

Review article:

Tsunami 2004 – a review of one year of continuous forensic medical work for victim identification

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ABSTRACT

The Tsunami after the sea quake in Southeast Asia at the 26th of December 2004 represents one of the largest disasters in the modern World. Approximately 228,000 people from the countries surrounding the Indian Ocean have died. A large number of visitors from different European countries staying for their Christmas holidays in Thailand and Sri Lanka became victims of the natural disaster. The large number of foreign victims in these countries required additional forensic investigations which were organized by internationally working DVI (Disaster Victim Identification) teams. Victim identification was a great challenge due to the environmental conditions rapidly leading to heavily decomposed bodies. Thus the forensic medical investigations were very important to identify the victims. The different steps of forensic medical, odonto-stomatological and molecular genetic investigations beginning at the end of 2004 with the identification of a small number of victims and ending with the closing of the TTVI IMC (Thai Tsunami Victim Identification Information Management Center) in Phuket one year later are described and critically discussed. Up to 31 international DVI Teams worked in the TTVI IMC during 2005.

Keywords: Disaster victim identification, Tsunami, Mass disaster, Forensic Odontostomatology, Forensic Medicine, Forensic Molecular Biology

Organisation and workflow

The magnitude of the disaster became apparent shortly after it had occurred, and the number of expected victims from Germany required a fast reaction. So the first members – the team leader three officers of the German Federal Police and one forensic odonto-stomatological expert – of the German Disaster Victim Identification

(DVI) Team travelled to Thailand on the 27th of December to assess the situation and to establish a strategy for further investigations. The situation found at the 28th of December at Phuket Island was chaotic, as large parts of the public infrastructure were in disarray. Information available to the local authorities about the handling of victims was incomplete. A fast reaction was recommended. A decision to send the whole

German DVI Team was already made on December 28. Twenty-two members of the German Federal Police and four forensic medical and odonto-stomatological experts of the team went to Phuket on December 29. An evacuation flight by Condor Airline from Munich to Phuket was organized to carry emergency equipment, as well as to bring survivors back home. It was possible for the team to use this direct flight which arrived in the morning of December 30.

At the same time the International DVI Coordinating Centre was established under the leadership of the Royal Thai Police at the Police Station in Phuket Town (Fig. 1). The first decision was to establish places for forensic medical investigations in three regions, called Site I – region of Takua Pa (Site Ia: Wat Yan Yao, Site Ib: Wat Ban Muang), Site II – region of the Phuket Island (Wat Tha Cha Chai), and Site III – region of Krabi (Fig. 2) (Peschel et al. 2005, Peter 2006).

On December 31 two identification lines of the German DVI team began to work after building a provisional mortuary near the international airport in the area of the Wat Tha Cha Chai (the Thai word for temple is Wat). Only half a day after the completion of the site the work began in cooperation with the Austrian DVI Team at Site II (Fig. 3).



Fig. 1: Phuket Police Station with the DVI (Disaster Victim Identification) Coordinating Center at 31st of December 2004



Fig. 2: Localisation of the investigation sites in Southern Thailand



Fig. 3: Site Ib at Wat Tha Cha Chai Phuket on December 31, 2004



Fig. 4: Site II at Wat Ban Muang on January 2, 2005

31.12.04 – 02.01.05 Site II – Wat Tha Cha Chai

At site II victims stored in the hospital of Phuket Town were investigated. The conditions were problematic, there were no hand washing facilities, and the work had to be stopped after sunset because no electricity was available to operate spotlights. In addition the work had to be interrupted following a reported earth quake. The evacuation of the DVI team took place after a Tsunami warning had been issued. An emergency plan with the Geological Research Institute in Potsdam was established. Until the end of 2005, 5,000 subsequent earth quakes were recorded (Peter 2006).

The support by the Thai people serving drinking water, food and fruits, and by the German THW (Technical Support Organisation) arriving until the first week of January was very helpful. The first victim investigations demonstrated already the full spectrum of stomatological treatments – fillings, inlays, onlays, partial dentures, combined dentures etc. The high potential of forensic odonto - stomatological identifications raised the hope for successful casework operations. A small number of victims could be identified by several teams using directly sent ante mortem (AM) data. All post mortem (PM) data collected by the German DVI team were recorded on standardized Interpol protocols (“Victim Identification Form, P.M.”) according to the Interpol disaster victim identification guide (Interpol 2005).

Only three days later, following the investigation of these bodies, the DVI Teams had to move to Site Ib at the temple Ban Muang approximately 90 km north of the Phuket Island.

02.01.05 – 03.01.05 Site Ib – Wat Ban Muang

An enormous problem in this area was the large number of victims – there were more

than 2,000 bodies stored on the ground in the open air. (Fig. 4) For half a day, a place to work in the open was found, where the Scandinavian DVI teams were working as well. Due to the direct transfer of AM data the identification of a German dentist was achieved. However, on the next day, the body - like many others - was missing. A story began which ended in the middle of April! Only one day later it was decided by the Centre to move again to Site Ia, the Yan Yao temple in Takua Pa (Fig. 5).



Fig. 5: Wat Yan Yao (Site Ia) in January 2005 representing one of the places for storing of the victims and the main working place until February 2005.

03.01.05 – February 2005 Site Ia – Wat Yan Yao

At Site Ia an area was built for the international teams to work more professionally. Mortuaries were erected in tents or temple buildings including water and electricity supply to allow working for 24 hours. Examination of the bodies followed recommendations of the international teams. It was decided to take fingerprints, make an external and internal forensic pathological examination, to document the dental records including a radiological examination (bitewings), and to collect tissue samples for DNA extraction (healthy teeth, rib or bones segments).

After introduction of the Thai Tsunami Victim Identification Information Management Center (TTVI IMC) on January 12, a harmonisation of the work carried out

by the international teams became possible (Fig. 6 and Fig. 7). The first German DVI team left Phuket on the 13th of January. Subsequently, 20 international DVI teams were present to help with the identification of the recovered bodies.



Fig. 6: The TTVI IMC (Thai Tsunami Victim Identification Information Management Center) on Phuket Island established in the middle of January to organise the identification process.

February 2005 - 14.12.2005 Site II – Tha Cha Chai

After preparation of the work area by the Norwegian Company Normeca a container village was erected and used as the first work place for the German DVI team (Figs. 8, 9, and 10). The teams got greatly improved working conditions compared to Site Ia, with complete autopsy lines. At the same time the organisation structure was established. In the TTVI IMC near Phuket Town the collection and comparison of AM and PM data was carried out in parallel to allow the identification of victims. The guidelines for establishing the identity of a victim requested a positive match with at least two different methods, e.g. forensic odonto-stomatological and fingerprinting, or DNA and forensic medical investigations.



Fig. 7: Inside the TTVI IMC (Thai Tsunami Victim Identification Information Management Center) showing the working places for data collection and comparison.



Fig. 8: Site II with the container village representing the working places of the medico-legal investigations and the storing of the victims.

At the end of March the initial phase of investigations was completed. A decision was made to continue with the so called Final Inventory Protocol. The still unidentified victims were investigated a second time to prevent and eliminate errors in the PM database. From the TTVI IMC requests for additional investigations were sent to Site II. These investigations ended in May. After that, only one team was responsible for Site II. The work included further investigations of the victims upon special request by the TTVI IMC to resolve discrepancies. In addition, the release of identified bodies was a part of the work. For three time periods, the German DVI team was responsible for Site II. All work by the international teams ended on December 14, 2005, when the place and the containers with

remaining unidentified victims were handed over to the Thai Police.



Fig. 9: Container Lines for the investigation process of the victim at Site II (outside view).



Fig. 10: Container Lines at Site II (inside view)

The forensic medical investigation

From the beginning, three forensic pathologists, one of them with a specialisation as forensic dentist, were part of the German DVI team. Two forensic dentists completed the team, which was thus able to work in two investigation lines. The comfortable situation with three forensic dentists allowed support other teams missing such specialists, e.g. the DVI team from Singapore. The forensic medical examination followed the recommendations issued by the IMC and using the Interpol Post Mortem Victim Identification Form (Interpol 2005, Soomer et al. 2001). As first step of the protocol fingerprints were taken by specialists. In the second step external items of the victim including clothes, jewellery, and other features were

documented by a photographer as team member. The autopsy was limited to the abdomen. The aim was to find typical results of surgery such as a missing appendix, gall bladder etc. At the end of the examination, tissue samples as a source for DNA were collected.

For the forensic medical examination the largest problem was the advanced stage of decomposition of the bodies. The environmental conditions with constant temperatures above 30°C together with a high humidity led to a very fast autolysis. The temperature of the Indian Ocean was approx. 28°C at this time of the year. Directly after the disaster, the victims were collected at several temples of the Khao Lak region. No cooling equipment was available during the days. Thus all bodies were highly decomposed already after a short time period, which could not be prevented by covering the bodies with large pieces of dry ice (Fig. 11).



Fig. 11: Victims in advanced stage of decomposition; the bodies are covered with dry ice to slow down the decay.

Furthermore, a large number of victims showed numerous injuries. Due to these circumstances, an ethnic allocation was not possible in most cases. Immediately after the Tsunami it was decided to separate the Thai victims from the foreigners. The Thai victims investigated by Thai specialists were labelled using an electronic chip (RFID) and stored in mass graves (Meyer et al. 2006). However, it was then reported about the possibility of foreign victims in these graves,

and consequently, most of them had to be exhumed again and were brought back to the routine examination procedure at the time of the final inventory. The working conditions were very complicated in the first weeks (Fig. 12). Beginning with the year 2005, a large number of refrigerated containers arrived at the work places to store the bodies. So it was possible to cool the bodies and stop the decomposition.



Fig. 12: Crowded working conditions at Site Ia

After opening the container village at Site II the working conditions were further improved. The three container lines with two investigation lines allowed for a steady workflow.

THE FORENSIC ODONTO-STOMATOLOGICAL INVESTIGATION

Forensic odonto-stomatological investigations were performed based on the typical documentation of the status of the teeth. In the first days, the German DVI team removed both jaws for the examination. After the first week the Center gave the order to exarticulate only the lower jaw. At the Site Ia it was also possible to make x-rays. The guidelines included to take bite wings (complete x-rays of the crowns of the molars) during every examination. The daily processing of the large numbers of x-rays caused a bottleneck. Furthermore, all findings had to be documented by photography. The forensic odonto-stomatological investigation was the leading method from the first days until the end of

the work. In some cases the special quality of dentures gave information about the victim's nationality (Fig. 13).



Fig. 13: Denture with special sign often used in Scandinavian countries

In the last months a so-called final dental check was recommended before the release of an identified body to prevent errors. The German DVI team had already implemented an additional check before release of identified German victims as a control of plausibility. This included a comparison of the results from the odonto-stomatological and the medical investigations of the released body with the documentation of the case (Fig. 14).



Fig. 14: Plausibility control prior to the release of a victim

THE FORENSIC MOLECULAR GENETIC INVESTIGATION

The forensic molecular genetic investigation by DNA analysis was a great hope for the DVI teams, especially to identify victims

lacking other relevant findings. This was in part due to the success of DNA-based identifications of the victims following the attack on the World Trade Center in New York on September 11, 2001 (Holland et al. 2003). However, the high degree of decomposition of the Tsunami victims caused more problems than anticipated. In the first days, it was recommended by the IMC to take two healthy teeth only for storing of tissue samples for DNA extraction. In the second week of January a decision was made to use the AmpFLSTR® Identifiler kit (Applied Biosystems) for PCR-based short tandem repeat (STR) typing. Similar kits such as the PowerPlex 16 (Promega Corp.) could be also used. A profile was accepted if 12 STRs had been detected successfully. The samples were initially sent to a scientific laboratory in Beijing, China, offering to perform the analysis without costs.

A first analysis of samples from Tsunami victims carried out by the DNA laboratory at the Institute of Legal Medicine in Leipzig showed that autolysis was highly advanced (Fig. 15). Thus some samples failed to give results, or it was only possible to identify short tandem repeat (STR) fragments shorter than 200bp. Figure 16 represents show a typical example of the STR analysis of a bone sample. Only eight of the 16 STR loci comprised in the kit gave a successful result. STR loci with fragments larger than 200 bp failed. As a consequence of the initial sampling strategy, only a few results were returned. It was extremely difficult to analyse the samples taken during the first days of the investigations. At the end of March only three successful identification cases using DNA were documented (Lessig et al. 2005).

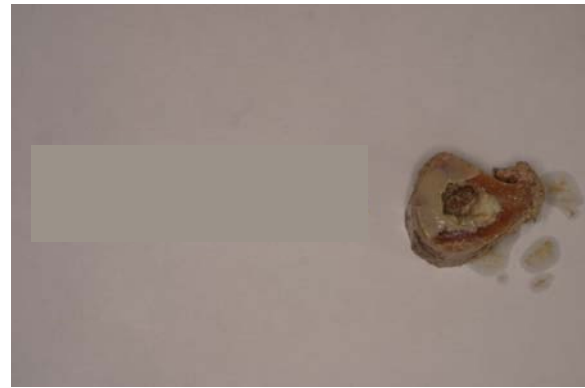


Fig. 15: Highly decomposed bone sample

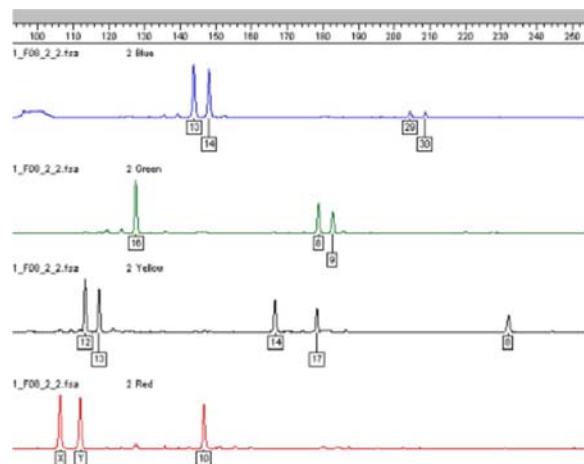


Fig. 16: Result of DNA STR analysis obtained by automated fluorescent capillary electrophoresis showing an incomplete profile. Each peak (or pair of peaks) represents the genotype of a given STR locus.

During the final inventory protocol the recommendations were changed. Samples from the femur were taken, at first 10 cm, later two 5 cm pieces. One part of the sample was sent out to an external laboratory, and one sample was stored for additional investigations. More DNA laboratories were involved after a quality control exercise to increase the number of results. Finally the following laboratories were involved: Forensic Alliance (England), Institute for Forensic Genetics (Schweden), Beijing Genomics Institute (China), ICMP DNA laboratory (International Commission on Missing Persons, Bosnia and Hercegovina) (Lessig et al. 2005). The identification rate using DNA profiling increased until the end of 2005 to 18 %.

The difficulties in getting adequate results from DNA analysis demonstrate that established protocols failed, and indicated a

lack of standards for this type of work. It became necessary to define a generally accepted sampling strategy, to establish reliable extraction and typing methods, and to identify competent laboratories with a potential for high sample throughput. Furthermore, commercial interests brought forward by service and software providers caused a significant delay and thus had a negative influence on the decision making process. The experiences of the Tsunami should be used in time to develop adequate scientific standards for DNA investigations in mass disasters (Alonso et al. 2005, Brenner 2006, Prinz et al., 2007).

Case reports

The following cases represent the first successful identifications and illustrate the potential of forensic odonto-stomatological investigations in mass disasters.

In the first case the tattoo showing a shark (Fig. 17) was detected during the examination of a male victim. The tattoo was located in the region of the left thorax. At the same time the German Federal Police sent information about a missing 55 year old man. The detailed description of the missing person included the presence of a tattoo, but unfortunately it was referred to as a "dolphin".



Fig. 17: Tattoo found on a victim representing a dolphin

The direct contact to the head quarter allowed the transfer of a photo of the tattoo. It was shown to the German relative and recognised. So the verbal AM description of the tattoo led to the first problem. Comparing the dental records of PM and AM status, discrepancies regarding the teeth 15 and 27 became apparent, as both teeth should have been missing. However, the investigation of the victim showed both teeth, no. 15 healthy and no. 27 mostly destroyed by caries. A call to the attending dentist in Germany solved the problem. The dentist planned the treatment of the upper jaw extracting the teeth 15 and 27 before providing partial dentures. However, the patient did not agree with the plan and thus had not received the dentures. Thus the AM file included the planned treatment, and not the actual status.

In a second case the dental record of a missing 10 year old boy was transferred. Results of the investigation of a young victim at Site Ib matched concerning the age, height and swimming trunks.

The PM dental record showed a typical transitional status with milk and permanent teeth. The AM dental record included a missing tooth 35 (second premolar in the left lower jaw). So a dental X-ray of this region was carried and revealed the missing tooth 35 in the lower jaw (Fig. 18). This highly individual record allowed positively to identify the boy.



Fig. 18: X-ray showing the missing second premolar in the left lower jaw. Lower jaw with the milk tooth (red circle) at this position.

A third example from our casework illustrates the problems of incorrect documentation of the ante mortem data at the stage of the final inventory protocol. A German victim had been identified by fingerprints. After the release by the board of the TTVI-IMC a final control before cremation showed differences regarding several missing teeth – one in the upper jaw should have been present and four front teeth in the lower jaw should have been missing. The investigation of the body showed no teeth in the upper jaw and four front teeth in the lower jaw (Fig. 19).



Fig. 19: Lower jaw with crowns on the front teeth

The differences of the status of the lower jaw should have been sufficient evidence for an exclusion of the identity. In addition, a specific denture was found on the lower jaw (Figs. 20 and 21). It was rather unusual that the body could not be identified by odontostomatological methods, and the release was therefore stopped.



Fig. 20: Specific partial denture of the lower jaw fixed by clasps at the crowns

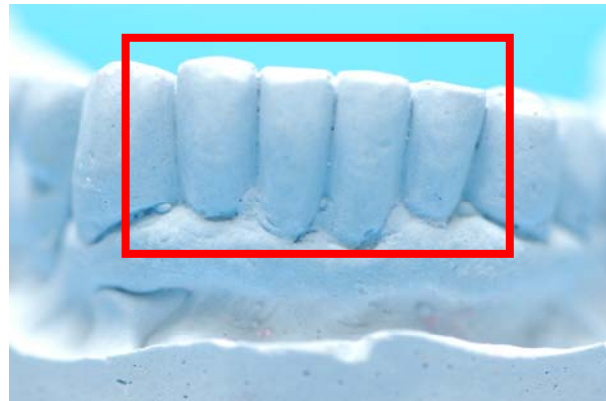


Fig. 21: Model of the lower jaw sent by a dentist showing the existing front teeth

A detailed control of the case files first revealed a data transfer error regarding the tooth of the upper jaw. According to the attending dentist's protocol the tooth in the upper jaw had been extracted. The transferred PM data with photo documentation were presented to the German dentist, and he recognised the patient. Furthermore the documents showed a full repair of the entire denture a short time earlier. A model of the lower jaw, which is normally necessary for such repair, was available and helped to establish an exact match of the AM and PM data. An incorrect documentation of the patient's dental status in the record from the dentist was revealed. The lower jaw had not been treated in his practice.

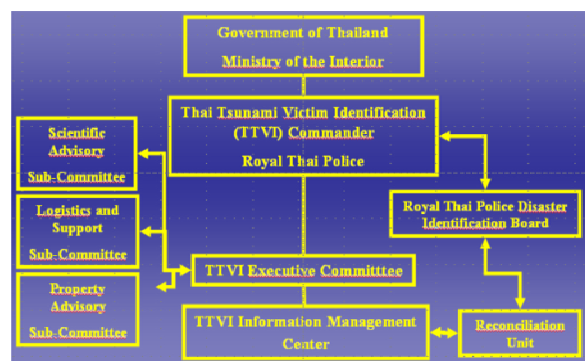


Fig. 22: Structure of the organisation of the TTVI IMC (Thai Tsunami Victim Identification Information Management Center)

Summary of the forensic investigations in Khao Lak

The large number of different teams and the unusual circumstances in the Khao Lak area

were a great challenge for the organisation. It was necessary to adapt the different teams to a common strategy. The established center was forced to formulate ad-hoc guidelines for the forensic-medical, forensic-odontological and forensic genetic investigations. Over the time, a good and strong organisation of the work could be established. The organisational structure of the TTVI IMC is shown in Fig. 22 (Peter 2006).

The large number of bodies (5,395) and the advanced degree of decomposition were the two greatest problems (Center for Disease Control and Prevention 2005). Post mortem data were collected by forensic odonto-stomatological specialists. The guidelines for the forensic odonto-stomatological investigations required a documentation of the dental status and bite wings as x-rays. The post mortem status of the teeth exhibited a high degree of individuality. Thus approximately 90% of the victims could be identified using forensic odonto-stomatological methods until the end of April, as logistic obstacles were more and more overcome (Rutty et al. 2005).

The reported cases demonstrate that positive identifications were possible in the first days too. The collection of ante mortem data included problematic documentation as shown by a wrongly described tattoo and by the errors in dental records.

Starting with the establishment of the TTVI IMC on January 12 until March 31, 2005, a total of 4,247 PM data files have been created. 1,152 victims of different nationalities were identified in this period from these case files by matching them with AM data. 1,046 victims were identified on the basis of one type of data (962 dental, 71 fingerprints, 10 physical, and three DNA) and 66 others identified by combinations of data types (Center for Disease Control and Prevention 2005).

At the end of 2005 83.5 % of the German missing persons had been identified by forensic-stomatological, 13.2 % by fingerprint, and 3.3 % by DNA investigations. 68% of all victims including

Thais have been identified in the same time. 46.3 % of these identifications were based on forensic-stomatological, 35 % on fingerprint, 18.3 % on DNA, and 0.5 % on physical methods. It mostly depended on the AM data which were available from the different countries. Many Thai victims could be identified by fingerprints using AM data which are collected routinely by the Thai authorities to issue a personal document such as a passport. 60 % of the Thai victims could be identified by fingerprints, and 38.5 % by DNA analysis, the latter were mostly children (TTVI IMC, pers. comm.).

Perspectives for forensic examinations in mass disasters

Post mortem dental examination was the most successful method of identification of unknown bodies. A lot of different strategies allow successful casework under difficult environmental conditions (Hunger et al. 1992, Benthhaus et al. 1998, DuChesne et al. 2000, Valenzula et al. 2000, Lessig 2001, Lessig and Benthhaus 2003, Tsokos et al. 2006). Post mortem dental radiographs are helpful especially in cases of non-specific matches (Brannon and Kessler 1999) such as the one reported here. Experiences in identification of victims were drawn from previous mass disasters, e.g. the Estonia ferry disaster in 1994 (Soomer et al. 2001), the destruction of the World Trade Center in 2001 (Brenner and Weir 2003, Budimlija et al. 2003, Holland et al. 2003), the Bali bombing in 2002 (Lain et al. 2003), and the aircraft disaster over the lake Constanz in Germany (Grundmann and Benthhaus 2003), as well as from exhumations of human remains from mass graves in the former Yugoslavia (Brkic et al. 2000). In contrast to the examination of the victims of the World Trade Centre attack, where identification of the nearly 3,000 victims, represented by about 15,000 body parts, rested heavily on DNA analysis (Brenner and Weir 2003), the identification of Tsunami victims in Thailand was most based on traditional forensic odonto-stomatological methods. From the

beginning of the work these investigations have led to positive identifications of victims (James et al. 2005, Peschel et al. 2005, Lau et al. 2006, Lessig et al. 2005a, Lessig et al. 2005b, Lessig et al. 2006).

The forensic specialists play an important role for the identification process in mass disaster management. The forensic team is a small part of a large effort. Teamwork and planning are essential (Fixott et al. 2001). Identification of and investigation into cause of death of foreign nationals in mass disasters are generally conducted according to the jurisdiction of the country in which the disaster has occurred. The identification can be achieved only through cooperation with the authorities of the victims' countries of residence (Lunetta et al. 2003, Alonso et al. 2005). So conclusions for the future work in this field are urgently required. The establishment of guidelines requiring high quality control for the collection of the ante mortem and post mortem data is essential for an efficient disaster management including a reliable identification of all victims.

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