The interrelationship of childbirth-related pelvic floor injury in primiparas after vaginal delivery

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Research Article

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Abstract

Objective
This study aimed to explore the underlying relationship between the pubic bone injury and levator ani muscle injury.

Methods
150 primiparas after vaginal delivery were prospectively enrolled and divided into the pubic bone injury group and the non-pubic bone injury group according to imaging appearance on postpartum magnetic resonance imaging. The levator ani muscle morphology and function were evaluated, including injury score, H line, M line, levator plate angle, iliococcygeal angle, and levator hiatus area. The levator ani muscle morphology and function were compared between the two groups using univariate analysis. The association between the severity of the pubic bone injury and the levator ani muscle injury was calculated using the Spearman or Kendall’s tau-b correlation coefficient.

Results
Compared to the non-pubic bone injury group, the pubic bone injury group more frequently complained of pelvic pain and stress incontinence (28% vs. 9.3%, \(P = 0.003\); 29.3% vs. 13.3%, \(P = 0.017\), respectively). The levator ani muscle morphological injury score, the H line at straining, the M line, and the levator hiatus area at rest and straining were different between the two groups (all \(P < 0.05\)). There was a positive correlation between the severity of the pubic bone injury and levator ani muscle injury score (\(r = 0.332\)), M line (\(r = 0.139, 0.150\)), and levator hiatus area (\(r = 0.181, 0.164\)) at rest and straining, respectively (all \(P < 0.05\)).

Conclusions
The pubic bone injury was a reliable reminder of morphological injury and decreased function in levator ani muscle.

Take-home Message
Vaginal delivery may result in pubic bone and levator ani muscle injury. The childbirth-related pubic bone injury can suggest morphological injury and poor function in levator ani muscle.

Introduction
A growing body of research has shown that vaginal childbirth is more traumatic to mothers than generally assumed [1]. Passing the newborn through the birth canal requires exceptional pelvic floor stretch. Childbirth exerts remarkable stresses on maternal pelvic bones from the pressures of the fetal head and the forces of abdominal muscles during the delivery of a baby. In these circumstances, pelvic floor injury occurs in certain parous women, especially when there are high-risk obstetric factors (second-stage labor > 150min or < 30min, anal sphincter tear, forceps, maternal age > 35y, and birth weight > 4000g) [2]. Several pelvic floor injuries include bony and soft birth canal injuries.

Stress-related pelvic bone injuries occur in up to 61% of vaginal deliveries [3]. They present clinically as localized pain exacerbated at activity and relieved at rest [4]. However, apart from pelvic bone injury, trauma to the levator ani muscle (LAM) is a common form of maternal injury but less well-recognized and often undiagnosed [5]. LAM is the crucial pelvic floor support associated with later long-term sequelae of pelvic floor dysfunction diseases [6]. Previous studies reported that 13–36% of parous women were detected with pelvic muscle injuries during their first vaginal delivery, and the symptoms of LAM injury were usually insidious and without specified pain [7–11]. Therefore, it is essential to identify pelvic floor support abnormalities in primiparas after vaginal delivery before it worsens.

Magnetic resonance imaging (MRI) is an excellent imaging technique to visualize and assess pelvic floor structures, including soft tissue and pelvis. In contrast, ultrasounds and clinical examinations are inaccessible [12]. Additionally, several studies demonstrated that pelvic floor MRI was widely approved in simultaneously manifesting pelvic floor abnormalities, including injury conditions and pelvic floor dysfunction diseases [13].

It is confirmed that childbirth-related injuries to the pelvic floor are holistic and correlative [14]. In this study, we explore the relationship between pelvic bone injury and pelvic floor support injury during childbirth, in order to predict the possible pelvic floor support injuries or function abnormalities in early period postpartum by means of symptomatic pelvic bone injuries.

Materials And Methods

Patients

This prospectively cohort study was approved by the Institutional Review Board in Tianjin First Central Hospital. Primiparas at six weeks postpartum were enrolled from October 2016 to October 2018. The inclusion criteria included first vaginal delivery, single birth, term delivery, and accepting pelvic floor MRI at six weeks postpartum. The exclusion criteria included a history of pelvic floor disorders, trauma, or surgery, severe artifacts on images, and incomplete clinical information. The clinical characteristics included age, height, weight, duration of the second stage of labor, fetal weight, anal sphincter tear, postpartum pelvic pain, stress urinary incontinence, defecation disorder, and a sense of vaginal obstruction obtained from the electronic medical record system.
The sample size was determined with PASS (power analysis and sample size, PASS) software (power = 0.8, alpha = 0.05). Totally, 150 women (mean, 29 years; range, 20–40 years) were enrolled in the study. 75 women (mean, 29 years; range, 20–37 years) with pubic bone injury by MR criterion were included in the pubic bone injury group, while the other 75 (mean, 29 years; range, 20–40 years) with normal appearance of pubic bone were classified as the non-pubic bone injury group.

**MR Imaging**

**Preparation**

All the primiparas were asked to empty their bladders and drink 200-300ml of water one hour before the MR examination to maintain optimal bladder filling. No contrast agent was injected into the vagina or rectum in our study. One radiologist trained all the primiparas to do the Valsalva maneuver before the MR examination until they understood the essentials of the maneuver. All the primiparas were placed in a supine position with a soft wedge-shaped pad under their knees to simulate lithotomy position to assist force and asked to breathe calmly during MR examination.

**MR protocols**

The pelvic floor MRI was performed using a 3T MR scanner (Ingenia, Philips, Netherlands). The imaging sequences included axial, sagittal, coronal mDIXON-T2WI, and axial T1WI at rest (mDIXON-T2WI: TR 4110ms, TE 102ms, Slice thickness 3mm, FOV 260mm×260mm, matrix 320 × 256; Axial T1WI: TR 450ms, TE 11ms, Slice thickness 3mm, FOV 260mm × 260mm, matrix 320 × 256); Mid-sagittal Balanced Fast Field Echo (B-FEE) images during Valsalva maneuver (TR 5.3ms, TE 2.4ms, Slice thickness 5mm, FOV 300m × 300mm, matrix 280 × 276); Axial, sagittal, and coronal T2-weighted Single-shot fast spin-echo (SSFSE) images at straining (TR 4818ms, TE 95ms, Slice thickness 6mm, FOV 280mm × 280mm, matrix 269 × 256). The total examination time varied from 12 to 15 minutes.

**Imaging analysis**

The acquired images were evaluated on Picture Archiving and Communication System (PACS). Two radiologists with five years of genitourinary diagnosis experience reviewed images in consensus. The standard musculoskeletal magnetic resonance imaging (MSK-MRI) grading categories were used to assess the pubic bone and LAM injuries [15–20].

1. **The pubic bone assessment**

Injuries to the pubic bone included marrow edema and fractures. The pubic bone marrow edema manifested obvious hyperintensity on fat-suppressed T2WI compared to the ischial trochanter bone marrow. The pubic fracture was diagnosed when pubic bone cortex was discontinuous and a line-like hypointensity on T1WI combined with hyperintensity on fat-suppressed T2WI or not.

The severity of the pubic bone injury was graded in four categories, 0: non-injury; 1: mild marrow or periosteal edema on fat-suppressed T2WI; 2: moderate marrow or periosteal edema on T2WI; 3: severe
marrow or periosteal edema on both T2WI and T1WI (in the same location); 4: fracture line in addition to severe marrow or periosteal edema on either T1WI or T2WI (Fig. 1) [15–16]. We chose the most severe injury for bilateral pubic bone injury to do the next analysis.

2. The levator ani muscle assessment

2.1 Morphological evaluation

LAM morphological injury referred to a visible avulsion on T2WI. The LAM scoring system was used to assess the injury severity. A score of “0” indicated invisible avulsion; “1” if less than half of muscle was lost, “2” if more than half of muscle was lost; and “3” if the origin of the insertion part was disrupted (Fig. 2). The bilateral muscles were categorized from 0 to 6: a score as 0 indicated no defect, a score as 1–3 indicated a minor defect, and a score as 4–6 indicated a major defect. A unilateral score of 3 or a bilateral score of 4–6 indicated a major defect [17–18].

2.2 Functional evaluation

The measurements of LAM related to function on MRI included H line, M line, levator plate angle (LPA), iliococcygeal angle (ICA), and levator hiatus area (LHA) [19–20]. The schematics are presented in Fig. 3. All parameters were measured at rest and straining.

Statistical Analysis

Statistical analyses were performed with SPSS software version 22.0 (IBM Corporation, Armonk, NY, USA). Kolmogorov-Smirnov test was used to assess the normal distribution of the continuous variables. The data were described as mean and standard deviations, median and interquartile ranges. Categorical variables were expressed as frequency and percent. Independent-sample t-tests, Mann-Whitney U-test, Chi-square test, and Fisher’s exact tests were appropriately used to compare the differences between two groups. The Spearman correlation coefficient or Kendall’s tau-b correlation coefficient was used to investigate the correlation between the severity of pubic bone injury and LAM abnormalities. $P < 0.05$ was considered a significant difference.

Results

The clinical characteristics

There were no significant differences in obstetric characteristics between two groups. However, a more significant percentage of primiparas in the pubic bone injury group suffered from pelvic girdle pain or stress incontinence compared with the non-pubic bone injury group (28% vs. 9.3%, $P = 0.003$; 29.3% vs. 13.3%, $P = 0.017$, respectively) (Table.1).
The morphological and functional evaluation of levator ani muscle

50.67% (38/75) of primiparas in the pubic bone injury group had a visible LAM avulsion; of these, 8% (6/75) had major defects, and 42.7% (32/75) had minor defects. However, only 24% (18/75) of primiparas in the non-pubic bone group had apparent muscle defects, and most primiparas had a normal appearance of the LAM. There was a significant difference in the percentage of LAM defects between the pubic bone injury group and the non-pubic bone injury group ($P = 0.002$) (Fig. 4).

The M lines and LHA at rest and straining of primiparas with pubic bone injury were significantly enlarged compared with those without pubic bone injury (all $P < 0.05$). Primiparas with pubic bone injury had more prolonged H lines at straining ($P = 0.025$). The remaining measurements were comparable between groups (Table 2, Fig. 5).

The correlation between pubic bone injury and levator ani muscle injury

A positive correlation was found between the pubic bone injury score and LAM morphological injury score ($r = 0.332, P < 0.001$), M lines at rest and straining ($r = 0.139, P = 0.025; r = 0.150, P = 0.015$, respectively), and LHA at rest and straining ($r = 0.181, P = 0.004; r = 0.164, P = 0.008$, respectively) (Fig. 6).

Discussion

We investigated the incidence of LAM injury in primiparas with obviously pubic bone injury and the underlying relationship between pelvic floor muscle injury and bony injury induced by childbirth. In our study, we mainly draw three conclusions. Firstly, primiparas with pubic bone injuries were more likely to have pelvic girdle pain and stress incontinence symptoms. Secondly, the percentage of LAM morphological injury and function measurements were significantly different between primiparas with and without pubic bone injury. At last, the pubic bone injury score was linearly relative to the LAM morphological injury score; meanwhile, the H line at straining, the M line and LHA at rest and straining were enlarged in the pubic bone injury group.

Our study found that up to 28% of primiparas with pubic injury had pelvic girdle pain. Previous research has confirmed a link between chronic pelvic pain and pubic bone injury [4]. Besides pelvic pain, stress urinary incontinence was more prevalent in primiparas with pubic bone injury. As a component of the anterior compartments, the pubic bone, bladder urethra, and pelvic floor support structures were anatomically interrelated and relied on each other. For example, the tendinous arch of pelvic fascia (TAPF) and pubovesical ligament were attached to the pubic bone, and birth trauma to the pubic bone may involve the adjacent urethral supporting system, which was responsible for postpartum SUI [21].
In our study, the primiparas with pubic bone injury were more likely to suffer from LAM morphological injury than those without injury. As reported in the previous study, LAM avulsion has been reported in 13–36% of parous women [7–11]. 24% of primiparas without pubic bone injury were detected with LAM injury, consistent with the incidence reported by the above studies. However, in the pubic bone injury group, we found that the percentage of LAM injury was up to 50.67%, twice as much as in the non-bone injury group, indicating that primiparas suffering from pubic bone injury take a high risk of LAM injury.

Several explanations existed for the underlying relationship between pubic bone injury and LAM injury during childbirth [1]. A series of conditions, such as fetal head descent, dorsiflexion, rotation, posterior rotation, and baby delivery, as well as the pushing of maternal abdominal force during the second stage of labor, could cause different degrees of compression on both the pubic bone and LAM. Exceptionally high floating fetal heads, large infant bodies, and rapid descent of the fetal head, the severe compression events drove the development of pubic bone marrow edema and fracture. Meanwhile, a previous study reported that the expansion of the pelvic floor hiatus and the extreme stretching of the LAM could reach 217% of its maximum stretch, which was 3.26 times that of other skeletal muscles, causing the muscle to avulsion and avulsion fracture of the pubic bone [22–23].

It could explain that the pubic bone injury and LAM injury coincide based on the above background. However, the correlation between each other was weaker. As we all know, pubic bone injuries may also be caused by apparent compression. Compared to the pubic bone, which had a fixed morphology, the LAM was more capable of contraction and diastole and could vary significantly. LAM was inclined to functional decompensation instead of morphological changes regarding permanent or dramatic compression. Then we propose that if there are any changes in LAM microstructure, we will analyze the correlation between the two groups.

An "H line" showed the anterior-posterior width of the pelvic floor hiatus. An "M line" showed the degree of pelvic floor descent. The "LHA" referred to the ability to close a pelvic floor hiatus [24]. Our study found primiparas with pubic bone injury had more prolonged H lines at straining, more extensive M lines, and LHA at rest and straining. Meanwhile, there was a positive relationship between the pubic bone injury score and the M line at rest and straining as well as the LHA at rest and straining. These pelvic floor measurements indicated a significant reduction of LAM function in the pubic bone injury group. Quantitative imaging measurements represented abnormal microstructural changes in the LAM, such as edema, invisible defect, or altered alignment of some small fiber bundles. Also, irreversible overdistension of the LHA may indicate microtrauma [25].

Our study had some limitations. Firstly, we only had postnatal imaging features and an absence of prenatal. We could only rely on the previous history of the primiparas to rule out pre-pregnancy pubic bone abnormalities. In addition to labor and delivery-related pubic bone injury, there were many other causes of pubic bone injury during pregnancy and delivery, including hormone-induced osteoporosis, micronutrient deficiency, and fetal head compression [26–27]. We did not include the above information.
A future study was required to fully explain the location of the pubic bone injury concerning the specific site and grade of LAM avulsion.

In conclusion, childbirth-related pubic bone injury can suggest LAM morphological injury; the more severe the injury to the pubic bone, the more serious the injury to the LAM. Additionally, pubic bone injury can suggest a poor function of LAM. Nonetheless, when a parous woman appears with a history of significant pain in the pubic area, additional evaluation of LAM morphology and function is recommended for excluding abnormalities.

**Declarations**

**Acknowledgments**

The authors would like to thank the Department of Obstetrics and Gynecology of Tianjin First Central Hospital for assistance in case collection.

**Authors' contributions**

Cheng Zhang: Project development, Data analysis, Manuscript writing

Yujiao Zhao: Project administration, Resources, Supervision, Manuscript editing

Cong You: Data management, Investigation, Software

Xiaotian Li: Data management, Investigation, Software

Yanhong Wu: Data management, Investigation, Software

Xiaodong Zhang: Software, Validation, Visualization

Wen Shen: Funding acquisition, Project administration, Resources, Supervision, Manuscript editing

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Cheng Zhang, Yujiao Zhao and Cong You. Data management, investigation and validation were performed by Xiaotian Li, Yanhong Wu and Xiaodong Zhang. Funding acquisition, project administration, supervision and manuscript editing were performed by Wen Shen and Yujiao Zhao. The first draft of the manuscript was written by Cheng Zhang and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Competing Interests

The authors of this manuscript declare no relationships with any companies whose products or services may be related to the subject matter of the article.

Ethics approval

This study was approved by the Institutional Review Board in Tianjin First Central Hospital (2022DZX14). It was conducted in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

Consent to participate

Written informed consent was obtained from all individual participants included in the study.

Consent to publish

The authors affirm that human research participants provided informed consent for publication of the images in Figure(s) 1, 2 and 3.

References


**Tables**

**Table 1** Comparison of clinical characteristics in primiparas with and without pubic bone injury

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>PBI group (n=75)</th>
<th>NPBI group (n=75)</th>
<th>t/c² value</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Demographics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (y)</td>
<td>29.12±2.85</td>
<td>28.76±3.57</td>
<td>-0.682a</td>
<td>0.496</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>1.63±0.05</td>
<td>1.64±0.04</td>
<td>0.600a</td>
<td>0.549</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>63.69±8.02</td>
<td>63.25±7.84</td>
<td>-0.340a</td>
<td>0.734</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>23.91±3.14</td>
<td>23.57±2.62</td>
<td>-0.730a</td>
<td>0.467</td>
</tr>
<tr>
<td>Interval delivery-MRI (d)</td>
<td>52.40±10.48</td>
<td>54.27±10.35</td>
<td>1.097a</td>
<td>0.274</td>
</tr>
<tr>
<td><strong>Birth-related variables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Second stage ≥150 min</td>
<td>9 (12.00)</td>
<td>6 (8.00)</td>
<td>0.667b</td>
<td>0.414</td>
</tr>
<tr>
<td>Fetal weight (kg)</td>
<td>3.37±0.37</td>
<td>3.30±0.37</td>
<td>1.097a</td>
<td>0.261</td>
</tr>
<tr>
<td>Anal sphincter tear</td>
<td>2 (2.67)</td>
<td>1 (1.33)</td>
<td>-</td>
<td>0.999</td>
</tr>
<tr>
<td>Forceps delivery</td>
<td>10 (13.33)</td>
<td>7 (9.33)</td>
<td>0.597b</td>
<td>0.440</td>
</tr>
<tr>
<td><strong>Symptoms</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pelvic girdle pain</td>
<td>21 (28.00)</td>
<td>7 (9.33)</td>
<td>8.607b</td>
<td>0.003*</td>
</tr>
<tr>
<td>Stress incontinence</td>
<td>22 (29.33)</td>
<td>10 (13.33)</td>
<td>5.720b</td>
<td>0.017*</td>
</tr>
<tr>
<td>Vaginal obstruction</td>
<td>8 (10.67)</td>
<td>3 (4.00)</td>
<td>2.453b</td>
<td>0.117</td>
</tr>
<tr>
<td>Defecation disorder</td>
<td>2 (2.67)</td>
<td>0 (0.00)</td>
<td>-</td>
<td>0.497</td>
</tr>
</tbody>
</table>

Note: Data are given as mean ± SD or n (%). a t-value, b chi-squared value, - no data, * represent statistical significance. PBI=pubic bone injury. NPBI=non-pubic bone injury. BMI=body mass index.

**Table 2** Comparison of LAM function in primiparas with and without pubic bone injury
<table>
<thead>
<tr>
<th>Measurements</th>
<th>PBI group (n=75)</th>
<th>NPBI group (n=75)</th>
<th>U/t value</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>H line (mm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At rest</td>
<td>62.34±6.95</td>
<td>61.14±6.66</td>
<td>-1.075</td>
<td>0.284</td>
</tr>
<tr>
<td>At straining</td>
<td>70.86±11.07</td>
<td>66.80±10.94</td>
<td>-2.258</td>
<td>0.025*</td>
</tr>
<tr>
<td>M line (mm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At rest</td>
<td>22.61 (18.20, 26.69)</td>
<td>18.84 (15.63, 25.73)</td>
<td>-2.456</td>
<td>0.014*</td>
</tr>
<tr>
<td>At straining</td>
<td>32.81±9.49</td>
<td>27.81±9.96</td>
<td>-3.153</td>
<td>0.002*</td>
</tr>
<tr>
<td>LPA (°)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At rest</td>
<td>49.78±10.37</td>
<td>49.38±8.68</td>
<td>-0.256</td>
<td>0.799</td>
</tr>
<tr>
<td>At straining</td>
<td>56.50 (49.10, 66.55)</td>
<td>47.40 (39.80, 56.50)</td>
<td>-0.605</td>
<td>0.545</td>
</tr>
<tr>
<td>R-ICA (°)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At rest</td>
<td>37.41±6.63</td>
<td>36.00±7.49</td>
<td>-1.219</td>
<td>0.225</td>
</tr>
<tr>
<td>At straining</td>
<td>49.10 (42.30, 56.70)</td>
<td>47.40 (39.80, 56.50)</td>
<td>-0.643</td>
<td>0.520</td>
</tr>
<tr>
<td>L-ICA (°)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At rest</td>
<td>36.78±7.42</td>
<td>34.88±6.58</td>
<td>-1.657</td>
<td>0.100</td>
</tr>
<tr>
<td>At straining</td>
<td>49.94 (43.00, 55.00)</td>
<td>47.00 (38.20, 58.70)</td>
<td>-0.915</td>
<td>0.360</td>
</tr>
<tr>
<td>LHA (mm²)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At rest</td>
<td>1185.67 (1058.63, 1419.92)</td>
<td>1097.00 (961.40, 1240.14)</td>
<td>-3.103</td>
<td>0.002*</td>
</tr>
<tr>
<td>At straining</td>
<td>2547.24 (2003.26, 3710.15)</td>
<td>1930.81 (1395.46, 3280.60)</td>
<td>-3.178</td>
<td>0.001*</td>
</tr>
</tbody>
</table>

Note: Data are given as mean ± SD or M (P_{25}, P_{75}). * Represent statistical significance. PBI=pubic bone injury. NPBI=non-pubic bone injury. LPA=levator plate angle. R-ICA =right iliococcygeal angle. L-ICA =left iliococcygeal angle. LHA=levator hiatus area.

**Figures**
Figure 1

Pubic bone injury grading A, Normal pubic bone on fat-suppressed T2WI, B, Bilateral grade 1 of the pubic bone on fat-suppressed T2WI with increased signal confined to the subchondral bone at the pubic symphysis (arrow), C, Grade 2 of the right pubis on fat-suppressed T2WI which does not diffuse the entire pubic body (arrow), D, Grade 3 of the left pubis on fat-suppressed T2WI, diffusing over the entire pubic body (arrow), E&F, Grade 4 of the right pubis on fat-suppressed T2WI and T2WI, with a linear low-signal fracture line on T1WI (arrow), Grade 3 of left pubis.
**Figure 2**

LAM injury grading A, Normal LAM on T2WI, B, Grade 1 of the left LAM on T2WI with <50% muscle fiber loss at the pubic symphysis attachment (arrow), C, Grade 2 of the right LAM on T2WI with >50% muscle fiber loss at the pubic symphysis attachment (arrow), D, Grade 3 of bilateral LAM on T2WI with complete rupture of the LAM at the pubic symphysis attachment and retraction of the severed end (arrow).
A schematic of measurements of LAM related to function on MRI. A, An “H line” is measured from the inferior tip of the pubic symphysis to the posterior circular fibers of the anorectal junction on Mid-sagittal T2WI. An “M line” is drawn perpendicularly down from the PCL to the posterior extent of the H-line at the posterior aspect of the anorectal junction on Mid-sagittal T2WI. B, Levator plate angle (LPA) is measured between the levator plate and the horizontal line on Mid-sagittal T2WI. C, Iliococcygeal angle (ICA) is measured between the iliococcygeal muscle and the pelvic horizontal plane on perineal coronal T2WI. D, Levator hiatus area (LHA) is drawn with anteriorly the inferior of the pubis, posteriorly the inner aspect of puborectalis muscle at the anorectal angle, and bilaterally the pubovisceral muscles on inferior pubic symphysis' axial T2WI.

**Figure 3**
Figure 4

A dot plot of LAM morphological injury between groups with and without pubic bone injury PBI = pubic bone injury. NPBI = non-pubic bone injury. LAM = levator ani muscle.
Figure 5

A histogram of LAM functional injury between groups with and without pubic bone injury. LPA = levator plate angle. R-ICA = right iliococcygeal angle. L-ICA = left iliococcygeal angle. LHA = levator hiatus area. PBI = pubic bone injury. NPBI = non-pubic bone injury.
Figure 6

A heatmap of correlation between pubic bone injury score and LAM injury. PBIS = pubic bone injury score. LAMIS = LAM morphological injury score. H line-R = H line at rest. M line-R = M line at rest. LHA-R = levator hiatus area at rest. LICA-R = left iliococcygeal angle at rest. RICA-R = right iliococcygeal angle at rest. LPA-R = levator plate angle at rest. H line-S = H line at straining. M line-S = M line at straining. LHA-S = levator hiatus area at straining. LICA-S = left iliococcygeal angle at straining. RICA-S = right iliococcygeal angle at straining. LPA-S = levator plate angle at straining.