International Journal of Clinical Obstetrics and Gynaecology

ISSN (P): 2522-6614
ISSN (E): 2522-6622
Indexing: Embase
Impact Factor (RJIF): 6.71

www.gynaecologyjournal.com
2025; 9(6): 1555-1562
Received: 04-09-2025
Accepted: 07-10-2025

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Assessment of Anal Sphincter Measurement Pre and Postnatal Vaginal Delivery using Transperineal Ultrasound: A prospective cohort study

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DOI: https://www.doi.org/10.33545/gynae.2025.v9.i6k.1829

Abstract

Background: Vaginal childbirth is a key risk factor for injury to the anal sphincter complex and for the later development of anal incontinence. Obstetric anal sphincter injuries (OASIS) may be overt or occult, and even when recognised and repaired, a proportion of women continue to experience bowel symptoms and deteriorated quality of life.[1-3] Clinical examination alone can underestimate the true burden of sphincter damage, and there is growing interest in imaging-based assessment of the anal sphincter in the immediate postpartum period.[2, 4] Transperineal ultrasound (TPUS) offers a simple, non-invasive method to visualise and measure anal sphincter morphology.[8-12]

Aim: To evaluate the immediate effect of vaginal delivery on internal anal sphincter (IAS) and external anal sphincter (EAS) thickness using two-dimensional (2D) transperineal ultrasound in primigravidae.

Materials and Methods: This prospective cohort study included 36 healthy primigravidae with term singleton cephalic pregnancies, planned for vaginal delivery, at a tertiary care teaching hospital in Karnataka, India. Women with previous anorectal surgery, known anal incontinence, gastrointestinal disease or third/fourth degree perineal tears were excluded. Standardised 2D TPUS examinations were performed within 24 hours prior to labour and repeated at 48 hours postpartum. IAS and EAS thickness were measured in millimetres at a predefined reference position by a single trained operator. Demographic and obstetric data (age, mode of delivery, neonatal birth weight) were recorded. Continuous variables were summarised as mean±standard deviation; categorical variables as frequency and percentage. Pre-post comparisons were made using paired t-tests, with $p < 0.05$ considered significant.

Results: Mean maternal age was 25.19±3.53 years; half of the women (50.0%) were 26-30 years and 38.9% were 21-25 years. Normal vaginal delivery occurred in 31 women (86.1%), and 5 (13.9%) had vacuum-assisted delivery. The mean neonatal birth weight was 2.94±0.24 kg; 91.7% of babies weighed 2.5-3.5 kg. Before labour, mean EAS thickness was 2.20±0.33 mm (range 1.536-2.662 mm) and mean IAS thickness was 2.57±0.10 mm (range 2.422-2.828 mm). At 48 hours postpartum, mean EAS thickness decreased to 1.91±0.24 mm (range 1.522-2.233 mm), and mean IAS thickness decreased to 1.93±0.17 mm (range 1.677-2.325 mm). The mean reduction in IAS thickness was 0.64±0.18 mm ($t = 20.784$; $p < 0.001$) and in EAS thickness 0.29±0.20 mm ($t = 8.939$; $p < 0.001$).

Conclusion: Vaginal delivery in primigravidae is associated with a significant immediate reduction in both internal and external anal sphincter thickness as assessed by 2D TPUS, with a more pronounced effect on the IAS. Incorporating TPUS into early postpartum assessment may help detect subclinical sphincter changes and identify women at risk of later anal incontinence.

Keywords: Anal sphincter, transperineal ultrasound, vaginal delivery, obstetric anal sphincter injury, primigravida, pelvic floor

Introduction

Anal continence is maintained by a complex interaction between the internal anal sphincter (IAS), external anal sphincter (EAS), puborectalis muscle, rectal compliance and sensory mechanisms. Any disturbance in this finely balanced system can lead to anal incontinence, defined as the involuntary loss of flatus or faeces, which has major psychosocial and physical consequences for affected women. [1-3] Among women, childbirth is the leading cause of acquired anal sphincter damage.[1, 2]

Multiple prospective cohort studies have demonstrated that anal incontinence is not rare after vaginal delivery. Pollack *et al*. reported significant rates of anal incontinence at five-year follow-up after childbirth in a cohort of Norwegian women and highlighted that symptoms can occur even in women without overt sphincter tears at delivery.[1] Sultan *et al*. used endoanal

ultrasound (EAUS) to show that a substantial proportion of women sustain anal sphincter disruption during vaginal birth, much of which is not appreciated clinically. [2] Schei *et al*. confirmed in a Scandinavian cohort that vaginal delivery is associated with a higher risk of subsequent anal incontinence than caesarean section.[3]

Obstetric anal sphincter injuries (OASIS; third- and fourth-degree perineal tears) are now clearly defined and graded in contemporary obstetric practice. Nevertheless, the true burden of sphincter trauma is probably underestimated because many injuries are occult or subclinical. [3, 5] Furthermore, even when OASIS are correctly identified and repaired, a subset of women go on to experience long-term bowel symptoms such as urgency, soiling and incontinence. [11-13] Early detection of structural changes in the sphincter complex may provide an opportunity for counselling and targeted rehabilitation.

Conventional diagnosis of OASIS relies upon perineal inspection and digital rectal examination immediately after delivery. However, studies have shown that clinical examination alone can miss a significant proportion of sphincter defects. [2] Imaging therefore plays an increasingly important role. EAUS is widely accepted as the reference standard for sphincter imaging but requires a dedicated probe, is invasive, and may not be acceptable or feasible for routine use in all postpartum women, especially in low- and middle-income settings. [8, 9]

Pelvic floor ultrasound has emerged as a versatile and less invasive tool to assess pelvic anatomy, levator integrity and anal sphincter morphology. [8, 9] Transperineal ultrasound (TPUS), performed with a conventional curved-array transducer placed between the vulva and anus, allows real-time visualisation of the anal canal, IAS, EAS as well as the vaginal and levator structures. [8-12] Dietz and colleagues have shown that TPUS provides reproducible measurements of pelvic floor structures and can detect levator trauma after delivery. [8, 9] More recently, Stickelmann *et al*. and Tanwar *et al*. demonstrated that TPUS can detect and monitor OASIS and occult sphincter injuries, respectively, in the postpartum period. [12, 13]

Despite these advances, there are relatively few studies that quantify the change in anal sphincter thickness before and after vaginal delivery using TPUS, particularly in primigravida with no prior pelvic floor insult. Most existing work has focused on the presence or absence of discrete sphincter defects rather than subtle changes in thickness and echogenicity. [11-13] Yet, small changes in sphincter thickness may still have functional implications or serve as a marker of stretching and oedema resulting from labour. The current study, conducted as a postgraduate thesis, aimed to address this gap by prospectively measuring IAS and EAS thickness using 2D TPUS immediately before labour and at 48 hours after vaginal delivery in primigravidae. By restricting the cohort to first-time mothers, confounding from previous deliveries and surgeries was avoided. The central hypothesis was that vaginal delivery would be associated with a measurable reduction in sphincter thickness, even in the absence of clinically diagnosed OASIS, and that TPUS could serve as a practical tool to document these changes.

Aims and Objectives

Primary objective

To assess internal anal sphincter (IAS) and external anal sphincter (EAS) thickness Pre and Postnatal vaginal delivery in primigravidae using two-dimensional transperineal ultrasound.

Secondary objectives

- To quantify the magnitude of change in IAS and EAS thickness within 48 hours postpartum.
- To describe the demographic and obstetric profile (maternal age, mode of delivery, neonatal birth weight) of the study population.

Materials and Methods

Study design and setting

This was a hospital-based prospective cohort study conducted in the Department of Obstetrics and Gynaecology of a tertiary care teaching hospital in Karnataka, India. The work formed part of the MS (Obstetrics and Gynaecology) dissertation titled "Assessment of Anal Sphincter Measurement in Pre and Post Natal Vaginal Delivery" submitted to Rajiv Gandhi University of Health Sciences.

The hospital caters to both rural and urban populations and functions as a referral centre, with a high volume of deliveries per year. This setting ensured an adequate pool of eligible primigravidae and allowed standardised imaging to be performed using the same equipment and operator.

Study population

The study included 36 consecutive primigravida who fulfilled the eligibility criteria and consented to participate. Recruitment was done from women admitted to the labour unit for planned vaginal delivery.

Inclusion criteria

- Primigravida aged 18-40 years.
- Term singleton pregnancy (≥ 37 weeks of gestation).
- Cephalic presentation.
- Planned vaginal delivery (spontaneous or vacuum-assisted).
- Ability and willingness to provide informed consent and undergo ultrasound examinations.

Exclusion criteria

- Third or fourth-degree perineal tear (OASIS) diagnosed clinically at delivery.
- Known gastrointestinal diseases such as Crohn's disease or ulcerative colitis.
- Previous anal or major perineal surgery.
- Women with sphincter interruption postpartum at the measurement site on ultrasound.
- Women presenting in advanced labour where pre-delivery imaging could not be performed.
- Multiparous women.

These criteria ensured a relatively homogeneous cohort of first-time mothers with low risk of pre-existing sphincter pathology, allowing clearer attribution of findings to the index vaginal birth.

Sample size

A sample size of 36 was chosen based on feasibility and in keeping with comparable ultrasound studies that evaluated anal sphincter dimensions before and after childbirth.[11-13] Although not powered to detect small effect sizes or rare outcomes, this number was considered adequate to demonstrate clinically meaningful pre-post changes in sphincter thickness in a pilot setting and to generate data for future larger studies.

Data collection procedure

After confirming eligibility, written informed consent was obtained. A structured proforma was used to record baseline

details:
- Maternal age.
- Obstetric history (primigravida in all cases).
- Gestational age at delivery.
- Planned mode of delivery.

Perinatal details were later added:
- Mode of delivery (normal vaginal or vacuum-assisted).
- Neonatal birth weight (kg).

All ultrasound examinations were carried out by a single trained investigator familiar with pelvic floor imaging, to minimise inter-observer variation.

Transperineal ultrasound technique
A conventional curved-array transducer (3.5-6 MHz) compatible with the obstetric ultrasound machine was used. The technique followed the principles described in pelvic floor ultrasound literature. [8-12].

Patient preparation and positioning
- The woman was examined in the dorsal lithotomy or semi-recumbent position with hips flexed and slightly abducted.
- Privacy and appropriate draping were ensured.
- The perineal area was cleaned and coupling gel applied.

Probe placement and imaging planes
- The transducer was placed on the perineum in the midsagittal plane, between the posterior commissure of the vulva and the anal verge.
- Gentle pressure was applied to maintain contact without causing discomfort or distortion of anatomy.
- The anal canal, IAS, EAS, rectum, vaginal wall and puborectalis muscle were identified by their echogenicity and anatomical relationships.

Measurement of anal sphincter thickness
- The IAS was visualised as a relatively hypoechoic circular layer surrounding the anal canal.
- The EAS appeared as a more echogenic outer muscular ring.
- Measurements were taken in millimetres using the built-in calipers of the ultrasound machine.
- A standardised reference position was used so that pre- and post-delivery values would be comparable.
- Each measurement was taken carefully, avoiding artefacts such as acoustic shadowing or motion.

All examinations were well tolerated. Because the women were scanned again at 48 hours postpartum rather than immediately after delivery, discomfort was minimal and no analgesia was required.

Timing of ultrasound examinations
Two ultrasound assessments were planned for each participant:

1. **Pre-delivery scan**
a) Performed within 24 hours before the onset of labour or soon after admission in early labour when the woman was still comfortable.
b) Provided baseline IAS and EAS thickness values.
2. **Post-delivery scan**
a) Performed at 48 hours after vaginal delivery once the woman was haemodynamically stable and comfortable.
b) Allowed early assessment of structural changes in the sphincter complex after childbirth.

Outcomes
Primary outcomes
- IAS thickness (mm) before and after delivery.
- EAS thickness (mm) before and after delivery.

Secondary descriptive outcomes:
- Age distribution.
- Mode of delivery.
- Neonatal birth-weight distribution.

Statistical analysis
Data entry and compilation were done using Microsoft Excel. Statistical analysis was carried out using SPSS version 26.0.
- Continuous variables were summarised as mean±standard deviation (SD) and range.
- Categorical variables were expressed as frequency and percentage.
- Differences between pre-delivery and post-delivery IAS and EAS thickness were assessed using paired t-tests.
- A p-value < 0.05 was considered statistically significant.

Ethical clearance for the study was obtained from the Institutional Ethics Committee prior to commencement, and all procedures adhered to standard ethical guidelines for human research.

Results
Demographic and obstetric profile
Age distribution

A total of 36 primigravida were included. The age distribution is presented in Table 1.

Table 1: Age distribution

Age Group	Frequency	Percent
18-20	2	5.6%
21-25	14	38.9%
26-30	18	50.0%
31-35	2	5.6%
Total	36	100%
Mean	25.19±3.528	

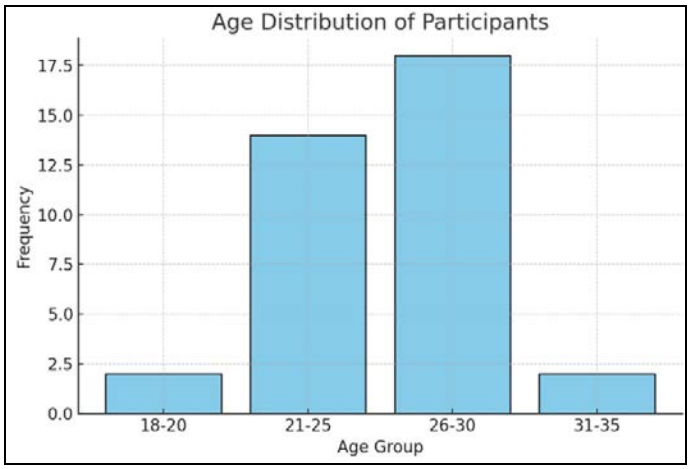

Fig 1: Age Distribution

Mean maternal age was 25.19±3.53 years. Half of the cohort was within the 26-30-year range (50.0%), followed by 21-25 years (38.9%).

Mode of delivery

Mode of delivery is summarised in Table 2.

Table 2: Type of Delivery

Delivery	Frequency	Percent
NVD	31	86.1
VACUUM	5	13.9

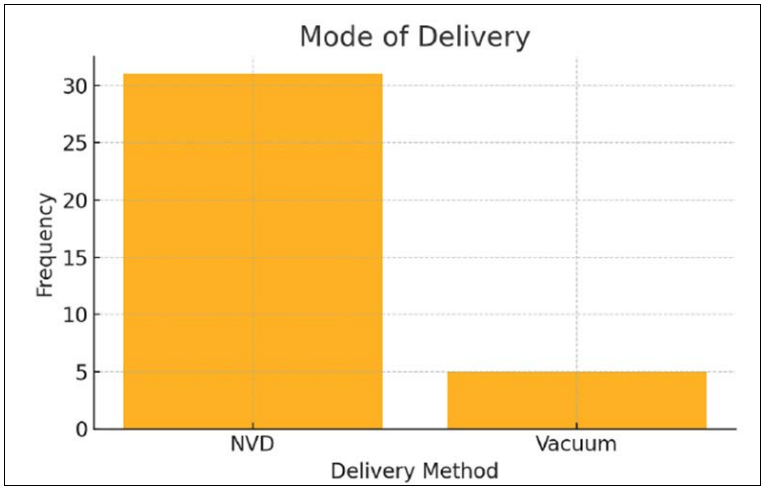

Fig 2: Distribution of mode of delivery among participants

Normal vaginal delivery occurred in 31 women (86.1%), and 5 (13.9%) had vacuum-assisted vaginal delivery. No forceps deliveries occurred.

Neonatal birth weight

Neonatal birth-weight distribution is shown in Table 3.

Table 3: Birth weight

Birth weight	Frequency	Percent
Low Birth Weight (<2.5 kg)	2	5.6%
Normal Birth Weight (2.5-3.5 kg)	33	91.7%
High Birth Weight (>3.5 kg)	1	2.8%
MEAN±SD	2.94±0.24	

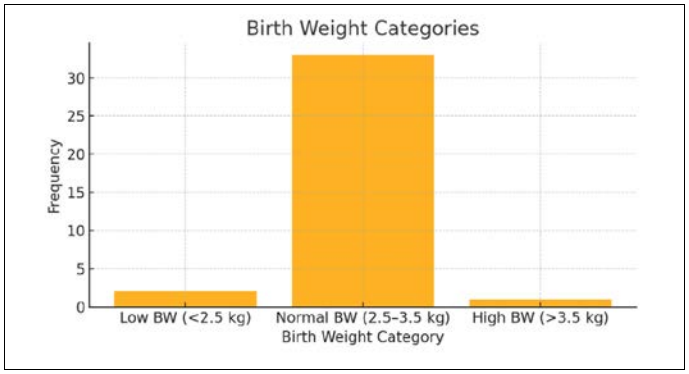

Fig 3: Distribution of neonatal birth weights among participants

The mean birth weight was 2.94±0.24 kg. Most neonates (91.7%) had a normal birth weight (2.5-3.5 kg), with only one weighing more than 3.5 kg.

Anal sphincter thickness before vaginal delivery

Baseline anal sphincter measurements are presented in Table 4.

Table 4: Sphincter thickness before vaginal delivery

Anal Sphincter thickness	Minimum	Mean	Maximum	SD
External	1.536	2.20006	2.662	0.333564
Internal	2.422	2.57103	2.828	0.108200

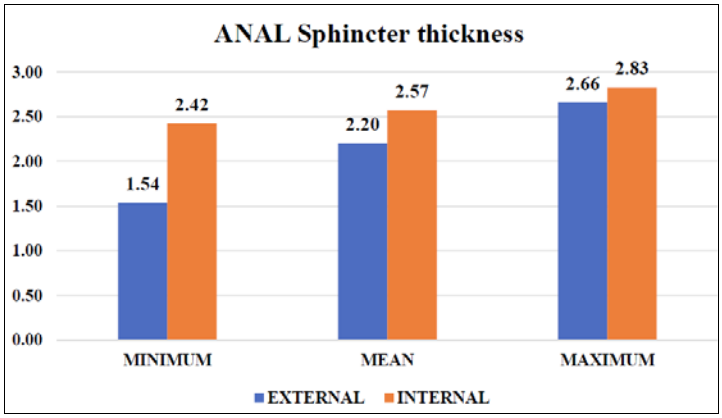

Fig 4: Sphincter thickness before vaginal delivery At baseline, the IAS was consistently thicker than the EAS. The narrow SD for IAS suggests relatively little inter-individual variability.

Anal sphincter thickness at 48 hours postpartum

Post-delivery sphincter measurements are summarised in Table 5.

Table 5: Sphincter thickness at 48 hours post vaginal delivery

Anal Sphincter thickness	Minimum	Mean	Maximum	SD
External	1.522	1.90581	2.233	0.239638
Internal	1.677	1.93136	2.325	0.171269

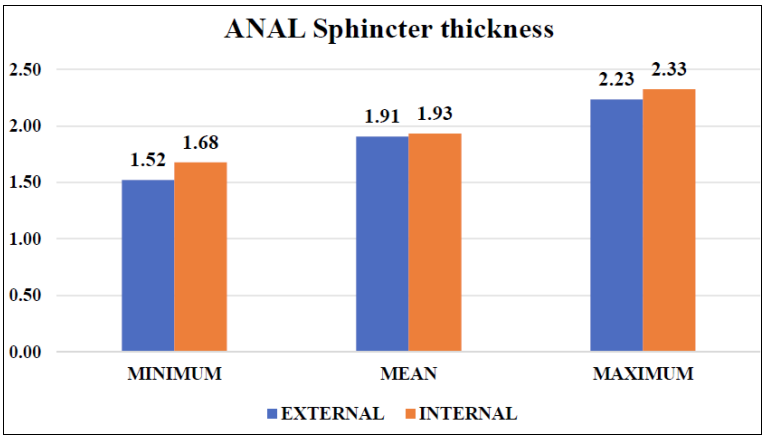

Fig 5: Sphincter thickness at 48 hours post vaginal delivery

By 48 hours postpartum, both IAS and EAS thickness had decreased compared with baseline, with the IAS demonstrating a larger downward shift.

Pre-post comparison of sphincter thickness

The magnitude and significance of pre-post differences were examined using paired t-tests.

Table 6: Paired Samples Statistics for internal anal sphincter thickness

Internal Anal Sphincter	Mean	SD	95% CI Lower	95% CI Upper	t	P Value
Pre	2.57	0.10	0.577185	0.702148	20.784	<0.001
Post	1.93	0.17				

Table 7: Paired Samples Statistics for external anal sphincter thickness

External Anal Sphincter	Mean	SD	95% CI Lower	95% CI Upper	t	P Value
Pre	2.20	0.33	0.227427	0.361073	8.939	<0.001
Post	1.90	0.23				

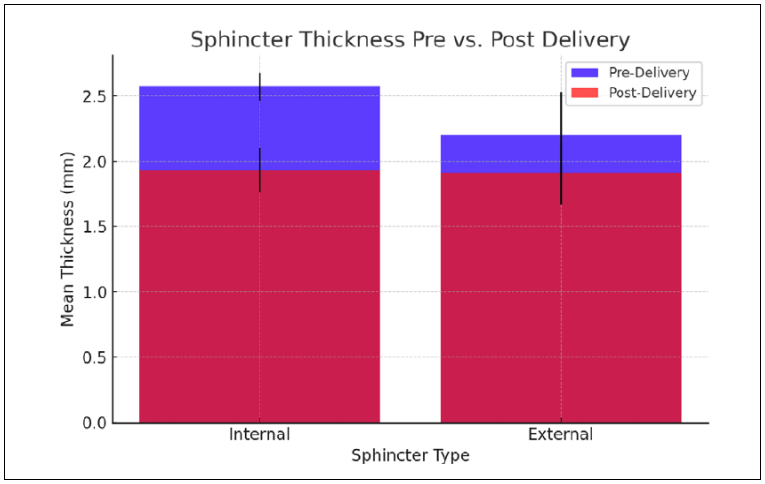

Fig 6: Paired Samples Statistics for external and internal anal sphincter

For the IAS, the mean reduction was 0.64 mm ($t = 20.784$; $p < 0.001$). For the EAS, the mean reduction was 0.29 mm ($t = 8.939$; $p < 0.001$). Thus, both sphincters showed a highly significant reduction in thickness post-delivery, with the IAS showing approximately double the absolute reduction.

Post-delivery sphincter thickness by mode of delivery

A descriptive comparison of post-delivery sphincter thickness between normal vaginal and vacuum-assisted deliveries is presented in Table 8.

Table 8: Comparison of Internal and External Anal Sphincter Thickness Post Delivery by Mode of Delivery

Delivery Mode	Inter-POST Mean±SD	Exter-POST Mean±SD
NVD	1.92±0.16	1.89±0.24
Vacuum	1.98±0.25	1.98±0.22
P-value	0.525	0.447

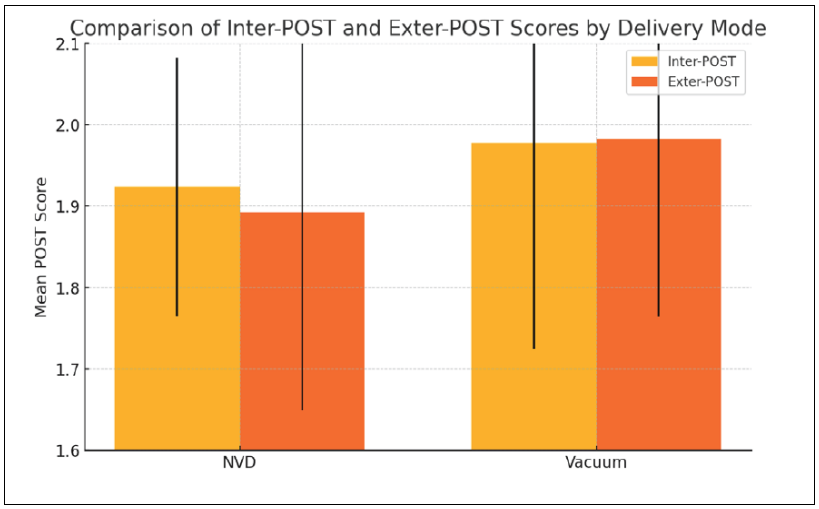

Fig 7: Comparison of Internal and External Anal Sphincter Thickness Post Delivery by Mode of Delivery

In this small cohort, women delivered by vacuum had slightly higher mean post-delivery sphincter thickness than those with spontaneous vaginal delivery, but differences were small and not formally statistically significant.

Discussion

Principal findings

This prospective cohort study of 36 primigravida demonstrates that vaginal delivery is associated with a statistically significant reduction in both internal and external anal sphincter thickness within 48 hours postpartum, as measured by 2D transperineal ultrasound. The internal anal sphincter showed a greater absolute reduction (≈0.64 mm) than the external sphincter (≈0.29 mm). Importantly, these changes occurred in a cohort without clinically diagnosed third- or fourth-degree perineal tears, underscoring that subclinical sphincter changes may occur even after apparently uncomplicated vaginal births.

Comparison with existing literature

Our findings align with previous reports that childbirth exerts substantial mechanical and functional impact on the anal sphincter complex. [1-4] Pollack *et al.* showed that anal incontinence is not uncommon at five years post-vaginal delivery.[1] Sultan *et al.* highlighted that many sphincter disruptions are not detected by clinical examination alone and require EAUS for diagnosis.[2] Schei *et al.* demonstrated a higher risk of anal incontinence after vaginal birth compared to caesarean section.[3] Unlike many earlier studies that focused mainly on overt sphincter tears, the present study quantifies changes in sphincter thickness. Karcaaltincaba *et al.* showed that both vaginal and caesarean delivery influence sphincter measurements, with more pronounced changes after vaginal birth. [11] Tanwar *et al.* reported that 2D TPUS can identify occult OASIS in primigravidae and that such injuries are associated with worse anal tone and symptoms at six weeks. [13]

Stickelmann *et al*. used TPUS to detect and monitor OASIS in the postpartum period, demonstrating its value in clinical follow-up. [12]

The current thesis-based work adds to this evidence by providing objective pre- and post-delivery thickness data in low-risk primigravidae, confirming that significant early postpartum sphincter thinning can occur even in the absence of clinically recognised OASIS.

Possible mechanisms

Several mechanisms may explain the observed reduction in sphincter thickness. During the second stage of labour, the fetal head distends the pelvic floor and anal canal, stretching and compressing the IAS and EAS. [5, 8, 9] Histologically, sphincter muscle fibres and surrounding connective tissue may undergo microtears, oedema and temporary disruption.

The greater reduction in IAS thickness may reflect its composition and function. Because the IAS is smooth muscle and contributes significantly to resting anal pressure, it may be more vulnerable to stretch-related thinning and microtrauma. The EAS, as a striated muscle under voluntary control, may respond differently and perhaps retain more of its bulk in the immediate postpartum period.

While acute oedema and transient changes in hydration could also influence ultrasound appearance immediately after birth, the 48-hour interval used in this study allows some early resolution of oedema. Therefore, the recorded reductions likely represent genuine early changes in sphincter morphology rather than purely artefactual variations.

Clinical implications

The observed sphincter thinning has several clinical implications:

1. **Importance of postpartum imaging**
   The finding that measurable sphincter thinning occurs in women without clinically diagnosed OASIS suggests that reliance on perineal inspection and digital rectal examination alone may miss relevant changes. Early TPUS could serve as a useful adjunct, particularly in women with risk factors such as instrumental delivery, prolonged second stage or large babies. [5-7, 11-13]
2. **Risk stratification and follow-up**
   Women demonstrating marked postpartum thinning, especially of the IAS, might be considered at higher risk for later anal incontinence and offered more intensive follow-up, early pelvic floor rehabilitation and timely referral if symptoms arise.
3. **Feasibility and accessibility**
   TPUS requires only standard obstetric equipment and basic training, making it feasible in many settings where EAUS is unavailable or impractical. It offers a realistic way to integrate anal sphincter assessment into postpartum care.
4. **Research and quality improvement**
   Quantitative TPUS measurements could be used in studies evaluating obstetric techniques aimed at reducing pelvic floor trauma, including perineal support methods, episiotomy angle and midline vs mediolateral episiotomy. [6, 7]

Strengths and limitations

Strengths

- Prospective design with pre- and post-delivery measurements in the same women.
- Homogeneous cohort restricted to primigravidae, minimising confounding by previous deliveries.
- Standardised TPUS protocol performed by a single trained operator.
- Focus on early postpartum changes at a defined 48-hour time point.

Limitations

- Modest sample size (n = 36) and single-centre setting, limiting generalisability.
- Short follow-up: only early postpartum changes were assessed; the study cannot comment on medium- or long-term recovery or symptom development.
- Lack of functional correlation: no anal manometry or validated anal incontinence scores were recorded.
- Operator dependency inherent in ultrasound-based assessments.

Future directions

Future research should include larger, multicentric cohorts with longer follow-up, incorporating both structural (ultrasound/EAUS) and functional (symptom scores, manometry) data. Comparative studies between TPUS and EAUS will help validate the role of TPUS as a screening or monitoring tool. [8-12] Interventional trials could evaluate whether early detection of significant sphincter thinning and targeted pelvic floor rehabilitation improves long-term continence outcomes.

Conflict of Interest

Not available

Financial Support

Not available

Conclusion

In this prospective cohort of primigravida, vaginal delivery was associated with a highly significant early reduction in both internal and external anal sphincter thickness, as assessed by two-dimensional transperineal ultrasound at 48 hours postpartum. The internal sphincter showed a greater absolute reduction than the external sphincter, highlighting its particular vulnerability to childbirth-related mechanical stress.

These findings support the view that even apparently uncomplicated vaginal deliveries can result in subclinical sphincter alterations that may not be detected by routine clinical examination alone. Incorporating TPUS into early postpartum assessment protocols could help identify women at risk of later anal incontinence and facilitate timely counselling and intervention.

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How to Cite This Article
Athira RA, Fernandes SF. Assessment of Anal Sphincter Measurement Pre and Postnatal Vaginal Delivery using Transperineal Ultrasound: A prospective cohort study. International Journal of Clinical Obstetrics and Gynaecology 2024; 9(6): 1555-1562.