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Study of levator ani anatomy and function using dynamic 4D ultrasound after vaginal versus caesarean delivery in primiparous women, a cross-sectional study

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Abstract

Background: Childbirth is a central experience in women's lives. Vaginal delivery is more physiological having superior outcome compared to caesarean section (CS). It is obvious that clinical assessment alone is insufficient to assess pelvic floor function and anatomy as it focuses on description of surface anatomy which is unable to reveal underlying abnormalities, therefore the role of imaging is increasing. Non-invasive nature of pelvic floor ultrasound allows a comprehensive assessment, enabling a new dimension in obstetric quality control and secondary prevention of pelvic floor dysfunctions. This study was conducted to assess pelvic floor function using four dimensional (4D) dynamic ultrasound in women after vaginal versus caesarean delivery and the ultimate objective was to predict the impact of vaginal delivery on pelvic floor function and also to study the potential use of 4D ultrasound in assessment of pelvic floor dysfunction. **Methods:** This study was a cross-sectional study conducted on 120 primiparous women 2-3 months after delivery. Women were recruited after counselling from urogynaecology, family planning clinic and ultrasound unit in El-Shatby Maternity Hospital, after approval of the local Ethical Committee and having informed consents from patients included in the study. **Results:** We found no statistically significant differences between the primiparous after vaginal and caesarean delivery regarding levator ani hiatus area, transverse, and antero-posterior diameters at rest and during contraction. During Valsalva, there was significant increase in the primiparous after vaginal delivery group than caesarean delivery regarding levator ani hiatus anteroposterior, transverse diameter and area, yet they did not exceed upper limit normal range. No significant differences were seen in levator ani structure in both groups. **Conclusions:** Vaginal delivery with good practice has no significant effect on levator ani compared to caesarean delivery however, widening in levator ani hiatus can be seen during Valsalva after vaginal delivery without exceeding the normal range.

Keywords: 4D ultrasound, transperineal ultrasound, levator ani hiatus, delivery.

Introduction

With the rapid development of social economy and the continuous improvement of people's living standards, people's health consciousness has been further enhanced, and women of childbearing age pay more and more attention to pregnancy and pelvic floor function (1).

The pelvic floor is a dome-shaped muscular sheet separating the pelvic cavity above from the perineal region below. This cavity encloses the pelvic viscera including urinary bladder, intestines, and uterus in females (2). The main functions of the pelvic floor muscles are to support the abdominal and pelvic viscera, maintain urinary and faecal continence and allow sexual activity, and childbirth (2).

The main components of pelvic floor are levator ani muscles (largest component), coccygeus muscle and fascia coverings of the muscles. The levator ani is a broad sheet of muscle that is composed of three separate paired muscles which are pubococcygeus, puborectalis and iliococcygeus (3). The puborectalis is the most important of the levator ani group for maintaining faecal continence. Some fibres of the puborectalis muscle (pre-rectal fibres) form U-shaped sling that flank the urethra and vagina in the female forming pubovaginalis or sphincter urethrae /vaginae. These fibres are very important in preserving urinary continence, especially during abrupt increase of the intra-abdominal pressure (4).

During pregnancy, the uterus will gradually expand and change from the original horizontal position to the longitudinal position in the pelvic and abdominal cavity (5). Especially for women in the third trimester of pregnancy, the position of the uterus is close to a vertical state, and the pelvic floor supporting tissues will be relatively stressed. With the slowly grow up of uterus, the spine position of pregnant women will bend forward, and the pelvic cavity will be subjected to pressure from the front and lower parts (6).

The dissolution rate of pelvic floor ligament collagen in pregnant women in the third trimester of pregnancy also continues to increase (7). The ligaments will gradually become loose; although the cervical ring is affected by the combined force of the posterior and inferior, it faces downward as a whole and plays a role in the genital hiatus (7). When the delivery is completed, uterus will no longer continue to receive the force from the front and lower parts, hormonal levels will slowly return to normal, and so will the support force received from the pelvic floor. The cervical ring will also return to its original state, therefore under normal conditions there is no irreversible damage to the pelvic floor after childbirth (8).

Routine pelvic floor function examination should be performed 42 days after delivery, and pelvic floor rehabilitation treatment can be conducted after 42 days of postpartum lochia. The best time for pelvic floor muscle rehabilitation is within 3 months after delivery to avoid urinary incontinence, uterine prolapse, and other pelvic floor dysfunction in the future (9).

Risk factors for maternal pelvic injuries during delivery include nulliparity, operative vaginal delivery, increased fetal weight and malpresentation, including persistent occiput posterior position also advancing gestational age (10).

Birth injuries in mothers typically fall into two main categories, injuries to the perineal area and injuries to the pelvic floor. Perineal injuries range from superficial injuries to vaginal mucosa to involvement of rectal mucosa (11). Severe perineal injuries, which include third- and fourth-degree lacerations, are referred to as obstetric anal sphincter injuries (OASIS) (12). Injuries also include nerve damage, nerves in the perineal area can get damaged during childbirth, which can lead to a condition called pudendal neuralgia (long-term pelvic pain) (12).

Pelvic floor injuries include levator avulsion which is commonly occult because of greater distensibility of vaginal tissues compared to the puborectalis muscle insertion on the inferior pubic ramus. Occasionally an avulsion will be exposed by a large vaginal tear. Failure of recognition of levator ani avulsion leads to a series of pelvic floor dysfunction diseases such as genital prolapse, fecal incontinence, and urinary incontinence (13).

It is more obvious that clinical assessment alone is insufficient to assess pelvic floor function and anatomy. Our clinical examination generally focuses on the description of surface anatomy which is often unable to reveal true underlying structural abnormalities (14). The greatest use of pelvic floor ultrasound imaging is likely to be in postnatal follow-up, especially after a first vaginal delivery, and in women at high risk of somatic trauma (14). The non-invasive nature of pelvic floor ultrasound allows a comprehensive pelvic floor assessment, enabling an entirely new dimension in obstetric quality control and secondary prevention in those with positive diagnoses of avulsion or sphincter tears (15).

Maternal birth trauma has failed to become a key performance indicator of obstetric services. This is primarily because such trauma is either occult (as is common with avulsion) or underdiagnosed clinically (as with sphincter trauma). The only way to overcome the massive detection bias inherent in clinical diagnosis of maternal birth trauma is imaging (16).

It is only very recently that imaging of the levator ani has become feasible using trans-perineal ultrasound (17). With trans-perineal acquisition, the whole levator hiatus and surrounding muscle (pubococcygeus and puborectalis) can be visualized, provided acquisition angles are at or above 70° (17).

Magnetic resonance imaging (MRI) has gained in importance as a diagnostic and research tool for assessment of pelvic floor disorders. It certainly has capability of high-resolution superb imaging of the soft tissues of the pelvic floor.(18) However, the major technical limitation of MRI is its poor ability to fully capture present-time pictures because its spatial resolution is often spared as imaging time becomes faster (18). Other clinical limitations include its high cost, time and space constraints, and limited availability (18).

Compared to MRI method, ultrasonographic examination has some practical advantages, like shorter examination time, fewer exclusion criteria, less expense, and good patient compliance (18). Under the Valsalva movement or pelvic floor muscle contraction and other dynamic states, it is more convenient to collect data by using the perineal ultrasound examination (18).

The ability of 3D pelvic floor ultrasound (PFUS) to produce high-resolution images of the pelvic floor in 3 planes has rendered it a valuable tool in studying pelvic floor disorders stemming from childbirth injury (19). Levator ani injuries can be depicted on 3D PFUS in the axial plane or the rendered volume, which is reproduced automatically by synthesis of the sagittal, coronal, and axial planes. For this, the plane of minimal hiatal dimensions is identified in the midsagittal view, as the shortest distance between the inferior most aspects of the symphysis pubis to the anorectal angle, marked by the levator plate (20).

Regarding biometric parameters of the puborectalis/pubococcygeus complex and the levator hiatus, there has been good agreement between 3D/4D ultrasound and MRI, both for dimensions of the levator hiatus and levator thickness (20). It is expected that ultrasound measurements should be more reproducible because of the ease with which measurements in the axial plane can be obtained in the plane of minimal dimensions, whether at rest, on Valsalva, or on pelvic floor muscle contraction.(20) On MRI, the plane of minimal dimensions is virtually impossible to image reproducibly because of slow acquisition speeds, even of single predefined planes (20).

The aim of this study was to assess levator ani anatomy and function using four dimensional (4D) dynamic ultrasound in women after vaginal delivery versus caesarean delivery. The ultimate objective was to try to predict the impact of vaginal delivery on pelvic floor function. The secondary objective was to study the potential use of 4D ultrasound in assessment of levator ani abnormalities.

Patients and methods

This study was a comparative cross-sectional study conducted on 120 primiparous women 2-3 months after delivery. Women will be recruited after counselling from urogynaecology unit, family planning clinic and ultrasound unit in El-Shatby Maternity Hospital, Alexandria, Egypt after approval of the local Ethical Committee and having an informed verbal consent from every patient included in the study.

Sample size

Sample size was calculated by staff members of Medical Research Institute, Alexandria University minimum required total sample size of 120 females [60 females per group] was needed to assess pelvic floor function and dysfunction using fourth dimensional dynamic ultrasound that achieves 80% power and detect a difference of 1.7 /cm in levator ani hiatus AP diameter which is ARJ-VDv (Vertical distance between inferior margin of symphysis pubis and Anorectal Junction) between both groups (Vaginal delivery group Versus Cesarean delivery group) with estimated group standard deviations of (1.3 and 4.3) using a two-sided independent sample t-test, at a significance level of 0.05.

Inclusion and exclusion criteria:

The inclusion criteria were as follows:

- Asymptomatic primiparous women who had birth in El-Shatby hospital with full term singleton either by vaginal or CS delivery.
- Cases were appointed and approached after delivery after taking their consent to perform fourth dimensional pelvic floor ultrasound.

The exclusion criteria were 3rd and 4th degree perineal tear, pre-existing symptoms of pelvic floor dysfunction, pelvic masses like fibroid or cysts and comorbidities like diabetes mellitus, hypertension, or multiple sclerosis.

All patients were subjected to:

Detailed obstetric history: to inquire about recent delivery events, any obstetric injuries, and degree of any possible perineal tears.

Indications of caesarean section either elective or emergency should be included.

Asking about pelvic floor dysfunction symptoms.

Clinical Examination: general and gynaecologic examination (abdominal and pelvic examination).

Pelvic floor clinical examination is performed, when doing internal vaginal palpation various aspects of pelvic floor muscle strength need to be examined.

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Transvaginal ultrasound to assess uterine position, involution, resumption of ovulation and residual urine volume.

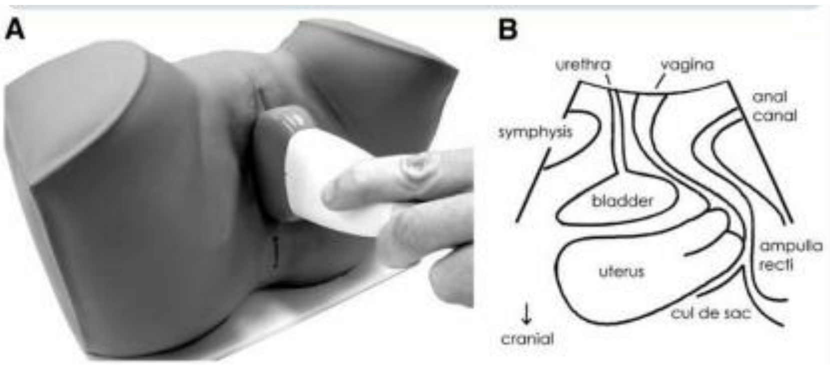
4D dynamic pelvic floor ultrasound using abdominal curved array volume transducers (4–8 MHz) placed over the introitus, trans-perineal approach, with angle of acquisition 70°.

Topographic images of levator ani can be taken using 4D volumetric curvilinear probe by transperineal approach, with interval of 2.5 mm between parallel slices within the volume.

To achieve best views of pelvic floor muscles most importantly levator ani muscle, step-by-step standardized rotation technique is described below:

- The transverse (axial) 3D volume is rotated approximately 90° clockwise in the plane of the puborectalis muscle (PRM) for an appropriate anterior-posterior (AP) orientation of the image. (The plane is defined as a line joining the inferior border of the pubic symphysis and the apex of the anorectal angle).
- The cursor dot is placed in the area of pubic bone that allows the symphysis pubis to come into view on the coronal view.
- The coronal image is then analysed millimetre by millimetre to identify and mark the location where the 2 pubic rami meet to form the inferior border of the symphysis pubis.
- The sagittal plane is then rotated to align the inferior border of the symphysis pubis with the apex of the anorectal angle, noting that this allows the puborectalis muscle to come into the full view on the transverse (axial) plane.

Figure 1: Showing application of tranperineal ultrasound (20)



Measurements to be taken using trans-perineal ultrasound assessment of pelvic floor include:

- Levator ani hiatus measurement including area normally 5.4 cm2, a hiatal area of ≥ 25 cm^2 on Valsalva maneuver be defined as abnormal distensibility or ‘ballooning’

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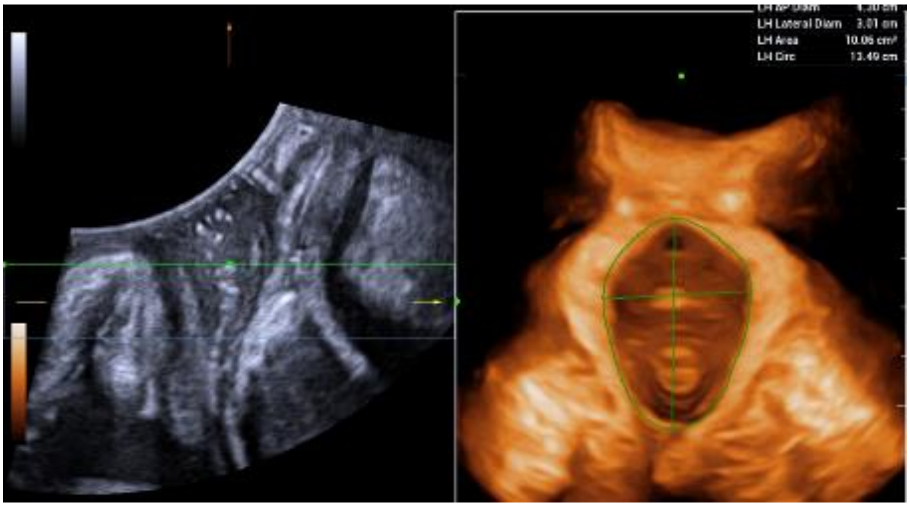
of the levator hiatus, 25–29.9 cm^2 can be defined as 'mild', 30–34.9 cm^2 as 'moderate', 35–39.9 cm^2 as 'marked' and ≥ 40 cm2 as 'severe' ballooning.

Figure 2: Showing axial view of levator ani through transperineal approach from our study



- Levator ani deficiency score, described by Dietz, (20) preferably examined using endo-cavitary probe by assessment of both right and left pubovaginalis, puboanalis/ pubo-perinealis and puborectalis muscles, each muscle damage will be given score according to the extent of damage, 0 for no damage, 1 for mild, 2 for moderate, 3 for severe, then total score of all muscles will be calculated with highest score 18, (0-6) is considered mild, (7-12) moderate while more than 13 is considered severe deficiency.

Figure 3: Showing axial image of levator ani using transvaginal approach showing better details of parts of levator ani to assess its deficiency from our study

Statistical analysis of the data

Data were fed to the computer and analyzed using IBM SPSS software package version 20.0. (Armonk, NY: IBM Corp). Qualitative data were described using number and percent. The Kolmogorov-Smirnov test was used to verify the normality of distribution Quantitative data were described using range (minimum and maximum), mean, standard deviation, median and interquartile range (IQR). Significance of the obtained results was judged at the 5% level.

The used tests were

1 - Chi-square test

For categorical variables, to compare between different groups

2 - Monte Carlo correction

Correction for chi-square when more than 20% of the cells have expected count less than 5

3 - Mann Whitney test

For abnormally distributed quantitative variables, to compare between two studied groups.

Results

A total of 120 women were analysed, divided equally between vaginal delivery group and the caesarean section (CS) group each group with 60 patients.

The two groups were comparable in age (mean ± SD: 26.17 ± 2.88 vs 26.0 ± 3.49 years; p=0.776) and BMI (26.67 ± 2.50 vs 27.08 ± 2.27 kg/m²; p=0.342), with no significant difference seen regarding demographic data including age and BMI as shown in Table 1.

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Table 1 -Comparison between the two studied groups according to demographic data

Demographic data	Vaginal (n = 60)		CS (n = 60)		Test of sig.	P
	No.	%	No.	%		
Age (years)						
Min – Max.	22.0 – 42.0		19.0 – 33.0		t= 0.286	0.776
Mean ± SD.	26.17 ± 2.88		26.0 ± 3.49			
Median (IQR)	26.0 (25.0 – 27.0)		26.0 (24.0 – 28.50)			
BMI (kg/m²)						
Normal	14	23.3	9	15.0	χ^2= 1.381	0.501
Overweight	40	66.7	45	75.0		
Obese	6	10.0	6	10.0		
Morbidly obese	0	0.0	0	0.0		
Min – Max.	21.0 – 33.0		21.0 – 33.0		t= 0.955	0.342
Mean ± SD.	26.67 ± 2.50		27.08 ± 2.27			
Median (IQR)	27.0 (25.0 – 28.0)		27.0 (26.0 – 28.0)			

Among vaginal deliveries, 81.7% were spontaneous and 18.3% induced; episiotomy was performed in 80.0% of cases. In the CS group, 73.3% were elective and 26.7% emergency procedures, with complications reported in only 2 cases, as shown in Tables 2 and 3.

Table 2 - Distribution of the studied vaginal delivery according to spontaneous labor or induced and episiotomy (n = 60)

Vaginal (n = 60)	No.	%
Sponteneous labor or induced		
Sponteneous	49	81.7
Induced	11	18.3
Episiotomy		
Not done	12	20.0
Done	48	80.0

Table 3 - Distribution of the studied CS cases according to CS delivery Elective VS Emergency and complications (n = 60)

CS (n = 60)	No.	%
CS delivery		
Elective	44	73.3
Emergency	16	26.7
Complications		
No	58	96.7
Yes	2	3.3

Neonatal birthweight did not differ significantly between vaginal delivery group with median 2.90 kg and caesarean delivery group with median 3 kg avoiding potential effect of fetal weight on our study as shown in Table (4).

Table 4 - Comparison between the two studied groups according to fetal birth weight

	Vaginal (n = 60)	CS (n = 60)	U	P
Fetal birth weight (kg)				
Min – Max.	2.40 – 3.80	2.70 – 3.90		
Mean ± SD.	2.93 ± 0.26	3.01 ± 0.23	1554.0	0.186
Median (IQR)	2.90 (2.80 – 3.10)	3.0 (2.90 – 3.0)		

Pelvic floor dysfunction symptoms were rare in both groups with only two cases in vaginal delivery group vs only one in CS group).

Clinical examination using PERFECT criteria showed no significant difference between both groups (Monte Carlo p=0.525). as shown in Tables 5 and 6.

Table 5 - Comparison between the two studied groups according to pelvic floor dysfunction symptoms

	Vaginal (n = 60)		CS (n = 60)		χ^2	^{FE}p
	No.	%	No.	%		
Pelvic floor dysfunction symptoms						
No symptoms	58	96.7	59	98.3		
Urinary incontinence	2	3.3	1	1.7	0.342	1.000
Anal incontinence	0	0.0	0	0.0		
Both	0	0.0	0	0.0		

χ^2: Chi square test, FE: Fisher Exact test; p: p value for comparing between the two studied groups

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Table 6 - Comparison between the two studied groups according to clinical examination according to PERFECT criteria

	Vaginal (n = 60)		CS (n = 60)		χ^2	^{MC}p
	No.	%	No.	%		
Clinical examination according to perfect criteria						
Score 0	0	0.0	0	0.0		
Score 1	0	0.0	0	0.0		
Score 2	2	3.3	1	1.7	1.298	0.525
Score 3	43	71.7	48	80.0		
Score 4	15	25.0	11	18.3		

χ^2: Chi square test, MC: Monte Carlo test; p: p value for comparing between the two studied groups

Dynamic measurements of levator ani functions including levator ani hiatus anteroposterior, transverse diameters and levator ani hiatus area did not show any significant differences between vaginal and caesarean delivery groups during rest and contraction while during Valsalva they revealed significant differences favouring greater distensibility after normal delivery, as shown in Tables 7, 8 and 9.

The mean levator ani hiatus AP diameter was 5.43 ± 0.58 in vaginal delivery group more than that of caesarean group which was 4.95 ± 0.36 cm, the mean transverse diameter in vaginal delivery group was 4.01 ± 0.42 more than that of caesarean delivery group which was 3.76 ± 0.31 cm. The mean levator hiatus area was 18.61 ± 3.09 in vaginal delivery group more than that of caesarean delivery group which was 17.11 ± 1.90 cm². However, the mean values of dynamic measurements did not exceed the upper limit normal values.

Table 7 - Comparison between the two studied groups according to Midsagittal (Levator ani AP diameter in cm)

Midsagittal (Levator ani AP diameter in cm)	Vaginal (n = 60)	CS (n = 60)	U	P
Rest				
Min – Max.	3.66 – 5.79	3.60 – 5.0		
Mean ± SD.	4.43 ± 0.50	4.32 ± 0.35	1645.0	0.415
Median (IQR)	4.38 (4.04 – 4.69)	4.35 (4.10 – 4.60)		
Contraction				
Min – Max.	3.12 – 4.95	3.10 – 4.30		
Mean ± SD.	3.85 ± 0.45	3.74 ± 0.33	1534.50	0.163
Median (IQR)	3.74 (3.53 – 4.20)	3.70 (3.50 – 4.10)		
Valsalva				
Min – Max.	4.34 – 6.48	4.30 – 5.70		
Mean ± SD.	5.43 ± 0.58	4.95 ± 0.36	868.50*	<0.001*
Median (IQR)	5.37 (5.06 – 5.93)	5.0 (4.60 – 5.10)		

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Table 8 - Comparison between the two studied groups according to LH area on cm²

LH area on cm²	Normal (n = 60)	CS (n = 60)	U	P
Rest				
Min – Max.	10.18 – 19.06	11.0 – 18.40		
Mean ± SD.	13.55 ± 2.33	13.70 ± 1.67	1716.50	0.661
Median (IQR)	14.0 (11.28 – 15.57)	13.75 (13.0 – 14.60)		
Contraction				
Min – Max.	8.07 – 16.21	8.0 – 15.0		
Mean ± SD.	11.21 ± 2.14	11.32 ± 1.67	1686.50	0.551
Median (IQR)	11.09 (9.16 – 12.68)	11.0 (10.0 – 12.48)		
Valsalva				
Min – Max.	14.25 – 25.29	14.0 – 22.0		
Mean ± SD.	18.61 ± 3.09	17.11 ± 1.90	1322.50*	0.012*
Median (IQR)	18.53 (15.78 – 20.5)	17.0 (16.0 – 18.52)		

Table 9 - Comparison between the two studied groups according to Transverse diameter

Transverse diameter	Normal (n = 60)	CS (n = 60)	U	P
Rest				
Min – Max.	3.11 – 4.91	2.96 – 4.20		
Mean ± SD.	3.62 ± 0.39	3.48 ± 0.29	1435.50	0.055
Median (IQR)	3.50 (3.36 – 3.88)	3.40 (3.20 – 3.80)		
Kegel				
Min – Max.	2.90 – 4.06	2.70 – 3.90		
Mean ± SD.	3.28 ± 0.29	3.22 ± 0.29	1573.50	0.234
Median (IQR)	3.20 (3.10 – 3.35)	3.16 (3.0 – 3.50)		
Valsalva				
Min – Max.	3.35 – 5.54	3.20 – 4.50		
Mean ± SD.	4.01 ± 0.42	3.76 ± 0.31	1209.0*	0.002*
Median (IQR)	4.04 (3.67 – 4.16)	3.60 (3.50 – 4.0)		

IQR: Inter quartile range ; SD: Standard deviation ; U: Mann Whitney test; p: p value for comparing between the two studied groups; *: Statistically significant at $p \le 0.05$

Levator ani deficiency scores did not differ significantly between both groups as shown in Table 10, suggesting very mild effect of vaginal delivery on anatomy of levator ani muscle compared to caesarean delivery.

To summarize the results , we found no statistically significant differences between the primiparous after vaginal and caesarean delivery regarding levator ani hiatus area, transverse, and antero-posterior diameters at rest and during contraction. During

Valsalva, there was significant increase in the primiparous after vaginal delivery group than caesarean delivery regarding levator ani hiatus anteroposterior, transverse diameter and area, yet they did not exceed upper limit normal range. No significant differences were seen in levator ani structure in both groups.

Table 10 - Comparison between the two studied groups according to LA deficiency score

	Vaginal (n = 60)		CS (n = 60)		χ^2	^{MC}p
	No.	**%**	**No.**	**%**		
LA deficiency score						
No damage	42	70.0	31	51.7	4.733	0.061
Mild	18	30.0	28	46.7		
Moderate	0	0.0	1	1.7		
Severe	0	0.0	0	0.0		

χ^2: Chi square test, MC: Monte Carlo test; p: p value for comparing between the two studied groups

Discussion

Female pelvic floor is an integral structure composed of pelvic muscle group, bone, connective tissue, nerves and organs. During pregnancy, the weight of foetus gradually increases over time, leading to increased weight of the uterus, the pelvic floor tissue will be compressed, leading to its stretching to result in the relaxation and gradual weakening of connective tissue ligament. During delivery, the fetal pressure on the pelvic floor supporting tissue increases, and the pelvic floor tissue expands continuously, resulting in possibility of mechanical injury (21).

All the above factors are risk factors for pelvic floor disorders resulting in a series of symptoms like stress urinary incontinence, pelvic organ prolapse, sexual dysfunction and faecal incontinence. During complicated delivery, structural and functional damage to the pelvic floor can be inevitable regardless of what kind of delivery methods (22).

Levator ani muscle is the most important muscle group in the pelvic floor supporting pelvic organs and maintaining their positions. The levator ani hiatus is formed by the bilateral levator anal muscles and the anterior pubic ramus. It is the largest portal in the peritoneum and the main path of pelvic organ descent (23).

Levator ani muscle integrity can be assessed by 4D dynamic ultrasound by measuring levator ani hiatus anteroposterior diameter, transverse diameter, and levator hiatus area at rest, contraction and Valsalva manoeuvre. Levator ani muscle deficiency can be diagnosed by using transperineal and transvaginal approaches (24).

In our study, 4D dynamic transperineal and transvaginal ultrasound were employed to quantitatively assess anatomy and function of primiparas with different delivery methods, and to find the factors associated with pelvic floor disorders, to achieve early diagnosis, delaying pelvic floor disorders progression, and providing guidance for subsequent pregnancies. Our study was conducted on 120 primiparous women divided into two groups 60 each, according to mode of delivery either vaginal or caesarean delivery.

In our study, there was no significant difference between vaginal and caesarean delivery groups, in levator ani hiatus AP, transverse diameters and hiatal area during rest and contraction, while statistically significant difference occurred during Valsalva yet all the values were within normal range.

Cai et al. (25) concluded that the risk of levator ani muscle injury during vaginal delivery is significantly elevated, particularly for mothers giving birth to larger infants. This is attributed to the stretching of pelvic floor muscles during delivery, which enlarges the levator ani hiatus, potentially causing tearing or even rupture of the muscle during the birth of the fetus.

Cai et al. (25) also found that the levator hiatus area increased regardless of the delivery method chosen, which was more significant in the vaginal delivery group than in the cesarean delivery group. Those findings differ from our study which included primiparous women after delivery and didn't include nullipara women. Our study also excluded fetal macrosomia, third- and fourth-degree perineal tears.

Wang et al, (26) used transperineal four-dimensional ultrasonography to evaluate how different delivery techniques affect women's pelvic floor function 6–8 weeks postpartum while we performed the study on primiparous women 3 months after delivery. Compared to the selected caesarean section group, the vaginal group had considerably larger pelvic diaphragm hiatus characteristics under the maximum Valsalva action ($P < 0.05$). Additionally, the differences in parameters between the two groups' resting patient populations were not statistically insignificant ($P > 0.05$), agreeing with our study.

The levator ani hiatus increased on Valsalva in normal vaginal delivery group, agreeing with our study and 4% of the women even showed a ballooning in the 3D sonography, while our study showed no ballooning of levator ani hiatus. In that study, following vacuum extraction delivery (VE), a levator ani muscle (LAM) avulsion occurred in 4% of women, however, our study didn't include any instrumental delivery (26).

Wang et al. (26) stated that vaginal delivery may undermine the structure supporting the pelvic organs, harm the muscles and fascia of the pelvic floor change the pelvic floor's movement, and alter the position of the bladder neck. Urinary incontinence caused by stress is largely caused by these alterations. A caesarean delivery can successfully stop the pelvic floor tissue from rupturing or dilatation, protecting the parturient early pelvic floor function and preventing urinary tract injury, disagreeing with our study which showed no statistical significant difference in urethral length and mobility, levator ani anatomy and function in case of good practice in vaginal delivery

In another study, Stroeder et al. (27) studied pelvic floor disorders (PFDs) and their effects on women's quality of life (QoL) and the changes in the pelvic floor architecture that lead to PFDs in primigravidae during and after pregnancy. When comparing the Valsalva maneuver (VM) three months after birth to the third trimester 2D sonography, bladder neck mobility (BNM) increased considerably across all delivery groups. Our study was on postpatum primiparous and wasn't performed antenatally.

Blomquist et al. (28) found that weakened PFM was linked to the cumulative incidence of POP, SUI, and overactive bladder in an analysis of 1143 participants following vaginal birth. The study was done on larger sample than ours with longer time of follow up of the patients.

Hector et al. (29) found that during vaginal delivery, the fetus was delivered through the levator hiatus, and the pelvic floor muscle stretching and expansion were 1.47 times that in the non-delivery state, on his study of effect of bariatric surgery on pelvic floor muscles. According to his study, the levator group was overstretched during vaginal delivery, even exceeding the physiological limit, and levator tearing was detected in some women after vaginal delivery, which subsequently developed into PFD. Despite this fact our study showed no statistical significant different in levator ani hiatus area between vaginal and CS delivery groups at rest and contraction, only significant difference was detected during Valsalva yet no increase above upper limit normal value was detected.

Choi et al. (30) studied on 63 women, 33 women had vaginal delivery and 30 women had Caesarean delivery. The pelvic floor parameters including hiatal AP diameter, hiatal transverse diameter, hiatal angle, levator-urethra gap, hiatal area during resting were not different between the two groups. However, during Valsalva manoeuvre, hiatal AP diameter (13.41 ± 0.26 cm vs 12.25 ± 0.28 cm, $p < 0.01$, respectively) and hiatal area (11.59 ± 0.42cm2 vs. 9.79 ± 0.44 cm2, $p < 0.01$, respectively) increased in VD group compared with CS group, the other three parameters were not different between the two groups, agreeing with our study.

Liu et al. (31) study was performed on patients divided into vaginal delivery group, Cesarean section group and nullipara group with no significant difference in general demographics of the three groups ($P>0.05$) similar to our study which showed no significant difference in demographic data yet didn't include nullipara group

In that study, compared with the Nullipara group, the HA, AP and LR of the levator hiatus in postpartum women were significantly increased at rest, on maximum Valsalva and maximum pelvic floor contraction, and hiatal dimensions in Vaginal delivery group were larger than that in Caesarean section group ($P<0.001$).

This study, using 3D ultrasound, illustrated several morphological alterations in the pelvic floor of postpartum women compared to nulliparas. In the Postpartum group, the hiatal dimensions were larger, the morphology tended to be circular, and puborectalis avulsion and pelvic organ prolapse were also detected (31).

That study found that the hiatal dimensions in Vaginal delivery group were larger than those in Caesarean section group; the puborectalis avulsion occurred exclusively in Vaginal delivery group; the incidence of pelvic organ prolapse was obviously higher in women who have undergone vaginal delivery, disagreeing with our study which showed no significant difference in levator ani deficiency score between two groups.

That study also found that the puborectalis avulsion occurred exclusively after vaginal delivery, and the percentage of women with puborectalis avulsion after normal vaginal delivery without instrument-assisted was 17.02%. The result is consistent with previously published data, which reported an injury rate ranging from 13.3% to 38.5% after spontaneous vaginal delivery. In our study, deficiency was detected on parts of levator ani muscle yet insignificant using levator ani deficiency score.

According to Zhao et al. (32) who studied how various delivery modes affected Chinese primipara postpartum pelvic floor muscle's short-term strength. They found that the group that had a cesarean delivery had stronger pelvic floor muscles (PFMs) than the group that had a vaginal delivery ($p < 0.05$), our study was more specific about pelvic floor muscles with no statistically significant difference in levator ani hiatus area at rest between the groups.

There are several limitations of our study that should be mentioned. As we did not obtain ultrasound volume datasets prior to childbirth in Postpartum group, peripartum changes in individual patients could not be analysed. We performed our examinations relatively early in the postpartum period, which means that some of the changes the patients presented may be reversed, such as those due to transient neuropathy; therefore, long-term follow-up observation is underway to establish their true significance and changes of recovery. Our study is limited by the relatively small sample size and in a specific population (patients of Alexandria University Hospitals, hence it's possible that the findings cannot be applied to different groups or environments. Additionally, the study did not account for other factors that may influence pelvic floor structure and function, such as being overweight or obese, straining to pass gas or stool for an extended period of time, hard lifting, persistent coughing due to health issues or smoking, and pre-existing pelvic floor abnormalities.

Conclusions

There were no statistically significant differences between vaginal versus caesarean delivery on levator ani anatomy and functions at rest and during contraction yet statistically significant increase in anteroposterior, transverse diameter and levator ani hiatus area at Valsalva in vaginal delivery group without exceeding the normal range. We concluded that in case of good practice in vaginal and caesarean delivery, there would be insignificant affection of pelvic floor anatomy and function. It is worth further studying on a large scale of patients in a randomized controlled trial and inclusion of other groups like nullipara patients and gravid women.

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