10 HD41263, U10 HD41269, and U10 HD41267).

References

1. Koyama T, Togashi K. Functional MR imaging of the female pelvis. J Magn Reson Imaging. 2007; 25:1101–12. [PubMed: 17520731]
2. Fielding JR. Practical MR imaging of female pelvic floor weakness. Radiographics. 2002; 22:295–304. [PubMed: 11896220]
3. DeLancey JO, Morgan DM, Fenner DE, et al. Comparison of levator ani muscle defects and function in women with and without pelvic organ prolapse. Obstet Gynecol. 2007; 109:295–302. [PubMed: 17267827]
4. Hoyte L, Jakab M, Warfield SK, Shott S, Flesh G, Fielding JR. Levator ani thickness variations in symptomatic and asymptomatic women using magnetic resonance-based 3-dimensional color mapping. Am J Obstet Gynecol. 2004; 191:856–61. [PubMed: 15467553]
5. Kaufman HS, Buller JL, Thompson JR, et al. Dynamic pelvic magnetic resonance imaging and cystocolpoproctography alter surgical management of pelvic floor disorders. Dis Colon Rectum. 2001; 44:1575–83. discussion 83-4. [PubMed: 11711726]
6. Healy JC, Halligan S, Reznek RH, Watson S, Phillips RK, Armstrong P. Patterns of prolapse in women with symptoms of pelvic floor weakness: assessment with MR imaging. Radiology. 1997; 203:77–81. [PubMed: 9122419]
7. Kelvin FM, Maglinte DD, Hale DS, Benson JT. Female pelvic organ prolapse: a comparison of triphasic dynamic MR imaging and triphasic fluoroscopic cystocolpoproctography. AJR Am J Roentgenol. 2000; 174:81–8. [PubMed: 10628459]
8. Stav K, Alcalay M, Peleg S, Lindner A, Gayer G, Hershkovitz I. Pelvis architecture and urinary incontinence in women. Eur Urol. 2007; 52:239–44. [PubMed: 17207915]
9. Handa VL, Pannu HK, Siddique S, Gutman R, VanRooyen J, Cundiff G. Architectural differences in the bony pelvis of women with and without pelvic floor disorders. Obstet Gynecol. 2003; 102:1283–90. [PubMed: 14662216]
10. Sze EH, Kohli N, Miklos JR, Roat T, Karram MM. Computed tomography comparison of bony pelvis dimensions between women with and without genital prolapse. Obstet Gynecol. 1999; 93:229–32. [PubMed: 9932561]
11. Frudinger A, Halligan S, Spencer JA, Bartram CI, Kamm MA, Winter R. Influence of the subpubic arch angle on anal sphincter trauma and anal incontinence following childbirth. Bjog. 2002; 109:1207–12. [PubMed: 12452456]
12. Zaretsky MV, Alexander JM, McIntire DD, Hatab MR, Twickler DM, Leveno KJ. Magnetic resonance imaging pelvimetry and the prediction of labor dystocia. Obstet Gynecol. 2005; 106:919–26. [PubMed: 16260507]
13. Borello-France D, Burgio KL, Richter HE, et al. Fecal and urinary incontinence in primiparous women. Obstet Gynecol. 2006; 108:863–72. [PubMed: 17012447]

14. Richter HE, Fielding JR, Bradley CS, et al. Endoanal ultrasound findings and fecal incontinence symptoms in women with and without recognized anal sphincter tears. Obstet Gynecol. 2006; 108:1394–401. [PubMed: 17138772]
15. Bump RC, Mattiasson A, Bo K, et al. The standardization of terminology of female pelvic organ prolapse and pelvic floor dysfunction. Am J Obstet Gynecol. 1996; 175:10–7. [PubMed: 8694033]
16. Diokno AC, Brock BM, Brown MB, Herzog AR. Prevalence of urinary incontinence and other urological symptoms in the noninstitutionalized elderly. J Urol. 1986; 136:1022–5. [PubMed: 3490584]
17. Herzog AR, Diokno AC, Fultz NH. Urinary incontinence: medical and psychosocial aspects. Annu Rev Gerontol Geriatr. 1989; 9:74–119. [PubMed: 2514773]
18. Rockwood TH, Church JM, Fleshman JW, et al. Patient and surgeon ranking of the severity of symptoms associated with fecal incontinence: the fecal incontinence severity index. Dis Colon Rectum. 1999; 42:1525–32. [PubMed: 10613469]
19. Hoyte L, Schierlitz L, Zou K, Flesh G, Fielding JR. Two- and 3-dimensional MRI comparison of levator ani structure, volume, and integrity in women with stress incontinence and prolapse. Am J Obstet Gynecol. 2001; 185:11–9. [PubMed: 11483897]
20. Hodroff MA, Stolpen AH, Denson MA, Bolinger L, Kreder KJ. Dynamic magnetic resonance imaging of the female pelvis: the relationship with the Pelvic Organ Prolapse quantification staging system. J Urol. 2002; 167:1353–5. [PubMed: 11832730]
21. Etlik O, Arslan H, Odabasi O, et al. The role of the MR-fluoroscopy in the diagnosis and staging of the pelvic organ prolapse. Eur J Radiol. 2005; 53:136–41. [PubMed: 15607865]
22. Steyn M, Pretorius E, Hutten L. Geometric morphometric analysis of the greater sciatic notch in South Africans. Homo. 2004; 54:197–206. [PubMed: 15216665]

NIH-PA Author Manuscript

NIH-PA Author Manuscript

Table 1

Characteristics of women in the study population by delivery cohort. Data presented as mean ± standard deviation or N (%)

	Vaginal Delivery with Anal Sphincter Tear (N=109)	**Vaginal Delivery without Anal Sphincter Tear (N=100)**	**Cesarean Delivery before Labor (N=37)**
Age (years)	27.5 ± 6.2	26.3 ± 5.6	28.6 ± 7.5
Race			
Caucasian	79 (73.8)	70 (70.0)	29 (78.4)
Black	25 (23.4)	24 (24.0)	7 (18.9)
Other	3 (2.8)	6 (6.0)	1 (2.7)
Body mass index 6 months postpartum (kg/m^2)	34.8 ± 7.6	34.0 ± 7.8	36.3 ± 7.0

Table 2

Comparison of pelvimetry dimensions for women with and without pelvic floor disorders, 6 months from delivery. All dimensions are in millimeters unless otherwise noted. Values represent mean ± SD. P < 0.01 considered significant, due to multiple comparisons.

	Urinary Incontinence			Prolapse Stage					Fecal Incontinence[†]		
	Yes (n= 73)	**No (n=167)**	**P value[*]**	**Stage 0 (n=67)**	**Stage 1 (n=79)**	**Stage 2 (n=75)**	**Stage 3-4 (n=12)**	**P value[*]**	**Yes (n= 26)**	**No (n= 80)**	**P value[*]**
Transverse inlet diameter (Sagittal view)	105.6 ± 6.7	105.4 ± 7.5	0.59	103.6 ± 7.9	105.6 ± 6.7	105.9 ± 7.1	109.8 ± 9.4	0.034	106.78 ± 7.35	104.03 ± 7.45	0.56
Transverse inlet diameter (Oblique view)	124.2 ± 7.5	124.3 ± 8.4	0.69	123.0 ± 8.	124.8 ± 8.0	124.5 ± 7.1	124.8 ± 12.5	0.20	126.02 ± 7.89	122.9 ± 8.4	0.81
Interspinous distance	106.5 ± 7.3	104.4 ± 8.6	0.10	103.1 ± 8.7	105.4 ± 8.2	105.8 ± 8.4	106.1 ± 8.2	0.68	106.4 ± 8.35	104.67 ± 8.0	0.808
Intertuberous distance	124.5 ± 8.7	121.0 ± 9.9	0.017	119.0 ± 9.1	121.8 ± 9.7	124.5 ± 9.8	122.3 ± 9.8	0.50	125.41 ± 8.78	120.65 ± 9.1	0.170
Angle of subpubic arch (degrees)	85.4 ± 6.3	83.0 ± 7.1	0.017	82.6 ± 6.9	83.7 ± 6.9	85.1 ± 7.4	84.5 ± 5.0	0.54	86.21 ± 6.7	83.42 ± 5.9	0.068
Obstetrical conjugate	122.2 ± 11.2	122.4 ± 10.6	0.83	121.5 ± 8.9	122.0 ± 12.5	122.2 ± 10.3	125.8 ± 9.8	0.34	121.57 ± 11.79	122.1 ± 8.9	0.912
Length of sacrum and coccyx	115.7 ± 13.5	118.7 ± 14.8	0.39	115.1 ± 15.6	118.6 ± 14.0	118.4 ± 13.4	124.0 ± 16.9	0.30	118.9.1 ± 13.24	118.12 ± 12.6	0.303
Depth of sacral hollow	39.4 ± 7.3	40.0 ± 7.8	0.56	39.0 ± 7.5	40.5 ± 8.3	39.7 ± 6.7	39.5 ± 9.5	0.53	44.6 ± 7.9	38.5 ± 7.5	0.005
Anterioposterior outlet	111.8 ± 10.2	111.7 ± 11.4	0.84	115.2 ± 12.0	111.2 ± 9.4	109.4 ± 11.0	107.6 ± 12.9	0.38	107.7 ± 8.6	110.32 ± 9.12	0.792

[*] P value adjusted for site, race and cohort.

[†] Analysis limited to women with a known anal sphincter tear