ROLE OF EXTENDED FIELD OF VIEW ULTRASONOGRAPHY IN MUSCULO-SKELETAL DISORDERS

Meryat Tawfik Mohammad, Mona Abdullah Al-Sebaie, Mohammad Abdul-Bassett and Azzam Hussien Aly Hussein

Radiodiagnosis and Rheumatology & Rehabilitation Departments, Ain Shams University Faculty of Medicine

KEY WORDS: IMAGING FOR MUSCULOSKELETAL DISORDERS, EXTENDED FIELD OF VIEW ULTRASONOGRAPHY.

ABSTRACT

Hypothesis: Real time ultrasound (U/S) scanning is useful to detect abnormalities of musculo-skeletal system (MSK) and shows the effect of movement. However, documentation is best with the extended field of view (Fov) ultrasonography. This new imaging technique identifies identical structures on two successive images for position registration to display a large area in real time without position sensors.

Aim of Study: To evaluate the usefulness of extended Fov U/S in displaying and documenting on a single, static image a more panoramic depiction of MSK abnormality and its relationship to adjacent structures. Abnormalities of tendons, muscles, and soft tissue infection and masses are examples of lesions documented by high frequency extended Fov U/S.

Materials & Methods: The study was monitored for 24 months period and included 18 patients (7 males and 11 females) of variable age groups. Six patients with tendon pathology, three with muscle pathology, eight with soft tissue masses, and one with a bony lesion. Large resolution preserved composite images of up to 30 cm were obtained.

Results: The display of the relationship of abnormalities to surrounding structures is very important and allows for better
interpretation of findings and appreciation of the diagnosis on a static image. In addition, easily useful applicable comparative measurements on follow up scanning were done.

**Conclusion:** Extended Fov U/S allowed: (a) better appreciation of MSK disorders (b) sizing of large masses on a single global image (c) relating the lesion to surrounding structures (d) greater measurement reproducibility at follow up scanning in circumstances under which conventional real time scans could not provide this information.

**INTRODUCTION**

With the advent of high-resolution linear array transducers (7.5, 10, 13 Mhz etc), interest in MSK U/S has continued to develop. U/S at least consider an initial investigation to start with, and determine the need for other more costly procedure such as MRI or more invasive technique such as arthrography or biopsy (Kaplan et al., 1990). The application of U/S in the evaluation of MSK disorders include muscle and tendon disease, soft tissue masses, identification of foreign bodies, certain joint abnormalities, and infectious processes such as osteomyelitis, cellulites, and subcutaneous abscesses (Chhem and Cardinal, 1999).

During U/S examination, a user usually moves the hand-held probe back and forth to observe large abnormalities. The user must piece together the spatial relationships between parts of the anatomy in his or her mind by memorizing small image frames (typically 4-6 cm across). Furthermore, for curvilinear arrays, phase arrays, and mechanical probes, the sector-shaped image Fov is also limited by the probe-scanning angle, which is 60-120 degrees. As a result, real time U/S is able to detect the abnormality, but often impossible to display it completely and demonstrate its relationship to adjacent structures on a single, static image. However, wider Fov real-time images can be obtained using larger linear arrays or curved arrays. So, resolution is sacrificed with these transducers, as they require lower frequency crystals. For extremity and small parts scanning, the superior resolution provided by high frequency linear transducers combined with large Fov is optimal, but regular real-time U/S is unable to provide this combination (Lin et al., 2000).
Extended Fov U/S imaging is a new technique that provides both features as well as document the whole abnormality by simply combines the convenience of a real-time scanner with the spatial advantages of a static B-mode scanner (Weng and Tirumalai...1996). Extended Fov U/S imaging is made possible with a custom-designed, programmable image processor board that uses a state-of-the-art digital signal processing chip i.e. the multimedia video processor (MVP). Extended Fov U/S imaging technology exploits several of the unique capabilities of the MVP for parallel processing and high-speed data transfer to achieve real-time performance (Sauerbrei, ...1999).

The current study was designed to assess and explore the numerous potential advantages and new capability of extended Fov U/S imaging technology in clinical utility of MSK disorders.

**MATERIALS AND METHODS**

Over 24 months period, we used real time extended Fov U/S technology (SiScape, Siemens Elegra ultrasound machine; Siemens Medical System, Issaquah, WA) in evaluation of some diseases of MSK system. The study included 18 patients (11 females & 7 males), their age range from 15 to 67 years old.

By simply pushing a button, we used real-time scanning to produce a panoramic image without position sensors or cumbersome articulating arms. An image-registration-based position-sensing technique was used to track probe motion and reconstruct a large composite image during real time scanning. The probe motion (translation and rotation) was estimated accurately by combining multiple local motion vectors-a computationally intensive process that uses a special programmable image processor and a fuzzy-logic technique to make the local and global motion estimates.

During examination, the plane of interest was selected with the real time probe. Then, extended Fov mode was established. The probe was then slide along the skin surface in direction of the extended Fov image. The real time image was monitored on the screen allowing visualization of structures added to the extended Fov file. The transducer moved along the skin surface at variable rate as reversals of scan direction destroy the image.
The display of the relationship of abnormality to surrounding structures was carried-on allowing better appreciation of the diagnosis on the static image.

**RESULTS**

The variable abnormalities of MSK system and the number of patients included in our study are demonstrated in Table (1). The informations seen by extended Fov and were not visible in standard Fov were documented, considering that the findings routinely appreciated by conventional real time ultrasonography are limited by the probe width (around 4-6 cm).

Table (1): Types of different musculoskeletal lesions in the study.

<table>
<thead>
<tr>
<th>Part examined</th>
<th>No. Of Patients</th>
<th>Pathological lesions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tendon</td>
<td>6</td>
<td>4 Tendinitis &amp; Peritendinitis, 2 Tears</td>
</tr>
<tr>
<td>Muscle</td>
<td>3</td>
<td>2 Hematomas, 1 Tear</td>
</tr>
<tr>
<td>Soft tissue</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Infection</td>
<td>4</td>
<td>3 Abscesses, 1 Bursitis</td>
</tr>
<tr>
<td>b. Masses</td>
<td>4</td>
<td>2 Lipomas, 1 Epidermoid inclusion cyst, 1 Popliteal cyst</td>
</tr>
<tr>
<td>Bone</td>
<td>1</td>
<td>1 Osteomyelitis</td>
</tr>
</tbody>
</table>

Our study included six patients with tendon abnormalities; four tendinitis and peritendinitis (Fig. 1) & two tears one partial and the other complete (Fig. 2). Tendons examined were 2 achilles, 2 rotator cuff, 1 patellar and 1 quadriceps. Extended Fov U/S showed the findings (disruption, hemorrhage, edema, collection and disorganized loose strands of tendon) in relation to identifiable surrounding structures. The width of this extended Fov U/S image was about 30 cm + i.e., more than 5 times that of standard Fov.

Muscle lesions were three, 2 hematomas (Fig. 3) and 1 tear. Extended Fov showed characteristic feathery sonographic appearance of homogenous, multiple, fine, parallel echoes. Dynamic examination with muscle contraction and relaxation was valuable in differentiating partial tear
from a complete muscle rupture, which could be globally displayed on the static image by extended Fov U/S image (Fig. 4 a, b).

Fig. (1): Left Achilles tendinitis. Forty-two years old women. U/S EFOV showed hypoechoic and thickened tendon with loss of the normal internal fibrillar pattern at the inferior aspect of the Achilles tendon.

Fig. (2): Complete tear supraspinatus. Fifty-five years old man with acute onset of
right shoulder pain. U/S EFOV showed complete disruption of the supraspinatus tendon with disorganized loose strands of tendon.

Fig. (3): Gastrocnemius hematoma. Nineteen years old man with pain and swelling of the right calf. U/S EFOV showed hypoechoic hematoma with irregular inferior margin of medial head of right gastrocnemius muscle.

Fig. 4 (a): Rectus femoris muscle rupture. Thirty-two years old man with a mass in the left thigh since an old injury. U/S EFOV showed relaxation studies denoting complete tear of the left rectus femoris muscle.
Fig. 4 (b): Rectus femoris muscle rupture. Thirty-two years old man with a mass in left thigh since an old injury. U/S EFOV showed retraction studies denoting complete tear of the left rectus femoris muscle.

Fig. (5): Presternal abscess. Thirty-eight years old diabetic woman with erythema and pain over the sternomanubrial joint. U/S EFOV showed an echo-poor abscess cavity over anterior surface of manubrium.
Fig. (6): Lipoma of vastus lateralis muscle. Sixty-seven years old woman with painless mass of right thigh. U/S EFOV showed two hyperechoic masses (arrows) within the vastus lateralis muscle.

Fig. (7): Epidermoid inclusion cyst. Forty-four years old man with a chronic mass overlying the right hip that has recently enlarging. U/S EFOV showed an echogenic mass with good through transmission in subcutaneous tissue overlying the greater trochanter.
Fig. (8): Baker’s cyst. Thirty-four years old woman with acute onset of left calf pain and swelling. U/S EFOV showed a cyst arising from medial aspect of popliteal fossa extending caudally. (Arrow) points to medial femoral condyle.

Fig. (9): Osteomyelitis of right ulna. 65 years old woman with fever, pain and soft tissue swelling of the distal right forearm for six months. U/S EFOV showed an echo-poor mass like-lesion anterior of right ulna with cortex destruction. Aspiration showed pus.
Eight patients with soft tissue pathologies (4 with infection and the other 4 with masses). 3 soft tissue abscesses (Fig. 5) and 1 septic bursitis of the olecranon bursa (confirmed by needle aspiration) were visualized by real time U/S as fluid collection surrounded by thickened muscle wall and extended Fov U/S documented its relationship to local anatomical landmarks. In the work-up of soft tissue masses, identification of existence, location and nature of these masses are depicted. Extended Fov U/S showed the referred clinician the relationship of lesions to surrounding structures. Furthermore, two lipomas (Fig. 6) and one epidermoid inclusion cyst (Fig. 7) were diagnosed (where extended Fov detected the presence of the latter prior to bone destruction and document its location). In addition, extended Fov also established the diagnosis of a single popliteal (Baker’s) cyst (Fig. 8) and demonstrated its adjacent structures on the static image.

A rather single case of osteomyelitis (Fig. 9) revealed ill definition of the cortical bone and cartilage with soft tissue swelling. Extended Fov displayed the inflammatory mass identifiable surrounding structures.

On average, extended Fov U/S added 6 minutes to the total scan time. Overall extended Fov was useful for measurement of structures larger than the conventional Fov U/S as well as provided anatomic context that was not possible with the smaller standard Fov. Furthermore, concurrent lengths gained by extended Fov U/S for some lesions were comparable with measured distances obtained with magnetic resonance image for the same lesions (done for confirmation) with no significant errors were detected.

**DISCUSSION**

The substantial disadvantage of conventional real time ultrasound scanner is the limited image field of view, clearer when compared with the field of view of other imaging modalities such as computed tomography and magnetic resonance imaging. Static B-mode U/S scanner, which was replaced by real time scanner in the late 1970s, did not suffer from this limited Fov problem. It was equipped with a mechanical articulated arm. The static B-mode scanner could image anatomy large as the reach of this arm but the bulky arm was cumbersome. However, the real time imaging capability and superior image quality of modern U/S scanners, aside from their limited Fov, are important advantages over old static B-mode scanners (Holm et al., 1980).
Weng et al. (1997) was the first to describe the technology of real time extended Fov U/S. It allows real-time generation of sonogram images up to 60 cm field-of-view without the use of external sensors. All ultrasound probes may be used, and many areas of the body were scanned in this mode of our daily routine work (e.g. obstetric, breast, scrotum, angiology...etc), however our study concerned only with the MSK disorders. A recent article described by Barberie et al. (1998) demonstrated the use of extended Fov U/S in MSK lesions was helpful for our work. The extended Fov system uses a programmable Image Processor Board, which has multiple computer chips, allowing parallel processing at 4 billion operations per second.

The detection and correlation of internal landmarks allows the system to acquire multiple images in a spatially and anatomically accurate fashion (Cooperberg et al., 2001). The guidelines are quite general and they emphasized the portrayal of abnormalities versus normal structures. The decision of whether or not to employ extended Fov U/S was made by the sonologist based on the guidelines (Fornage et al., 2000). As the normal structures were not targeted in the guidelines of our study, so only patients with abnormalities underwent extended Fov U/S. Therefore, the rate of extended Fov U/S used (18 patients) reflect the prevalence of large MSK abnormalities in our patient population.

Considerable variation occurred in the use of extended Fov among sonologist; this appeared to be dependent of years of scanning experience. A correlation may exist with acquired skill in the technique and with insight into the potential and real benefits of extended Fov U/S in clinical practice during consultation with physicians after images have been generated and recorded (Bucklein et al., 2000).

In all of our patients, the detection of abnormalities and formulation of differential diagnosis was mainly based on conventional real-time scanning. The extended Fov U/S images were used to portray imaging information. It was most useful for clinical consultation and for teaching. In addition, we could measure large structures accurately with extended Fov U/S but not with standard real time scans. Furthermore, the extended Fov image occasionally gave diagnostic information that was not obvious in real time scans. In addition, color Doppler capability was valuable, used usefully in one case of our study to differentiate hematoma from pseudoaneurysm. Extended Fov U/S allowed tracking and displaying the pseudoaneurysm in relation to the whole length of the vessel. In addition, U/S-guided
compression provided a method of pseudoaneurysm treatment (this is beyond scope of our study).

Because measuring large structures and portraying abnormalities in the context of normal surrounding anatomy often were not possible with current conventional ultrasonographic technology. While extended Fov does undertake this intension, so sequential extended Fov sonograms allowed us monitoring of large neoplasm and fluid collection during therapy like these of hematomas and abscesses patients. Currently, CT or MRI imaging is required to provide this information. However, as extended Fov sonography was able to provide accurate and reproducible measurements, so the extra costs of serial and/or confirmatory CT or MRI scans in addition to various drawbacks of latter two modalities could often be avoided. Considering; from our experience; that when extended Fov U/S images was printed in large format, the reaction of referring clinicians was even more positive. Also, some of the illustrations demonstrate the potential of power color extended Fov sonogram, so blood flow information was also added (Hara et al., 1999).

Conclusion:

The display of the relationship of abnormalities to surrounding structures as well as measuring large structures by new technology of extended Fov U/S are very important. This allows for better appreciation of the diagnosis on the static image. Secondly, extended Fov is particularly useful to compare measurements at follow-up scanning. Thirdly, clinicians can readily appreciate the abnormality on extended Fov images and may be more willing to accept the less expensive and more readily available ultrasound modality as compared to MRI. Lastly, for teaching and filing purposes, extended Fov images are much easier to interpret.
REFERENCES


