

Radiology Japan

Japan Industries Association of Radiological Systems

August 2003 No. 47

Trends in the Japanese Market for Medical Imaging and Therapeutic Systems in the Year 2002

Diagnostic Imaging and Therapeutic Systems (production, exports, imports, domestic market)

From January through December 2002 Unit: Millions of yen

Item	Category	Production		Exports		Imports		Domestic Market			
		Amount	% to Previous Year	Amount	% to Previous Year	Amount	% to Previous Year	Number of Units	% to Previous Year	Amount	% to Previous Year
1	X-ray	95,308	93	25,942	95	21,063	110	22,247	128	90,428	96
	• General-purpose R/F	29,664	94	5,689	84	270	68	1,575	99	24,245	97
	• Cardio & angio	9,065	65	4,176	73	14,237	117	314	68	19,127	94
	• General-purpose radiography	21,719	103	4,980	131	645	222	3,837	111	17,383	99
	• Mobile	2,814	83	1,133	70	277	73	749	90	1,958	92
	• Dental	6,350	99	1,039	80	0	-	5,140	98	5,311	104
	• Others	25,696	97	8,925	109	5,633	95	10,632	183	22,404	92
2	CT	76,649	98	40,644	102	8,082	74	1,050	89	44,086	89
3	Nuclear medicine	2,730	78	168	60	5,060	108	122	70	7,623	96
4	MRI	44,042	107	30,665	126	16,144	69	330	77	29,520	73
5	Image processing systems	8,161	115	741	94	925	133	3,910	90	8,345	119
6	Related items & accessories	25,094	112	9,528	129	1,717	93	-	-	17,283	103
7	Diagnostic ultrasound	62,813	101	38,120	102	4,604	92	6,844	-	29,296	99
8	Therapeutic systems	8,998	105	2,301	108	5,314	79	546	107	12,012	92
Total		323,795	99	148,110	106	62,909	87	-	-	238,595	92

(Note 1) Domestic market: Calculated by the formula (Production - Exports + Imports)

(Note 2) Statistics from the Ministry of Economy, Trade and Industry (METI) were used for the calculation of market value for diagnostic ultrasound up to March 2001. JIRA's own statistics were used from April of the same year onward.

(Note 3) Data column of the Number of Units is added to the Domestic Market from this issue onward.

Review of the results for 2002

The total domestic market was 92% of the figure for the previous year. Although exports were up to 106%, imports were down significantly to 87%, and this had an adverse effect on the total. Production was supported by high exports, therefore it declined only slightly to 99%.

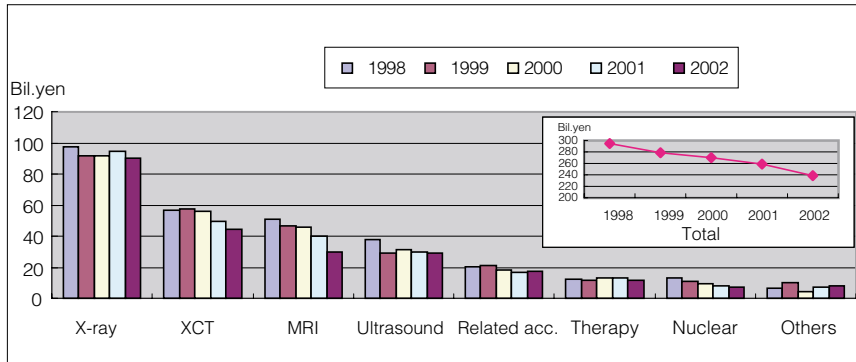
With regard to the trends for each modality, the X-ray market was down to 96% relative to the preceding year, but imports were up to 110%. The CT market was down to 89%, with imports making a sharp decline to 74%. Although the nuclear medicine market was down to 96%, imports increased to 108%. The MRI market was drastically reduced to 73%, with imports doing even worse at 69%. The ultrasound market was about the same at 99%, with the slight increase of domestic production to 101% compensating for the drop in imports to 92%. Image

processing systems (119%) and related items and accessories (103%) experienced expansion compared to the previous year.

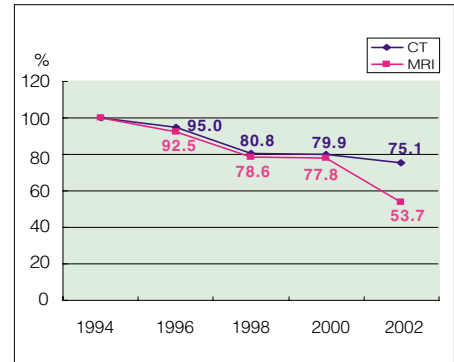
The depressed MRI and CT markets had the effect of lowering the total market value. The revisions in reimbursement implemented in April 2002 resulted in the fee points for general MRI examinations being reduced by 31% and those for general CT scans being reduced by 5% to 7%, although the latter figures differ depending on the region being scanned.

The large decrease in market value in 2002 indicates that the long-term deterioration of the domestic market has not stopped yet. Since health insurance finances have been fragile for some time now, repeated downward revisions in reimbursement and increases in the amounts to be shared and paid by patients have led to increasingly difficult hospital management. This may have led to longer equipment replacement intervals which, in turn, may have depressed the market.

Five-Year Overview of the Diagnostic Imaging and Therapeutic Systems Market in Japan by Modality



Reimbursement Reduction History (especially for CT and MRI)



Report on JRC 2003

ITEM 2003 Held Successfully in Yokohama with the JRS and JSRT Annual Meetings

JRC (name changed from JMCP last year) was held in Yokohama from April 11 to 13. At JRC, JIRA held the International Technical Exhibition of Medical Imaging, ITEM 2003, in conjunction with the annual meetings of JRS and JSRT. This year's exhibition was the biggest ever, covering an area of 6729 m² (about 30% larger than last year), with 123 companies participating.

Mr. Masamichi Katsurada, the chairman of JIRA, stated in his address, "We hope that this exhibition will serve as a forum for friendly exchanges between academia and industry that will lead to further development of medicine in Japan."

Many companies adopted the theme "Digitalization and Networking", indicating the progress being made in the integration of digital images and networking, and proposed specific solutions. Large diagnostic systems showed performance improvements and progress in their detectors, resulting in continued lowering of exposure doses, and shortening of image processing time. The progress in interventional angiography, which covers diagnosis and therapy, stood out. In addition, many systems focused on reducing patient anxiety and increasing patient comfort by offering quiet and simple operation, permitting large movement ranges, and adopting warm colors, taking clinical situations into consideration. Thus greater harmony and development in the technological and clinical fields can be expected in the future.

The next International Technical Exhibition of Medical Imaging, ITEM 2004, will be held in Yokohama again on April 8 to 10, 2004. The details will be announced in the next issue of Radiology Japan.

Events	Registered congress members		Exhibition
	JRS Apr. 11 to 13	JSRT Apr. 11 to 13	ITEM 2002 Apr. 11 to 13
Participants			
Radiologist	3705 (3146)		4670 (5003)
Radio-Technologist		3464 (2873)	13467 (13842)
Co-medical			1246 (1201)
Others			15871 (15975)
Total	3705 (3146)	3464 (2873)	35254 (36021)

Note 1) The numbers of visitors to the exhibition include repeat visitors.

Note 2) The numbers in parentheses are the corresponding figures for Y2002.

Note 3) The number of registered exhibitor staff was 4745 (4514) of 123 exhibitors.



ITEM2003

JIRA Activity Reports

Report on the Joint Mission's Visit to China

As part of the 30th anniversary of Sino-Japanese friendship, the Japan Federation of Medical Devices Associations (JFMDA) and JIRA sent a joint mission to China from November 3 to 7, 2002. The mission visited the International Health Exchange Center of the Chinese Ministry of Health and the China Association for Medical Equipment Industry. In addition, the JIRA members visited the China Quality Certification Centre (CQC) to learn about the new CCC mark.

Visit to the International Health Exchange Center, Ministry of Health, People's Republic of China (MOH)

The Chinese government is currently promoting domestic medical care system reforms. The representatives of the International Health Exchange Center explained the aims of the reforms, outlined investment plans for medical equipment for examinations and diagnosis, and presented an overview of the new medical insurance system.

1) Medical Administration and Investment Plans

- (1) Promoting the improvement of medicine in remote areas
 - Investment will be focused on medical facilities for remote areas, with emphasis on constructing hospitals, updating facilities, and training personnel.
 - Aggressive investments will be made in hospitals in remote areas and low income areas (Guangxi, Yunnan, Sichuan, Xinjiang Weimuer zizhiqu, Nei-menggu zizhiqu).
- (2) Policies for medical systems investments
 - State-of-the-art systems are to be introduced.
 - Allocation plans provide for the installation of 2 or 3 large and expensive systems per million people. However, there will be 8 systems per million people in the Beijing district. Procurement plans will be made every 5 years, and they will depend on the economic conditions and the number of systems already installed. Currently there are about 4,000 CT scanners and 600 MRI systems in operation.



MOH

- The 46 hospitals that are managed directly by the Ministry of Health (Beijing Xiehe yiyuan, Beijing Tiantan yiyuan, China-Japan Friendship Hospital, etc.) use a bidding system when introducing expensive equipment.
 - Of the imported medical equipment market, USA has a 30% share, Europe has a 37% share, and the rest (ROK, Japan, other Asian countries) have a 33% share.
- (3) The Ministry of Health has established judgment criteria regarding the effective service life of CT scanners and MRI systems, and is using these criteria to manage them.
 - The criteria for effective service life established in 1995 stipulate a service life of 8 to 10 years. A system can, however, continue to be used as long as it passes its annual inspection.
 - (4) Introduction and authorization conditions for expensive new equipment introduced in the Chinese market
 - Must be easily operated by medical staff.
 - Must have high clinical effectiveness.
 - It must be possible to set a reimbursement level that is reasonable for general Chinese patients.
 - Imported medical equipment must be authorized by the Chinese State Drug Administration (SDA), Department of Medical Devices.

2) New medical insurance system in China

- (1) This system, created by the Ministry of Health and the Ministry of Labour and Social Security, has been implemented only in urban areas (coverage is provided to approximately 80 million people).
- (2) The premium is 8% of a worker's salary, with the company paying 6% and the individual 2%.
- (3) There is also commercial medical insurance that individuals can purchase or that can be purchased for individuals by their companies.
- (4) As a new policy for remote areas, cooperatives are providing health insurance using mutual aid systems.

Visit to the China Association for Medical Equipment Industry (CAMDI)

This association is authorized by the Ministry of Civil Affairs, and is an officially registered national social activity organization (membership: 490 companies). The association promotes medical equipment exhibitions every



CAMDI

spring and autumn. The head of the association is usually an officer from the Chinese SDA (Department of Medical Devices). JFMDA made some overview presentations on JMED (Japan Medical Devices Manufacturers Association) and JIRA.

Visit to the China Quality Certification Centre (CQC)

We have had a continuous series of exchanges with the CQC and therefore we were able to use this opportunity to further clarify the contents of the new CCC system. We were able to clarify the following expenses required for obtaining approval:

- 1) Factory inspection expenses: 14,000 yuan
- 2) Follow-up audit expenses: 7,000 yuan/factory
- 3) Translation expenses for inserted drawings in manuals: 1,000 yuan/system
- 4) Communication expenses: 500 yuan/system

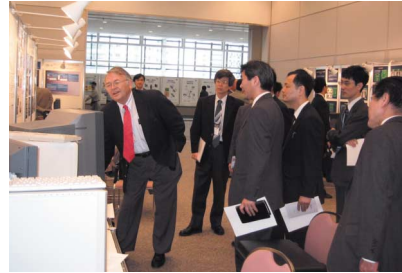


CQC

JIRA's representatives informed the CQC members of the results of the seminars on "Trends in Chinese Medical Equipment Regulations" held in Japan.

Report on the CyberRad 2003 Exhibition

The CyberRad 2003 exhibition was held during JRC 2003 (April 11 to 13, 2003, Yokohama). This year's theme was "Towards an E-Hospital: Barrier-Free Information Exchange and Linkage Between Departments". The project team of Integrating the Healthcare Enterprise - Japan (IHE-J) once again organized an interconnectivity demonstration, this time involving 17 companies (2002: 11 companies), most of whom were JIRA members (the participating companies are listed in the connection test result table below).



CyberRad2003

IHE Japan connection confirmation table 2003

CyberRad 2003 connection confirmation table	Scheduled Workflow (SWF)						Patient Information Reconciliation (PIR)					Consistent Presentation of Images (CPI)					Simple Image and Numeric Report (SINR)					BasicSecurity (SEC)					
	ADT	Order Placer	DSS/Order Filler	Image Manager	Acq. Modality	Image Creator	Image Display	ADT	Order Placer	DSS/Order Filler	Image Manager	Acq. Modality	Acq. Modality	Image Manager	Image Creator	Image Display	Print Composer	Print Server	Report Creator	Report Manager	Report Repository	Report Reader	External Report Repository	Enterprise Report Repository	Secure Node	Audit Record Repository	Time Server
EBM TECHNOLOGIES JAPAN, INC.				○		○								○	○	○	○										
A&T CORPORATION			○							○																	
H.I.C. CO., LTD.				○		○				○				○	○	○		○	○	○	○					○	○
NEC CORPORATION		○																									
CANON INC./CANON SALES CO., INC.					○								○				○										
CLIMB MEDICAL SYSTEMS INC.						○									○	○											
KONICA MEDICAL AND GRAPHIC CORP.					○						○			○		○	○										
SHIMADZU CORPORATION						○																					
TOTOKU ELECTRIC CO., LTD.															○												
TOSHIBA CORPORATION				○	○	○				○	○																
TOYO CORPORATION														○	○	○											
NIHON BINARY CO., LTD.															○												
PIONEER CORPORATION				○		○							○		○												
HITACHI MEDICAL CORPORATION				○	○					○								○	○	○	○					○	
FUJITSU LIMITED	○	○					○	○		○																	
FUJIFILM MEDICAL CO., LTD.					○																						
YOKOGAWA ELECTRIC CORP.			○																								

Connection test result table for the CyberRad 2003 demonstration

In December 2002, the participating companies and the IHE-J project team members formed a working group and started creating a demonstration scenario and assigning functions (actors). At the end of March 2003, a comprehensive connection test was conducted for 2 days in preparation for the actual demonstration at the exhibition.

The results are shown in the connection test result table for the CyberRad 2003 demonstration.

In this demonstration, 4 of the 10 integration profiles specified by IHE were covered: Scheduled Workflow (SWF), Patient Information Reconciliation (PIR), Consistent Presentation of Images (CPI), and Basic Security (SEC). These were presented in a demonstration clinical scenario. The demonstration was centered on the radiology department and showed how information was linked and exchanged between the reception desk, doctor's room, conference room, and biochemical laboratory room.

The participating actors were from multiple vendors, confirming that information could be linked and exchanged smoothly even in a system configuration involving multiple vendors.

Although the site of the demonstration was quite a distance from the site of the academic lectures, a total of about 500 people participated in the 11 tours of the presentations (including English presentations).

The demonstrations were well received; the questionnaires filled in by the participants indicated that the combination of the IHE introductory lecture in the tutorial session and the demonstration was generally easy to understand and useful.

To prepare for the CyberRad demonstration for next year, IHE will hold a vendor workshop in August 2003 and a "Connectathon" (a connection test to check compatibility with the IHE Technical Framework) in February 2004.

Regulation and Economy Division – Assessment of Reimbursements in the Diagnostic Imaging Field and Upcoming Tasks –

Through various advances, diagnostic imaging technology has made great contributions to medical care. Medical facilities buy new diagnostic imaging equipment to improve the accuracy of diagnosis and assure safe medical practices. By receiving appropriate fees for medical examinations and procedures, medical facilities have so far been able to afford these devices. Because of the recent downward revision of reimbursements, however, there may be cases where this paradigm is no longer feasible, and the improvement of the level of medical care may be adversely affected. Therefore, JIRA would like to present some issues related to the improvement of the basis and the assessment structure of reimbursements.

1. Reassessment of the fees for CT and MRI examinations

Along with the increased division of functions in each area covered by medical institutions, the reimbursement fee points

for expensive equipment, such as MRI and CT systems, have been reduced significantly in order to improve the efficiency of distribution of medical resources and to facilitate appropriate allocation of these resources. In the recalculations, revisions were made based on the report "Basis for cumulative calculations: Purchasing price of devices; labor expenses; maintenance expenses; and daily throughput" prepared by the Central Social Insurance Medicine Committee (Chuo Shakai Hoken Iryo Kyogikai). Since the price of MRI systems had decreased to the level of CT systems, the reimbursement fee points for MRI examinations were reduced by 31% in April 2002. This approach does not take into account the efficacy of the equipment; its aim is to reduce the cost of medicines and materials. The effects and efficacy of diagnosis are not considered in the debate.

The introduction of fixed rate assessments is being considered, but we believe that the assessment criteria for individual technologies and the bases for their calculation formulas must be clarified. In addition, the basis for the concept "common use percentage of 5% for special CT and MRI systems" is also unclear; therefore, this concept must be reorganized and reconstructed.

2. Cost assessments related to the maintenance of medical equipment

With respect to the assessment of machine maintenance, it is doubtful whether each machine is being evaluated appropriately according to its features and functions. Pharmaceuticals are studied carefully through usage studies that detail the various costs, making it possible to assign appropriate reimbursement fee points. However, for systems other than expensive diagnostic imaging equipment such as MRI and CT systems, the contents of the assessments are not obvious.

In order to ensure diagnostic accuracy and safety at medical institutions, daily maintenance work is indispensable, and the maintenance expenses for advanced medical equipment is expensive. Until now, such maintenance costs have been interpreted to be distributed across the whole range of imaging studies and covered accordingly. There are, however, no clear guidelines in the reimbursement fee point tables; therefore, this must be considered in the future.

3. Miscellaneous

With the development of digital imaging, there has been an increase in soft copy diagnosis. In the insurance system, however, an assessment (point) system for reimbursement fees equivalent to that for conventional film-based diagnosis has not yet been established.

Now there is a necessity for a comprehensive evaluation for positioning of devices used for soft copy diagnosis as medical devices and for the assessment of the value of various types of clinical application software used on workstations from the viewpoint of the medical economics within the diagnostic process. It

is also necessary to make the required adjustments in regulations and administrative systems. In addition to the economic assessment, the status of such equipment within the tax system must be clarified, and quality assurance systems within medical institutions must be created at the same time.

Submission of Opinions and Requests Concerning the FY 2004 Reimbursement Revisions

The JIRA Regulation and Economy Division has summarized the desires of the industry concerning the reimbursement revisions and, after discussions at the Policy Planning and Administration Council in JIRA, submitted them to the head of the Economic Affairs Division of the Health Policy Bureau and the head of the Medical Economics Division of the Health Insurance Bureau of the Ministry of Health, Labour and Welfare under the name of the chairman of JIRA.

1. Essential points of the requests and opinions

Emphasis was placed on the importance of maintenance in the "use" phase of the life-cycle of the equipment - an area also covered in the "Medical Systems Industry Vision" issued by the Ministry of Health, Labour and Welfare in March 2003. Priority was given to the need for clarification of the maintenance expenses - a point that is still vague within the reimbursement system - and the need for an appropriate assessment structure.

In addition to the above, we included a new request for the creation of a separate reimbursement table for mammography. Also, with regard to soft copy diagnosis and remote diagnosis, which were among the points we raised during the reimbursement revision in 2002, we organized and summarized not only our requests and thoughts, but also the discrepancies in the current system.

2. Individual request items

- 1) Clarification of various maintenance expenses
- 2) Fair assessment of soft copy diagnosis and clarification of its requirements for use
- 3) Expansion of facilities for the transmission and reception of images for remote image diagnosis
- 4) Separate reimbursement table for mammography
- 5) Fee point assessment for quantitative measurement techniques used in single-photon emission CT (SPECT) systems and PET systems
- 6) Reassessment of FDG-PET systems and improvement of common use percentages
- 7) Requests regarding CT and MRI
- 8) Establishment of new fee points for navigation imaging during surgery
- 9) Establishment of new fee points for new imaging methods used in interventional radiology

- 10) Requests regarding radiation therapy
- 11) Assessment of immobilization devices for extracorporeal radiation therapy
- 12) Establishment of new fee points for quantitative bone-mineral studies and expansion of their application
- 13) Improvements in the discrepancies in interpretation of cinematic roll film

Medical Systems Industry Vision

A report entitled "Medical Systems Industry Vision" was issued by the Ministry of Health, Labour and Welfare on March 31, 2003. As a contribution to this document, JIRA created and submitted a report on the medical systems industry vision for the diagnostic imaging and radiation therapy fields. In compiling this report, we placed importance not only on diagnosis and treatment, but also on the viewpoint of the creation of a business core that encompasses the entire medical flow, including the prevention of disease, improvement of health, and care for the elderly. With regard to the basic policy, because of the importance of the system life cycle, we emphasized the positioning of system products that can be used repeatedly through maintenance/repair and disposal/recycling.

1. Purpose

In order to meet the growing demand for advances in medicine and to contribute to the improvement of health and medical care levels, it is important to further the research and development of medical systems in leading-edge fields and introduce them as quickly as possible at clinical sites. By creating this medical systems industry vision, we hope to facilitate, from Japan, the development of innovative medical systems that are both better and safer. Our aim is to strengthen the international competitiveness of the medical systems industry and thus contribute to improved health and medical care levels not only for patients in Japan, but also for those around the world.

2. Basic Concepts of Medical Systems Industry Policy

The development of industry should come about through free competition among companies based on market principles. However, because the medical systems industry must contribute to the health and medical care improvements of people and gain their trust, the surrounding environment of the industry creates hurdles that make the smooth functioning of market principles difficult. Therefore, to ensure that people's needs are met, the national government and industry must cooperate sufficiently from the research stage to the usage stage and overcome all hurdles.

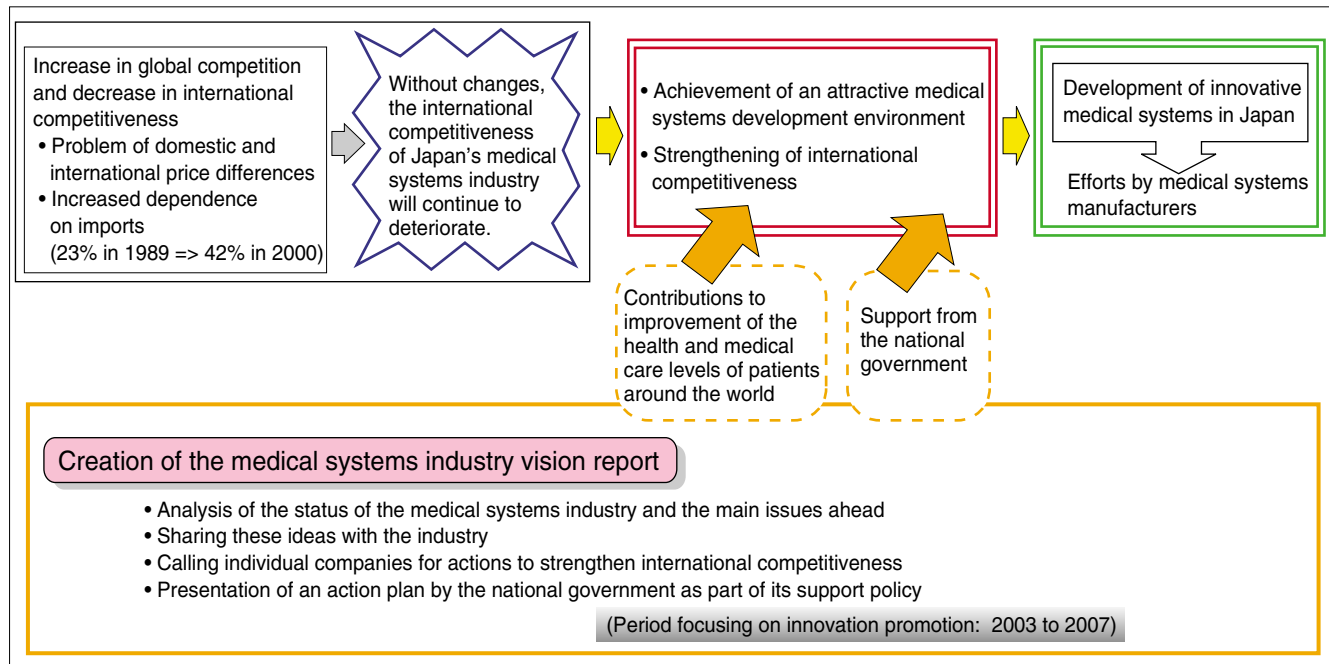
Hurdles at various stages

- (1) Research stage: Diversity of medical systems. Creation of a research and development environment that allows for advances in medical systems.

- (2) Development stage: Establishment of a clinical testing and evaluation environment. Development of leading-edge medical systems, such as systems for transplantation and regenerative medicine.
- (3) Production stage: Obtaining authorization in compliance with medical regulations.

- (4) Sales stage: Application for health insurance. Sales activities in accordance with local business customs.
- (5) Use stage: Establishment of methods of use, maintenance, and disposal.

3. Background



4. Measures to be Taken in the Period Focusing on Innovation Promotion (2003 to 2007)

There is a great variety in medical systems, and even if they are all lumped together in the same industry, each company faces different circumstances. In order to effectively use limited resources and funds to develop innovative medical systems in Japan, support should be focused on specific fields.

1) Criteria for selecting specific fields

- (1) Research should be at a stage where basic research results can be linked into practical applications.
 - Because medical systems are eventually used widely by people through medical institutions, research funds should be channeled to support research and development activities that transform basic research results into practical applications.
- (2) The fields should be those that are not yet mature.
 - In fields where the maturity of products is low and there is still a great deal of technical innovation required, a single innovation can lead to great leaps in treatment results, possibly leading to great increases in market share. Therefore, such fields offer the opportunity to enter and compete effectively in the research and development race.

(3) The fields should be those in which there are prospects for increased demand.

- When the national government is providing the support, the fields should be those in which there are medical needs or those in which the needs of patients are high. From the point of view of industry, a field in which there is growing demand provides a chance to dramatically increase market share through new technologies or business strategies.

2) Specific examples of fields that should be focused on

- Medical systems for transplantation and regenerative medicine
- Medical systems for cardiovascular applications
- Minimally invasive treatment systems
- Bio-imaging systems
- Automated diagnostic devices to assist health monitoring

Development of Japanese Radiological Equipment in the Post-World War II Period (12)

Development of X-ray Tomography Systems (Part 3) — Research to Develop Multiorbital Tomography Systems

Sumio Makino
Advisor, JIRA



Outline of the story up to the last issue

The article in the previous issue described the ceaseless efforts and enthusiasm of researchers up through the development of the “Takahashi tomogram”. History has shown us that axial transverse tomography systems were completely replaced by X-ray CT systems, which were developed later, but it was axial transverse tomography that established the importance of cross-sectional images of the human body in clinical diagnosis.

Previously, the author reviewed the history of the development of X-ray tomography systems, describing the most commonly employed type of tomography, “planar tomography”, as well as the history of the above-mentioned axial transverse tomography systems. The article in the present issue traces the subsequent development of tomography systems (i.e., the road from “circular tomography systems” to “multiorbital tomography systems”) up to the present time.

Development of circular tomography systems

Diagnosis based on X-ray tomographic images was found to suffer from limitations in identifying lesions while recognizing blurred structures located away from the focus.

In order to reduce such blurring, in 1935, Dr. Grossmann developed the arc method, in which the X-ray tube is moved along a circular arc. Measures to minimize blurring were also investigated in Japan by Dr. Miyaji of Nagasaki University (1939) and Dr. Akaboshi of Kyushu University (1949)(Fig. 1), and were finally successfully achieved by Dr. Akira Matsukawa of Fukushima Medical University, who developed a circular tomography method known as “circus tomography” (1953).

The progress of Dr. Matsukawa’s research and development work has been described in a paper written by Dr. Kazue

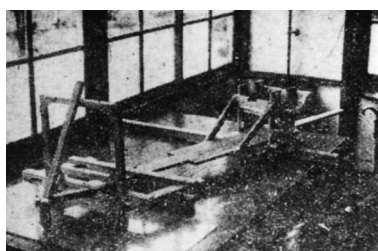


Fig.1 Dr. Akaboshi's experimental system (1949)

Kimura, who was then an associate professor and later a professor at Fukushima Medical University. His paper, entitled “History of Tomographic Imaging and Its Future Prospects”, was published in the Japanese Journal of Tomography (Volume 18, No. 2) in 1992. Excerpts from this paper are presented below.

I believe there are a variety of barriers preventing researchers from completing their work. A series of approaches in the research of Matsukawa have given us valuable guidance, reminding us of the “daily spirit to perform research”, which is often forgotten in recent studies of diagnostic imaging.

At that time, one had to first gain an understanding of the characteristics of blurred images before interpreting Grossmann circular tomograms. “How to Read Tomograms” by Tasaka (Igaku Shoin Ltd., 1954) was a popular reference work. In 1952, Dr. Matsukawa, who had recently arrived at Fukushima Medical University, thought that rather than dealing with the difficulties of interpreting blurred images, efforts should be directed toward obtaining images free of blurring. Although this may seem to be a very obvious concept, it was a major “perceptual change” at that time. Unless the basic principles of tomography were changed, images would inherently suffer from blurring. However, if this blurring could be spread out over a wider range, the blurring would be thinned out and thus become less obvious or even completely unnoticeable. Blurring in a circular pattern would result in an increase in the blurring range by a factor of p . We found a small factory in town that was willing to build a system to test this theory. This was the Hattori Factory. The conceptual prototype was completed and installed at the research laboratory in 1953. The floor was covered with concrete, and wooden frames were put in place. Under the direction of Dr. Mishina, an associate professor, the installation work was carried out with the combined efforts of the entire staff, including radiology technicians. In this prototype, the X-ray tube was mounted on a parallelogram consisting of four supports and eight pipes. When chest tomograms were obtained using this system, the ribs appeared to be projected in the lung fields in a staircase-like manner. However, when we were about to conclude that the system was not practical, Chief Radiology Technician Ueda obtained images with a piece of blende placed between the tabletop and the patient’s back. As a result, blurring of the ribs was completely eliminated from the acquired images. Intentionally or unintentionally,

the X-rays responsible for blurring of the ribs were blocked. The same result was observed when the X-rays were cut off electronically. The concept of selective exposure was born (Fig. 2).

The prototype was judged to be practical for clinical use, and a number of phantom experiments were performed to compare the circular movement method and the arc method. Following negotiations with several manufactures, Toshiba agreed to manufacture a trial system despite the risk that there might be no financial return, and the first production prototype was completed in 1955 (Fig. 4).

As shown above, Dr. Kimura described the progress of prototype research at the university up to around 1953.

Dr. Matsukawa reported the results of these experiments at the General Assembly of the Japan Radiological Society (JRS) in the spring of 1955. During his presentation, a somewhat critical question was raised by a person in the audience, "Wouldn't such a system become weak in the joints? Would it function properly?," suggesting that such a difficult concept would fail to succeed in the long run. Dr. Matsukawa answered with complete

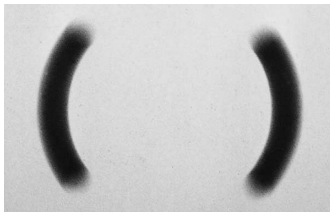


Fig.2 Grid experiment. Electronically controlled X-ray exposure.

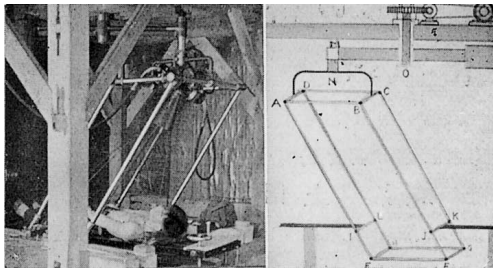


Fig.3 Dr. Matsukawa's experimental system and a description of its design.

A, B, C, D, E, F, G, H, I, J, K, and L are specially constructed rectangular frames for circular orbital movement tomography. The X-ray tube focus is mounted at the center of the upper rectangle (ABCD), and the cassette is placed at the center of the lower rectangle (EFGH). This frame structure is anchored to the floor from the level (I, L, J, K). When the motor on top rotates, the arm (OM) rotates in a circular path around point O. As a result, rectangles ABCD and EFGH rotate in opposite directions. The ILJK plane remains stationary, and the target object is placed on this plane. This plane is therefore referred to as the "cross-section rectangle".

The gyro-holder is mounted at the center (N) of the upper rectangle (ABCD). This gyro-holder is designed so that the port of the X-ray tube assembly can move freely in all directions while the focus of the X-ray tube remains at a fixed point. The X-ray tube is mounted with the tubular cone collimator, and the round port of the collimator is divided in the same way as the cross-section rectangle. These four points are connected to the corresponding sides of the anchor pipes using four springs. Therefore, when the X-ray tube is rotated in a circular path, its port remains directed at the center of the cross-section rectangle, and the center line of the X-ray beam passes through the center of the rectangular frame and is projected onto the center of the "film" plane.

confidence, "Academic research and development focuses on possibilities. Producing a machine without weak joints is the responsibility of the industry."

Dr. Kimura recalled that all of the members of the department who had been working on the project were encouraged to hear these words.

Immediately after his presentation at the JRS assembly, Dr. Matsukawa (with Hitoshi Mishina, Kazue Kimura, and Minoru Ueda) published "Research on circular orbital movement method tomography, initial report: Imaging system" in the Journal of the Japan Radiological Society (Vol. 15, No. 7). An excerpt from this paper follows.

Introduction

The tomography systems widely employed today suffer from significant interference from shadows, which frequently make it difficult to identify important findings or lesions in clinical diagnosis. In order to minimize these problems as far as possible, we have developed and constructed a prototype tomography system employing a new circular orbital movement method. This paper presents a general description of this system and its imaging principles. It also describes the results of studies comparing the images obtained using this new system against those obtained with a conventional arc movement method tomography system (with an X-ray tube rotation angle of 50°).

Imaging system

The imaging system we have developed incorporates specially constructed frames to achieve circular orbital movement, which permits the X-ray tube assembly and cassette holder to travel in a gyroscopic pattern, as well as a power source to control circular orbital movement.

The paper goes on to describe the design details of the prototype and to discuss how it differs from conventional systems. The paper continues as follows, describing Fig. 3.

The specially designed frames for the circular orbital movement method are constructed of metal pipes and have a rectangular shape measuring 155 cm in height and 90 × 50 cm at the base. Ball joints of the same size are mounted at each intersection point on the sides. The receivers for the ball joints are mounted at points 45 cm

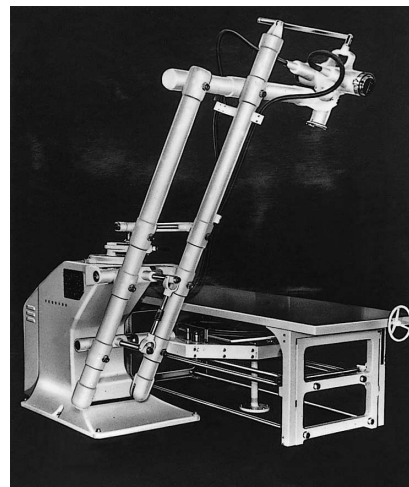


Fig.4 First production prototype, manufactured by Toshiba.

from the lower ends of the four metal pipes making up the horizontal sides (I, J, K, and L). Two 50-cm-long pipes with balls mounted at both ends are then placed to connect I to L and J to K. Furthermore, arms extend outward from these two connecting pipes on both sides of the frame and are anchored to the floor at the locations where the four ball joint centers are placed in the same horizontal plane, forming a rectangle measuring 90×50 cm. The rectangle defined by these four ball joints is referred to as the "cross-section rectangle". In addition, a gyro-holder is mounted at the center of the rectangle on the upper side of the frames (A, B, C, and D). This gyro-holder is designed so that the X-ray port of the tube assembly can move freely in all directions while the focus of the X-ray tube remains fixed. An X-ray tube is mounted with a tubular cone collimator, and the round port of the collimator is divided in the same way as the cross-section rectangle. These four points are connected to the corresponding sides of the anchor pipes using four springs. The upper part of the gyro-holder supporting the tube assembly is connected to a 57-cm iron arm, the other end of which is connected, via a vertical shaft, to a step-down pulley and a 1/4-horsepower motor. The shaft is positioned so as to be aligned with a plumb line passing through the center of the cross-section rectangle. In addition, at the bottom of the frames, a device for securing the film holder is mounted at the center. With regard to the mechanical action of the upper frames, when the motor operates, the rotational speed is reduced by the pulley, the shaft rotates vertically to induce horizontal rotation of the iron arm, and the other end of the arm connected to the frames rotates horizontally. As described above, the frames are connected to the floor via the ball joints of the cross-section rectangle, and therefore the upper and lower surfaces of the frames, the tube, and the film holder are precisely rotated in the horizontal plane. In this case, the line between the tube and the film holder passes through the center of the cross-section rectangle and maintains exactly the same angular velocity relative to the plumb line, with the difference in direction maintained at a constant 180° . In addition, the X-ray tube assembly is mounted to the gyro-holder, and four points of the X-ray tube on the holder are connected to four points of the cross-section rectangle with springs. Therefore, as the X-ray tube is rotated in a circular orbit, its X-ray port is constantly directed at the center of the cross-section rectangle, and the center line of the X-ray beam passes through the center of the rectangular cassette holder. The projection angle of the center of the X-ray beam to the film can be adjusted by changing the length of the iron arm. An angle of 60° was initially selected in our experiments. Because this system is heavy and requires a high degree of mechanical precision, it is placed on strong supports during use.

The paper then describes the imaging principles (which will not be discussed in the present article) and presents the detailed results of experiments to demonstrate the functional capabilities of the system. Dr. Matsukawa's paper continues as follows.

Using the system described above, we performed tomographic imaging at various heights to obtain images of a beeswax sphere measuring 54.5 mm in diameter, an aluminum cylinder measuring 8.4 cm in length and 2.6 cm in internal diameter, an iron

cylinder measuring 4.0 cm in length and 1.0 cm in diameter, and the chest of a human body. Then, using the circular arc movement method tomography system (with a rotation angle of 50°), images were acquired in the same planes for the same target objects and the results obtained using the two methods were compared. In both methods, we employed the same imaging conditions for the X-ray tube, the intensifying screen, the film, and the distance between the tube focus rotation center and the film. In addition, the rate of change in the rotation angle of the X-ray tube in the circular orbital movement method was set to $360^\circ/4.5$ s.

(1) Tomography of the beeswax sphere. Using both methods, tomography was performed to acquire planar images through the center of the sphere. The tomographic images obtained using both methods showed a circle measuring 7.5 cm in diameter, indicating that there was no difference between the two methods. Next, tomography was performed to obtain images of cross-sectional planes at various distances from the center of the sphere: 6.8 mm ($r/2$), 20.4 mm (r), 34.0 mm, 41.0 mm ($3r/2$), 47.8 mm, and 54.5 mm ($2r$). The tomographic images obtained are shown in Figs. 5 and 6. The circular orbital movement method showed a circular image in each plane, with the diameter of the circle gradually decreasing from 74 mm, 64 mm, 56 mm, 43 mm, 32 mm, 19 mm, and 6 mm to 0 mm. In contrast, the circular arc movement method suffered from variation in the aspect ratio of the diameters from plane to plane as shown in the figure. The sphere was shown with variations in size from 73×63 mm, 70×60 mm, 68×55 mm, 65×45 mm, 62×40 mm, 58×31 mm and 54×24 mm to 43×19

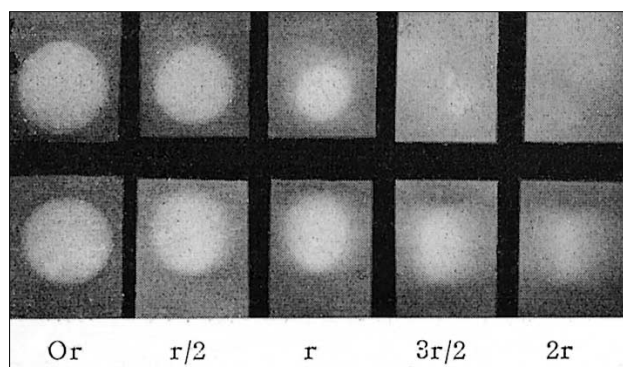


Fig.5 Corresponding to Fig.3 in Dr. Matsukawa's paper -- Comparison of the two methods based on cross-sectional images of a beeswax sphere.

The images in the upper row and in the middle row show cross-sectional images of a beeswax sphere obtained using the circular orbital movement method and the arc movement method, respectively. The numbers in the lower row indicate the distance between the center of the sphere and the cross-sectional plane. When the images of upper and middle rows are compared, the images in the upper row show that the size of the sphere is gradually reduced as the cross section moves farther from the center of the sphere. The shape is always shown as a circle. In contrast, the images in the middle row show distortion from the point at which the cross section is located at a distance of one half the radius from the center of the sphere, and this distortion becomes more severe as the distance between the center of the sphere and the cross section increases. Moreover, the degree of distortion is markedly greater than that seen in the images in the upper row.

mm. The cross sections of the sphere appeared to have an elliptical shape, with the long axis in the direction perpendicular to X-ray tube movement. The severity of this distortion increased as the cross-sectional plane was moved away from the center of the sphere.

In summary, the circular orbital movement method more accurately demonstrates the structure of the target object, while the arc movement method suffers from distortion on both sides in the direction perpendicular to X-ray tube movement and is also far less effective in eliminating blurring than the circular orbital movement method.

Dr. Matsukawa and others performed further imaging experiments by replacing the target object with pieces of aluminum. The details are not described here, but the imaging accuracy of the system was confirmed in these experiments.

Furthermore, Dr. Matsukawa also reported the results of clinical studies as follows.

We would now like to evaluate the advantages provided by our

tomographic method. First, the images obtained in the phantom experiments showed that the circular orbital movement method was able to accurately depict the cross-sectional structure of the target object with minimal central shadows. Second, the blurred images, which are in regions other than the cross-sectional image of the target object, become less obtrusive, and because the blurring is spread over a wider range, the density of the blurring is reduced. In chest tomography, interfering shadows from the 1st and 2nd ribs are significantly reduced, and cross-sectional structures are accurately demonstrated together with the other ribs, the clavicles, the sternum, the vertebrae, the scapulae, and the heart and other mediastinal structures. Therefore, the apex of the lung in the lung fields and the mediastinum can be accurately visualized. It is therefore considered that the method described here is far superior to the conventional method (Fig. 7, 8).

After conducting various experiments, Dr. Matsukawa concludes as follows.

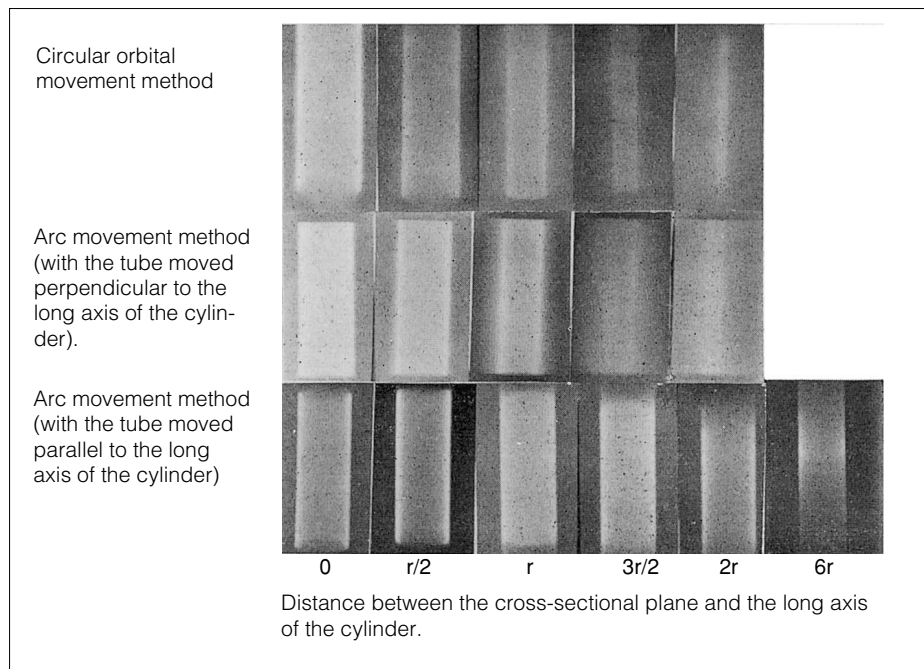


Fig.6 Corresponding to Fig.4 in Dr. Matsukawa's paper -- Comparison based on cross-sectional images of an aluminum cylinder.

The images in the upper row are cross-sectional images obtained using the circular orbital movement method, and those in the middle and lower rows are images obtained using the arc movement method. The numbers at the bottom indicate the distance between the cross section and the long axis of the cylinder, where "r" is the diameter of the cylinder. No significant differences are observed between the images in the upper row and those in the middle row, but marked differences are seen between those in the upper row and those in the lower row.

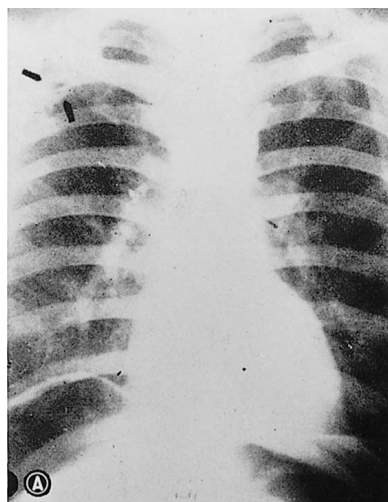


Fig.7 Arc movement method tomographic image obtained from a patient with tuberculosis involving the apex of the right lung.

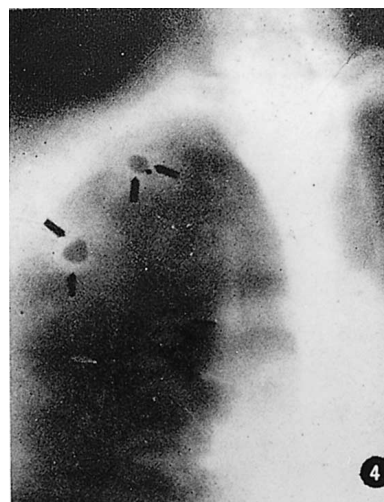


Fig.8 Circular orbital movement method tomographic image of the same patient as in Fig.7.

Conclusion

We have developed a prototype of a new circular orbital movement method tomography system, have conducted various experiments, have compared the results obtained with our system against those obtained using conventional arc movement method tomography, and have reached the following conclusions.

(1) The use of the tomography system described here permits cross-sectional planes of the target object to be accurately depicted.

(2) Tomographic imaging performed using this system results in a thinner planar image with a significant reduction in shadows that can interfere with diagnosis.

(3) In chest tomography, blurred images of, first of all, the first and second ribs, as well as the other ribs, the clavicles, the sternum, the vertebrae, the scapulae, hilar shadows, and the heart are sufficiently reduced so as not to interfere with evaluation of the apex of the lung, the ribs, and the mediastinum. More accurate and thinner cross-sectional images are also obtained.

The history of the development of the circular orbital movement method tomography system by the team led by Dr. Matsukawa has been described in this article.

Experimental studies conducted around 1945 and papers presented around 1955 allow us to follow the course of the work of researchers in Japan, which can be likened to footprints leading away from the ruins of war. The attitudes and approaches of the researchers of that period continue to serve as a valuable touchstone and inspiration to researchers today.

Nevertheless, these so-called “classical” X-ray imaging methods were eventually superseded by X-ray CT, MRI, and ultrasound systems, which are generally referred to as “high-tech diagnostic imaging systems”, or they were abandoned, which has led to dramatic changes in diagnostic imaging methods. That was the history during the postwar period.



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