บทความปริทัศน์
Review Article

A Critical Role for Forensic Odontology in Disaster Victim Identification: the Tsunami Aftermath in Thailand

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ชม.ทันตสาร 2549; 27(1) : 17-24
CM Dent J 2006; 27(1) : 17-24

บทคัดย่อ

เหตุการณ์ธรณีพิบัติและคลื่นยักษ์สึนามิได้นำมาซึ่งความสูญเสียอย่างใหญ่หลวงต่อคนไทยและชาวต่างประเทศจำนวนมาก ปัญหาที่สำคัญมากที่สุดข้อหนึ่งที่ส่งผลกระทบโดยตรงต่อรัฐบาลไทยคือ การพิสูจน์เอกลักษณ์บุคคลของผู้ที่เสียชีวิตจำนวนมากในเหตุการณ์ดังกล่าว งานพิสูจน์เอกลักษณ์บุคคลในเหตุการณ์ครั้งนี้ทำให้ทันตแพทย์ที่เกี่ยวข้องได้ตระหนักถึงบทบาทหน้าที่ของตนเองในการทำงานทางด้านนิติทันตวิทยาขึ้นมาเป็นครั้งแรก ในบทความนี้ผู้นิพนธ์และคณะจึงได้อธิบายบทบาทและขั้นตอนการทำงานที่สำคัญของทันตแพทย์ในการพิสูจน์เอกลักษณ์บุคคลจากศพที่เสียชีวิตจากเหตุการณ์สึนามิ ซึ่งรวมถึงการตรวจฟันและการบันทึกข้อมูล ตลอดจนถึงการนำฟันมาใช้ในการสกัดสารพันธุกรรม ถึงแม้เหตุการณ์ที่ผ่านมาจะมีอุปสรรค ความยากลำบาก ความท้าทาย และข้อจำกัดจำนวนมากมาย แต่ทันตแพทย์ไทยก็ได้แสดงบทบาทความเป็นผู้นำทางด้านนิติทันตวิทยาได้เป็นอย่างดี อย่างไรก็ตามบทเรียนต่างๆ ที่ได้รับการภัยพิบัติสึนามิครั้งนี้ ควรที่จะได้นำเอาไปศึกษาเพิ่มเติมหรือนำไปใช้สำหรับเหตุการณ์ภัยพิบัติหมู่ที่อาจเกิดขึ้นได้ในอนาคต

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Abstract

The tsunami catastrophe occurring in the six southern Andaman coast provinces of Thailand in December 2004 immensely impacted not only many local Thai people but also foreigners from various countries. One of the major problems directly confronting the government was how to identify the large number of dead bodies. This challenging task caused many Thai dentists involved in this mass disaster to recognize their critical role in forensic odontology for the first time. We here, therefore, addressed an important role of dentists in forensic identification as conducted for tsunami victims, including dental examination and recording and using teeth as a source of DNA. In spite of impediments, difficulties, challenges and limitations, Thai dentists had shown their leading role in forensic odontology. Yet, many lessons learned from the tsunami catastrophe should be further explored and used for any possible mass disasters in the future.

Key words: dentist, DNA, forensic odontology, Thailand, tsunami

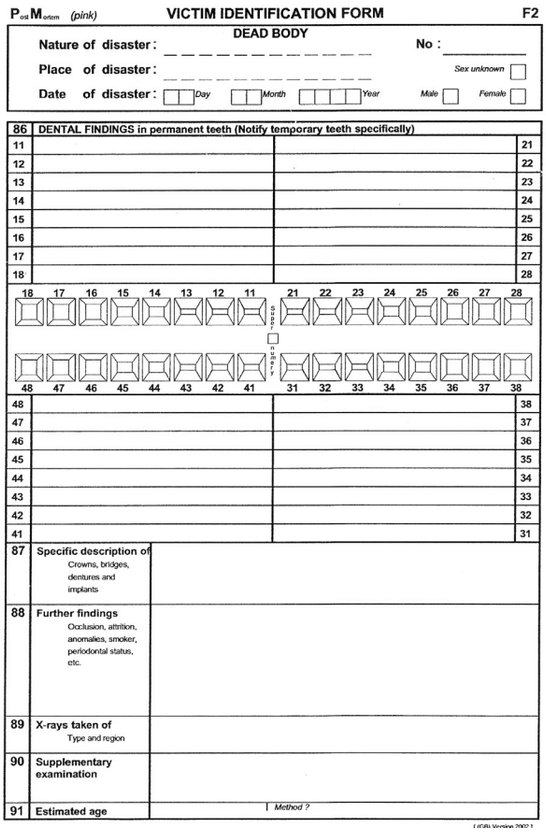
Introduction

During the apparently serene morning of December 26, 2004, people who lived in the six southern provinces of Thailand along the coastline of the Andaman Sea encountered one of the worst natural disasters the world has ever seen, a tsunami. Although the gigantic waves claimed thousands of lives, Thai as well as foreign, the Thai people witnessed media reports of unceasing generosity within Thailand and from all over the world to help badly affected Tsunami victims. In particular, health personnel in every area from both government and private hospitals treated injured Thai and foreign victims. The badly injured victims were transferred to many private hospitals in Bangkok. Although Thailand could deal with the injured survivors effectively, we were faced with a new problem we had never before seen, i.e. to identify a large number of dead bodies simultaneously in this chaotic situation. With help from several forensic teams, this problem was tackled systematically. However, the lesson of this disaster was that Thailand needed to significantly improve the capacity of all involved Thai organizations to deal with rescue and recovery, management of relief efforts for the victims, and the system of both medical and dental forensic identification of bodies. As part of the health professional community, we as dentists helped identify the bodies by conducting forensic dental examinations, including making radiographs and photographs, recording the findings, and extracting teeth for subsequent DNA identification. Indeed, more than 500 dentists representing the Thai Dental Council volunteered to serve in the disaster area. With all kinds of joint efforts from people in Thailand and around the world, the situation and people's lives in the disaster areas have gradually been returning to normal. The purpose of this article was to present significant roles of dentists in dead body identification, particularly in the aspects of dental examination and recording and of using teeth as a source of DNA. Other aspects, such as forensic pathology, fingerprinting, etc., were not dealt by this report and can be found elsewhere.

Forensic identification as conducted for tsunami victims

The process of identification started when the body was brought into the mortuary (Fig. 1) and followed the INTERPOL Victim Identification protocol, using the 2002 version of Interpol forms. The forms consist of several sections and are divided in two groups: 1) the Yellow form (Antemortem, AM, form) for listing the latest known data concerning a missing person and 2) the Pink form (Postmortem, PM, form) for listing all findings concerning a dead body (Fig. 2). There was a checklist of operations, carried out in the following sequence 1) four photographic views of the body, 2) fingerprints or palmprints, 3) autopsy, 4) removal of rib and femur for DNA analysis, 5) dental examination and recording, 6) tooth extraction for DNA analysis, and 7) a quality control evaluation.

Figure 1 *The temporary mortuary established at Wat Yan Yao, Pang-nga Province where bodies of the victims were initially brought and collected for identification.*


P$_{os}$M$_{ortem}$ (pink) VICTIM IDENTIFICATION FORM F2

DEAD BODY

Nature of disaster : No :

Place of disaster : Sex unknown

Date of disaster : Day Month Year Male Female

86	DENTAL FINDINGS in permanent teeth (Notify temporary teeth specifically)	
11		21
12		22
13		23
14		24
15		25
16		26
17		27
18		28

18 17 16 15 14 13 12 11 21 22 23 24 25 26 27 28

48 47 46 45 44 43 42 41 31 32 33 34 35 36 37 38

48		38
47		37
46		36
45		35
44		34
43		33
42		32
41		31

87	Specific description of Crowns, bridges, dentures and implants	
88	Further findings Occlusion, attrition, anomalies, smoker, periodontal status, etc.	
89	X-rays taken of Type and region	
90	Supplementary examination	
91	Estimated age	Method ?

Figure 2 *F2 form for dental recording consists of the odontogram and tables on which to be recorded in words, details of sex and dental findings.*

Dental examination and recording

The dental examination and recording were performed by the dental team after the postmortem examination performed by forensic pathologists. The dental team included at least two dentists: one worked as a "dirty-handed" dentist, but wearing protective gown, head-covering, mask, glasses and gloves, who would be responsible for all aspects of the dental examination, and another as a "clean-handed" dentist, who would be responsible for recording data and would at no time touch the body. This aspect of the protocol was to minimize the risk of contaminating the body with material from any other source. The procedures began with rinsing and cleaning the teeth and making photographs of the dentition and occlusion. An occlusal view of each jaw and a frontal view of both jaws with teeth together were made (Fig. 3). A sand bag was used to keep both jaws together because the mandible was already dissected by the forensic pathologists. The INTERPOL Victim Identification form, sections F1 and F2 (Pink form), was used to record the forensic dental examinations. General dental findings were recorded on the F1 form, whereas detailed findings were recorded on the F2 form including a dental charting. After making photographs, the "dirty-handed" dentist performed a dental examination of the dentition and called out the findings in detail, while the "clean-handed" dentist recorded them using the three-letter code from the INTERPOL Disaster Victim Identification (DVI) protocol. Any alterations found in the victims' oral cavity, such as tooth alignment (tilting, rotation, etc.), morphology, restorations (crowns, bridges, dentures and orthodontic appliances, fillings/inlays, implants, and root canal treatments), diseases (dental caries, periodontal or other lesions), etc., were charted and recorded on the F2 form. To verify the accuracy of the examination, the "clean-handed dentist" called out the recorded data to the "dirty-handed dentist," who checked them against the oral cavity. Removable dentures or any personal belongings were placed in a sealed plastic bag, which was labeled and placed in the same bag as the body (Fig. 4). At least two bitewing radiographs and selected periapical views were made of teeth with root canal treatments, crowns, or bridges (Fig. 5). A portable x-ray machine was used for this task and radiographs were processed in an automatic processor. Information from radiographs was then recorded. After the record of the dentition was completed and verified, at least two teeth were extracted for DNA analysis. Posterior teeth without any restoration were preferred. This step was carefully performed with a

sterile technique in order to avoid contamination of any genetic materials from other sources. The teeth were cleaned with alcohol, dropped into a clean container, and sealed with evidence sealing tape. All samples (rib, femur, and teeth) used for DNA extraction from each body were kept together in a sealed plastic bag and labeled. Subsequently, the records and the specimens were kept separately from the bag of the body. All information was scrutinized for completeness at the end of the procedure by a quality control team before the body was returned to a refrigerated storage container. All of these data were later transferred into a database, using a computerized matching program, PLASS Data software[1].

Figure 3 *A, The frontal view of the jaws showing the maxillo-mandibular relationship. B, the occlusal view of the resected mandible. Amalgam fillings on the molar teeth are noted. This information can be matched with AM dental records.*

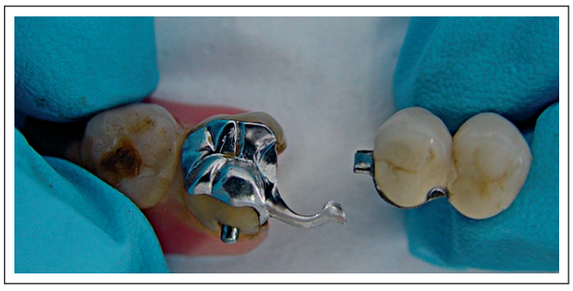


Figure 4 *A pair of partial dentures obtained from one of the victims.*

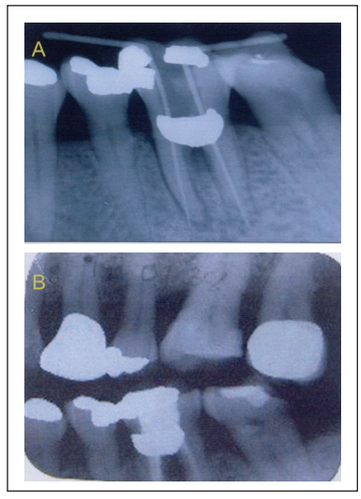


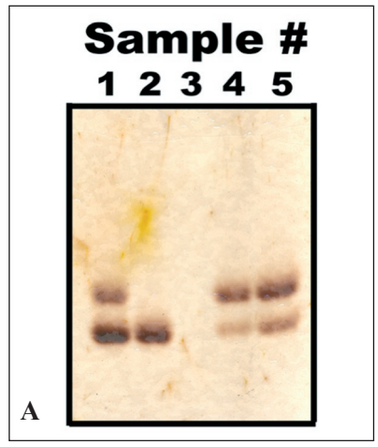
Figure 5 *A, The AM radiograph of one of the victims shows restorations on the lower left premolars and the first molar that match with the PM radiograph, B.*
B, The PM bitewing radiograph shows a complete root canal treatment of the first molar that matches with the AM periapical radiograph revealing the first molar being endodontically treated.

Teeth as a source of DNA

To extract DNA from teeth, the tooth crowns were separated from their roots. The method of DNA recovery from human teeth was modified from Sweet and Hildebrand (1998)[2]. Briefly, the roots were mechanically ground into powder with a mortar and a pestle in the presence of liquid nitrogen. The root powder was then transferred into a 1.5-ml micro-centrifuge tube containing 1 ml of DNase-free distilled water. The tube was centrifuged and the supernatant was aspirated. Subsequently, Chelex (Sigma, St. Louis, MO, USA) suspension (20% W/V in water) was added into the root powder and 2 µl of proteinase K at 10 mg/ml was added into the mixture. This step was modified from Walsh et al (1991)[3]. The mixture was then incubated, boiled, and centrifuged. The

supernatant containing the DNA template was carefully removed for further polymerase chain reaction (PCR) analysis

To verify the DNA integrity in each sample, PCR was conducted using specific primer pairs of amelogenin gene that was located on both X and Y chromosomes. PCR products were resolved on a native high-resolution 8.5% polyacrylamide gel (PAGE), and the gels were then stained with silver and dried on blotting paper[4]. It was found that the sex of the victims as well as the DNA integrity could be identified (Fig. 6A). To further identify the victim by investigating microsatellite DNA typing from teeth, PCR was conducted for 40 cycles using specific primer pairs that located 5′ upstream and 3′ downstream of microsatellites from different chromosomes[5]. Microsatellites are short DNA fragments about 100 bases in length on human genome that contain multiple copies of repeated sequences, such as tetranucleotides (AATG), etc. This feature makes personal identification possible by examining different patterns of DNA fingerprints, which are unique between individuals. In addition, typing DNA microsatellites is an appropriate method for partially degraded DNA recovered mostly from decomposed tissue of dead bodies. PCR products were run on the gel along with allelic ladders by combining different known alleles, which were used as DNA templates for PCR. An example of microsatellite DNA typing on 5 loci is shown in Fig. 6B, and the results demonstrated different sizes of PCR products between victims. Collectively, these indicated that DNA could be successfully recovered from teeth, and cross-contamination was unlikely to happen as a result of different DNA profiles between victims. Our DNA extraction method from the root could, therefore, be an alternative method of DNA extraction from the whole tooth and might be another tool in conjunction with dental and oral examinations and radiography in body identification.



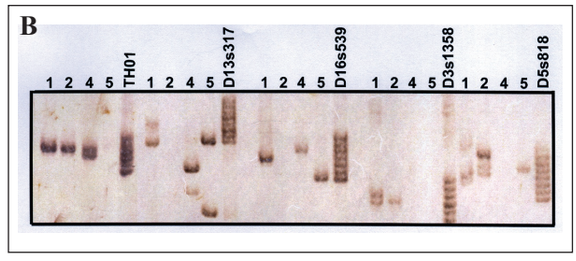


Figure 6 *A, Sex identification. PCR was conducted for 32 cycles using a specific primer pair for an amelogenin gene. The sex could be identified from four victims. Whereas the sex of victim#2 is female (one band), that of victim #s 1,3, and 4 is male (two bands).*

B, Microsatellite DNA typing from victims' teeth. PCR was conducted for 40 cycles using specific primer pairs that located 5' upstream and 3' downstream of microsatellites from 5 loci on different chromosomes including HUMTH01, HUMD13s317, HUMD16s539, HUMD 3s1358, and HUMD5s818, and the results showed different sizes of PCR products.

Antemortem and postmortem data matching and body release

Dental findings, fingerprints, and DNA are regarded as primary evidence of positive identification, whereas physical findings and personal effects or belongings are regarded as secondary evidence. Comparison of AM and PM radiographs, in particular, is claimed to be the most accurate and reliable method of identifying remains since unique and distinctive shapes of restoration, root canal treatments, buried root tips, bases under restorations, tooth and root morphology, and sinus and jawbone patterns can be identified thoroughly only by radiographic examination[6].

Comparisons of the AM and PM dental records were performed with the aid of PLASS Data software. For each record, the program assigned a search value for each tooth according to its observed conditions, e.g. a tooth with distinctive characteristics, such as a metal crown had a score of 6, a root-canal-treated tooth a score of 4, and a sound tooth a score of 0, etc. The program then produced a list of possible matches according to the total search value of each record.

The dental matching team consisted of two dentists who reviewed all relevant AM and PM data of the possible matches. The results of the dental identification process were recorded as established, probable, possible, or insufficient evidence, and were presented at the Identification Board. The Identification Board, including the chiefs of each specialized section, i.e. photography, fingerprints, properties, medical, dental, and DNA, was headed by the Director of Victim Identification. This board was responsible for the final identification and body release of each individual victim.

Discussion and lessons learned

Although the worst situation of the tsunami disaster in Thailand has already passed by, the task of disaster victim identification remains. The Thai DVI team encountered many problems, difficulties and limitations. We have collected and scrutinized those problems, particularly as they related to forensic odontology and provide some suggestions that may be useful for future mass disasters as follows.

1. Several studies have shown that dental records provide fast, reliable, and relatively inexpensive personal identifications of a large number of victims[7-10]. As of March 14th, 2005, approximately 91% (793/872) of the positive identifications came from dental findings (Dr. Paisan Kangvonkit, Secretary General of the Thai Dental Council, personal communication), confirming findings of previous reports. The above data are principally applicable to victims from foreign countries where AM dental data of victims are rather complete and available. Unfortunately, AM dental data of Thai victims are poorly recorded resulting in a large number of unidentified Thai bodies. We suggest that DNA matching either from teeth or other parts of the body may be useful in identifying the remaining Thai bodies.

2. The dental profession as a whole can play significant roles in mass disaster victim identification. Dentists should keep accurate dental records and provide all necessary information so that legal authorities can use those records and relevant information for AM and PM data matching. Upon PM examination, dental personnel can be helpful in recording all dental information of the deceased. It is recommended that the dental record as well as the results of clinical laboratory tests, photographs and radiographs be kept for 7 to 10 years[6].

3. As emphasized in this article, teeth may be an alternative source of DNA. In fact, various parts of the bodies of the tsunami victims, including teeth, have been collected for DNA extraction. Unfortunately, DNA extraction from teeth mainly performed by Chinese laboratories appeared fruitless. We speculate that the negative results might have resulted from the use of dental pulp for DNA extraction. (Dr. Siribang-on Piboonniyom Khovidhunkit, personal communication). We, therefore, conducted a pilot study and found that the tooth root was a better and more reliable tissue for DNA extraction[11]. Further studies on the use of tooth roots for DNA extraction and personal identification are in progression at the Center for Personal Identification, Faculty of Dentistry, Chiang Mai University, Thailand. So far, the results have been very promising. Tooth extraction from the bodies of victims should, therefore, be recommended as a standard protocol for DNA examination.

4. Thai DVI team was challenged with the biggest mass disaster this country had ever seen when they worked on identifying victims of the tsunami of December 2004. Although, the Dental Council of Thailand gathered more than 700 volunteers to work on the cases, a lack of experience and training in forensic odontology led to some poor radiographic and photographic quality and unacceptable dental charting. Kieser et al[10] reported that of the 78 PM records received while working as part of the New Zealand DVI team based in Phuket, Thailand, only 68% of radiographs and 49% of photographs confirmed the accompanying dental charting. They suggested that in the future there should be controlling agencies to prescreen volunteers for training, knowledge and experience to help set a uniform standard among volunteers. The administrative agency should also distribute the newest version of the Interpol identification forms for the training and usage. The standard operating procedures (SOP) and quality protocols should be routinely discussed at briefing and debriefing sessions at all working sites. There should also be formal induction sessions for newly arrived volunteers at the location of the PM examinations including an overview of the operation, its command structure, SOPs and quality control protocols.

4. We suggest that the National Center for Missing Persons, Royal Thai Police Department, being established, should take the initiative to set up a complete Thai DVI team composed of persons knowledgeable in finger print identification, forensic pathology and forensic odontology and then take responsibility for training personnel or volunteers to work on victim identification. Continuing education in forensic odontology should be provided openly and regularly so the dental profession can maintain current standards in forensic odontology.

Acknowledgements

We would like to acknowledge Dr. Khunying Porntip Rojanasunan, Central Institute for Forensic Sciences, General Dr. Pisan Thepsitha, Dr. Paisan Kangvonkit and their staff from the Dental Council of Thailand, and the National Health Security Office (NHSO), Bangkok, Thailand, for their kind comments and generous supports. Special thanks go to Dr. M. Kevin O Carroll, Professor Emeritus, University of Mississippi School of dentistry and Faculty consultant, Chiang Mai University, for his assistance in preparation of the manuscript and Mr. Suthat Sridounkeaw for his technical assistance.

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