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Original Research Article

Comparative Assessment of Shear Wave Elastography between Normal Myometrium, Uterine Fibroids, and Adenomyosis

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Conflict of interest: Nil

Abstract:

Background: The differential diagnosis between uterine fibroid and adenomyosis is sometimes difficult; a precise diagnosis is required in women with infertility because of the different choice of treatments. Ultrasound elastography (UE) is a novel technique to evaluate the elasticity or the stiffness of the tissue of interest. The present study aims to compare UE shear wave velocity (SWV) among normal uterine myometrium, uterine fibroid, and adenomyosis, and assess the accuracy of shear wave elastography in the diagnosis of adenomyosis.

Materials and Methods: This cross-sectional study recruited 25 subjects for each group (control, adenomyosis, and fibroid) from April 2024 to April 2025. Transvaginal UE with ultrasound mapping for point of tissue biopsy was performed for all subjects. The diagnosis was confirmed by histology.

Results: The mean ± standard deviation (SD) for SWV was 3.44 ± 0.95 m/seconds (control group), 4.63 ± 1.45 m/ seconds (adenomyosis group), and 4.53 ± 1.07 m/seconds (fibroid group). The mean SWV differed when comparing normal myometrium and adenomyosis after adjustments for age and endometrial pathology (P=0.019). The cut-off point of SWV at 3.465 m/seconds could differentiate adenomyosis from the normal uterus with an 80% sensitivity, 80% specificity, and an area under the curve (AUC) of 0.80 (95% confidence interval [CI]: 0.68-0.93) (P<0.001). No significant difference in SWV between the adenomyosis and fibroid groups was detected.

Conclusion: Shear wave elastography could be an alternative tool to distinguish between normal myometrium and adeno- myosis; however, it could not differentiate adenomyosis from uterine fibroid or uterine fibroid from normal myometrium.

Keywords: Adenomyosis, Elasticity, Elasticity Imaging Techniques, Leiomyoma, Uterus

Introduction

Uterine fibroids and adenomyosis are common gynecologic problems, with reported incidences of 20-70% and 5%-70%, respectively [1-3]. Both diseases have unspecific and similar clinical symptoms, including abnormal uterine bleeding, cyclic and non-cyclic pelvic pain, dyspareunia, and infertility [4-8]. Management for both diseases overlap and depend on clinical features, age, fertility desire, and preference of patients. Although differential diagnosis between these two diseases is sometimes difficult, the precise diagnosis is important, especially in women with infertility or incomplete childbearing because of the different choice of treatments. Ultrasonography (USG) is the most common investigation for distinguishing these two conditions; however, there is a wide range of accuracy for USG results (mostly attributed to technician experience), thus requiring an additional tool to overcome this problem [9, 10].

Ultrasound elastography (UE) is a novel technique to evaluate the elasticity or the stiffness of the tissue of interest. UE is now available in some sonogram machines. The UE measurement depends on the excitation methods (manual, acoustic radiation force impulse or external vibration) and the imaging technique (strain or shear wave imaging). In strain imaging, the stimuli trigger the longitudinal wave to move through the tissue, whereas in elastography or shear wave imaging, the stimuli cause shear wave propagations, which move up and down throughout the tissue [11].

Adenomyosis is typically diagnosed when ectopic glands and stroma are observed in the myometrial with surrounding hyperplasic and hypertrophic smooth muscle cells in a hyper- fasciculate trabecular pattern. The histology shows extensive fibrosis

and increased microvascularisation. The progression of fibrosis in advanced adenomyosis has been demonstrated in a mouse study [12]. The microscopic pathology of uterine fibroid shows the hypertrophy and hyperplasia of the smooth muscle cells with a prominent nucleus surrounded by an abnormal increase in the fibrous extracellular matrix. These changes in the tissue ultrastructure might modify the stiffness of the myometrium, which may be detected by UE. The tissue elasticity of normal myometrium, adenomyosis, and fibroids are assumed to be different.

The few previous studies on uterine pathologic elastography reported inconsistent results [13-16]. Several limitations from these studies included the use of strain elastography (SE), which required uncontrolled external force from the user; lack of tissue pathology; and limited sample size. The present study aims to compare the ultrasound elastographic shear wave velocity (SWV) among normal uterine myometrium, uterine fibroids, and adenomyosis confirmed diagnoses with histology.

Methodology:

The present cross-sectional study was approved by the Institutional Ethical Committee of Pacific Institute of Medical Sciences, Udaipur, Rajasthan. The study was conducted at the Department of Radiodiagnosis and Obstetrics and Gynaecology, in PIMS Udaipur. All patients with benign gynaecologic diseases who were candidates for abdominal, vaginal, laparoscopic hysterectomy or conservative surgery from April 2024 to April 2025 were assessed for enrolment. Finally, 75 patients were recruited for study participation and they provided informed consent. The patients were recruited into one of three groups: normal myometrium, adenomyosis, or fibroid. The participants of these three groups were not matched. The inclusion criteria were women (20-70 years old); uterus length 16 cm or less; a lesion in the myometrium with a diameter of 1 cm or more; and willingness for transvaginal ultrasonography (TVS). The participants were excluded if there was a suspected myometrial cyst; degeneration of fibroids or calcified fibroids; gynecologic cancer; or refusal to provide consent. Pelvic examination and TVS were performed for all participants one day before surgery. The following ultrasonographic features were criteria for suspicion of adenomyosis:

1. globular uterine configuration
2. heterogeneous myometrial echotexture
3. myometrial anterior-posterior asymmetry
4. poor definition of the junctional zone, and subendometrial cysts [17, 18].

Adenomyosis is suspected to be present in the uterus when there are three or more ultrasonographic features. Focal adenomyosis is defined when normal myometrium surrounds the adenomyosis lesion by more than 25% [4,19]. Uterine fibroid ultrasonographic features are defined as well-defined hypoechoic masses (normal myometrium surrounds the uterine fibroid lesion by more than 75%) with possible calcifications and acoustic shadowing [20]. During the TVS procedure, SWV was measured at the point of interest (POI). TVS and SWV were performed by one trained Radiologist. After the surgery, tissue at the POI that was approximately 0.5×0.5×0.5 cm was collected and kept in 10% formaldehyde. The biopsied tissue was sent for haematoxylin and eosin (H&E) and Masson's trichrome staining, while the remaining operative tissue was sent for routine histopathological diagnosis. Both tissues were verified and definitely diagnosed by clinical pathologist. Participants whose biopsied tissue results were negative for adenomyosis or myoma were excluded from the study. The data (age, menstrual phase [identified by histology], parity, uterine volume, pre-operative diagnosis, indication for surgery, type of surgery, and type of adenomyosis [focal or diffused]) were collected and analysed.

Statistical analyses were performed using IBM SPSS for Windows version 18 (IBM Corp., Armonk, NY, USA). The relationship between SWV and the area of fibrous tissue was analysed by Pearson's correlation. The level of statistical significance was set as $P<0.05$.

Observations:

There were significant differences between age, uterine volume, endometrial phase/pathology, and menopausal status among the control, adenomyosis, and uterine fibroid groups (Table 1). Multiple comparisons showed that the mean age of subjects with normal myometrium was 62.5 years, which was significantly higher than the adenomyosis (48.1 years) and fibroid (46.9 years) groups ($P<0.001$). The majority of the endometrial pathology in the control group was inactive endometrium (84%), while this proportion was 40% in the fibroid group. The mean uterine volume was significantly larger in the adenomyosis and fibroid groups when compared to the normal myometrium group.

Table 1: Demographic data

Variables	Control (n=25)	Adenomyosis (n=25)	Fibroid (n=25)	P value (three-group comparison)	P value (between groups)

Age (Y)	62.5 ± 15.5	48.1 ± 27.9	46.9 ± 16.1	<0.001	<0.001*,**
Endometrial pathology Proliferative Secretory Inactive Progestin effect Unknown	3 (12) 1 (4) 21 (84) 0 (0) 0 (0)	16 (64) 2 (8) 6 (24) 1 (4) 0 (0)	7 (28) 4 (16) 10 (40) 2 (8) 2 (8)	0.001	0.001*,**
Menopausal status Premenopausal Postmenopausal	4 (16) 21 (84)	20 (80) 5 (20)	19 (76) 6 (24)	<0.001	<0.001*,**
Parity Null Parous	5 (20) 20 (80)	7 (28) 18 (72)	9 (36) 16 (64)	0.452	
Type of surgery Hysterectomy Excision	25 (100) 0 (0)	25 (100) 0 (0)	23 (92) 2 (8)	<0.001	0.001*,**
Uterine volume, cm^3	45.4 ± 48.2	219.5 ± 201.1	232.2 ± 187.3	<0.001	0.001* <0.001**
Type of adenomyosis Diffuse Focal	N/A	22 (88) 3 (12)	N/A		N/A

Data are presented as mean ± SD. SD; Standard deviation, NA; Not available, *; Control vs. adenomyosis, **; Control vs. fibroid, and *; Adenomyosis vs. fibroid.**

The SWV values were 3.44 ± 0.95 m/seconds (control group), 4.63 ± 1.45 m/seconds (adenomyosis group), and 4.53 ± 1.07 m/seconds (fibroid group). Participants in the adenomyosis and fibroid groups had significantly higher mean SWV than those with normal myometrium (P<0.001). However, the mean SWV was not significantly different between the adenomyosis and fibroid groups. Only the mean SWV was significantly different when comparing the normal myometrium and adenomyosis, which was adjusted for age and endometrial pathology (P=0.019).

The mean SWV between pre- and post-menopausal participants was also compared. No difference in SWV was detected when comparing these two groups of patients (P=0.390). There was no difference in mean SWV between pre- and post-menopausal participants in the adenomyosis (P=0.061) and fibroid (P=0.843) groups The relationship between mean SWV and uterine volume in each group was also analyzed, but no correlation was found. Subgroup analysis was performed by comparing the mean SWV between focal (n=3) and diffuse adenomyosis (n=22). The mean SWV values were 5.59 ± 1.84 m/seconds (focal adenomyosis) and 4.47 ± 1.38 m/seconds (diffuse adenomyosis) (P=0.211). There was no correlation between the fibroid maximum diameter and SWV. The cut-off SWV value of 3.465 m/ seconds could differentiate adenomyosis from a normal uterus with 80% sensitivity and 80% specificity, at an AUC of 0.80 (95% confidence interval [CI]: 0.68-0.93) (P<0.001).

The analyses showed no correlation between the extension of fibrosis and mean SWV, regardless of whether we evaluated the whole group or individual groups. The means for fibrosis were 78.66 ± 13.01% (control group), 82.92 ± 13.95% (adenomyosis group), and 82.85 ± 14.04% (fibroid group). The mean difference was not statistically significant when comparing the three groups (P=0.492).

Discussion

The present study demonstrates that the mean SWV for adenomyosis was significantly higher than normal myometrium, which resulted in improved differentiation of adenomyosis from normal myometrium. There was no significant mean SWV difference when comparing the fibroid and normal myometrium. Shear wave elastography could not differentiate adenomyosis/adenomyoma from uterine fibroids. Additionally, no significant correlation between myometrium stiffness (identified by SWV) and fibrosis, identified by collagen special histological staining was detected.

Adenomyosis could be differentially diagnosed from normal myometrium by shear wave elastography with a high sensitivity and specificity. However, adenomyosis could not be differentiated from the fibroid group with this elastography. The stiffness of adenomyosis measured by SWV was higher than normal myometrium, but not significantly different when comparing the adenomyosis and fibroid groups. Interestingly, our results were consistent with the only two published studies that focused on shear wave elastography [14,16]. One previous study [14] used histopathology as a final diagnosis, which was similar to our study, while the other study [16] used magnetic resonance imaging (MRI) for the diagnosis of adenomyosis. The accuracy of conventional TVS for the diagnosis of adenomyosis depends on operator experience and USG image characteristics of the myometrium. Data from the literature show a wide range of USG sensitivity and specificity for the diagnosis of adenomyosis, which ranges from 80% to 90% and 60% to 80%,

respectively [10]. Image characteristics, such as myometrial echoic heterogeneity, provide high sensitivity (80.8%) but moderate specificity (61.4%), while sub-endometrial echogenic linear striations show very high specificity (95.5%) and unacceptable low sensitivity (30.8%). In addition, globular shape and disproportionate uterine wall provide only moderate sensitivity and specificity (70%) [21]. However, few women who present with early-stage adenomyosis have typical USG characteristics for adenomyosis. In these cases, conventional USG could show a normal uterine appearance or only a slightly enlarged uterus. Data from the present study show that shear wave elastography could be useful for diagnosis in this situation, with up to 80% sensitivity and specificity. However, future work should investigate whether there are correlations between the early diagnosis of adenomyosis as well as stiffness assessment of adenomyosis and clinical outcomes (e.g., preterm labour pain, abortion).

Different types of USG elastography demonstrated different results for the diagnosis of a pathological uterus (e.g., adenomyosis and uterine fibroid). The most frequent elastography technique reported in the literature was strain elastography (SE) [13, 15, 22, 23]. However, it is difficult to compare between studies because both qualitative [22,23] and quantitative [13,15] measurements were used to evaluate the outcome. Until now, no standardized measurement for these techniques has been defined.

In the present study, we did not detect any significant correlation between stiffness verified by SWV and fibrosis identified by collagen histological staining of both adenomyosis and fibroid tissues. Adenomyosis is reported to originate from the inside (endometrial invasion from EMJ) or from the outside (invasion of seeding peritoneal endometriosis from the uterine serosa) [24]. The results of previous studies indicate that substantial fibrosis in fibroids increases with larger fibroid mass [25], while the ability of the shear wave elastography probe was limited depending on the distance from the tip of the probe. Second, there were heterogeneities of cellular and fibrotic components in each fibroid mass [26]. Biopsy tissue at the centre of the mass might not represent the entire amount of fibrosis in the uterus. Third, the stiffness of the myometrium of adenomyosis might not be explained only by the collagen staining area but also by hyperplasia and hypertrophy of the myometrium that surrounds the endometrial gland. Fourth, the type of elastography might influence the results. A study on SE demonstrated a correlation between SE lesion stiffness and extension of fibrosis in adenomyosis, fibroid, and benign pathologic uterus groups [15], while no correlation between fibroid stiffness and fibrotic extension was evaluated by directed tissue shear modulus rheometry [26].

Conclusion

Shear wave elastography can be used as an alternative diagnostic tool to distinguish between normal myometrium and uterine fibroid located at the middle to lower part of the uterus by measuring SWV. This UE technique could not differentiate adenomyosis from uterine fibroid.

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