# Session 2aBAb

## Biomedical Acoustics: General Topics in Biomedical Acoustics III

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### *Contributed Papers*

9:00

**2aBAb1. A focused limited-diffraction beam for high-resolution imaging.** Jian-yu Lu (Bioengineering, The Univ. of Toledo, 2801 West Bancroft St., Toledo, OH 43606, jian-yu.lu@ieee.org)

Unfocused limited-diffraction beams such as Bessel beams and X waves have been studied extensively to obtain a large depth of field for medical imaging. In this study, a focused zeroth-order Bessel beam $j_0(\alpha r)$, where $\alpha = 1202.45\ \mathrm{m}^{-1}$ and $r$ is the radius, produced with a 50 mm diameter and 2.5-MHz transducer and with an acoustic lens of 50-mm focal length ($f$-number = 1) was used to obtain a C-mode image of an object in water (0.6 mm wavelength). The results of the study showed that at the focal distance, the lateral resolution of the image obtained with an unapodized transducer in both transmission and reception was lower than that obtained with an unapodized beam in transmit but the $j_0$ Bessel beam was used in receive. Beam plots of the unapodized beam and the $j_0$ Bessel beam at the focal distance showed that the lateral beamwidths were about 0.78 and 0.59 mm, respectively. The 0.59-mm beamwidth of the focused Bessel beam is better than that of the diffraction limit ($1.22 \times$ wavelength $\times f$-number = 0.732 mm). The decreased beamwidth of the $j_0$ Bessel beam results in a higher lateral image resolution while the sidelobes of the beam were suppressed by the focused unapodized transmit beam.

9:15

**2aBAb2. Ultrasound coherent plane-wave compound imaging: Image quality evaluation in phantoms and breast lesions.** Gijs Hendriks (Medical UltraSound Imaging Ctr., Radboud Univ. Med. Ctr., P.O. Box 9101, Nijmegen 6500HB, The Netherlands, gijs.hendriks@radboudumc.nl), Gert Weijers, Chuan Chen (Medical UltraSound Imaging Ctr., Radboud Univ. medical Ctr., Nijmegen, The Netherlands), Madeleine Hertel (Siemens Heathcare GmbH, Forchheim, Germany), Chi-Yin Lee (Siemens Ultrasound, Issaquah, WA), Peter Dueppenbecker, Marcus Radicke (Siemens Heathcare GmbH, Forchheim, Germany), Andy Milkowski (Siemens Ultrasound, Issaquah, WA), Hendrik Hansen, and Chris L. de Korte (Medical UltraSound Imaging Ctr., Radboud Univ. Med. Ctr., Nijmegen, The Netherlands)

Coherent plane-wave compound imaging (CPWCI) can achieve high temporal resolution (e.g., to prevent breathing artefacts in volumetric scanning). It has to be verified that CPWCI using a limited number of steering angles ($n_a$) can achieve at least similar image quality as conventional focused imaging (CFI). The aim is to compare image quality between CPWCI and CFI in phantom and in breast lesions. In CPWCI, plane-wave channel data were recorded ($n_a = 15$, $\pm 11$ deg) by a Sequoia Ultrasound system (10L4, 14L5; Siemens Healthineers); beamformed (delay-and-sum (DAS), Lu's-fk and Stolt's-fk) for each steering angle, and coherently compounded. For comparison, images were recorded by CFI (10, 35 mm focus). Image quality metrics were obtained in images of a multipurpose phantom (CIRS Model057). We have just initiated a reader study ($n = 200$) to investigate how these phantom results translate to *in vivo*. Phantom results showed that contrast sensitivity (CS) and resolution (CR), lateral resolution (LR) and contrast-to-noise ratio (CNR, depth < 45 mm) were similar for CPWCI and CFI (10, 35mm) for both transducers, whereas CNR (>45 mm), LR and penetration were improved. In CPWCI, Lu's f-k and DAS resulted in optimal CS (10L4) and LR, and CNR, respectively. In the ongoing reader study, image quality of breast lesions will be evaluated.

9:30

**2aBAb3. Improving ultrasonic evaluation of osteochondritis dissecans using a cadaveric model.** Philip M. Holmes (Mayo Clinic Graduate School of Biomedical Sci., 200 1st St. SW, RO_OS_02_2008, Rochester, MN 55902, holmes.philip@mayo.edu), Kun-Hui Chen (Dept. of Orthopedics, Mayo Clinic, Rochester, MN), Hyungkyi Lee, Shuai Leng (Dept. of Radiology, Mayo Clinic, Rochester, MN), James Fitzsimmons, Shawn O'Driscoll (Dept. of Orthopedics, Mayo Clinic, Rochester, MN), and Matthew W. Urban (Dept. of Radiology, Mayo Clinic, Rochester, MN)

Osteochondritis dissecans (OCD) is a joint disease that is prevalent among youth athletes. Medical ultrasound is currently limited in its ability to detect and monitor OCD due to limitations of current Delay-and-Sum (DAS) reconstruction algorithms. In this work, we used a Delay-Multiply-and-Sum (DMAS) reconstruction algorithm to improve medical ultrasound's ability to diagnose OCD. We artificially generated OCD lesions in unfixed cadaveric elbows and imaged them with a research ultrasound machine. We also imaged these cadaveric limbs with x-ray computed tomography (CT) with a high-resolution acquisition. These CT images were used as a gold standard for OCD geometry. We reconstructed the ultrasound images using both DAS and DMAS algorithms and compared them quantitatively by taking several profiles across the images of the artificial OCD lesions. The image metrics that we measured within these profiles were OCD lesion contrast, bone interface clarity, and lesion crack thickness accuracy. We found that the DMAS algorithm improved OCD lesion contrast by up to 26% when compared to DAS. We also found that the DMAS algorithm reduced the variability of bone interface clarity overall. Future work will involve an *in vivo* study, as well as optimization, of the DMAS algorithm for OCD lesion imaging.

9:45

**2aBAb4. Z-section and 3D rendering imaging using 130 and 50 MHz ultrasound and bacteria generated ultrasound contrast agents.** Sangnam Kim (Aerosp. and Mech. Eng., Univ. of Notre Dame, 213B Multidisciplinary Res. Bldg., Notre Dame, IN 46556, skim52@nd.edu), Gyoyeon Hwang, and Sangpil Yoon (Aerosp. and Mech. Eng., Univ. of Notre Dame, Notre Dame, IN)

We present an ultrasound z-sectioning imaging approach to visualize small vasculature. The major difference between confocal and conventional microscopy is the sectioning capability to generate three-dimensional images by stacking multiple sections. To visualize small vessels, we used 130 and 50 MHz ultrasonic transducers and gas vesicles (GV) isolated from bacteria as contrast agents. We developed 130 and 50 MHz ultrasonic transducers using lithium niobate. The focus and aperture of 130 MHz transducer are 1.5 and 1 mm and 50 MHz transducer has 3 mm aperture and 4 mm