INVITED REVIEW ARTICLE

Nagoya J. Med. Sci. **63**. 19 ~ 24, 2000

# EVALUATION OF THE SPACE COLLABORATION SYSTEM: ITS HISTORY, IMAGE QUALITY AND EFFECTIVENESS FOR JOINT CASE CONFERENCE

KAZUNOBU YAMAUCHI[1], MITSURU IKEDA[1], YOSHIHIRO OTA[1], SHU YANG[1], TAKEO ISHIGAKI[2], EIICHIRO ITOUJI[3], SHUJI ADACHI[3], SHOUZOU HIROTA[3] and MICHIO KOHNO[4]

[1] *Department of Medical Information and Medical Records, Nagoya University Hospital*
[2] *Department of Radiology, Nagoya University School of Medicine*
[3] *Department of Radiology, Kobe University School of Medicine*
[4] *Radiology Division, Kobe University Hospital*

## ABSTRACT

A joint case-conference was conducted between the Departments of Radiology at Nagoya and Kobe Universities using the Space Collaboration System (SCS), which connects 39 national universities and institutes by communication satellite. In the conference, both sides presented cases using medical images such as those from CT, MRI, and DSA, and the cases were discussed between participants at the two universities. After the final conference, we distributed a questionnaire to solicit responses from the 43 participating radiologists on the quality of the transferred images and their overall impression of the conference. The responses showed that the CT, MRI, and DSA images were clear enough to allow discussion, whereas the plain X-ray images were not. Hence from the standpoint of image quality, the SCS may be unsuited for medical image diagnosis, but useful for presentation of case images in joint conferences and seminars.

Key Words: Case-conference, Quality of image, Space Collaboration System

## INTRODUCTION

Telemedicine today is being conducted with a variety of methods. Among these, satellite communications systems hold great promise for use in telemedicine and remote-area medical education. In some countries, several uses have been described,[1,2] but in Japan until very recently only a small number of reports discussed the restricted aspect of medical services in remote areas.[3]

In recent years, the Japanese Ministry of Medicine, Science, Sports and Culture (Monbusho) has established and encouraged trials in the use of two national communication satellite systems: the Medical Information Network by Communications Satellite for University Hospitals (MINCS-UH), and the Space Collaboration System (SCS). Of these two, the MINCS-UH was developed for medical conferences between university hospitals, so its use is limited to hospitals belonging to national universities. This system uses digital television (HDTV) specifications, and includes encryption devices. Thus, the equipment is large and extremely cumbersome. In contrast, SCS is a communications satellite joint conferencing system set up by Monbusho in

Correspondence: Kazunobu Yamauchi, M.D., Department of Medical Information and Medical Records, Nagoya University Hospital, Tsuruma-cho 65, Showa-ku, Nagoya 466-8560, JAPAN, Phone: +81-52-744-2664 Fax: +81-52-744-1356

October 1996. Centered at the National Institute of Multimedia Education (NIME),[4] this system connects 39 national institutions nationwide, including universities, trade schools and university joint research facilities. It is put to a wide range of uses, including remote interactive or joint classes, joint seminars and symposiums. Because it is a network based on the NTSC system, it is superior to MINCS regarding ease of use, cost effectiveness and the large networks through which a high-level multimedia education system can be put in place. Currently, however, the only stations set up have been in the medical departments of Nagoya and Kobe Universities.

Because MINCS-UH uses high definition images, the quality of the images is assumed to be good enough for medical use. SCS, on the other hand, has not to date been used for medical case conferences, so the precision and reliability of its medical images are not well understood. Since it is likely that in the future there will be opportunities to transmit and receive images through SCS at other institutions as well, evaluating the system, particularly its image quality, is of utmost importance. We held joint conferences between the departments of radiology at Nagoya and Kobe Universities using this system starting in 1997. In the present paper, we will trace the course of these conferences, report the results of a questionnaire survey of participating radiologists through which they evaluated a case conference using SCS with particular focus on the quality of the images, and discuss future problem areas.

## MATELIALS AND METHODS

### System Overview

SCS is based at NIME, and connects a communications satellite network of smaller regional stations set up at major national universities and institutions around the country. The system facilitates high-level, multimedia education. Circuit control is provided by the base station while local operation is conducted by a non-technical instructor; no licensed technician is present. Each station is equipped, with such equipment as a telephoto camera, visual presenter, video deck, and slide projector, in addition to multiple presentation monitors, based on each station's specifications.

The specifications of the SCS were determined by researchers including those at NIME. The characteristics of the system are as follows[4]

1) Bi-directional communications

SCS uses two satellite communication lines and achieves real-time, bi-directional communication between universities.

2) Compromised quality of moving pictures

The data transfer rate of the system is 1.5 M bps per channel for moving pictures and sound. NTSC-based cameras, monitors and video instruments are used in SCS. Considering that a speed of around 5 M bps is necessary to transfer compressed ordinary color television (NTSC (National Television System Committee) or PAL (Phase Alternation by Line color television)) moving pictures, the quality of the images is somewhat low.

3) No security protection mechanism

There are no security protection mechanisms in SCS.

4) Centralized management system

SCS adopts a VSAT (Very Small Aperture Terminal) method. The center for SCS was established at NIME, and it controls all the equipment installed at each university.

### Historical Précis

Joint conferences using SCS were held in classrooms in the medical departments at Nagoya and Kobe Universities 4 times: on March 18, 1997, on May 20, 1997; on January 21, 1998;

and on October 22, 1998. During these case conferences, case studies were presented by both sides, and the sessions adopted a question-and-answer format. For the case presentations, X-ray photographs, CT, MRI and other images were photographed using a visual presenter, while slides were put into the system from a slide projector for transmission to the other site, All images were displayed on large monitors for the question-and-answer sessions (Fig. 1).

The case conferences were used to investigate diverse conditions such as aortic aneurysm, renovascular malformation, lung cancer, hypersensitivity pneumonitis, lung arteriovenous malformation and benign tracheostenosis. As participants were unfamiliar with the operation of the equipment during the first two conferences, trial-and-error experimentation was necessary to determine the type of image that was easiest to see at the other site. However, proficiency gradually increased with the number of presentations, and by the fourth conference the discussion could progress as far as setting the treatment course for the case presented. Several problems occurred during the conferences. At the first conference, the images from Kobe University did not reach Nagoya University, and the participants from Kobe were forced to cancel their presentation. During the third conference, the Nagoya University presentation could not be given due to problems with the visual presenter. There were also problems with background noise in the audio transmissions, but these were referred back to the base station at NIME each time for solution. No problems whatsoever were experienced during the fourth conference, so the earlier difficulties seem to have been overcome.

Questionnaire Survey

1. Subjects

The survey subjects were 43 radiologists from the radiology departments of Nagoya and Kobe Universities who participated in the joint case conferences.

2. Survey method

Following the fourth conference, self-entry questionnaires were distributed to the participants and collected afterward. The survey had questions asking: 1) the respondent's year of graduation from medical school (affiliation); 2) an evaluation of the quality of the received images

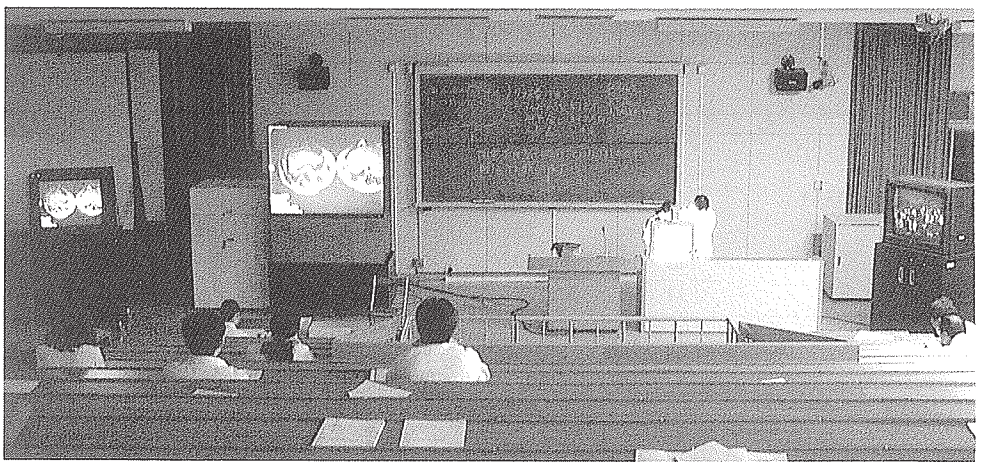

Fig. 1 Case-conference with a radiograph via SCS from Nagoya University
In the right center, 2 physicians are presenting a case using a visual presenter. The photograph taken using the camera is shown on the center display. The scene at Kobe University can be seen on the video at right.

from original plain X-ray photographs, angiographic photos, digital subtraction angiograms (DSA), CT and MRI images using a scale of 1 to 3 (where 1 represents an SCS image equal to or better than the original image; 2 an SCS image poorer than the original image, but making a diagnosis possible; and 3 an SCS image unsuitable for diagnosis); and 3) opinions including overall impression, the feeling of being on site, and bi-directionality, rated on a scale 1 to 3 (where 1 represents good, 2 average and 3 poor). In addition, respondents were asked to enter their impressions of and opinions about the conference. The results from the 43 people who responded were analyzed.

## RESULTS

1. Evaluation of images

As shown in Table 1, DSA, CT and MRI images were judged superior to those of plain X-rays or angiograms (excluding DSA). In particular, nearly 25% of the respondents rated CT and MRI images as 1 meaning they considered these images to be equal to or better than the some images observed on normal film. Adding those who gave these images a ranking of 2 (sufficient for diagnosis) over 90% of the responses (41/43 and 40/43) fell in these satisfactory categories. In comparison, 42% (18/43) and 36% (14/39) of the respondent's ranked plain X-rays and angiograms (excluding DSA), respectively as 3 (unsuitable for diagnosis).

2. Feeling of being at the actual site and bi-directionality

The results are shown in Table 2. Both feeling of being at the actual site and bi-directionality received rather high evaluations of either good or average from 86%((14+23)/43) and 91% ((17+22)/43) of the correspondents, respectively.

3. Feasibility of practical applications of such case conferences

Forty-seven percent (20/43) of the respondents judged through written responses that it would be possible to use SCS case conferences as true case conferences. However, roughly the

Table 1. Evaluation of Images with each modality

| Modality | Equal or above | Compromised, but diagnosis possible | Unacceptable for diagnosis | Other | No response |
|---|---|---|---|---|---|
| Plain XP | 3 | 20 | 18 | 2 | 0 |
| Angiogram (excluding DSA) | 4 | 22 | 14 | 1 | 2 |
| DSA | 4 | 35 | 3 | 0 | 1 |
| CT | 12 | 29 | 2 | 0 | 0 |
| MRI | 11 | 29 | 3 | 0 | 0 |

Table 2. Evaluation of the environment while using SCS

| | Good | Average | Poor | Other |
|---|---|---|---|---|
| Bi-directionality | 17 | 22 | 3 | 1 |
| Feeling of being on site | 14 | 23 | 6 | 0 |
| Overall impression | 18 | 22 | 1 | 2 |

same number (44% or 19/43) indicated that this would be possible only under certain conditions, meaning that further improvements will be necessary to achieve this goal.

4. Overall impression

Overall impression was rated good by 42% (18/43) and average by 51% (22/43) of the respondents, indicating that case conferences using the SCS received a favorable evaluation.

## DISCUSSION

The use of satellite communications in the medical field has just started recently. SCS was originally planned to allow joint classes, joint seminars, and symposiums, and so it was not developed to transmit medical images. However, as it became apparent that there would be many opportunities to use SCS in lectures or training sessions using medical images, it was considered important to assess it for this purpose.

SCS uses a broadcast system, the same used for home television, with an NTSC signal containing 525 scanning lines. The image read as RGB signals by the visual presenter is transformed into NTSC signals, and then is sent as radio waves to communications satellites. These radio waves are received by the next station's receiving equipment, which converts the waves into images for viewing on a NTSC monitor. The precision of a single sheet original CT or MRI image is 512 × 512, with an 8-bit density resolution. From the results of the present survey, it would appear that with images of this precision there is little deterioration in image quality even on the NTSC system. In contrast, plain photographs such as chest X-rays have a resolution of at least 1000 × 1000, with an 8 bit resolution in the density direction,[6] and even higher resolution is required in order to evaluate fine lesions. The SCS system is limited when such high resolution is required.

Using a PC-based telemedicine system, we investigated the recognition rate of tumor shadows on a chest X-ray. The results of an analysis of receiver operating characteristics (ROC) showed that even at 1000 × 1000 × 8 bits there was no change from the original image and tumor shadows could be detected,[7] although there are undeniable limitations in the diagnosis of fine lesions on X-ray photographs viewed within the NTSC format. From this point of view, the high-vision images and security protection provided by MINCS-UH makes it a significant communications satellite system for medical use; however its accuracy remains to be evaluated in detail.

Since to date there has been no assessment of the SCS system when it is used to transmit medical images, the results of the present study are important. However, since an ROC analysis is necessary to compare the original image with its CRT equivalent, further investigation is required.

In the 4 joint conferences we conducted, radiologists rated the level of the system as being nearly satisfactory. Before being used in an actual conference, however, many areas in need of improvement can be isolated, including determining the optimum light for taking images from transparent film with a digital camera and better proficiency in the use of SCS equipment during presentations. In order for this system to be effectively used in case conferences, it will be necessary to solve these problems in the future.

In conclusion, given its ease of operation, the SCS can be used satisfactorily in conferences or lectures *a longe* which center around CT or MRI images provided it can supply sufficiently precise resolution of each image. X-ray or angiograms are not suitable for use. However, the SCS will be most useful for images presented for reference rather than diagnostic purposes.

## ACKNOWLEDGEMENTS

The authors would like to thank the radiologists participating in the survey and conferences for their cooperation. The authors also thank Dr Zhixing Xu and Dr Jun Yang for their technical assistance for SCS operation.

## REFERENCES

1) Schwarz, M.R., Schaad, D.C., Evans, F.W. Dohner, C.W.: Communications satellites in health education and health care provision — The WAMI experience. *JAMA,* 250, 636–639 (1983).
2) Gunby, P.: Satellite hookup links major US military hospital with army physicians in Magadishu, Somalia. *JAMA,* 269, 1606 (1993).
3) Asakura, K., Hanamura, K., Takizawa, M., Sone, S., Takashima, S., Maruyama, Y. Hasegawa, M.: New telemedicine project uses of mobile station and satellite communication system. *The 3rd International Conference on the Medical Aspects of Telemedicine,* 165 (1997).
4) National Institute of Multimedia Education. Homepage of the National Institute of Multimedia Education, 1998 (http://www.nime.ac.jp/index-e.html).
5) Ota, Y., Ikeda, M., Yamauchi, K., Ishiguchi, T., Ishigaki, T., Itouji, E., Adachi, S. Hirota, S., Kohno, M.: Evaluation of the joint case-conference using the space collaboration system (SCS) between two universities. *17th JCMI (NOV., 1997),* 538–539 (1997).
6) URL http//square.umin.ac.jp/enkaku/96.
7) Xu, Z., Yamauchi, K., Ikeda, M., Yang, S. and Hasegawa, Y.: Evaluation of a PC-based teleconferencing system for reading chest radiographs. *Journal of Telemedicine and Telecare,* 5(2), 122–125 (1999).