Biomedical grating-based phase-contrast imaging using synchrotron and conventional X-ray sources

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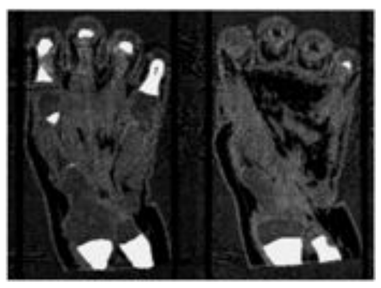
Motivation

Ex-vivo PC-CT of human hand with conventional X-ray tube

conventional absorption-contrast CT



grating-based phase-contrast CT

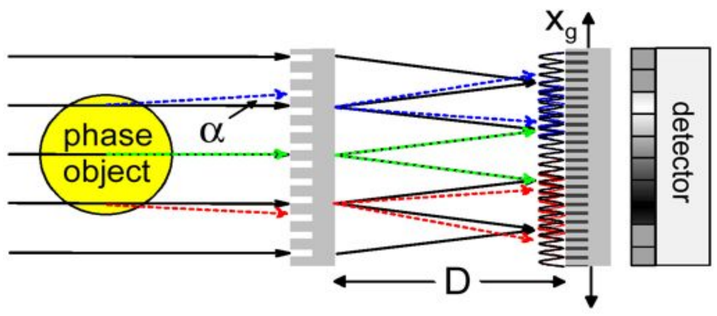
Donath et al | Investigative Radiology | **45** (2010) 445

With our work we aimed to study the performance of the method in visualizing different human diseases *ex vivo* at different length scales: at high spatial resolution using highly brilliant synchrotron radiation sources, and at lower spatial resolution with a polychromatic X-ray source.

Here, we present our recent results on *ex vivo* atherosclerotic plaques and on different *ex vivo* human breast carcinoma. These tissues reveal only weak soft-tissue contrast in conventional CT. Our study shows that grating-based phase-contrast computed tomography significantly enhances the soft-tissue contrast in human *ex vivo* specimens at high and low spatial resolution. The phase-contrast signal allows clearly distinguishing between healthy and diseased tissue even in the case of low-resolution polychromatic measurements.

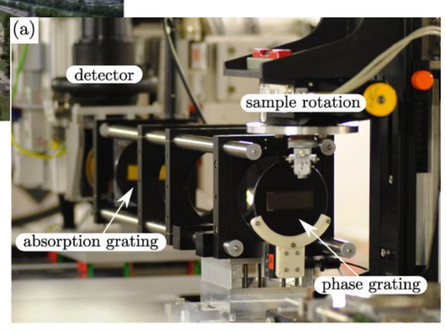
Methods & Materials

Grating interferometer method

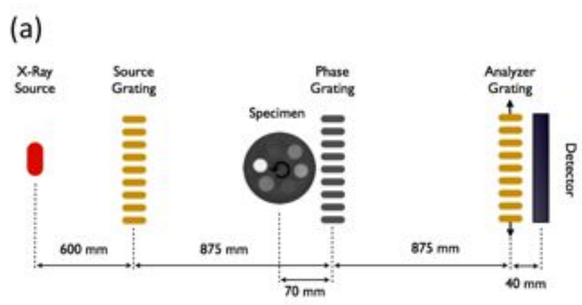


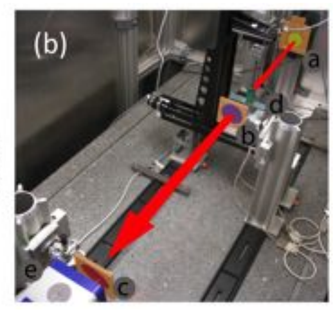
Momose et al. I Optics Express I **11** (2003) 2303
Weitkamp et al. I Optics Express I **13** (2005) 6296
Pfeiffer et al. I Physical Review Letters I **94** (2005) 164801

ID 19 @ ESRF, Grenoble, France



X-ray lab @ TUM, Garching, Germany

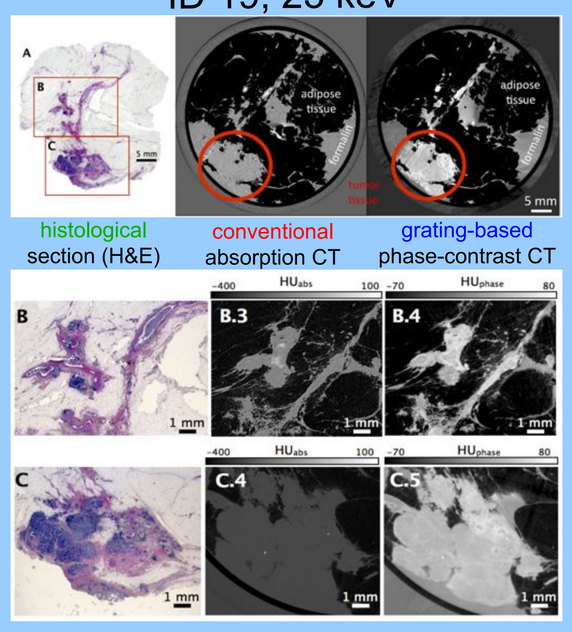




Results ID19 and X-ray tube

ID 19, 23 keV

Cancerous breast tissue

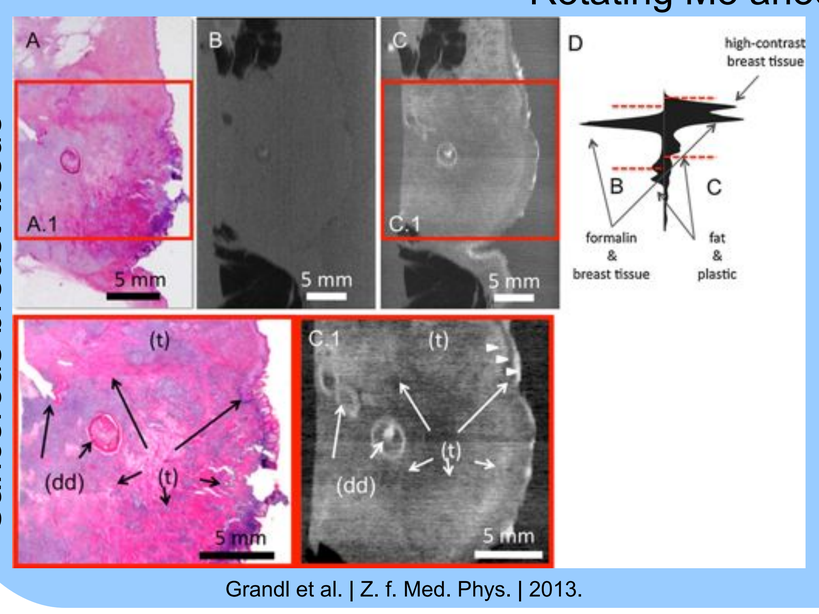


histological section (H&E) | conventional absorption CT | grating-based phase-contrast CT

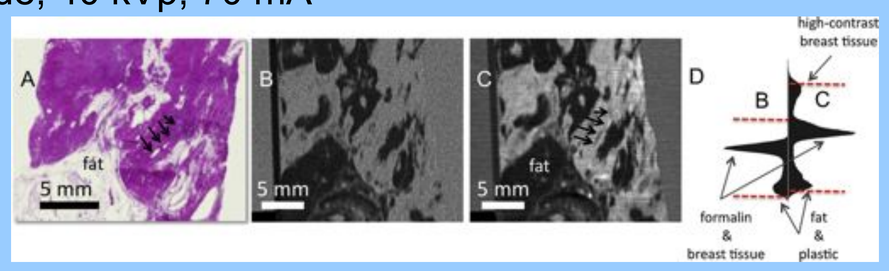
Szrtókay et al. | European Radiology **23**(2) | 2011.

Rotating Mo anode, 40 kVp, 70 mA

Cancerous breast tissue



Grandl et al. | Z. f. Med. Phys. | 2013.

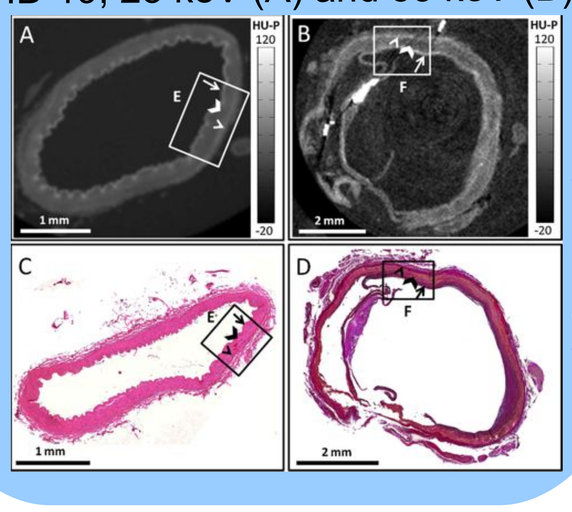


Top: Histological slice (hematoxylin eosin staining) of patient 1 (A) and corresponding absorption-contrast (B) and PC-CT (C) images. (D) shows the histograms of the corresponding slices shown in (B) and (C) and the window levels are marked with dashed red lines. Prominent T-shaped dilated duct indicated by arrows.

Left: Histological slice (hematoxylin eosin staining) of patient 2 (A) and corresponding absorption-based (B) and PC-CT (C) images. (D) shows the histograms of the corresponding slices shown in (B) and (C) and the window levels are marked with dashed red lines. In A.1 and C.1 respectively, dilated ducts (dd) and tumor (t) extension are indicated by arrows. Epidermis, subepidermal edematous and fibrous tissue layers are indicated by arrowheads.

ID 19, 23 keV (A) and 53 keV (B)

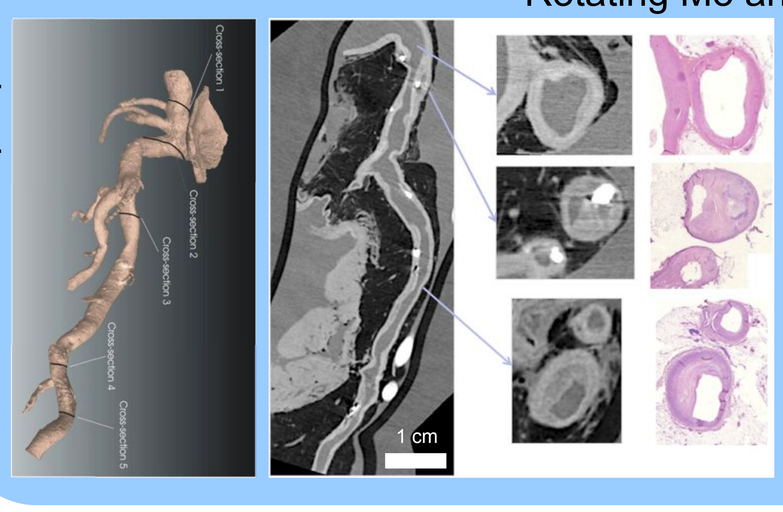
Atherosclerotic plaque

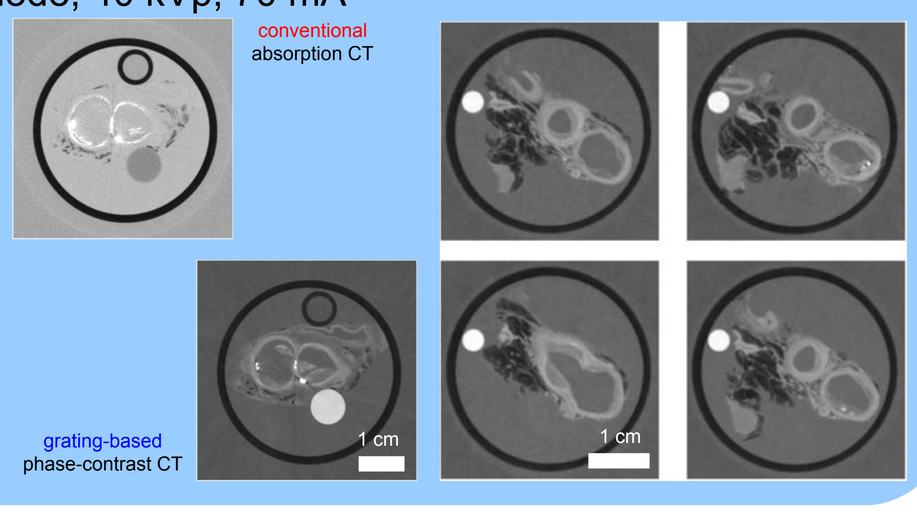


Hetterich et al. | Z. f. Med. Phys. | 2013.

Rotating Mo anode, 40 kVp, 70 mA

Atherosclerotic plaque





Conclusions

The phase-contrast signal allows clearly distinguishing between healthy and diseased tissue even in the case of low-resolution polychromatic measurements. We found a significant contrast-to-noise improvement in the phase-contrast signal compared to the absorption signal, which was reached without any use of contrast agents. The improvement in contrast especially for human carotid arteries will allow for studying arteries with implants made of polymers and giving only a low signal in conventional absorption-based imaging.

[1] Sztrókay, A. et al., *"Assessment of grating-based X-ray phase-contrast CT for differentiation of invasive ductal carcinoma and ductal carcinoma in situ in an experimental ex vivo set-up."* European Radiology, 2012: p. 1-7.

[2] Hetterich, H., et al., *"Grating-based X-ray phase-contrast tomography of atherosclerotic plaque at high photon energies."* Z Med Phys., 2013.

[3] Grandl S., et al., *„Evaluation of phase-contrast CT of breast tissue at conventional X-ray sources - presentation of selected findings."* Z. Med Phys., 2013.

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