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Levator plate upward lift and levator muscle strength

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Abstract

Objective—The aim of study was to compare digital palpation with the levator plate lift measured by endovaginal and transperineal dynamic ultrasound.

Methods—Dynamic transperineal and endovaginal ultrasound were performed as part of multicompartamental pelvic floor functional assessment. Patients were instructed to perform Kegels while a probe captured the video clip of the levator plate movement at rest and during contraction in 2D mid-sagittal posterior view. We measured the distance between the levator plate and the probe on endovaginal ultrasound as well as the distance between the levator plate and the gothic arch of the pubis in transperineal ultrasound. The change in diameter (lift) and a levator plate lift ratio (lift / rest) x 100) were calculated. Pelvic floor muscle strength was assessed by digital palpation and divided into functional and non-functional groups using the Modified Oxford Scale (MOS). Mean differences in levator plate upward lifts were compared by MOS score using student t-tests and analysis of variance (ANOVA).

Results—74 women were available for analysis. The mean age was 55 (SD±11.9). When measured by vaginal dynamic ultrasound, mean values of the lift and lift/rest ratio increased with increasing MOS score (ANOVA $p=0.09$ and $p=0.04$, respectively). When MOS scores were categorized to represent non-functional (MOS 0-1) and functional (MOS 2-5) muscle strength groups, the mean values of the lift (3.2 mm vs. 4.6 mm, $p=0.03$) and lift/rest ratio (13% vs 20%, $p=0.01$) were significantly higher in women with functional muscle strength. All patients with 30% lift detected by vaginal ultrasound had functional muscle strength.

Conclusions—Greater levator plate lift ratio detected by dynamic endovaginal ultrasound was associated with higher muscle strength as determined by MOS. This novel measurement can be incorporated into ultrasound evaluation of the levator ani function.

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Keywords

endovaginal ultrasound; levator function; modified oxford scale

Introduction

According to the International Urogynecology/ International Continence Society Joint Report, voluntary pelvic floor muscle contraction and relaxation may be assessed by visual inspection, digital palpation, electromyography, dynamometry, perineometry or ultrasound(1). Vaginal pressure is a key measure of the strength of the pelvic floor muscles. Kegel was the first to use a pneumatic resistance chamber to measure vaginal pressure and perform biofeedback therapy using this device to improve the strength of pelvic floor muscle (2, 3). Digital palpation, which is the basic form of functional assessment of the levator ani muscle, has limited repeatability (1). Messelink et al. recommended quantifying contractions by using the Modified Oxford Scale (MOS) to classify digital pelvic muscle strength into six categories ranging from absent to strong (1). MOS is widely used in clinical practice, as it is easy to perform, inexpensive, and requires no special equipment. Furthermore, vaginal palpation is an effective aid in providing feedback to patients when they perform a pelvic floor muscle contraction (4).

With the advent of Magnetic Resonance Imaging (MRI) (5-7) and dynamic ultrasound imaging technology (8, 9), there have been recent advances in the understanding of the anatomic changes occurring in pelvic floor architecture as a consequence of pelvic floor contraction. A good levator contraction will substantially shorten minimal levator hiatus diameters, effect a change in angle between levator plate and symphysis pubis, and shift the bladder neck cranioventrally (8, 10, 11). In seeking a reliable method to evaluate pelvic muscle function, transperineal ultrasound has been used. More recently endovaginal ultrasound has reported new indices for pelvic floor measurement. The vaginal ultrasound probe has the advantage of providing higher resolution and also helps patients to contract the pelvic floor muscles against the probe mimicking the digital examination. Upward lift of levator plate as a result of pelvic floor contraction is used as indicator of levator muscle function in our study. The aim of our study was to compare pelvic floor strength assessed by digital palpation with the amount of levator plate lift on endovaginal and transperineal dynamic ultrasound for pelvic muscle function evaluation.

Methods

The study was approved by the Institutional Review Board at our institution. This cross-sectional study included 74 women who were referred to our urogynecology clinic because of different pelvic floor dysfunction symptom and received dynamic pelvic floor ultrasound assessment and documented digital pelvic floor palpation based on MOS between January 2013 and January 2014. Patients signed the informed consent and completed a standardized interview and received an examination using POP-Q staging system, assessment of pelvic floor by dynamic three dimensional endovaginal automatic acquisition ultrasound (3D EVUS) and dynamic transperineal ultrasound, and digital assessment of pelvic floor

function using MOS. Patients with a history of prior pelvic floor reconstructive surgery and central nervous system or peripheral neurology diseases were excluded.

Ultrasound protocol

Imaging was obtained at the time of the primary visit using the BK Medical Ultrafocus (Peabody, MA, USA) and an 8838 12 MHz transducer and convex transperineal probe. All ultrasound exams were performed in the office setting, with the patient in dorsal lithotomy position, with hips flexed and abducted. No preparation was required and the patient was recommended to have a comfortable volume of urine in the bladder. No rectal or vaginal contrast was used. To avoid excessive pressure on surrounding structures that might distort the anatomy, the probe was inserted into the vagina in a neutral position. The 360 degrees EVUS volumes were digitally stored for further analysis.

Dynamic transperineal and endovaginal ultrasound were performed as part of multicompartamental pelvic floor assessment in an office setting. Patients were instructed to perform a Kegel while the probe captured the video clip of the levator plate movement in 2D mid-sagittal posterior view. Ultrasound volumes were evaluated by the senior investigator blind to digital palpation score by MOS. The distance from the levator plate to the probe in endovaginal ultrasound (Figure 1) and the distance from the levator plate to the gothic arch of the pubis in transperineal ultrasound (Figure 2) were measured in millimeters at rest and contraction modes. The absolute change in diameter (lift) was calculated by subtracting the contraction measure from the resting measure. The relative change was calculated as the levator plate lift ratio ($\text{lift} / \text{rest} \times 100$) and expressed as a percentage.

In order to calibrate the technique, initially ten endovaginal levator plate resting and squeeze movements were obtained by two operators. The measurements were obtained live during the scanning by freezing the screening and using the ultrasound machine software to obtain the measurements. Complete agreement was found between the operators.

Digital palpation based on MOS protocol

Pelvic floor muscle function was assessed subjectively by digital palpation while inserting a lubricated gloved index finger approximately 4 cm into vagina (12, 13). All women were instructed to squeeze their levator ani muscles without activation of other groups of muscles; abdominal, gluteal and adductor muscles. Muscle strength was graded using six-point MOS: 0, no contraction; 1, minor muscle flicker; 2, weak muscle contraction; 3, moderate muscle contraction; 4; good and 5, strong muscle contraction against resistance by the examining finger (1, 13). A score was recorded for both left and right side and the lower score was used for analysis.

Statistical methods

Statistical analysis was performed using SAS v9.2 (SAS Institute, Cary, NC). Descriptive statistics were used to summarize the distribution of patient characteristics. T-tests and analysis of variance (ANOVA) were used to evaluate differences in absolute and relative mean measurements by pelvic floor muscle function (MOS scores). Mean measures of lift and lift/rest ratio were compared by MOS score (0 - 5), combining scores 4 and 5 into a

single category due to the small number (n=3) of women with a score of 5. Due to the limited sample size within each group defined by MOS score, mean comparisons were also examined after categorizing MOS scores to reflect non-functional (scores 0-1) and functional (scores 2-5) pelvic floor muscles.

Results

Seventy-four women were available for analysis. The mean age and BMI were 55 (SD±11.9) and 28.6 kg/m² (SD± 6.3), respectively. Median parity was 3 (range 1-6). 95.4% of patients were Caucasian and 70.4% had prior hysterectomy. Mean, median and range of perineal and vaginal ultrasound measurements are summarized in Table 1 and Table 2. By endovaginal ultrasound, mean levator plate lift and mean lift ratio increased with increasing MOS score (Figure 3, ANOVA p=0.09 and p=0.04, respectively). While mean levator plate lift increased from 2.1 mm in those with an MOS score of 0 to 5.2mm in those with an MOS score of 4 or 5, this difference was marginal but did not achieve statistical significance. Mean lift ratio, however, significantly increased from 10% to 24% in those with MOS scores of 0 and 4/5. When MOS categories were collapsed by functional status to improve precision, mean levator plate lift and mean lift ratio were 3.2 mm (SD 2.1) and 13.0% (SD 8.2) respectively, in women with non- functional muscle strength; however, the lift and lift/rest ratio were 4.6mm (SD 2.8) and 20.1% (SD11.2), respectively in women with functional muscle strength, Figure 4. The position of levator plate at rest relative to vaginal probe is lower in women with non-functional muscle strength compared to those with functional muscle strength, 24.1 mm vs 22.5 mm, which may be attributed to loss of resting muscle tone.

Only when measured by vaginal dynamic ultrasound were the mean values of the lift and lift/rest ratio significantly different between non-functional and functional muscle strength groups assessed by MOS digital palpation (p = 0.03 and 0.01, respectively). All eight patients with 30% lift detected by vaginal ultrasound had good muscle strength on their MOS digital palpation (Figure3). In contrast, the lift and lift/rest ratio differences observed using perineal ultrasound were not statistically significant when compared across each MOS score (p=0.53 and p=0.37, respectively) nor when compared by non-functional versus functional muscle strength (p=0.23 and p=0.17, respectively).

Discussion

Our study showed that levator plate lift ratio as detected by dynamic endovaginal ultrasound is a good predictor of levator ani muscle function as measured by the MOS. All women who could elevate their levator plate more than 30% of its rest position had functional (MOS score of 2-5) levator muscle strength. On average, patients with non-functional muscle strength (MOS score of 0-1) had a mean lift/rest ratio of 13% and those with functional muscle strength (MOS score of 2-5) had a mean lift/rest ratio of 20%. Additionally, when muscle strength was scored 0-1 on MOS, endovaginal ultrasound could still detect levator plate lift in most women. That is, 20% with MOS 0-1 had lift/rest ratios greater than 10%. Per Table 1, the mean resting position of the levator plate in the non-functional group was lower than the functional group's, and although the non-functional group could lift their levator plate, this lift brought the mean levator plate lift of the non-functional group at kegels

barely to the resting position of the functional group. This indicates that although these muscles move, their movement is ineffective and in some cases below the threshold of a human digit's sensitivity.

In a study of correlation of digital palpation (MOS) and dynamic transperineal ultrasound for muscle function evaluation (14), the authors used bladder neck displacement as their index of muscle strength and found correlation ranging from 0.52-0.62 with dynamic transperineal ultrasound. In another study of 31 women, change in anorectal angle in transperineal ultrasound was used as an index of pelvic floor muscle contraction (15). These authors reported that pelvic floor muscle responses of the healthy subjects and stress urinary incontinent subjects were significantly different. In another study of 446 nulligravid women in their first pregnancy and after their delivery, muscle function was evaluated with digital palpation based on MOS and dynamic transperineal ultrasound (16). Pelvic floor muscle function by transperineal ultrasound was determined as amount of bladder neck lift in the midsagittal plane, shortening of midsagittal hiatal diameter, and change in anorectal angle. The study showed that levator avulsion was associated with reduced contractile function of pelvic floor. This effect was more easily detected by palpation than by sonographic indices of levator function. Steensma et al. studied the prevalence of major levator abnormalities in symptomatic patients with underactive pelvic floor contraction (17). The quality of pelvic floor contractions was evaluated on transperineal ultrasound as reduction in the levator hiatus dimensions. The study showed that underactive pelvic floor muscles were associated with increased prevalence of levator ani avulsion and fecal incontinence; however, the study did not compare different methods of muscle function evaluation. Our study showed that dynamic endovaginal ultrasound is useful tool for predicting levator muscle function, but the associations observed using endovaginal ultrasound measurements were not replicated when using transperineal ultrasound. In addition, endovaginal ultrasound could visualize levator plate movements not palpated during MOS.

Our study has certain limitations. A larger study population would be beneficial to achieve greater statistical power and improved precision. This will be addressed in our future projects. The method of MOS digital palpation performed by our three physicians has intermediate interrater reliability; however, all evaluators were trained under the senior author's supervision to enhance the reliability of the method. Categorization of muscle strength evaluated by MOS to functional and non-functional is based on the definition of scores and not a validated term in literature.

Measurement of the levator plate lift using endovaginal ultrasound seems more strongly associated with digital MOS rather than bladder neck lift, change in the anorectal angle or change in hiatal dimensions. Lift of levator plate as well as strength and duration of contraction are three parameters evaluated while performing digital palpation; therefore, our study's use of the digital palpation method is consistent with standard techniques that are common in most practices. Additionally, the vaginal probe helps patients to contract the pelvic floor muscles against the probe mimicking the digital examination. In summary, our technique creates a feasible method for muscle function evaluation in the field. Studies are needed to replicate these findings in larger samples. In addition, comparison of the levator plate lift to perineometry measurements may provide further evidence in favor of reliability

of endovaginal ultrasound measurement as a method of evaluation of the pelvic floor function.

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Figure 1.

the distance between levator plate and endovaginal probe in dynamic EVUS A) at rest, B) at Kegels

A: anterior, AR: anorectum, C: cephalad, EVP: endovaginal probe, LP: levator plate, P: posterior

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Figure 2.
 the distance between levator plate and pubis in dynamic transperineal ultrasound A) at rest,
 B) at Kegels
 A: anterior, AR: anorectum, B: bladder, C: cephalad, LP: levator plate, P: posterior, PS:
 pubic symphysis, TPP: transperineal probe

Figure 3.
Distribution of dynamic vaginal ultrasound measurement of levator plate lift and lift ratio by MOS digital palpation

Figure 4. Distribution of Dynamic Vaginal Ultrasound measurement of levator plate lift ratio by MOS digital palpation

Table 1

Levator plate lift detected by endovaginal ultrasound measurements and levator strength detected by MOS

MOS	n	Vaginal US Measures	Mean (SD)	Median	25 th pctl	75 th pctl	Min	Max
Poor (Non-functional)	22	Vaginal rest	24.05 (5.58)	25.05	21.60	27.10	10.80	34.30
		Lift (mm)	3.15 (2.05)	3.20	1.30	4.80	0	7.20
		Lift/Rest Ratio (%)	12.95 (8.21)	11.47	6.48	20.83	0	28.42
Good (functional)	43	Vaginal rest	22.53 (5.72)	21.30	18.60	25.90	12.50	42.10
		Lift (mm)	4.64 (2.80)	4.50	2.70	6.60	0.20	11.90
		Lift/Rest Ratio (%)	20.13 (11.23)	20.46	10.00	28.37	1.39	55.22

*Lift and Rest measurements in both methods are in mm.

Table 2

Levator plate lift detected by perineal ultrasound measurements and levator strength detected by MOS

MOS	n	Perineal US measures	Mean (SD)	Median	25 th pctl	75 th pctl	Min	Max
Poor (non-functional)	22	Perineal rest	56.14 (8.66)	57.60	51.10	62.10	33.40	68.20
		Lift (mm)	6.81(4.21)	6.05	3.20	10.50	0.60	14.50
		Lift/Rest Ratio (%)	12.12 (7.61)	10.27	5.64	17.89	1.80	30.59
Good (functional)	52	Perineal rest	53.55 (9.50)	54.05	47.65	59.10	22.70	78.60
		Lift (mm)	8.28 (5.02)	7.35	4.65	10.55	1.20	22.00
		Lift/Rest Ratio (%)	14.75 (7.38)	14.22	9.44	20.08	2.99	33.59

*Lift and Rest measurements in both methods are in mm.