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Original Research Article

Impact of vaginal delivery on pelvic floor musculature in terms of clinical and elastographic changes

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ABSTRACT

Background: Vaginal delivery imposes considerable strain on pelvic floor musculature, often resulting in structural and functional changes that may contribute to postpartum pelvic floor dysfunction (PFD). This study aimed to assess clinical and elastographic changes in pelvic muscle tone following vaginal delivery. To evaluate the recovery of pelvic floor muscle tone through clinical grading and shear wave elastography (SWE) in primigravida women post vaginal delivery and to correlate both assessment modalities.

Methods: A prospective observational study was conducted over 18 months at TMMCRC. Primigravida women with vaginal deliveries were enrolled. Clinical tone (Oxford scale) and elastographic stiffness (kPa) were assessed pre-delivery, 48 hours, 3 months and 6 months postpartum. Data were analyzed using SPSS, with correlations tested with Kappa statistics.

Results: The mean age of participants was 24.4±2.8 years and 64% were overweight (BMI>25 kg/m²). Most had a second stage of labor<60 minutes (92%) and spontaneous vaginal delivery (96%). Pre-delivery clinical grading revealed 86% with Grade 2 tone, while elastography showed 64% with ES4 stiffness. At 6 months postpartum, 76% achieved Grade 4 tone and 60% achieved ES1 elasticity, indicating significant recovery ($p<0.01$). A strong correlation was observed between clinical and elastographic grading (Kappa=0.76, $p=0.007$). Persistent symptoms included dyspareunia in 14% and stress urinary incontinence in 8%.

Conclusions: Pelvic floor muscle tone progressively improved post vaginal delivery. SWE and clinical grading are complementary and reliable for tracking postpartum recovery.

Keywords: Elastography, Muscle tone, Postpartum recovery, Pelvic floor, Vaginal delivery

INTRODUCTION

Vaginal delivery, is a natural physiological process that exerts significant mechanical and physiological stress on the female pelvic floor, which leads to structural and functional alterations making it persistent for long. The pelvic floor musculature, a complex network of muscles and connective tissues, plays a critical role in maintaining continence, supporting pelvic organs and facilitating sexual function in females. PFD, including urinary incontinence (UI), fecal incontinence and pelvic organ prolapse (POP), is commonly associated with vaginal delivery. While pregnancy itself contributes to biomechanical loading of the pelvic structures, significant neuromuscular damage often occurs during vaginal birth. These effects are attributed to direct trauma to the levator ani muscles, connective tissue stretching and pudendal nerve injury, which may not be immediately apparent but manifest clinically over time.

Snooks et al demonstrated partial denervation of the pelvic floor muscles following vaginal delivery, particularly in women with stress incontinence, reinforcing the association between childbirth and lasting neuromuscular injury.[1] Quantitative imaging tools, such as elastography and magnetic resonance imaging (MRI), allow more precise evaluation of pelvic floor muscle elasticity and architecture. These tools have uncovered distinct differences in muscle function and elasticity between women who have delivered vaginally versus those who underwent cesarean section.[2] Moreover, biomechanical assessments reveal that pelvic floor strength and endurance are considerably reduced after vaginal birth. Hilde et al, reported a 54–66% reduction in pelvic floor muscle strength and endurance in women post vaginal delivery, with only minor declines in those who had cesarean births.[3] This deterioration can result in long-term consequences such as urinary leakage and pelvic support defects.

MRI studies further support the idea that structural changes are measurable postpartum. Zhou et al, used MRI to compare pelvic morphology after vaginal and cesarean delivery, observing significant differences in pelvic floor parameters as early as one week postpartum, with many changes persisting up to six months.[4] These include increased levator hiatus dimensions and bladder descent, all indicative of compromised pelvic floor support. In terms of structural adaptations, Alperin et al, examined cadaveric specimens and found that vaginal parity was associated with increased muscle fibre length in proximal pelvic muscles and reduced force-generating capacity, especially in younger women.[5] These adaptations likely represent a chronic response to the physical demands placed on the pelvic floor during and after delivery. The clinical relevance of these structural changes is seen in cohort studies showing increased incidence of PFD symptoms post vaginal delivery. Juliato et al reported that vaginal birth was associated with a nearly 3-fold higher risk of stress urinary incontinence and over 5-fold greater risk of prolapse compared to cesarean section, even five to ten years post-delivery.[6]

Interestingly, some cohort studies suggest that not all women experience significant pelvic floor muscle strength loss after vaginal birth. Caroci et al noted that muscle strength measured via perineometry and digital palpation did not significantly decline postpartum in their Brazilian cohort, suggesting individual variability in pelvic resilience.[7] However, these findings may reflect differences in study populations or assessment methods. The evidences undoubtedly supports that vaginal delivery exerts considerable stress on the pelvic floor, resulting in both measurable structural changes and clinically significant dysfunction. These outcomes can be quantified using imaging modalities like elastography and MRI, offering potential for early detection and intervention. Understanding the elastographic and clinical evolution of these changes will help in improving maternal postpartum care.

METHODS

The study was conducted in the Department of Obstetrics and Gynaecology at Teerthanker Mahaveer Medical College and Research Centre, Moradabad, over a period of 18 months. Ethical clearance was obtained from the institutional ethics committee and written informed consent was obtained from all participants after explaining the study objectives and procedures. All primigravida women aged 18 years and above with singleton term pregnancy (≥34 weeks gestation) and vaginal delivery were included. Women with planned cesarean deliveries, pre-existing pelvic floor disorders, previous pelvic surgery, pelvic organ prolapse, chronic cough, constipation, connective tissue disorders or obstetric complications such as multiple gestation or preeclampsia were excluded from the study.

Participants underwent a thorough clinical and elastographic assessment of pelvic floor musculature at four time points: pre-delivery, 48 hours postpartum, three months postpartum and six months postpartum. The pelvic floor tone was evaluated clinically using the Modified Oxford Grading Scale, (Grade 0 (no contraction) to Grade 5 (strong contraction)). Elastographic evaluation was donesing transperineal SWE with the patient in the lithotomy position. SWE values were recorded in kilopascals (kPa) and categorized into elastographic grades (ES1–ES4), with ES1 indicating normal stiffness and ES4 indicating severe laxity.

Sonographic examinations were performed by radiologist using a high-frequency transducer to ensure measurement consistency. Obstetric parameters and post-partum complications (PPH, dyspareunia, stress, urinary incontinence) were recorded. Participants were counselled regarding pelvic floor exercises and postpartum care to promote natural recovery. Confidentiality of patient data was maintained throughout the study. Data was analysed using (SPSS) software version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean±standard deviation (SD) and categorical data as frequencies and percentages. Changes in clinical and elastographic grading across different time intervals were analyzed using the Chi-square test. P value <0.05 was considered significant.

RESULTS

The present study included 50 primigravida women who delivered vaginally and were followed up for six months postpartum. Majority of participants were young, with 66% aged between 19–25 years and a mean age of 24.42±2.82 years. Most were either laborers (52%) or housewives (26%) and belonged predominantly to lower middle (30%) and upper lower (26%) socioeconomic classes. The average body mass index (BMI) was 28.67±3.91 kg/m², with 64% of participants classified as overweight.

Hematological evaluation showed a high prevalence of anemia, with 58% of women exhibiting hemoglobin levels between 7–8.9 g/dl, while only 10% had values above 11 g/dl. This emphasizes that most women entered labor with suboptimal hemoglobin reserves. At baseline (pre-delivery), clinical assessment of pelvic floor tone revealed that 86% of women had Grade 2 tone, while 14% had Grade 3 tone. None of the subjects demonstrated either poor tone (Grade 0 or 1) or strong tone (Grade 4). Corresponding elastographic findings showed that 36% had ES3 stiffness grade and 64% had ES4 grade, indicating a predominance of reduced muscle elasticity prior to delivery.

Labour and delivery characteristics indicated that the majority of women (92%) had a second stage of labor lasting less than 60 minutes. Spontaneous vaginal delivery occurred in 96% of cases, while only 4% required instrumental assistance, evenly divided between forceps and vacuum extraction.

Episiotomy was performed in 14% of cases and perineal lacerations were observed in 6%. Neonatal outcomes were favorable, with a mean birth weight of 3.16±0.84 kg; 58% of neonates weighed between 2.6–3.0 kg and only 2% exceeded 4 kg. Postpartum hemorrhage occurred in 6% of women, including 2% atonic and 4% traumatic cases, all managed conservatively.

Serial assessments demonstrated a clear, statistically significant improvement in pelvic floor muscle tone over time. At 48 hours postpartum, clinical grading showed that 18% of women retained Grade 2 tone, 50% achieved Grade 3 and 32% reached Grade 4. By three months, Grade 4 tone increased to 64% and at six months, it further rose to 76%. No participants exhibited Grades 0 or 1 at any stage.

The Chi-square test confirmed a highly significant difference in clinical tone across intervals ($p<0.01$), indicating progressive neuromuscular recovery. Similarly, elastographic analysis reflected consistent improvement in muscle stiffness. ES1 grade (normal stiffness) was recorded in only 10% of women at 48 hours, increasing to 48% at three months and 60% at six months. Conversely, ES4 (severe laxity) declined from 64% pre-delivery to 8% at six months postpartum, demonstrating a statistically significant difference ($p<0.01$).

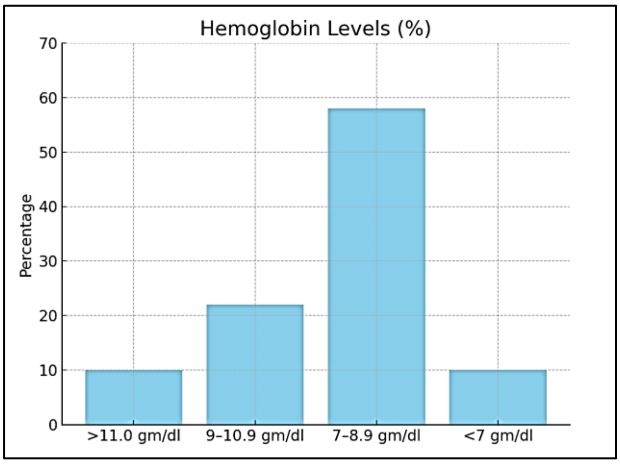

Figure 1: Hemoglobin levels.

At the six-month follow-up, 14% of participants reported dyspareunia, 8% experienced stress urinary incontinence and 6% had minor pelvic discomfort. Despite these residual symptoms, most women showed complete functional recovery both clinically and elastographically. Correlation analysis revealed strong concordance between the two assessment methods, with a Kappa value of 0.76 ($p=0.007$), confirming that clinical grading and shear wave elastography were reliable and complementary tools for evaluating pelvic floor recovery.

Table 1: Demographic characteristics of study participants.

Variable	Category	N	%
Age group (in years)	19–25	33	66
	26–30	17	34
	Mean±SD		24.42±2.82
Occupation	Labourer	26	52
	Housewife	13	26
	Teacher	5	10
	Clerk	2	4
	Others	4	8
Socio-economic Status	Lower middle	15	30
	Upper lower	13	26
	Lower	10	20
	Upper middle	8	16
	Upper class	4	8
BMI (kg/m²)	18.5–24.9	11	22
	25–29.9	32	64
	>29.9	7	14
	Mean±SD		28.67±3.91

Table 2: Pre-delivery clinical and elastographic grading of pelvic floor musculature.

Parameter	Grade	N	%	Grade	N	%
Clinical grading	0	0	0	Elastography grading	ES1	0
	1	0	0		ES2	0
	2	43	86		ES3	18
	3	7	14		ES4	32
	4	0	0			

Table 3: Labor characteristics and obstetric outcomes of study participants.

Variable	Category	N	%
Duration of second stage of labor	< 60 minutes	46	92
	> 60 minutes	4	8
Mode of delivery	Spontaneous Vaginal Delivery	48	96
	Instrumental Delivery	2	4
	└ Forceps	1	2
	└ Vacuum	1	2
Episiotomy	Performed	7	14
Perineal laceration	Present	3	6
Birth weight (kg)	2.0–2.5	10	20
	2.6–3.0	29	58
	3.1–3.5	8	16
	3.6–4.0	2	4
	> 4.0	1	2
	Mean±SD	3.16±0.84	
Postpartum hemorrhage (PPH)	Total	3	6
	Atonic	1	2
	Traumatic	2	4

Table 4: Comparative clinical and elastographic grading of pelvic floor musculature at different postpartum intervals.

Interval	Clinical grading (%)					Elastography grading (%)			
	0	**1**	**2**	**3**	**4**	**ES1**	**ES2**	**ES3**	**ES4**
48 hours after delivery	0	0	18	50	32	10	42	28	20
3 months after delivery	0	0	10	26	64	48	28	14	10
6 months after delivery	0	0	10	14	76	60	18	14	8
P value					<0.01*				<0.01*

*Statistically significant (p<0.01).

Table 5: Correlation between clinical grading and ultrasound elastography (grading) among the study subjects.

Parameters	Value
Kappa	0.76
P value	0.007*

*Statistically significant.

DISCUSSION

The above study evaluated the impact of vaginal delivery on pelvic floor musculature using both clinical grading and SWE, offering a dynamic insight into postpartum recovery over a six-month period. The findings demonstrated significant improvement in muscle tone and elasticity, confirming that physiological restoration occurs gradually after childbirth. However, a subset of women continued to experience symptoms of PFD, emphasizing the importance of individualized postpartum follow-up. At baseline, most participants had moderate pelvic tone (Grade 2 clinically, ES4 elastographically), consistent with findings by Hilde et al who reported substantial stretching and reduction in pelvic floor strength in late pregnancy due to hormonal relaxation and mechanical distension.[3] The progressive recovery observed where Grade 4 tone increased to 76% and ES1 stiffness reached 60% by six months postpartum reflects effective neuromuscular restitution. This pattern is in agreement with Zhou et al who observed via MRI that pelvic structural parameters such as levator hiatus dimensions and bladder descent improved significantly by six months after vaginal delivery.[4] The statistically significant improvement (p<0.01) in both clinical and elastographic grading in the present study reinforces that muscle remodelling continues well beyond the immediate postpartum period.

The strong correlation between clinical and elastographic evaluations (Kappa=0.76, p=0.007) substantiates the complementary value of both modalities. Kim et al similarly reported that 2D and 3D ultrasound elastography effectively quantified pelvic floor stiffness at six weeks postpartum and correlated well with clinical muscle tone scores.[2] Likewise, Yin et al demonstrated that SWE reliably detects postpartum changes in pelvic muscle elasticity, showing marked improvement in shear modulus values over successive follow-ups.[8] The present study extends these observations by confirming that SWE findings align with clinical recovery up to six months, suggesting it as a reproducible, objective alternative for evaluating postpartum muscle integrity.

Despite overall improvement, 14% of women experienced dyspareunia and 8% reported stress urinary incontinence at six months. These findings are slightly lower than those reported by Juliato et al who documented a 30% incidence of urinary incontinence and higher rates of sexual dysfunction among women after vaginal delivery.[6] The lower prevalence in our cohort may be attributed to relatively shorter second stages of labor (<60 minutes in 92% of women) and fewer instrumental interventions (only 4%), both of which are known to reduce pelvic floor trauma.

Tsunoda et al previously demonstrated that prolonged second-stage labor and perineal tears significantly increase pelvic floor descent and anorectal angle changes, predisposing to dysfunction a finding consistent with the milder symptom rates observed in this study.[9] Obstetric parameters such as episiotomy and birth weight also influenced recovery patterns. Only 14% underwent episiotomy and the mean neonatal weight (3.16±0.84 kg) was comparable to that in studies by Kady et al and Alperin et al where higher birth weight correlated with increased pelvic muscle strain.[5,10] The predominance of spontaneous vaginal deliveries (96%) and limited perineal trauma likely contributed to favorable recovery outcomes in this population.

The improvements detected by elastography highlight its growing utility as a quantitative adjunct to clinical assessment. SWE offers non-invasive, real-time estimation of muscle stiffness, correlating with microstructural recovery of the levator ani and adjacent tissues. Zhou et al and Yin et al have emphasized its superiority in identifying subtle tissue remodelling not perceptible on palpation.[4,8] The consistent reduction from ES4 (64%) to ES1 (60%) in this study underscores elastography's sensitivity to physiological recovery. Although most women achieved near-complete recovery by six months, a minority with persistent symptoms could benefit from early physiotherapy, as recommended by Caroci et al who demonstrated improved continence and sexual satisfaction with postpartum exercise interventions.[7]

Clinical significance

This study highlights the significant recovery of pelvic floor muscle tone following vaginal delivery, as assessed through both clinical grading and elastographic methods. The strong correlation between clinical and elastographic assessments (Kappa=0.76) validates the use of these tools in evaluating postpartum pelvic floor recovery. Despite overall improvement, some women still experienced persistent symptoms, such as dyspareunia and stress urinary incontinence, underscoring the need for ongoing postpartum rehabilitation. These findings stress the importance of individualized care and early detection of pelvic floor dysfunction to ensure long-term maternal health.

CONCLUSION

From the above study it can be concluded that vaginal delivery imposes transient strain on the pelvic floor that resolves substantially within six months in most primiparous women. Integrating elastographic imaging with conventional clinical grading enhances the precision of postpartum monitoring and enables timely intervention for women at risk of persistent pelvic floor dysfunction, thereby promoting better maternal quality of life.

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