Chapter

Empirical Study on Medical Information and Communication Technology System in Dentistry in Southeast Asia

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Abstract

In the field of dentistry, diagnoses based on data obtained using medical imaging modalities such as digital panoramic radiography and cone beam computed tomography (CBCT) have been widely recommended for advanced dental care. In Lao People's Democratic Republic (Laos), there are place where advanced dental imaging devices are available in only one university dental hospital. The establishment of an information and communication technology (ICT) system has been expected as telemedicine system, for sharing medical imaging data among medical institutions in Laos. Recently, regional medical cooperation using telemedicine has been developed in Japan, and medical imaging data have been provided and shared among medical institutions, by using a mobile tablet terminal application. Therefore, we have carried out the empirical research on the telemedicine system with the university in Laos. The technologies and research results from our project will be presented in this chapter.

Keywords: osteoporosis, medical ICT, cone beam CT, teleradiology, Lao People's Democratic Republic

1. Introduction

Telemedicine has great potential to address some challenges faced by both developed and developing countries in providing accessible, cost-effective, high-quality health care services [1]. It has been developed by such information and communication technologies (ICTs) in medical fields (medical ICT) [2–8]. However, there are few studies on the effect of ICT on dentistry in areas with low medical supply from a long-term

perspective. To build sustainable health care as set forth by the United Nations, it is necessary to conduct and present a case study on the role of ICT in medical care.

Therefore, this chapter reports the results of an international joint project that medical ICT was effective on clinical introduction of the digital imaging system in dentistry in Laos. The report of this project activity will state the importance of continuing human resource development in the field of international health care in the long term.

2. Medical ICT in telemedicine

ICTs have great potential to address some challenges faced by both developed and developing countries in providing accessible, cost effective, high-quality health care services [1]. Based on expertise, telemedicine uses medical ICTs to overcome geographical barriers and increase access to health care services. In Japan, at a broad level, telemedicine is divided into two types [9].

2.1 Telemedicine for patients

Medical treatment is provided to patients by the physician in charge. A patient at home interacts with the physician in charge located in a remote medical facility through the video telephone system. Simultaneously, based on the transmitted information, the physician in charge determines the physical and mental condition of the patient and the patient's medical treatment. This type of telemedicine is sometimes referred to as "telecare." "Telenursing" is an example of this type, where a nurse performs a key role and aids patients in home care.

2.2 Telemedicine between health care providers

This telemedicine is conducted primarily between the physician in charge and medical specialist and is referred to as "narrow sense telemedicine."

Besides, it is mainly classified into teleradiology, telepathology, teledermatology, and telepsychiatry. In WHO report, each field is defined as follows.

- Teleradiology is the use of ICT to transmit digital radiological images (e.g., X-ray images) from one location to another for the interpretation and/or consultation.

- Telepathology is the use of ICT to transmit digitized pathological results (e.g., microscopic images of cells) for interpretation and/or consultation.

- Teledermatology is the use of ICT to transmit medical information concerning skin conditions (e.g., skin tumors) for interpretation and/or consultation.

- Telepsychiatry is the use of ICT for psychiatric evaluations and/or consultation via video and telephony.

Of the four fields of telemedicine that were highlighted in the survey, teleradiology has the highest rate of established service provision. Teleradiology is built on the medical ICT system of diagnostic imaging studies from one location to another for conferences or consultations.

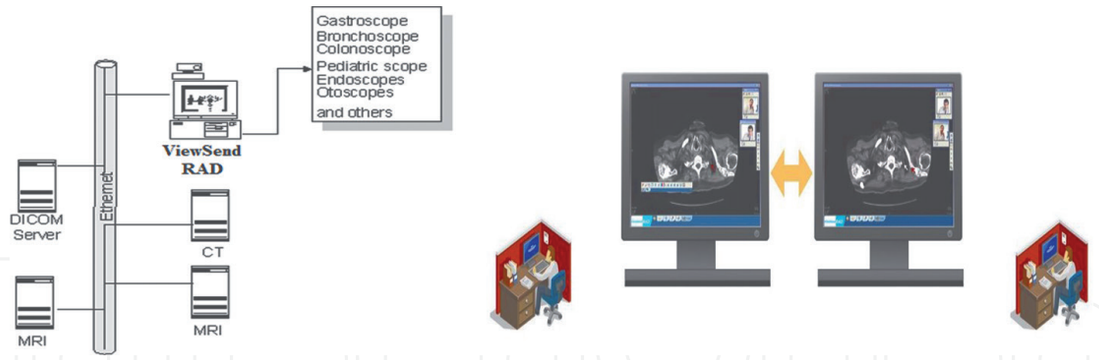

Figure 1.
Rapid application development system (RAD) developed by ViewSend ICT. ViewSendRAD provides a real-time 3-in-1 telemedsolution for telemedicine, tele-radiology, and videoconferencing. This product is designed to be a real-time software solution –collaboration, consultation, or training. These functions were advantageous to sharing information and deepening understanding of imaging data in the joint research.

In Japan, the teleradiology system is well used to support underserviced hospitals in the depopulated area to have timely access to a radiologist. Recent telemedicine research has developed the system that integrates functions of telemedicine and video conference (**Figure 1**).

3. Digital image processing of dent-maxillofacial radiographs

Digital panoramic radiography (DPR) and cone-beam-type of computed tomography (CBCT) were developed and patented by Nihon University School of Dentistry in the late 1980s and 1990s, respectively [10] (**Figure 2**). These technologies were transferred to Morita Corporation (Kyoto).

Regarding CBCT, Nihon University School of Dentistry obtained the Kinki Bureau of International Trade and Industry Regional New Industry Creation Technology Development Subsidy (1997–1999) to develop a commercial machine and pharmaceutical approval in 2001. CBCT allows three-dimensional diagnostic imaging of the teeth and inner ear. The National Health Insurance has covered it since 2012 in Japan, and since then, it has become an essential diagnostic imaging in dental care. Presently, CBCT machines are available at a rate of 1 per 10,000 people in Japan. We have installed the Veraviewepocs R100, a model of CBCT, at the University of Health

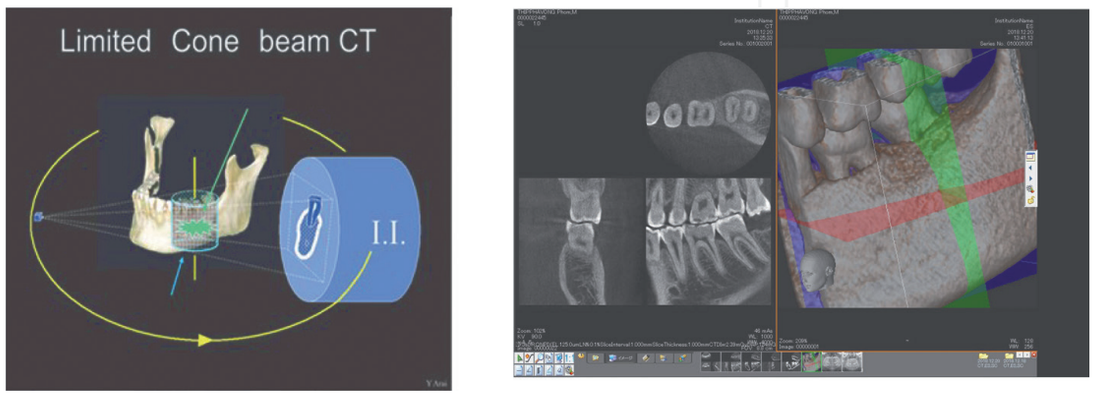

Figure 2.
Schematic diagram of the CBCT device used in this study. Left: measurement principle. Right: maxillofacial tomographic image. These figures are taken from Ref. [10].

Sciences (UHS). Veraviewepocs R100 can be used to perform panoramic tomography and CBCT. This CBCT has four types of fields of view (FOV): diameter of 4 cm and height of 4 cm, 4 cm × 8 cm, 8 cm × 8 cm and 10 cm× 8 cm. The optimal size of FOV was selected according to the purpose of diagnosis.

When FOV with a diameter of 4 cm and height of 4 cm is used, its dose is several times that of panoramic tomography but only approximately 1/100 that of conventional CT.

The spatial resolution of CBCT is calculated via the modulation transfer function using the wire method. It was as good as >10% at 2.0-line pair/mm. It was few times higher than that of conventional CT.

As described above, this device was characterized by low radiation dose and high resolution. It was optimized for dental practice. Currently, it has been further improved and provides detailed views of very fine anatomical structures in the head and neck, such as the temporal bone, paranasal sinus, eye sockets, jaw, and skull base. Consequently, it can be used for ENT (ear, nose, and throat) and plastic surgery, and all dental indications.

4. Digital medical imaging in Laos

Lao People's Democratic Republic (hereinafter referred to as Laos) is an Association of Southeast Asian Nations member country with a population of approximately 6.49 million (as of 2019) in a land area (approximately 240,000 km^2) equivalent to Japan's mainland [11]. There are 429 dentists in Laos. Among these, 153 have dental clinics in Vientiane city, and 72 work in the UHS (as of 2019). Compared to neighboring countries, there are scarce medical personnel and resources, causing delay of home medical care system for the elderly population.

Currently, as life expectancy increases, the needs for dentistry for the elderly population have become apparent (i.e., oral tumors, and periodontal disease) in the world [12]. Diagnostic imaging is becoming essential in the field of dentistry from the viewpoint of medical safety.

The DPR and the CBCT images have been widely used for diagnosing diseases in the complex maxillofacial area and have become indispensable for safe and secure medical care in the dental field [13, 14]. However, in Laos, DPR and CBCT are expensive, so only one pair of DPR and CBT devices are installed at the University of Health Sciences (UHS), which is the only medical university in the country. Thus, there has been an unsolved problem in the effective utilizing of the digital medical imaging devices in community medicine in Laos.

The establishment of medical ICT system has been expected to solve these problems of sharing digital imaging data among medical institutes.

Recently, regional medical cooperation using medical ICT has been developed in Japan [15, 16], and medical imaging data have been provided and shared using a mobile tablet terminal application among medical institutions [17]. Therefore, we were inspired to take advantage of medical ICT to solve the inconvenient situation of the CBCT in Laos, as the joint research project between Nihon University and UHS (Duration 2011–2020).

The outline of the project is as follows.

- Purpose: Our project aims to provide DPR and CBCT images to dentists by constructing the medical ICT network using smartphones and tablet type terminals (data terminal equipment) from UHS in Vientiane city.

- Based on the sustainability of effective utilization of this medical ICT, likewise, we have developed an approach of sharing information on digital medical imaging among dentist in Laos.

- Significance: Our project is important to demonstrate the accessibility of providing and sharing image data information between different medical institutions using medical ICT in Laos. As a result, the foundation of a medical ICT system utilizing data terminal equipment will be established in the Southeast Asian region, and a model for building the spread and deployment of Japanese-style medical care overseas will be created.

- Contents: We conducted technical training on medical ICT using data terminal equipment for university faculty members and then examine the problems and solutions to diagnostic situations based on medical ICT with them in Laos. Furthermore, we verify the economic effects of medical ICT in the country in collaboration with local dental institutions.

From the perspective of sustainability in the application of dental diagnostic imaging in Laos, we decided to gradually start technology transfer to clinical dentists through joint research among researchers. Our project started from the stage of clinical research as the first phase to empirical research as the second phase, utilizing the medical ICT system.

In this joint research project, we first trained clinical researchers for digital image on maxillofacial radiology in Laos. In the next stage, we supported researchers to create an environment where they could train radiology professionals.

5. Diagnostic imaging research (first phase)

5.1 Research purpose

Clinical research planning was conducted to clarify changes in the development and aging of the jawbone of Lao people by digital imaging via telemedicine. The research theme was a morphological study on the cortical bone of the mandible in Lao people, using digital panoramic images.

Osteoporosis is a major public health problem confronting both developed and developing countries [18, 19]. Osteoporosis can affect both children and adults and is especially detected in postmenopausal women. The typical clinical presentation of osteoporosis is the radiographic detection of bone fractures, largely in the absence of causative trauma. These fractures occur due to a reduction in bone mineral density and general reduction in bone mass. Osteoporosis is usually diagnosed by measuring bone mineral density of the spine or femur. Dual energy X-ray absorptiometry (DXA) is recommended for precise diagnosis of low bone mass. No DXA equipment is currently available in Laos. Recently, it has been reported that mandibular cortical bone thickness is associated with bone mineral density and can be an effective indicator for the diagnosis of bone litigation. Therefore, we are conducting joint research to create a standard mandibular cortical wide (MCW) in Laos. Our diagnostic imaging study aimed to establish the diagnosis technology for osteoporosis using digital imaging of the jawbone. To proceed with this study, an ICT system for diagnostic imaging between Japan and Laos was required.

5.2 Utilized ICT system

In most countries, such a medical ICT system has been developed with Picture Archiving and Communication System and enterprise communication in teleradiology fields.

We have already installed the teleradiology system (View Send ICT, Tokyo) between Japan and Laos (**Figure 3**). The definition of a network with built security complied with the Japanese Ministry of Health, Labour and Welfare "Guidelines for Security Management of Medical Information Systems" using Virtual Private Network encryption. We designed a system that does not cause information leakage. Under these research conditions, we conducted clinical research on dental imaging.

5.3 Outline of research projects

A conference was held in real time between researchers in Japan and Laos by sharing image information and using a TV monitor, utilizing the medical ICT function. Researchers shared information on morphological measurement of the teeth and jawbones on images (**Figure 4**).

In 2015, as part of a quality assessment of our teleradiology collaboration, Matsumoto et al. [20] evaluated the validity of patient information gathered during teleradiology, panoramic imaging technique at the Lao PDR UHS, and ability of Laotian oral and maxillofacial radiologists to interpret images and detect temporomandibular joint (TMJ) abnormalities [20]. A total of 2446 joints from 1223 radiographs were evaluated for TMJ abnormalities to compare the image interpretation abilities of Laotian and Japanese radiologists. They reported that the kappa coefficient was 0.836 for the comparison of the judgments of the two observers in detecting TMJ abnormalities on radiographs ($P < 0.01$), which was considered very good agreement. Based on these results, we started research on osteoporosis between Japan and Laos using digital imaging data as materials.

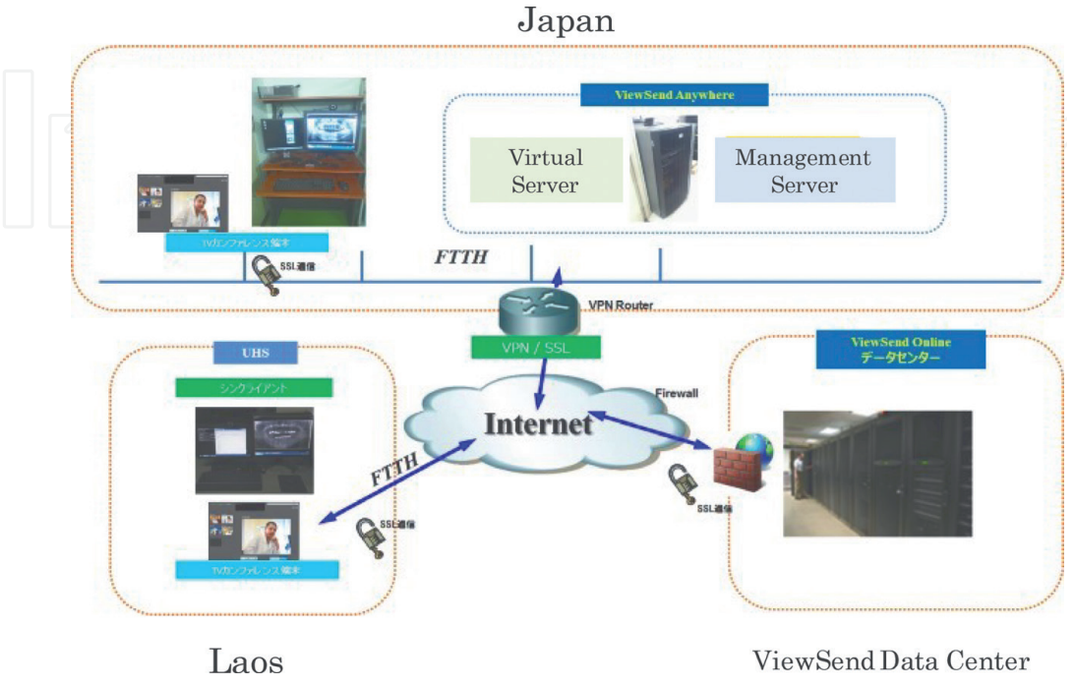

Figure 3.
Network overview of teleradiology in the first phase.

Figure 4.
Diagnostic imaging using medical ICT.

In the same year, Sisounthone et al. also established the average MCW in 519 Laotian subjects (age, 7–79 years; mean, 38.21 years) [21] (**Figure 5**). According to these results, the average MCW showed significant differences between all age groups. The average MCW in the youngest age group of 7–19 years was 2.90 ± 0.81 mm (range, 1.50–5.80), which was higher than the data obtained for the 4–6 years age group in this study. They also described a statistically significant sexual dimorphism in overall average MCW. In summary, the MCW of Laotian children aged 4–6 years increases slightly, but changes were more significant following adolescence.

In 2018, Souksavanh et al. established MCW standards for Laotian preschool children (4–6 years) at Vientiane [22]. According to their study, MCW increased slightly with increasing age but had no significant difference between age groups.

Moreover, the positive correlation between MCW and height was significant, but no significant correlation was noted between MCW and weight, suggesting that MCW in this period is not a useful indicator for the diagnosis of osteogenesis in children. They concluded that further studies were needed to examine if other panoramic radio morphometric indices could be more relevant in children.

In this way, the introduction of the medical ICT system has been shown to be effective tool in promoting international joint research in the field of medical imaging, indicating the possibility of effective calibration of image reading among dentists in Laos.

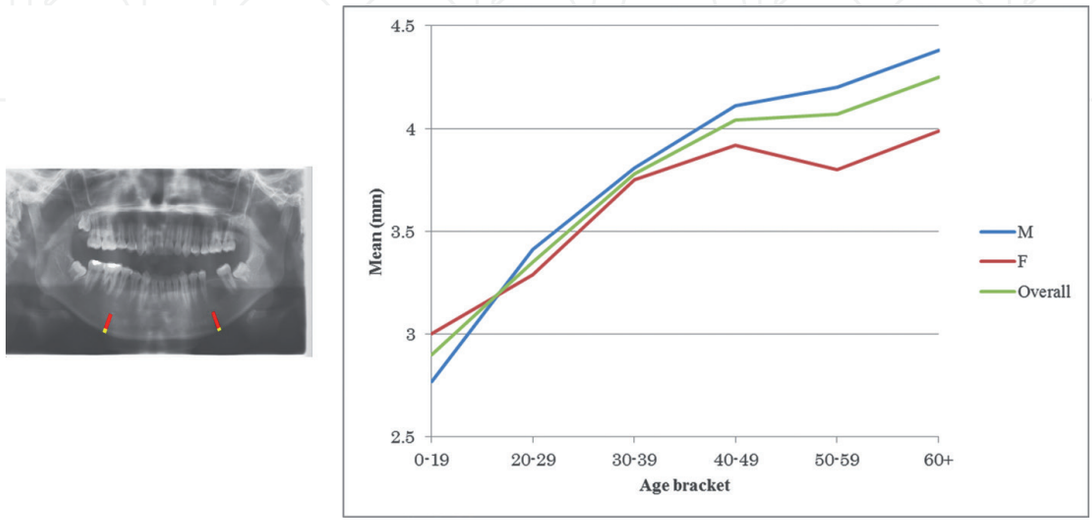

Figure 5.
Changing in MCW in Laotian people. Left: measurement of MCW. Yellow bars indicate MCW. Right: Changing of MCW in Lao people. These figures are taken from Ref. [21].

6. Clinical training for diagnostic imaging utilizing medical ICT (second phase)

6.1 Purpose of educational development

After previous research achievements, the foundation for clinical research using dentistry images was formed in Laos. We determined that the diagnostic imaging technique was shared between Japan and Laos, based on research achievements. As the second step, the educational system was developed to support the diagnostic imaging technique utilizing telemedicine for dentists in Laos.

The purposes of the medical ICT systems in the second phase were as follows.

- To determine the symptoms of stomatognathic lesions on digital images accurately.
- To operate medical ICT equipment correctly.
- To explain the symptoms to the patient using digital images adequately.

6.2 Utilized telemedicine system

Medical ICT is known to be developed to the point where image data can be shared with mobile tablet terminals/smartphones that use data terminal devices.

Recently, many studies confirmed the effect of tablet terminals in medical education. The use of mobile tablet terminals has an impact on how medical residents approach medical education, clinical practice, and patient education [23, 24]. The educational tool may be useful in collecting data on mobile tablet terminals used by other graduate medical education programs.

In 2018, as a clinical training tool, therefore, we adopted new ICT system, using the mobile tablet (View Send ICT, Tokyo). This system allows dentists to receive image data from a university hospital on a mobile tablet terminal in Vientiane city. This system created an environment in which the dentist who requested the diagnosis could view the image data anywhere in the city (**Figure 6**).

6.3 Project activities

The workshop was held with the Laotian collaborators who participated in the first phase as the main members. The purpose of the workshop was to transfer the techniques of digital image reading and telemedicine operation for faculty members.

A total of 72 faculty members enrolled in the digital medical imaging class in the Faculty of Dentistry, UHS (hereinafter referred to as the Faculty of Dentistry). Following the lecture of radiology, a hands-on seminar on medical ICT was held (**Figure 7**). In the seminar, the digital panoramic images were sent and downloaded as teaching materials from the medical image database of the Faculty of Dentistry of the UHS to the tablet terminal (iPad®), and the participants will be informed about the operative method of diagnostic imaging. Participants had the training of reading images using tablet terminal. Ten clinically experienced dentists were selected from the seminar participants. The dentist requests the dental radiology room of the Faculty of Dentistry to perform image examination by DPR or CBCT for the patient,

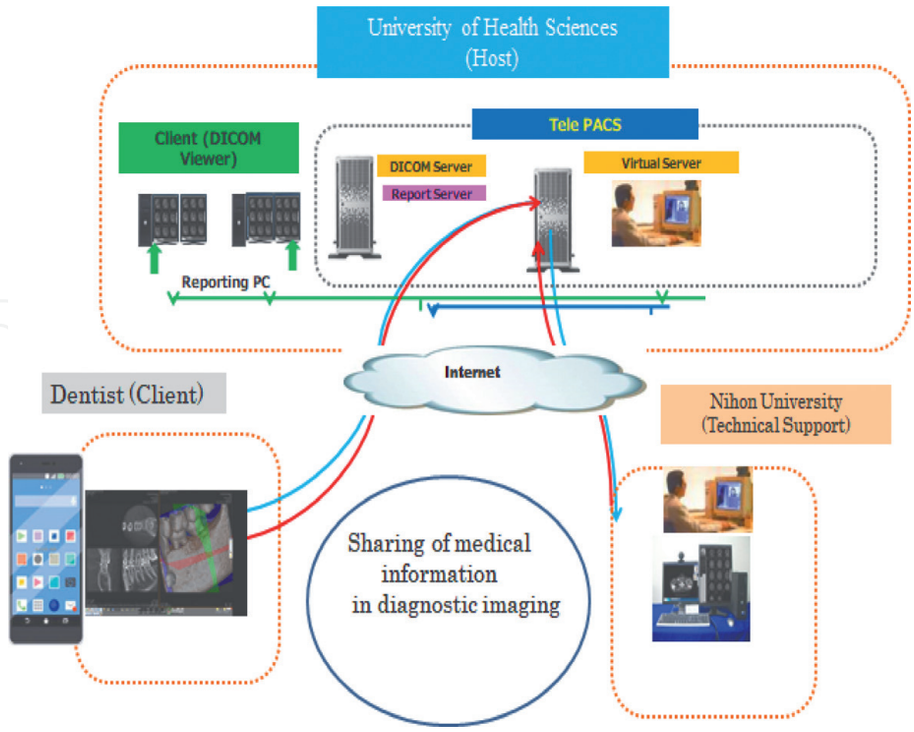

Figure 6.
Overview of the medical ICT system in phase 2.

Figure 7.
Medical ICT system using the tablet terminal. Left: Digital image data (A) are transferred through PC server (B) to the tablet terminal (C). Right: Workshop for dentists (teachers).

and always shares the image data with the tablet terminal. The dentist explained regarding oral diseases to the patient with a tablet terminal. The demonstration experiment period was 90 days.

6.4 Effect of clinical training

A total of 171 medical ICTs were used in all clinical departments in 3 months (66 actual days excluding holidays). Of these, the numbers of requests for CBCT and DPR imaging were 126 and 45, respectively. Medical ICT has been used in approximately 700 cases (January 2021). The average daily medical ICT utilization rate for all clinical departments was 2.6 cases/day. For example, in the case of dental hospitals

of Nihon University, telemedicine is used approximately 10 cases a month. Because of the difference in medical conditions in Japan and Laos, it is not possible to simply compare them, but the number of telemedicine cases in Laos tended to be larger. These results suggested the possibility that the use of DPR and CBCT in university hospitals has a positive effect on access to dental imaging in Laos. After this 90-day test period, we interviewed 10 hospital faculty members about the advantages and problems of telemedicine using the questionnaire (**Table 1**).

Respondents listed three points, "accuracy of diagnosis", "improvement in patient satisfaction", and "increase in the number of patients" as the effect of using telemedicine. The evaluation of medical ICT seemed to be positive. Use of tablet terminals may promote the sharing of digital medical imaging data between university hospital and dentists or dentists and patients, in the dental fields.

However, they pointed out three problems, "communication speed", "image accuracy", and "complexity of operations and the system". The reasons of these problems were the internet environment (low capacity) and operation of the mobile tablet terminal (inexperienced).

All respondents answered "Yes, I think so very much" for the question on the usefulness of telemedicine in their country. They seemed to understand the need for telemedicine through clinical training.

Given these results, we continued discussions to improve the problems of medical ICT in the hospital. As a result of the discussion, we were able to agree on problem extraction and countermeasures (**Figure 8**). As a future development, we will support the spread of digital medical imaging diagnosis by improving medical ICT under the plan-do-check-act cycle.

Question 1 Which is the effect of using telemedicine?	**Case**
a. Accuracy in diagnosis	6
b. Increase in number of patients	2
c. Improvement in patient satisfaction	5
d. Others ()	0
e. No change	0
Question 2 What are the problems to be solved in telemedicine system?	
a. Image data accuracy	2
b. Communication speed	6
c. Operation and system complexity	2
d. Number of imaging cases	0
e. No problem	0
Question 3 Do you think this telemedicine service is useful in Laos?	
a. Yes, I think so very much	10
b. Yes, I think so	0
c. No, I do not think so	0
d. No, I do not think at all	0

Table 1.
Advantages and problems of telemedicine.

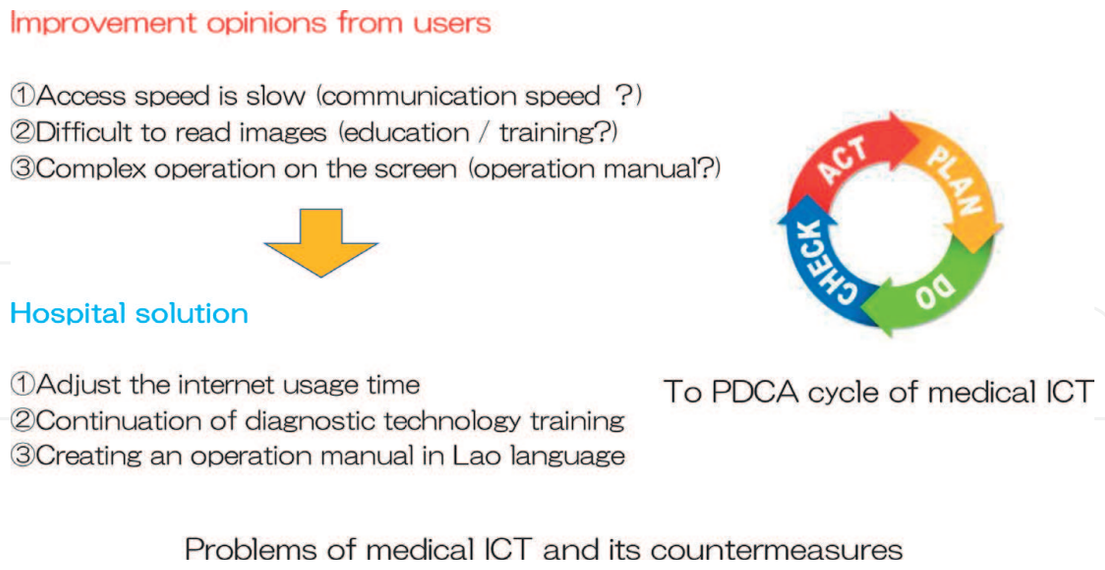

Figure 8.
Improvement of medical ICT system based on opinions from faculty members.

Outcome of this project that lasts 10 years suggest an importance to share the common goal of training specialists under the international collaboration.

For the introduction of medical ICT in community medicine, it is necessary to further examine the clinical evidence. As the further step, we will continue to develop the network of teleradiology in order to contribute sustainable oral health in Laos.

7. Conclusions

The results of our project show that information sharing of dental images by tablet terminals is effective in Laos. In this project, both Laotians and Japanese shared the common goal of training specialists. We concluded that teleradiology can usefully improve dental services in Laos.

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Conflict of interest

The authors declare no conflict of interest.

Notes/thanks/other declarations

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