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Importance of dental records for victim identification following the Indian Ocean tsunami disaster in Thailand

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Summary *Objectives:* To determine the usefulness of dental records for victim identification following the Indian Ocean tsunami disaster in Thailand, and to evaluate the dental identification system in Thailand, the homeland of a large number of the victims.
Study design: A descriptive study conducted at the Thai Tsunami Repatriation Centre in Phangnga Province one year after the tsunami hit Thailand on the 26th December 2004.
Methods: The dental records of 3750 dead bodies and 3547 missing persons in the Thai Tsunami Victim Identification (TTVI) database, updated on 12th December 2005, were analysed.
Results: The identification rate of missing persons with dental records was significantly higher than that of those without ($P<0.01$). Most victims identified by dental records were returned home within the first four months after the disaster. Dental records were the primary identifier in 46.2% of those identified. However, among the Thai citizens reported missing, only 2.0% used dental identification, 18.1% had dental charts and 0.8% had dental X-rays. In addition, only 7.4% of Thai dental records could be used for dental identification and one-third of Thai victims remained the majority of those unidentified.

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Conclusions: Based on this study, the usefulness of dental records for victim identification in a disaster was confirmed. The dental identification system for nationals of Thailand could not work efficiently due to lack of dental records and insufficient recorded detail.

Introduction

The Indian Ocean earthquake and resultant tsunami of 26th December 2004 killed more than 200 000 people in 12 countries around the Indian Ocean.[1] In southern Thailand, six provinces along the Andaman coast were hit and 5395 people were killed.[2] The most devastated area was Khao-Lak, a renowned tourist area on the west coast of Phangnga Province, where 96 resorts were destroyed,[3] resulting in the death of 4225 people, half of whom were foreigners. Approximately 1600 bodies were released by the local authorities in the first period before a formal identification system was set up; their identifications were made by visual recognition of family members and by physical appearance under the various protocols of several contributors who self-reported to the site in the early chaotic situation.

On 12th January 2005, the Thailand Tsunami Victim Identification (TTVI) operation was formally established by the Thai government to integrate operations into a single process using the International Police Organization (Interpol) guidelines for mass fatality incidents. Nearly 2000 personnel from 31 countries contributed their expertise and skill to this operation,[4] resulting in the identification of 2894 victims within one year. Dental identification was reported to be the most useful method in this disaster,[5–7] especially in the case of victims from Europe and North America.

The success of the dental identification of foreign victims has created challenges in forensic identification in Thailand. Prior to the tsunami disaster, forensic dentistry in Thailand had played only a minor role in the forensic sciences and no national standards or guidelines had been established.[7] Although dental records are commonly used to identify unknown persons and victims recovered from mass disasters in other countries,[8] they are used significantly less in Thailand and their study is still inadequate. As the local team at the Thai Tsunami Repatriation Centre in Phangnga, the authors aimed to determine the usefulness of dental records for victim identification and to evaluate the performance of the dental identification system in Thailand following the Indian Ocean tsunami disaster.

Methods

Dead bodies

Dental evidence from the recovered bodies was examined by forensic dentists from over 20 countries[5] and 520 dentists throughout Thailand.[9] Initially, the international teams were restricted to processing the bodies presumed to be foreigners after being so classified by the Thai authorities. The Thai team examined the bodies of those presumed to be Thai.[6] All data were recorded in a single database and then assessed. Finally, after quality control assessment, those bodies with incomplete or unclear photographs or X-rays were referred for re-examination.

Missing persons

The dental records of foreign missing persons were collected by the police agencies of their home countries, coordinated by Interpol.[5] In the case of Thai victims, their families were asked to collect dental records from clinics or hospitals and send them to TTVI. Phangnga provincial dental personnel contacted the victims' families directly to locate dental records available in their areas. At the same time, the Thai Dental Council distributed lists of the missing to all dental facilities and requested them to submit the appropriate records back if any of their patients were on the list. All dental data for the missing persons were entered into the same database as that for dead bodies.

Dental identification process

Thailand used the Disaster Victim Identification (DVI) System International Software to assist in the identification process. The software is based on the Interpol DVI antemortem and postmortem forms. The antemortem form is yellow and records the most current known data concerning a missing

person and the postmortem form is pink and records all findings concerning a body. Each form is divided into a number of sections of either one or two pages and the sections are alphabetically labelled. Section 'A', the first section of the yellow form, includes the personal data of the missing person, while 'B', the first section of the pink form, consists of a report on the recovery of the body from the site. All other sections are the same on both the yellow and pink pages. Section 'C', describes personal belongings; 'D', physical characteristics of the person; 'E', medical information; 'F', dental information; and 'G', any other information that may assist in identification.[10] With respect to dental data, the F section consist of parts F1 and F2. Part F1 of the yellow form is data about the dentist or institution that the missing person visited for examination or treatment, while F1 of the pink form is a description of the condition of the dead body. Part F2 of both yellow and pink forms contains dental data classified into six categories: the condition of each tooth, a specific description of any dental prosthesis, further findings of dental characteristics, X-rays, supplementary examination and age. Data on the condition of each tooth provide the most important information for dental searching. Using 107 pre-formatted dental codes together with free-text description, one or more condition(s) can be described for each tooth.

TTVI used several methods to search the database. Potential matches of dead bodies and missing persons were achieved using a dental match index.[11] After the database search was performed, hard copies of the files were compared by forensic dentists. Once the identifying evidence was determined to be sufficient, a case report was prepared outlining the methods of identification and the reasons for the definitive conclusion. The case was then presented before the Reconciliation Board of the TTVI Commission.[5] If the identification was accepted by the Board, a death certificate was issued. In order to verify that the correct body was being released, the dentists had to compare the dental data recorded in the system with the oral status of the dead body. After this last check, called the final vetting process, the body could be released to the family. Unidentified bodies were kept in refrigerated containers in the Thai Tsunami Repatriation Centre in Phangnga, where the current final examination and release procedures will be continued.

Data analysis

A total of 5395 people were confirmed dead in Thailand. Approximately 1600 victims released by the local authorities in the first period before TTVI was initiated were excluded. The present study focused on the records in the DVI System International database of the Thai Tsunami Repatriation Centre, which was last updated on 12 December 2005. At that time, it included listings for 3750 dead bodies and 3547 missing persons. The F2 sections of all records were exported as xml files into a Microsoft Access database. A Chi-squared test in SPSS version 12.0 was used to confirm the importance of dental records in victim identification. A *P*-value of less than 0.01 was considered to indicate significance.

Results

Dead bodies

The total number of dead bodies examined in the present study was 3750. Most of them (3652 or 97.4%) were bodies including the head for which it was possible to gather dental evidence. The remaining 2.6% consisted of body parts without the head and it was therefore impossible to obtain any dental information in these cases.

Missing persons

A total of 3547 missing persons from 39 countries were reported as missing by their families. The largest national group were Thai (1573), and 1693 tourists from 19 European countries were also reported missing. The availability of dental records varied from country to country. Although few Thai victims had dental charts (18.1%) or dental X-rays (0.8%), the figures were quite high for victims from Europe, North America, Oceania and Africa (Table 1).

Identified cases

Dental identification was used primarily in the first four months, while the second five months made use of fingerprints and the last three months used DNA (Fig. 1). The identification rate of missing persons with dental charts or dental X-rays was significantly higher than that for those without such records ($P<0.01$) (Table 2).

Among 2894 identifications, dental data were the primary identifier (46.2%) (Table 3). Dental identification was most useful for victims from other countries, while for victims from Thailand and other Asian countries fingerprints were mainly used. Overall, where dental records were available, 67.6% were successfully used for identification. However, for

Table 1 Missing persons' dental records from different countries.

Region	(Countries)	Reported missing persons	Dental records available (%)	
			Dental charts	Dental X-rays
Europe	(19)	1693	1598 (94.4)	1278 (75.5)
Thailand	(1)	1573	284 (18.1)	13 (0.8)
Asia[a]	(14)	227	49 (21.6)	29 (12.8)
North America	(2)	34	30 (88.2)	26 (76.5)
Oceania	(2)	16	14 (87.5)	11 (68.8)
Africa	(1)	4	4 (100.0)	4 (100.0)
Total	(39)	3547	1979 (55.8)	1361 (38.4)

[a]Asia: Thailand excluded.

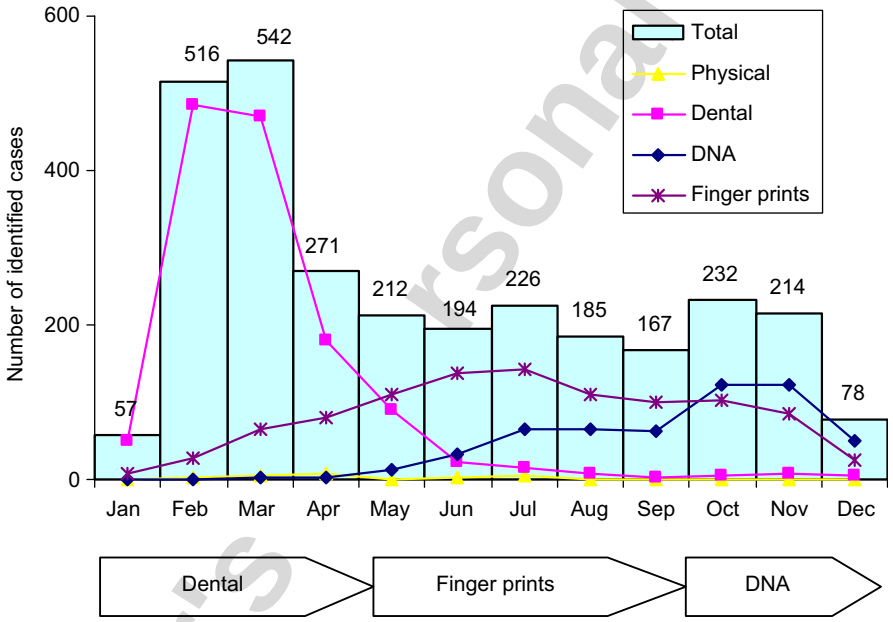

Figure 1 The main identifiers during the first 12 months after the disaster.

Table 2 Identification rates among missing persons with and without dental records.

Dental records		Identified (%)		Total (%)
		Yes	No	
Dental charts[a]	Yes	1852 (93.6)	127 (6.4)	1979 (100.0)
	No	1042 (66.5)	526 (33.5)	1568 (100.0)
Dental X-rays[a]	Yes	1316 (96.7)	45 (3.3)	1361 (100.0)
	No	1578 (72.2)	608 (27.8)	2186 (100.0)
	Total	2894 (81.6)	653 (18.4)	3547 (100.0)

[a]$P<0.01$ (Chi-squared).

Table 3 Number of identified cases and the main identifier by country.

Region	Number of identified cases (%)	Main identifier (%)			
		Dental	DNA	Fingerprints	Physical
Europe	1638 (96.8)	76.4	6.6	15.7	1.3
Thailand	1065 (67.7)	2.0	38.6	59.2	0.2
Asia[a]	138 (60.8)	15.9	12.3	71.0	0.7
North America	34 (100.0)	76.5	5.9	17.6	0.0
Oceania	15 (93.8)	86.7	0.0	13.3	0.0
Africa	4 (100.0)	75.0	0.0	25.0	0.0
Total	2894 (81.6)	46.2	18.6	34.4	0.8

[a]Asia: Thailand excluded.

Table 4 Usefulness of dental records for dental identification.

Region	Dental records in total	Dental records successfully used for dental identification	
		Number	%
Europe	1598	1252	78.3
Thailand	284	21	7.4
Asia[a]	49	22	44.9
North America	30	26	86.7
Oceania	14	13	92.9
Africa	4	3	75.0
Total	1979	1337	67.6

[a]Asia: Thailand excluded.

Thai victims only 7.4% of the dental records obtained could be used and only 2.0% of Thai victims were identified by this method (Table 4).

Unidentified cases

After one year, 856 unidentified bodies remained, while only 653 records of missing persons were still unresolved. Most unidentified missing persons were Thai (508), followed by other countries in Asia (89), Europe (55) and Oceania (1). There were 362 unidentified bodies with evidence of some dental treatment (Fig. 2).

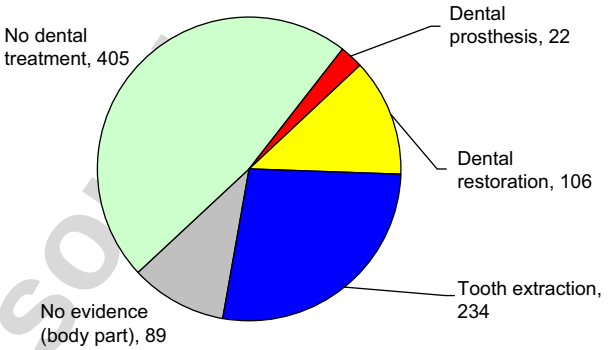

Figure 2 Dental evidence of the unidentified dead bodies.

Discussion

The durability of teeth is a feature that makes forensic dentists regular participants in forensic investigation. Teeth can survive most postmortem events that can disrupt or change other body tissues.[12] This tsunami disaster clearly showed that almost all bodies with heads had retained dental structure. The availability of dental records of missing persons determined the chance of dental identification and was found to be a statistically significant factor in this disaster (Table 2). Because of the much larger proportion of available dental records, the victims from Europe, North America, Oceania and Africa were identified at a rate of more than 90%, mainly through the use of those records (Tables 1 and 3). However, not all dental records could be used effectively for identification. Records with accurate and complete data were obviously much more likely to be matched. The high percentage of dental records used for the identification of victims from other countries reflected the quality of their records. On the other hand, the uselessness of more than 90% of Thai dental records (Table 4) can be explained by their lack of content. Most Thai dental charts did not describe all teeth, but only the treated tooth, and essential details such as dental material or treated

surfaces were missing. This situation, together with the lack of dental X-rays, meant that Thai records for the most part did not provide sufficient data for identification. In addition, some abbreviations could not be understood, some dentists' handwriting was illegible, and some copies of dental charts or X-rays were not clear, resulting in more time needed to contact dental offices and confirm data.

In this disaster, most of those identified by dental records were released to their families within the first four months, while identification based on fingerprints or DNA required more time (Fig. 1). The significant contribution of dental evidence, particularly in the early identification process, is consistent with findings in other disasters.[13] This rapid dental identification reduces costs both for families and for the operation site. Furthermore, the use of dental records is less costly than other methods such as the use of DNA.

In the case of Thai victims, only 2% could be identified by dental records, whereas more than half were identified by fingerprints, and DNA was used in 38.6% of cases. Thus, the identification of Thai victims was particularly expensive, compared with that of European and North American victims, for whom more dental records were available and who required DNA identification in less than 10% (Table 3).

One year after the tsunami, one-third of Thai victims remained the majority of those unidentified, and there was little chance of dental identification for them if they lacked dental records or if they had never received any dental treatment. Nevertheless, some evidence of dental treatment was found in the dead bodies: 234 of them had had at least one extraction, 106 had undergone dental restoration and 22 had a dental prosthesis (Fig. 2). If only 10% of such dental records could be found and their content was sufficient, at least 30 more victims would have the chance to be identified using low-cost dental records in the last phase of the TTVI operation.

For developing countries like Thailand, dental identification is an appropriate method to be considered in DVI. Fingerprint documentation is more readily available in the case of Thai victims, but due to decomposition, only dental evidence or DNA may remain for comparison. With respect to cost, DNA is both much more expensive and more time consuming. However, without adequate dental records of missing persons, it is impossible for dental identification to be successful. This element is beyond the control of forensic dentistry investigation, since it depends critically on the availability and quality of records generated during the victim's life.[14]

This problem with antemortem records is a recurring theme in disasters, especially in inexperienced countries. In 1995, for example, when a ferry carrying passengers from many countries sank in Estonia, 97% of Swedish victims had full dental records, while the respective rates for Estonian victims was only 27%. In this case, the lack of records was attributed in part to the fact that dental record-keeping was not legally required in Estonia, and some dentists thus used their records only for billing purposes; additionally, some dental clinics had recently reorganized their record-keeping systems and had discarded old records, and some victims did not have any dental records because they had not seen a dentist in recent years.[15]

Although nine years had passed since the Estonian disaster, a similar situation had arisen in Thailand. Few dental records were received from the victims' families. Some of them did not know whether or not the missing person had visited a dental clinic. Although computerized patient registration had been introduced in almost all government dental facilities, it was not widely used in private dental clinics, especially in small clinics or in clinics in rural areas. Without computer records, it was an enormous task to match the large number of missing persons to patient lists. Therefore, very few dental records were submitted, even after the Thai Dental Council had distributed lists of the missing persons' names throughout the country. Furthermore, a dental clinic with 2000 patient records, nearly 100 of whom were victims, was demolished in the tsunami disaster. All computer records were destroyed, and paper dental charts and dental X-rays (in paper envelopes) sank in the mud. Although most of the paper charts could be recovered, some were lost, some had parts missing, and the quality of X-rays had deteriorated considerably.

The countries with high rates of antemortem dental records such as the European countries and North America have several legislative mandates regulating dental record-keeping.[15,16] Furthermore, they sometimes embed the patient's name or a unique number in the dental prostheses. For example, in the UK, the National Health Service provides compensation for dentists who label their patients' dentures,[17] and in the USA, at least 21 states require dentists to place identifying marks on dentures for forensic identification purposes.[16] Experience in other disasters in identifying victims from such countries has showed a high rate of dental identification.[15,18] In the tsunami disaster, the Canadian team used Internet technology to transport records swiftly halfway around the

world; all Canadian victims have already been identified.[19]

The present study confirms the usefulness of dental records for victim identification in a disaster. The dental identification system for nationals of Thailand could not work efficiently due to lack of dental records and insufficient recorded detail. Regulation by law is an effective measure of improving dental record-keeping that should be put into effect in Thailand. We must also implement an efficient system of locating the dental records of missing persons in the aftermath of disaster. Furthermore, national and international standardization in record-keeping styles and abbreviations must be revised so that records can be used effectively in multinational disasters.

To date, progress has been made in establishing a tsunami warning system along the Andaman coast and many dentists have independently upgraded their dental record systems. However, action from the Thai government to standardize and regulate dental record-keeping is still awaited.

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