DATA TRANSMISSION IN DENTAL IDENTIFICATION OF MASS DISASTER VICTIMS

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ABSTRACT

Dental evidence, especially from radiographs, has been found to be an effective method in personal identification. Previously, it has been shown that wireless personal digital assistants (PDA) can be used to transfer digitized radiographs. The purpose of this study was to set up a secure and reliable mobile connection for transferring dental digital images for disaster victim identification, and to test this new way of working in Phuket, Thailand, following the December 2004 Asian Tsunami disaster. Material and methods: Digital dental radiographs and clinical images were transferred in two separate sets using secured data transmission from a server in Finland to PDA terminals in Thailand. The mean size of the images in test 1 and test 2 were 90.7 kB and 88.1 kB, respectively. Results: The mean speed of the transmission was 3.7 kB/s with the Nokia 9500 and 3.4 kB/ s with the Qtek 2020i. The quality of all the pictures was found to be good enough for dental identification purposes. Conclusions: Wireless personal digital assistants (PDA) together with data secure transmission of digital clinical information could be used in order to assist in disaster victim identification in areas where GSM cellular networks are available.

(J Forensic Odontostomatol 2007;25:17-22)

Keywords: dental identification, data security, forensic information technology, telemedicine

INTRODUCTION

In December 2004 the Asian Tsunami disaster resulted in devastation of nature, infrastructure and people. More than 200,000 people were killed when the earthquake triggered giant waves that hit twelve countries around the Indian Ocean. In January 2005 the Thai Tsunami Victim Identification Information Management Centre (TTVI IMC) was established in Phuket, Thailand. The task of the centre was to collect the antemortem and postmortem data and carry out the comparison of those in order to identify the bodies.[1]

Dental evidence was found to be a particularly effective method of personal identification in the Thai Tsunami disaster.[2,3] Dental x-rays and clinical photos are an accurate means of positive identification. Digital images can readily be transferred via an information network. However, new information and communication tools have been used to quite a limited extent for the identification of mass disaster victims.

Previously, it has been shown that a wireless PDA, based on a GSM digital cellular phone, can be used to transfer digitized radiographs. A remote consultation link had been built with readily available technology, which was useful in radiological consultations for CT images.[4,5]

The purpose of this study was to set up a secure and reliable mobile connection for transferring dental radiographs and clinical images for disaster victim identification and to test this technology while working in the TTVI IMC in Phuket, Thailand.

MATERIALS AND METHODS

Two PDA terminal devices for image reception and viewing were used for the trial. The first was a Nokia* 9500 Communicator with Nokia mobile VPN client weighing 230 g and with dimensions of 148 x 57 x 24 mm. The device had full keyboard and two 65,536-color displays, tri-band operation for use on five continents and 80 MB built-in memory, and support for additional memory with MultiMediaCard (MMC). Nokia 9500 Communicator operated on Symbian 7.0S OS, Series 80 platform, Java MIDP 2.0 and Personal profile 1.0. In addition it had high-speed data connectivity with EGPRS (EDGE) and Wireless LAN access (WiFi, IEEE 802.11b, 2.4 GHz). The device was equipped with mobile e-mail with attachments and HTML 4.01 / XHTML browser. Security solutions were as follows: Device Lock, MMC Password Lock, OMA DRM 1.0 Forward Lock,

* Nokia Ltd., Helsinki, Finland

Fig.1: *Example of a typical radiograph used for dental identification*

SSL 3.0/TLS 1.0, Ipsec, 802.11 WPA 1.0/WEP, Operator WLAN/EAP SIM for Wireless LAN security, Java MidP 2.0 Full Security Domain, Cisco CCX Compliance and Nokia mobile VPN client. The device also had integrated VGA camera, video recorder and multimedia messaging (MMS).

The second PDA device trialed was Qtek 2020i**. It weighed 190 g and its dimensions were 60.9 x 130 x 18.2 mm. The device operated on Microsoft Windows Mobile system, Pocket PC 2003 2nd edition. It had Intel® Bulverde 520Mhz processor and memory capacity was standard 128MB ROM and standard 128MB SDRAM. The liquid crystal display was a sensitive touch screen of 3.5" transflective TFT-LCD with Back Light LEDs, 64K colours, and with the resolution of 240 x 320 pixels. In addition the device had CMOS camera of 1.3 mega pixels and colour resolution VGA (480 x 640). Qtek 2020i was equipped with Celesta file transfer software.[§] The forensic dental expert was given a half hour training session in the use of the equipment.

Altogether 21 digital images of Finnish voluntary test persons were transferred in two separate sets. There were 12 radiographs, consisting of five orthopantomographs, four periapical and three bite-wing radiographs. The total number of digital clinical photos was nine. Radiographs represented typical cases used for dental identification (Fig.1). Clinical images represented cases which could assist identification of a disaster victim. The image properties of the original images are shown in Table 1.

In order to reduce the time required for transmission, the original images were compressed with a JPEG (Joint Photographers Expert Group) algorithm. The mean size of the images in test 1 and test 2 were 90.7 kB and 88.1 kB, respectively (range 26-153 kB and 28-153 kB, respectively). An experienced forensic dentist evaluated the usability of images for dental identification purposes. An experienced radiologist evaluated the quality of the radiographic images both before and after compression. The criteria used in evaluation were the quality of contrast and sharpness of the images in order to recognize tooth morphology, restorations and bone structure.

Secured data transmission to pocket terminals was tested in Phuket, Thailand. In test 1 the transmission was done with webmail over a secured connection (https) with Nokia 9500 Communicator. In test 2 images were transferred from a private Web server in Finland to Qtek 2020i terminal as simulating the situation of secured transmission of data from the server of the National Bureau of Investigation to a disaster management site. After transmission the images were saved at the mobile devices.

** HCT Corporation, M-Technology Ltd, Oulu, Finland

§ Celesta MDO Mobile Data Organiser, CCC Mobile Ltd., Oulunsalo, Finland

Table 1: *Image properties*

	Pantomographs	Intraoral radiographs	Clinical images
Original size (pixels)	2570 x 1248	1262 x 1640	768 x 576
Resolution (dpi)	72	72	72
Original colours (BitsPerPixels)	24	8	24
Number of unique colours	256	256	256
Current memory size (Mbytes)	9.18	2.03	1.30

RESULTS

The mean speed of the transmission was 3.7 kB/s in test 1 with the Nokia 9500 Communicator and 3.4 kB/s in test 2 with the Qtek 2020i (range 1.7 to 4.6 kB/s and 0.8 to 6.7 kB/s, respectively). The average total image transmission time was 30.4 sec (range 19.7 sec to 43.9 sec) in test 1, and 25.7 sec (range 23.0 sec to 37.0 sec) in test 2. There were no disconnections during the test transmissions. After transmission, the images could be successfully saved at PDA devices for possible further use.

The quality of all dental radiographs was found to be sufficient to allow dental comparison. The personal digital assistants were found to be light, easy to carry and easy to use by a forensic dentist who was familiar with using a personal computer, mobile phone, email and Windows applications.

DISCUSSION

Personal identification was the major task of forensic experts, including odontologists, in the aftermath of the Asian Tsunami. Identification of disaster victims can be done by visual identification, circumstantial evidence and physical evidence. In several disasters it has been seen that among the physical evidences, dental data are the most effective method of identification, followed by fingerprints and DNA.[6] In the Estonia ferry accident (1994) identification was established by dental means in 60% of the deceased.[7] The contribution of forensic odontology to tsunami victim identification was indisputable.[1] However, the process still could be improved with the use of modern technology.

Kieser *et al*. [8] found significant sources of error in antemortem and postmortem data. In their study, of the 78 postmortem records received from the morgue, only 68% of radiographs and 49% of photos confirmed the accompanying dental charting. This underlines the value, particularly of clinical photographs, in quality control. Of the 106 antemortem records received, 64% were either not accompanied by radiographs or had poor quality radiographs.

Dental radiographs are important data for comparison for personal identification. However, without correct notes on the original picture, it might be very difficult to distinguish left from right side from the radiographs. The first author has personally faced this problem in Thai Tsunami Disaster identification tasks, as well as in some previous identification cases.

In health care, teleradiology has been used for many years in remote consultations.[9] The greatest benefits have been shown in neurological emergencies.[10] Wireless PDA based on a GSM digital cellular phone has been used to transmit images to neuroradiologists.[5] In the studies of Reponen *et al.*[4,5] the neuroradiological diagnosis from transmitted images did not change after a later review of the original images in 97% of cases. In various studies it has been shown that a compression ratio of 1:10 to 1:15 does not affect the diagnostic quality of radiological images.[11,12] In this study the compression ratio was 1:5. Most often dental comparison for personal identification is based on dental hard tissue and dental materials such as gold or amalgam, which are easily visible in radiographs. Tooth colored dental materials are more challenging for diagnosis from radiographs. Where there is uncertainty in decision-making based on compressed pictures, the final conclusion should be made from the original radiographs.

In the Thai Tsunami Disaster Victim Identification process only Finland and Sweden delivered all the antemortem data in digital form. In Finland the collection of antemortem data and sending it to Phuket, Thailand, in digital form could be done in a few weeks.[13] The use of wireless connections and mobile equipment in the aftermath of mass disasters would offer a fast and flexible way to collect the data at the disaster site, transmit the data from home countries, and carry out the identification at the information management centre (Fig.2). The simulation of the system was carried out successfully with personal digital assistants in this study. Similar protocol could possibly be used also for the postmortem personnel.

DVI Systems International[§§] was the software used in Thai tsunami identification.[14] It operates on the PC

§§ Plass Data Software, Holback, Denmark

Windows platform, and it is one of the few internationally approved systems. It is capable of managing aspects of identification in day-to-day cases and major disasters, where it has particular advantages when victims of several nationalities are involved. The system uses Interpol forms as standard protocols for input and transfer of antemortem and postmortem information. Digital images transferred with the system tested in this study could be imported to DVI System International, and used for personal identification.

When widely available network tools are used and confidential patient data are transmitted, the privacy and data security should be high. Confidentiality of communications should be guaranteed in accordance with the international protocols relating to human rights. According to the Directive on privacy and electronic communications[15] of the European Parliament, new advanced digital technologies give rise to specific requirements concerning the protection of personal data and privacy. The successful cross-border development of the digital mobile services is partly dependent on the confidence of users that their privacy will not be at risk. Efforts have been made in the European Union[15] and other countries[16-19] to create national and international standards for the procedures and technology for protection of privacy in the electronic communications sector. Coordinated activities related to public health information architecture, standards, confidentiality, best practices, and research will be needed by all parties to improve the protection of privacy and confidentiality.[19] The privacy technology used in this study was the state of the art technology at that time.

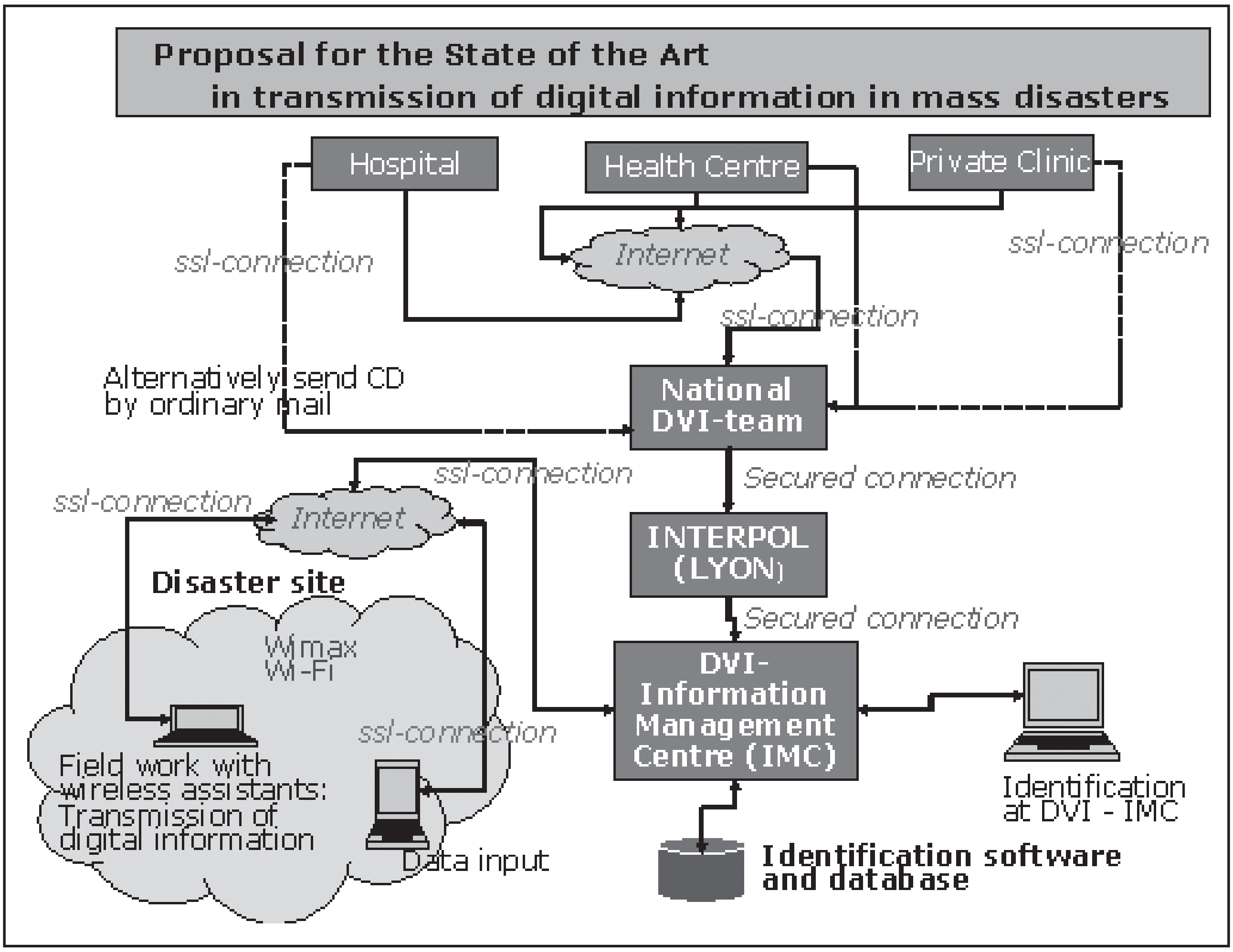

Fig.2: *Proposal for the State of the Art in transmission of digital information in mass disasters. Abbreviations: DVI, Disaster Victim Identification, SSL, Secure Sockets Layer, Wimax, Worldwide Interoperability for Microwave Access, Wi-Fi, Wireless Fidelity*

The modern portable technology is small enough to be carried at disaster sites, allowing equipment with updated databases rapid transmission of data from the morgue to the information management centre. However, there is a risk of losing portable devices, which might cause a serious risk for data privacy. Therefore, it would be important to assure that the mobile device is equipped with authorized access, user identification and password. Most often the weakest link in protection of privacy is not the technology but the human factor.

In this experiment the GSM network could be used. In some disasters, the use of GSM in the first stage might not be possible due to large devastation of the infrastructure. There exist also other global possibilities for wireless communication, such as mobile satellite services.[20] The usage of satellite communications for telemedicine was first introduced during disasters in mid 1980's.[21] However, the disadvantage compared to cellular networks is the higher price and lack of integrated PDA devices. In this study there were no interruptions during the data transmission. However, in a real scenario where there is a large volume of data to be transferred, some problems might occur.

CONCLUSION

In conclusion, wireless personal digital assistants (PDA), together with data secure transmission of digital clinical information, could be used in order to assist in dental identification of disaster victims in areas where GSM cellular networks are available. Based on experience in this study, both Nokia and Qtek systems provided good data transmission capability.

The usage of transmitted, compressed images might hasten the identification process, and help to use investigation resources more rationally. The greatest benefit would be the fast transmission of digital data to the information management centre of the disaster site, and secondly, the added value of being able to collect and/or use the data for identification at temporary morgues without fixed telecommunication lines.

ACKNOWLEDGEMENTS

The National Bureau of Investigation of Finland is acknowledged for making it possible to carry out the study in Phuket, Thailand. Nokia Ltd. and Celesta, CCC Group are acknowledged for providing the equipment and software.

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