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Time and Flow Study Results Before and After Installation of a Hospital Information System and Radiology Information System and Before Clinical Use of a Picture Archiving and Communication System

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The effectiveness of a hospital information system (HIS) and a radiological information system (RIS) was evaluated to optimize preparation for the planned full clinical operation of a picture archiving and communication system (PACS), which is now linked experimentally to the HIS and the RIS. One thousand IC (integrated circuit) cards were used for time studies and flow studies in the hospital. Measurements were performed on image examination order entry, image examination, reporting, and image delivery times. Even though after the HIS and the RIS operation only a small amount of time savings were realized in each time fraction component, such as in the patient movement time, examination time, and film delivery time, the total turn-around time was shortened markedly, by more than 23 hours on average. It was verified that the HIS and the RIS was beneficial in the outpatient clinics of the orthopedic department. Our method of measurement employing IC cards before and after HIS and RIS operations can be applied in other hospitals.

KEY WORDS: technology assessment, picture archiving and communication system (PACS), radiological information system (RIS), hospital information system (HIS), radiological reporting, computers, radiology.

TO SUCCESSFULLY operate the picture archiving and communication system (PACS) in a hospital radiology practice, it is indispensable to establish routine operation of the systems supporting the PACS, such as the hospital information system (HIS) and radiological information system (RIS). In the Osaka University Hospital, HIS and RIS have been in clinical operation since October 1993.

Several experimental PACS units have been installed and their clinical operation attempted since 1986; this provided opportunities for improvement to be found and realized.[1-3] The final version of the experimental PACS was introduced into the hospital in October of 1996 and linked to the existing HIS and RIS. A quantitative evaluation of the PACS will be performed. The effectiveness of the HIS and the RIS evaluated by quantitative studies before and after the separate introduction of the HIS and of the RIS as reported in this paper will permit us to measure the impact of the PACS alone.

Many papers have been published regarding this issue,[4-6] but concrete data and results of measurement acquired using a rigorous method of comparison such as that presented here have not yet been published.

It is also clear that the effect of the HIS and the RIS on radiological practice should be assessed and compared along with the effect on other departments. The analysis of the measurement results should be employed to optimize the design and future development of PACS as well as the HIS and the RIS.

Finally, the methodology of generating quantitative data for the same target processes should be standardized so that the same evaluation can be conducted in other hospitals following the same method.

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In our series of technology assessments of radiological practice in our hospital, many parameters were measured before the installation of the HIS and the RIS and were analyzed.[2,3,7-9] The outlines of the HIS and of the RIS were presented in previous publications.[1,7] The total of 36 items measured included those pertaining to turn-around time in image diagnosis, off-site film examinations, image reading, radiological reporting, image quality, and cost analysis. The methods of analysis included time studies, flow studies, layout studies, cost analyses, and receiver operating characteristic (ROC) analyses.

Table 1 lists the studies performed after the HIS and the RIS operations commenced in the hospital. The results of the studies presented in this report are referenced in Table 1. The time and flow studies were conducted after the implementation of the HIS and the RIS using the same variables, parameters, and conditions employed before the introduction of the systems. The studies performed before the introduction of the systems are listed in Table 1 in the article by Kondoh et al.[2]

This article presents a generalized methodology of the HIS and the RIS (and PACS) evaluation based on the quantitative comparison of each of these items in the manual operation before and the computer operation after the introduction of the HIS and the RIS, which might be useful elsewhere. The effect of the film transport system with the HIS and the RIS was studied to extrapolate the likely effect of the PACS.

MATERIALS AND METHODS

Flow studies were first conducted throughout the entire hospital before the time studies were performed.[2,3,7-9] Detailed

Table 1. Items of the Studies Performed After HIS/RIS Operation and Results

Classification	Data Item	Figure or Table Number
Flow study	Flow studies on patients, images, orders, requisitions, reports, etc.	Fig 1 shows outline
Time study	Turn-around time from order entry until report/radiographs return for all outpatient clinics and wards	Fig 3A
	Turn-around time from order entry until report/radiographs return for orthopedics department	Fig 3B
	Time between order entry and the order reception (patient movement time) for all patient clinics	Fig 4B
	Time between order entry and the order reception for outpatient clinics of internal medicine 1, internal medicine 2, orthopedics, and surgery	Fig 4C for orthopedics
	Time for imaging process for all modalities and examination rooms	Fig 5B
	Time for imaging process for each modality and each examination room	
	Time required for image delivery; film transport time to the outpatient clinics and wards of all departments	Fig 6B
	Film transport time to the outpatient clinics of all departments, internal medicine, surgery, and orthopedics departments	Fig 6C for only orthopedics
	Film transport time to the wards of all departments by carts or by hand	
	Film transport time to the wards of internal medicine 2, internal medicine 3, orthopedics, and surgery 1	
	Patient waiting time in front of all image examination room	
	Patient waiting time in front of each image examination room	
	A patient's waiting time and examination time for all examination rooms and each examination room	
	A patient's waiting time and examination time for each modality	
Report analysis	Time spent in generating a report for all modalities	Fig 7B, Table 3
	Time spent in generating a report for each modality	Table 4 only for general radiography, CT, and MRI
	Time spent in writing a report for all modalities	Fig 8B, Table 3
	Time spent in writing a report for each modality	Table 4 for only general radiography, CT, and MRI
	Time ratio of writing to reporting for all modalities	Fig 9B, Table 3
	Time ratio of writing to reporting for each modality	
	Number of characters in a report for all modalities	Fig 10B, Table 3
	Number of characters in a report for each modality	
	Frequency of referral to archived images for all reports	Table 3 (only average)
	Frequency of employment of anatomic sketches for all reports	Table 3 (only average)

charts of the flow of image examination orders, patients, films, images and radiological reports, and other relevant documents were drawn based on information that was obtained from the interviewed medical staff of every outpatient clinic and ward in all departments, including referring physicians, radiologists, nurses, radiological technologists, and film management clerks. Figure 1 shows the essential outline of flow charts from the image examination orders to delivery of images and reports to the care units. The details of the flows with the HIS and the RIS operation differ only slightly from those without the computer systems operation. The essential parts of the flow charts are identical for both, and the figure shows the common flow and common checkpoints for the time studies. Integrated circuit (IC) cards were employed for the time and flow studies of image examination order entry, image examinations, reporting, and image delivery. An order sheet for each image examination ordered was placed in a transparent jacket with a pocket for the IC card to be carried together with the order sheet. The IC card is the size of a credit card and has an internal digital memory. When the card is inserted into an IC card reader/writer unit, the time and identification number of the unit are written into the digital memory. A total of 50 IC card reader/writer units were installed at key checkpoint locations all over University Hospital. The places at which and the time when each IC card was read were recorded on the IC cards. After each session of the time study, all of the IC cards in use were collected and read into a personal computer, and statistics were derived from the data analysis.

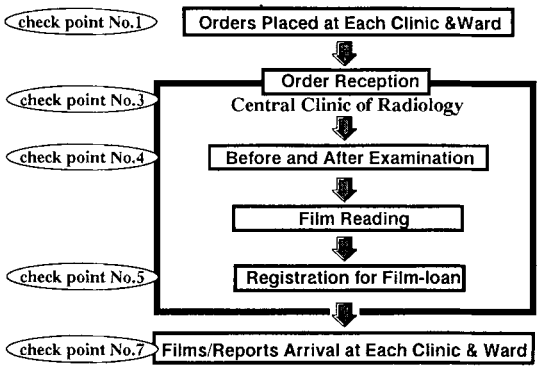

Fig 1. Checkpoints for time study of patient movement, examination order flow, and film/report flow at our hospital. Read/write stations for IC cards were installed at every key location. The place and time were recorded when an IC card was put into a read/write unit by the patient, or with an order sheet, film, or report. In Japan, the radiological report is written by hand and kept together with the films in a jacket folder, which is delivered to the clinic or ward by the radiology department. Checkpoint 1: The clinic or ward HIS/RIS where the examination orders were issued. Before introduction of the HIS/RIS systems, the time recorded on the IC cards was when the examination order sheets were written by referring physicians. After introduction of the HIS/RIS systems, the time recorded was when examination orders were entered through HIS terminals by referring physicians using the radiological order entry program. Checkpoint 2: Points between the clinic and the reception desk of the central clinic of radiology. These are located in hallways and stairways that the patients pass through. Check point 2 is omitted from the figure. Checkpoint 3: The order reception desk at the central clinic of radiology. Checkpoint 4: Image examination rooms. Checkpoint 5: The film registration site after film reading. Checkpoint 6: The library for film loans. This is omitted from the figure. Checkpoint 7: The arrival points of films and radiological reports at each clinic and ward before introduction of the systems. In Japan, a written radiological report together with the films is sent to the clinic or ward. Reports are not transcribed. This checkpoint is also the arrival point of films after the introduction of HIS/RIS. Radiological reports are automatically filed at the central database of HIS immediately after the radiological reports are entered through the RIS terminal, and referring physicians are able to access and see the radiological reports at the nearest HIS terminal within at least 15 minutes of the time of radiological reporting.

The times required to collect the image examination orders and to deliver the images and reports to the clinics and wards in the manual systems were measured on July 27 (Monday) through July 31 (Friday) 1992. In this measurement IC cards were not employed; only stopwatches were used. These measured results were compared with those acquired by IC card measurement obtained in 1993 as described below, the two data sets were very highly consistent with each other, confirming that the IC card time study method was reliable.

The time study before the introduction of the HIS and the RIS was conducted on March 18 (Thursday) and 19 (Friday), 1993. Of the total of 1,000 IC cards delivered to each clinic and ward for that time study, 361, 370, and 269 were collected, respectively, on those two days and on the following day. The 300 transparent jackets used to carry examination order sheets, and radiological reports were put into film envelopes to be recorded on arrival at the various film and reports destinations.

The times between pairs of checkpoints (CK) arbitrarily selected from among the seven checkpoints were calculated and printed out. These data were presented, for example, as the time between CKs 1 through 7, 1 through 3, and 4 through 7. The time between CK 1 and CK 7 is designated by the term *turn-around time*, meaning the total time spent in acquiring the study (images) and the report starting from the time the image examination order was issued at a clinic or ward before the introduction of the computer systems.[7-9] After the introduction of the HIS and the RIS, turn-around time was defined as the total time spent in acquiring images and the report, beginning from the time the image examination order was entered through a HIS terminal at a clinic or ward.

Figure 2 shows schematically the HIS, RIS, and experimental PACS that are now in operation in our hospital.[1,2] The HIS has 548 terminals for use by medical doctors, nurses, technicians, and clerks throughout the hospital in interfacing with the radiology central clinic. Fifty-eight RIS terminal units are distributed in the radiology central clinic and radiology-related departments and wards. Various modalities in several examination rooms are interfaced to the experimental PACS. Digital images with 2,000 × 2,000 matrix and 10-bit depth can be sent from 17 computed radiography (CR) units to the experimental PACS. Computed tomography (CT) and magnetic resonance (MR) images can also be sent to the PACS. CR images are compressed to 512 × 512 matrix image by the JPEG 12-bit hardware of the large scaled integrated circuit (LSI) and delivered to 20 PACS terminal units, which implement JPEG 12-bit decompressors. Each of the 20 terminals has the functions of both a HIS terminal and a PACS terminal. The reduced matrix images of 512 × 512 × 12 bits are referred to as "optimized

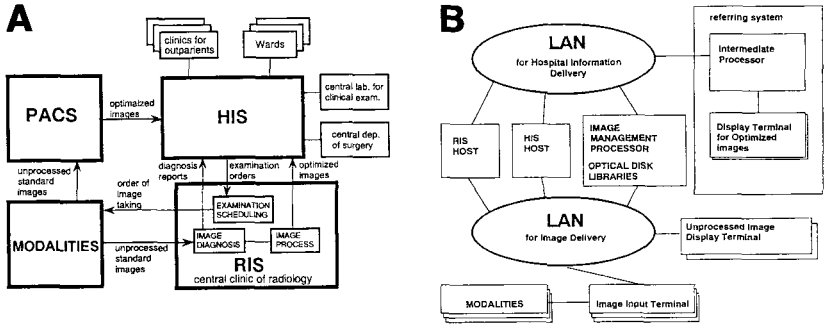

Fig 2. System configuration and the outline of hardware configuration of our HIS/RIS/PACS. The HIS/RIS have been in operation since October 1993, and the experimental PACS has been operated on a trial basis since February 1994. The design and development of both the HIS/RIS was conducted in 1991 and that of the PACS in 1993. (A) System configuration. (B) Outline of hardware configuration.

images" in our terminology. In our experimental PACS, these optimized images of CR, CT, and MR images are displayed with the radiological reports on request by the referring physicians. Our current experimental PACS does not contribute to the primary diagnosis nor to the clinical operation. Table 2 shows the equipment on-line for our PACS at phase I.

These were the conditions under which the time studies were conducted on March 18 and 19, 1994, after the introduction of the HIS and the RIS. The time studies both before and after use of the HIS and the RIS systems were performed using the film-screen system. CR images were hard copied onto film and interpreted from film in both parts of the study to avoid introducing other changes.

The time required to create each diagnostic report in the manual system, that is, the time for viewing, interpretation, and actually writing the report, was then measured with stopwatches, and the number of Japanese characters and letters in each diagnostic report were counted afterwards. The time spent just in the actual writing of each diagnostic report was also measured. This time study was conducted on July 27 (Monday) through July 31 (Friday), 1992.

The same two time studies were conducted after the introduction of the RIS using the same definitions of time interval and enumeration of the characters and letters. The only difference was that writing time was the time spent in keying in and mouse handling with the RIS terminals. These time studies were conducted on August 10 (Wednesday), 1994, which was 10 months after the RIS operation had been introduced at the hospital.

During the image interpretation time, the radiologists sometimes refer to prior images for the same patient. The number of such referrals to previous images was counted, and the dates of acquisition of the images were recorded.

The radiologists also drew sketches and annotations on their reports before the use of the RIS. Thereafter, they called up ready-made anatomic drawings from a workstation memory and displayed them on the CRT screen, and annotations are attached to complete the illustration as aids to interpretation. Such instances of employment of anatomic sketches were also counted in this study.

RESULTS

The results of comparison of turn-around times are shown in Figure 3. The distribution of turn-around times before the systems was rather wide (range, 16 hours to 39 hours), the mean and standard deviation (SD) being 26.8 hours and 6.8 hours, respectively. The turn-around time with the system was 3.6 hours (SD, 2.5 hours). The turn-around time was shortened to 13.8%, and the SD is narrowed to 36.8%. The distribution without the systems was bimodal. But the distribution with the HIS and the RIS is very keen and unimodal, and concentrated at within 1 hour.

The orthopedics department showed the greatest percentage of the turn-around times less than 1 hour with the systems.

The mechanical film transport system did not exist in the manual system, and film folders were delivered by hand to the clinics and wards. The mechanical film transport system was installed with the HIS and the RIS.

The disadvantage of the hand-carrying system was that the personnel left the central clinic of radiology only once a day, so that the net time interval between the film reading finish and new films' and reports' arrival at each clinic or ward was very long, because new films and reports were left in the central radiology clinic to be picked up for distribution by the cart. The maximum waiting time was 24 hours. An advantage of the film transport system is that the images can be sent to clinics or wards at any time from the central clinic of radiology.

Figure 4A shows the distribution of order collection times (patient movement time before use of the systems, when examination order sheets were carried by the patients or nurses). The average time between CK 1 and CK 3 was shortened, from 7 minutes to 5 minutes. The distribution with the systems was very concentrated, within 5 minutes. In the orthopedics department the outpatients showed very short intervals, within 2 minutes (Fig 4C).

The distributions of imaging examination times

Table 2. Phase I of Osaka University Hospital PACS

		No. of Machines Installed
RIS/PACS		
RIS server	EWS4800/350(NEC Corp)	3
PACS server	EWS4800/350 + jukebox type optical disk unit + HD + magnetic tape	3
RIS terminal/ PC-IDT (personal computer-image display terminal)		58
	1) PC-98 Mate (CPU: i486 66 MHz, RAM: 14.6 Mbyte) (NEC Corp)	
	2) 12-bit JPEG compression-decompression board (25)	
	3) Branch 4680 Ethernet board	
Modality interface terminal		17
	1) PC98 Mate (CPU: i486 66 MHz, RAM: 14.6 Mbyte) (NEC Corp)	
	2) 12-bit JPEG compression-decompression board	
	3) Branch 4680 Ethernet board	
	4) Image input I/F	
	DR11/W—FCR, IIDR, Konica film scanner (film digitize)	
	Ethernet—YMS (Tokyo, Japan) DATAVIEW, Toshiba CT, Hitachi (Tokyo, Japan) WS (nuclear medicine)	
	RS-422—Konica laser printer (MRI)	

Abbreviations: RAM, random access memory; HD, hard drive; I/F, interface.

before and after introduction of the systems measured at CK 4 were comparable to each other (Fig 5). The examination times themselves were not influenced by the operation of the HIS and the RIS nor by the type of diagnostic imaging. However, the patient's waiting time near the image examination room was considerably shortened. These waiting times were measured and found to be shortened to 1/5 to 1/7 because of the operation of the RIS and patient guidance system, respectively. For example, the average of the waiting time for chest examination was shortened to 4.9 minutes from 24.3 minutes before the RIS and HIS.

The location of each clinic and ward had a major effect on the time required for delivery of new images and reports under the old procedure, because new images and reports were hand-carried by personnel (Fig 6). Physically removed sites such as the ninth floor showed much longer delivery times, and the sites closer to the radiology department on the second floor showed less time. For the nearby sites, the average time was approximately 10 minutes without the system (Fig 6A), and the operation of the mechanical film transport system under the new procedure did not improve this time very much (Fig 6B). In the orthopedics department (Fig 6C), nearest to the central clinic of radiology, most film deliveries took 10 ± 2 minutes.

The results of time study measurement pertaining to radiological reporting are shown in Figures 7 to 10.

The total time spent in completing a report, including viewing, interpretation, and the actual writing, was increased when the RIS terminal was

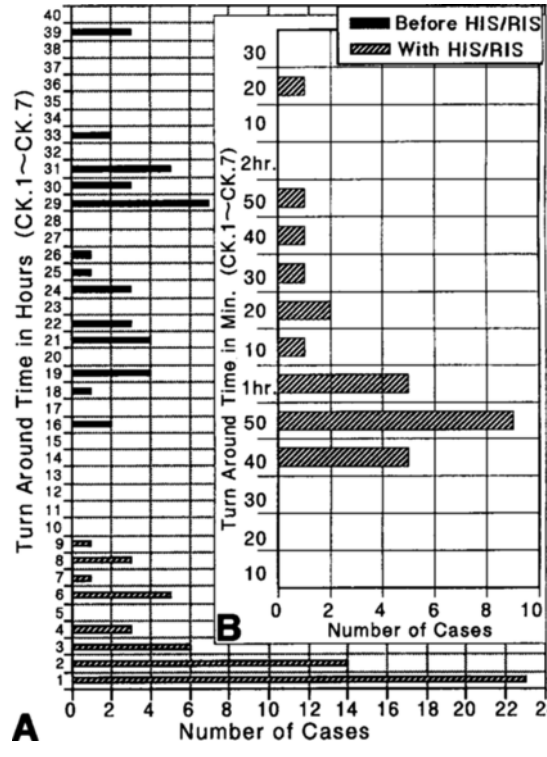

Fig 3. Comparison of turn-around time before and after introduction of the HIS/RIS systems. (A) Turn-around time for all outpatient clinics and wards. The solid bars show the distribution of the turn-around time before HIS/RIS; and the shaded bars, that after the introduction of the systems. (B) Turn-around time for outpatient clinics and wards of the orthopedics department with HIS/RIS.

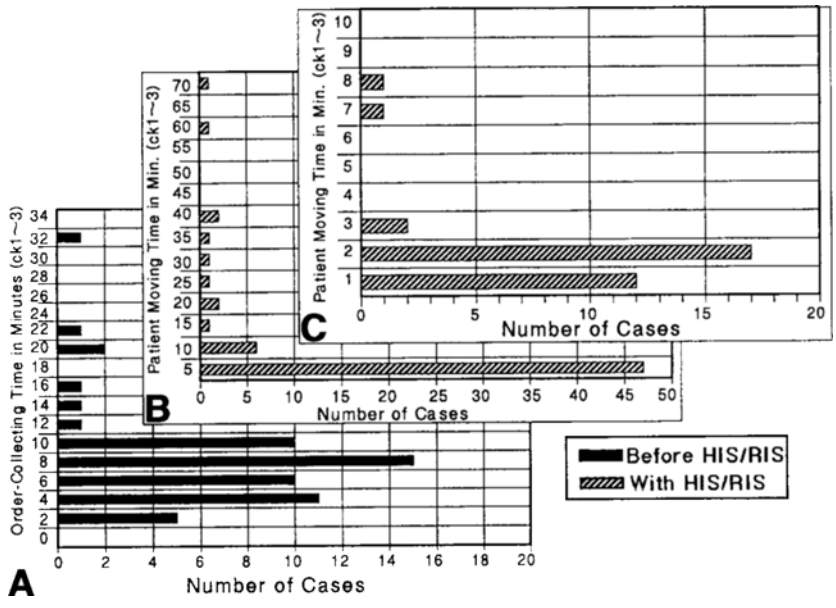

Fig 4. The time between order entry and the order reception. (A) The order collection time before introduction of the HIS/RIS systems. (B) The patient movement time after introduction of the HIS/RIS systems. After introduction of HIS, image examination orders were collected by the order entry procedure through HIS terminals operated by referring physicians, so that orders were directly sent to the central computer and appear on RIS terminals at the central radiology clinic. (C) The patient movement time for the orthopedics department after introduction of the HIS/RIS systems.

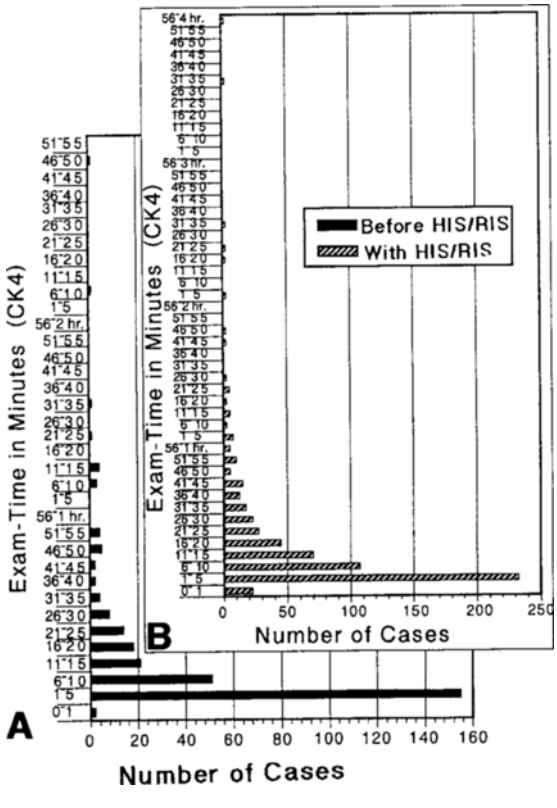

Fig 5. Comparison of image examination times measured at image examination rooms (A) before and (B) after use of the HIS/RIS systems. The imaging modalities were those of conventional imaging of the chest, abdomen, extremities, bones, head and neck by CT, MRI, and other modalities.

employed, and the distribution was broader (Fig 7). The RIS terminal input operation for just creating a report also took longer than that for writing a report by hand (Fig 8). Furthermore, the RIS terminal input operation time was much longer for total reporting time when the RIS terminal was used (Fig 9). Moreover, the number of characters and letters increased markedly, to approximately 3.8 times as many, as shown in Figure 10. This magnitude of

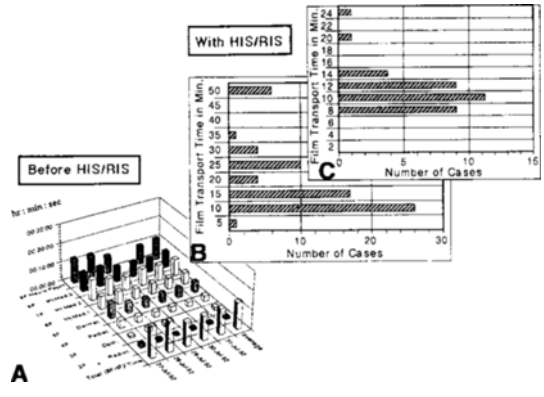

Fig 6. Comparison of image/report delivery times (between the library for film loans and the film/reports arrival) before and after introduction of the systems. (A) The results of measurement from July 27 to July 31, 1992. The height of the bars indicates the time spent in delivery of images/reports from the central radiology clinic (the library for film loans) to the outpatient clinics and wards (film/report arrival) of all departments. (B) Film transport time to the outpatient clinics and wards of all departments after use of RIS and film transport system. (C) Those for only the orthopedics department.

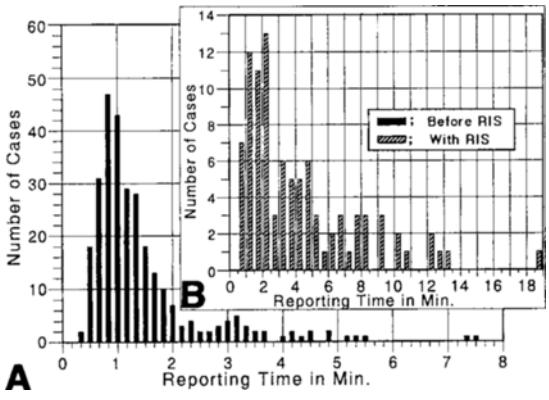

Fig 7. Time spent in completing a single diagnostic report. Shown are data for all modalities such as general radiography, angiography, CT, MRI, and so forth. (A) Before introduction of RIS, (B) After introduction of RIS.

increase, however, is less than that of writing time (6.4 times), so that it is clear that unfamiliarity with the machine operation is the main cause of the extra time for making reports with RIS terminals.

As Table 3 indicates, the average time for inputting or writing 10 characters in the case of RIS terminal method was more than that in the case of handwriting on a radiological report.

The frequency of interpretations in which comparison studies were examined was slightly increased, and the use of anatomic sketches was increased by more than twofold.

The reporting time for CT examination and MRI examination as well as the writing time clearly took longer than those for general radiography, as shown in Table 4. The results for the number of characters

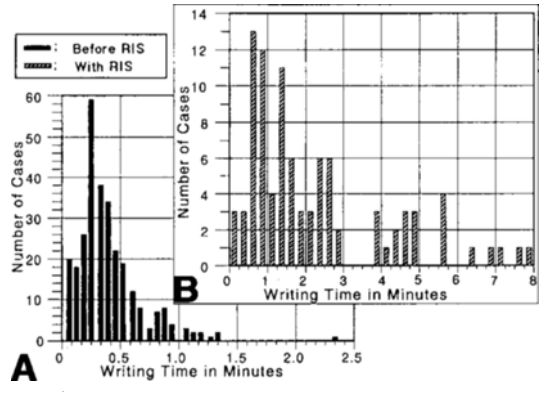

Fig 8. Time spent in writing a diagnostic report. In Japan, diagnostic reports are written by hand, and they are not orally recorded and not transcribed. Data for the same modalities as in Fig 7 are shown. (A) Before introduction of RIS, (B) After introduction of RIS; writing time is defined as the time to operate the keyboard and mouse.

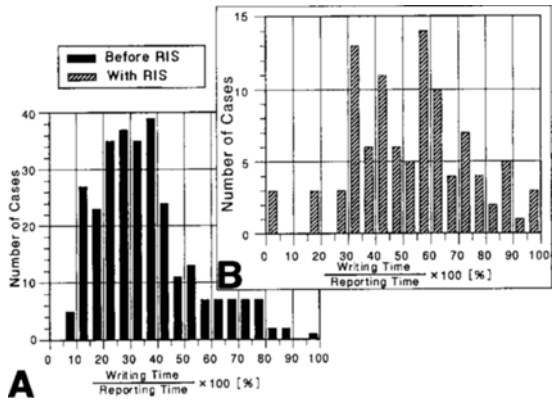

Fig 9. Time ratio of writing to reporting. Each time shown in Fig 7 was divided by the corresponding time in Fig 8. (A) Before introduction of RIS, (B) After introduction of RIS.

and letters also confirmed this pattern (data not shown).

DISCUSSION

Even though only small increments of time saving were realized in the patient movement time and examination time through the introduction of the HIS and the RIS and the mechanical film transport system, the total turn-around time was shortened markedly, by more than 23 hours on average. The time savings is due to the decreased dead time during which the new films and reports were held for pickup in the central radiology clinic. The film transport speed itself is not much faster than human transport speed, but the capability to send films at any time to clinics or wards resulted in the time savings. However, the frequency of departure from the central radiology clinic remains key to the amount of time saved, because the transport

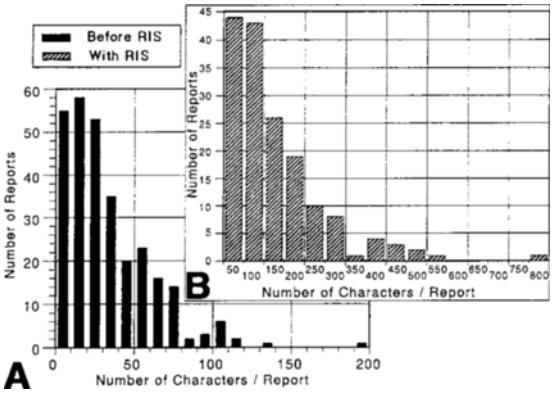

Fig 10. Number of characters in each diagnostic report. (A) Before introduction of RIS, (B) After introduction of RIS.

Table 3. Comparison of Time Study Results of Radiological Reporting Before and After Introduction of HIS/RIS

Items	Before	After
Number of reporting samples	289	95
Average reporting time for a reporting	1 min 29 sec	4 min 17 sec
Average writing time for a reporting	21 sec	2 min 14 sec
Average ratio of writing time to reporting time	24%	52%
Average number of characters for a report	34.1 (289 cases)	130 (162 cases)
Average time to write 10 characters	6.15 sec	10.31 sec
Frequency of referral to archived images	14%	17.8%
Frequency of employment of anatomic sketches	4.9%	13.7%

system has a limited number of capsules available on line. Consequently, the clinical operation of the PACS is expected to shorten the turn-around time even further, because it is capable of sending images any time immediately after they are entered.

We could have chosen to have a person hand-deliver the new film and reports four times a day instead of once a day in the manual system. But it was not possible for us to hire more personnel dedicated to new film and reports delivery because of cost constraints.

According to the results of our time study, the orthopedics department shows the most obvious benefit from the operation of the HIS and the RIS in terms of time savings for a relatively large number of radiological examination orders. Consequently, the future clinical operation of PACS is anticipated to make that department much more efficient in terms of patient waiting time.

Radiological examination orders are now entered through 548 HIS terminal units in the outpatient clinics and wards and transmitted to the central radiology clinic immediately. This contributes to the shortening of patient waiting time before entering the image examination room. It also contributes to shortening of the turn-around time. However, this order entry system cannot eliminate unavoidable patient movement time from the clinics to the reception desk of the central radiology clinic.

Table 4. Comparison of Time Study Results of Reporting Among Three Imaging Modalities After Introduction of RIS

Modality	Sampled Number of Cases	Average Reporting Time	Average Writing Time
General radiography	56	2 min 58 sec	1 min 41 sec
CT	17	6 min 29 sec	3 min 15 sec
MRI	11	7 min 16 sec	3 min 0 sec

Radiological reports can now be sent to the clinics and wards within 15 minutes after they are filed in the RIS database. This contributes to shortening of the report turn-around time. The referring physicians of the first department of internal medicine have stated that they appreciate this very much, because these reports can be used in their decision making. However, the number and percentage of referring physicians who can take advantage of this quick delivery of reports could not be ascertained in this study, nor could the frequency of immediate opening of the radiological report file on receipt by the referring physicians. The time and place of viewing of the radiological report by the referring physician who placed the order is automatically recorded by HIS terminals. An automatic logging program is under development that will measure the report viewing turn-around time. Time studies to be conducted in the future after the clinical introduction of PACS must involve the automatic logging for examination order entry as well as access to reports. We anticipate that we will be able to ascertain the overall effectiveness of the HIS and the RIS/PACS integration and the effectiveness of PACS itself using our methods of measurement.

We confirmed that more detailed reports were written after the introduction of the HIS and the RIS, requiring more time, with more frequent reference to comparison and more frequent calling up of the newly introduced anatomic drawings. RIS terminals can display ready-made sentences previously specified by the radiologist, and he or she can modify or revise the sentences as appropriate to fit the case. This feature has been appreciated and adopted by the referring physicians, because it affords the opportunity to call up the sentence and anatomic drawings and then to produce notes and charts for their personal use or correspondence with other physicians or radiologists. Operation of the RIS contributes to the quantitative expression and objective accuracy of diagnosis because of the several advantages mentioned. In particular, reports of CT examinations and MRI examinations include longer passages, which make the fullest use of RIS

terminal functions. The results of time study of CT and MRI reporting corroborate these observations.

One of the reasons for the increased frequency of comparison study review of archived images during diagnostic reporting seems to be the presence of the questionnaire panel displayed on the RIS terminal, which might serve to remind the radiologist of this option. The clinical operation of PACS is expected to further increase the use of comparison studies, because these images will be listed on the terminal screen and will be displayed on command very easily.

Regarding the current status of our experimental PACS, it is now closely integrated with the HIS. Twenty of the 548 HIS terminals now display CR, CT, and MRI images. The image quality is acceptable to most of the clinicians in our hospital only when the images are observed in conjunction with the radiological report on those images. This phase I operation began in October 1993 and was completed by March 1994.

The speed of the image display terminal (PC 98 X A with 166MHZ Pentium machine) made by NEC Corporation in Tokyo will be four times faster than current terminals (PC 98 Mate). The 20 units functioning as HIS terminals are used in outpatient clinics in internal medicine and orthopedics. Notification of the availability of the optimized images is to be sent to the HIS terminals together with the radiological report. Requests to display images with the radiological report will be made through the HIS via the local area network.

The clinical operation of our PACS commenced on October 24, 1996. The efficacy of the PACS will be improved by employing the lessons gleaned from this analysis of the time and flow studies. The results of the measurement of HIS and RIS impact described in this report will serve as baseline data in the evaluation of the impact of the full PACS.

As to the efficacy of the HIS and the RIS, one of our original objectives was realized in that the department of orthopedics enjoyed the maximum benefit from the use of the HIS and the RIS, as well as from optimizing spatial relationships and film transport conditions. It is also anticipated that the orthopedics department will benefit further and substantially from the full PACS.

The advantages and effectiveness of PACS must be quantitatively measured by a methodology that is defined clearly and generally applicable. This article has described a quantitative method to evaluate the impact of the HIS and the RIS and to later separate the evaluation of PACS effectiveness from all other factors. We plan, in conjunction with other researchers, to develop this method more extensively to obtain a higher degree of integration and generalization in future.

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