PF-ISAC Medical Imaging Subcommittee Report

The Medical Imaging Subcommittee was held on February 29, 2008, at the Photon Factory, Tsukuba. The agenda for the meeting is attached.

The advantages of the synchrotron radiation (SR) over the conventional X-ray sources are that synchrotron radiation can provide intense monochromatic X-rays, and highly collimated and partially coherent X-rays. Therefore, the importance of SR in medical imaging is on the application of these advantages to the development of a new diagnostic method and/or to the study for medical/biological science. The subcommittee evaluates the activities and the future plan at the PF with respect to the contribution to clinical use, pre-clinical study and medical/biological science for the following subjects.

Clinical study of coronary angiography

[Activities]

There is a long history of the development of intravenous coronary angiography (IVCAG) in collaboration with medical doctors from the University of Tsukuba. At the beginning of this project, noninvasive assessment of stenoses in coronary arteries was a big challenge. Synchrotron radiation has been anticipated to contribute this challenge. Therefore, the start of this project is very reasonable. At the PF, different from line scan method developed by other SR facilities, two-dimensional diagnostic system has been developed and made the dynamical observation be possible. With the system they found the following diagnostic abilities: 100% for right coronary artery, 97% for left main trunk and left anterior descending, and 76% for left circumflex. This project will be terminated at the end of March, 2008.

[Comments]

(1) Development of two-dimensional dynamical imaging system and its successful application to 58 patients are very valuable experience.

(2) Unfortunately, IVCAG is not absolutely a superior method at hospital in the light of present progress in other methods for the assessment of coronary arteries.

(3) Therefore, it is a reasonable decision to terminate this project.

(4) Nevertheless, the experience should be remarked as a sensitive imaging method for blood vessels with a monochromatic X-rays from SR.

(5) The subcommittee strongly recommends to find the way to reserve the experience and to explore the future applicability to micro-angiography, keeping in mind the development of compact and intense monochromatic light sources for practical use.

(6) In this respect, the subcommittee appreciates the proposal on the development of the system for micro-vascular imaging by a group from the University of Tsukuba.

Micro-angiography of 50-100 μm vessels

[Activities]

To investigate various physiological and pathological responses of microvasculature to external and

internal stimuli, visualization of 50-100 μm vessels by micro-angiography is required. At the PF, the system of a resolution of 26 μm/pixel and field size of 26 mm x 26 mm with sensitive HARP detector has been developed and successfully visualizes 100 μm in diameter of coronary arteries and 50 μm of peripheral vessels. The method is for the functional study and images the following responses such as vascular constriction down to 63% by smoking occurring only in vessels larger than 100 μm in diameter, enlargement of deep arteries of the extremities starting within 2-3 seconds following exposure to cold, and coronary micro-vascular spasms induced by a voltage-gated potassium channel blocker. A group from the University of Tsukuba proposes to develop the system for clinical use. Estimation of the absorbed dose by Dr. Hyodo for visualization of micro-vessels of 50-100 μm in diameter suggests a clinical use to be allowable.

[Comments]

(1) There is no other way at present to evaluate the response of size change in vessels down to 50-100 μm in diameter.

(2) The subcommittee recommends to accumulate the evidence in pre-clinical animal study.

Phase contrast imaging based on refraction contrast

[Activities]

For phase contrast imaging based on refraction contrast, there are propagation-based method and analyzer-based method. Analyzer-based systems have been established in two ways, transmission type and reflection type. Transmission type has been developed at the PF and has an advantage of collecting the entire diffracted beams resulting in brighter image than reflection type. At the PF, transmission type (Laue type) system has been applied to two-dimensional imaging and reflection type (Bragg case) to CT study. These systems have been successfully applied to image human knee articular cartilage in collaboration with Okayama University and breast cancer in collaboration with Kobe University, National Cancer Center, and National Hospital Organization, Nagoya Medical Center. The group proposes pathological study as an application of the system.

[Comments]

(1) Phase contrast imaging with X-rays is a new method in medical/biological science and needs much more evidence to establish the importance of the method in the field.

(2) The characteristic nature and superior applicability in comparison with phase contrast imaging with interferometer should be critically assessed especially in pathological study.

(3) The subcommittee recommends to accumulate the evidence in animal study to establish the importance of this method in medical imaging.

Phase contrast imaging based on phase shift

[Activities]

Single crystal interferometer or interferometer with two separate crystals is applied for phase contrast imaging based on phase shift. The system with a single crystal has been developed at the PF, in

collaboration with the group from Hitachi and the University of Tsukuba, and applied to CT observation of non-stained cancerous rabbit liver tissues. The system is successfully applied to image smaller density difference than any other X-ray imaging methods. Then, they have developed the system with separate crystals. The interferometer with two separate crystals has advantages over that with single crystal of bigger field of view and of the point to isolate possible temperature changes caused by the sample such as a whole animal from interferometer system which is seriously temperature sensitive. The construction and alignment of two-crystal interferometer succeeded in enlarging the imaging field and enabled to image live small animals. These phase-contrast X-ray CT systems have been applied to study amyloid plaques in a brain from a mouse model of Alzheimer's disease and to subcutaneously implanted cancers in live nude mouse. The PF proposes to establish a fixed station at BL14C2 exclusively for a two-crystal interferometer.

[Comments]

(1) Phase contrast imaging with interferometer also needs much more evidence in medical/biological science to establish the importance of the method in the field.
(2) The characteristic nature and superior applicability in comparison with phase contrast imaging based on refraction should be critically assessed.
(3) The subcommittee appreciates the plan to establish a station at BL14C2 as a fixed station for a separate type interferometer.

Other comments on medical application of synchrotron radiation

(1) To establish a new method in medical/biological science, examples of effective results should be accumulated as many as possible.
(2) For this purpose, the collaboration of the staff at the PF with the medical researchers from outside must be essential. Achievement of remarkable results and full support by the staff at the PF will be appreciated and accelerate the progress. The outcome will be expected to draw attention of medical/biological scientists not familiar with the synchrotron radiation.
(3) The contribution of synchrotron radiation should be explored in the light of current topics in medical science such as molecular imaging, in which associated X-ray image at high resolution may play an important role.
(4) The subcommittee understands the serious lack of manpower for medical imaging. Nevertheless, for the advancement of medical imaging, an arrangement of coordinator(s) would be greatly helpful.
(5) X-ray microscopy and radiation therapy are missing at the PF. The subcommittee recommends to consider the supporting system for these studies in future.

The subcommittee expresses its appreciation to the PF staff and external users for a series of excellent and informative presentations. The subcommittee thanks to PF for the great hospitality.

Committee members:

Fumihiko Kajiya	Kawasaki University of Medical Welfare
Kunio Miki	Kyoto University
Kunio Shinohara (Chair)	Waseda University
Mitsuhiro Yokoyama	Hyogo Prefectural Awaji Hospital

PF-ISAC Medical Imaging Subcommittee agenda

Place: Rinko-shitsu2 on 2F in the 4-go-kan in KEK

Members:

Fumihiko Kajiya (Kawasaki University of Medical Walfare)

Kunio Miki (Kyoto University)

Kunio Shinohara(Waseda University)

Mitsuhiro Yokoyama (Hyogo Prefectural Awaji Hospital)

<Friday, February 29th 2008>	
10:00–10:05	Welcome : O. Shimomura (5 min)
10:05–10:10	Intruduction of the PF-ISAC & Subcommittees: S. Wakatsuki (5 min)
10:10–10:20	Imaging at the PF: H. Kawata (10 min)
10:20–10:50	1. Medical imaging at the PF –Overview NE1A2, NE5A, BL-14B, BL-14C1: K. Hyodo (30 min)
10:50–11:30	2. Topics IVCAG, Phase-shift, DEI-CT & DFI (12minx3＝36 min): M. Ando T. Takeda, S. Sakai
11:30–12:00	Discussion (30 min)
12:00–13:00	Lunch (60 min)
13:30–13:40	3. Future Plan –Overview NE1A3. NE7or9, BL14C: K. Hyodo (40 min)
13:40–14:00	4. Future plan –Angiography Micro-angiography and other new techniques : Y. Saskakibara, S. Matsushita (20 min)
14:00–14:20	Discussion (20 min)
14:20–14:35	Coffee Break (15 min)
14:35–15:35	Discussion <closed session> (60 min)
15:35–16:35	Time for writing the report (60 min)
16:35–16:50	Summary presentation by the subcommittee chair (15 min)