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Pubic bone injuries in primiparous women: magnetic resonance imaging in detection and differential diagnosis of structural injury

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KEYWORDS: birth trauma; Cesarean; levator ani; MRI; pelvic floor; pelvis injury; vaginal delivery

ABSTRACT

Objective *To evaluate the utility of magnetic resonance imaging (MRI) in diagnosing structural injury in primiparous women at risk for pelvic floor injury.*

Methods *This was an observational study of 77 women who underwent 3T MRI after delivery. Women were operationally defined as high risk (*n = *45) for levator ani muscle tears (risk factors: second-stage labor > 150 min or < 30 min, anal sphincter tear, forceps, maternal age > 35 years and birth weight > 4000 g) or low risk (*n = *32): vaginally delivered without these risk factors (*n = *12); delivered by Cesarean section after second-stage labor > 150 min (*n = *14) or delivered by Cesarean section without labor (*n = *6). All women were imaged using fluid-sensitive MRI sequences. Two musculoskeletal radiologists reviewed images for bone marrow edema, fracture, pubic symphysis measurements and levator ani tear.*

Results *MRI showed pubic bone fractures in 38% of women at high risk for pelvic floor injury and in 13% of women at low risk for pelvic floor injury ($\chi^2(3) = 9.27$, P = 0.03). Levator ani muscle tears were present in 44% of the high-risk women and in 9% of the low-risk women ($\chi^2(3) = 11.57$, P = 0.010). Bone marrow edema in the pubic bones was present in 61% of women studied across delivery categories. Complex patterns of injury included combinations of bone marrow edema, fractures, levator ani tears and pubic symphysis injuries. No MRI-documented injuries were present in 18% of women at high risk and 44% at low risk for pelvic floor injury ($\chi^2(1) = 6.2$, P = 0.013).*

Conclusions *Criteria identifying primiparous women at risk for pelvic floor injury can predict increased risk of bone and soft tissue changes at the pubic symphysis. Fluid-sensitive MRI has utility for differential diagnosis of structural injury in postpartum women. Copyright © 2012 ISUOG. Published by John Wiley & Sons, Ltd.*

INTRODUCTION

Criteria identifying women at high risk for labor-related injuries, such as anal sphincter injury and damage to the levator ani muscles have been identified[1,2]. However, despite the frequent clinical occurrence of pubic pain after delivery, limited descriptions of pubic changes and relationships of bone and joint trauma to muscular injury have been reported in the literature. Complex combinations of osseous and soft tissue injuries may be occurring that could impact postpartum recovery for women, especially those at high risk for pelvic floor injury.

The reported incidence of levator ani muscle damage is as high as 15% at first births[3–5]. Damage to this important supportive musculature is associated with later long-term sequelae of vaginal and rectal prolapse[4,6–8]. Levator ani muscles can tear at their insertions on the pubic bones and do not recover after difficult vaginal births[9]. Injuries to the pubic bones and pubic symphysis, while known to occur, have been incompletely evaluated by magnetic resonance imaging (MRI). Yet, such bone and soft tissue trauma might explain why some women have difficulty recovering postpartum owing to refractive symptoms of pain or activity intolerance and the diverse clinical presentations of symphysis pubis dysfunction[10] or symphyseal pelvic dysfunction[11]. Evaluation of these soft tissue and bony alterations on MRI may contribute to a better understanding of pregnancy-related structural

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changes, and thus represent an important clinical area of concern for childbearing women.

While evaluating levator ani muscle status after vaginal birth, we became aware of changes visible in the pubic bones in certain women. The purpose of this paper was to examine the MRI-detected occurrence of bone marrow edema in the pubic bone, evidence of fracture and changes to the pubic joint in primiparous women, comparing women with criterion-based high risk and low risk for pelvic floor injury during childbirth.

SUBJECTS AND METHODS

Patient sample

The study sample consisted of 77 women after their first birth (Table 1) who underwent MRI approximately 6 weeks postpartum. The women were recruited from a larger parent study on levator ani muscles and childbirth that our Institutional Review Board approved.

One group consisted of 45 primiparous women whose birth events included factors known to be associated with levator ani muscle injuries (categorized as the high-risk group). Our definition of high risk was based on the data available in 2007 when the study was initiated, and these factors were for levator ani injury, not fracture. Criteria defining high risk included prolonged second-stage labor (> 150 min), third- or fourth-degree lacerations, instrument-assisted delivery (vacuum or forceps), maternal age ≥ 35 years, baby's birth weight > 4000 g and an unusually short second stage of labor (< 30 min of pushing)[3]. The operationally defined low-risk group ($n = 32$) consisted of women who delivered vaginally without these risk factors for levator ani muscle injury ($n = 12$), women with a long second stage of labor (> 150 min) who delivered by Cesarean section ($n = 14$) and women who delivered by planned Cesarean section with no labor ($n = 6$). These risk factors were selected for the parent study to enhance sampling for those with major levator ani injury, as based on Kearney *et al.*[3]. For instance, the cut-off point of 150 min for second-stage labor was chosen as a compromise between the average 93-min second stage shown in primiparous women without any levator injury and the average 195-min second stage in primipara with major levator injury.

Subjects were recruited by reviewing birth records for all primiparous women at a tertiary-level maternity care hospital. Subjects meeting high-risk criteria were recruited between May 2007 and September 2009. The comparison low-risk group was recruited in the same institution from April 2009 to September 2009. After chart review indicating likely eligibility, women were mailed an informational invitation shortly after their hospital discharge, which was followed by a telephone call of invitation to participate. If interested in participating, they were screened during the telephone conversation. Exclusion criteria included women under 18 years of age, non-English speakers, women with infants in intensive care units, women unable to make the commitment for repeat visits to the hospital or those without childcare. For all women in the study, informed consent was obtained and participants were compensated for their time. None of the authors clinically managed the women in the study.

Magnetic resonance imaging

Women were invited to be imaged after delivery (mean ± SD = 43.6 ± 15.8 days). The time frame of 2–7 weeks postpartum was selected to allow for resolution of typical post-traumatic acute blood products and non-specific soft tissue edema, which may mask the visualization of structural changes. After a few weeks with resolution of blood products and edema, the remaining structural injuries are more likely to be clinically significant. However, seeing muscle tears acutely helps to tie any later muscle atrophy to the acute event. Fracture healing follows a well-documented cascade of processes. Mineralization, endochondral ossification and new woven bone formation do not begin until 2 weeks after a fracture. Bone remodeling at the fracture site proceeds for at least 12 weeks, depending on the size of the fracture, motion at the fracture site and bone quality[12–14]. Woven bone formation is also a response to fatigue loading of bone and can be detected as early as after one episode of such loading[15]. New bony remodeling, whether bone marrow edema or fracture, can continue to be detected by MRI and bone biopsy for many months, even after clinical recovery has occurred[15].

MRI was performed using a 3 Tesla Philips Achieva scanner (Philips Medical Systems, Eindhoven, The Netherlands), with an 8-channel cardiac coil positioned over the pelvis, and included coronal, axial and sagittal proton density-weighted sequences (relaxation time (TR) = 2107 ms; echo time (TE) = 30 ms; number of slice averages (NSA) = 2; slice thickness = 4 mm; gap = 1 mm; and field of view (FOV) = 20 cm, matrix = 256×256). For better definition of the anterior pelvic floor anatomy, additional 2-mm proton density-weighted sequences in the axial, coronal and sagittal planes were obtained (TR = 2107 ms; TE = 30 ms; NSA = 2; slice thickness = 2 mm, gap = 0.2 mm; and FOV = 18 cm, matrix = 256×256). Additional fluid-sensitive image sequences in axial and coronal planes through the anterior pelvic floor were obtained with either proton density-weighted fat saturation (TR = 2355 ms; TE = 30 ms; NSA = 2; slice thickness = 2 mm, gap = 0.2 mm; FOV = 18 cm, matrix = 256×256) or short tau inversion recovery (STIR) sequences (TR = 5987 ms; TE = 60 ms; NSA = 2; slice thickness = 2 mm, gap = 0.2 mm; and FOV = 18 cm, matrix = 256×256). The MR images were reviewed by two board-certified radiologists with fellowship training in musculoskeletal imaging. They used a standard monitor of the Picture Archiving and Communication System (PACS) and were blinded to obstetric and delivery factors. The radiologists agreed on 98% of the categories, and disagreements were between adjacent grades. Consensus was achieved by reviewing the images together and discussing the findings.

One radiologist graded 22 women more than 6 months before the final grading sessions and disagreement of 2–7% was reported between the presence or absence of the mildest grades of fractures and bone marrow edema.

Pubic bone evaluation

Bone marrow edema was assessed by noting the presence of increased signal within the marrow of each of the pubic bones compared with the ischial tuberosity on either proton density-weighted fat saturation or STIR sequences. If present, the increase in signal was recorded as symmetric or asymmetric, and for each side the location of increased signal was noted.

Fractures were defined as linear decreased signal on the proton density-weighted sequence associated with matching focal increased signal on the proton density-weighted fat saturation or STIR sequences. To be documented as present, this finding had to be visible in two imaging planes. Fractures were recorded as either subcortical or cortical. Location of the fracture was noted for each side.

The pubic symphysis was assessed for changes. The pubic joint capsule was measured, with electronic calipers at a workstation, from the anterosuperior pubic cortex to the undersurface of the superior pubic ligament in the coronal plane 2-mm proton density-weighted sequence. Measurements of pubic symphysis width were made at the midpoint of the joint (cephalocaudad) in the axial plane 2-mm proton density-weighted sequence.

Levator ani evaluation

The levator ani muscles were evaluated for muscle fiber loss in two or more adjacent 2-mm sections in both axial and coronal plane proton density-weighted sequences. Each side of the muscle was graded separately. A muscle tear was recorded if greater than 20% of the expected muscle volume was absent. Evaluation of muscle volume or bulk was based on overall appearance of the muscle in all three planes, an estimate common in clinical and research practice, rather than on detailed quantification of individual images. Similarly, 20–25% is a general threshold for decision-making. This paper focused on injury of the pubic symphysis and not on analysis of levator ani injury.

Demographics, labor and delivery variables

Labor and delivery variables were obtained by hospital chart review conducted by a certified nurse midwife.

Statistical analysis

Analyses were conducted using SPSS version 11 (SPSS Inc., Chicago, IL, USA). Descriptive statistics were used to characterize the sample and distributions of injuries. Chi-square tests examined differences in the distribution of injury among groups. ANOVA was used to examine differences by injury and number of days to imaging time, and for pubic symphysis measures across risk groups. All tests of statistical significance were set at a predetermined level of $P < 0.05$.

RESULTS

Risk factors

The distribution of women among criterion-based high-risk and low-risk labor and delivery categories is shown in Table 1. The most frequently occurring risk factor among the high-risk group was extended duration of the second stage of labor (53%). Among the lower-risk deliveries, in the group that delivered by Cesarean section after a prolonged second stage of labor, 14% of infant birth weights were greater than 4000 g. The distribution of MRI-detected postbirth pubic injuries among these risk groups is summarized in Table 2.

Table 1 Characteristics of labor and delivery for primiparous women categorized according to their risk of levator ani injury

		Low-risk delivery		
Characteristic/variable	*High-risk delivery* (n = *45*)	*Vaginal delivery* (n = *12*)	*CS after long second stage* (n = *14*)	*CS, no labor* (n = *6*)
Patient characteristics				
Time post-delivery to MRI (days)	43.3 ± 15.2	44.8 ± 15.8	42.8 ± 20.8	43.6 ± 9.3
Age (years)	30.9 ± 6.4	25.7 ± 6.0	28.0 ± 5.1	30.6 ± 6.2
Birth variables				
Second stage ≥ 150 min	24 (53)	0	14 (100)	0
Duration of second stage of labor (min)	166.5 ± 137.3	88.2 ± 40.9	301.6 ± 78.6	0
Birth weight ≥ 4000 g	5 (11)	0	2 (14)	0
Anal sphincter tear	10 (22)	0	0	0
Forceps delivery	2 (4)	0	0	0
Epidural placed	33 (73)	12 (100)	12 (86)	0

Data are given as mean ± SD or *n* (%). CS, Cesarean section; MRI, magnetic resonance imaging.

Table 2 Summary of pubic injuries detected on magnetic resonance imaging (MRI) in primiparous women categorized according to their risk of levator ani injury

		Low-risk delivery			
Type of injury/ characteristic	*High-risk delivery* (n = *45*)	*Vaginal delivery* (n = *12*)	*CS after long second stage* (n = *14*)	*CS, no labor* (n = *6*)	*Test statistic (d.f.)*, P
Injury					
Pubic bone fracture	17 (37.8)	0 (0.0)	4 (28.6)	0 (0.0)	$\chi^2(3) = 9.27$, $P = 0.03$
Bone marrow edema	30 (66.7)	5 (41.7)	9 (64.3)	3 (50.0)	$\chi^2(3) = 2.86$, $P = 0.41$
Levator ani tear	20 (44.4)	2 (16.7)	1 (7.1)	0 (0.0)	$\chi^2(3) = 11.57$, $P = 0.01$
Pubic symphysis					
Capsule height (mm)	2.24 ± 1.7	1.58 ± 1.0	2.21 ± 1.4	2.30 ± 1.4	F (3,76) = 0.658, $P = 0.58$
Width of pubic symphysis (mm)	2.98 ± 0.7	3.00 ± 0.4	3.64 ± 1.9	3.06 ± 1.0	F (3,76) = 2.34, $P = 0.08$
No related MRI findings*	8 (17.8)	6 (50.0)	5 (35.7)	3 (50.0)	$\chi^2(1) = 6.2$, $P = 0.013$

Data are given as *n* (%) or mean ± SD. *For the presence/absence of MRI-documented injuries, we compared the data from the high-risk group with the combined data from the low-risk groups to facilitate comparisons with results in the existing research literature[3]. CS, Cesarean section; d.f., degrees of freedom.

Pubic bone fracture

Pubic bone fractures were present in 21 of the 77 women (Table 2). Injuries varied by group, with a significantly higher proportion of fractures (17 of 45 women) occurring in the high-risk group ($\chi^2(3) = 9.27$, $P = 0.03$). Only four of the 32 women in the low-risk group showed pubic bone fracture; all four were in the group of 14 women who delivered by Cesarean section after a long second stage of labor. All fractures originated within the posteroinferior and/or parasymphyseal region of the pubis bone (Figure 1). Although most fractures were unilateral, three women had a fracture in both pubic bones. There were two cortical fractures, one of which extended along the inferior pubic ramus (Figure 2).

Pubic bone marrow edema

Bone marrow edema was present in 47 of the 77 women (Table 2), with bilateral edema in 31 women and unilateral edema in the remaining 16 (eight on the right side only and eight on the left side only). There was no statistically significant difference in the presence of bone marrow edema according to risk group ($\chi^2(3) = 2.86$, $P = 0.41$). There were also no statistically significant differences between the presence or absence of bone marrow edema associated with the number of days between childbirth and imaging (44.4 ± 17.8 days vs. 43.1 ± 14.6 days, respectively). While the numbers are small, there does appear to be a possible pattern of mild anterior pubic bone edema seen only in the women who delivered by Cesarean section. This was the only pattern seen in the women who delivered by elective Cesarean section and was not seen in the vaginal delivery groups.

Pubic symphysis results

The mean (± SD) height of the pubic symphysis capsule was 2.14 (± 1.5) mm. The differences among risk groups did not differ significantly (F (3,76) = 0.658, $P = 0.58$ (Table 2)). The mean (± SD) width of the pubic symphysis also did not differ significantly across groups (3.10 (± 1.3) mm; F (3,76) = 2.34, $P = 0.08$). There was one exception, a patient in whom a pubic symphysis width of 12 mm and extensive bone marrow edema was reported (Figure 3). In this patient, the length of the second stage of labor was 7 h 39 min before delivery was performed by Cesarean section. Another case of pubic symphysis injury involved distension of the superior joint capsule to 7 mm

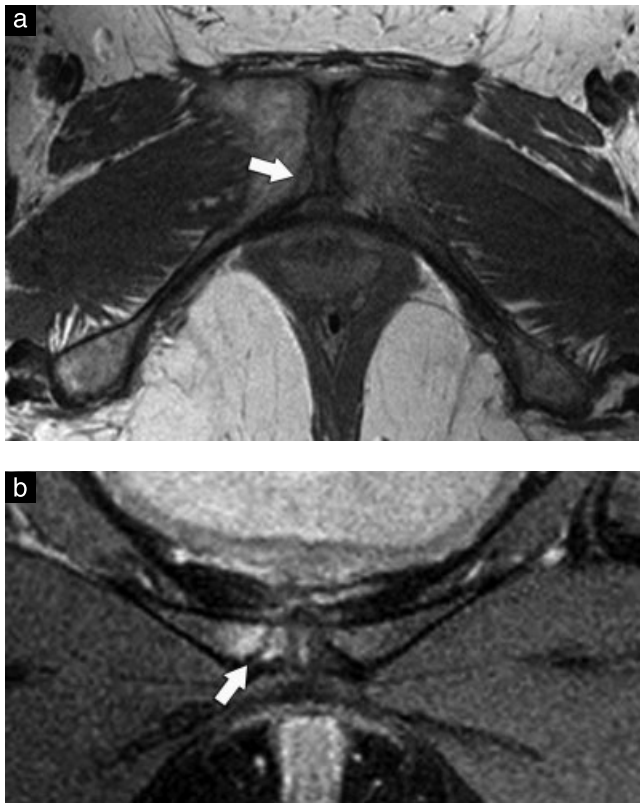

Figure 1 Pubis fracture in a 26-year-old woman 4 weeks after Cesarean section for prolonged labor. Axial proton density weighted (a) and coronal proton density-weighted with fat saturation (b) images show pubic bone fracture at the posteroinferior symphysis location (arrow), with bone marrow edema (b).

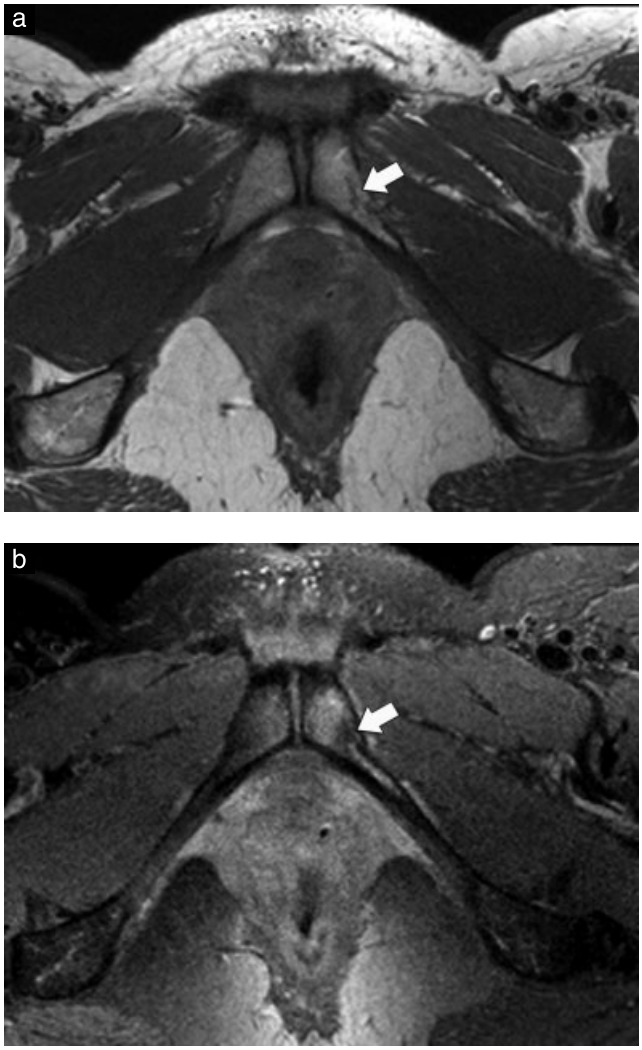

Figure 2 Fracture and levator ani tear in a 34-year-old woman after a 'high-risk' vaginal delivery. Axial proton density magnetic resonance image (a) and proton density-weighted image with fat saturation (b) show focal-intense left inferior pubic ramus bone marrow edema and cortical fracture (arrows).

Figure 3 A 20-year-old woman with pubic symphysis abnormalities following Cesarean section delivery after 7 h and 39 min of second-stage labor. Coronal proton density-weighted magnetic resonance image with fat saturation shows abnormal widening, torn fibrocartilaginous disc and fluid in symphysis (arrow).

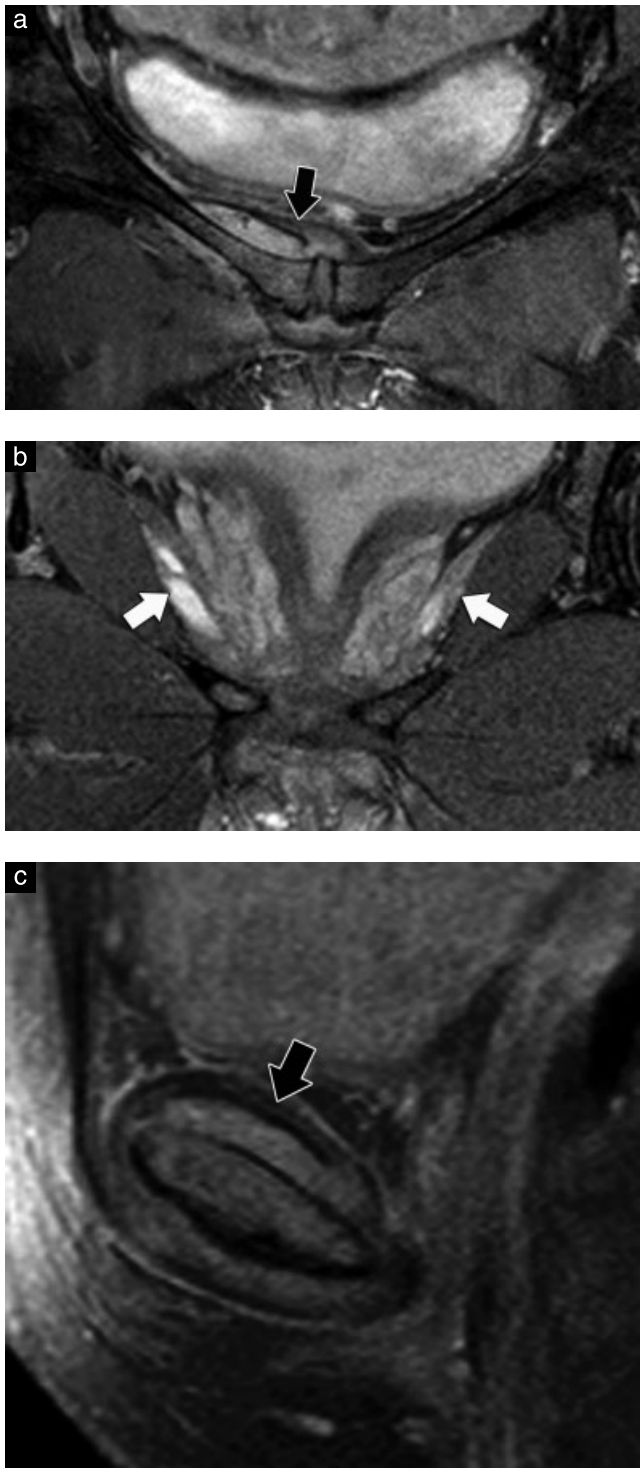

Figure 4 Pubic symphysis capsule rupture and bilateral levator ani tear in a 39-year-old woman after a 'low-risk' vaginal delivery. Proton density-weighted magnetic resonance images with fat saturation: (a) coronal plane, mid symphysis; (b) coronal plane, posterior to symphysis; and (c) sagittal plane, right parasymphysis. Images (a) and (c) show distension of superior and inferior joint capsule with rupture (black arrow) along right side. Fluid tracks into both levator ani muscles (b), which are partially torn (white arrows).

with rupture of the capsule and fluid dissecting along the superior pubic ramus into the pelvis adjacent to the levator ani muscles (Figure 4). This patient had bilateral bone marrow edema and bilateral levator ani muscle tears, representing a low-risk vaginal delivery complicated by operative postpartum management for hemorrhage.

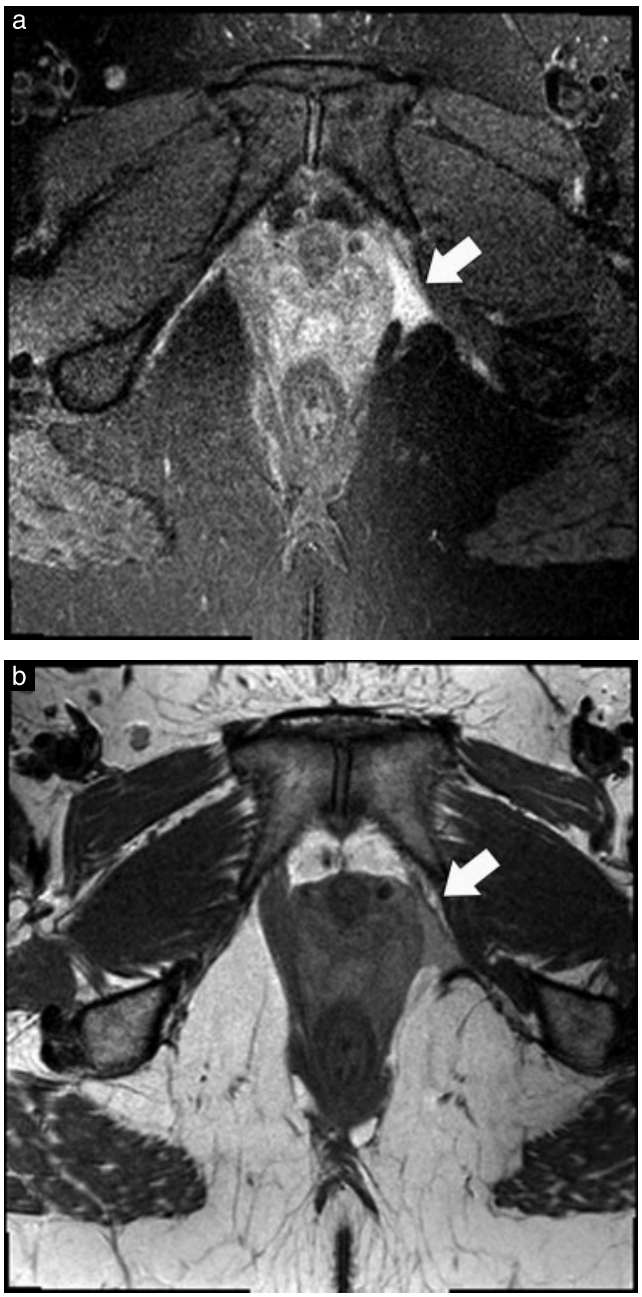

Figure 5 A 39-year-old woman 7 weeks after a 'high-risk' vacuum-assisted vaginal delivery. Axial proton density-weighted magnetic resonance image (a) and axial proton density-weighted image with fat saturation (b) demonstrating tear in left levator ani muscle with fluid within the torn muscle (arrows).

Levator ani tears

Among the 77 study participants, 54 women had no tear and 23 had at least one levator ani tear (Table 2). Of these 23 women, 14 had bilateral tears. The distribution of women with tears varied by delivery group (Table 2), with a significantly higher proportion of women (20 of 45) occurring in the high-risk group compared with three of 32 in the low-risk groups ($\chi^2(3) = 11.57$, $P = 0.01$). All the levator ani muscle tears involved at least the anterior fibers of the muscle insertion along the posterior surface of the pubic bones and were incomplete tears in that at least some muscle volume was detectable, although the increased signal from associated muscle edema and surrounding tissue injury limited evaluation in some cases (Figure 5).

Injury combinations

To explore the complexity of osseous and soft tissue findings, we reviewed the images for various types of injury combinations. Pubic bone fractures never occurred in isolation; they were always accompanied by pubic bone marrow edema. In nine of the 21 women with a pubic bone fracture, a levator ani muscle tear was also present. Nineteen women showed an isolated finding of bone marrow edema, and eight women showed an isolated finding of levator ani tear. Potential clinically significant injuries to the pubic symphysis included widening with bone marrow edema (Figure 3) and capsular rupture (Figure 4). Of the 77 women in the study, 22 (29%) had no related MRI findings (i.e. no areas of bone marrow edema, no fractures, no levator ani tears and no abnormal widening or capsular distension of the pubic symphysis). The distribution of women without any of the above findings on MRI varied by group (Table 2) with a significantly lower proportion in the high-risk women, eight of 45 (18%), in comparison with the combined low-risk women, 14 of 32 (44%) ($\chi^2(1) = 6.2$, $P = 0.013$).

DISCUSSION

This study's investigation with fluid-sensitive MRI sequences identified patterns of injuries among primiparous women. Despite the relative novelty of this approach in obstetrics research, interpreting the meaning of our results can be guided by considering mechanisms associated with labor and delivery as well as the growing body of such MRI studies of the pubic region evaluating sports-related trauma[16–19].

While MRI-detected pubic symphysis injuries occurred in all groups, they were more frequently associated with labor and delivery risk factors for pelvic floor muscle injury. Bone marrow edema, also called 'bone marrow contusion' and 'bone bruising', indicates a non-specific stress injury within bone. Fractures occur when stress exceeds trabecular (subcortical) or cortical strength. Conventional radiography and MRI without fluid-sensitive sequences do not image bone marrow edema and subcortical fractures. Bone marrow edema was present in all delivery groups. Fractures were more frequent among high-risk women and in women delivered by Cesarean section after prolonged labor, suggesting that labor plays an important role.

The pubic symphysis functions as the central anterior attachment for abdominal wall, thigh and pelvic floor (levator ani) musculature, spreading forces generated in the torso and lower extremities across the pelvis. The joint capsule is supported anteriorly, inferiorly and superiorly by an aponeurosis blending abdominis rectus and adductor tendons, the pubic arcuate ligament and the

superior pubic ligament[16,17]. Hyaline cartilage covers each articular surface that abuts a central fibrocartilaginous disc. This reinforced complex makes the pubic symphysis a strong anchor but susceptible to distraction[18].

Stress-related bone injuries present clinically as localized pain that is exacerbated by activity and relieved by rest. Clinical findings can be non-specific, with insidious, diffuse or radiating pain[16–21]. Treatment emphasizes analgesic medication and, in athletes with chronic pain and/or pubic bone marrow edema or stress-related fractures, up to 3 months of rest without athletic weight-bearing activities[15,16,22]. Clinical healing of most stress injuries occurs in 6–8 weeks, although the pubic rami may need 2–5 months[13]. Imaging and clinical findings of pelvic stress fractures usually resolve in 6 months[13]. In an MRI study of consecutive conscripts with pelvic stress pain, 137 of 340 had bone injuries[20]. In a similar study of 100 consecutive soccer players with pubic/groin pain, 91 had pubic symphysis bone edema, in contrast to the matched controls, who had no pubic symphysis bone edema[16]. Chronic pain can be associated with these pubic findings[15,16,20]. Although bone marrow edema is generally considered as benign, cartilage loss seen at follow-up suggests that joint line bone marrow edema may indicate long-term cartilage damage predisposing to early osteoarthrosis[23,24].

The pubic symphysis undergoes acute distractive stress during childbirth. Pubic diastasis is a known complication, especially in women without surgical delivery for difficult vaginal births. Hormonally induced ligamentous laxity during pregnancy is stated to permit increased joint motion. A computed tomography study performed within 24 h of uncomplicated vaginal delivery compared with controls showed widening[25]. In our study, such laxity may have resolved by the time of our measurements. In a study comparing nulliparous controls with symptomatic and asymptomatic women within 2 weeks of vaginal or Cesarean section delivery, parasymphyseal bone marrow edema was documented by MRI only in the postpartum women (13 of 19)[26]. In a study of 56 vaginally delivered women (35 symptomatic and 21 asymptomatic), parasymphyseal bone marrow edema was noted in 86% and 76% of the women, respectively, at 2 weeks[27]. In both studies, the width of the symphysis was significantly larger 2 weeks postpartum than in nulliparous women[26] or controls[27]. No fracture information was provided in either study. The pubic symphysis was not evaluated in postpartum MRI studies including Cesarean section with fluid-sensitive sequences[28] or in two studies without fluid-sensitive sequences including serial examinations[29] and delivery by Cesarean section[30].

Our findings of pubic fractures and capsular ruptures extend the previous MRI observations of bone marrow edema[26,27]. As most injuries were along the posterior and inferior parasymphyseal region, distractive forces may be most pronounced in this region. The pubic portion of the levator ani muscle inserts here and is known to undergo most stress and lengthening during vaginal delivery[31]. As all of our delivery groups demonstrated pubic bone marrow edema, we speculate that distractive forces can occur without passage of the infant head beneath the joint. The mild anterior edema seen in women who have undergone elective Cesarean section may be secondary to anterior abdominal musculature alterations from Cesarean surgery or postoperative biomechanics. However, our high-risk women had the most injuries, including combinations of fractures and muscle tears. Fewer women in our high-risk group, compared with our low-risk group, had no MRI findings; this indicates that the risk group classification criteria also identified risk for pubic symphysis injury.

A limitation of our study was that we did not systematically document pain data or symptoms associated with pubic trauma. Changes occurring before childbirth, such as possible symphyseal separation, or resolution before imaging were not detected. The number of women did provide sufficient power to detect injury patterns across the four risk groups but was too small to estimate overall prevalence of fractures or symphyseal ruptures.

This study demonstrates our capability to evaluate women for pubic symphysis osseous and soft tissue injury using fluid-sensitive MRI sequences. Criteria used to separate primiparous women into high-risk and low-risk groups for pelvic floor muscle injury also may predict vulnerability to pubic symphysis injury. Evaluation of the relative contribution of soft tissue injury vs. bony injury as sources of post-traumatic pain is difficult at any location. In postpartum women, multivariate analysis of a larger study population with clear symptom definition would be needed to clarify the relationship of clinical findings with pubic changes seen on MRI. Antepartum ultrasound could evaluate pubic symphyseal widening and capsular injury. These imaging modalities may be used in the presence of suspected muscle and bone injury[32] and for pubic symphysis-associated dysfunction syndromes. Chronic pubic pain and osteoarthrosis may result from childbirth-related bone and joint injuries. Selective use of MRI to evaluate women at risk may offer the ability to refine and individualize clinical decision-making to enhance prevention and recovery strategies.

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