Elastography: A New Imaging Technique and its Application.

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***Abstract**: In clinical practice, palpation of any organ remains the main examination to determine the consistency of the organ andthus plan for future investigation. However,it has got limitation in terms of its accessibility to deeper organs as well as its subjectivity. "palpation by imaging" i.e. Elastography is a new promising technique to determine the nature of the tissue with promising results in different organs of the body. The present review article briefly highlight its principal and application to different organ of the body.*

INTRODUCTION

Palpation continues to be of great value in modern medicine, both practiced by doctors and as a technique for self-examination. However, palpation is limited to a few accessible organs, and the interpretation of the information sensed by the fingers is highly subjective. Recently, elastography has emerged as an option in several commercial ultrasound systems, and is starting to prove clinically valuable in many areas. It is a newly developed dynamic technique that uses US to provide an estimation of tissue stiffness by measuring the degree of distortion under the application of an external force. Hence, also known as 'palpation by imaging'.

Principle: softer parts of tissues deform easier than the harder parts under compression, thus allowing an objective determination of tissue consistency. In ultrasound, its premise is built on two known facts:

a) that significant differences between mechanical properties of several tissue components exist
b) that the information contained in the coherent scattering, or speckle, is sufficient to depict these differences following an external or internal mechanical stimulus

Fundamental concepts in elasticity imaging include stress, strain, and the elastic modulus; strain imaging has received the most attention from researchers. Strain represents the amount of deformation; thus, stiff tissue shows less strain than softer tissue. Strain images or elastograms are displayed with a color map.

During elastography, it is assumed that the main displacement of tissue occurs in the longitudinal direction (ie, in the direction of the beam). This condition can be largely met by applying compression with a well-controlled stepping motor. With freehand compression, however, the influence of probe movement on the skin's surface in the lateral direction (so-called creep or slip) must be suppressed (Fig 1). A high-speed algorithm for estimating strain distribution is required for real-time measurement. In addition, an ideal elastography system will have a large dynamic range of strain for stable measurements that does not depend on the speed and extent of compression[1].

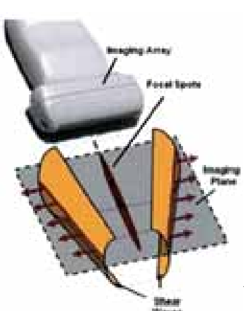

***Fig 1:** shear waves in imaging plane due to longitudinal compression by probe*

METHODS FOR MEASURING STRAIN

1. **SPATIAL CORRELATION METHOD:** uses an ordinary two-dimensional pattern-matching algorithm to search for the position that maximizes the cross correlation between regions of interest (ROIs) that are selected from two images (one obtained before and the other obtained after deformation).
2. **PHASE-SHIFT TRACKING METHOD:** is based on an autocorrelation method that is well known as a principle of color Doppler ultrasonography - determine longitudinal tissue motion because of phase-domain processing. Because of errors related to aliasing, the phase-shift tracking method fails when used to measure large displacements. It poorly compensates for movement in the lateral direction.
3. CAM: enables rapid and accurate detection of longitudinal displacement by using phase-domain processing without aliasing. A modification of CAM to better demonstrate lateral and elevational tissue movements, inevitable during palpation-like freehand manipulation of the probe, is called extended CAM. The dynamic range of strain that is estimated by using the extended CAM is 0.05%–5.00% (optimal dynamic range, 0.50%–2.00%); this method can compensate for up to about 4 mm of lateral slip.

***Table 1:** Comparison of Different Methods for Measuring Strain[1]*

Method	Processing Speed	Precision	Measureable Range of Strain	Sensitivity to Lateral Slip
Spatial correlation	Slow	Moderate	Large	Robust
Phase-shift tracking	Fast	High	Small	Weak
CAM	Fast	High	Large	Robust

Traditionally, strain estimators aim to accurately derive tissue displacements between before and after compression and to compute strain from the displacements. However, the displacement can be as large as 1000 times the strain for typical compression levels used in US elasticity imaging. Error in displacement estimation leads to a large variance in strain, thereby resulting in poor signal-to-noise ratio for the estimated strain. Bae and Kim have developed a novel strain estimator that can be used to directly estimate strain from the phase of temporal and spatial correlation instead of estimating small strain from large displacements. Signal-to-noise ratio and contrast-to-noise ratio of the elastogram measured by using the direct strain estimator are at least three times and six times larger, respectively, than values obtained by using conventional displacement-based strain estimators. This indicates that the direct strain estimator can substantially improve accuracy and lesion detectability in US elasticity imaging. In addition, the direct strain estimator is computationally efficient compared with conventional estimators, thus enabling the real-time implementation and clinical use of this new US imaging mode[2].

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