GYNECOLOGY

# Pelvic floor morphometry and function in women with and without puborectalis avulsion in the early postpartum period

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**BACKGROUND:** Pelvic floor muscles are subject to considerable stretching during vaginal birth. In 13-36% of women, stretching results in avulsion injury whereby the puborectalis muscle disconnects from its insertion points on the pubis bone. Until now, few studies have investigated the effect of this lesion on pelvic floor muscles in the early postpartum period.

**OBJECTIVE:** The primary aim of this study was to compare pelvic floor muscle morphometry and function in primiparous women with and without puborectalis avulsion in the early postpartum period. Our secondary objective was to compare the 2 groups for pelvic floor disorders and impact on quality of life.

**STUDY DESIGN:** In all, 52 primiparous women diagnosed with (n = 22) or without (n = 30) puborectalis avulsion injury were assessed at 3 months postpartum. Pelvic floor muscle morphometry was evaluated with 3-/4-dimensional transperineal ultrasound at rest, maximal contraction, and Valsalva maneuver. Different parameters were measured in the midsagittal and axial planes: bladder neck position, levator plate angle, anorectal angle, and levator hiatus dimensions. The dynamometric speculum was used to assess pelvic floor muscle function including: passive properties (passive forces and stiffness) during dynamic stretches, maximal strength, speed of contraction, and endurance. Pelvic floor disorder—related symptoms (eg, urinary incontinence, vaginal and bowel symptoms) and impact on quality of life were evaluated with the International Consultation on Incontinence Questionnaire and the Pelvic Floor Impact Questionnaire-Short Form. Pelvic Organ Prolapse Quantification was also assessed.

**RESULTS:** In comparison to women without avulsion, women with avulsion presented an enlarged hiatus area at rest, maximal contraction, and Valsalva maneuver ($P \leq .013$) and all other ultrasound parameters were found to be significantly altered during maximal contraction ($P \leq .014$). They showed lower passive forces at maximal and 20-mm vaginal apertures as well as lower stiffness at 20-mm aperture ($P \leq .048$). Significantly lower strength, speed of contraction, and endurance were also found in women with avulsion ($P \leq .005$). They also presented more urinary incontinence symptoms ($P = .040$) whereas vaginal and bowel symptoms were found to be similar in the 2 groups. Pelvic Organ Prolapse Quantification revealed greater anterior compartment descent in women with avulsion ($P \leq .010$). The impact of pelvic floor disorders on quality of life was found to be significantly higher in women with avulsion ($P = .038$).

**CONCLUSION:** This study confirms that pelvic floor muscle morphometry and function are impaired in primiparous women with puborectalis avulsion in the early postpartum period. Moreover, it highlights specific muscle parameters that are altered such as passive properties, strength, speed of contraction, and endurance.

**Key words:** childbirth, dynamometry, pelvic floor disorders, puborectalis avulsion, ultrasound

## Introduction

Vaginal delivery is the most important risk factor for developing pelvic floor disorders such as urinary and fecal incontinence as well as pelvic organ prolapse (POP).[1] It is recognized that trauma to the pelvic floor muscles (PFMs) can occur during childbirth, manifesting as a muscle injury, a rupture of the connective tissue, a nerve injury, or all 3.[2] These injuries are known to jeopardize pelvic organ support and continence. A common muscle injury that has received growing scientific and clinical attention in the last decade is avulsion of the puborectalis muscle. Occurring in 13-36% of primiparous women,[3] avulsion is defined as a detachment of the muscle from its insertion on the pubic bone.

Few studies have investigated the impact of avulsion on PFM morphometry and function in the early postpartum period.[4-9] Transperineal ultrasound has been the most common method of investigating morphological changes in the PFMs postpartum but this methodology only takes into account the geometric changes of the muscle and does not allow a direct PFM assessment.[10,11] Studies using direct assessment methods report contradictory results, with some showing that women with avulsion have a lower PFM strength compared to women with intact muscle[6] whereas others found a nonsignificant difference between the 2 groups.[8] Likewise, the effect of avulsion on PFM tone was found by Brincat et al[4] but not by Hilde et al.[7] These inconsistencies may be explained by methodological issues in PFM function assessment such as the subjectivity of vaginal palpation and techniques related to tone evaluation. Since evidence is lacking about the effect of avulsion on the PFMs in early postpartum, we combined 2 methods, namely ultrasound and dynamometry, to undertake a more comprehensive evaluation and overcome the limitation of current assessment tools.

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Although a strong relationship between avulsion injury and long-term development of prolapse has been clearly demonstrated,[12,13] this effect remains poorly studied in women in the early postpartum period.[5,8,9,14] This is particularly relevant considering that prolapse may be present early after muscle trauma and may not necessarily develop after a substantial period of time. Likewise, the association of avulsion with urinary and fecal incontinence in postpartum is not well understood.[15]

Therefore, given the paucity of data on the impact of avulsion on PFM morphology and function in the early postpartum period, we combined transperineal ultrasound imaging with validated dynamometric measurements to compare PFM morphometry and function in primiparous women with and without a puborectalis avulsion injury in the early postpartum period. The secondary objective was to compare the 2 groups for pelvic floor disorders and related impact on quality of life.

## Materials and Methods

### Participants

A total of 58 women >18 years old who had their first vaginal delivery at term (>37 weeks of gestation) were recruited by means of invitation letters, leaflets, and posters. Women at 3 months postpartum with known risk factors for avulsion were specifically targeted.[16-18] To be included, participants had to have at least 1 of the risk factors for avulsion: use of forceps, prolonged (≥120 minutes) or precipitous (≤30 minutes) second stage of labor, third- or fourth-degree perineal tear, fetal occiput posterior position, or maternal age >35 years.[16-18] Exclusion criteria were: (1) previous pregnancies (>18 weeks); (2) past pelvic irradiation, urogynecologic surgery, or PFM physiotherapy; or (3) current medical conditions (ie, cancer, vaginal or urinary infection, chronic constipation according to the Rome III criterion)[19] or ongoing treatments that could influence the evaluation outcomes.

The study took place at the Research Center of the Centre Hospitalier Universitaire de Sherbrooke. The local institutional ethics committee approved the study and each participant provided informed written consent.

### Procedure

Women interested in participating in the study were invited to contact the research assistant to take part in a screening telephone interview. All eligible participants attended an assessment including a structured interview for collecting sociodemographic, medical, gynecological, and obstetrical information. Any additional delivery data were accessed from the patient's medical records. Thereafter, a pelvic floor examination was conducted by an experienced physiotherapist-assessor blinded to the avulsion status. Participants adopted a supine position on a conventional gynecological examination table with their feet in stirrups. The diagnosis of avulsion was determined offline using a validated tomographic ultrasound protocol by 3 independent assessors blinded to the clinical delivery outcomes.[20] Agreement in the avulsion diagnosis had to be unanimous according to all 3 assessors, all of whom had an extensive experience and knowledge in pelvic floor ultrasound (V.W., M.M., and J.K.). Participants diagnosed with a complete avulsion were included in the avulsion group and those without avulsion were in the no-avulsion group. Women presenting with partial avulsion were excluded.

### Main outcomes

#### PFM morphometry

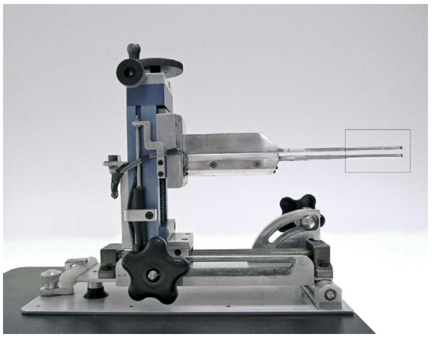
PFM morphometry was evaluated using transperineal ultrasound imaging (Voluson E8 Expert BT10; GE Healthcare) with a 3-/4-dimensional transperineal probe (RM6C next-generation matrix). The physiotherapist conducted the measurements at rest, during maximum PFM contraction and Valsalva maneuver, after bladder emptying. Each maneuver was performed twice and the ultrasound volume with the highest anorectal angle displacement was considered for analysis. Morphometry was assessed by measuring the following parameters in the midsagittal plane and axial plane (taken at the level of minimal hiatal dimensions)[21] according to a previously published methodology[21-25]: bladder neck position defined as the *x*-axis and *y*-axis positions, levator plate angle, anorectal angle, levator hiatus area, levator hiatal anteroposterior, and left-right transverse diameters. Ultrasound data were analyzed offline with software (4D View, Version 10.2; GE Healthcare) by an observer blinded to the avulsion status. Previous studies have shown good test-retest and interrater reliability for all parameters.[22,23,25-30]

#### PFM function

The PFM function was assessed using a dynamometric speculum. A complete description of this technology was published previously.[31-36] It should be noted that the size of the speculum branches was reduced to allow assessment of women who might experience pain, such as those who have had traumatic vaginal delivery (Figure).

Prior to conducting the PFM function assessment, detailed instructions on PFM contraction were given and digital palpation was used to ascertain adequate isolated PFM contraction. Speculum branches covered with a condom and lubricated with a hypoallergenic gel were then inserted into the vaginal cavity. To ensure comfort and familiarization with the dynamometer, women were asked to

**FIGURE**
**Dynamometric speculum**



Speculum set to minimal aperture. Portion of speculum inserted into vagina (dotted rectangle).

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perform 3 unrecorded PFM contractions. The PFM function was evaluated under 6 conditions for which the reliability and validity of the parameters measured have been demonstrated.[32-36] First, passive forces (N) were assessed at minimal vaginal aperture (corresponding to an 11-mm anteroposterior diameter).[35,36] Second, passive forces at maximal aperture, determined by the participant's tolerance, were also evaluated.[35,36] Third, passive properties were measured during 5 stretch-relax cycles including a lengthening phase (ie, separation of the branches until maximal aperture) and a shortening phase at a constant speed of 5 mm/s.[35,36] All parameters were averaged for cycles 3-4-5 as proposed by Morin et al.[35] Forces (N) and passive elastic stiffness (PES) (change in forces/change in vaginal aperture [N/mm]) were extracted at minimal, maximal, and a common aperture of 20 mm. Vaginal aperture (mm) at a common force of 2 N was also obtained. Fourth, for the maximal strength test,[32] women were asked to strongly contract their PFMs for 15 seconds and the maximal force minus the baseline force was calculated. Fifth, during the speed test,[34] participants were instructed to contract maximally and relax as fast as possible for 15 seconds. The speed of contraction and coordination were defined as the rate of force development of the first contraction (N/s) and the number of contractions performed, respectively. Sixth, the endurance test[32,34] consisted of a maximal contraction sustained >90 seconds. The area under the force curve taken between 10-60 seconds after the beginning of the effort was computed (N*s). The average of 2 trials was considered for the conditions 1, 2, and 4. Dynamometric data analysis was conducted offline by an assessor blinded to the avulsion status.

### Pelvic floor disorder-related symptoms and impact on quality of life

International Consultation on Incontinence Questionnaire (ICIQ) modules were used to evaluate the severity of pelvic floor disorders, including the ICIQ-Urinary Incontinence Short Form,[37] the ICIQ-Vaginal Symptoms,[38] and the ICIQ-Bowel.[39] The Pelvic Floor Impact Questionnaire-Short Form[40-42] allowed the assessment of quality-of-life impact using 3 subscales: the Urinary Impact Questionnaire, the POP Impact Questionnaire, and the Colorectal-Anal Impact Questionnaire. Furthermore, clinical prolapse assessment was assessed with the International Continence Society POP Quantification (POP-Q) system.[43]

### Statistical analyses

Statistical analyses were performed using software PASW Statistics, Version 18.0 (SPSS Inc, Chicago, IL). Normality was checked using the Kolmogorov-Smirnov test. To compare women with and without avulsion, Student *t* test and the Mann-Whitney *U* test were used according to the distribution normality. The $\chi^2$ tests were used for categorical data. Effect sizes were calculated with $\eta^2$ to better appreciate the significance (.01 indicated a small effect, .06 a medium effect, and ≥.14 a large effect).[44] *P* values ≤.05 were considered statistically significant.

## Results

From the 58 women assessed, 22 (38%) were diagnosed as having a complete avulsion while 30 (52%) showed no avulsion. Six women (10%) had only a partial avulsion and were excluded from analysis. The participants were aged 29.3 (SD 5.3) years, had a mean body mass index of 26.3 (SD 5.5), and were mainly Caucasian (98%). The mean gestational age at delivery was 39.7 (SD 1.2) weeks. The mean baby weight was 3.23 (SD .45) kg and head circumference was 34.06 (SD 1.92) cm. In all, 50 women (96%) had intrapartum analgesia, 19 (37%) had episiotomy, 32 (62%) had forceps, 4 (8%) had vacuum, 9 (17%) had an occiput posterior fetal position, 16 (31%) had a third-degree tear, and none had a fourth-degree tear. The median of the active second stage of labor was 59 (interquartile range 28-120) minutes. The assessments were conducted at a mean delay from childbirth of 13.2 (SD 2.4) weeks. Of the 22 women with a complete avulsion, 10 (45%) had a unilateral injury and 12 (55%), bilateral injuries.

A comparison of PFM morphometry in women with and without avulsion is presented in Table 1. There was a statistically significant enlargement for levator hiatus areas at rest and during contraction and Valsalva in women with avulsion ($P \leq .013$) and all parameters presented a deficit during maximal contraction ($P \leq .014$) (except for the anorectal angle, all other parameters have $\eta^2 \geq .14$ indicating a large effect size).

The PFM function assessed with the dynamometric speculum is shown in Table 2. During stretching, women with avulsion showed significantly lower passive forces at 20-mm and maximal vaginal apertures than women with no avulsion. Lower PES at 20-mm aperture as well as greater vaginal aperture at 2 N were also observed in women with avulsion, suggesting a lower PFM tone. Given that muscle length and, thus, vaginal aperture were shown to influence passive properties,[32] it should be stressed that the 2 groups were assessed at similar vaginal apertures ($P \leq .224$). Women with avulsion also demonstrated lower maximal strength, endurance, and speed of contraction ($P \leq .005$, $\eta^2 \geq .151$ indicating a large effect size).

Pelvic floor disorders and impact on quality of life are given in Table 3. Women with avulsion had a higher score for urinary incontinence severity ($P = .040$) than women without avulsion whereas vaginal and bowel symptoms were found nonsignificantly different between the 2 groups. The overall impact of pelvic floor disorders on quality of life was significantly higher in women with avulsion. However, when comparing questionnaire subscales, the impact of vaginal symptoms was significant ($P = .041$), a trend was observed for the impact of urinary incontinence ($P = .068$), and the impact of bowel symptoms between the 2 groups was not significantly different.

Regarding POP-Q scores between women with and without avulsion (Table 4), significant differences were identified for points Aa and Ba ($P \leq .010$) implying greater anterior compartment prolapse in women with avulsion.

**TABLE 1**
**Pelvic floor muscle morphometry**

| Parameters | Complete avulsion n = 22 Mean ± SD | No avulsion n = 30 Mean ± SD | *P* value | Effect size, $\eta^2$ |
|---|---|---|---|---|
| Rest | | | | |
| Bladder neck position — *y*-axis, cm | 2.62 ± 0.26 | 2.78 ± 0.25 | .034 | .087 |
| Bladder neck position — *x*-axis, cm | 0.09 ± 0.58 | −0.13 ± 0.53 | .155 | .040 |
| Levator plate angle, degrees | 27.45 ± 7.69 | 29.89 ± 7.27 | .248 | .027 |
| Anorectal angle, degrees | 115.38 ± 6.49 | 114.29 ± 6.99 | .567 | .007 |
| Levator hiatus area, $cm^2$ | 15.21 ± 3.17 | 12.15 ± 2.08 | <.001 | .237 |
| Levator hiatus AP diameter, cm | 5.52 ± 0.49 | 5.20 ± 0.58 | .043 | .079 |
| Levator hiatus LR diameter, cm | 4.62 ± 0.75 | 3.61 ± 0.37 | <.001 | .402 |
| Maximal contraction | | | | |
| Bladder neck position — *y*-axis, cm | 2.59 ± 0.30 | 2.86 ± 0.35 | .006 | .140 |
| Bladder neck position — *x*-axis, cm | −0.22 ± 0.64 | −0.73 ± 0.56 | .003 | .160 |
| Levator plate angle, degrees | 33.34 ± 10.32 | 41.84 ± 8.26 | .002 | .179 |
| Anorectal angle, degrees | 113.51 ± 7.95 | 108.09 ± 7.26 | .014 | .115 |
| Levator hiatus area, $cm^2$ | 13.82 ± 2.69 | 9.79 ± 1.51 | <.001 | .444 |
| Levator hiatus AP diameter, cm | 5.01 ± 0.55 | 4.26 ± 0.60 | <.001 | .295 |
| Levator hiatus LR diameter, cm | 4.29 ± 0.77 | 3.30 ± 0.33 | <.001 | .393 |
| Valsalva maneuver | | | | |
| Bladder neck position — *y*-axis, cm | 1.65 ± 0.75 | 1.54 ± 0.94 | .667 | .004 |
| Bladder neck position — *x*-axis, cm | 1.43 ± 0.68 | 1.30 ± 0.84 | .557 | .007 |
| Levator plate angle, degrees | 21.63 ± 7.42 [a]n = 19 | 17.52 ± 10.11 [a]n = 29 | .112 | .054 |
| Anorectal angle, degrees | 115.93 ± 5.25 [a]n = 19 | 110.54 ± 11.15 [a]n = 29 | .029 | .099 |
| Levator hiatus area, $cm^2$ | 21.22 ± 4.66 [a]n = 18 | 17.35 ± 5.03 [a]n = 27 | .013 | .136 |
| Levator hiatus AP diameter, cm | 5.97 ± 0.75 [a]n = 19 | 5.72 ± 0.87 [a]n = 29 | .326 | .021 |
| Levator hiatus LR diameter, cm | 5.13 ± 0.73 [a]n = 18 | 4.16 ± 0.51 [a]n = 27 | <.001 | .354 |

*AP*, anteroposterior; *LR*, left-right transverse.

[a] For some participants, anatomic landmarks were lost during Valsalva maneuver, making ultrasound analyses impossible.

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## Comment

Our findings reveal, through a comprehensive PFM assessment combining ultrasound and dynamometric measurements, that primiparous women with avulsion in the early postpartum period have impaired PFM morphometry and function such as passive properties, strength, speed of contraction, and endurance compared to women without avulsion. Women with avulsion also present more symptoms of pelvic floor disorders, namely incontinence, as well as greater anterior compartment descent.

Comparison of PFM tone in women with and without avulsion has been investigated through a combined evaluation of PFM morphometry and passive properties using transperineal ultrasound and dynamometry, respectively. An enlarged levator hiatus was found in women with avulsion, which is consistent with findings from other studies.[45,46] As underlined by Bo and Sherburn,[11] ultrasound assessment of PFM morphometry remains an indirect evaluation of muscle that should be complemented by another direct assessment technique. This is the first study to examine the passive properties of PFMs during dynamic stretching in women with avulsion, which is highly relevant considering that passive properties of muscles are time-dependent.[47] Moreover, it enables the PFM passive properties to be evaluated at different vaginal apertures and thus sheds light on current controversies in the literature about the related impact of avulsion on PFM tone. We showed that women with avulsion had lower passive forces than women with intact muscle at 20-mm vaginal aperture while the passive forces at minimal aperture were found nonsignificantly different between the 2 groups. This is in line with Brincat et al[4] who showed lower passive forces in women with avulsion using a comparable dynamometer with a 25-mm aperture, while Hilde et al[7] reported no statistical difference using a smaller manometer with a 17-mm aperture. Our study thus emphasizes the importance of the vaginal aperture in the assessment of PFM tone. It can be argued that smaller apertures could not allow proper contact of the device with the PFMs, thus leading to inconclusive results. Moreover, assessment at smaller vaginal apertures was also found to be related to lower reliability[35] and thereby contributes to the nonsignificant difference observed. Considering the relationship between passive forces and PFM length,[36,48] our results also support the notion that an increased vaginal aperture may facilitate intergroup comparison, with a moderate aperture showing the largest effect size. Furthermore, PFM dynamic stretching also allows evaluation of PES, a widely used parameter in skeletal muscle assessment.[47,49] Lower PES was found in women with avulsion at 20-mm aperture with a large effect size, which further supports viscoelastic alterations in women with avulsion.

TABLE 2
**Pelvic floor muscle function**

| Parameters | Complete avulsion n = 22 Mean ± SD | No avulsion n = 30 Mean ± SD | *P* value | Effect size, $\eta^2$ |
|---|---|---|---|---|
| Initial passive resistance at minimal vaginal aperture | | | | |
| Passive forces, N | 0.87 ± 0.33 | 1.02 ± 0.52 | .245 | .030 |
| Passive resistance at maximal vaginal aperture | | | | |
| Passive forces, N | 7.86 ± 3.83 | 8.57 ± 4.23 | .537 | .008 |
| Maximal aperture, mm | 38.87 ± 10.51 | 35.38 ± 9.76 | .224 | .029 |
| Dynamic stretches during lengthening and shortening cycles | | | | |
| Force at minimal aperture, N | 0.20 ± 0.46 | 0.20 ± 0.33 | .990 | <.001 |
| Force at maximal aperture, N | 8.73 ± 4.09 | 11.30 ± 4.79 | .048 | .076 |
| Force at common aperture of 20 mm, N | 1.72 ± 0.55 [a]n = 20 | 2.62 ± 1.27 [a]n = 29 | .002 | .195 |
| PES at minimal aperture, N/mm | 0.37 ± 0.18 | 0.42 ± 0.15 | .278 | .023 |
| PES at maximal aperture, N/mm | 0.64 ± 0.35 | 0.54 ± 0.46 | .403 | .014 |
| PES at common aperture of 20 mm, N/mm | 0.22 ± 0.10 [a]n = 20 | 0.37 ± 0.20 [a]n = 29 | .001 | .219 |
| Vaginal aperture at common force of 2 N, mm | 21.69 ± 4.32 | 19.12 ± 3.50 [a]n = 29 | .023 | .101 |
| Maximal strength test (15 s) | | | | |
| Maximal strength, N | 1.05 ± 0.68 | 2.60 ± 1.87 | <.001 | .259 |
| Speed test (15 s) | | | | |
| Coordination evaluated by no. of contractions | 8.45 ± 3.82 | 8.47 ± 3.01 | .990 | <.001 |
| Speed of contraction measured as rate of force development, N/s | 1.35 ± 1.09 | 3.17 ± 3.09 | .005 | .151 |
| Endurance test (90 s) | | | | |
| Endurance on 50 s, N × s | 18.03 ± 10.81 | 59.43 ± 58.20 | .001 | .225 |

*PES*, passive elastic stiffness.

[a] Three participants did not reach vaginal aperture of 20 mm and 1 force of 2 N.

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Results from both ultrasound and dynamometric assessment concur with a reduction of PFM strength in women with avulsion. Women with avulsion showed an altered PFM morphometry during maximal contraction, evidenced by a more caudodorsal position of the bladder neck, a less acute levator plate angle, a larger anorectal angle, as well as increased hiatal dimensions. They also showed a lower PFM strength evaluated with the dynamometric speculum in comparison to women with intact muscle. These findings are in agreement with those of other workers who also reported a PFM weakness using manometry[7] or dynamometry.[4] Laterza et al,[8] on the other hand, found a nonsignificant difference between women with and without avulsion, which may be attributed to the subjectivity of vaginal palpation assessment.[33,50,51] However, this is the first study to find a lower speed of contraction and endurance in avulsion injury cases. Alterations of PFM function have been previously found in women with urinary incontinence and POP, thus supporting the clinical relevance of the results from this study.[52-54]

Contradictory findings have been published regarding the association between avulsion and urinary incontinence in a general female population.[55-57] Morgan et al[57] argue that a more extensive anterior descent may mask incontinence as a result of urethral obstruction. We found that women with avulsion had significantly more incontinence symptoms. These findings are in agreement with other studies undertaken in women in the early postpartum period.[8,9,16] In support of the explanation of Morgan et al,[57] these studies as well as the current study report a greater anterior compartment descent in women with avulsion, even though the prolapse remains mostly mild in severity.

**TABLE 3**
**Pelvic floor disorders**

| | Complete avulsion n = 22 Median [IQR] | No avulsion n = 30 Median [IQR] | *P* value |
|---|---|---|---|
| ICIQ scores | | | |
| ICIQ-Urinary Incontinence Short Form (/21) | 7.5 [0–11.3] | 0 [0–6.0] | .040 |
| ICIQ-Vaginal Symptoms (/53) | 8.5 [4.0–14.8] | 10.0 [5.0–14.0] | .853 |
| ICIQ-Bowel (bowel pattern) (/21) | 4.5 [2.0–6.0] | 5.0 [2.8–6.0] | .858 |
| ICIQ-Bowel (bowel control) (/28) | 2.5 [1.0–5.0] | 3.0 [0–5.0] | .586 |
| ICIQ-Bowel (quality of life) (/26) | 2.0 [2.0–4.3] | 1.0 [0–3.3] | .427 |
| PFIQ-Short Form scores | | | |
| Total (/300) | 19.1 [8.3–52.4] | 7.1 [0–20.2] | .038 |
| Urinary Impact Questionnaire (/100) | 7.1 [0–16.7] | 0 [0–6.0] | .068 |
| POP Impact Questionnaire (/100) | 9.5 [0–19.1] | 0 [0–6.0] | .041 |
| Colorectal-Anal Impact Questionnaire (/100) | 0 [0–20.2] | 0 [0–6.0] | .321 |

*ICIQ*, International Consultation on Incontinence Questionnaire; *IQR*, interquartile range; *PFIQ*, Pelvic Floor Impact Questionnaire; *POP*, pelvic organ prolapse.

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Avulsion has been clearly identified as a strong factor for the development of severe prolapse later in life.[58] Our results demonstrate that women with avulsion in the early postpartum period already present an anterior compartment prolapse.

**TABLE 4**
**Pelvic Organ Prolapse Quantification**

| | Complete avulsion n = 22 Median [IQR] | No avulsion n = 30 Median [IQR] | *P* value |
|---|---|---|---|
| Point Aa | −2.0 [−2.5 to −2.0] | −2.5 [−3.0 to −2.0] [a]n = 29 | .010 |
| Point Ba | −2.0 [−2.5 to −2.0] | −2.5 [−3.0 to −2.0] [a]n = 29 | .005 |
| Point C | −7.0 [−8.5 to −5.5] | −7.5 [−8.5 to −7.0] [a]n = 28 | .345 |
| Point D | −9.0 [−10.0 to −8.0] | −9.0 [−10.0 to −8.5] [a]n = 28 | .844 |
| Point Bp | −3.0 [−3.0 to −3.0] | −3.0 [−3.0 to −2.5] [a]n = 29 | .262 |
| Point Ap | −3.0 [−3.0 to −3.0] | −3.0 [−3.0 to −2.5] [a]n = 29 | .283 |
| Total vaginal length | 10.5 [9.0 to 11.0] | 10.0 [9.0 to 11.0] [a]n = 28 | .686 |
| Genital hiatus | 3.5 [3.0 to 4.0] | 3.5 [3.0 to 4.0] | .597 |
| Perineal body | 3.0 [2.5 to 4.0] | 3.0 [2.5 to 3.5] | .756 |

*IQR*, interquartile range.

[a] Some measurements are missing due to assessment refusal or pain.

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Although the severity of prolapse remains mild, women with avulsion report their vaginal symptoms to be more bothersome. Others have also suggested that avulsion is linked with a rapid development of prolapse and symptoms in young postpartum women.[5,8,9,14] We found more extensive hiatal ballooning during Valsalva in women with avulsion, which concurs with Dietz et al,[59] who demonstrated a strong association among avulsion, hiatal ballooning, and symptoms/signs of prolapse. In agreement with other studies,[7-9,60] women with avulsion were nonsignificantly different from women with intact muscle regarding bowel symptoms such as fecal incontinence. So far, only Heilbrun et al[61] have shown an association between avulsion and fecal incontinence postpartum. However, it should be noted that the latter specifically targeted women with a third-/fourth-degree perineal tear, which may have influenced the results. Some studies pointed out a stronger relation between avulsion and fecal incontinence in older women.[62]

One of the strengths of our study is the use of a combined approach to assess PFM morphometry and function, in addition to validated questionnaires and POP-Q, providing a comprehensive assessment of pelvic floor disorders. Another strength is the blinding of our assessors and data analyst to avulsion status. Nonetheless, some limitations should be acknowledged when interpreting the results. Given the study design in which we targeted women with known risk factors for avulsion, our data cannot be used to determine the overall incidence of avulsion injuries after vaginal delivery. Likewise, these selection criteria may have contributed to increase the likelihood of pelvic floor dysfunctions in our sample.[53,63] However, it is important to underline that these criteria were applied to both groups. Furthermore, the number of significance tests conducted may have increased the chance of type 1 error. A longitudinal study design with a larger sample size may have afforded us an opportunity to investigate links among PFM morphometry, PFM function, pelvic floor disorders, and obstetric factors. Moreover, a larger sample would have been required to compare women with unilateral, bilateral, and partial avulsion as well as to investigate the relative contribution of obstetrical factors to the PFM alterations and symptoms.

In conclusion, by combining ultrasound imaging and dynamometry, this study confirms that PFM morphometry and function are impaired in primiparous women sustaining a complete avulsion in the early postpartum period. It also provides new evidence on specific muscle parameters that are altered such as the passive properties, strength, speed of contraction, and endurance, all of which contribute to a better understanding of the physiopathology of pelvic floor disorders related to avulsion. PFM training is recognized as a noninvasive first-line treatment for pelvic floor disorders.[64] Future research should therefore investigate whether these PFM alterations in women with avulsion could be improved or corrected through PFM training. ■

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