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● *Original Contribution*

ACCURACY AND REPRODUCIBILITY OF SONOELASTOGRAPHY FOR THE ASSESSMENT OF FIBROIDS AND ADENOMYOSIS, WITH MAGNETIC RESONANCE IMAGING AS REFERENCE STANDARD

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Abstract—The aims of this prospective diagnostic evaluation study were (i) to estimate the inter-observer agreement and reproducibility of real-time sonoelastography and real-time gray-scale ultrasound in the measurement of uterine and fibroid volumes; (ii) to evaluate the agreement between real-time gray-scale ultrasound, sonoelastography and magnetic resonance imaging with respect to these outcomes; and (iii) to evaluate the diagnostic accuracy of sonoelastography in the diagnosis of uterine pathology on stored sonoelastography and gray-scale cine loops. Women without a history of uterine pathology and with the diagnosis intrauterine fibroids or adenomyosis were included. All participants underwent gray-scale ultrasound, sonoelastography and magnetic resonance imaging. Compression sonoelastography was found to have high inter-observer and inter-method agreement for the measurement of uterine and fibroid volumes. The addition of sonoelastography to gray-scale ultrasound seems to be useful in the differentiation between fibroids, adenomyosis and normal uteri as reflected by an increase in accuracy and diagnostic agreement. (E-mail: b.stoelinga@vumc.nl)

Key Words: **Sonoelastography, Ultrasound, Magnetic resonance imaging, Fibroids, Adenomyosis.**

INTRODUCTION

Sonoelastography is an imaging technique that delivers information on the elasticity of tissue using ultrasound. It is based on the principle that pathologic tissue is stiffer or softer with a different elasticity, compared with adjacent normal tissue. There are different types of sonoelastography: compression elastography, shear wave elastography and acoustic radiation force impulse (ARFI). Shear wave elastography and ARFI use ultrasound waves that propagate through the tissue. The velocity of the wave or the induced movement of the region of interest can be measured as the degree of elasticity (Nightingale et al. 2011; Wells and Liang 2011). In this study we used compression elastography. With this technique, gentle compression of the tissue is carried out, causing mild changes in shape and size. The change in deformation is shown in the elastography image presented with a color map, in which different colors correspond to stiffer or softer tissue. This color map can be subjectively measured, with bright colors corresponding to soft tissue and darker colors corresponding to stiffer tissue. The color map can also be quantified by the ultrasound machine, which assigns each color a different strain value.

Sonoelastography has been used, with promising results, for several purposes such as identifying breast cancer, prostate cancer or thyroid pathology (Garra 2011). Within the field of gynecology there is growing experience in the use of sonoelastography for uterine pathology, and several articles have recently been published on its use during pregnancy and labor and in evaluation of intrauterine, cervical or adnexal pathology.

With sonoelastography, adenomyosis and fibroids can be distinguished by their different degrees of elasticity. Adenomyosis can be recognized as relatively soft lesions with an irregular shape caused by the presence of endometrial glands and stroma within the myometrium. With sonoelastography, adenomyosis can be recognized as bright (corresponding to softer tissue), irregularly shaped lesions

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(Acar et al. 2016; Stoelinga et al. 2014). Fibroids are benign monoclonal tumors arising from the smooth muscle cells of the myometrium. They contain a large amount of extracellular matrix and are surrounded by a thin pseudocapsule and compressed muscle fibers. This makes them firmer than, or at least of the same consistency as, the surrounding myometrium. On sonoelastography, fibroids are presented as dark (corresponding to stiffer tissue), well-delineated lesions with a clear regular border (Stoelinga et al. 2014).

Before sonoelastography can be promoted in general practice, we need to confirm its reproducibility, inter-observer agreement and its value additional to that normal gray-scale ultrasound. The aims of the present study were (i) to estimate the inter-observer agreement and reproducibility of real-time sonoelastographic measurements of uterine and fibroid volumes and (ii) to evaluate the agreement for these outcomes between real-time gray-scale, sonoelastography and magnetic resonance imaging (MRI) (inter-method agreement). Additionally, we evaluated (iii) the diagnostic accuracy of sonoelastography in the diagnosis of uterine pathology from stored sonoelastographic and gray-scale cine loops (evaluated by an independent observer), with MRI as the reference.

METHODS

We performed a prospective diagnostic evaluation study in a tertiary university hospital. This study was exempted from ethical approval granted by the institutional review board (2012/445). Patients signed informed consents before participating.

Patient selection

Pre-menopausal women visiting our outpatient clinic and suspected of having uterine fibroids (10 patients) or adenomyosis (10 patients) based on regular gray-scale ultrasound were asked to participate. We also asked volunteers (10 women) without a history of gynecologic disorders or current complaints to be controls (women were recruited through posters in the hospital asking healthy young females without an abnormal gynecologic history to respond). All 30 participants underwent an MRI scan. MRI was not repeated in patients who recently (within the last 3 mo) underwent scanning. Patients who had started medication or had undergone uterine surgery in the period between the ultrasound and MRI were excluded.

Study flow

Figure 1 illustrates the imaging techniques used. In the real-time phase, two independent physicians (gynecologist and resident) performed gray-scale ultrasound followed by real-time sonoelastography, showing the real-time dual-mode images, with the sonoelastogram on the right side and the regular B-mode image on the left side of the screen. Cine loops were made of each patient, and the most optimal cine loop was saved anonymously. In the offline phase, the stored anonymized gray-scale and sonoelastography cine loops of both physicians were randomly evaluated by two different and independent observers, a senior (with more than 10 y of experience in conventional ultrasound and 3 y in sonoelastography) and a junior observer (with 3 y of experience in conventional ultrasound and less than 1 y in sonoelastography).

Three different comparisons were made: (i) real-time inter-observer study comparing uterine/fibroid size with sonoelastography between two independent physicians; (ii) real-time inter-method study comparing uterine/fibroid size with sonoelastography versus gray-scale ultrasound; and (iii) offline diagnostic inter-observer study

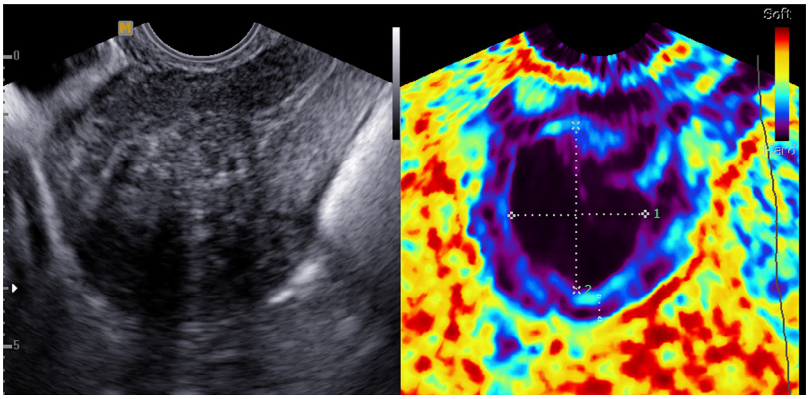

Fig. 1. Dual-mode steady-state sonographic images of the uterus and a single intra-mural fibroid: Left—conventional gray-scale ultrasound image; right—sonoelastography image (gray-scale image with color map superimposed). An ascending-color map is used: *dark purple* or *dark blue* indicates harder tissue; *green* and *yellow* indicate moderately stiff tissue; and *orange* and *red* indicate soft tissue. The capsule is well delineated with some bright parallel lines, and its relationship to the serosa is visible. Delineation of the fibroid is less obvious in the conventional gray-scale image.