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ORIGINAL ARTICLE

Perineal body length as a risk factor for ultrasound-diagnosed anal sphincter tear at first delivery

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Abstract
Introduction and hypothesis Shortened perineal body (PB) is associated with an increased risk of ultrasound-detected obstetric anal sphincter tear. The objective was to determine if shortened perineal body length (<3 cm) is a risk factor for ultrasound-detected anal sphincter tear at first delivery.
Methods Pregnant nulliparous women were recruited over 18 months. At 35–37 weeks' gestation and 6 weeks' postpartum perineal body length (PB) was measured and subjects completed quality of life questionnaires. Primary outcome was ultrasound-diagnosed anal sphincter tear at 6 weeks postpartum. Secondary outcomes were also assessed. A priori power analysis determined that 70 subjects were needed to detect a difference in anal sphincter tear based on a PB cut-off of 3 cm.
Results Seventy-three subjects completed the study. Mode of delivery was 69.9 % spontaneous vaginal, 15.1 % operative vaginal, and 15.1 % labored cesarean. There were 25 anal sphincter abnormalities (34.2 %) seen on ultrasound: 11 (15.1 %) internal or external sphincter tears, 3 (4.1 %) internal sphincter atrophy, 6 (8.2 %) external sphincter thinning, and 7 (9.6 %) external sphincter scarring. Only the 11 sphincter tears qualified as abnormal for the primary outcome. In the vaginal delivery group 16.4 % (10 out of 61) had a sphincter tear, compared with 8.3 % (1 out of 12) in the labored cesarean group ($p=0.68$). Women with PB<3 had a significantly higher rate of ultrasound-diagnosed anal sphincter tear (40.0 % vs 11.1 %, $p=0.038$). When comparing women with and without sphincter tear, there was a significant difference in mean antepartum PB (3.1 vs 3.7 cm, $p=0.043$).
Conclusions A shortened perineal body length in primiparous women is associated with an increased risk of anal sphincter tear at the time of first delivery.

Keywords Obstetric anal sphincter tear · Endoanal ultrasound · Perineal body · Risk factors · Primiparous

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Introduction

Obstetrical trauma involving anal sphincter injury can lead to fecal incontinence during the postpartum period as well as later in life [1–4]. The reported rate of anal sphincter tear, based on clinical detection of third- and fourth-degree perineal laceration, ranges from 0.6–9 % of all vaginal deliveries [1, 5–8]. An estimated 40–47 % of women with a clinically recognized anal sphincter injury report fecal incontinence [9, 10]. There is also a high rate of undiagnosed anal sphincter tear at the time of delivery. Sultan et al. found that as many as 35 % of primiparous women had an unrecognized anal sphincter tear when studied with endoanal ultrasound at 6 weeks postpartum [1], while Pinta et al. reported a rate of 23 % at 4 months postpartum [10]. This discrepancy between clinical and radiographic findings can be interpreted in several ways: a portion of anal sphincter injuries may go unrecognized at the time of delivery; anal sphincter repair at the time of delivery may be inadequate; or further damage may occur to the sphincter postpartum (from tissue necrosis, scarring or other mechanisms) resulting in chronic sphincter disruption and dysfunction [11]. Clinical diagnosis alone is likely inaccurate, as demonstrated by one study of 752 primiparous women, in which the use of endoanal ultrasound in the delivery suite identified an additional 5.6 % with an anal sphincter tear [12].

Women who have an anal sphincter injury with their first delivery have a seven-fold increased risk of sphincter injury during subsequent deliveries; which increases the risk of fecal incontinence in later years [13, 14]. Many research efforts have focused on understanding risk factors for perineal injury, and specifically anal sphincter injury, at the time of delivery. In addition to obstetrical factors, maternal perineal length has been associated with the clinical diagnosis of vaginal/perineal injury at delivery [15, 16]. Perineal length, however, has not been studied in association with endoanal ultrasound detection of sphincter injury. Understanding risk factors for anal sphincter injury provides an opportunity for improved awareness and prevention of fecal incontinence and other pelvic floor dysfunction resulting from pelvic floor injuries sustained during obstetric delivery. Assessing perineal length prior to delivery may provide a low-risk, non-invasive and inexpensive screening tool to evaluate the risk of anal sphincter injury.

Our primary aim was to evaluate perineal body (PB) length as a predictor of anal sphincter tear at the time of first vaginal delivery, based on postpartum endoanal ultrasound assessment of the anal sphincter complex. Secondary aims were to describe the rate of anal sphincter tear not diagnosed at the time of delivery, and to determine whether a short PB is associated with more pelvic floor disorders after delivery.

Materials and methods

After obtaining IRB approval from the University of North Carolina at Chapel Hill (UNC), pregnant nulliparous women were recruited from the UNC prenatal clinics. Those electing to participate gave written consent and enrolled in the third trimester. STROBE guidelines were followed [17]. Inclusion criteria were: nulliparity, singleton gestation, age ≥ 18, planning vaginal delivery at UNC, and ability to speak English. Exclusion criteria were: delivery before 37 weeks, active labor at enrollment, planning for cesarean delivery, history of anorectal surgery or trauma, inflammatory bowel disease or irritable bowel syndrome. Failed labor with ultimate cesarean delivery was not a reason for exclusion. A PB measurement was performed at the time when the group beta-hemolytic streptococcus (GBS) culture was obtained, between 35–37 weeks' gestation. The measurement was obtained using a wooden cotton swab according to Pelvic Organ Prolapse Quantification (POP-Q) criteria [18]: performed with maximal Valsalva effort, measuring from the posterior hymenal ring to the middle of the anal opening to the nearest half centimeter. Subjects also completed three condition-specific quality of life questionnaires assessing pelvic floor and sexual function: the Pelvic Floor Distress Inventory Short Form (PFDI-20) [19], the Pelvic Floor Impact Questionnaire Short Form (PFIQ-7) [19], and the Fecal Incontinence Severity Index (FISI) [20]; as well as one measuring general sexual function: the Female Sexual Function Index (FSFI) [21]. The PFDI-20 comprises three symptom subscales: bladder (UDI), bowel (CRADI), and prolapse (POPDI). The PFIQ-7 also comprises three symptom subscales: bladder (UIQ), bowel (CRAIQ), and prolapse POPIQ). Demographic and delivery information were collected from the electronic medical record, including: age, race, BMI, gravidity, parity, smoking status, medical and surgical history, length of labor, gestational age at time of delivery, infant birth weight, Apgar scores, head circumference, delivery complications (defined as dystocia, arrest of dilation or descent, non-reassuring fetal heart rate, chorioamnionitis, postpartum hemorrhage, or manual extraction of placenta), mode of delivery (spontaneous vaginal, forceps- or vacuum-assisted vaginal, or labored cesarean), position of the infant's head at delivery, degree of perineal laceration, and type of repair. At 6 weeks postpartum subjects were re-evaluated with: measurement of postpartum PB, pelvic floor and sexual function questionnaires (PFDI, PFIQ, FISI, and FSFI), and two-dimensional endoanal ultrasound for assessment of the integrity of the anal sphincter complex using a BK Medical 2101 Falcon model with a 6.5 mHz endoanal transducer (Fig. 1). All PB measurements were performed by study personnel. Endoanal ultrasounds were performed by either a study physician or a licensed radiology technician. A standardized protocol was taught to all study personnel by one senior radiologist (JRF) in order to ensure consistency. This protocol involved placing the subject in a left lateral decubitus position and inserting the transducer until the puborectalis muscle was visualized. The transducer was then slowly withdrawn, with serial images taken beginning at the level of the puborectalis through removal, in order to obtain upper, mid, and lower canal images of the internal and external anal sphincter complex. Care was taken to maintain a midline orientation in order to avoid skewing the image and creating a false thinning or tear of the sphincter complex. Personnel were all trained by the senior radiologist prior to performing scans independently. Personnel performing the ultrasounds were blinded to all clinical subject data. All ultrasounds were reviewed and interpreted by one attending radiologist for standardization of the assessment. Ultrasounds were separately interpreted in real time by a study physician (unless a technician performed the scan, in which case they were read by the radiologist only). The classification categories for the ultrasound findings were pre-determined by the senior radiologist (JRF) at baseline, based on radiographic markers indicating the extent of the injury. The five classifications were: internal sphincter tear, external sphincter tear, internal sphincter atrophy, external sphincter thinning, and external sphincter scarring. These classifications were used by both the study physicians and radiologist when making a determination for each scan. However, only an internal or external sphincter tear were used to define a sphincter injury for our primary outcome. On initial analysis, all five categories were defined as a sphincter injury, but we found an abnormally high rate of injury. We decided to re-define the primary outcome as only internal and external tears (excluding atrophy, thinning, and scarring) in order to accurately reflect the more clinically relevant outcome of sphincter tear (Fig. 1).

An a priori power analysis was performed. In the year prior to study enrollment, there were 1,062 primiparous deliveries at UNC, with 6.59 % undergoing repair of a 3rd or 4th degree perineal laceration. This was used as a proxy for anal sphincter tear, since endoanal ultrasound is not standard at the time of delivery. Average perineal body length has been estimated to be 4 cm [14]. With existing data showing a 40 % risk of a clinically recognized 3rd or 4th degree laceration in patients with a shortened PB [15], we assumed that the incidence of ultrasound-detected anal sphincter tear for a shortened PB (defined as < 3 cm) to be 25 %, versus 5 % in subjects with a PB≥3 cm. Based on this, we estimated a sample size of 14 subjects (20 %) with a shortened PB (< 3 cm) and 56 subjects (80 %) with a normal PB (≥ 3 cm), for a total of 70 subjects, in order to have 80 % power to detect a 20 % difference between groups in the rate of ultrasound-diagnosed anal sphincter tear, with an alpha of 0.05. Assuming a drop-out rate of 25 %, we planned to enroll approximately 100 subjects. Statistical analysis was undertaken with SPSS version 16 (IBM, Armonk, NY, USA), using paired and Student's t tests, Chi-squared test, Mann–Whitney test, McNemar's test, and Spearman's correlations, where appropriate.

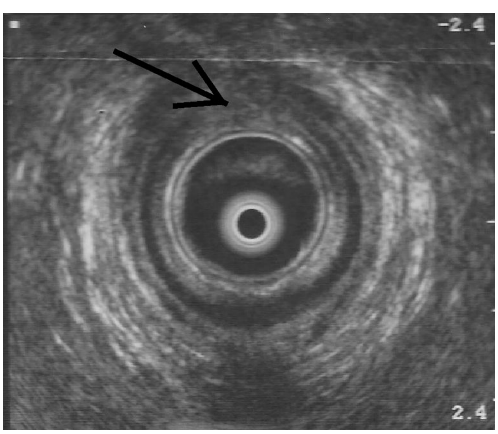

Fig. 1 Actual endoanal ultrasound image of a study subject with an internal anal sphincter tear, indicated by the *black arrow*

Results

Over an 18-month enrollment period 119 subjects were enrolled in order to reach our completion goal, and 73 completed the study. Patient characteristics are displayed in Table 1. The majority of subjects (69.9 %) had a spontaneous vaginal delivery. There was one episiotomy (1.4 %) in a subject with an intact sphincter. No subjects underwent an unlabored cesarean delivery, as this was an exclusion criterion for the study. Median antepartum PB was 3.5 cm (range 2–5 cm). Eighty-six percent of subjects had a PB≥3 cm, while 14 % had a shortened PB (< 3 cm). There were 26 (35.1 %) anal sphincter abnormalities seen on endoanal ultrasound at 6 weeks postpartum: 11 (15.1 %) had an internal and/or external sphincter tear, 3 (4.1 %) had internal sphincter atrophy, 6 (8.2 %) had external sphincter thinning, and 7 (9.6 %) had external sphincter scarring. Only internal and external sphincter tears were considered abnormal for our primary outcome. The distribution of internal and external sphincter tears was similar: 5 out of 11 (45 %) vs 6 out of 11 (55 %). In assessing PB with our hypothesized cut-off value of 3 cm, women with PB<3 had a significantly higher rate of ultrasound-diagnosed anal sphincter tear (40.0 % vs 11.1 %, p =0.038; Table 1). There were no baseline differences between PB groups. When assessed as a continuous variable, PB correlated inversely with the presence of an anal sphincter tear on ultrasound (p =0.04). In other words, the shorter the PB, the higher likelihood of a sphincter tear. When comparing women with and without a sphincter tear, those with a sphincter tear had a significantly shorter mean antepartum and postpartum PB (p =0.04; Table 2). There were no baseline differences between those with and without a sphincter tear. Four out of 73 (5.5 %) anal sphincter tears were diagnosed clinically vs 11 out of 73 (15.1 %) diagnosed by ultrasound, for a rate of undiagnosed anal sphincter tear of 9.6 %.

In terms of postpartum pelvic floor symptoms, PB<3 was correlated with greater pelvic floor dysfunction on the PFDI (p =0.049) and greater bowel dysfunction on the CRADI (p =0.004). There was no difference in postpartum fecal incontinence rates, based on FISI score. Mean FISI score was 9 for the intact sphincter group and 8 for the sphincter tear group (p =0.74); Table 2). The highest possible FISI score is 61, indicating low rates of fecal incontinence in general. When comparing women who underwent vaginal versus labored cesarean delivery, there was no difference in the rate of anal sphincter tear based on route of delivery (16.4 % [10 out of 61] vaginal vs 8.3 % [1 out of 12] cesarean, p =0.77). There was also no difference between vaginal and cesarean delivery in antepartum PB (3.6 vs 3.5 cm, p =0.87) or postpartum PB (3.3 vs 3.3 cm, p =0.98)

There was a 38.6 % drop-out rate. We compared the baseline demographics of the responders with those of the non-responders and found no difference in age, race, BMI, smoking status, epidural, birth weight, neonatal characteristics, or PB

Table 1 Patient characteristics and outcomes for all subjects and subdivided based on perineal body (PB) length

	All subjects, $n=73$	PB≥3, $n=63$	PB<3, $n=10$	P value
Age	28±5	27±5	28±7	0.64*
Race				
White	33 (45)	27 (43)	6 (60)	0.69†
Black	19 (26)	18 (29)	1 (10)	
Hispanic	7 (10)	6 (10)	1 (10)	
Asian	3 (4)	3 (5)	0 (0)	
Other	11 (15)	9 (14)	2 (20)	
BMI (kg/m^2)	28±7	27±7	29±9	0.46*
Mode of delivery				
SVD	51 (70)	42 (67)	9 (90)	0.41†
Vacuum	8 (11)	7 (11)	1 (10)	
Forceps	3 (4)	3 (5)	0 (0)	
Labored cesarean	11 (15)	11 (17)	0 (0)	
Gestational age at delivery (weeks)	40±1	40±1	40±1	0.61*
Length of second stage (min)	99±78	96±74	113±101	0.54*
Infant birth weight (g)	3,341±475	3,341±476	3,343±499	0.99*
Infant head circumference (cm)	34±5	34±5	35±2	0.43*
Ultrasound results				
Sphincter tear	11 (15)	7 (11)	4 (40)	0.038‡
Sphincter thinning	6 (8)	6 (10)	0 (0)	0.59‡
Sphincter scarring	7 (10)	6 (10)	1 (10)	0.99‡
Sphincter atrophy	3 (4)	2 (3)	1 (10)	0.36‡
Postpartum PFDI	30±38	26±34	55±51	0.16*
Postpartum PFIQ	5±12	5±13	3±5	0.68*
Postpartum FISI	9±13	9±13	11±14	0.60*
Postpartum FSFI	15±11	15±11	13±9	0.72*

Data presented as n±SD, or n (%), p value is comparing PB≥3 with PB<3.

PB = perineal body, BMI = body mass index, SVD = spontaneous vaginal delivery, PFDI = Pelvic Floor Distress Inventory, PFIQ = Pelvic Floor Impact Questionnaire, FISI = Fecal Incontinence Severity Index, FSFI = Female Sexual Function Index

*Student's t test

†Pearson's Chi-squared

‡Fisher's exact

length. However, the rate of vaginal delivery was lower in the non-responder group ($p=0.03$). There was no difference in the rate of operative vaginal delivery.

Discussion

As clinical outcomes following obstetric anal sphincter injury and repair are poor [22], primary injury prevention with identification of antepartum clinical risk factors is essential. We chose to evaluate perineal body length as a predictor of anal sphincter tear at the time of first vaginal delivery because it is a safe, non-invasive and inexpensive assessment tool. Previous studies have found this marker to be associated with an increased risk of perineal trauma, based on association with clinical examination [15, 16]. Deering et al. reported an increased rate of clinically detected third- and fourth-degree perineal lacerations with a PB≤2.5 cm [15]. In our study, we confirmed that a shortened PB (<3 cm) was associated with a higher rate of anal sphincter tear on endoanal ultrasound. Based on these findings, women with a shortened PB are at greatest risk of sphincter tear.

One of our goals was to assess the rate of undiagnosed anal sphincter tear in this group of healthy primiparous women. Our 9.6 % rate of ultrasound-diagnosed undiagnosed sphincter tear in primiparous women is the same as that quoted in more recent data using three-dimensional anal ultrasound, which report a rate of 11 % [23]. This highlights the need for accurate recognition of anal sphincter tear at the time of delivery.

We did not identify any obstetric risk factors for ultrasound-documented anal sphincter tear in this primiparous cohort. As the outcomes in this study were secondary, we likely did not find an association because we were not fully powered to assess their impact on anal sphincter tear. Other studies have also shown an association between anal sphincter tear and epidural, as well as elective induction of labor, prolonged second stage, non-OA head position, infant birth weight, episiotomy, training level of the delivering provider, and operative delivery [5, 6, 15, 24–26].

Mode of delivery was assessed both for predictive risk factors and its association with anal sphincter tear. We found no difference in PB length or the rate of anal sphincter tear between successful vaginal delivery and labored cesarean delivery. Data have shown that sphincter injury can occur even with an intact PB [27]. We found one case of anal sphincter tear in the labored cesarean group. Fynes et al. illustrated that cesarean delivery after labor is not protective

Table 2 Patient characteristics and outcomes based on anal sphincter injury

	Intact anal sphincter, $n=62$	Anal sphincter tear, $n=11$	P value
Antepartum PB (cm)	3.7±0.8	3.1±0.7	0.04*
Postpartum PB (cm)	3.4±0.6	2.9±0.8	0.04*
Age	27±5	29±8	0.34*
Race			
White	29 (47)	4 (40)	0.34†
Black	17 (27)	2 (20)	
Hispanic	6 (10)	1 (10)	
Asian	3 (5)	0 (0)	
Other	7 (11)	4 (40)	
BMI (kg/m^2)	28±8	26±6	0.28*
Mode of delivery			
SVD	42 (67)	9 (90)	0.77‡
Vacuum	7 (11)	1 (10)	
Forceps	3 (5)	0 (0)	
Labored cesarean	10 (16)	1 (0)	
Gestational age at delivery (weeks)	40±1	40±1	0.66*
Length of second stage (min)	96±74	113±101	0.85*
Infant birth weight (g)	3,348±489	3,301±410	0.76*
Infant head circumference (cm)	34±5	34±2	0.93
Postpartum PFDI	31±40	28±30	0.84*
Postpartum PFIQ	5±13	1±2	0.39*
Postpartum FISI	9±13	8±13	0.74*
Postpartum FSFI	14±11	17±11	0.46*

Data presented as n ±SD, or n (%)

PB = perineal body, BMI = body mass index, SVD = spontaneous vaginal delivery, PFDI = Pelvic Floor Distress Inventory, PFIQ = Pelvic Floor Impact Questionnaire, FISI = Fecal Incontinence Severity Index, FSFI = Female Sexual Function Index

*Student's t test

†Fisher's exact

‡Pearson's Chi-squared

of the anal sphincter mechanism, a finding corroborated in our study [28]. Based on current data, there is likely no overriding factor that predicts anal sphincter tear. Risk factors that may increase the likelihood of anal sphincter tear include a combination of factors, including previous sphincter tear (even if not currently symptomatic), a shortened PB (< 3 cm), a history of transient or persistent fecal incontinence after the first delivery, and fetal macrosomia [1, 15, 28, 29].

Limitations of this study include the small number of subjects with a sphincter tear, the high drop-out rate, lack of randomization, and lack of pre-pregnancy assessment. While the number of subjects with a sphincter tear was low, it was sufficient to find a difference between groups for our primary outcome. The 38.6 % drop-out rate is likely attributable to the fact that women were enrolled during pregnancy and were less likely to be followed up after delivery because of the obligations of having their first newborn child. In terms of randomization, this is always difficult for research involving obstetrical outcomes and mode of delivery. A well-designed prospective cohort study is more feasible and avoids the ethical issues surrounding randomization. In addition, collection of pre-pregnancy data is always difficult as most women do not present for obstetric care until after conception.

Strengths of the study include the prospective design with an a priori power analysis. We designed the study to assess the ability of PB to predict anal sphincter tear. While we estimated that 25 % of our study population would have a PB<3 cm, our actual rate was 14 %. Nonetheless, we did find a difference in the rate of anal sphincter tear for PB<3 cm and were able to reject the null hypothesis. PB<3 was also associated with increased pelvic floor and bowel symptoms based on postpartum quality of life questionnaires. Another strength of the study is the use of endoanal ultrasound to assess our primary outcome. This modality is the standard of care for assessment of anal sphincter integrity [30]. Research has shown that relying on the clinical assessment of perineal laceration at time of delivery does not accurately predict anal sphincter tear [29]. In addition, such data are often collected retrospectively from the obstetrical medical record, which can also affect its accuracy. For the majority of the ultrasounds (52 out of 73), two interpretations were given: the study physician performing the scan and the radiologist. Both were blinded to the subjects' PB and delivery data. (The other 21 ultrasounds were performed by a radiology technician and were only interpreted by the radiologist.) Of these 52 scans, only 4 had discrepant findings regarding sphincter tears: 2 cases of an external sphincter tear vs normal reading, 2 cases of internal sphincter tear vs normal reading. The use of endoanal ultrasound to detect postpartum sphincter tear has been reported and validated by the senior author (JRF) [31]. An additional strength of the study is the use of validated and objective assessment tools to measure pelvic floor and sexual function.

In conclusion, anal sphincter tear is common after the first delivery and is associated with a shortened perineal body length. Identification of women at high risk of sphincter tear may assist with prevention. Measurement of the perineal body may be a clinically useful marker, used in combination with other identified risk factors, to aid in counseling women regarding labor management.

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Author contributions EJ Geller: study design, implementation, statistical analysis, manuscript preparation; BL Robinson: study implementation, statistical analysis, manuscript review; CA Matthews: study implementation, manuscript review; KP Celauro: study design, implementation, manuscript review; GC Dunivan: study design, implementation, manuscript review; AK Crane: study implementation, manuscript review; RA Ivins: study implementation, research coordination; PC Woodham: study implementation, manuscript review; JR Fielding: study implementation, manuscript review.

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