

REVIEW ARTICLE

Gynecology

Association between levator ani avulsion and urinary incontinence in women: A systematic review and meta-analysis

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Abstract

Background: Urinary incontinence is a bothersome symptom. Although the relationship between stress urinary incontinence (SUI) and vaginal delivery is established, the pathology underlying SUI after vaginal birth remains to be elucidated.

Objectives: To determine whether levator ani muscle avulsion predisposes for SUI in women.

Search strategy: Pubmed and Embase were searched for terms and their variations “levator ani muscle avulsion” and “urinary incontinence”, from inception until 5 November 2019.

Selection criteria: Inclusion criterion: studies describing the relationship between urinary incontinence and levator ani muscle avulsion in women at least 1 year after delivery. Exclusion criterion: studies only analyzing the urethral sphincter or hiatus dimensions.

Data collection and analysis: Odds ratios were used and if not available, were calculated as means of data synthesis, adjusted odds ratios if presented by the study, random-effects model to compute a pooled estimate.

Results: Seven studies were included, accounting for 2388 women. Comparing women with and without levator ani muscle avulsion, the overall odds ratio for SUI is 0.87 (95% confidence interval 0.56–1.34), and after adjustment for possible confounders was 0.72 (95% confidence interval 0.40–1.30).

Conclusion: There is no relationship between levator ani muscle avulsion and SUI in women.

KEYWORDS

Levator ani muscle avulsion, Pathophysiologic urinary incontinence, Stress urinary incontinence, Urinary incontinence

1 | INTRODUCTION

Urinary incontinence in women is a frequent and bothersome symptom with a high prevalence worldwide of about 27.6% between the

age of 18 and 75 years.¹ Urinary incontinence is defined as the involuntary loss of urine and is associated with previous vaginal delivery.² The prevalence of any type of urinary incontinence in women who had at least one vaginal delivery reported in the literature varies up

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to 54%.^{3,4} Although the relationship between stress urinary incontinence and vaginal delivery is well established, the pathology underlying stress urinary incontinence after vaginal birth remains to be elucidated.

It is known that vaginal delivery predisposes women to levator ani avulsion. In fact, levator ani muscle avulsion was found in 15%–30% of women after vaginal deliveries.^{5,6} The levator ani muscle is the complex of the pubococcygeus, the iliococcygeus, and the puborectalis, and is part of the pelvic floor muscles. The definition of levator ani muscle avulsion is the partial or complete detachment of the pubic portion of the levator ani muscle from the normal site of insertion at the anterior pubic ramus, which may be unilateral or bilateral.⁷ The levator ani muscle is part of the pelvic floor muscles and is important for pelvic floor support.⁸ Previous studies have shown that both unilateral and bilateral levator ani muscle avulsion are associated with a larger opening of the urogenital hiatus and predisposes to pelvic organ prolapse.^{9–11} In addition to the relationship between levator ani muscle avulsion and pelvic organ prolapse, there appears to be a pathophysiologic link between levator ani muscle avulsion, vaginal birth, and the emergence of pelvic floor disorders (e.g. pelvic organ prolapse, incontinence) years after delivery.^{12,13} The objective of this study was to systematically review and report on the current evidence regarding the association between urinary incontinence and levator ani muscle avulsion.

2 | METHODS

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) and Meta-analysis of Observational Studies in Epidemiology (MOOSE), were used as a guideline for reporting this systematic review and meta-analysis.^{14,15}

2.1 | Inclusion and exclusion criteria

All studies that described the relationship between urinary incontinence and levator ani muscle avulsion in women were possibly eligible for inclusion if they met the following criteria. The diagnosis of urinary incontinence must be done by one of: a validated questionnaire, urodynamics, or interview by a physician. Levator ani muscle avulsion must be diagnosed by using either transabdominal ultrasound or magnetic resonance imaging.¹⁶ Studies were excluded if they investigated women within 1 year after delivery. The reason for this was because the etiology of urinary incontinence might be different directly after delivery compared with later in life and the possible recovery of pelvic floor structures during the first year.¹⁷ Another reason for exclusion was the absence of a control group without urinary incontinence. Studies only analyzing hiatus dimensions or only the urethral sphincter were excluded.⁵ Letters, commentaries, editorial notes, and reviews were also excluded. Studies in any language were eligible for inclusion.

2.2 | Search strategy

The primary investigator (CFAS) performed a comprehensive search from inception until 5 November 2019 in the following online databases: PubMed and Embase. To capture all relevant articles on this subject, Medical Subject Headings (MeSH) and Thesaurus terms and text words with different variations were used. There were no restrictions on publication date or language. The structured search (see Appendix S1) can be reproduced using the following keywords and logical operators: levator ani muscle and urinary incontinence. A manual search of the references of each selected article was performed to identify studies not captured by the online search but potentially relevant for this article.

2.3 | Study selection

Two researchers (CFAS and TFMV) screened the eligible studies separately, then compared if the same studies were selected. First, manuscript titles and abstracts were assessed for potential relevance. For all of the selected studies, the full-text was reviewed to determine eligibility. In case of disagreement, two other researchers (SMJVK and KJBN) decided whether the study was suitable for inclusion. In case full text was unavailable, the author was contacted to obtain the full text. None of the studies eligible for full-text assessment were in a language other than English.

2.4 | Data extraction

After the final selection, data were extracted on study design, sample size, study population, definition of outcome, and results of analysis.

2.5 | Data analysis

Raw data were used to compute the unadjusted odds ratio for each study, this to be able to pool a common measure of association. The random-effects model was used to compute a pooled estimate, which was visualized using a forest plot. When adjusted odds ratios were described, they were visualized using a forest plot. Values of I^2 were calculated as a measure of between-study variance due to heterogeneity; P values less than 0.05 were considered statistically significant.

2.6 | Risk of bias assessment

The quality of all included studies was assessed using the Newcastle-Ottawa Scale for cohort studies and case-control studies. This scale is a tool used for assessing the quality of studies for systematic reviews and meta-analyses. Assessment was carried out by two researchers (CFAS and TFMV) independently.

3 | RESULTS

3.1 | Study selection

The PubMed and Embase searches revealed 257 and 493 articles, respectively. After the elimination of duplicates, 524 unique articles were evaluated by manuscript title and/or abstract. After reading the full text of 70 studies, seven articles met the inclusion criteria. All protocols for the primary studies of included studies were available. No additional studies were identified by cross-checking reference lists. Figure 1 shows the flow diagram of the selection process.

3.2 | Characteristics of included studies

The articles investigating the relationship between levator ani muscle avulsion and urinary incontinence are listed in Table 1. Of the seven articles included, five were prospective observational cohort studies,¹⁷⁻²¹ and two were case-control studies.^{22,23}

In 2009, Dietz et al.²² explored the association between symptoms of stress urinary incontinence and/or urodynamic stress incontinence with levator ani muscle avulsion in 420 women with symptoms of pelvic floor disorders (e.g. frequent voiding, incontinence, urgency) and pelvic floor dysfunction. Morgan et al.²³ performed a secondary analysis of a case-control study²⁴ in 2009, which included 151 women with primary pelvic organ prolapse. In 2014, Chan et al.¹⁹ performed an extended study of a prospective observational study,²⁵ evaluating the effect of levator ani muscle avulsion on pelvic floor disorders and health-related quality of life in Chinese primiparous women 12 months after their first vaginal delivery. In 2017, Chan et al.¹⁷ performed a follow-up study of two prospective cohort studies^{26,27} different from the study of Chan et al. in 2014.¹⁹ They evaluated the impact of levator ani avulsion on pelvic floor disorders in women 3–5 years after their first delivery. In 2017, Garcia Mejido et al.¹⁸ performed a prospective cohort study with 105 women 36 months after delivery in which the relationship between levator ani muscle avulsion and urinary stress incontinence was assessed. In 2018, Handa et al.²⁰ derived data from a previous longitudinal cohort study of parous women, the Mothers' Outcomes After Delivery study.²⁸ They assessed 453 women annually for pelvic floor disorders. In 2019, Mathew et al.²¹ assessed 608 parous women, 15–24 years after their first delivery for pelvic floor disorders and levator ani muscle avulsion.

Levator ani muscle avulsion was divided by several studies into minor avulsion, macro-avulsion, and no avulsion. For the analysis of results, micro-avulsion was not taken into account.

3.3 | Risk of bias assessment

Table 2 provides quality scores for the studies, derived from assessing the risk of bias with the Newcastle-Ottawa Scale. Basis of assessment can be found in Table S1. Overall, there is heterogeneity between studies which should be taken into account. Despite the quality of

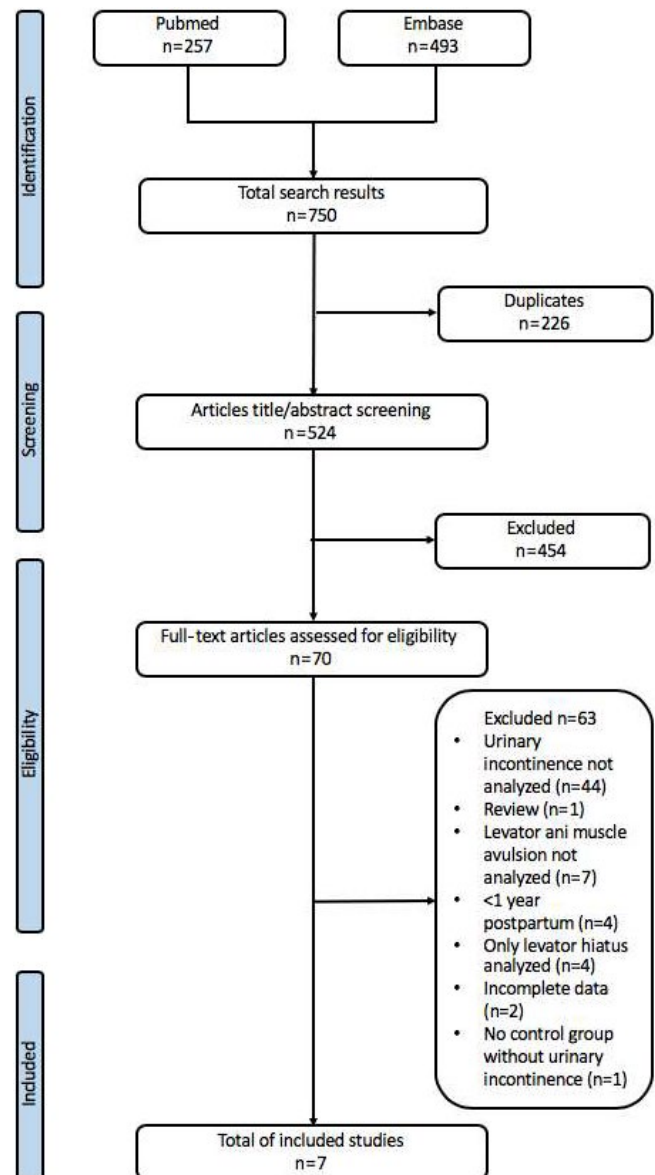


FIGURE 1 Flow diagram of the selection process

the studies included being assessed as adequate: all studies used correct methods for analyses of results and the main results were well presented and gave clear answers to their study's aims. Analysis of independent variables as possible confounders was performed in five studies.^{17,20-23} Levator ani avulsion was diagnosed using ultrasound in six studies,¹⁷⁻²² and using magnetic resonance imaging in one study.²³ Five studies^{17,19-21,23} only used validated questionnaires for diagnosis of urinary incontinence, and two studies^{18,22} used urodynamics.

The seven articles included enrolled a total of 2388 women.

3.4 | Meta-analysis

All studies provided results that were suited for meta-analysis.¹⁷⁻²³ Figure 2 shows the individual study results and the pooled estimate in

TABLE 1 Characteristics and results of individual studies

Study	Study design	N	Study population	Mean age, y	Prevalence LAM avulsion [#]	Diagnostic method ^c	Prevalence SUI	Results				
								Urinary incontinence	No LAM avulsion	LAM avulsion ^b	P value	
								N patients	UI/total N (%)	LAM avulsion ^b	OR (95% CI) ^a	
Dietz et al. (2009)	Case-control	420	Australian women with lower urinary tract symptoms and pelvic floor dysfunction	55	25%	3D translabial ultrasound	69%	269/316 (85%)	71/104 (68%)	0.38 (0.22–0.63)	<0.001	
Morgan et al. (2009)	Case-control	151	American women with primary pelvic organ prolapse	56	55%	MRI	– ^e	50%	20.5%	0.26 (0.12–0.57)	0.003	
Chan et al. (2014)	Prospective observational cohort	252 ^e	Chinese women with singleton pregnancy, evaluated 12 months after delivery	31	15%	3D translabial ultrasound	29%	63/213 (29.6%)	11/38 (28.9%)	0.97 (0.45–2.07)	0.958	
Chan et al. (2017)	Prospective observational cohort	399	Chinese primiparous and multiparous women, 3–5 years after delivery	35	15%	3D translabial ultrasound	38%	119/338 (35.2%)	34/61 (55.7%)	2.23 (1.33–4.03)	0.002	
Garcia Mejido et al. (2017)	Prospective observational cohort	105	Spanish women evaluated 36 months after delivery	30	31%	3D translabial ultrasound	19%	10/52 (19.2%)	4/24 (16.7%)	0.87 (0.25–3.04)	0.82	
Handa et al. (2018)	Prospective observational cohort	453	American parous women assessed for pelvic floor disorders	44	15%	3D translabial ultrasound	29%	112/387 (29%)	21/66 (32%)	1.1 (0.7–2.0)	0.64	
Mathew et al. (2019)	Prospective observational cohort	608	Norwegian parous women assessed for pelvic floor disorders, 15–24 years after delivery	48	19%	3D translabial ultrasound	43%	214/491 (43.6%)	42/111 (37.8%)	0.9 (0.6–1.3)	0.47	
								155/486 (31.9%)	30/111 (27%)	0.8 (0.5–1.3)	0.46	

Abbreviations: 3D, three dimensional; CI, confidence interval; LAM, levator ani muscle; MUI, mixed urinary incontinence; OR, odds ratio; SUI, stress urinary incontinence; UDS, urodynamics; UI, urinary incontinence; UUI, urge urinary incontinence.

^aAdjusted odds ratios were not stated in this table.

^bMinor avulsion was not seen as LAM avulsion, nor was no LAM avulsion.

^cQuestionnaire—all questionnaires used were validated, which questionnaire was used is specified in Table S1.

^dNo percentage given or raw data available.

^eParticipants of an earlier follow up in the study were not included.

a forest plot. Comparing women with and without levator ani muscle avulsion, the overall odds ratio for stress urinary incontinence was 0.87 (95% confidence interval 0.56–1.34). We recorded substantial heterogeneity between studies, as exemplified by the I^2 value of 71%.

Five studies^{17,20–23} adjusted for possible confounders, making levator ani avulsion the only risk factor. Additional risk factors that were controlled for in the adjustment in each study are shown in Table S1. Figure 3 shows the individual adjusted results, comparing women with and without levator ani muscle avulsion, the overall odds ratio for stress urinary incontinence when adjusted for additional risk factors is 0.72 (95% confidence interval 0.40–1.30).

4 | DISCUSSION

4.1 | Main findings

This systematic review including a meta-analysis concludes that there is no significant relationship between levator ani muscle avulsion and stress urinary continence in women. Dietz et al.²² and Morgan et al.²³ show levator muscle avulsion as a protective factor for stress urinary incontinence, confirmed after controlling for other risk factors. Chan et al.,¹⁹ Garcia Mejido et al.,¹⁸ Handa et al.,²⁰ and Mathew et al.²¹ do not show an association between levator ani muscle avulsion and stress urinary incontinence. On the other hand, Chan et al.¹⁷ show that levator ani muscle avulsion is a risk factor for stress urinary incontinence, even after adjusting for possible confounders. This heterogeneity in the outcome of results might be explained by several factors.

4.2 | Strengths and limitations

Unfortunately, not enough studies were found to allow for a proper meta-regression to assess sources of heterogeneity. We acknowledge that patient characteristics such as age may differ to a substantial degree, and we have therefore selected the random-effects meta-analysis model to account for between-study heterogeneity. As we were not interested in the association between levator ani muscle avulsion and stress urinary incontinence separately for pre-defined groups, stratified analyses were not performed.

Chan et al. stands out as being the only positive association. In their study, only 60% of the eligible women attended follow up. An explanation for this low percentage might be the lack of symptoms in women who were lost to follow up in comparison to women who did attend. This might cause a higher a priori probability of pelvic floor disorder symptoms (e.g. frequent voiding, incontinence, urgency) and be an explanation of why the odds ratio is considerably higher compared with the other studies.

Studies showing a protective association, Dietz et al.²² and Morgan et al.,²³ included women who had symptomatic pelvic organ prolapse or other pelvic floor disorder symptoms. Furthermore, the mean age of between 55 and 65 years, was higher in these two

studies,^{22,23} compared with the other five studies,^{17–21} where the mean age was between 29 and 48 years. Considering these two factors, we would expect the a priori probability of these two studies to be higher compared with the other studies.²⁹ There is not a direct explanation for why these women are less likely to have stress urinary incontinence. An indirect explanation could be the therapeutic success of pelvic floor muscle training, where all muscular structures of the pelvic floor are trained. The possible beneficial effect of pelvic floor muscle training relies on the basis of strengthening the urethral sphincter and control.³⁰ All women had pelvic organ prolapse or other pelvic floor disorder symptoms and had been seen by a urogynecologist. It is possible that a large proportion of the study population had undergone pelvic floor muscle training and so had improvement of or no urinary incontinence symptoms. Another explanation could be the anatomical changes in women with cystocele, which could lead to pseudo-continenence and explain the positive association.

In the studies by Chan et al.,¹⁹ Garcia Mejido et al.,¹⁸ Handa et al.,²⁰ and Mathew et al.,²¹ no association was found and they included primiparous and multiparous women, varying from 12 months to 24 years postpartum. The fact that no association was found, but the association between vaginal birth and urinary incontinence remains, can be explained by several other potential pathophysiologic mechanisms, including the devascularization of the urethra and denervation of the pudendal nerve, causing urinary incontinence.^{31,32}

Moreover, all studies assessed stress urinary incontinence by using different validated questionnaires. The cut-off values for the diagnosis of urinary incontinence were yes or no on the question asked in four studies^{17,19,21,23} and a validated questionnaire with scores, but no further specification for cut-off values in Handa et al.²⁰ Garcia Mejido et al.¹⁸ and Dietz et al.²² used urodynamics as an additional diagnostic tool to assess urinary incontinence. Whether the diagnostic accuracy of validated questionnaires and urodynamics are the same is debatable.³³ Studies using only validated questionnaires might provide a less accurate representation of women with urinary incontinence compared with studies that did both. Despite this, even with urodynamics no differences were found.

Further, the diagnosis of levator ani muscle avulsion was made with translabial ultrasound or magnetic resonance imaging in all studies. Detecting levator ani muscle avulsion with translabial ultrasound shows moderate to good agreement when compared with magnetic resonance imaging.³⁴ Studies using ultrasound all assessed the levator ani muscle left and right separately, definitions for levator muscle ani avulsion were similar but still slightly different for the studies. In Morgan et al.,²³ using magnetic resonance imaging, the levator ani muscle was scored for degree of muscle defect with more than half of the muscle missing seen as levator ani muscle avulsion, which is in agreement with definitions used by studies using ultrasound. Definitions used for magnetic resonance imaging and translabial ultrasound show good agreement.³⁵

In conclusion, due to heterogeneity, it is challenging to compare the included studies and their results. To account for these

TABLE 2 Risk of bias assessment cohort studies and case-control studies (Newcastle-Ottawa Quality Assessment Scale criteria)^a

Study	Selection			Comparability		Outcome		Quality	
	Representative-ness exposed cohort	Selection cohorts same source	Ascertainment of exposure	Outcome of interest not present at start study	Comparability of cohorts	Assessment of outcome	Follow-up time		Adequacy of follow up
Risk of bias assessment cohort studies (Newcastle-Ottawa Quality Assessment Scale criteria)									
Chan et al. (2014)	★	★	—	★	—	—	★	—	Fair
Chan et al. (2017)	★	★	—	★	★★	—	★	—	Fair
Garcia Mejido et al. (2017)	★	★	★	★	—	★	★	★	Good
Handa et al. (2018)	★	★	—	★	★★	★	★	—	Good
Mathew et al. (2019)	★	—	★	★	★	★	★	★	Good
Risk of bias assessment case-control studies (Newcastle-Ottawa Quality Assessment Scale criteria)									
Study	Selection		Comparability		Exposure		Quality		
	Adequacy case definition	Representativeness of cases	Selection of controls	Definition of controls	Comparability of cases and controls	Ascertainment of exposure	Same method of ascertainment	Non-response rate	
Dietz et al. (2009)	★	★	★	★	★★	★	★	★	Good
Morgan et al. (2009)	★	★	★	—	★★	★	★	—	Good

^aIn the category "comparability" two stars could be acquired (★★), in all other categories a maximum of one star could be acquired (★) when criteria were met. For the basis of assessment see Table S1.

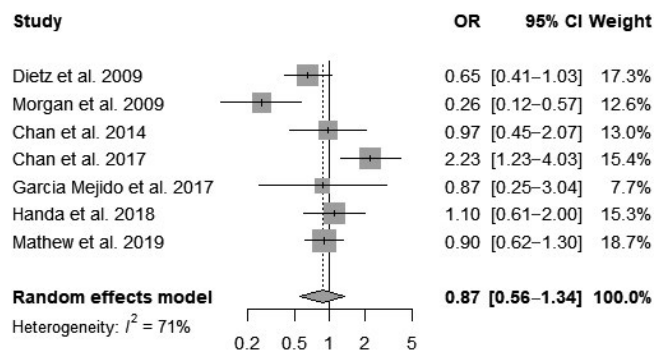


FIGURE 2 Pooled estimate forest plot

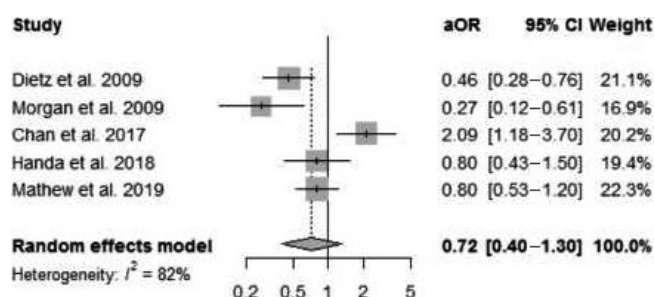


FIGURE 3 Pooled estimate forest plot adjusted for possible confounders

differences, the random-effects model was used for pooling measures of association, in contrast to the fixed-effects model, which assumes that differences in results are only due to sampling variance, not due to differences between studies.

4.3 | Hypothesis of continence after avulsion

Reflecting on the possible pathophysiologic link between levator ani muscle avulsion and stress urinary incontinence, we know that levator ani muscle avulsion is an important factor in the pathophysiology of pelvic organ prolapse, considering its effect on pelvic floor anatomy and function.^{24,36,37} The levator ani muscle provides dynamic support to the urethra through the connection to the endopelvic fascia of the anterior vaginal wall. This connection permits active contraction of the levator ani muscle to elevate the vesical neck and relaxation of the muscle to allow it to descend. The resting constant activity of the levator ani muscle supports the vesical neck during normal activities. Besides, for effective urethral closure and continence, the proper functioning of urethral sphincters is necessary. The external urethral sphincter consists of a horseshoe-shaped part anterolateral of the urethra, which is seen as the compressor of the urethra. It is only attached to the puborectalis muscle, part of the levator ani muscle, and has no bony attachment. Therefore, it appears reasonable to expect that avulsion of the levator ani muscle contributes to ineffective urethral closure and could influence continence in a negative way.³⁸⁻⁴⁰

4.4 | Conclusion

In summary, although it is a reasonable possible pathophysiologic relationship, this systematic review and meta-analysis could not support a relationship between levator ani muscle avulsion and urinary incontinence in women. This contributes to a better understanding of pathophysiologic mechanisms in stress urinary incontinence. Further research concerning the relationship between levator ani muscle avulsion and urinary incontinence after vaginal delivery might elucidate the pathophysiology.

CONFLICTS OF INTEREST

The authors have no conflicts of interest.

AUTHOR CONTRIBUTIONS

CFAS and TFMV screened all titles and all abstracts, and reviewed full articles. CFAS performed data extraction for meta-analysis. SMJVK and KJBN were a third and fourth reviewer in cases where consensus could not be reached. CFAS and SMJVK performed all data analysis. CFAS, TFMV, KJBN, SMJVK, and FMJM interpreted the data. CFAS created the initial draft of the manuscript, and all other authors critically appraised it. All authors gave their approval for the final version of this paper to be published.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

How to cite this article: Smeets CF, Vergeldt TF, Notten KJ, Martens FM, Kuijk SM. Association between levator ani avulsion and urinary incontinence in women: A systematic review and meta-analysis. *Int J Gynecol Obstet.* 2021;153:25-32. <https://doi.org/10.1002/ijgo.13496>