MicroVids: A new approach for dynamic ultrasound documentation of the musculoskeletal system.

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Authors: F. Huber, A. Wielandner, B. Neubauer, A. Sachs, L. Hirtler, F. Kainberger; Vienna/AT
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Purpose

a) To evaluate the use of short-video documentation for ultrasound examinations.

b) To develop indication-based examination guidelines for musculoskeletal ultrasound (MSUS) and evaluate their efficiency and usability in non-patient training setting.

c) To improve and standardize student education in MSUS.
Methods and Materials

Introduction

Over the last years and decades the influence of musculoskeletal ultrasound in daily clinical practice has significantly and constantly been increasing. The number of investigations goes along with the broadened spectrum of indications. Several indications referred to trauma, inflammation and degeneration, as well as oncologic and neuropathic diseases, show good sensitivity for ultrasound diagnostics (Klauser, Tagliafico et al. 2012).

In addition to this trend of using ultrasound as first choice modality more often, equipment and transducers with constantly higher resolution produce better image quality in musculoskeletal ultrasound.

Basic knowledge in examination modalities and ultrasound/radiologic diagnostics are more and more needed in various medical professions. Ultrasound today is often used by non-radiologic professionals. A broadband training in medical sonography for both undergraduate students and residents is not only wise, but obligatory to guarantee efficient diagnostic in future clinical practice. Hence, apart from the compulsory radiologic education as part of the undergraduate curriculum of human medicine, the Medical University of Vienna offers several electives. Those shall train diverse skills in examination and diagnostics, one of it is named "Ultrasound in medicine".

Background

Despite numerous existing guidelines, educational papers and video workshops on Youtube-channels and other internet portals, the authors of this study weren’t aware of any indication-based help for examination and documentation in musculoskeletal ultrasound.

Our aim was to develop an educational base that allows training non-radiologist users how to examine a complete anatomic area systematically, supported by strictly defined indication protocols and MicroVids-documentation method. Using this system, non-experts would assess anamnesis and other available patient data, and with this information decide for one of five indication groups. We defined the groups "Inflammation", "Degeneration", "Trauma/Sport", "Nerves" and "Tumor". We tried to emphasize ease of decision-making for non-trained examiners as primary aspect. Once chosen the correct indication protocol, the user should be able to examine by efficiently documenting only a few standard views and in consequence of, to diagnostically covering a clinically reasonable spectrum of pathologies.

Dynamic Ultrasound Documentation
Sonography in medicine, especially in musculoskeletal issues, is a dynamic examination modality. Compared to other radiologic methods, in both diagnostic and therapeutic application settings, examiners often move the transducers to assess neighboring anatomy or get better views of relevant structures. However, documentation of ultrasound examinations for long-time patient records is still commonly performed with static US images, which only give an exemplary insight into the complete examination at most. For us, two main problems arise by using this documentation method.

Firstly, after the examination, only few of the diagnostic results are logically traceable for other doctors, who are to be involved in the following steps of the patient's way. Static US images aren't meaningful at all, further interpretations depend on the written report of the primary examiner itself. Without notes about recorded view, special modalities and found pathologic conditions or anatomic variations, recognizing the examined structures as well as double reading afterwards are hardly possible.

Coming along with this matter, ultrasound examination these days is still temporally coupled with the documentation and diagnostic finding procedure. Neither storage problems, nor other technical issues explain why examination and documentation processes in MSUS couldn't be done at separated times. Therefore, we tested a novel video documentation method in combination with the use of the above mentioned indication-based examination protocols in this pilot study. The application of both was integrated in an elective for medical students, in order to get objective results and opinions that won't be biased by different levels of expertise in MSUS (compared to testing by radiologists).

**Indication-based examination Protocols**

The new MicroVids-protocols with five indication groups largely based on the adoption of the already existing ESSR guidelines for standard views in musculoskeletal ultrasound of wrist and hand region (ESSR, Beggs I. et al. 2006).

We tried to combine those "technical" guidelines with accessible literature about relevant pathologies in daily clinical MSUS. For example, the protocol "Inflammation" tried to integrate parts of "German US7 Score" by Backhaus M (Backhaus, Ohrndorf et al. 2009). After review and correction by expert's opinion, we developed the first version of these indication-based examination guidelines (Fig.1).

The guidelines were separated into five groups of examination protocols, differing by the etiology of pathologies. After evaluation of anamnesis and other patient data the examiner chooses one of the protocols "Inflammation", "Degeneration", "Trauma/Sport", "Nerves" and "Tumor" - each of them containing not more than max. 6 standard views in two different planes.

The use of those protocols should give also non-expert examiners the safety to find all common pathologies (see figure 2) when scanning a complete region. At the same
time it should decrease duration of examination to a minimum level. When a protocol is completed, there are two options left:

a) Patient's pathologic condition is common and was diagnosed by the use of a standardized examination protocol.

b) Patient's pathology couldn't be identified within the 6 standard views (for numerous reasons) and needs further diagnostic procedure.

**Integration of MSUS in undergraduate education**

In an elective for undergraduate students of human medicine, basic knowledge and skills in musculoskeletal ultrasound diagnostics were taught and trained. Besides lectures in abdominal, cervical and nerve anatomy and ultrasound diagnostics, participants learned standard views in musculoskeletal US of hand and wrist (which was chosen as "pilot region"). After short theoretic lectures the participating students examined each other. All workshops were done under supervision by a tutor or radiologist, using GE Healthcare Logiq 9 and E9 ultrasound systems. MSUS sessions were the last part of the elective, which guaranteed the existence of basic knowledge of the participants in ultrasound diagnostics and anatomy.

To fulfill a clinical approach, students first learned to examine the wrist region with lower resolution (12-14 Mhz linear transducer), and afterwards scanned the area again with a high-resolution 18 Mhz hockey stick transducer. Thereby, students also learned finding anatomical structures with basic examination equipment which is more common in non-radiologic departments.

Besides lectures of anatomical, clinical and diagnostic knowledge, the MSUS sessions focused on the use of the MicroVids-examination protocols. Students should understand the value of a dynamic examination for both efficiency and quality of image material. Instead of trying to "find" the correct reference positions for standard views (as often done at first time of examining), the participants learned to display and scan surrounding areas that contain an important standard view, and can be saved as 5-10 seconds short MicroVids for the indication-based protocols.

In order to check practicability and ease of use of MicroVids-documentation, all participants screened each other (all of them healthy individuals) for the protocol groups "Degeneration" and "Nerves". As all of the elective students were healthy individuals, objective of the participants was to quickly identify normal anatomical reference structures of the respective standard views.

The students were asked to take part in a voluntary paper exam about wrist MSUS. The test contained 9 questions about reference structures and examination modalities of 2 pictures of MSUS standard views. As the MSUS session took place on two separate dates for two groups of students, we decided to check the ultrasound skills of the first
group before the specific MSUS lectures, while the second group took the exam after MSUS training.

**Evaluation of "MicroVids"**

After the end of the elective we evaluated image quality and efficiency of MicroVids-documentation. Several standard views were documented twice, first time as standard static US pictures, the second time by use of short videos. For this purpose, we produced video material of the standard view's surrounding areas which should contain the standard view we were originally looking for. Afterwards, the videos were edited on PC and standard views were cut out and saved as images. Quality of those images was then compared with the static pictures that were recorded during examination.

The recorded standard views were

- Carpal tunnel, axial
- Median nerve, longitudinal
- All six wrist extensor compartments, axial
- MCP 2, longitudinal
Fig. 1: Indication-based MicroVids protocols with five separated groups of indications. "A"- and "B"-standard views in "Degeneration" protocol mean joints of the two clinically most affected fingers.

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<table>
<thead>
<tr>
<th>Degeneration</th>
<th>Sports/ Trauma</th>
<th>Inflammation</th>
<th>Nerves</th>
<th>Tumor</th>
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<tbody>
<tr>
<td>Osteoarthritis</td>
<td>Tenosynovitis</td>
<td>Rheumatoid Arthritis</td>
<td>CTS</td>
<td>Palpable mass</td>
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<td></td>
<td>Scaphoid fracture</td>
<td>Psoriatic Arthritis</td>
<td>Glycerine</td>
<td>Cyst</td>
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<td></td>
<td>Kienbock’s disease</td>
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<td>Wartenberg Syndrome</td>
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Fig. 2: Common pathologies of the 5 indication groups shall be found by documentation with MicroVids protocols.
Results

The diagnostic skills of the participating students were improving immediately after a short time of theoretic lectures and a hands-on part. The time needed for the examination and for recognizing anatomic structures rapidly decreased with every round of newly learned standard views. Likewise, the image quality of displayed views correlated with team learning aspects, as our group size of 6 students allowed the participants to sit around one ultrasound system and to observe colleagues during their attempts of documentation.

Shortly after the demonstration and practical experience every student was familiar with the regional ultrasound anatomy and could name all relevant reference structures (e.g. Median nerve, trapezium and hamate bone as landmarks for axial view of carpal tunnel). In addition, the recorded material was useful and acceptable for clinical standards.

Due to a small number of test samples, the results of the written MSUS exam showed large differences between the two exam groups, but were not statistically significant. We expected a better exam score of the second group, as they trained examination of the respective regions right before. But although nearly all of the participants were probably familiar with the basic anatomy of the region (due to their progress in the main studies) before MSUS session, the second group had much better test results, although the images on the second exam round were printed in worse quality. However, mean score of the second group was over 50% higher than average points of participants of the first exam group.

Oral feedback of the students was very positive, the main pro argument was probably the extended practical aspect of the elective.

Comparison of the video and the image recording method showed huge differences in examination time, but nearly similar results in image quality. We edited the short videos on PC and captured the respective standard views. Reference structures could be seen as good as in static documentation material (see Figures 3-5). Recording video material was performed without training. The examiner was familiar with regional anatomy and experienced in MSUS. To include standard views into videos, Transducer was simply placed nearby expected position of reference structures and region was filmed in one turn into direction of expected position for standard view. Of the 9 tested standard views, length of short videos was 10.5 seconds in average. Shortest time filmed was 7 seconds (MCP2 longitudinal, Fig.6), longest video was 15 seconds of length (Tendon of EPL muscle axial). In contrast, it took longer in every attempt to adjust the transducer for static US pictures.
Images for this section:

**Fig. 3:** From left to right: US picture and two different video snapshots of ECU tendon (asterisk).

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**Fig. 4:** From left to right: US picture and two different video snapshots of second MCP joint. Asterisks show Mm.flexor digitorum tendons.

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**Fig. 5:** From left to right: US picture and two different video snapshots of Median nerve (asterisk).

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Fig. 6: MicroVids-documentation of MCP2 joint in longitudinal aspect.

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Conclusion

Training medical students in ultrasound early probably brings large benefits for future diagnostic skills of both radiologists and non-radiologists, since even short sessions of MSUS lectures and workshops show remarkable improvements in the examiner's efficiency and quality of documentation. Application of indication-based MicroVids-protocols is an easy and efficient way to screen specific regions for common pathologies, even if performed by less experienced examiners. As future step, the results of this pilot project shall lead to more detailed and systematic protocols for indication-based examination of musculoskeletal structures. This time we trained the new guidelines to medical students, who then examined healthy individuals. Diagnostic sensitivity of each of the five protocols should be tested on big patient population. Besides, the MicroVids-documentation guidelines should be enhanced by developing high quality multimedia learning content for self-studying of standardized examination in MSUS - like a similar paper, that combined a systematic examination approach of the shoulder region with sketches, anatomical photos, US and MR images (De Maeseneer, Marcelis et al. 2012). Documentation with short videos, instead of documentation with static images, significantly benefits standardized MSUS examination. Even with little experience in MSUS, recording short videos of surrounding regions of standard views mostly contain the needed image material for documentation. Testing of MicroVids-documentation in larger population would possibly show that documentation could also be done temporally separated from the examination itself. Apart from that, transition of information after examination improves due to higher anatomic range of recorded material and better three-dimensional measurement of pathologic structures.
References


Personal Information

F. Huber, A. Wielandner, B. Neubauer, A. Sachs, L. Hirtler, F. Kainberger. Vienna/Austria.

Department of Radiology, Medical University of Vienna,
Währinger Gürtel 18-20, 1090 Vienna, Austria.

mail to: huber.muw@gmail.com