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Lessons Learned from Large-scale Comparative Dental Analysis Following the South Asian Tsunami of 2004

ABSTRACT: The aim of this study was to examine the quality of the ante-(AM) and postmortem (PM) dental data that were submitted for entry into the PLASSdata system in Phuket, Thailand, following the Boxing Day (December 26) Tsunami, 2004. The investigators were two forensic odontlogists who were part of the New Zealand Disaster Victim Identification team that worked at Wat YangYao morgue and at the Information Management Center in Phuket. Our findings underline the usefulness of dental data in human identification, but point to a number of significant sources of error. Of the 78 PM records received, only 68% of radiographs and 49% of photos confirmed the accompanying dental charting. This underlines the value, particularly of photographs of the dental arches, in quality control. It also points to a large error component, which may have been due to inexperience of the operators, fatigue, poor conditions in the temporary morgue, or the problem of tooth-colored fillings. Of the 106 AM records received, 62% were of unacceptable quality and 64% were either not accompanied by radiographs or had poor quality radiographs. These results indicate that AM data collection ideally needs to be collated and checked by a forensically trained dentist(s) in the country of origin.

KEYWORDS: forensic science, forensic odontology, human identification, dental records, tsunami

On 26 December 2004, 1000 km of fault ruptured beneath the sea west of Sumatra, creating an earthquake that measured 9 on the Richter scale. The resultant tsunami was the third biggest natural disaster in the past 100 years and claimed over 250,000 lives, including some 5,300 in southern Thailand (1). In response a multinational Disaster Victim Identification (DVI) Center was set up in Phuket to identify those killed. This newly assembled Information Management Center (IMC) processed firstly, postmortem (PM) data obtained from the 31 national teams involved in examining victims of the tsunami in temporary morgues established at Wat YangYao and Mai Kau; and secondly, antemortem (AM) data gathered from the numerous countries involved. These data were entered into the PLASSdata system (2) under standard operating procedures defined in Interpol Disaster Identification Manual (3). Where reconciliations could be made, these were presented to the Thai Reconciliation Commission, who if satisfied, then authorised the issue of a Thai death certificate.

Three main categories of data were entered into the system; fingerprints, DNA, and dental records. In this paper, we document our own findings of the quality of dental records, obtained while we were part of the New Zealand DVI team based in Phuket, Thailand, 16 January to 7 February 2005.

Method

According to standard Interpol DVI protocols (3), PM dental data for each individual body were entered onto pink DVI forms. Additionally, bitewing and periapical radiographs were taken where necessary in accordance with standard operating procedures authored by J. Taylor and issued after 16 January 2005; "RADIOGRAPHS Standard for each body is bitewings and any other films as deemed appropriate; 1 or 2 periapicals for children for age determinations" (J. Taylor, Standard Operating Procedure document submitted to the Scientific Advisory Sub-Committee, Thai Tsunami Victim Identification Committee). Constraints on time, especially in the early weeks of the exercise, precluded taking full mouth radiographic surveys of each PM case. Polaroid images of the maxillary and mandibular occlusal tables and an anterior edge-to-edge view of the incisors were also taken. These data were then entered into the Plassdata system at the IMC. To determine the quality of the PM dental data entered, we (J. K. and W. L.) checked the quality of each of the three sets of input; dental PM charting, radiographs, and photographs. Each charting was ranked as being either of good or poor quality, based upon features such as clarity of writing and drawing and also of conformation to the Interpol instructions. We then noted whether the charting conformed to the written description entered on the pink form. Radiographs were rated according to criteria adapted from Helminen et al. (4) It was accepted that although a radiograph might be technically imperfect, it could still provide useful information, and hence quality indicators had to be pertinent to the realities of the situation we found ourselves in. Radiographs were taken as acceptable when they conformed to the following criteria:

1. Image not too dark or light—enamel, dentine, pulp, alveolar bone distinguishable.
2. Periapical shows entire crown and root of tooth or teeth radiographed, bitewings show entire crowns as well as marginal bone lines.
3. There was no approximal overlapping of crowns such that the enamel of one tooth obscured the dentine of its neighbor.
4. There were no ghost images, stains, scratches, stripes, or artifacts.

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TABLE 1—*Summary statistics for the quality measures of 78 postmortem data sets.*

Dental charting			
Quality		Writing conforms to charting*	
Good 72 (92.3)	Poor 6 (7.7)	Yes 62 (79.5)	No 16 (20.5)
Radiographs			
Quality		Confirms charting	
Good 67 (85.9)	Poor 11 (14.1)	Yes 53 (67.9)	No 25 (32.1)
Photographs			
Quality		Confirms charting	
Good 75 (96.2)	Poor 3 (3.8)	Yes 38 (48.7)	No 40 (51.3)

*Does the dental charting conform to the written description entered onto the Interpol pink form?
( ), percentage.

Polaroid photographs were similarly evaluated, firstly as being of good or poor quality, and secondly whether they confirmed the original dental charting or not.

Each yellow AM file was evaluated by noting firstly, whether the dental charting was manual or computer generated and secondly, whether it conformed to Interpol protocols or not. In each case we noted whether the file had been accepted for entry into the PLASSdata system or had been returned for additional information.

Results

Table 1 lists the summary statistics for the quality of 78 PM data sets evaluated. Of the chartings examined, 92% were of good quality and in 79% of cases the written record conformed to the dental charting. Eighty-six percent of radiographs were classified as of good quality and 68% confirmed the corresponding dental charting. Similarly, 96% of photographs were classified as being of good quality and 49% confirmed their attendant charting. Table 2 gives a crosstabulation of PM dental charting quality compared to radiographic and photographic quality and confirmation of the corresponding dental charting. Of the dental chartings that were classed as good, 89% were accompanied by good quality X-rays and 99% by good quality photographs. Yet of these, only 72% of radiographs and 53% of photographs confirmed their original dental charting. When we looked at those chartings that were classed as poor, 50% were accompanied by poor quality X-rays and 33% by poor quality photographs. Of these, 83% of X-rays and 100% of photographs failed to confirm their corresponding chartings. Similar results were found when we crosstabulated correspondence of written dental records and charting to quality of radiographs and photographs (Table 2).

TABLE 3—*Summary statistics for quality measures of 106 AM data sets.*

Charting	
Method	
Hand*	50 (47.2)
Computer†	56 (52.8)
Quality	
Acceptable	73 (68.9)
Nonacceptable	33 (31.1)
Radiographs	
Quality	
Acceptable	49 (46.2)
Nonacceptable	57 (53.8)
Fate of record	
Accepted	52 (49.1)
Returned	54 (50.9)

*Hand, AM odontogram hand-drawn on a standardized printed template.
†Computer, AM odontogram computer-drawn on a standard template and electronically transferred.
( ), percentage; AM, antemortem.

Summary statistics of quality measures for antemortem data sets are given in Table 3. Of the 106 records examined, 53% were computer generated, 69% were found to be of an acceptable standard and 46% of the radiographic data were found to be acceptable. Of the records evaluated, only 49% were accepted—51% had to be returned because the data contained were either incomplete or of unacceptable standard. Crosstabulations for the method of charting against quality of charting, of X-rays and of the fate of the record are given in Table 4. While 96% of the computer-generated chartings were an acceptable standard, only 38% of hand-chartings were acceptable. However, only 55% of radiogaphs accompanying computer-generated data were acceptable and 41% of these data sets had to be returned. Of the hand-written data sets, 64% were accompanied by unacceptable radiographs and 62% had to be returned.

Discussion

Numerous studies have underlined the usefulness of forensic odontology in providing fast, reliable, and relatively inexpensive personal identification of large numbers of victims (5–9). There has been a surge of interest in the computerisation of dental DVI methods and more recently, in the use of sophisticated computer methods to increase the reliability and speed by means of which dental AM and PM dental radiographs may be compared (10–14). However, there have been those who have cautioned that despite the sophistication of computerised data-capture methods used, there is no substitute for the practical experience of the forensic

TABLE 2—*Crosstabulations contrasting the quality of postmortem dental charting with the quality of dental radiographs and polaroid photographs.*

	Radiographs				Photographs			
	Quality		Confirms Charting		Quality		Confirms Charting	
Dental charting	Good	Poor	Yes	No	Good	Poor	Yes	No
Quality								
Good	64 (88.9)	8 (11.1)	52 (72.2)	20 (27.8)	71 (98.6)	1 (1.4)	38 (52.8)	34 (47.2)
Poor	3 (50.0)	3 (50.0)	1 (16.7)	5 (88.3)	4 (66.7)	2 (33.3)	–	6 (100)
Writing conforms								
Yes	54 (87.1)	8 (12.9)	48 (77.4)	14 (22.6)	59 (95.2)	3 (4.8)	37 (59.7)	25 (40.3)
No	13 (81.3)	3 (18.8)	5 (31.3)	11 (68.8)	16 (100)	–	1 (6.3)	15 (93.8)

( ), percentage.

TABLE 4—*Summary statistics for quality measures of 106 AM data sets.*

Charting	
Method	
Hand*	50 (47.2)
Computer†	56 (52.8)
Quality	
Acceptable	73 (68.9)
Nonacceptable	33 (31.1)
Radiographs	
Quality	
Acceptable	49 (46.2)
Nonacceptable	57 (53.8)
Fate of record	
Accepted	52 (49.1)
Returned	54 (50.9)

*Hand, AM odontogram hand-drawn on a standardized printed template.
†Computer, AM odontogram computer-drawn on a standard template and electronically transferred.
( ), percentage; AM, antemortem.

dentists operating the system (15,16). Dailey (17) in particular has cautioned about quality control for both AM and PM records and has warned against over-confidence in inexperienced operators and also against the effects of burnout. Dental identifications are only as reliable as the "weakest link"; nondiagnostic AM data cannot be reliably used for victim identification. In fact, bad data can lead to false positive or false negative (exclusion) identification.

PM Data

Our results show that there was only a moderate standard of charting, radiographs, and photographs achieved by dental volunteers working at Wat YangYao (Table 1). Moreover, only 68% of radiographs and 49% of photographs were found to confirm the PM dental charting when this was checked upon data input at the IMC. The value of radiographs and particularly dental photographs in quality control is highlighted by the data presented in Table 2. In 28% of chartings that were considered to be of good quality, PM radiographs pointed to charting errors. This percentage rose to 47% in the case of dental PM photographs. Photographs also confirmed errors in all of the chartings rated as poor. Forensic dentists conducting PMs were not only confronted with lack of experience and/or burnout, but also with the problems posed by tooth-colored restorations. These are difficult to detect at autopsy, especially in limited lighting available in the makeshift morgue at Wat YangYao. This, together with the fact that they are often radiolucent or vaguely radio-opaque (18–20) may also account for the high levels of charting inaccuracy recorded here. An additional issue relates to the wide spectrum of countries represented and the consequent nonuniformity of standards of forensic odontological training and experience. While huge numbers of dentists no doubt benefited from their individual experiences in Phuket, our study suggests that in future, controlling agencies will have to prescreen volunteers for training, knowledge, and experience. If properly performed, PM charting should be a relatively simple procedure with a low error rate.

While standard operating procedures (SOP) and quality protocols were regularly discussed at debriefing sessions in the Information Management Center, this was not the case at Wat Yang Yao. It is suggested that in future there should be formal induction sessions for newly arrived volunteers, at the location of the PM examinations, which should include an overview of the operation, its command structure, SOPs, and quality protocols. These should also be regularly reviewed during debriefings on site and led by the person in charge.

Antemortem Data

Delattre and Stimson (21) have stressed the value of reliable AM records in the speedy identification of human remains. Recently, Sakoda et al. (22) stated that the main factors involved in successful dental identification were the availability of recent dental records, the accuracy of the collected antemortem dental data, and the alteration of dental fillings after the last clinical examination. Identification of the Boxing Day Tsunami victims in Phuket presented huge logistical as well as organizational challenges. Large numbers of victims came from a wide range of countries, and volunteer dentists were drawn from at least 31 countries of origin, each with its own unique approach to DVI. These two issues melded in the presentation and interpretation of AM data to be entered into the PLASSdata system. For instance, 47% of the AM dental records we entered were hand-drawn, 54% of radiographs were not of acceptable quality (Table 3). This resulted in half of all AM records having to be returned for additional information. That hand-drawn chartings were simply inadequate is underlined by data in Table 4; 62% of these were of unacceptable quality, 64% were accompanied by unacceptable radiographs, and 62% had to be returned.

The single lesson we learned as far as AM data are concerned was that dental data needs to be collated *in the country of origin, by a forensically trained dentist or dentists*. Family practitioners were either too busy to prepare adequate records, or not aware of the unique requirements of DVI charting and radiographs. How the foregoing might be addressed will be a challenge. In 1988, Brown (23) concluded prophetically; "International cooperation in forensic odontology begins with the dentists in every country, faithfully recording details of the daily treatment they provide, thereby building up reliable dossiers of the status of all their patients' dentitions. It requires the recognition of forensic odontology by the professional bodies and teaching institutions in each country and their active encouragement and support for the achievement of high standards of practice and research in this important field. Finally, it requires action and financial support by the governments of every country to establish within their borders a central identification agency and procedures which are internationally compatible."

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