1 **Levator ani defects and the severity of symptoms in women with**
2 **anterior compartment pelvic organ prolapses (POP)**

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15 Financial disclaimer/ Conflicts of interest: None

16 SH Oversand. None

17 AC Staff: None

18 L Sandvik: None

19 I Volløyhaug: None

20 R Svenningsen: Advisory board for Astellas, speaker fees from Astellas.

21 Funded by the institution

22

23 Each author's contribution to the manuscript:

24 SH Oversand: Project development, Data collection and analysis, Manuscript

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29 R Svenningsen: Project development, Data collection and analysis, Manuscript

30 editing, Other: supervision

31

32

33 A limited abstract presentation, including some of the data was presented at the 30th

34 Bi-Annual meeting of the Nordic Urogynecological Association in Reykjavik, Iceland

35 in April 2017

36

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40 Word count abstract: 250 words

41 Word count manuscript: 2964 words

Abstract:

Introduction and Hypothesis: The aims of this study were to evaluate the prevalence of levator ani muscle (LAM) avulsions in a selected cohort of patients with primary anterior compartment pelvic organ prolapse (POP) and assess whether LAM avulsions, as an independent factor, affect the degree of POP symptoms and sexual dysfunction. Additionally, clinical and demographic variables between women with and without avulsions were compared.

Methods: Cross-sectional analysis of a prospective cohort study including 197 women scheduled for anterior compartment POP surgery. LAM avulsions were diagnosed on transperineal 4D ultrasound. Preoperative symptom severity and sexual dysfunction were evaluated using validated questionnaires (PFDI-20 and PISQ-12). Linear regression was performed with avulsion as main independent variable against total PFDI-20 and domain scores, symptom of bulge, and PISQ-12 score. Clinical and demographic variables for women with and without avulsions were compared by independent samples t-test, Mann-Whitney U test or chi square test.

Results: The prevalence of LAM avulsions was 50.3 %. Avulsions were not associated with symptom severity or sexual dysfunction. “Chronic disease causing pain, fatigue or increased intra-abdominal pressure” was the only independent factor associated with all domains of the PFDI-20. Women with avulsions were younger at presentation, older at their first delivery, had lower BMI and had more often a history of forceps delivery ($p < 0.01$).

Conclusions: LAM avulsions were highly prevalent in this preoperative POP cohort. Avulsions were not associated with the severity of POP symptoms or sexual dysfunction. Women with avulsions seem to require less additional cofactors for developing POP.

68 **Keywords:**

69 Pelvic Floor Disorders

70 Pelvic Organ Prolapse

71 Sexual Dysfunction, Physiological

72 Sexual Dysfunction, Psychological

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77 **Brief Summary:**

78 In this preoperative POP cohort, LAM avulsions were highly prevalent but did not
79 correlate with the severity of pelvic organ prolapse symptoms or sexual dysfunction.

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Introduction:

Pelvic organ Prolapse (POP) impacts and deteriorates the quality of life for a large proportion of women worldwide with a reported prevalence ranging from 2.9% - 50%, depending on definitions and population groups [1,2]. The most common form of POP is a defect in the anterior compartment [3]. The development of pelvic organ prolapse (POP) in women is multifactorial, with recognized risk- factors being age, obesity, chronic constipation and above all vaginal childbirth [4]. If the vaginal delivery causes a major injury to the levator ani muscle (LAM), known as LAM avulsion, the risk of developing POP particularly in the anterior and mid-compartment is doubled [5]. LAM avulsions are defined as the detachment of the pubic portion of the most medial part of the LAM from its normal site of insertion at the anterior pubic ramus [6]. Minor levator injuries do not have the same impact on pelvic floor function [7], so the term avulsion is generally reserved for major injuries. The avulsions may be uni- or bilateral [8]. Levator avulsions have been described in 13-20 % of women after their first vaginal delivery [8,9] and an increased risk has been suggested for forceps deliveries and older age at first delivery [9,10].

Previous studies have indicated that surgeries for POP in women with LAM avulsions are less successful than in women without avulsions due to a significantly higher risk of recurrence [11]. Therefore, some authors suggest that women with avulsions need a different surgical approach to POP repair than women with intact LAM [11]. For that reason it is important to identify women with LAM avulsions among patients scheduled for POP surgery in order to give these women proper counseling prior to surgery.

Since LAM avulsion has been shown to exert an independent impact on pelvic floor symptoms in women 3 months postpartum [12,13] we wanted to investigate whether that also holds true for women seeking surgical treatment for symptomatic POP.

The aims of the present study were firstly to evaluate the prevalence of LAM avulsions in a cohort of women scheduled for primary surgery for anterior compartment POP and to assess whether avulsions exert an independent impact on the severity of POP symptoms and sexual dysfunction in such a population. Secondly, the study aimed at comparing clinical and demographic differences in women with and without LAM avulsions.

Materials and Methods:

The present study was a cross-sectional analysis of an ongoing prospective cohort study (clinical trial number NCT 02246387) evaluating anatomical outcomes in women scheduled for surgical correction of anterior compartment prolapse at the Department of Gynecology, Oslo University Hospital, Norway between October 2014 and June 2016.

Women scheduled for POP surgery due to symptomatic prolapse with a dominating anterior compartment defect and who understood Norwegian or English were offered inclusion. Exclusion criteria were previous POP surgery or previous hysterectomy (total/subtotal). Patients were approached for study enrollment after the decision for surgery had been made. A signed, informed written consent was obtained. The study was approved by the Regional Ethics Committee for the South Eastern Region of Norway (reference 2013/2093).

All women had a standardized interview including clinical and obstetric antecedents. They were objectively assessed with Pelvic Organ Prolapse Quantification (POP-Q) measurements [14], as well as with 4D transperineal ultrasound. The first author (SO) obtained ultrasound volumes at rest and at maximal pelvic floor muscle contraction using a GE Voluson S8 with a 4-8 MHz 4D abdominal probe.

Tomographic Ultrasound Imaging (TUI) with 2.5 mm steps from 5mm below the plane of minimal dimensions to 12.5 mm above this plane was performed to diagnose uni- and bilateral total LAM avulsions. Only major avulsions were considered [7,9].

The diagnosis was confirmed off-line, on a desktop computer using 4D View (GE Healthcare, Austria). An intra- and inter-rater validation process for the diagnosis of uni- and bilateral levator avulsions was performed a minimum of 3 months after the initial examination. Fifty randomly selected cases were re-examined both by the primary investigator (SO) and an external evaluator (IV). The randomization and renumbering for the re-evaluation of the tomographic images was performed by a third person (RS) using the SPSS randomization function to ensure blinding of both ultrasound-image interpreters. Inter- and intra- observer reliabilities were determined using Cohen's Kappa.

Preoperatively, the women were asked to fill out two validated short form questionnaires. The Pelvic Floor Distress Inventory - Short Form 20 (PFDI-20), consists of 3 domains (POPDI-6, CRADI-8 and UDI-6) and whereas the Pelvic Organ Prolapse/Urinary Incontinence Sexual Questionnaire - Short Form 12 (PISQ-12) is treated as a total score [15,16]. The questionnaires were translated into Norwegian from the linguistically similar validated Swedish versions [17], as none of them had been validated in Norwegian before study start. For women not fluent in Norwegian, but who spoke and understood English, the English versions of the questionnaires were offered [15,16]. Missing values were accounted for as indicated in the original papers [15,16]. Symptom scores were treated as continuous variables in the final analyses.

Sample size was originally estimated for the ongoing prospective study on postoperative anatomical outcome. However, a post study power analysis for this

cross-sectional study was performed with an 80% test power and a 5% significance level, supposing a 50% prevalence of LAM avulsion and proposing a difference in PFDI-20 outcome of 25 to be clinically relevant (1 point increase in mean score of one of the domains). With a SD of 55 (from our own data), the necessary sample size was 152. We included 197 women in our study (see below in the Results section), thus the test power should be appropriate.

To evaluate the impact of LAM avulsions on symptom severity and sexual function, linear regression analyses were performed. The outcome variables analyzed were the following: total PISQ-12 score, total and domain PFDI-20 scores as well as the single question; “Do you usually have a bulge or something falling out that you can see or feel in the vaginal area?”(Question 3, POPDI-6). The latter question was tested because others have identified the single symptom of bulge to be the one most strongly correlated with POP severity [18].

Spearman’s correlation was used to analyze independent variables against the above outcomes to identify which factors, in addition to LAM avulsion (main independent factor) to include in the linear regression analysis. The variables tested were: age, BMI, POP-Q stage of anterior compartment, parity, previous vacuum delivery, previous forceps delivery, sexual activity, use of local estrogen as well as chronic disease causing pain, fatigue or increased intra-abdominal pressure. The latter, represented by entities such as fibromyalgia, chronic fatigue syndrome, irritable bowel syndrome or chronic obstructive lung syndrome was included as independent variable because others have found such conditions to be closely correlated with pelvic pain [19]. Assumptions for linear regression analyses were adequately met. For each linear regression model, only variables with a *p*-value below 0.1 using Spearman’s Correlation were included in addition to LAM avulsion.

Differences in clinical and demographic variables were tested between women with LAM avulsions and intact LAM. Independent samples t-test was used when adequate, otherwise Mann-Whitney U-test was used. Pearson's chi-square test was used for categorical variables. Additional analyses were also performed comparing women with unilateral avulsions against non-avulsions and women with bilateral avulsions against non-avulsions.

A p -value <0.05 was considered statistically significant. The analyses were performed using SPSS version 24.

Results:

The final study population consisted of 197 women (Figure 1) of which 98.5% were of European origin. Mean age was 61 years (SD 12, range 34-86) and mean BMI was 24.9 (SD 3.5, range 17.5–39.4). Systemic estrogen was used by 6.6% and local vaginal estrogen by 43.7%. Median parity was 2 (range 0-7). Six women (3%) were nulliparous; the remaining 97% had undergone at least one vaginal delivery. Of the women having had a minimum of one vaginal delivery, 16.8% ($n=191$) had undergone at least one forceps delivery and 5.2% ($n=191$) at least one vacuum delivery. Two women had experienced both forceps and vacuum deliveries. For both women, the forceps delivery was performed before the vacuum delivery, thus they were classified within the forceps group. Mean age at first delivery was 26 years (SD 5.2, range 17-41). Symptom scores were distributed as follows; PFDI-20: mean 102.4 (SD 50.8), and median 99.0 (range 4.2- 264.6); POPDI-6: mean 45.7 (SD 21.7) and median 45.8 (range 0-100.0); CRADI-8: mean 22.3 (SD 19.1) and median 18.8 (range 0-81.3); UDI-6: mean 34.3 (SD 22.5) and median 29.2 (range 0-100.0) and PISQ-12: mean 14.1 (SD 7.0) and median 14.0 (range 0-32.0).

215 A total of 39 women planned for primary POP surgery were not included either
 216 because of insufficient Norwegian/English skills or due to missed/denied inclusion
 217 (Figure 1). These women did not differ significantly from the study population
 218 regarding age or stage of prolapse in the anterior compartment, but they had a
 219 significantly higher BMI (mean 26.9 vs. 24.9; $p=0.02$).

220 The prevalence of LAM avulsions was 50.3% ($n=197$). Unilateral avulsions were
 221 seen in 18.8%, whereas bilateral avulsions were seen 31.5%. The inter-rater
 222 Cohen's Kappa was 0.82 and the intra-rater Cohen's Kappa was 0.80 for the
 223 diagnosis of LAM avulsion on transperineal ultrasound.

224 Only "chronic disease causing pain, fatigue or increased intra-abdominal pressure"
 225 was significantly associated with all domains of the PFDI-20 symptoms score ($p<$
 226 0.05), using Spearman's Correlation. Increasing POP-Q stage in the anterior
 227 compartment was significantly associated with CRADI-8 ($p<0.05$) and the total PFDI-
 228 20 score ($p<0.05$), whereas parity was significantly associated with UDI-6 score
 229 ($p<0.01$). None of the clinical and demographic variables were significantly
 230 associated with the PISQ-12 score.

231 In addition to LAM avulsion (main independent variable), variables with $p<0.1$ from
 232 Spearman's correlation analyses were entered into the multivariate linear regression
 233 model. Table I presents the adjusted impact of the independent variables on
 234 symptoms scores when using multivariate linear regression analyses.

235 In the multivariate analyses, LAM avulsion was not significantly associated with any
 236 of the outcomes. Nor did testing unilateral and bilateral avulsions separately against
 237 the outcomes uncover any significant associations (data not shown). "Chronic
 238 disease causing pain, fatigue or increased intra-abdominal pressure" remained
 239 significantly associated with all three domain sub-scores of the PFDI-20 as well as
 240 the total PFDI-20 score (Table I). Parity remained significantly associated with the

total PFDI-20 score and the UDI-6 sub-score, and age was the only factor associated with sexual symptoms (Table I).

Figure 2 depicts the distribution of total PFDI-20 scores among women with and without avulsions, illustrating almost identical distributions of subjective pelvic floor distress scores.

Clinical and demographic data for women with and without LAM avulsions are presented in Table II. When compared to women without avulsions, women with avulsions were significantly younger at presentation, had a significantly lower BMI and were significantly older when they gave birth to their first child. Moreover, they had significantly more often had a forceps delivery.

Discussion:

In our population of women seeking primary surgery for anterior compartment POP the prevalence of LAM avulsion was 50.3 %, in the upper end of rates previously reported from urogynecological patient populations[20]. A likely explanation is that women in the present study have more severe prolapse and were scheduled for surgery for this condition. Previous studies have found a clear association between LAM avulsions and more severe pelvic floor symptoms 3 months postpartum [12,13], but such an independent impact of avulsions on the severity of symptoms was not seen in our cohort. The lack of association between avulsions and POP symptom bother has also been indicated in another study, however retrospective and with a heterogeneous urogynecologic population [21]. It is plausible that the impact of LAM avulsions on pelvic floor symptoms in the immediate postpartum period is greater due to the more extensive acute vaginal trauma with additional damage to nerves, fascia and connective tissue that to some extent may be partly reversible with

healing and reconstruction over time. A more likely explanation is that any association between LAM avulsions and POP symptoms could be masked by the fact that all of our patients had POP symptoms severe enough to warrant surgical intervention. Some studies have identified that stage of POP alone is associated with the severity of symptoms [22].

This study found that the only significant factor impacting all domains of pelvic floor symptoms was “chronic disease causing pain, fatigue or increased intra-abdominal pressure” (detailed as fibromyalgia, irritable bowel syndrome, chronic obstructive lung disease etc.). Bump et al named some of these chronic conditions “promoting factors” in the natural history of POP development [23], potentially because women with a symptomatic chronic condition will have more severe baseline symptoms and thus a lower threshold for seeking medical evaluation for additional increase in symptom intensity. An association between chronic diseases and sexual function has not been identified to the same extent as for POP symptoms, although poor physical condition has been shown in a study by Laumann et al to be a risk factor for sexual impairment [24]. In our study of women with symptomatic POP, older age was the only factor associated with preoperative sexual dysfunction.

There are many factors that contribute to sexual dysfunction in POP patients, it is known that many aspects are involved, not just pain, discomfort and dyspareunia but also psychological factors such as embarrassment and reduced libido [25]. The cohort selection might have impeded the possibility of identifying any separate impact from LAM avulsions as the effect from the stage of prolapse alone may have diluted any impact from the avulsions.

The present study supports acknowledged risk factors for major pelvic floor trauma causing LAM avulsions such as forceps delivery [9] and older age at first delivery [10], as these were significantly more prevalent among women with avulsions.

Although forceps delivery is the most widely accepted risk factor for LAM avulsions, our study indicates that the association between older age at first delivery and avulsions is equally strong.”. As postulated by others, this may be because older age at first delivery exerts an independent impact on the development of POP regardless of LAM avulsion [26], possibly because the pelvic floor in older women is less elastic and thus more vulnerable to delivery-related trauma of nerves, connective tissue and muscles[11].

High BMI is a commonly accepted risk factor for POP [2]. We found, however, that women with LAM avulsions in this cohort had a significantly lower BMI than women with intact LAM. This supports the notion of women with a fragile, injured levator ani muscle needing less additional risk factors to develop POP due to the importance of the LAM for normal pelvic floor function.

In our study, women with avulsions were significantly younger when they presented for POP-related symptoms compared to women without avulsions, indicating that the time- gap between pelvic floor trauma and symptoms is narrowed by the muscle injury per se and not only because women with LAM avulsions gave birth closer to menopause. Thomas et al describe a similar association between forceps delivery (causing vaginal trauma) and POP presentation [26]. These findings implicate that women with LAM avulsions require less additional risk factors to develop a symptomatic POP with need for surgery.

Since women with LAM avulsions tend to develop symptomatic POP at a younger age and possibly have a higher risk of postoperative symptomatic recurrence [11], special surgical methods have been proposed for LAM reconstruction [27]. It is however not generally accepted to perform such surgeries (with the inherent risk of unsuccessful postoperative results) in asymptomatic women with avulsions in order to prevent possible future pelvic floor symptomatology. The main prevention

therefore relies on avoiding LAM injury during delivery. In obstetrics, attention has been put on preventing obstetric anal sphincter injuries by manually slowing the delivery of the infant 's head [28]. A similar focus must be given to the prevention of levator injuries, while optimizing short and long- term outcomes for mother and child. Such increased awareness on prevention has reduced the incidence of anal sphincter injuries in Norway over the last decade [28] and it is plausible that the same reduction can be achieved for levator avulsions.

The main strength of the present study is a clinically well-described population and an adequate sample size. We compared groups of women with and without LAM avulsions of equal size. The calculated inter- and intra-rater reliabilities for ultrasonographic diagnosis of avulsions were excellent (Cohen's Kappa values of 0.82 and 0.80 respectively for inter-rater and intra-rater observer reliability). We were not able to find any information in previous publications on how to dichotomize PFDI-20 and PISQ-12 symptom scores in POP patients, so the scores were treated as continuous variables. The mean and median symptom scores from the present study may however help dichotomizing into low/high scores for POP patients in future studies.

The study questionnaires were translations from the validated Swedish versions (Sweden being similar linguistically and socioculturally), implying potential misinterpretations. The PISQ-12 questionnaire on sexual symptoms is only validated for sexually active women in heterosexual relationships, therefore important information on sexual symptoms in homosexual or "sexually inactive" women could have been lost. Moreover, the expression of sexual symptoms may also vary according to ethnicity [29] so that our population of mainly women of European heritage may not be representative for other populations. However, ethnicity has

previously not been demonstrated to have an important impact on pelvic floor symptoms [30].

In conclusion, our study confirms a high prevalence of LAM avulsions in women with predominant anterior compartment prolapse scheduled for surgical intervention. Levator avulsions seem to shorten the time-gap between the inciting vaginal birth and symptomatic POP, but do not seem to impact the severity of pelvic floor symptoms or sexual dysfunction. Moreover, our study indicate that older age at first delivery and forceps delivery increase the risk of avulsions, which implies that special care must be taken to avoid major obstetric vaginal trauma, especially in older primiparas.

Acknowledgements: We are grateful to the patients and staff at the Gynecological Department at Oslo University Hospital who willingly contributed to this study.

365 **Figure legends:**

366 Figure I: Women scheduled for surgery for anterior compartment POP, inclusion and
367 study population (n=197)

368 Figure II: Distribution of PFDI-20 total symptom scores, women with and without LAM
369 avulsions (n=197)

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376 **Tables:**

TABLE I: Association between independent variables and symptoms scores in women scheduled for POP surgery.

Results from multivariate linear regression analyses (n=197).

Independent variables	B ^a	95% CI	P	R ² ^b
	TOTAL PFDI-20 SCORE (Pelvic Floor Distress)			
LAM avulsion Chronic Disease Parity	-9.8 42.6 6.5	-23.5; 3.9 20.3; 64.9 -0.1; 13.1	0.16 <0.001 0.05	0.11
	POPDI-6 SCORE (Pelvic Organ Prolapse Distress)			
LAM avulsion Chronic Disease	-4.2 13.0	-10.2; 1.8 3.3; 22.7	0.17 <0.01	0.05
	QUESTION 3: Sensation of bulge			
LAM avulsion Chronic Disease	-0.2 0.5	-0.5; 0.2 -0.1; 1.1	0.40 0.09	0.02
	CRADI-8 SCORE (Colorectal-Anal Distress)			
LAM avulsion Chronic Disease POP-Q Stage Ant Comp	-2.0 16.5 -4.6	-7.1; 3.1 8.0; 25.0 -9.5; 0.3	0.44 < 0.001 0.06	0.11
	UDI-6 SCORE (Urinary Distress)			
LAM avulsion Chronic Disease Parity Local estrogen	-2.7 13.0 3.9 5.3	-8.8; 3.5 3.0; 23.0 0.9; 6.8 -0.8; 11.5	0.39 <0.05 <0.05 0.09	0.09
	PISQ- 12 SCORE (Sexual Symptoms)			
LAM avulsion Chronic Disease Age	-1.1 2.9 -0.1	-3.8; 1.5 -1.2; 7.1 -0.2; -0.0	0.41 0.17 <0.05	0.06

^a Linear regression Coefficient B : expected change in dependent variable (symptom scores) per unit independent variable (symptom scores) predictable from the independent variable

^b R² refers to the proportion of variation in dependent variable (symptom scores)

Table II: Comparison of baseline data for POP patients scheduled for surgery, either with LAM avulsions (n=98) or without LAM avulsions (n=99)

	LAM avulsions (n=99)	Without LAM avulsions (n=98)	Mean difference (95% CI)	P-value
Age at presentation ^a	Mean (SD)	Mean (SD)		
	58.6 (12.2)	63.1 (11.1)	- 4.51 (-7.78; -1.23)	<0.01
BMI ^a	24.1 (2.9)	25.6 (3.8)	-1.44 (-2.40; -0.49)	<0.01
Age at first delivery ^a	27.7 (5.5)	25.0 (4.5)	2.70 (1.27; 4.13)	<0.001
POP-Q Stage, anterior compartment ^a	2.59 (0.52)	2.54 (0.56)	0.05 (-0.11; 0.20)	0.56
Parity ^b	Median (range)	Median (range)		
	2.0 (0-7)	2.0 (0-6)		0.29
Forceps delivery ^c	Percentage (n/N)	Percentage (n/N)	OR (95% CI)	
	25.3% (25/99)	8.7 % (8/92) ^d	3.55 (1.50; 8.34)	<0.01
Vacuum delivery ^c	7.1 % (7/99)	3.3% (3/92) ^d	2.26 (0.57; 9.00)	0.33
Postmenopausal ^c	76.8% (76/99)	87.8% (86/98)	0.38 (0.17; 0.84)	<0.05
Sexually active ^c	60.6% (60/99)	50.0% (49/98)	1.53 (0.87; 2.70)	0.13

^a Independent samples t-test; ^b Mann-Whitney U-test ^c Pearson chi-square ^d 6 nulliparous women excluded

REFERENCES:

1. Nygaard I, Barber MD, Burgio KL, Kenton K, Meikle S, Schaffer J, Spino C, Whitehead WE, Wu J, Brody DJ, Pelvic Floor Disorders N (2008) Prevalence of symptomatic pelvic floor disorders in US women. *Jama* 300 (11):1311-1316. doi:10.1001/jama.300.11.1311
2. Awwad J, Sayegh R, Yeretian J, Deeb ME (2012) Prevalence, risk factors, and predictors of pelvic organ prolapse: a community-based study. *Menopause* 19 (11):1235-1241. doi:10.1097/gme.0b013e31826d2d94
3. Hendrix SL, Clark A, Nygaard I, Aragaki A, Barnabei V, McTiernan A (2002) Pelvic organ prolapse in the Women's Health Initiative: gravity and gravidity. *Am J Obstet Gynecol* 186 (6):1160-1166
4. Hallock JL, Handa VL (2016) The Epidemiology of Pelvic Floor Disorders and Childbirth: An Update. *Obstet Gynecol Clin North Am* 43 (1):1-13. doi:10.1016/j.ogc.2015.10.008
5. Dietz HP, Simpson JM (2008) Levator trauma is associated with pelvic organ prolapse. *BJOG : an international journal of obstetrics and gynaecology* 115 (8):979-984. doi:10.1111/j.1471-0528.2008.01751.x
6. DeLancey JOL, Sorensen HC, Lewicky-Gaupp C, Smith TM (2012) Comparison of the puborectal muscle on MRI in women with POP and levator ani defects with those with normal support and no defect. *Int Urogynecol J* 23 (1):73-77. doi:DOI 10.1007/s00192-011-1527-8
7. Dietz HP, Bernardo MJ, Kirby A, Shek KL (2011) Minimal criteria for the diagnosis of avulsion of the puborectalis muscle by tomographic ultrasound. *International urogynecology journal* 22 (6):699-704. doi:10.1007/s00192-010-1329-4
8. DeLancey JOL, Kearney R, Chou Q, Speights S, Binno S (2003) The appearance of levator ani muscle abnormalities in magnetic resonance images after vaginal delivery. *Obstetrics and gynecology* 101 (1):46-53. doi:Pii S0029-7844(02)02465-1

Doi 10.1016/S0029-7844(02)02465-1
9. Shek KL, Dietz HP (2010) Intrapartum risk factors for levator trauma. *BJOG : an international journal of obstetrics and gynaecology* 117 (12):1485-1492. doi:10.1111/j.1471-0528.2010.02704.x
10. Rahmanou P, Caudwell-Hall J, Atan IK, Dietz HP (2016) The association between maternal age at first delivery and risk of obstetric trauma. *Am J Obstet Gynecol* 215 (4). doi:ARTN 451.e1-7

10.1016/j.ajog.2016.04.032
11. Dietz HP, Chantarasorn V, Shek KL (2010) Levator avulsion is a risk factor for cystocele recurrence. *Ultrasound Obst Gyn* 36 (1):76-80. doi:10.1002/uog.7678
12. Cyr MP, Kruger J, Wong V, Dumoulin C, Girard I, Morin M (2016) Pelvic floor morphometry and function in women with and without puborectalis avulsion in the early postpartum period. *Am J Obstet Gynecol*. doi:10.1016/j.ajog.2016.11.1049
13. van Delft K, Sultan AH, Thakar R, Schwertner-Tiepelmann N, Kluivers K (2014) The relationship between postpartum levator ani muscle avulsion and signs and symptoms of pelvic floor dysfunction. *BJOG : an international journal of*

- obstetrics and gynaecology 121 (9):1164-1171; discussion 1172.
doi:10.1111/1471-0528.12666
14. Haylen BT, Maher CF, Barber MD, Camargo S, Dandolu V, Digesu A, Goldman HB, Huser M, Milani AL, Moran PA, Schaer GN, Withagen MI (2016) An International Urogynecological Association (IUGA) / International Continence Society (ICS) Joint Report on the Terminology for Female Pelvic Organ Prolapse (POP). *Neurourol Urodyn*. doi:10.1002/nau.22922
 15. Barber MD, Walters MD, Bump RC (2005) Short forms of two condition-specific quality-of-life questionnaires for women with pelvic floor disorders (PFDI-20 and PFIQ-7). *Am J Obstet Gynecol* 193 (1):103-113.
doi:10.1016/j.ajog.2004.12.025
 16. Rogers RG, Coates KW, Kammerer-Doak D, Khalsa S, Qualls C (2003) A short form of the Pelvic Organ Prolapse/Urinary Incontinence Sexual Questionnaire (PISQ-12). *International urogynecology journal and pelvic floor dysfunction* 14 (3):164-168; discussion 168. doi:10.1007/s00192-003-1063-2
 17. Telemann P, Stenzelius K, Iorizzo L, Jakobsson U (2011) Validation of the Swedish short forms of the Pelvic Floor Impact Questionnaire (PFIQ-7), Pelvic Floor Distress Inventory (PFDI-20) and Pelvic Organ Prolapse/Urinary Incontinence Sexual Questionnaire (PISQ-12). *Acta Obstet Gyn Scan* 90 (5):483-487. doi:10.1111/j.1600-0412.2011.01085.x
 18. Ghatti C, Gregory WT, Edwards SR, Otto LN, Clark AL (2005) Pelvic organ descent and symptoms of pelvic floor disorders. *Am J Obstet Gynecol* 193 (1):53-57. doi:10.1016/j.ajog.2004.12.004
 19. Yosef A, Allaire C, Williams C, Ahmed AG, Al-Hussaini T, Abdellah MS, Wong F, Lisonkova S, Yong PJ (2016) Multifactorial contributors to the severity of chronic pelvic pain in women. *Am J Obstet Gynecol* 215 (6):760.e761-760.e714.
doi:10.1016/j.ajog.2016.07.023
 20. DeLancey JOL, Morgan DM, Fenner DE, Kearney R, Guire K, Miller JM, Hussain H, Umek W, Hsu Y, Ashton-Miller JA (2007) Comparison of levator ani muscle defects and function in women with and without pelvic organ prolapse. *Obstetrics and gynecology* 109 (2):295-302. doi:DOI 10.1097/01.AOG.0000250901.57095.ba
 21. Endress E, Shek KL, Dietz HP (2015) Levator avulsion is not associated with symptom bother of female pelvic organ prolapse. *Arch Gynecol Obstet* 292 (3):629-633. doi:10.1007/s00404-015-3633-1
 22. Ellerkmann RM, Cundiff GW, Melick CF, Nihira MA, Leffler K, Bent AE (2001) Correlation of symptoms with location and severity of pelvic organ prolapse. *Am J Obstet Gynecol* 185 (6):1332-1337; discussion 1337-1338.
doi:10.1067/mob.2001.119078
 23. Bump RC, Norton PA (1998) Epidemiology and natural history of pelvic floor dysfunction. *Obstet Gyn Clin N Am* 25 (4):723-+. doi:Doi 10.1016/S0889-8545(05)70039-5
 24. Laumann EO, Paik A, Rosen RC (1999) Sexual dysfunction in the United States: prevalence and predictors. *Jama* 281 (6):537-544
 25. Rantell A, Srikrishna S, Robinson D (2016) Assessment of the impact of urogenital prolapse on sexual dysfunction. *Maturitas* 92:56-60.
doi:10.1016/j.maturitas.2016.07.001
 26. Thomas V, Shek KL, Guzman Rojas R, Dietz HP (2015) Temporal latency between pelvic floor trauma and presentation for prolapse surgery: a

retrospective observational study. *International urogynecology journal* 26 (8):1185-1189. doi:10.1007/s00192-015-2677-x

27. Rostaminia G, Shobeiri SA, Quiroz LH (2013) Surgical repair of bilateral levator ani muscles with ultrasound guidance. *International urogynecology journal* 24 (7):1237-1239. doi:10.1007/s00192-012-1912-y

28. Laine K, Rotvold W, Staff AC (2013) Are obstetric anal sphincter ruptures preventable?- Large and consistent rupture rate variations between the Nordic countries and between delivery units in Norway. *Acta Obstet Gyn Scan* 92 (1):94-100. doi:10.1111/aogs.12024

29. Atallah S, Johnson-Agbakwu C, Rosenbaum T, Abdo C, Byers ES, Graham C, Nobre P, Wylie K, Brotto L (2016) Ethical and Sociocultural Aspects of Sexual Function and Dysfunction in Both Sexes. *J Sex Med* 13 (4):591-606. doi:10.1016/j.jsxm.2016.01.021

30. Dessie SG, Adams SR, Modest AM, Hacker MR, Elkadry EA (2016) Bladder Symptoms and Attitudes in an Ethnically Diverse Population. *Female pelvic medicine & reconstructive surgery* 22 (1):37-42. doi:10.1097/spv.0000000000000213