Levator trauma is associated with pelvic organ prolapse

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Objective To estimate the risk of prolapse associated with levator avulsion injury among a urogynaecological clinic population.

Design Retrospective observational study.

Setting Tertiary urogynaecological unit.

Sample A total of 934 women seen for interview, examination using the pelvic organ prolapse quantification (POP-Q) staging system and imaging of the levator ani muscle by four-dimensional translabial ultrasound.

Methods Retrospective review of charts and stored imaging data.

Main outcome measures Pelvic organ prolapse stage II and higher and presence of defects of the levator ani muscle.

Results After exclusion of 137 women with a history of anti-incontinence or prolapse surgery, and a further exclusion of 16 women in whom either examination or imaging was impossible, we compared prolapse and imaging data in 781 women. Mean age was 53 years (range 15–89 years), and median parity was 2 (range 0–12). Women reported stress incontinence (76%), urge incontinence (69%), frequency (47%), nocturia (49%) and symptoms of prolapse (38%). Significant prolapse (stage II or higher) was diagnosed in 415 (53%) women, and 181 (23%) women were found to have levator avulsion defects. Prolapse was seen in 150/181 (83%) women with avulsion and in 265/600 (44%) women without avulsion, giving a relative risk (RR) of 1.9 (95% CI 1.7–2.1). The association was strongest for cystocele (RR 2.3, 95% CI 2.0–2.7) and uterine prolapse (RR 4.0, 95% CI 2.5–6.5).

Conclusions Women with levator avulsion defects were about twice as likely to show pelvic organ prolapse of stage II or higher than those without. This effect is mainly due to an increased risk of cystocele and uterine prolapse.

Keywords 3D ultrasound, avulsion, birth trauma, levator ani, pelvic floor ultrasound, pelvic organ prolapse.

Introduction

Trauma to the levator ani muscle is a common consequence of vaginal childbirth and generally seems to manifest as a partial or complete detachment or ‘avulsion’ of the pubo-rectalis muscle from its insertion on the pelvic sidewall. Such trauma is almost certainly the direct result of childbirth, because perinatal comparison of imaging data direct observation immediately postpartum, biomechanical studies and large imaging case series make a convincing case for the assumption that levator avulsion occurs during crowning of the fetal head. As a result of such trauma, the levator hiatus is enlarged, in particular in its anterior part, which is clearly associated with pelvic organ prolapse, especially of the anterior and central compartment, and may be a risk factor for recurrence after pelvic reconstructive surgery. This form of birth trauma is associated with vaginal operative delivery and higher maternal age at first delivery, as shown in studies using both magnetic resonance and ultrasound imaging. However, there also are women who show congenitally high pelvic organ mobility, and in others, prolapse may be due to fascial trauma or overdistension of the levator hiatus rather than due to avulsion injury.

To date, there have been no attempts at developing preventive strategies, aimed at reducing the prevalence of female pelvic organ prolapse. Such strategies should be a high research priority, given the fact that in the USA alone over 250 000 surgical procedures are carried out each year for prolapse.

In this study, we set out to determine the risk of complete avulsion injury of the levator ani muscle in women with prolapse, and the risk of significant prolapse in women with...
complete levator avulsion, in an attempt to quantify the aetiological link between such trauma and pelvic organ prolapse and to allow estimates of the potential effect of preventative intervention. We used translabial four-dimensional (4D) ultrasound to confirm findings because, while such trauma is palpable and was in fact first diagnosed by palpation in the 1940s, the repeatability of palpation and its agreement with imaging data is limited, even for trained operators.

**Study design, materials and methods**

A total of 934 women were seen in a tertiary urogynaecological unit. They were assessed by the first author or under his immediate supervision, with a standardised interview that included questions about symptoms of prolapse (sensation of a vaginal lump and/or a dragging sensation), an examination using the pelvic organ prolapse quantification system of the International Continence Society (ICS POP-Q) and assessment of the levator ani muscle by three-dimensional (3D)/4D translabial ultrasound as previously described, using Voluson 730 Expert ultrasound systems. Ultrasound data were acquired with the patient supine and after bladder emptying. For the assessment of muscle integrity, we used volumes obtained on maximal pelvic floor contraction or, in those who were unable to contract, volumes obtained at rest. A levator avulsion injury was diagnosed when there was a discontinuity between the inferior pubic ramus and the puborectalis muscle, evident as a V-shaped loop defining the plane of minimal hiatal dimensions, as previously described. Multislice imaging (tomographic ultrasound) was used to confirm the diagnosis. We consider multislice imaging confirmatory of a complete defect if at least the reference slice (at the level of the plane of minimal dimensions) and the two slices cranial to the reference slice show an avulsion, but it is understood that our definition is arbitrary and impossible to verify at present. The repeatability of the sonographic diagnosis of levator avulsion has been shown to be good (kappa of 0.7 of better) by the authors and others, even when using a more basic methodology and less sophisticated equipment. Digital assessment of the levator ani was performed in the context of grading the muscle for strength (modified Oxford grading) to confirm complete avulsion, although the diagnosis of avulsion was only rated as positive if evident on imaging. Examinations for prolapse and levator integrity were undertaken at the same time and by the same operator, making blinding impossible. Figure 1 illustrates the detection of levator avulsion on palpation (left) and axial plane 3D ultrasound (right). Figure 2 shows examples of a normal puborectalis muscle (top), a unilateral avulsion (middle) and a bilateral avulsion (bottom) as obtained on tomographic ultrasound.

This study is a subanalysis of a project that was approved by the local Institutional Human Research Ethics Committee (ref 05-029). Statistical analysis was undertaken using SAS Version 9 (SAS Institute Inc., Cary, NC, USA) and Minitab V.13 (Minitab Inc., State College, PA, USA). The Mantel–Haenszel’s chi-square test was used to test for trend in the proportion of women with defects by stage of prolapse.

**Results**

Of the 934 women seen for assessment, 137 were excluded from further analysis because they had previously undergone anti-incontinence or prolapse surgery. A further 16 women were
excluded because they were either not examined clinically due to vaginal scarring, atrophy or refusal \((n = 9)\), or not imaged satisfactorily \((n = 7)\). All analyses presented here refer to the remaining 781 women. Mean age was 53 years (range 15–89 years), and median parity was 2 (range 0–12). Women reported stress incontinence (76%), urge incontinence (69%), frequency (47%), nocturia (49%) and symptoms of prolapse (38%).

Significant prolapse (POP-Q stage II or higher) was diagnosed in 415 women (53%), and 181 women were found to have levator defects (23%). Thirty-nine women could not voluntarily contract the levator ani (5%), and volumes obtained at rest were used for levator assessment in those women. Prolapse was seen in 150/181 (83%) women with defects and in 265/600 (44%) women without defects \((P < 0.0001)\), giving a relative risk (RR) of prolapse of 1.9 (95% CI 1.7–2.1) among women with defects. When the analysis was performed separately for cystocele, uterine prolapse and rectocele, most of this effect appeared to be due to anterior and central compartment prolapse (Table 1 for RRs of each type of prolapse in women with avulsion). When the analysis was

**Figure 2.** Tomographic ultrasound (axial plane) of a normal puborectalis muscle (A, top three images), a typical right-sided avulsion (B, middle three images) and a bilateral avulsion (C, bottom three images). Defects are indicated by ‘*’. The images are obtained at a slice interval of 2.5 mm, at the plane of minimal dimensions (left three images), as well as at 2.5 and 5 mm cranial to this plane (middle and right three images, respectively). Reproduced from: Dietz HP, Shek KL. Single validity and reproductibility of the digital detection of levator trauma. *Int Urogynecol J* 2008. DOI: 10.1007/s00192-008-0575-1. With kind permission of Springer Science and Business Media.

<table>
<thead>
<tr>
<th></th>
<th>Cystocele ((n = 781))</th>
<th>Uterine prolapse ((n = 681))*</th>
<th>Rectocele ((n = 781))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unilateral avulsion</td>
<td>2.2 (1.9–2.7)</td>
<td>2.0 (1.0–4.1)</td>
<td>1.2 (0.9–1.7)</td>
</tr>
<tr>
<td>Bilateral avulsion</td>
<td>2.5 (2.1–3.0)</td>
<td>7.1 (4.3–11.6)</td>
<td>1.6 (1.2–2.1)</td>
</tr>
<tr>
<td>Any levator avulsion</td>
<td>2.3 (2.0–2.7)</td>
<td>4.0 (2.5–6.5)</td>
<td>1.4 (1.1–1.7)</td>
</tr>
</tbody>
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*Excluding 100 women who had had a hysterectomy.
inverted to determine the risk of avulsion in women with prolapse, the result was a RR of 4.3 (95% CI 3.0–6.1) and an odds ratio of 6.2 (95% CI 4.1–9.3), \( P < 0.001 \).

Figure 3 shows the distribution of women with no, unilateral and bilateral defects among those with stage 0, I, II and III of anterior, central and posterior compartment prolapse. While only 10 and 11% of women with no or first-degree cystocele were diagnosed with an avulsion injury, this percentage rose to 31% in those with second-degree cystocele and to 56% in third-degree cystocele (\( P < 0.0001 \)). For uterine prolapse, the figures were 14% in women without uterine descent, 40% in first-degree, 60% in second-degree and 42% in third-degree uterine prolapse (\( P < 0.0001 \)). For rectocele, defects were seen in 19% of women with normal support, 23% in first-degree rectocele, 28% in second-degree rectocele and 34% in third-degree rectocele (\( P = 0.003 \)).

Discussion

It has long been accepted that vaginal childbirth is a factor in the pathogenesis of female pelvic organ prolapse. Large epidemiological studies leave little doubt that childbirth can impair pelvic organ support.\(^{13,22}\) This study was designed to quantify the role of a newly identified aetiological factor, direct trauma to the insertion of the inferior part of the levator ani, the puborectalis muscle, on the inferior pubic ramus. Such trauma is common\(^ {5,9} \) and clearly linked to vaginal delivery.\(^ {3,4} \)

Among women attending a tertiary clinic, the presence of an identified levator defect approximately doubled the risk of significant prolapse (RR 1.9, 95% CI 1.7–2.1). The prevalence of levator avulsion was about four times greater in women with significant clinically diagnosed pelvic organ prolapse (POP-Q stage II or higher) than in those without prolapse. The association was strongest for the anterior and central compartments, and women with bilateral avulsion were particularly likely to suffer from uterine prolapse (RR of 7.1).

Our findings are consistent with results obtained by magnetic resonance imaging where women with prolapse were more likely to have major levator ani defects than controls (55 compared with 16%), with an adjusted odds ratio of 7.3 (95% CI 3.9–13.6).\(^ {8} \) When we analysed our data to allow for comparison of data, we obtained an unadjusted odds ratio of 6.1 (95% CI 4.0–9.3), with 150/415 (36%) women with prolapse showing an avulsion compared with 31/366 (8%) without significant prolapse.

Together, these data further strengthen the aetiological link between childbirth and female pelvic organ prolapse. It now seems likely that delivery-related major levator trauma (avulsion injury) may be a significant factor in the pathogenesis of prolapse. This seems particularly likely for cystocele and uterine prolapse.

It is understood that levator avulsion may not be the only mechanism by which pelvic floor muscle function may be impaired. Childbirth clearly leads to an enlargement of the levator hiatus, even if avulsion injury does not ensue;\(^ {1} \) and such overdistension of an intact muscle may equally predispose to prolapse. Finally, it is likely that congenital factors and/or fascial trauma play a role in some women, even if both may be more difficult to identify than muscular trauma as shown for rectocele.\(^ {23} \)

Regardless of whether other aetiological factors coexist in a population or an individual woman, it now appears very likely that major levator trauma is a significant aetiological factor for female pelvic organ prolapse. This finding opens up novel opportunities for prevention because levator avulsion is likely to be a useful intermediate outcome variable for intervention studies. Any change in clinical practice resulting in a reduced prevalence of levator avulsion, detectable a few weeks or months after childbirth by palpation or imaging, would be expected to have a positive effect on the prevalence of significant prolapse later in life. We are currently undertaking two randomised controlled trials aimed at reducing the incidence of levator avulsion in childbirth, using antenatal intervention strategies.
One of the more obvious weaknesses of our study is the fact that it was undertaken in a urogynaecological population. While the majority of our women did not complain of symptoms of prolapse, they were certainly not asymptomatic because they presented with other urogynaecological complaints such as urinary incontinence, voiding dysfunction or recurrent urinary tract infections. It remains to be shown to what extent these results are applicable to the general population. Furthermore, operators were not blinded against prolapse findings when they assessed for levator defects. We do not expect this bias to be significant: in an unrelated study examining the repeatability of the digital detection of levator trauma, the association between prolapse and defects was in fact stronger for the examiner who was blinded against clinical data than in the operator who undertook the levator assessment immediately after examining for prolapse (unpublished own data). However, we cannot exclude that bias may have contributed to the association observed in this population.

It would therefore be preferable to confirm findings by using a study design that separates prolapse assessment and the diagnosis of levator injury, allowing for blinding of separate operators, and we intend to conduct such a study in the future.

**Conclusions**

Women presenting to a urogynaecological clinic with levator avulsion injury were approximately twice as likely to show significant pelvic organ prolapse than those with an intact levator muscle, especially cystocele and uterine prolapse. Women with significant prolapse show a four-fold higher prevalence of levator avulsion injury than those without. These findings are further evidence for the importance of childbirth-related levator trauma in the aetiology of female pelvic organ prolapse.

**Contribution to authorship**

H.P.D.: Study design, data entry, analysis, writing of manuscript and final approval. J.M.S.: Data analysis, writing of manuscript and final approval.

**Details of ethics approval**

This study is a subanalysis of a project that was approved by the Local Institutional Human Research Ethics Committee (ref 05-029).

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**References**


