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Revised MUSA Criteria in the Sonographic Diagnosis of Adenomyosis: Direct and Indirect Features; A Narrative Review

Wael Hussein Osman Elbrmbly[1] , Somayya Magd-Eddin Sadek [1], Mai Mohamed Ibrahim Abd Elwahab [2], Omar Khaled Farag Ahmed [1], Osama Elsayed Mohamed Elsayed [1]

[1]Department of Obstetrics and Gynecology, Faculty of Medicine, Zagazig University, Zagazig, Egypt

[2]Department of Pathology, Faculty of Medicine, Zagazig University, Zagazig, Egypt

***Corresponding author: Omar Khaled Farag Ahmed**

Abstract

Background: The original MUSA consensus, published in 2015, established a lexicon for describing uterine morphology, including specific descriptors of myometrial texture, focal lesions, and the junctional zone. Subsequent experience, expanded evidence, and technological developments prompted a revised MUSA (MUSA2) consensus, which refines definitions, incorporates three-dimensional (3D) ultrasound, and emphasizes the distinction between features reflecting primary ectopic endometrium and those reflecting secondary myometrial changes.

Aim: Understanding how each ultrasound feature maps onto histologic reality is central to using MUSA-informed sonography as a surrogate for pathology in everyday clinical practice.

Conclusion: The revised MUSA consensus represents an important evolution in the sonographic assessment of adenomyosis, moving the field from loosely defined pattern recognition toward a structured, histopathologically anchored framework. By conceptually separating direct features that reflect ectopic endometrial glands and stroma from indirect features that reflect secondary myometrial remodeling, MUSA2 enhances diagnostic clarity, improves reproducibility, and aligns ultrasound findings more closely with underlying pathology.

Keywords: Adenomyosis; revised MUSA consensus; direct sonographic features; indirect sonographic features; transvaginal ultrasound; histopathology.

Introduction

The original MUSA consensus, published in 2015, established a lexicon for describing uterine morphology, including specific descriptors of myometrial texture, focal lesions, and the junctional zone. Subsequent experience, expanded evidence, and technological developments prompted a revised MUSA (MUSA2) consensus, which refines definitions, incorporates three-dimensional (3D) ultrasound, and emphasizes the distinction between features reflecting primary ectopic endometrium and those reflecting secondary myometrial changes (1).

In the context of adenomyosis, this conceptual distinction between “direct” and “indirect” sonographic features has clinical and pathophysiological relevance. Direct signs are those that most closely mirror the presence of ectopic endometrial tissue within the myometrium, while indirect signs reflect the uterine remodeling that ensues, such as hypertrophy, globular enlargement, and shadowing. Although the revised MUSA document remains descriptive rather than prescriptive, it provides a robust framework for structured diagnosis, facilitates comparison between studies, and enables more accurate clinicopathologic correlation. Understanding how each ultrasound feature maps onto histologic reality is central to using MUSA-informed sonography as a surrogate for pathology in everyday clinical practice (2).

The Revised MUSA Framework and Concept of Direct versus Indirect Features

The revised MUSA consensus preserves the core principles of the original statement: standardized terminology, systematic evaluation of the uterus in multiple planes, and structured reporting of myometrial findings. The refinement lies in more precise definitions of certain features, explicit recognition of their spectrum of severity, and clearer guidance on assessment of the junctional zone with 3D TVUS where available. In adenomyosis, the consensus acknowledges that no single sign is pathognomonic. Instead, the diagnosis relies on a composite impression based on the number, type, and distribution of abnormalities (3).

Within this framework, direct features are those that can be reasonably interpreted as sonographic correlates of microscopic adenomyotic foci, that is, ectopic glands and stroma within the inner or outer myometrium. Such features include small cystic spaces corresponding to dilated glands, localized echogenic foci representing compact gland-stroma complexes or fibrosis around them, and irregular projections of tissue from the endometrial–myometrial interface suggesting invagination of basalis endometrium. Indirect features are those whose pathogenesis is downstream of this ectopic tissue: global or segmental myometrial thickening driven by smooth muscle hyperplasia, altered acoustic transmission manifesting as fan-shaped shadowing, and disorganization of myometrial echotexture and vascularity (4).

The revised MUSA consensus encourages sonographers to explicitly document both direct and indirect findings, their location (internal versus external myometrium), and their focal or diffuse distribution. This structured description not only improves diagnostic reliability, but also aligns the sonographic phenotype more closely with histopathologic subtypes, such as inner myometrial (junctional zone–related) adenomyosis versus outer myometrial disease, often associated with endometriosis (5).

Direct Sonographic Features and Histopathological Correlation

Among direct features, myometrial cysts are perhaps the most specific and widely recognized. On TVUS, they appear as small, round or oval anechoic or hypoechoic spaces embedded within the myometrium, frequently in the inner myometrial layer, sometimes with fine internal echoes if hemorrhagic. Histologically, these correspond to dilated endometrial glands, frequently with secretory or menstrual content, or to small hemorrhagic lacunae lined by endometrial epithelium and surrounded by endometrial-type stroma. In hysterectomy series, the presence of multiple small myometrial cysts on ultrasound shows a strong positive predictive value for adenomyosis, and their distribution correlates with the depth and density of ectopic glands. The revised MUSA consensus clarifies that these cysts should be distinguished from larger cystic degeneration within fibroids and from vascular spaces, based on morphology, location, and Doppler characteristics (6).

Hyperechoic islands represent another salient direct feature. These are focal, often ill-defined bright areas within a relatively hypoechoic myometrium, which may or may not be associated with small cystic spaces. Microscopically, they correlate with compact aggregates of ectopic endometrial glands and stroma, frequently surrounded by concentric smooth muscle hyperplasia and fibrosis. These histologic interfaces between glandular, stromal, and muscular components create acoustic impedance differences that manifest as focal echogenicity. In some cases, the hyperechoic islands may reflect fibrotic scars left by regressed adenomyotic foci, particularly in perimenopausal uteri, explaining why they may persist even when cysts are less prominent (7).

Echogenic subendometrial lines and buds are features particularly emphasized in the MUSA lexicon. Sonographically, these appear as fine echogenic projections that extend from the endometrial–myometrial interface into the adjacent myometrium. They are often irregularly oriented and may be associated with adjacent myometrial heterogeneity. Histologically, these lines and buds are thought to represent downgrowth or invagination of basalis layer endometrium into the myometrium along paths of least resistance, such as vascular or connective tissue planes. They may contain glands and stroma and often sit at the leading edge of adenomyotic invasion into the inner myometrium. Their presence therefore represents a direct visual analogue of the pathophysiologic process of junctional zone disruption (8).

Taken together, these direct features provide the most compelling sonographic evidence of adenomyosis and correlate strongly with histologic confirmation when multiple signs co-occur. However, their absence does not exclude disease, especially in early or mild cases, underscoring the importance of also considering indirect features (4).

Indirect Sonographic Features and Their Pathological Basis

Indirect features of adenomyosis arise from the chronic myometrial response to embedded ectopic endometrial tissue. Globular uterine enlargement is a classic example. Rather than the normal pear-shaped outline, the adenomyotic uterus appears more rounded, with a spherically expanded body. On cut section at histology, such uteri display diffusely thickened myometrium with trabeculated or spongy appearance, within which adenomyotic foci are scattered.

The globular configuration reflects long-standing smooth muscle hyperplasia and hypertrophy surrounding multiple foci, as well as diffuse fibrosis. Although globular enlargement can also be produced by multiple fibroids, the absence of discrete, capsulated masses and the presence of MUSA-defined direct features incline the diagnosis toward adenomyosis (5).

Asymmetrical myometrial thickening, commonly of the posterior uterine wall, is another MUSA-recognized indirect feature. Sonographically, one wall appears thicker than the contralateral wall without a sharp interface suggesting a discrete mass. Histologically, the thicker wall is heavily infiltrated by adenomyotic glands and stroma interspersed within hyperplastic and hypertrophic myometrium, whereas the thinner wall may be relatively spared. This asymmetry is often associated with localized symptoms, such as posterior pelvic pain or dyspareunia, and may correspond to the distribution of disease at pathology (4).

Generalized myometrial heterogeneity is a frequent but less specific indirect feature. The myometrium displays an irregular, “coarse” echotexture with intermingled hypoechoic and more echogenic areas. At histology, this reflects the complex mosaic of normal smooth muscle bundles, adenomyotic foci, and fibrosis. The greater the burden of disease, the more pronounced the heterogeneity, although similar appearances can be produced by diffuse fibrotic change from other causes, emphasizing that heterogeneity alone is not diagnostic (3).

Fan-shaped acoustic shadowing, a hallmark in MUSA terminology, is a particularly useful indirect sign. Unlike the dense, edge-related shadowing produced by calcified or well-circumscribed fibroids, adenomyosis generates broad, ill-defined, radiating shadows that emanate from the inner or mid-myometrium and fan outward. Experimental work and clinicopathologic correlation suggest that this pattern results from multiple small interfaces tiny cysts, fibrotic bands, and irregular smooth muscle bundles causing scattering and attenuation of the ultrasound beam. At histology, regions corresponding to fan-shaped shadowing tend to be heavily remodeled, with extensive fibrosis and disorganized myometrial architecture, even when overt cysts are sparse (2).

Vascular patterns on color or power Doppler represent another class of indirect features. In focal adenomyosis (adenomyomas), blood vessels often traverse the lesion in multiple directions, creating a “translesional” flow pattern rather than the circumferential vascular ring typical of fibroids. Diffuse adenomyosis may show increased or irregular subendometrial and myometrial vascularity. Histologically, these changes correspond to pro-angiogenic stimuli from ectopic endometrial tissue and to remodeled vasculature within fibrotic myometrium. Although vascular features are supportive rather than diagnostic, their presence in conjunction with direct signs strengthens the suspicion of adenomyosis (1).

Focal adenomyosis or adenomyoma is characterized sonographically as a localized, poorly circumscribed area of altered myometrial echotexture, often containing cysts and hyperechoic islands, with fan-shaped shadowing and translesional vascularity.

Histologically, it corresponds to a nodular aggregation of ectopic glands and stroma in a background of hyperplastic smooth muscle, lacking the well-defined pseudocapsule of a fibroid. Diffuse adenomyosis, in contrast, affects large regions or the entire myometrium, with globally increased thickness, heterogeneity, and multiple scattered direct signs.

The revised MUSA framework supports explicit labeling of these patterns, as they have implications for treatment planning, particularly when uterine-sparing surgery is considered (5).

Diagnostic Performance, Reproducibility, and Correlation with Histopathology

When MUSA-based criteria are systematically applied, transvaginal ultrasound demonstrates good concordance with histopathologic diagnosis of adenomyosis in hysterectomy specimens. Studies that stratify features into direct and indirect categories consistently show that the presence of multiple direct signs, especially myometrial cysts and echogenic subendometrial buds, yields high specificity, often above 85–90%, while the combination of both direct and indirect signs enhances sensitivity. Interobserver agreement, historically a concern, improves significantly when observers use standardized definitions, assess features in a structured manner, and are experienced in myometrial scanning (6).

Correlation with histopathology, however, is imperfect, partly because of the patchy distribution of adenomyotic foci and variability in pathologic sampling. Some uteri with classic sonographic features may be underdiagnosed at histology if tissue blocks do not sample the affected regions in sufficient depth.

Conversely, very early or minimal adenomyosis—limited to a few microscopic foci just beneath the basalis layer—may not generate discernible sonographic abnormalities, particularly if the surrounding myometrial response is minimal. Thus, ultrasound tends to be most accurate in moderate to severe disease, where both direct and indirect features are conspicuous (7).

The revised MUSA consensus does not prescribe a numeric scoring system but encourages comprehensive documentation of the presence, number, and distribution of features. This descriptive approach allows future research to derive and validate scoring algorithms that correlate more finely with histologic burden and clinical outcomes. Early studies suggest that the number of MUSA-defined features present correlates with histologic density of adenomyotic foci and with symptom severity, particularly dysmenorrhea and heavy menstrual bleeding, providing a functional link between imaging, pathology, and clinical expression (8).

Future developments are likely to build upon this consensus framework. Three-dimensional imaging and automated analysis of the junctional zone may provide more objective and reproducible measures of internal adenomyosis. Texture analysis, elastography, and machine-learning approaches applied to stored TVUS datasets may help quantify indirect features and distinguish adenomyosis from mimics such as fibroids or diffuse myometrial fibrosis. Critically, further histopathologic correlation studies, especially those with systematic sampling and correlation with 3D datasets, are needed to refine the interpretation of specific direct and indirect signs and to better define thresholds for “sonographic adenomyosis” in women who are not candidates for hysterectomy (6).

The revised MUSA consensus represents an important evolution in the sonographic assessment of adenomyosis, moving the field from loosely defined pattern recognition toward a structured, histopathologically anchored framework. By conceptually separating direct features that reflect ectopic endometrial glands and stroma from indirect features that reflect secondary myometrial remodeling, MUSA2 enhances diagnostic clarity, improves reproducibility, and aligns ultrasound findings more closely with underlying pathology. When systematically sought and reported, these features allow transvaginal ultrasound to serve as a reliable, noninvasive surrogate for histopathology in most women, supporting earlier diagnosis, informed counseling, and tailored management of adenomyosis across the reproductive lifespan (2).

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