

The incidence of anal incontinence following obstetric anal sphincter injury graded using the Sultan classification: a network meta-analysis

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Introduction

In the United Kingdom, the mean rate of obstetric anal sphincter injuries (OASIs) is 2.9% (range, 0%–8%) of all vaginal deliveries.¹ In primiparous women, however, the rate is 6%.² Similarly, the incidence of OASI in the United States is also 2.9% (primiparous women, 6%).³ OASI is a substantial risk factor for the development of postpartum anal incontinence with approximately 4 in 10 women developing symptoms despite primary surgical repair.^{4,5} Anal incontinence is a cause of physical and psychological morbidity, and an increasing incontinence severity has been shown to be associated with worse quality of life outcomes.⁶

It was previously believed that OASIs were occult injuries with 33% of injuries being diagnosed on endoanal

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Received June 15, 2022; revised Nov. 6, 2022; accepted Nov. 8, 2022.

The authors report no conflict of interest.

N.A.O. reports receiving an educational grant from the Croydon Childbirth Charitable Trust.

This study did not receive any financial support.

This study was registered with the International Prospective Register of Systematic Reviews under identifier CRD4202126632 on July 6, 2021, and was amended on December 1, 2021.

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0002-9378

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<https://doi.org/10.1016/j.ajog.2022.11.1279>

OBJECTIVE: This study aimed to systematically determine and compare the incidence of anal incontinence between those with different grades of obstetric anal sphincter injury.

DATA SOURCES: Ovid MEDLINE, Embase, and the Cochrane Library were searched from January 2000 to April 2021.

STUDY ELIGIBILITY CRITERIA: Observational studies investigating the incidence of anal incontinence following an obstetric anal sphincter injury that was graded using the Sultan classification were eligible for inclusion. To allow comparison between individual tear grades (3a, 3b, 3c, fourth), a network meta-analysis was performed using Stata (version 15.1).

METHODS: For binary outcomes, odds ratios with corresponding 95% confidence intervals were reported. Obstetric anal sphincter injury grades were ranked from the best clinical outcome to the worst clinical outcome. The percentage chance of each grade taking each rank with regards to outcome was calculated. Study quality and risk of bias was assessed using the relevant tool from the Joanna Briggs Institute.

RESULTS: Of the 696 studies identified, 10 were eligible for inclusion and were included in the network meta-analysis (n=2467 women). The mean incidence of anal incontinence among those with 3a tears was 22.4% (range, 6.1%–51.2%), 24.9% (range, 6.9%–46.7%) among those with 3b tears, 26.8% (range, 0%–55.6%) among those with 3c tears, and 28.6% (0%–71.4%) among those with fourth-degree tears. Anal incontinence incidence was found to be significantly higher among those with 3c (odds ratio, 1.79; 95% confidence interval, 1.09–2.94) and fourth-degree tears (odds ratio, 2.37; 95% confidence interval, 1.40–4.02) than among those with 3a tears. In addition, anal incontinence incidence was significantly higher among those with fourth-degree tears (odds ratio, 1.89; 95% confidence interval, 1.10–3.22) than among those with 3b tears. Those with 3a tears had the highest probability of having the best clinical outcome; those with 3b; second-, 3c; third- and fourth-degree tears had the highest probability of having the worst clinical outcome. Overall, all studies had a high or unclear risk of bias across 1 or more assessed element.

CONCLUSION: This was a network meta-analysis comparing the incidence of anal incontinence among those with different grades of obstetric anal sphincter injury. Increasing tear-grade severity is associated with worse clinical outcomes. This study provides useful, clinically applicable information that can assist clinicians in the counseling of women following an obstetric anal sphincter injury. In addition, it highlights the importance of accurately diagnosing the obstetric anal sphincter injury grade and subsequently performing the appropriate repair.

Key words: anal incontinence, fecal incontinence, fecal urgency, flatal incontinence, meta-analysis, obstetric anal sphincter injuries, systematic review

ultrasound 6 weeks postpartum and only 3% of injuries being diagnosed clinically at the time of delivery.⁷ It was subsequently shown that these

undiagnosed injuries could have been diagnosed clinically by a trained clinician.⁸ Undiagnosed OASIs have substantial consequences and are

AJOG at a Glance

Why was this study conducted?

The Sultan classification is recommended for the grading of obstetric anal sphincter injuries (OASIs). To date, no study has systematically reported on the incidence of anal incontinence following an OASI that was graded using this classification.

Key findings

Anal incontinence incidence was 2-fold higher among those with 3c and fourth-degree tears than among those with 3a tears. The incidence was also 2-fold higher among those with fourth-degree tears than among those with 3b tears. Of note, those with 3a tears had the highest probability of having the best outcome; those with 3b, second-; 3c, third-; and fourth-degree tears had the worst outcome.

What does this add to what is known?

An increasing degree of OASI is associated with poorer outcomes. However, grouping OASIs into major and minor tears does not give a true reflection of the impact of tear grade.

associated with poorer outcomes than clinically diagnosed OASIs that were repaired at the time of delivery, particularly with regards to anal incontinence symptoms and residual anal sphincter defect size identified with an endoanal ultrasonographic scan.⁹ In addition, 10% of OASIs may be underclassified at delivery. This leads to inadequate repair, thereby increasing anal incontinence severity.¹⁰ Adequate training in the management of OASIs with dedicated hands-on courses has been shown to improve the knowledge of anal sphincter anatomy and the classification of OASIs.¹¹ However, previous obstetrical textbooks were not consistent in the classification systems used to grade OASIs.¹² The effect of this was highlighted in a national survey of the management of OASIs by Fernando et al¹³ who demonstrated that 22% of obstetrical trainees and 33% of consultant obstetricians incorrectly classified external anal sphincter (EAS) tears as second-degree tears. Therefore, Sultan¹⁴ suggested a more descriptive classification, which has been adopted internationally,¹⁵ including by the Royal College of Obstetrics and Gynaecology,¹⁶ the American College of Obstetricians and Gynecologists,¹⁷ and the International Consultation on Incontinence to ensure consistency in reporting.¹⁸ The classification grades are as follows:

- 3a—less than 50% of the EAS injured
- 3b—more than 50% of the EAS injured
- 3c—internal anal sphincter injured
- Fourth—anal sphincter complex and anal mucosa injured

Although a meta-analysis of the incidence of anal incontinence based on ultrasound-diagnosed OASIs has been performed previously, an endoanal ultrasound is not a modality routinely available to all clinicians.¹⁹ To the best of our knowledge, no meta-analysis has been performed previously to assess the incidence of anal incontinence following an OASI that was clinically graded according to the Sultan classification. Several observational studies have evaluated the effect of the degree of sphincter injury by grouping OASI grades into minor (3a, 3b) and major (3c, fourth-degree) tears.^{20–25} However, this makes it difficult for healthcare professionals to generate a hierarchy of anorectal symptom incidence based on the grades of OASI.

Objective

This study aimed to systematically determine and compare the incidence of anal incontinence among those with different grades of OASI (3a, 3b, 3c, fourth-degree tears).

Materials and Methods

A systematic review and network meta-analysis was performed in

compliance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines.²⁶ Meta-analysis of Observational Studies in Epidemiology guidelines for reporting meta-analyses of observational studies were also followed (Appendix 1).²⁷ The protocol was developed and registered with the International Prospective Register of Systematic Reviews under identifier CRD42021266332 on July 6, 2021.²⁸ The protocol was amended on December 1, 2021 to add an additional reviewer (A.T.) when data extraction indicated that there were sufficient data to perform a network meta-analysis instead of a traditional, pair-wise meta-analysis comparing the major (3a, 3b) and minor (3c, fourth degree) tear groups.

Search strategy and eligibility criteria

Our primary review question was as follows: “What is the risk of anal incontinence following OASI in women who are clinically diagnosed using the Sultan classification?” The MEDLINE, Embase, and Cochrane databases were searched from January 2000 to April 2021 using the terms “childbirth,” “pregnancy,” “delivery,” “obstetric anal sphincter injury,” “anal sphincter damage,” “anal sphincter injury,” and “incontinence” including Medical Subject Headings terms with no restriction on language (Appendix 2). We searched from 2000 because the Sultan classification was first described in 1999.¹⁴ Any translations required were sought by the librarian at the Croydon University Hospital (E.J.R.). Results were then exported to Zotero reference management system (Roy Rosenzweig Center for History and New Media, Fairfax, VA) and de-duplicated. Manuscripts were manually searched to identify additional relevant studies. No funding was required to complete this review. However, the Croydon Childbirth Charitable Trust provided an educational grant for N.A.O.

Inclusion and exclusion criteria

The following eligibility criteria were applied: observational studies reporting the incidence of anal incontinence

following OASI, graded clinically using the Sultan classification. Anal incontinence was defined as the involuntary loss of stool or flatus. Fecal incontinence was defined as the involuntary loss of solid or liquid stool. Flatal incontinence was defined as the involuntary loss of flatus (gas). Fecal urgency was defined as a sudden desire to defecate that is difficult to deter.¹⁸ Only studies that compared the incidence of symptoms among individuals with different grades of OASI were included. Case series, case reports, and conference papers were excluded. Studies with potential intervention bias (eg, comparison of primary OASI repair techniques) and those reporting the incidence of anal incontinence following subsequent deliveries after a diagnosis of OASI were also excluded. There was no limitation on follow-up period following a diagnosis of OASI. Two reviewers (N.A.O., A.T.) screened the titles and abstracts of all retrieved studies to obtain studies for full-text assessment. Disagreement about study selection was resolved through consensus or by the senior reviewers. Authors of included studies were contacted for unpublished data if the full text was unobtainable and if the data reported were published in a manner that was unclear or not extractable. A full list of excluded studies is given in [Supplemental Table 1](#). Full-text articles that met the inclusion criteria were independently assessed by the 2 reviewers (N.A.O., A.T.).

Data extraction

Data were collected using a standardized electronic data extraction form on Microsoft Excel. The data that were extracted included study characteristics (first author, publication year, study design, setting, sample size, validated incontinence score used) and outcome measures (incidence of anal incontinence, fecal incontinence, flatal incontinence, fecal urgency, and validated anal incontinence severity score). Two investigators (N.A.O., A.T.,) performed the data extraction to prevent errors. Any disagreements were resolved through consensus-based discussion.

Risk of bias of included studies

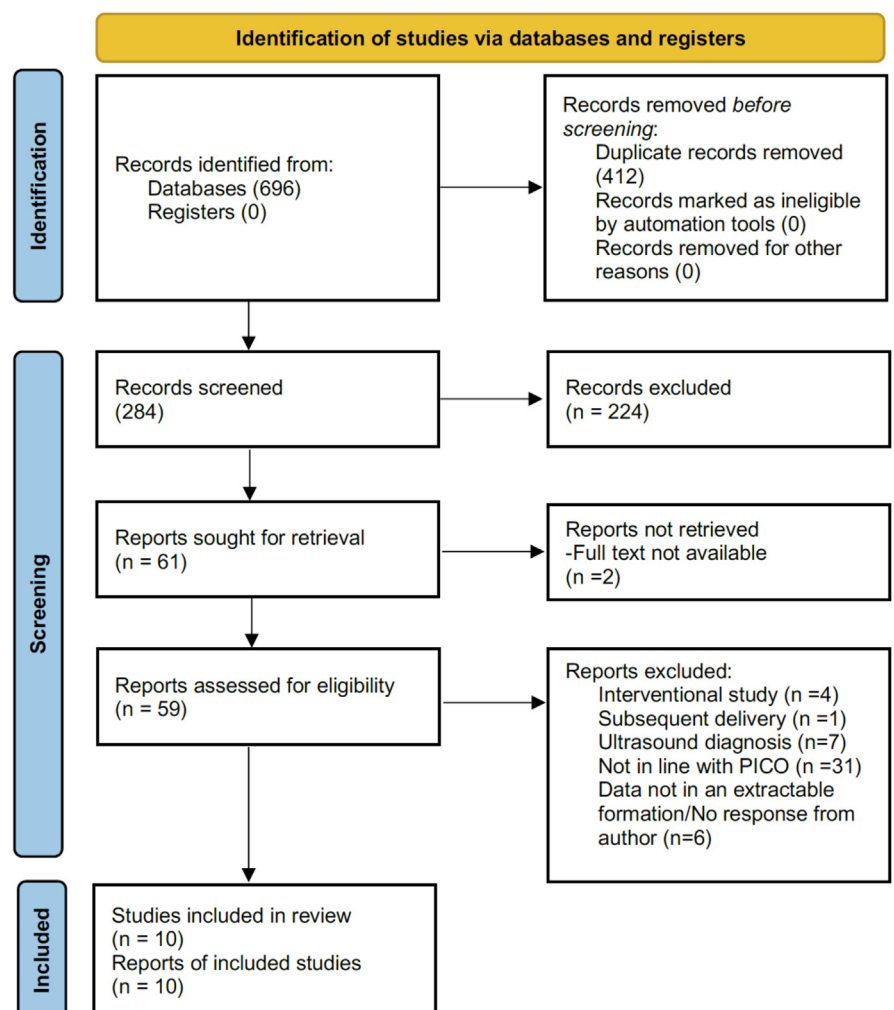
Risk of bias was independently assessed at an outcome level by the 2 reviewers (N.A.O., A.T.) using the relevant tool from the Joanna Briggs Institute.²⁹ Any disagreements on the study quality were resolved through consensus or by the senior reviewers (R.T., A.S.). These results were then integrated into the data analysis when interpreting and drawing conclusions from the meta-analysis findings.

Data synthesis

Stata (version 15.1; StataCorp LLC, College Station, TX) was used to analyze the data. The systematic review compared the 4 different tear grades using the Sultan

classification described previously.¹⁴ The analyses were performed using a network meta-analysis approach. A frequentist approach using the methods described by White et al³⁰ was used. Specifically, a model for treatment contrasts was used (the contrast-based model described by Salanti et al³¹), which considers treatment effects as fixed effects and heterogeneity between studies as random effects. Results were pooled and a meta-analysis was performed if each outcome was represented in at least 3 studies. For the binary outcomes, the differences between grades are summarized as odds ratios (ORs) with corresponding confidence intervals (CIs). These indicate the odds of the outcome in

FIGURE 1
PRISMA flow-chart



PRISMA, Preferred Reporting Items of Systematic Reviews and Meta-Analyses.

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TABLE 1
Included studies

Author, y	Follow-up	Country	Study design	Sample size	Anal incontinence incidence				Validated Score used
					3a	3b	3c	Fourth	
Bagade and Mackenzie, ³⁸ 2010	6 mo	United Kingdom	Retrospective cohort	75	16.10%	6.90%	10.00%	20.00%	Cleveland/Wexner
Everist et al., ²³ 2020	6 wk	Australia	Prospective cohort	122	17.20%	29.70%	55.50%	71.40%	SMIS
Gommessen et al., ³⁴ 2020	12 mo	Denmark	Prospective cohort	189	13.60%	15.20%	35.00%	33.30%	SMIS
Joris et al., ³⁵ 2019 ³⁵	6 wk	Switzerland	Prospective cohort	88	27.90%	43.80%	37.50%	40.00%	Holschneider-modified Kelly questionnaire/Parks staging
Linneberg et al., ³⁹ 2016	5 y	Denmark	Retrospective cohort	82	51.20%	38.50%	0%	53.30%	SMIS ^a
Ménard et al., ⁴⁰ 2016	2 mo	France	Retrospective cohort	79	41.50%	46.70%	55.60%	0%	None
Ramage et al., ³⁷ 2017	3–24 mo	United Kingdom	Retrospective cohort	161	— ^b	— ^b	— ^b	— ^b	Wexner
Ramalingam and Monga, ³⁶ 2013	6 mo	United Kingdom	Prospective cohort	255	6.10%	8.60%	11.10%	33.30%	Cleveland
Roos et al., ²⁰ 2010	9 wk	United Kingdom	Retrospective cohort	531	18.80%	18.50%	23.80%	10.00%	Manchester
Wan et al., ⁴¹ 2020	3 mo	United Kingdom	Retrospective cohort	1065	9%	16.20%	13.10%	30.60%	SMIS

SMIS, St Mark's Incontinence Score.

^a SMIS not reported in an extractable format; ^b Overall incidence of anal incontinence not reported, but incidence of fecal incontinence and flatal incontinence reported. Okeahidam. The incidence of anal incontinence following obstetric anal sphincter injury. *Am J Obstet Gynecol* 2022.

each category relative to the odds in the baseline category. For continuous variables, the mean difference (MD) between the grades was reported, again with the corresponding 95% CI. The chi-square statistic and corresponding *P* value were used to assess the presence of inconsistency.³² Consistency is a core assumption of a network meta-analysis and highlights the agreement between direct and indirect evidence.³³ A *P* value <.1 was considered statistically significant in inconsistency assessments, providing evidence of heterogeneity. The network meta-analysis was also used to rank OASI grades from the best outcome to the worst outcome. The percentage chance for each grade taking into account each rank with regards to outcome was calculated.

Results

Study selection

Of the 696 potentially relevant articles identified during the literature search, after removal of duplicates and screening of study titles and abstracts, 61 studies were selected for full-text review. A total of 10 studies were eligible and included in the network meta-analysis (Figure 1).

Study characteristics

Table 1 describes the characteristics of the included studies and the reported incidence of anal incontinence for each grade of OASI. A total of 2647 women were included in the review. This included 1117 (42.2%) women with 3a tears, 975 (36.8%) with 3b tears, 367 (13.9%) with 3c tears, and 188 (7.1%) with fourth-degree tears. The mean incidence of anal incontinence among women with 3a tears was 22.4% (range, 6.1%–51.2%), 24.9% (range, 6.9%–46.7%) among those with 3b tears, 26.8% (range, 0%–55.6%) among those with 3c tears, and 28.6% (range, 0%–71.4%) among those with fourth-degree tears. Studies were published between 2010 and 2020, and the design of these studies included 4 prospective observational studies^{23,34–36} and 6 retrospective observational studies.^{20,37–41}

Risk of bias of included studies

The risk of bias graph is shown in Supplemental Figure 1. It was unclear

TABLE 2
Summary of meta-analysis results

Outcome	Number of studies	Study (author, y)	Group 1	Sample size (n)	Group 2	Sample size (n)	Odds ratio (95% CI) ^a	P value	
Anal Incontinence	9	Bagade and Mackenzie, ³⁸ 2010 Everist et al, ²³ 2020 Gommesen et al, ³⁴ 2020 Linneberg et al, ³⁹ 2016 Menard, ⁴⁰ 2016 Ramalingam and Monga, ³⁶ 2013 Roos et al, ²⁰ 2010 Wan et al, ⁴¹ 2020	3a	1091	3b	923	1.26 (0.83–1.91)	.29	
						3c	296	1.79 (1.09–2.94)	.02
						4		2.37 (1.40–4.02)	.001
			3b	923	3c	296	1.43 (0.86–2.38)	.17	
						4	176	1.89 (1.10–3.22)	.02
			3c	296	4	176	1.32 (0.72–2.42)	.36	
			3a	680	3b	697	1.29 (0.53–3.12)	.58	
						3c	240	2.08 (0.81–5.31)	.13
						4	126	3.28 (1.25–8.61)	.02
Fecal Incontinence	4	Ramage et al, ³⁷ 2017 Ramalingam and Monga, ³⁶ 2013 Roos et al, ²⁰ 2010 Wan et al, ⁴¹ 2020	3b	679	3c	240	1.62 (0.66–1.89)	.30	
						4	126	2.55 (1.00–3.98)	.05
			3c	240	4	126	1.58 (0.60–4.16)	.36	
			3a	670	3b	679	1.41 (0.88–2.27)	.15	
						3c	240	1.27 (0.72–2.22)	.42
						4	126	2.41 (1.36–4.30)	.003
Flatal Incontinence	4	Ramage et al, ³⁷ 2017 Ramalingam and Monga, ³⁶ 2013 Roos et al, ²⁰ 2010 Wan et al, ⁴¹ 2020	3b	679	3c	240	0.89 (0.52–1.55)	.69	
						4	126	1.71 (0.97–3.01)	.06
			3c	240	4	126	1.91 (1.00–3.63)	.05	

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(continued)

TABLE 2
Summary of meta-analysis results (continued)

Outcome	Number of studies	Study (author, y)	Group 1	Sample size (n)	Group 2	Sample size (n)	Odds ratio (95% CI) ^a	P value			
Fecal Urgency	4	Ramage et al, ³⁷ 2017 Ramalingam and Monga, ³⁶ 2013 Roos et al, ²⁰ 2010 Wan et al, ⁴¹ 2020	3a	676	3b	689	1.09 (0.64–1.85)	.77			
					3c	258	1.40 (0.76–2.61)	.28			
					4	128	2.56 (1.33–4.90)	.005			
			3b	689	3c	258	1.29 (0.70–2.38)	.41			
					4	128	2.36 (1.24–4.49)	.009			
			3c	258	4	128	1.82 (0.92–3.61)	.09			
			Outcome	Number of studies	Group 1	Group 2	Mean difference (95% CI) ^b	P value			
			SMIS score	3	Everist et al, ²³ 2020 Patton 2018 Wan et al, ⁴¹ 2020	3a	558	3b	525	0.7 (0.3–1.0)	<.001
								3c	206	1.5 (0.9–2.1)	<.001
		4				79	0.9 (0.0–1.8)	.04			
3b	525	3c				206	0.8 (0.2–1.4)	.01			
		4				79	0.2 (–0.7 to 1.1)	.64			
3c	206	4				79	–0.6 (–1.6 to 0.4)	.24			

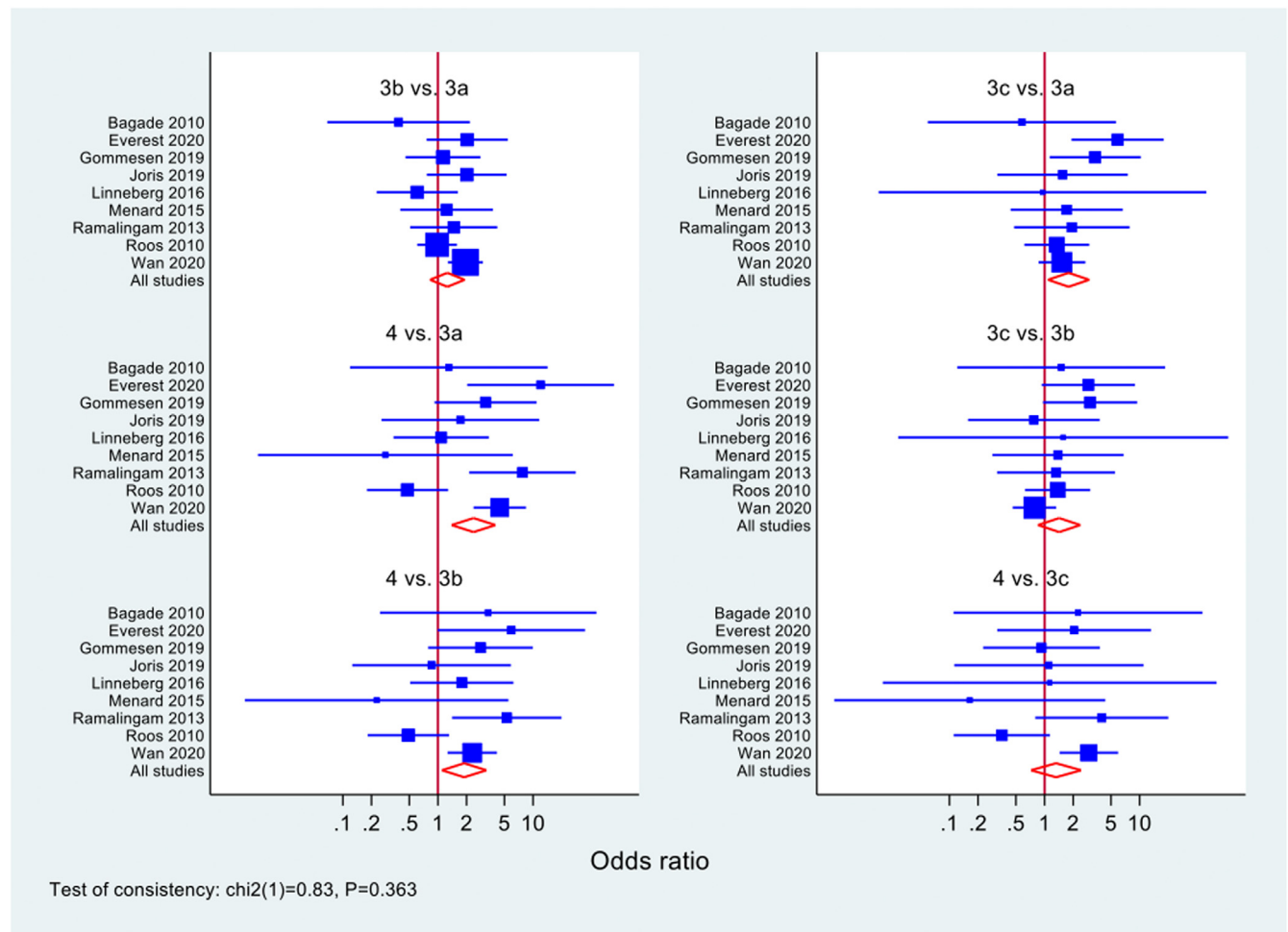
CI, confidence interval; SMIS, St Mark's Incontinence Score.

^a Odds ratios reported as odds of outcome in Group 2 relative to odds in Group 1; ^b Differences reported as Group 2 minus Group 1.

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FIGURE 2

The incidence of anal incontinence after obstetric anal sphincter injuries (3a, 3b, 3c, 4)



Okeahialam. The incidence of anal incontinence following obstetric anal sphincter injury. *Am J Obstet Gynecol* 2022.

from 8 (80%) studies if the participants did not have anal incontinence before the OASI.^{20,35–41} Although the follow-up time was sufficient in all studies, this was incomplete in 5 (50%) studies.^{35,37,39–41} In addition, strategies were not undertaken to address incomplete follow-up in 5 (50%) studies^{20,35,37,39,41} and were unclear in 3 (30%) studies.^{34,36,40} Overall, all studies had a high or unclear risk of bias across 1 or more assessed elements.

Synthesis of results

Network meta-analyses were performed to compare the outcomes of different

grades of OASIs (Table 2). The incidence of anal incontinence (n=9 studies) was found to be significantly higher among those with grade 3c (OR, 1.79; 95% CI, 1.09–2.94) and fourth-degree tears (OR, 2.37; 95% CI, 1.40–4.02) than among those with grade 3a tears and were significantly higher among those with fourth-degree tears (OR, 1.89; 95% CI, 1.10–3.22) than among those with 3b tears. (Figure 2). There was no evidence of network inconsistency ($\chi^2=0.83$; $P=.363$).

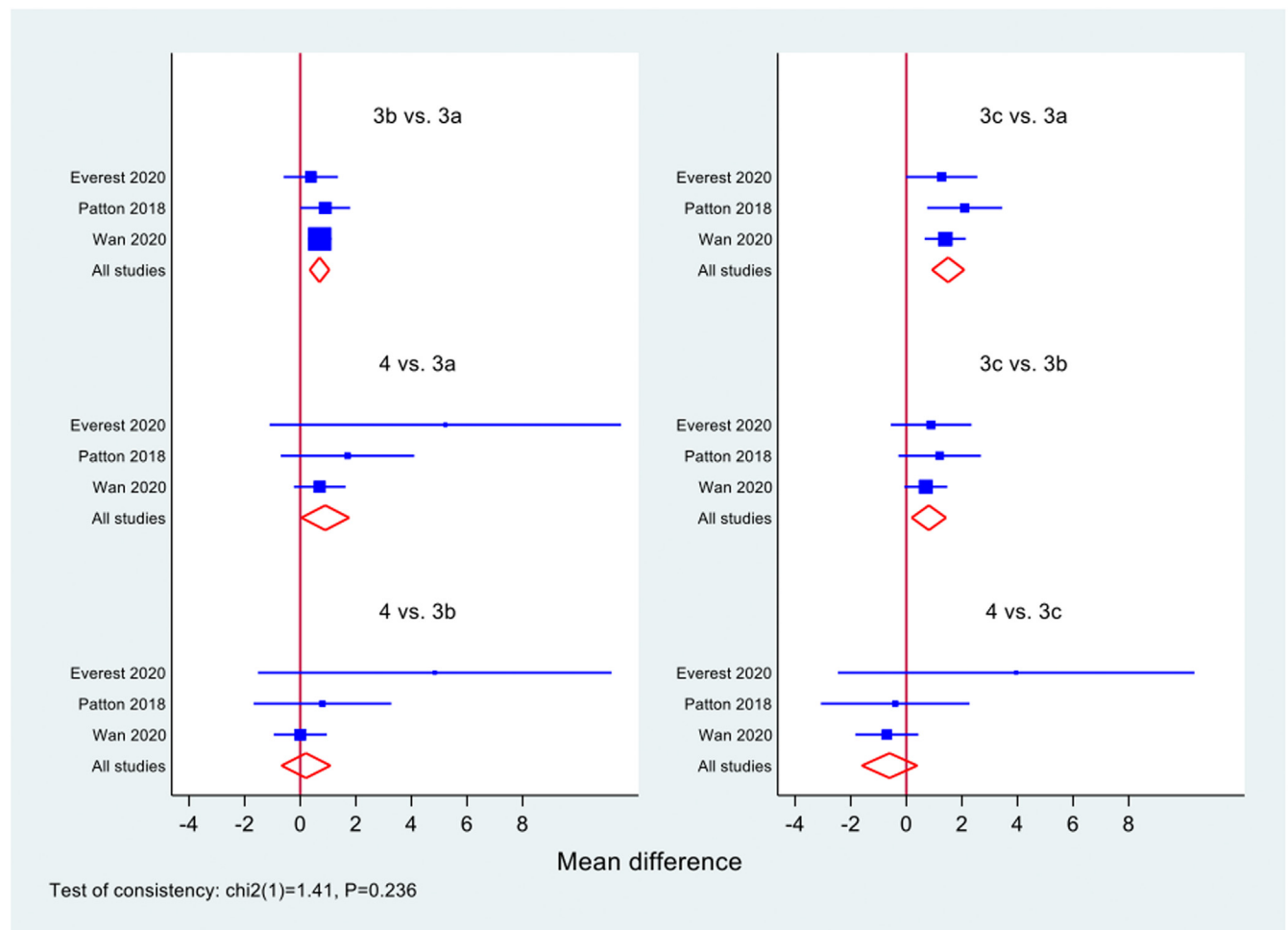
Three studies used the St Mark's Incontinence Score (SMIS) to evaluate the severity of anorectal symptoms. The

SMIS was significantly higher among those with 3b (MD, 0.7; 95% CI, 0.3–1.0), 3c (MD, 1.5; 95% CI, 0.9–2.1), and fourth-degree tears (MD, 0.9; 95% CI, 0.0–1.8) than among those with 3a tears. Scores among those with 3c tears (MD, 2.36; 95% CI, 1.24–4.49) were significantly higher than among those with 3b tears (Figure 3). There was no evidence of network inconsistency ($\chi^2=1.41$; $P=.236$).

Subgroup analyses were performed for different follow-up periods (Appendix 3). At 3 months, there was no significant difference in the incidence of anal incontinence across the tear groups.

FIGURE 3

The severity of anal incontinence using the St Mark's Incontinence Score after obstetric anal sphincter injuries (3a, 3b, 3c, 4)



Okeahialam. The incidence of anal incontinence following obstetric anal sphincter injury. *Am J Obstet Gynecol* 2022.

However, after 3 months, anal incontinence was significantly higher among those with fourth-degree tears (OR, 2.57; 95% CI, 1.24–5.29) than among those with 3a tears. In addition, anal incontinence was significantly higher among those with fourth-degree tears (OR, 2.93; 95% CI, 1.37–6.26) than among those with 3b tears.

Further subgroup analyses based on individual symptoms demonstrated the following findings. Fecal incontinence (n=4 studies) was significantly higher among those with fourth-degree tears (OR, 3.28; 95% CI, 1.25–8.61) than among those with 3a tears (Figure 4). The incidence of flatal incontinence

(n=4 studies) was highest among those with fourth-degree tears. However, the difference only reached statistical significance for the comparison with those with 3a tears (OR, 2.41; 95% CI, 1.36–4.30) (Figure 5). Fecal urgency (n=4 studies) was significantly higher among those with fourth-degree tears than both among those with 3a (OR, 2.56; 95% CI, 1.33–4.90) and 3b (OR, 2.36; 95% CI, 1.24–4.49) tears (Figure 6). However, there was evidence of network inconsistency with flatal incontinence ($\chi^2=3.87; P=.05$) and fecal urgency ($\chi^2=2.94; P=.09$)

Table 3 demonstrates the hierarchy of OASI grades in terms of anorectal

outcomes. Those with 3a tears had the highest chance of having the best outcome and the lowest chance of having the worst outcome in all assessed outcomes. Those with fourth-degree tears had the highest chance of having the worst outcome for 3 outcomes (anal incontinence, fecal incontinence, flatal incontinence, and fecal urgency) and the lowest chance of having the best outcome in all outcomes.

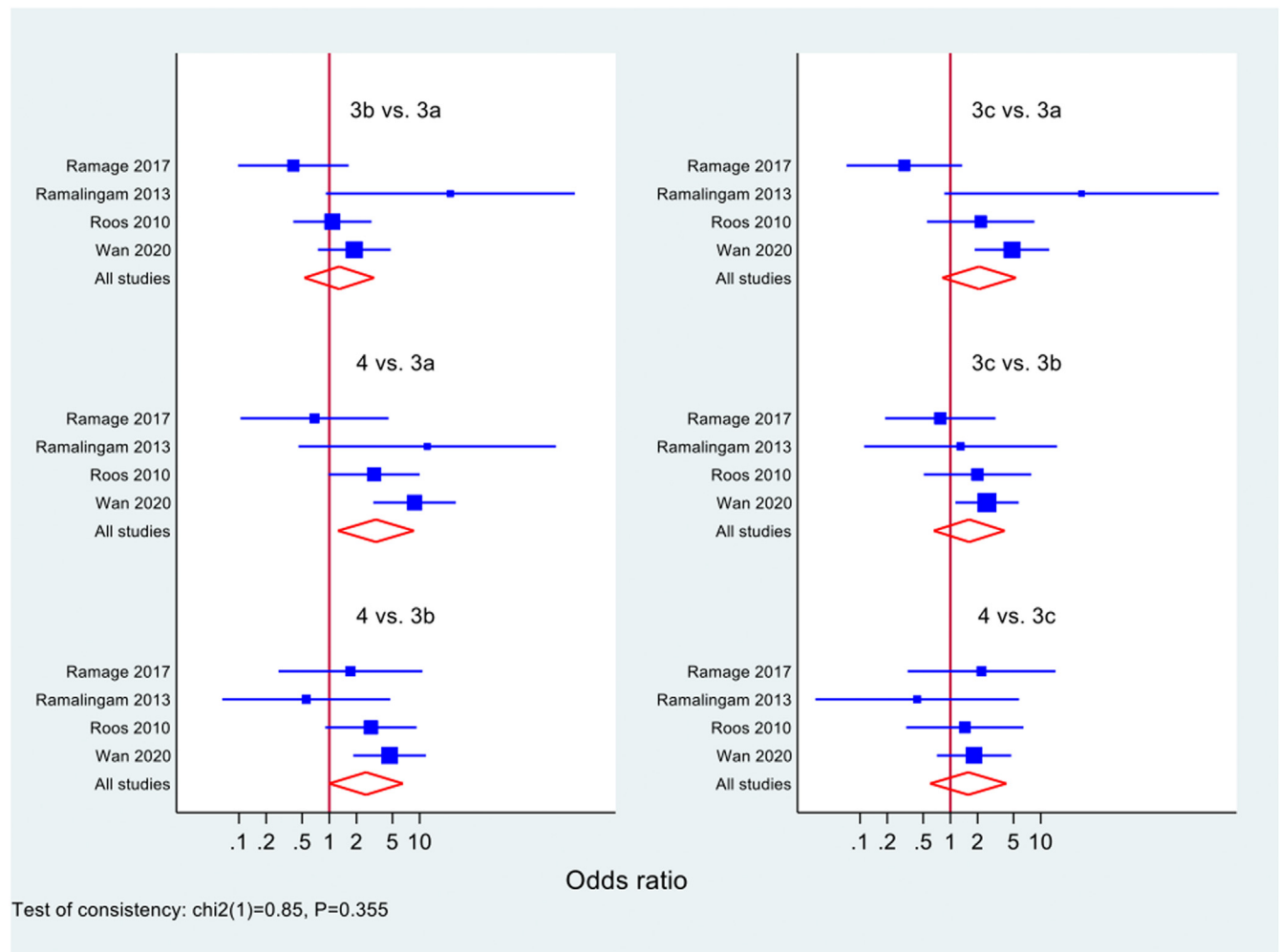
Comment

Principal findings

This network meta-analysis comprehensively evaluated the incidence of anal incontinence following an OASI,

FIGURE 4

The incidence of fecal incontinence after obstetric anal sphincter injuries (3a, 3b, 3c, 4)



Okeahialam. The incidence of anal incontinence following obstetric anal sphincter injury. *Am J Obstet Gynecol* 2022.

clinically graded using the Sultan classification. These results suggest that those with grade 3a tears have the best clinical outcome in terms of anal incontinence and those with 3b tears rank second, those with 3c tears rank third, and those with fourth-degree tears having the worst clinical outcome.

Comparison with existing literature

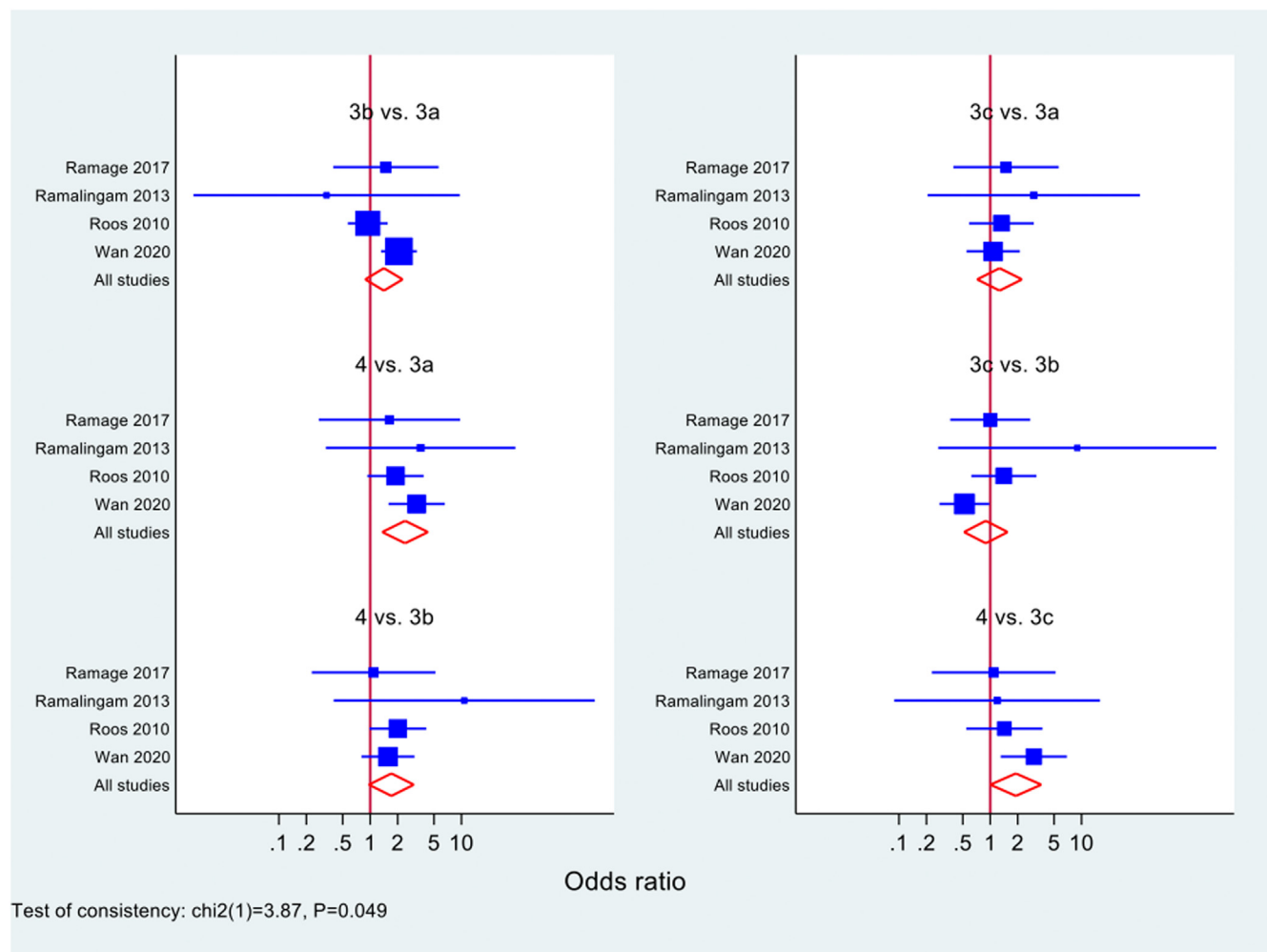
One meta-analysis has been published previously in which the incidence of anal incontinence following an OASI was evaluated.^{4,42} The meta-analysis, performed by LaCross et al⁴ found that in comparison with no OASI, OASI

increased the odds of anal incontinence 3-fold (OR, 2.66; 95% CI, 1.77–3.98). Their review included 11 studies, representing data from 2288 women with OASIs. However, the Sultan classification was not used, and OASIs was clinically classified as third or fourth degree only. Injury to the internal anal sphincter (IAS), which can occur in 3c and fourth-degree tears, has been shown to be predictive of anal incontinence following an OASI, increasing the odds of symptoms approximately 5-fold.⁴³ Acknowledging injury to the IAS in the diagnosis of an OASI is important, because it ensures appropriate repair and differentiation to

be made between incontinence secondary to IAS or EAS injury.¹⁶ The authors defined anal incontinence as the involuntary loss of stool or flatus. However, no subgroup analyses were performed to evaluate the validated symptom severity tools, fecal incontinence, flatal incontinence, or fecal urgency. The presence of fecal urgency in particular is an important symptom to assess and has been shown in long-term follow-up of women with anal incontinence secondary to OASIs to indicate a considerably worse quality of life.⁴⁴ Fecal urgency can occur without overt fecal incontinence and those with fecal incontinence associated

FIGURE 5

The incidence of flatal incontinence after obstetric anal sphincter injuries (3a, 3b, 3c, 4)



Okeahialam. The incidence of anal incontinence following obstetric anal sphincter injury. *Am J Obstet Gynecol* 2022.

with urgency reported a substantially worse quality of life, because of lifestyle effects, and reduced coping than those with passive fecal incontinence.⁴⁵ We acknowledge that with regards to anal incontinence, fecal incontinence, flatal incontinence, and fecal urgency, our results showed no difference between those with 3b and those with 3c tears. However, it important to appreciate that the SMIS not only takes into account the severity of fecal and flatal incontinence, but also fecal urgency.⁴⁶ Moreover, 3c tears were associated with a significant increase in the SMIS score when compared with those with 3b tears (MD,

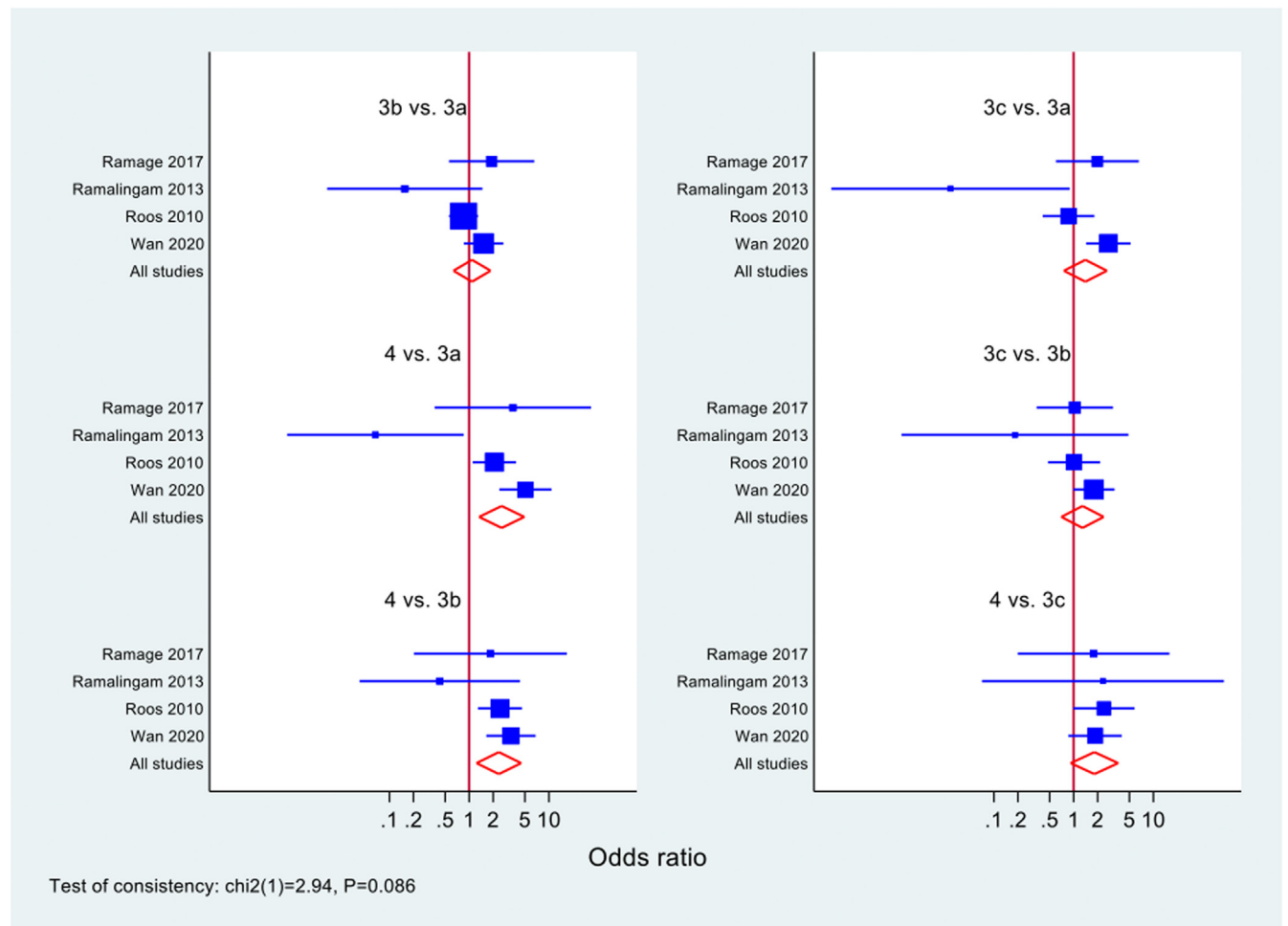
0.8; 95% CI, 0.2–1.4). A plausible explanation for the less consistent differences seen with subgroup symptoms could be owing to differences in symptom reporting because measurement of anal incontinence is subjective and based on patient reporting.⁴⁷ Because anal incontinence is variable in nature, using validated symptom scores allows better appreciation of symptoms and symptom severity and they are less prone to misinterpretation.

The incidence of anorectal symptoms including anal incontinence and fecal urgency has been evaluated previously in one systematic review.⁴² In the review by

Bols et al,⁴² which included 31 studies (n=33,342 women), outcomes analyzed included anal incontinence, fecal incontinence, flatus incontinence, soiling, and urgency. They demonstrated that OASIs (diagnosed clinically or on endoanal ultrasound) were strongly associated with anal incontinence and moderately associated with flatal incontinence. However, the date of publication of the included studies ranged from 1996 to 2009. This meant that OASIs were clinically classified as third- or fourth-degree tears, because the Sultan classification was first described later in 1999.¹⁴ To the best of our knowledge, no

FIGURE 6

The incidence of fecal urgency after obstetric anal sphincter injuries (3a, 3b, 3c, 4)



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meta-analysis has been performed previously to evaluate the incidence of anal incontinence following an OASI, graded using the Sultan classification. This simple but comprehensive classification is beneficial because it ensures that injury not only to the IAS is recognized, but also that the magnitude of injury to the EAS and any breach of the anal mucosa is identified. Therefore, this standardized grading system, which allows the systematic analysis of the incidence and risk of anorectal symptoms, takes into account the potential effect injury to the IAS may have. The extent of EAS injury and repair is also important because, when identified on endoanal

and transperineal ultrasound, the depth and angle of a residual EAS defect following primary repair has been shown to correlate with fecal and flatal incontinence.⁴⁸ We demonstrated that patients with 3a tears consistently had the best clinical outcome across all symptoms, and this information can be used to reassure women who sustain a 3a tear.

Both previously published systematic reviews seem to be solely based on published data and may thus be affected by reporting bias.^{4,42} In our network meta-analysis, we included both published and unpublished data. This improves the validity of our

analysis, because results with statistically significant findings are more likely to be published, thereby introducing publication bias when pooled for meta-analysis.⁴⁹ By including unpublished data in our meta-analysis and by using a different meta-analytical approach, we aimed to provide a comprehensive review of the evidence. A network meta-analysis has advantages over a standard, pair-wise meta-analysis, because it allows multiple direct and indirect comparisons to be made, which may increase estimate precision.^{50,51} In addition, rank estimations can then be made, allowing a hierarchy of the outcome examined to

TABLE 3
Probability ranking of tear grades in relation to anorectal symptoms

Outcome	Number of studies	Position	3a	3b	3c	4
Anal incontinence	9	First	84%	16%	0%	0%
		Second	16%	76%	7%	1%
		Third	0%	8%	73%	20%
		Fourth	0%	0%	20%	79%
Fecal incontinence	4	First	67%	30%	3%	0%
		Second	29%	57%	12%	2%
		Third	4%	12%	66%	19%
		Fourth	1%	2%	19%	79%
Flatal incontinence	4	First	75%	7%	18%	0%
		Second	20%	33%	46%	1%
		Third	5%	57%	33%	5%
		Fourth	0%	3%	3%	94%
Fecal urgency	4	First	55%	37%	7%	0%
		Second	35%	48%	17%	0%
		Third	9%	14%	71%	5%
		Fourth	0%	1%	5%	94%
SMIS	3	First	98%	0%	0%	2%
		Second	2%	67%	0%	31%
		Third	0%	33%	11%	56%
		Fourth	0%	0%	89%	11%

Figures are estimated percentage of each grade of tear being in each position.

SMIS, St Mark's Incontinence Score.

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be presented.³² The rank estimations we have demonstrated in our analysis could be used to guide the consent process for primary OASI repair and subsequent counseling.

The findings from our study are unsurprising, because it is known that outcomes, such as sexual function and wound complications, are worse with increasing grade of OASI.^{41,52} Our findings compliment this and demonstrate that the higher the grade of the tear, the worse the overall outcome. Moreover, because we found differences in anal incontinence severity between all grades of tears, this highlights that simply grouping OASIs into major and minor tears does not give a true reflection of the impact of tear grade.

Strengths and limitations

The main strength of this study is that it was a network meta-analysis comparing the incidence of anorectal symptoms including fecal incontinence, flatal incontinence, and fecal urgency in 3a, 3b, 3c, and fourth-degree tears. In addition, because the studies all reported the use of validated questionnaires to assess the presence and severity of anal incontinence, this meant that there was consistency in outcome reporting. The results of the validated SMIS strengthen our findings. Compared with the SMIS, other severity scoring tools, such as the Wexner score or the Cleveland Clinic Incontinence score, do not take into account the presence of fecal urgency.^{46,53} Moreover, the overall consistency of the

anal incontinence networks including SMIS was good, which improves the certainty of our findings. However, we do acknowledge that there was inconsistency found within the flatal and fecal incontinence networks. Network inconsistencies can occur if there are differences in the effect estimate obtained using direct and indirect evidence.³³ This may have occurred owing to the small number of studies included in those networks, because with low power it can be difficult to detect genuine inconsistencies.⁵⁴ Another potential cause includes a difference in study design seeing that 1 study was prospective in design and 3 were retrospective.^{20,36,37,41} Therefore, higher quality studies are required in the future.

Other study limitations also need to be acknowledged. First, because of the nature of observational studies, only association can be established, not causality. Particularly because it was unclear from most of the studies whether participants had anal incontinence before the OASI.^{20,35–41} This means that we cannot be sure whether symptoms were truly secondary to the OASI. In addition, there was no limitation on the follow-up period. With vaginal birth, injury to the anal sphincter and subsequent anal incontinence can be mechanical, neuro-pathic, or a combination of both.⁷ With neuropathic injury or stretch or compression injury of the pudendal nerve usually recovers and muscle reinnervation occurs within 6 months.^{7,55,56} Another limitation that should be considered is that because of the high risk of bias across the included studies, our effect estimates should be interpreted with caution. In addition, owing to insufficient data, we were unable to assess publication bias within individual pair-wise comparisons in the network meta-analysis. However, with network meta-analyses, assessing for publication bias is often difficult, particularly when there is no natural comparator. In our study, because we aimed to compare the incidence of anal incontinence among all OASI grades, there was not a natural comparator. Therefore, to address potential publication bias, we sought

unpublished data from the authors of the included studies.

With regards to study design, in the retrospective study by Linneberg et al,³⁹ 3b and 3c tears were combined because the authors stated that during that specific time period this was common practice in most obstetrical departments in Denmark. This may explain why there was no difference found in the rate of anal incontinence in the pair-wise comparison between those with 3b tears and those with 3c tears. Although the incidence of anal incontinence was higher among those with 3c tears (OR, 1.43; 95% CI, 0.86–2.38), one would expect this to be of significance because of injury to the IAS. This is because when the IAS is disrupted, it is associated with passive fecal incontinence and flatal incontinence because it is under autonomic control and contributes to 70% of sphincter resting pressure.⁵⁷ Furthermore, it is important to note that the retrospective studies by Wan et al,⁴¹ in which data between 2006 and 2016 (n=1065 women) were analyzed, and by Roos et al,²⁰ in which data between 2002 and 2008 (n=531 women) were analyzed, were performed in the same unit as the current study (Croydon University Hospital). This means that there is a 2 year (2006–2008) overlap of patients, meaning that some of the sample cohort may have been duplicated. However, Croydon University Hospital has approximately 3700 deliveries per year with an average OASI rate in 2021 of 2.4%. This means that 89 women may have been duplicated, which accounts for only 4% of our network meta-analysis sample size. We also note that there was variation in the follow-up time between the included studies, ranging from between 6 weeks to 5 years. Clinicians should bear this in mind when interpreting our results.

Conclusions and implications

After primary repair of an OASI, an increasing degree of sphincter injury is associated with poorer anal incontinence outcomes. Because anal incontinence can negatively affect a woman's quality of life, the approach used in this study provides useful, clinically applicable

information that can assist clinicians in the counseling of women following an OASI. In addition, this information can be used in medicolegal cases to determine the outcome of missed injuries (as identified by anal ultrasound) had the injury been diagnosed and repaired at the time of delivery. ■

ACKNOWLEDGMENTS

We thank E.J. Ramstead, MLIS, at Croydon Health Services Library, Croydon University Hospital, for the literature search support and P. Bassett, MSc, at Statsconsultancy Ltd for the support with the statistical analysis. We would also like to thank the following authors for providing their unpublished crude data: A.M. Roos, PhD, (Erasmus Medical Centre) and R. Everist (St George Hospital, Sydney).

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Appendix 1

MOOSE checklist		
Item number	Recommendation	Reported on page
Background		
1	Problem definition	To systematically determine the incidence and compare the incidence of anal incontinence between the individual grades of OASI (3a, 3b, 3c, 4 th degree tears) (page 7).
2	Hypothesis statement	Although a meta-analysis of the incidence of anal incontinence based on ultrasound diagnosed OASIs has been performed previously, endoanal ultrasound is not a modality routinely available to all clinicians. To our knowledge, no meta-analysis has been performed previously to assess the incidence of anal incontinence following OASI clinically graded using the Sultan Classification. A number of observational studies have evaluated the effect of the degree of sphincter injury, by grouping OASI grades into minor (3a, 3b) and major (3c, 4 th) tears. However, this makes it difficult for healthcare professionals to generate a hierarchy of anorectal symptom incidence based on the grades of OASI (page 7).
3	Description of study outcome(s)	Anal incontinence was defined as the involuntary loss of stool and/or flatus. Fecal incontinence: the involuntary loss of solid or liquid stool. Flatal incontinence: the involuntary loss of flatus (gas). Fecal urgency: a sudden desire to defecate, that is difficult to deter. (page 9)
4	Type of exposure or intervention used	N/A
5	Type of study design used	The following eligibility criteria were applied: Observational studies reporting the incidence of anal incontinence following OASI, graded clinically using the Sultan Classification. Anal incontinence was defined as the involuntary loss of stool and/or flatus. Fecal incontinence: the involuntary loss of solid or liquid stool. Flatal incontinence: the involuntary loss of flatus (gas). Fecal urgency: a sudden desire to defecate, that is difficult to deter. ¹⁸ Case series, case reports and conference papers were excluded. Studies with potential intervention bias (for example, comparison of primary OASI repair techniques) or reporting the incidence of anal incontinence following subsequent deliveries after OASI were also excluded. (page 9)
6	Study population	OASI, graded clinically using the Sultan Classification (page 9)
Search Strategy		
7	Qualifications of searchers	Credentials are listed on the title page
8	Search strategy, including time period included in the synthesis and key words	Search strategy and selection criteria (page 8) and Appendix 2
9	Effort to include all available studies, including contact with authors	Authors of included studies were contacted for unpublished data if the full text was unobtainable and if the data reported was published in a manner that was unclear or not extractable (page 9)
10	Databases and registries searched	Medline, EMBASE, EMCARE, Cochrane (page 8)
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		<i>(continued)</i>

MOOSE checklist (continued)

Item number	Recommendation	Reported on page
11	Search software used, name and version, including special features used	Zotero reference management system (page 8)
12	Use of hand searching	Additional references were hand searched to identify other relevant studies (page 8)
13	Lists of citations located and those excluded, including justification	Details of the literature search are described in the PRISMA flow chart (Figure 1)
14	Method of addressing articles published in languages other than English	Acknowledgments (page 19)
15	Method of handling abstracts and unpublished studies	Case reports, case series were excluded (page 9)
16	Description of any contact with authors	Authors of included studies were contacted for unpublished data if the full text was unobtainable and if the data reported was published in a manner that was unclear or not extractable (page 9)
Reporting of methods		
17	Description of relevance or appropriateness of studies assembled for assessing the hypothesis to be tested	Search strategy and selection criteria (page 8) and Appendix 2
18	Rationale for the selection and coding of data	Data extraction paragraph (page 9).
19	Documentation of how data were classified and coded	Data extraction paragraph (page 9).
20	Assessment of confounding	Studies with potential intervention bias (for example, comparison of primary OASI repair techniques) or reporting the incidence of anal incontinence following subsequent deliveries after OASI were also excluded (page 9)
21	Assessment of study quality, including blinding of quality assessors, stratification or regression on possible predictors of study results	Risk of bias was assessed at an outcome level by the two reviewers (N.A.O, A.T), independently using the relevant tool from the Joanna Briggs Institute (page 10), Supplementary figure 1
22	Assessment of heterogeneity	N/A
23	Description of statistical methods in sufficient detail to be replicated	The Chi ² statistic and corresponding p-value were used to assess the presence of inconsistency. ³² Consistency is a core assumption of a network meta-analysis and highlights the agreement between direct and indirect evidence. ³³ A p-value of <0.1 was considered statistically significant in inconsistency assessments, providing evidence of heterogeneity (page 11)
24	Provision of appropriate table and graphics	We provided the PRISMA flow-chart, included/excluded study characteristics tables and forest plots
Results		
25	Graphic summarising individual study estimates and overall estimate	Figure 2-6
26	Table giving descriptive information for each study included	Table 1
27	Results of sensitivity testing	N/A

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(continued)

MOOSE checklist (continued)

Item number	Recommendation	Reported on page
28	Indication of statistical uncertainty of findings	The Chi ² statistic and corresponding p-value were used to assess the presence of inconsistency. ³² Consistency is a core assumption of a network meta-analysis and highlights the agreement between direct and indirect evidence. ³³ A p-value of <0.1 was considered statistically significant in inconsistency assessments, providing evidence of heterogeneity (page 11)
Discussion		
29	Quantitative assessment of bias	Risk of bias was assessed at an outcome level by the two reviewers (N.A.O, A.T), independently using the relevant tool from the Joanna Briggs Institute (page 10), Supplementary figure 1
30	Justification for exclusion	Summary of excluded study table- Supplementary Table 1
31	Assessment of quality of included studies	Risk of bias was assessed at an outcome level by the two reviewers (N.A.O, A.T), independently using the relevant tool from the Joanna Briggs Institute (page 10), Supplementary figure 1
Conclusions		
32	Consideration of alternative explanation for observed results	Limitations are discussed on page 17-18.
33	Generalisation of the conclusions	After primary repair of OASI, increasing degree of sphincter injury is associated with poorer anal incontinence outcomes. As anal incontinence can negatively affect women's quality of life, the approach used in this study provides useful, clinically applicable information which, can assist clinicians in the counselling of women following OASI. Additionally, this information can be used in medicolegal cases to determine the outcome of missed injuries (as identified by anal ultrasound) had the injury been diagnosed and repaired at the time of delivery (page 19)
34	Guidelines for future research	Another potential cause includes a difference in study design, as one study was prospective in design whilst three were retrospective. Therefore, higher quality studies are required in the future." (page 17)
35	Disclosure of funding source	No funding required

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Appendix 2:

Search Strategy:

Database: Embase <1974 to 2021 April 13>

Search Strategy:

-
- 1 (Obstetric anal sphincter injur* or (obstetric anal sphincter adj3 injur*) or OASIS or obstetric anal sphincter trauma or (obstetric anal sphincter adj3 trauma) or obstetrical injury to the anal sphincter or third-degree perineal laceration* or third degree perineal laceration* or third-degree tear* or third degree tear* or fourth-degree laceration* or fourth degree laceration* or fourth-degree tear* or fourth degree tear* or severe perineal trauma or (severe perineal adj3 trauma) or third-degree perineal tear or third degree perineal tear* or fourth-degree perineal tear* or fourth degree perineal tear* or (single adj2 perineum) or (superficial adj2 perineum) or (complete adj2 perineum) or (complicated complete adj2 perineum)).mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword, floating subheading word, candidate term word] (6311)
 - 2 exp anus sphincter/ (9410)
 - 3 exp perineum/ or exp perineum injury/ (14085)
 - 4 1 or 2 or 3 (27652)
 - 5 (anal incontinence or fecal incontinence or faecal incontinence or bowel incontinence or faecal soiling or fecal soiling or faeces or feces or feceses or footstool* or stool*).mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword, floating subheading word, candidate term word] (205208)
 - 6 exp feces incontinence/ (21448)
 - 7 5 or 6 (205208)
 - 8 (flatus incontinence or flatus or flatulence* or passage of gas by anus or intestinal gas excretion* or farting or passing flatus or wind symptom or flatus function or flatul

- ence symptom or flatuses).mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword, floating subheading word, candidate term word] (15180)
 - 9 exp flatulence/ (13643)
 - 10 8 or 9 (15845)
 - 11 (faecal urgency or fecal urgency).mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword, floating subheading word, candidate term word] (562)
 - 12 (pregnancy or gestation).mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword, floating subheading word, candidate term word] (947616)
 - 13 exp pregnancy/ (691186)
 - 14 12 or 13 (948647)
 - 15 (childbirth or birth or labor or Parturition).mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword, floating subheading word, candidate term word] (602979)
 - 16 exp childbirth/ (59870)
 - 17 15 or 16 (603535)
 - 18 4 and 7 and 10 and 11 and 14 and 17 (7)
 - 19 4 and 7 and 14 and 17 (236)
 - 20 4 and 10 and 14 and 17 (35)
 - 21 4 and 11 and 14 and 17 (12)
 - 22 limit 18 to yr="2000 -Current" (7)
 - 23 limit 19 to yr="2000 -Current" (223)
 - 24 limit 20 to yr="2000 -Current" (35)
 - 25 limit 21 to yr="2000 -Current" (12)
- *****

Database: Ovid MEDLINE(R) and In-Process, In-Data-Review & Other Non-Indexed Citations and Daily <1946 to April 13, 2021>

Search Strategy:

-
- 1 (Obstetric anal sphincter injur* or (obstetric anal sphincter adj3 injur*) or OASIS or obstetric anal sphincter trauma or (obstetric anal sphincter

- adj3 trauma) or obstetrical injury to the anal sphincter or third-degree perineal laceration* or third degree perineal laceration* or third-degree tear* or third degree tear* or fourth-degree laceration* or fourth degree laceration* or fourth-degree tear* or fourth degree tear* or severe perineal trauma or (severe perineal adj3 trauma) or third-degree perineal tear or third degree perineal tear* or fourth-degree perineal tear* or fourth degree perineal tear* or (single adj2 perineum) or (superficial adj2 perineum) or (complete adj2 perineum) or (complicated complete adj2 perineum)).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms] (4156)
- 2 exp Perineum/ (9788)
- 3 1 or 2 (13541)
- 4 (anal incontinence or fecal incontinence or faecal incontinence or bowel incontinence or faecal soiling or fecal soiling or faeces or feces or feceses or footstool* or stool*).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms] (155552)
- 5 exp Fecal Incontinence/ or (bowel incontinence or fecal incontinence or fecal soiling or incontinence, bowel or incontinence, fecal or soilings, fecal).mp. (12153)
- 6 4 or 5 (155581)
- 7 (flatus incontinence or flatus or flatulence* or passage of gas by anus or intestinal gas excretion* or farting or passing flatus or wind symptom or flatus function or flatulence symptom or flatuses).mp. [mp=title, abstract, original title, name of substance word, subject heading

- word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms] (5181)
- 8 exp flatulence/ (1478)
- 9 7 or 8 (5181)
- 10 (faecal urgency or fecal urgency).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms] (265)
- 11 (pregnancy or gestation).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms] (1011599)
- 12 exp Pregnancy/ or (gestation or pregnancies or pregnancy).mp. (1034699)
- 13 11 or 12 (1034699)
- 14 (childbirth or birth or labor or Parturition).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms] (469046)
- 15 exp Parturition/ or (birth or births or childbirth or childbirths or parturition or parturitions).mp. (391662)
- 16 14 or 15 (486348)
- 17 3 and 6 and 9 and 10 and 13 and 16 (9)
- 18 3 and 6 and 13 and 16 (261)
- 19 3 and 9 and 13 and 16 (42)
- 20 3 and 10 and 13 and 16 (16)
- 21 (Obstetric anal sphincter injur* or (obstetric anal sphincter adj3 injur* or OASIS or obstetric anal sphincter trauma or (obstetric anal sphincter adj3 trauma) or obstetrical injury to the anal sphincter or third-degree perineal laceration* or third degree perineal laceration* or third-degree tear* or third degree tear* or fourth-degree laceration* or fourth degree laceration* or fourth-degree tear* or fourth degree tear* or severe perineal trauma or (severe perineal adj3 trauma) or third-degree perineal tear or third degree perineal tear* or fourth-degree perineal tear* or fourth degree perineal tear* or (single adj2 perineum) or (superficial adj2 perineum) or (complete adj2 perineum) or (complicated complete adj2 perineum)).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms] (4156)
- 22 exp Perineum/ (9788)
- 23 21 or 22 (13541)
- 24 (anal incontinence or fecal incontinence or faecal incontinence or bowel incontinence or faecal soiling or fecal soiling or faeces or feces or feceses or footstool* or stool*).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms] (155552)
- 25 exp Fecal Incontinence/ or (bowel incontinence or fecal incontinence or fecal soiling or incontinence, bowel or incontinence, fecal or soilings, fecal).mp. (12153)
- 26 24 or 25 (155581)
- 27 (flatus incontinence or flatus or flatulence* or passage of gas by anus or intestinal gas excretion* or farting or passing flatus or wind symptom or flatus function or flatulence symptom or flatuses).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms] (5181)
- 28 exp flatulence/ (1478)
- 29 27 or 28 (5181)
- 30 (faecal urgency or fecal urgency).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms] (265)
- 31 (pregnancy or gestation).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms] (1011599)
- 32 exp Pregnancy/ or (gestation or pregnancies or pregnancy).mp. (1034699)
- 33 31 or 32 (1034699)
- 34 (childbirth or birth or labor or Parturition).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms] (469046)
- 35 exp Parturition/ or (birth or births or childbirth or childbirths or parturition or parturitions).mp. (391662)
- 36 34 or 35 (486348)
- 37 23 and 26 and 29 and 30 and 33 and 36 (9)
- 38 23 and 26 and 33 and 36 (261)
- 39 23 and 29 and 33 and 36 (42)
- 40 23 and 30 and 33 and 36 (16)
- 41 limit 37 to yr="2000 -Current" (9)
- 42 limit 38 to yr="2000 -Current" (216)

43 limit 39 to yr="2000 -Current" (38)

44 limit 40 to yr="2000 -Current" (14)

Database: Cochrane

ID Search

#1 (Obstetric anal sphincter injur* or (obstetric anal sphincter adj3 injur*) or OASIS or obstetric anal sphincter trauma or (obstetric anal sphincter adj3 trauma) or obstetrical injury to the anal sphincter or third-degree perineal laceration* or third degree perineal laceration* or third-degree tear* or third degree tear* or fourth-degree laceration* or fourth degree laceration* or fourth-degree tear* or fourth degree tear* or severe perineal trauma or (severe perineal adj3 trauma) or third-degree perineal tear or third

degree perineal tear* or fourth-degree perineal tear* or fourth degree perineal tear* or (single adj2 perineum) or (superficial adj2 perineum) or (complete adj2 perineum) or (complicated complete adj2 perineum))

#2 MeSH descriptor: [Anal Canal] explode all trees

#3 MeSH descriptor: [Perineum] explode all trees

#4 #1 or #2 or #3

#5 anal incontinence or fecal incontinence or faecal incontinence or bowel soiling or faecal soiling or feces or feces or feces or footstool* or stool*

#6 MeSH descriptor: [Fecal Incontinence] explode all trees

#7 #5 or #6

#8 flatus incontinence or flatus or flatulence* or passage of gas by anus or intestinal gas excretion* or farting or passing flatus or wind symptom or flatus function or flatulence symptom or flatuses

#9 MeSH descriptor: [Flatulence] explode all trees

#10 #8 or #9

#11 faecal urgency or fecal urgency

#12 #4 and #7 and #10 and #11

#13 #4 and #7 with Cochrane Library publication date Between Jan 2000 and Dec 2021

#14 #4 and #10 with Cochrane Library publication date Between Jan 2000 and Dec 2021

#15 #4 and #11 with Cochrane Library publication date Between Jan 2000 and Dec 2021

Appendix 3

Summary of sub-group meta-analysis results for anal incontinence

Follow-up time	N. Studies	Study (author, year)	Group 1	Group 2	Odds Ratio (95% CI) ^(*)	P-value	
≤ 3 months	5	38	3a	3b	1.54 (0.86, 2.76)	0.15	
		23		3c	1.87 (0.97, 3.61)	0.06	
		35		4	2.15 (1.00, 4.61)	0.05	
		Ménard 2015					
		20	3b	3c	1.22 (0.36, 1.17)	0.56	
		41		4	1.40 (0.65, 3.24)	0.39	
			3c	4	1.15 (0.50, 2.63)	0.74	
> 3 months	4	Gommesen 2019	3a	3b	0.88 (0.48, 1.59)	0.66	
		39		3c	1.86 (0.79, 4.36)	0.16	
		36		4	2.57 (1.24, 5.29)	0.01	
		37					
			3b	3c	2.12 (0.90, 5.03)	0.09	
				4	2.93 (1.37, 6.26)	0.005	
			3c	4	1.38 (0.52, 6.66)	0.51	

(*) Odds ratios reported as odds of outcome in Group 2 relative to odds in Group 1

CI- confidence interval

Okeahialam. The incidence of anal incontinence following obstetric anal sphincter injury. *Am J Obstet Gynecol* 2022.

TABLE S1
Excluded studies

Title	Journal	Authors	Reason
Outcome of repair of obstetric anal sphincter injuries after three years.	International journal of gynaecology and obstetrics: the official organ of the International Federation of Gynaecology and Obstetrics	Reid, Annette J and Beggs, Andrew D and Sultan, Abdul H and Roos, Anne-Marie and Thakar, Raneer	Women without anal incontinence excluded and 3a tears
Immediate or delayed repair of obstetric anal sphincter tears-a randomised controlled trial.	BJOG : an international journal of obstetrics and gynaecology	Nordenstam, J and Mellgren, A and Altman, D and Lopez, A and Johansson, C and Anzen, B and Li, Zhong-Ze and Zetterstrom, J	Possible intervention bias as immediate vs delayed repair
Fecal and urinary incontinence in primiparous women.	Obstetrics and gynecology	Borello-France, Diane and Burgio, Kathryn L and Richter, Holly E and Zyczynski, Halina and Fitzgerald, Mary Pat and Whitehead, William and Fine, Paul and Nygaard, Ingrid and Handa, Victoria L and Visco, Anthony G and Weber, Anne M and Brown, Morton B and Pelvic Floor Disorders Network	No Sultan classification
Methods of repair for obstetric anal sphincter injury.	The Cochrane database of systematic reviews	Fernando, R and Sultan, A H and Kettle, C and Thakar, R and Radley, S	Possible intervention bias as immediate vs delayed repair
Prevalence of obstetric anal sphincter injury following vaginal delivery in primiparous women: a retrospective analysis.	Hong Kong medical journal = Xianggang yi xue za zhi	Kwok, S P K and Wan, O Y K and Cheung, R Y K and Lee, L L and Chung, J P W and Chan, S S C	Ultrasound diagnosis not clinical
Obstetric anal sphincter injuries - review of our data between 2015-2017.	Porodni poraneni analniho sfinkteru - analiza vlastniho souboru rodicek mezi lety 2015-2017.	Lincova, M and Neumannova, H and Mikyskova, I and Zikan, M	Full text not available
Prevalence and predictors of anal incontinence 6 years after first delivery.	Neurourology and urodynamics	Johannessen, Hege H and Stafne, Signe N and Falk, Ragnhild S and Stordahl, Arvid and Wibe, Arne and Morkved, Siv	OASIS not a measured variable
Mode of delivery following an OASIS and caesarean section rates.	European journal of obstetrics, gynecology, and reproductive biology	Cassis, Charlotte and Giarenis, Ilias and Mukhopadhyay, Sambit and Morris, Edward	Ultrasound diagnosis not clinical
[Anal incontinence and obstetrical anal sphincter injuries, epidemiology and prevention].	Incontinence anale et lesions obstetricales du sphincter anal, epidemiologie et prevention.	Fritel, X and Gachon, B and Desseauve, D and Thubert, T	Literature review

Okeahialam. The incidence of anal incontinence following obstetric anal sphincter injury. Am J Obstet Gynecol 2022.

(continued)

TABLE S1

Excluded studies (continued)

Title	Journal	Authors	Reason
Long-term anal incontinence after obstetric anal sphincter injury-does grade of tear matter?.	American journal of obstetrics and gynecology	Jango, Hanna and Langhoff-Roos, Jens and Rosthoj, Susanne and Saske, Abelone	Subsequent delivery included
Association between severities of striae gravidarum and Obstetric Anal Sphincter Injuries (OASIS).	Midwifery	Halperin, Ofra and Noble, Anita and Balachsan, Shosh and Klug, Ester and Liebergall-Wischnitzer, Michal	Outcome measure not applicable
The Effect of Perineal Lacerations on Pelvic Floor Function and Anatomy at 6 Months Postpartum in a Prospective Cohort of Nulliparous Women.	Birth (Berkeley, Calif.)	Leeman, Lawrence and Rogers, Rebecca and Borders, Noelle and Teaf, Dusty and Qualls, Clifford	No Sultan classification
Obstetric anal sphincter injury: a follow-up questionnaire study on longer-term outcomes.	International urogynecology journal	Cornelisse, Simone and Arendsen, Linda Petra and van Kuijk, Sander Martijn Job and Kluivers, Kirsten Birgit and van Dillen, Jeroen and Weemhoff, Mirjam	Data not in an extractable format- no response from author
Obstetric anal sphincter injury and incontinence 15-23 years after vaginal delivery.	Acta obstetricia et gynecologica Scandinavica	Halle, Tuva K and Salvesen, Kjell A and Volloyhaug, Ingrid	No Sultan classification
Does anal sphincter injury preclude subsequent vaginal delivery?.	European journal of obstetrics, gynecology, and reproductive biology	Fitzpatrick, M and Cassidy, M and Barassaud, M L and Hehir, M P and Hanly, A M and O'Connell, P R and O'Herlihy, C	Ultrasound diagnosis not clinical
Obstetric anal sphincter injury and anal incontinence following vaginal birth: a systematic review and meta-analysis.	Journal of midwifery & women's health	LaCross, Allison and Groff, Meredith and Smaldone, Arlene	Systematic review-References reviewed
Incidence and Predictors of Anal Incontinence After Obstetric Anal Sphincter Injury in Primiparous Women.	Female pelvic medicine & reconstructive surgery	Richter, Holly E and Nager, Charles W and Burgio, Kathryn L and Whitworth, Ryan and Weidner, Alison C and Schaffer, Joseph and Zyczynski, Halina M and Norton, Peggy and Jelovsek, John Eric and Meikle, Susan F and Spino, Cathie and Gantz, Marie and Graziano, Scott and Brubaker, Linda and NICHD Pelvic Floor Disorders Network	No Sultan classification
Perineal outcome and the risk of pelvic floor dysfunction: a cohort study of primiparous women.	The Australian & New Zealand journal of obstetrics & gynaecology	Rikard-Bell, Joan and Iyer, Jay and Rane, Ajay	No Sultan classification

Okeahialam. The incidence of anal incontinence following obstetric anal sphincter injury. *Am J Obstet Gynecol* 2022.

(continued)

TABLE S1

Excluded studies (continued)

Title	Journal	Authors	Reason
Incidence and risk factors of postpartum anal incontinence: a prospective study of 503 cases.	La Tunisie medicale	Malek-mellouli, Monia and Assen, Soule and Ben Amara, Fethi and Gada, Hamdi and Masmoudi, Kacem and Reziga, Hedi	No Sultan classification
Long-term function and morphology of the anal sphincters and the pelvic floor after primary repair of obstetric anal sphincter injury.	Colorectal disease : the official journal of the Association of Coloproctology of Great Britain and Ireland	Soerensen, M M and Pedersen, B G and Santoro, G A and Buntzen, S and Bek, K and Laurberg, S	Ultrasound diagnosis not clinical
Fecal incontinence, sexual complaints, and anorectal function after third-degree obstetric anal sphincter injury (OASI): 5-year follow-up.	International urogynecology journal	Visscher, A P and Lam, T J and Hart, N and Felt-Bersma, R J F	Women with OASI grade 3a without faecal incontinence 2 months following primary repair were excluded
Fecal incontinence after obstetric anal sphincter injuries.	International journal of gynaecology and obstetrics: the official organ of the International Federation of Gynaecology and Obstetrics	Huebner, Markus and Gramlich, Nathanja K and Rothmund, Ralf and Nappi, Luigi and Abele, Harald and Becker, Sven	No Sultan classification
Overlapping compared with end-to-end repair of complete third-degree or fourth-degree obstetric tears: three-year follow-up of a randomized controlled trial.	Obstetrics and gynecology	Farrell, Scott A and Flowerdew, Gordon and Gilmour, Donna and Turnbull, Geoffrey K and Schmidt, Matthias H and Baskett, Thomas F and Fanning, Cora A	Possible intervention bias
Mode of delivery and fecal incontinence at midlife: a study of 2,640 women in the Gazel cohort.	Obstetrics and gynecology	Fritel, Xavier and Ringa, Virginie and Varnoux, Noelle and Zins, Marie and Breart, Gerard	No Sultan classification
Early results of immediate repair of obstetric third-degree tears: 65% are completely asymptomatic despite persistent sphincter defects in 61%.	Colorectal disease : the official journal of the Association of Coloproctology of Great Britain and Ireland	Hayes, J and Shatari, T and Toozs-Hobson, P and Busby, K and Pretlove, S and Radley, S and Keighley, M	Ultrasound diagnosis not clinical
Incidence of fecal incontinence after childbirth.	Obstetrics and gynecology	Guise, Jeanne-Marie and Morris, Cynthia and Osterweil, Patricia and Li, Hong and Rosenberg, Deborah and Greenlick, Merwyn	No Sultan classification
Differences in outcomes after third- versus fourth-degree perineal laceration repair: a prospective study.	American journal of obstetrics and gynecology	Nichols, Catherine M and Lamb, Elizabeth H and Ramakrishnan, Viswanathan	No Sultan classification
Obstetric anal sphincter injury ten years after: subjective and objective long term effects.	BJOG : an international journal of obstetrics and gynaecology	Fornell, Eva Uustal and Matthiesen, Leif and Sjødahl, Rune and Berg, Goran	No Sultan classification

Okeahialam. The incidence of anal incontinence following obstetric anal sphincter injury. *Am J Obstet Gynecol* 2022.

(continued)

TABLE S1**Excluded studies** (continued)

Title	Journal	Authors	Reason
Anal sphincter function and integrity after primary repair of third-degree tear: uncontrolled prospective analysis.	ANZ journal of surgery	Rieger, Nicholas and Perera, Shevy and Stephens, Jacque and Coates, Donna and Po, Darren	No Sultan classification
Fecal and urinary incontinence after vaginal delivery with anal sphincter disruption in an obstetrics unit in the United States.	American journal of obstetrics and gynecology	Fenner, Dee E and Genberg, Becky and Brahma, Pavna and Marek, Lorri and DeLancey, John O L	No Sultan classification
[Vaginal delivery in primiparas and anal incontinence].	Vaginalni porod u primipar a analni inkontinence.	Kalis, V and Chaloupka, P and Turek, J and Sucha, R and Rokyta, Z	Full text not available
Symptoms and anal sphincter morphology following primary repair of third-degree tears.	The British journal of surgery	Davis, K and Kumar, D and Stanton, S L and Thakar, R and Fynes, M and Bland, J	No Sultan classification
Urinary and anal incontinence after vacuum delivery.	European journal of obstetrics, gynecology, and reproductive biology	Peschers, Ursula M and Sultan, Abdul H and Jundt, Katharina and Mayer, Anja and Drinovac, Visnja and Dimpfl, Thomas	Ultrasound diagnosis not clinical
Anal incontinence after childbirth.	CMAJ : Canadian Medical Association journal = journal de l'Association medicale canadienne	Eason, Erica and Labrecque, Michel and Marcoux, Sylvie and Mondor, Myrto	No Sultan classification
A randomized clinical trial comparing primary overlap with approximation repair of third-degree obstetric tears.	American journal of obstetrics and gynecology	Fitzpatrick, M and Behan, M and O'Connell, P R and O'Herlihy, C	Possible intervention bias
Anal incontinence in women with third or fourth degree perineal tears and subsequent vaginal deliveries.	The Australian & New Zealand journal of obstetrics & gynaecology	Sangalli, M R and Floris, L and Faltin, D and Weil, A	No Sultan classification
The effect of vaginal delivery on the pelvic floor.	Surgery today	Tsunoda, A and Shibusawa, M and Kamiyama, G and Kusano, M and Shimizu, Y and Yanaihara, T	OASI not a measured variable
Anal incontinence after childbirth: A hot topic..	Hepato-Gastro et Oncologie Digestive	Fathallah, Nadia and Spindler, Lucas and Thomas, Christian and De Parades, Vincent and Zeitoun, Jean-David and Sauvanet, Eric and Azria, Elie	Narrative review article
What is to blame for postnatal pelvic floor dysfunction in primiparous women-Pre-pregnancy or intrapartum risk factors?	European Journal of Obstetrics and Gynecology and Reproductive Biology	Kenny, Louise C. and Durnea, Uliana A. and Durnea, Constantin M. and O'Sullivan, Suzanne M. and O'Reilly, Barry A. and Khashan, Ali S. and Dornan, James C.	OASI not a measured variable

Okeahialam. The incidence of anal incontinence following obstetric anal sphincter injury. *Am J Obstet Gynecol* 2022.

(continued)

TABLE S1**Excluded studies** (continued)

Title	Journal	Authors	Reason
A systematic review of etiological factors for postpartum fecal incontinence	Acta Obstetrica et Gynecologica Scandinavica	Bols, Esther M.J. and Hendriks, Erik J.M. and De Bie, Rob A. and Berghmans, Bary C.M. and Baeten, Cor G.M.I. and Nijhuis, Jan G.	Systematic review-References reviewed
Defecatory symptoms during and after the first pregnancy: Prevalences and associated factors	International Urogynecology Journal	van Brummen, H. Jorien and Bruinse, Hein W. and van de Pol, Geerte and Heintz, A. Peter M. and van der Vaart, C. Huub	No Sultan classification
Anal incontinence after vaginal delivery: A five-year prospective cohort study	Obstetrics and Gynecology	Nordenstam, Johan and Brismar, Sophia and Lopez, Annika and Altman, Daniel and Zetterstrom, Jan and Pollack, Johan	No Sultan classification
Fecal and urinary incontinence after delivery: Risk factors and prevention	Gynecologie Obstetrique et Fertilité	Dupuis, O. and Rudigoz, R.-C. and Madelenat, P.	No Sultan classification
Anal function: Effect of pregnancy and delivery	American Journal of Obstetrics and Gynecology	Chaliha, Charlotte and Stanton, Stuart L. and Sultan, Abdul H. and Bland, J.Martin and Monga, Ash K.	Ultrasound diagnosis not clinical
The overlap technique versus end-to-end approximation technique for primary repair of obstetric anal sphincter rupture: a randomized controlled study	Acta obstetrica et gynecologica Scandinavica	Rygh, AB and K√{o}rner, H	Potential intervention bias
Mode of delivery after previous obstetric anal sphincter injuries (OASIS)-a prospective observational study	International urogynecology journal and pelvic floor dysfunction	Karmarkar, R and Bhide, AA and Digesu, A and Khullar, V and Fernando, R	Conference abstract
Medium- to Long-term Follow-up of Obstetric Anal Sphincter Injury.	Diseases of the colon and rectum	Turel, Friyan D and Langer, Susan and Shek, Ka Lai and Dietz, Hans Peter	Data not in an extractable format- no response from author
The relationship between residual sphincter damage after primary repair, faecal incontinence, and anal sphincter function in primiparous women with an obstetric anal sphincter injury.	Neurourology and urodynamics	Patton, Vicki and Kumar, Swetha and Parkin, Katrina and Karantanis, Emmanuel and Dinning, Phil	Data not in an extractable format- no response from author
Residual defects after repair of obstetric anal sphincter injuries and pelvic floor muscle strength are related to anal incontinence symptoms.	International urogynecology journal	Cerro, Cristina Ros and Franco, Eva Martinez and Santoro, Giulio Aniello and Palau, Maria Jose and Wiczorek, Pawel and Espuna-Pons, Montserrat	Data not in an extractable format- no response from author
Anal incontinence, urinary incontinence and sexual problems in primiparous women - a comparison between women with episiotomy only and women with episiotomy and obstetric anal sphincter injury.	BMC women's health	Stedenfeldt, Mona and Pirhonen, Jouko and Blix, Ellen and Wilsgaard, Tom and Vonon, Barthold and Oian, Pal	Data not in an extractable format- no response from author

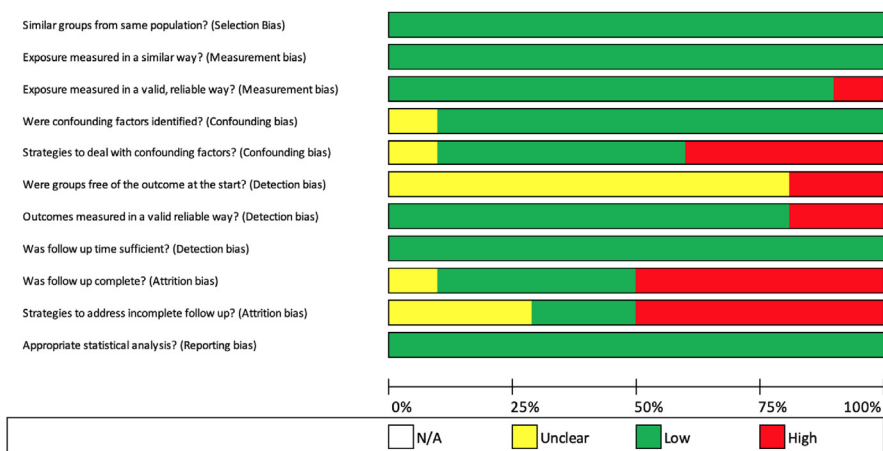
Okeahialam. The incidence of anal incontinence following obstetric anal sphincter injury. *Am J Obstet Gynecol* 2022.

(continued)

TABLE S1**Excluded studies** (continued)

Title	Journal	Authors	Reason
Risk factors and outcome of repair of obstetric anal sphincter injuries as followed up in a dedicated perineal clinic	International Urogynecology Journal	Breffini Anglim, Linda Kelly, Myra Fitzpatrick	Data not in an extractable format- no response from author

Okeahialam. The incidence of anal incontinence following obstetric anal sphincter injury. Am J Obstet Gynecol 2022.

FIGURE S1**Risk of Bias using the Joanna Briggs Institute Tool**

Okeahialam. The incidence of anal incontinence following obstetric anal sphincter injury. Am J Obstet Gynecol 2022.