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EDITORIAL

In recent years there have been localized natural disasters and terrorist acts which have highlighted Forensic Odontology within forensic science, police departments and the wider community. The Asian tsunami of 26 December 2004, however, is surely the biggest international disaster victim identification effort that we have faced.

The effects of the tsunami were felt in countries around the Indian ocean, with an estimated 300,000 people missing or dead. International efforts have been concentrated in Thailand, where many foreign tourists, as well as large numbers of Thai nationals, were killed. The sheer magnitude of the disaster, combined with the number of countries suffering lost citizens, has produced an unparalleled effort from DVI teams from over 30 separate countries. Odontologists from countries including Australia, Austria, Belgium, Canada, Denmark, France, Finland, Germany, Greenland, Iceland, Italy, Japan, The Netherlands, New Zealand, Norway, Singapore, South Korea, Switzerland, Sweden, United Kingdom & United States of America have joined Thai dentists in the DVI process. This has thrown a spotlight onto forensic odontology procedures and emphasized the need for co-operation, standard operating procedures, early quality assurance measures and much good humour.

Professor Kieser, from New Zealand, recently reminded me of an article published in 1988 in which Brown said "*Finally, it requires action and financial support by the governments of every country to establish within their borders a central identification agency and procedures that are internationally compatible. Well organized protocols will not only expedite the identification process and improve morale of the personnel involved, but more importantly, will project an image of professionalism that will inspire the confidence of the relatives of the deceased, thus minimizing their mental trauma and distress."* (Brown KA. International Communication and Cooperation in Forensic Odontology. J Forensic Odonto-Stomatol 1988;6:29-34.) This disaster has forced the international community to come to terms with that challenge.

If there can be considered to be an upside to such a disaster, it would have to be the international goodwill that has been generated, combined with the invaluable expertise that has been gained by those participating in such a huge undertaking. Simulated training exercises are undertaken by most national organizations, but are no substitute for reality.

In Thailand, over 5000 dead, from 44 countries, have stretched forensic odontology resources and personnel; with many odontologists already on their second or third rotation to Thailand. This has substantially increased the workload of all involved, making journal publication low on everyone's priority list, and an editor's nightmare. Consequently, I have accepted a series of unrefereed short reports from some of the many odontologists involved and, with their permission, I have produced a composite article to give you a picture of developments to this publication date. My heart-felt thanks to all contributors.

The poem on page 18 was composed by an Australian interpreter and read at a memorial service for the dead at Patong Beach.

Helen

THAI TSUNAMI VICTIM IDENTIFICATION - OVERVIEW TO DATE

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ABSTRACT

The boxing day tsunami of 26 December 2004 caused devastation and loss of life around the Indian ocean. International disaster victim identification efforts were centred in Thailand, with many odontologists from over 20 countries contributing to the examination of deceased, collection of antemortem information, comparison and reconciliation of data. The contribution of forensic odontology to the identification process conducted in Thailand in response to the tsunami devastation is presented in a composite of short reports focused on the five phases associated with disaster victim identification. To date 1,474 deceased have been identified. Dental comparison has been the primary identifier in 79% of cases and a contributor in another 8%, a total of 87%.
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Keywords: Forensic Odontology, Disaster Victim Identification, Tsunami

INTRODUCTION

Tsunami is a Japanese word meaning "harbour wave".[1] They can be caused by a variety of phenomena, including undersea volcanic eruption, coastal landslides or earthquakes, resulting in shifts to the tectonic plates and displacement of millions of tonnes of water to produce devastating waves.

At 0800 on 26 December 2004 an earthquake measuring 9 on the Richter Scale occurred, with the epicentre of the earthquake off the west coast of Sumatra, Indonesia. The sea floor was disrupted for 960 km and tsunami waves produced the "Boxing Day Tsunami".

The closest population base, Aceh at the northern tip of Sumatra, was inundated by water approximately 15 minutes later (estimated 130,000 dead). Waves radiated progressively across the Indian ocean, striking Malaysia (68), Thailand (5,400), Myanmar (90), Bangladesh (2), India (11,000), Sri Lanka (38,000), the Maldive (82) & Seychelle (2) Islands, and the East African coast of Tanzania (10), Kenya (1) and Somalia (300).[2]

Six coastal provinces in the south of Thailand were hit and consequently posed considerable social and economic impacts on the country. Many local people and tourists who came to appreciate the beautiful Thailand Andaman coast, were injured or lost their lives. Official reports[3] stated there were 8,457 injured, of which 72% were Thais and 28% were foreigners and 5,395 dead of which 37% were Thais, 42% foreigners and 21% unidentified. This incredibly high human cost was far beyond the expectation and experience of the nation, where a massive scale disaster had never happened before and a systematic management plan had never been set up.

According to Thai law, the Royal Thai Police Force is in charge of victim identification. Since there are few forensic pathologists and only one forensic dentist in the organization, the task of identifying thousands of tsunami victims was considered beyond the capability of the Royal Thai Police Force alone. On 27 December the Thai government issued an urgent request for assistance in view of the scale of the disaster and the number of foreign tourists affected. World-wide humanitarian relief, as well as Disaster Victim Identification plans, was activated in many countries affected by the tragedy.

The Ministry of Public Health contacted the Thai Dental Council to recruit Thai dentists throughout the country to help in the body identifications. As a result, more than 500 Thai volunteer dentists and dental personnel from both public and private sectors have participated in the tsunami dental forensic investigation, a well as an estimated 200 international dentists.

The traditional five phases structuring a DVI incident were put into place as a joint venture between Thai and Australian DVI experts – scene assessment, postmortem examination, antemortem record collection, reconcilliation to identify victims and debriefing.[4]

PHASE 1: THE SCENE

Damage

The damage to Phuket Island was variable and not evenly distributed. Patong Beach was largely destroyed, while several of the resort hotels along the coastline were back in full operation after 24 hours of frantic clean up. Phi Phi Island was totally devastated with large loss of life, but the most affected area was along the Khao Lak coast north of Phuket Island right up to the Burmese border, a distance of some 150 km. Along this coastline there were pockets of normality mixed with total devastation. There is only a small coastal plain, in some areas only 300 metres wide, backed by sharply rising hills. The tsunami rapidly inundated the coastal plain and finding its path blocked by immovable hills, turned back on itself, creating the classic maelstrom effect and massively increasing the damage. The coastal road was impassable in many places, being buried under two metres of sand and debris, with the powerlines that ran alongside the road also cut. Cars were picked up and carried great distances and some could be seen buried deep inside the first floor structure of the few remaining buildings. Several boats, of significant tonnage, were deposited half way up the hillsides, some almost 750 metres from the sea.

The vegetation rapidly died due to the massive increase in salinity and while a significant number of palm trees had demonstrated their ability to survive by flexing the way of the forces applied to them, most were bent at odd angles. The property damage along this stretch of coastline was extreme with entire hotels reduced to two courses of brickwork (Fig.1).

The loss of life was assessed as severe and while most deaths were expected to be by drowning, it was obvious from the property damage that injuries and

probably death from physical trauma would also be found.

A priority was identified as the opening of the coastal roads and re-establishment of power supplies with the setting up of refugee camps in the affected areas as soon as practicable.

A secondary, but no less significant, need was to collect the deceased and bring them to central holding areas before disease and contagion spread. This was an area in which the Thai authorities sought international help. Strong representations were made to the Thai authorities to establish a single body collection and mortuary site at or near the airport, and to this end QANTAS, the Australian national airline, was approached for the use of one of their hangars at Phuket International Airport. However, initially, the Thai authorities were unable to countenance such a massive movement of bodies, in a manner which may have proved offensive to the Buddhist faith, and the idea of a central facility was rejected by them.

The Thai authorities decided to utilise the various Buddhist temples or *Wats,* which abound in Thailand. These places have the advantage of being easily freed from their normal usage, and often have their own crematorium attached. In all societies, temples, churches and mosques are a source of comfort and solace in such situations. They are also used as information centres and as collection points for the dead. This was the case in Thailand, a predominantly Buddhist society and the attitude of the Buddhist monks should be highly praised.

Mortuary Sites

Mortuary sites were subsequently established at Takua Pa (Sites 1A & 1B), Mai Khao (Site 2), and Krabi (Site 3).

Site 1A was established at the temple complex of Wat Yan Yao and 1B at Wat Ban Muang.

Under the leadership of Thai pathologist Dr Pornthip Rotjanasunan, teams scoured the affected area for bodies and brought them to central holding areas. Given the large area involved and difficulty of transport along a still badly affected single road a decision was taken to establish local holding areas and in the earliest times many small body holding areas existed.

Initially there were over 500 bodies, mostly uncovered, lying in the sun or under primitive open-air shade at Wat Yang Yao (Fig.2). There was advanced bloating and decomposition evident with all the bodies. An additional 1500 bodies were delivered overnight, with a further 1500 bodies the next day. A precise count of the number of bodies was not possible until they had all been tagged and refrigerated and this took almost 2 weeks to complete, with more bodies arriving in varying numbers daily. Wat Yang Yao rapidly became the prime site in Phanh Nga province.

Priorities

Given the large number of bodies lying in the open with little or no protection from the elements and a daytime temperature above 30C with high humidity, several critical decisions had to be taken immediately upon arrival at Wat Yang Yao.

The major concern was identified as that of disease and this was recognised as being far more important than commencing identifications, especially as it was already very clear that the identification process

Fig 1: *Destruction on the coast road to Takua Pa*

Fig 2: *Bodies at Wat Yan Yao*

Fig 3: *Bodies waiting for container storage, Wat Yan Yao*

would take many months. The priorities for containing disease were identified as:

1. Implement some sort of body cooling process *in situ* by the use of dry ice or other agent
2. Obtain refrigerated containers as soon as practicable
3. Commence achieving some semblance of order at the site by tagging, recording and bagging bodies prior to refrigeration.
4. Clear parts of the site to allow easy access to the bodies
5. Commence a clean up of the site as soon as spaces were cleared to remove the already significant contamination caused by discarded gloves, masks and other debris
6. Identify a suitable site for the temporary mortuary
7. Commence construction of the temporary mortuary

The entire team set to work tagging, recording and bagging bodies, aided by many volunteers, while the site commander set about organizing refrigeration, power and identifying a suitable mortuary site. Truckloads of dry ice arrived at the site, followed by refrigerated containers which were immediately placed by the Thai army and connected to power supplies (Fig.3).

Personnel

The initial dental DVI team consisted of two forensic odontologists from Australia. They were joined 48 hours later by a dentist from New Zealand, followed rapidly by the Dutch, Belgian, Singaporean and Swedish teams. French and German teams also arrived on site shortly after and the entire operation grew in 6 days from a solo Australian response to a truly international effort.

Early problems and solutions

The Australian Rapid Response kit consists of a cache of pre-packed, containerised and air portable equipment and is designed to allow the team to operate in the field for 7 days before resupply. This allows for full field operations of a forensic and/or DVI nature for a week. The time frame was deliberately chosen, as this is the time it will take to assemble and deploy the larger teams needed and to arrange effective resupply. The DVI component of the kit includes portable dental X-ray machines, X-ray developing machines, and all the necessary dental mortuary equipment including personal protective equipment. It was never designed to supply the needs of dentists from 10 countries for 7 days, but sadly, with the exception of the superbly organised and equipped Dutch team, many National teams turned up woefully under-equipped for an operation of this nature and scale.

The Australian Department of Foreign Affairs and Trade signed a contract with Kenyon International to supply and maintain a mobile mortuary facility at Wat Yang Yao and thus took on the responsibility and cost of all international mortuary operations there. The Australian Rapid Response kit allowed immediate and effective aid to be given to the Thai authorities and greatly enhanced the speed at which the Australian team was able to deploy and subsequently reach full function. Re-supply was left to Kenyon International.

The mobile mortuary kit provided by Kenyon was impressive in size and scope, but customs and transport difficulties meant that its promised 24 hour deployment time was not achieved and when the kit finally arrived it was lacking in some critical areas. The provision of all electrical equipment to operate on 110V power supply meant transformers were required. The need to carefully check the voltage range of every piece of equipment was a severe limiting factor. The failure of the provided X-ray machine to function and the poorly designed stand meant that additional radiographic machines had to be sourced urgently from Australia. The initial provision of only two mortuary tables was a problem, given that the size of the disaster was well known before the kit was deployed. Praise must be given to the efforts of the Kenyon staff on the ground who worked tirelessly to establish infection control and decontamination areas.

Body handling provided its own special difficulties with different nations having varying standards, although the accepted standard for the operation was the Interpol DVI standard. The accepted protocol of having a unique number for each body was adopted and extreme care was taken to ensure that this number was not re-used. The unexpected

commencement of postmortems at other sites caused immense concerns and the unique number was rapidly modified to contain information about the site the postmortem was completed at and the country responsible for tagging the body initially.

Once a body was tagged with a durable tag marked with indelible ink attached with electrical ties to the left wrist, it was placed in a body bag which was then sealed and another tag marked with the body number placed on the zipper tag with an electrical tie. The body number was then recorded on the body bag with an indelible pen, and the head of the body indicated. The body bag was then transferred under escort to a pre-determined container and the container number noted on the post mortem form. It was stressed to all who performed this vital task that once the body had been assigned a number it was legally in their care and it was their responsibility to ensure correct storage.

While this protocol was adhered to, body tracking was simple. However there was sometimes a desire to sacrifice accuracy for speed and as a result some bodies were temporarily mislaid. This should never happen and would never have happened had all participants adhered to the guidelines.

An unforeseen and initially insoluble problem surfaced early on with the local Buddhists asking for and receiving permission to start decontaminating the site. This they did with a delightful orange scented spray which has special significance to Buddhists; however it also has a special affinity to indelible ink on body bags that rendered many of the numbers on the exterior of the bag unreadable. The wisdom of tags inside the bag on the body, as well as tags outside the bag, became abundantly clear.

Later decontamination was accomplished with more conventional chemicals; however the use of large amounts of hypochlorite bleach and formaldehyde did raise significant occupational health and safety issues and this was brought to the attention of the Thai authorities.

PHASE 2: POSTMORTEM

Site 1

Design requirements for an emergency mortuary

The design of a mortuary from scratch using only locally available materials and able to serve the needs of many disciplines while handling a large number of bodies, was a complex task and was made no easier by mounting political pressure to commence postmortem operations.

A list of requirements was established in order of importance:-

1. Adequate protection and decontamination for all staff
2. Optimum working conditions to allow maximum efficiency
3. Management of liquid waste was critical to avoid contamination of local water supplies and the nearby river
4. The mortuary had to be secure and easily protected from unwanted intrusions by journalists or members of the public
5. Areas had to be designated for specific procedures
6. An unrestricted flow of bodies had to be achieved
7. The flow and number of work stations had to reflect the time taken at each stage
8. Body handling had to be well coordinated with mortuary activities given the distance the bodies had to be moved from storage

With these requirements in mind it was determined that the best site was in the lower temple building. While the upper temple building was better situated, it was full of bodies still to be processed, and it was accepted that the time taken to remove these bodies would cause an unacceptable delay to the commencement of postmortem operations.

The flow of bodies was designed to accommodate the various disciplines, with each discipline determining their specific requirements. Fingerprinting was identified as the first stage and this was established in an air conditioned tent at the entrance to the fixed mortuary. The bodies were then moved on the same table into the mortuary. Pathologists opted for a visual examination for surface features and a laparotomy to determine if any organs had been surgically removed antemortem. The next stage established was to harvest a sample of femur or rib for subsequent DNA analysis. A decision was taken to deglove the face and resect the mandible in a manner which would allow later replacement with minimal evidence of interference.

The dental station was next where a full dental postmortem was performed with specified photographs.

The body then left the air conditioned area and went to dental radiography. Once the radiographs were checked and approved, two teeth were extracted for DNA analysis and the body returned to the care of the body handlers for placement in its designated

Fig 4: *Mortuary in operation, Site 1A*

container. It was identified that the dental radiography process was the time limiting factor and a large area was therefore allowed for body holding.

The mortuary was constructed of plywood on a pine stud frame, within the temple building. The floor was concrete and many options were canvassed before deciding that a floor covering would prove counter productive, but provision was made for specialised non-slip mats if they proved necessary. The walls were lined with plastic to stop contamination and improve ease of cleaning. A large number of fluorescent lights were installed to give optimal lighting, and three large air-conditioning units were installed to give a reasonable working temperature.

Fig 5: *Thai volunteers*

Supply of running water and fully plumbed sinks was easily achieved, although the need to rely on the local water tower for supplies meant that arrangements had to be made with the local fire brigade to supplement the actions of the meagre pump. Of far greater concern was drainage for the sinks and for the mortuary floor. This necessitated a penetration of the concrete slab, which had been specifically requested to be left intact by the Buddhist monks. As always the monks rose to the occasion and granted immediate permission for further desecration of their temple in the interests of the living. Having established the drainage capacity the problem of what to do with the waste was then paramount. An original idea to build a large soak away pit was rejected on the grounds of potential contamination of the ground water and an ingenious cascade system of septic tanks was designed and installed. This resulted in no contamination whatsoever of the ground water and nearby river.

Construction of the mortuary took 36 hours and resulted in a fully plumbed, air-conditioned, lined and well lit facility (Fig.4). The design and construction phase was challenging, not least of all because we were to be working in a Buddhist prayer house and the image of the Buddha was to remain and had to be respected.

Personnel

On day one at Wat Yang Yao over 50 Thai dentists arrived ready and willing to work. In keeping with the directive that the Australian team was to aid and not control the Thai effort Dr Russell Lain was tasked with conducting a rapid training course in basic dental postmortem procedures. This proved to be exceptionally successful and the Thai dental teams commenced their post-mortem examinations on day two, in sub optimal conditions, but with access to functional x-ray machines on site. When full mortuary operations commenced on day four, dentists from around the world had arrived to join the identification efforts.

Non-dental volunteers from Canada, USA, UK, Australia, Scandinavia and Thailand also arrived to help in the early days and without them the operation would have been seriously hampered. The role played by the Thai army cannot be overstated as squads of soldiers toiled tirelessly moving bodies and positioning containers. Most of the electricians on site were Thai volunteers as were the plumbing crews and these people were the unsung heroes of our early successes.(Fig.5)

Development of the Standard Operating Procedures (SOP)

Standard operating procedures for dental postmortem examination were written on day three by consultation between Australian and Dutch teams. The SOP established two-person teams to cover each phase of the dental postmortem with one pair being responsible for the postmortem examination, another pair responsible for the radiographic examination and harvesting teeth for DNA analysis. Each mortuary line was accorded its own dedicated dental team. It was decided that accuracy was paramount and that if necessary, speed should be sacrificed for accuracy. To this end a slightly top-heavy team structure was organised with a heavy emphasis on quality assurance. The need to ensure accuracy led to a requirement for regular breaks to be taken and the teams to be regularly rotated. The creation of a 'super dentist' to oversee each line proved to be an essential tool in the days to come when different nations started arriving to help. Incorporated within the identified dental duties, merely because of the position of the final dental procedures in the mortuary line, was enforcement of infection control and mortuary security.

Awareness of the cost of the operation and the inevitable political backlash when these costs became clear, led to a decision to avoid full mouth radiographic examinations and settle for bitewing radiographs and radiographs of any other feature identified as interesting by the charting team. Photographs were required of the anterior dentition, left and right molars and the occlusal surfaces of teeth. Polaroids had the advantage of being instantly ready and assessable, did not require a computer and were nowhere near as easy to lose as flash cards from digital cameras. It was decided that posterior teeth without restorations would be extracted for DNA profiling. This was later changed, against our advice, to anterior teeth.

The dental team was formed into the required groups to carry out the SOP effectively and it was decided at once that unless the dental group could be unified outside strict Nationalistic boundaries that it's effectiveness would be diminished. This led to the adoption of pre and post work team meetings where issues were aired, new members welcomed and a co-operative team framework built.

In mid-March New Zealand police carried out an audit to establish how many deceased persons remained to be examined at Site 1. The Thai government set a date for closure of the site and therefore all teams were aware of the workload for the days prior to closure. Efficiency lifted in all aspects over these days. The critical factors were timing of body transportation so that teams could commence work early. In the dental examination area, the Dutch team arrived earlier than the Australian and New Zealand teams, dissecting mandibles so that examination of the deceased persons could commence as soon as the Australian and New Zealand teams arrived. A sense of satisfaction was felt by all when all examinations were completed a day ahead of the scheduled closure.

Problems encountered

Some of the problems encountered were old favourites of the forensic dental world, such as the ability to detect tooth coloured restorations in difficult light conditions.

One area of potential problem was identified early when Thai authorities required a separation to be made of Thai and western bodies. It was suggested to them that such separation would at best be prone to error and this later proved to be the case.

Relieving teams took over from teams who were extremely tired. As a consequence there was limited time for briefing before the handover. While standard operating procedures (SOP) were available in written form, taped to walls of the temporary mortuary and to the desk in the Quality Assurance section at Site 1, smooth transition was hampered by lack of time.

Maintenance of the dental SOP at Site 1 was never a significant problem with rigorous enforcement being carried out by the 'super dentists', the team leader and his deputy. The same SOP, however, was not applied at the other sites with the same vigour and this resulted in variable post mortem results and standards.

With the generation of large numbers of radiographs (up to 200 per day) there were problems with film processing and film mix-ups. Assigning a single individual to accept, log, and process all radiographs resolved this issue. Ideally, this individual should adopt a quality assurance role that includes machine and chemical maintenance.

The need for one single dental DVI commander was rapidly identified, but never achieved except for a brief period at Site 1.

Site 2

On 31 December a provisional mortuary near the international airport in the area of Wat Tha Chat Chai was established. German and Austrian DVI teams

examined victims who had been stored at the hospital in Phuket Town. The conditions at this location were problematic as there were no hand-washing facilities. Furthermore, the work had to be stopped after sunset because no electricity was available to operate spotlights. Three days later the DVI teams moved to Site 1B, and then to 1A.

Site 2 was later selected as the site for the new central autopsy facility near the airport. Norway was approached to provide financing for the centre and the Norwegian company Normeca was contracted to provide the construction. Normeca construct and build temporary hospitals in areas of crisis. They have gained experience and built their reputation from Bosnia, Kosovo, Afghanistan and a number of other countries. The Norwegian government is covering all expenses of running the Site, including responsibility for supplies, security and cleaning.

The normal temporary hospital design consists of units of about 3 metres, which can be easily connected to form a long building. This concept was redesigned as a mortuary. Three such buildings (Fig. 6), with capacity for two examination lines per "tunnel" (Fig. 7), were set up in late January.

Fig 6: *Temporary mortuary consisting of three buildings*

Fig 7: *Interior view of one of the tunnels. Connecting units can be seen and the total length of the room was about 40 metres*

Advantages compared with the early sites include sufficient space in the tunnels to reduce bottle-necks. Since, again, no dedicated radiography area was incorporated into the design, the length of the tunnel at least allowed improved radiation hygiene. The rooms were fully air-conditioned, an important factor in improving working conditions, with sinks, running water and electricity available for lighting and computer terminals. The location had the advantage of proximity to the airport and accommodation, removing the long travel times that featured prominently at Site 1.

Currently, personnel at Site 2 are undertaking an inventory of bodies remaining at the site. The purpose of the Final Inventory Procedure (FIP) is to check that the available postmortem information is accurate, that the dental charting is correct and that good quality photographs and radiographs exist prior to bodies being sealed. Odontologists at the Thai Tsunami Victim Identification Information Management Centre assess existing postmortem records and issue target requests for any deficiencies. For example, extra radiographs may be requested of root filled teeth or for age estimation. Once the FIP is complete work at the site is expected to cease, except for the repatriation of bodies.

Site 3

At Krabi (Site 3), one of the major disaster sites in Thailand, operations by a combined International Disaster Victim Identification Team started on 5 January 2005. This team consisted of representatives from six countries: Israel, Switzerland, Canada, Italy, Portugal and Japan. The members of the team included dentists, forensic pathologists and anthropologists, DNA experts and police personnel. (Fig.8) Only two dentists from Thailand were at Site 3 since most of Thai dentists were involved at Site 1 at Takua Pa.

Each body was examined using the following protocols:

1. Two dental radiographs (bitewings) of right and left molar regions were taken on each body brought from the freezer container, and developed.
2. The body was then brought to a team. Dental examination (the status of each tooth) including anatomical features were done and the DVI dental form completed. Not all countries sent dentists to the site, therefore one dentist worked for a number of country teams.

Fig 8: *Body examination at Krabi*

Physical characteristics such as tattoos, evidence of surgery and so on were recorded. If possible, finger prints were also taken by the police. Clothes were washed and photographed. Personal belongings were also photographed. Lastly, two intact teeth were extracted for further examination of DNA.

After each day's operation a meeting was held at the hotel, where the number of bodies examined and the schedule for the following day were discussed. The total number of the bodies examined until 13 January 2005 was about 350. Bodies from Site 3 were eventually moved to the new Site 2 facilities.

Occupational Health, Safety and Welfare

Occupational health, safety and welfare issues associated with disaster management can be divided into three stages: pre-deployment, whilst on rotation and post-deployment.

For example: the pre-deployment information advice for the Australian contingent included advice on health, hygiene and acclimatization as well as cultural and religious information. Awareness of the occurrence of additional earthquakes/after shocks was noted.

Given that information about local conditions was initially uncertain, mandatory vaccinations for Hepatitis A & B, diphtheria, tetanus, meningitis, typhoid and polio were arranged. Anti-malarial treatment, in the form of oral doxycycline, was also prescribed. Impregnation of work clothing by immersion in permethrin was deemed appropriate for protection against mosquito borne dengue fever and malaria.

Initial concerns at Site 1 included infection control measures. Protective clothing, rubber boots and gloves were commonly used; protective eye wear and masks were less common due to the extreme heat. Attempts to demarcate clean from dirty areas, by use of bleach boot wash, change areas, etc was not always successful. (Fig.9)

Awareness of injury, from fragmented bones and the use of "sharps" – scalpel blades and dental probes, was emphasized. The experience of those involved resulted in few incidents amongst dental staff.

Radiation hygiene was of concern to a number of teams. It was, however, agreed that radiographs were essential to complete examinations and for the reconcilliation process. Proximity and direction from the cathode tube was emphasized, given the lack of a dedicated lead-lined area. (Fig.10)

Given that many odontologists arrived from a Northern Hemisphere winter, heat stroke and dehydration were potential problems in the hot, humid environment. Bottled water for drinking had to be taken to the sites on a daily basis.

Fig 9: *Disinfection measures*

Fig 10: *Radiation Hygiene*

The devastation of the local infrastructure meant that travelling times of 2-3 hours each way from accommodation added to fatigue when combined with work shifts of six hours. Initially, work-free days were haphazardly arranged, but this was soon recognized as counter-productive to a steady workrate.

An unexpected problem was the frequency of visitors, including political dignitaries, media personnel and high-profile sightseers. On the other hand, local and expatriate volunteers who moved bodies, developed radiographs and provided food rendered considerable assistance.

By the time the new Site 2 mortuary was created, most of these hazards had been recognized and appropriate safety measures documented to brief incoming staff. Two new problems were quickly identified – sharps left in body bags from previous examinations and hazardous fumes emitted when re-examining bodies preserved with formalin.

Trauma counsellors and chaplains were available during deployment and many teams underwent compulsory psychological debriefing at the end of their rotations.

PHASE 3: ANTEMORTEM

The antemortem and reconciliation phases of the process were co-ordinated at the Thai Tsumani Victim Identification Information Management Centre (TTVI-IMC). The building was lent to the process by the Telecommunications Organization of Thailand, (Fig.11) and with some quick additional wiring, was suitable for the computer-linked phases of the operation. Those working in the building include police investigation teams, Interpol representatives, forensic odontologists, fingerprint and DNA experts, country liason officers and representatives of Kenyon International. (Fig.12)

In any disaster, dental identification relies on the matching of postmortem records with their respective antemortem counterparts. Postmortem record creation will usually be reasonably straightforward, although possibly unpleasant, to achieve as the body (or parts thereof) is at the disaster site. Antemortem records present a far greater challenge to obtain, collate and standardise for incorporation into the DVI process. This can be very difficult in the “closed”-type of disaster, where a definitive victim list exists, such as with an aircraft crash. However, the difficulties are greatly magnified in the “open”-type of disaster, where no such list exists.[5] The DVR (Disaster Victim Register) process is required here, which attempts to create a victim manifest by requesting information from all interested parties to an incident. The resulting information is subject to inaccuracy, duplication and frank omission with regard to possible victim presence. Nevertheless, this is the information from which the antemortem record collection process must begin. This process is complicated enough when occurring in a single country, whereas an international incident introduces an exponential elevation to the situation. Such was the case in Thailand.

Antemortem record collection was the responsibility of the respective countries police agencies, co-ordinated by Interpol. For example: The Bureau of Legal Dentistry (BOLD) took an odontology leadership role in the identification of 17 Canadian

Fig 11: *Thailand Tsumani Victim Identification Information Management Centre*

Fig 12: *TTVI-IMC personnel*

citizens missing from several southern Thailand beach resorts following the tsunami. The dental records for all missing Canadians were received into custody at the laboratory. This was accomplished primarily by BOLD's interaction with provincial dental associations and by the Royal Canadian Mounted Police (RCMP) Task Force through contacts with the missing persons' families. High-resolution digital images of all dental records were produced as insurance against loss when the records were transported to the response area.

The digital dental records produced at BOLD became extremely important when difficulties were experienced in getting the original records to the TTVI-IMC. Part of the lab's website was encrypted, and secure usernames and passwords were supplied to Canadian odontologists. Thus, the electronic versions of the dental records and subsequently digital fingerprint records and photographic evidence could be supplied very quickly using the Internet. This was a significant development that expedited the entry of data in Phuket.

Unfortunately, record collection in many other countries was not as efficient. Often, dental information was scanty. Antemortem F1 and F2 forms were completed, not by experienced forensic odontologists, but by general dentists or, occasionally, by police officers. Forms completed in a language other than English had to be sent for translation. Information was difficult to verify without original dental records. In several instances, radiographs had been scanned in the reverse orientation.

Thai records were received from public clinics and private practitioners. However, a propensity to record only treatment received, together with few dental radiographs, meant that they were not a good source of identifying material.

When either antemortem or postmortem records were received at the TTVI-IMC, they followed the pathways shown in Fig.13. Prior to any dental data input, the antemortem information was analysed and standardised for inclusion into the program. This was done by two forensic dentists, as mistakes are easily made (with unacceptable results to the DVI process) by a solo operator.

The file management system selected by DVI commanders for use was Plass Data™ DVI System International, a Danish software program based on the Interpol DVI forms. It is the standard DVI computer operating system of many of the European and Scandinavian countries and, since use in Thailand, had generated considerable interest in a number of other countries.

The sheer scale of the tsunami disaster meant that an electronic system was needed in order to process the large number of antemortem and postmortem data sets. Plass Data™ offered a system that was Windows*-based and staff were able to operate it with a minimum of training.

The system allows retention and electronic transfer of all antemortem and postmortem data including general information, photograph files, dental charting, x-rays and notes, electronic fingerprint records and DNA information. Data can be remotely sent to an information management centre from the country where the missing person lives. The system runs automatic matching routines for dental and DNA information and can be used by forensic dentist, DNA experts and law enforcement officers to generate searches for probable matches.

A problem that became apparent at the TTVI-IMC was the forwarding of "processed" data for direct inclusion into the computer program, with original antemortem data being retained by host countries. This was deemed unacceptable, regardless of assurances from representatives from those countries as to the excellence of their forensic record compilers, as errors were noted in the very first such records brought up for comparison.

Another common noting was incomplete antemortem records, with chart information alluding to radiographs which were not supplied. Such happenings were referred to Interpol, for liaison with the respective police agencies and hopeful collection of the requested data.

So far, approximately 2200 antemortem records are on file at the TTVI-IMC, with over 4200 postmortem records also present. However, as the total mooted victim list is around 5300, the likelihood exists that many of the antemortem records may refer to victims whose remains have not been recovered. Nevertheless, as the overwhelming majority of the identifications have been achieved through dental means, the indisputable importance of antemortem dental records is obvious. This reinforces the onus on all dentists to ensure that their patient records are as complete as possible and retained for the maximum possible time.

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* Microsoft Corporation, Redmond, WA, USA

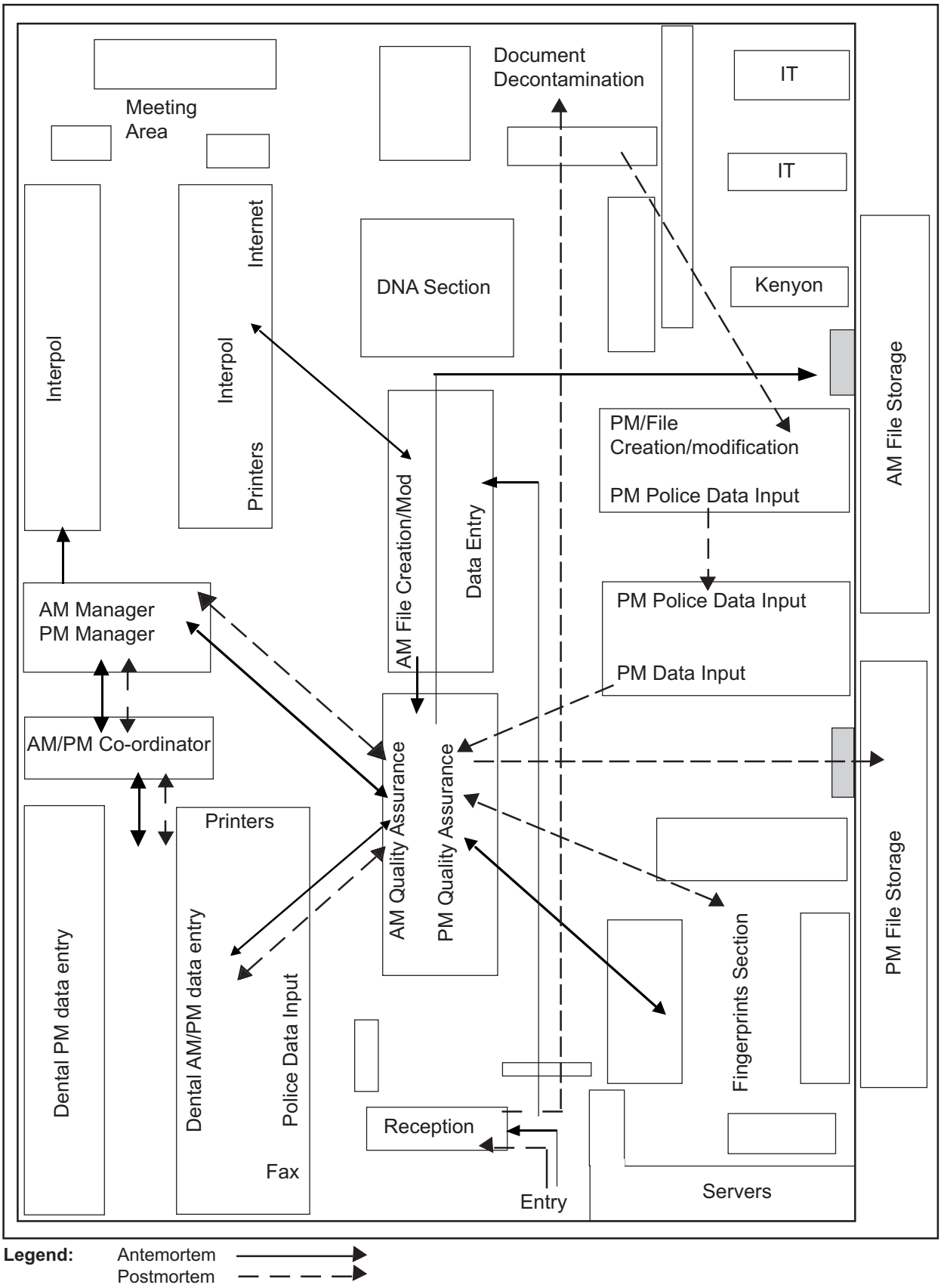


Fig.13: *Thai Tsunami Victim Identification - Information Management Centre: Layout and File Movement*

Kenyon Deployment
Within 48 hours of the tsunami, Kenyon International Emergency Services, a worldwide premier disaster management company, responded to the incident and established a coordination center in Bangkok, Thailand. The initial response group consisted of 11 disaster management experts, a forensic odontologist and a mortuary-operations specialist deployed from Kenyon offices in Singapore, London, Houston and Sydney.

As political issues mounted in Thailand, the Thai government was pressured to identify the human remains and return them to their families as quickly as possible. Although the Thai government declined any international financial assistance for the disaster, the Thai Prime Minister was quick to accept help with the identification effort. With the generous offer by the Australian government to partially fund the identification process and international effort, the Thai government brought in Kenyon International Emergency Services.

Kenyon initiated deployment of many of its forensic team members from around the world. The task at hand was to provide logistical support to the three remote mortuary sites, establish and staff the repatriation center and offer technical, administrative, and logistical support to the Thai Tsunami Victim Identification Information Management Centre.

Kenyon maintains a significant number of dental equipment kits in its mobile mortuary; however the number of dental radiograph machines, light view boxes and computer equipment was not sufficient to handle the massive case-load. It was recognized immediately that Kenyon needed to locate and outsource additional dental equipment that could be used to allow the forensic odontologists to effectively do their work. Catering to the personal preferences in protective clothing for a wide spectrum of dentists also provided a challenge.

Managing a disaster of this magnitude depends upon the ability to process antemortem and postmortem information to determine positive identifications. Kenyon provided the resources, technology and Plass Data™ software application to handle such extensive information. Forensic dentists were trained on Plass Data™, a sophisticated computer application that mirrors the Interpol DVI forms. Having the ability to provide and maintain a computer software application like Plass Data™ reduces the time spent on hand-collating information and reconciling the information for positive identification.

Information management is crucial and vital to the outcome of a disaster. Having protocols, procedures, and processes in place is paramount to obtaining positive identifications. Maintaining a cache of computers and supplies, along with the ability to acquire additional equipment helps expedite the identification process. Locating functional computer equipment was another challenge, especially while working in a facility that did not have the appropriate infrastructure in place. Having information technology staff on site enabled the infrastructure to be installed and the appropriate equipment put in place.

With over 75 years in business, Kenyon has knowledge, expertise and experience in managing various disasters on an international level. The ability for a private company to work harmoniously with the public sector is a credit to both in achieving the common goal. The commitment to obtaining positive identifications was the highest priority for everyone working in the Thai Tsunami Victim Identification Information Management Centre.

PHASE 4: RECONCILIATION
The task of Reconciliation is to find consistencies between specific antemortem and postmortem records and investigate these consistencies further with the ultimate aim of confirming the identities of the deceased based on the comparison of antemortem records with postmortem records.

In the early days, fortuitous examinations wielded some positive identifications. In one case, antemortem information, including a dental record, for a missing 10 year old boy was collated and transferred to Thailand. Examination of a young victim at Site IB matched concerning the age, height and clothing (swimming trunks). The postmortem dental examination showed a typical mixed dentition, with deciduous and permanent teeth. Age was estimated at 10 years +/- 3 months. Tooth 35 was congenitally missing (Fig.14). The antemortem record also indicated that tooth 35 was congenitally missing. Identification, based on dental and physical evidence, was accepted and allowed early repatriation of this child.

Reconciliation procedures were soon located at the TTVI-IMC and using the Plass Data™ program to generate potential matches. The reconciliation work area was separated from the antemortem/ postmortem data entry areas in order to prevent potential loss or contamination of files and to maintain a more transparent chain of evidence so that the

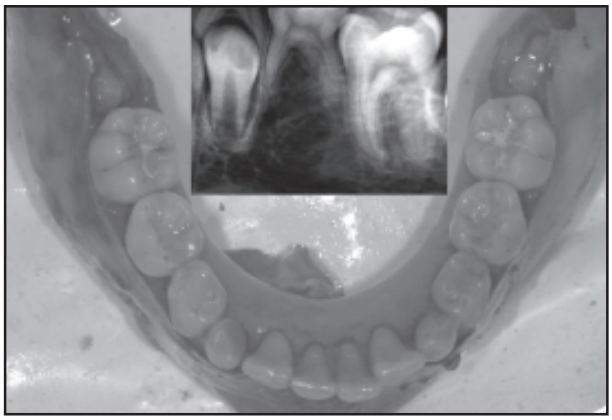


Fig.14: *Status of the lower jaw and the radiograph of the 35 region*

antemortem and postmortem files could be easily located and updated if required.

From a reconciliation perspective, the Plass Data™ program has a most important search function which runs during the night. This searching of potential links between certain antemortem and postmortem records allows for the process of data mining to occur. Data mining involved further investigation of the links between particular antemortem and postmortem records already made by the Plass Data™ program to assess whether these particular records warrant a thorough examination by a member of the Forensic Odontology reconciliation team. The method of data mining has evolved with time. Originally the data mining was done by non-dental personnel but this was discontinued in favour of using the Forensic Odontology reconciliation team. This had the advantage of being able to spread the workload to help improve productivity and, with the initial searching being done by the Odontologists, those records requiring more thorough examination could be more efficiently targeted. In recent weeks this search capacity had been discontinued due to the potential for unbiased data mining and the fact that many found the search facility a little clumsy. A new add-on search too is currently being trialed which allows searching for particular aspects of dental treatment such as root canal fillings in specific teeth.

Once a search had been made in the system and when there was a valid reason for thoroughly investigating a comparison between a particular antemortem and postmortem file, the hard copies of these files were requested. The comparison was made based on the antemortem and postmortem evidence made available, such as dental charts, dental records, photographs, radiographs and perhaps study models. This is where real difficulties in the comparison often surfaced. With regard to the postmortem dental evidence, the problems most often encountered were due to radiograph quality. There were cases in which an insufficient number of radiographs were taken, or were of diminished use due to problems with orientation and film quality. However it was more common for problems to occur with the antemortem evidence and this appears to be a recurring theme in disasters.[6]

The types of problems encountered with antemortem dental evidence were numerous but included inadequate or poor quality record keeping and a lack of good quality radiographs as well as the problem of unmarked dentures. These problems which have been identified were compounded by the fact that the radiographs were often scanned into the Plass Data™ program which further decreased the quality. Often there were no hard copies of the antemortem radiographs and dental charts available due to diplomatic difficulties in obtaining records from certain countries. This highlighted another difficulty, which not only affected reconciliation but also the entry of antemortem and postmortem dental data, being that of deciphering the different dental nomenclature, charting methods and language used in dental records from different countries. The difficulties associated with this were averted by having an important multi-national presence in both the reconciliation area as well as in the antemortem/ postmortem data entry area. Deciphering dental records from Germany is made just a little easier with a German forensic odontologist sitting alongside you.

Initially, Plass Data™ could only show one scanned or digital image at a time. This meant that there could not be an antemortem radiograph or photograph displayed at the same time as postmortem radiograph or photograph. This problem has been resolved.

For Reconciliation to work effectively, quality controls needed to be in place and the Dutch command has provided strong leadership and support in this regard. When a conclusion had been reached about a particular antemortem and postmortem file comparison it was assessed and checked by one of the Dutch odontologists. When making a conclusion regarding a particular antemortem and postmortem file comparison, there were five potential outcomes of this process. They were Established, Probable, Possible, Insufficient Evidence and Excluded. An example of a comparison where the identity could be established would be where there are many points of concordance between antemortem and

postmortem radiographs and dental records with any points of discrepancy being easily explainable. When the points of concordance were less due to inadequate antemortem information or a lack of antemortem radiographs, it was unlikely for the identity to be able to be established and perhaps only a probable or possible identity could be reached. In these cases additional methods of identification such as fingerprints, DNA or physical evidence would be required to help establish the identity.

Once enough evidence had been gathered to establish the identity of one of the deceased, the case report was prepared outlining the methods of identification used and the reasons for the conclusions being made. The case could then be presented before the Reconciliation Board of the Thai Tsunami Victim Identification Commission. If identification was accepted by the Board then the repatriation process could begin.

One of the tragedies within this disaster has been the number of children who lost their lives. Unfortunately from a forensic odontology perspective it is difficult to identify children due to the lack of dental treatment performed in young children with little antemortem dental information and few radiographs available. The use of age estimation techniques based on dental development has been helpful and may certainly be of use in at least making an identification possible. Having said this, these techniques need to be used cautiously as they can be only give a possible range of age for an individual and therefore are only an estimation.

The scope and complexity of the operation at hand in Thailand, with regard to the identification and eventual repatriation of the deceased, was evident after working in the Reconciliation wing of the TTVI-IMC. It evoked a greater appreciation of not only the importance of good quality dental evidence in the identification of the deceased but also the corroboration of this dental evidence with other identification methods including fingerprints, DNA and physical evidence. There have been and will continue to be many lessons learnt in the reconciliation of the deceased in mass disasters such as this one. With a disaster of this magnitude it has certainly extended our knowledge of the best way to approach and cope with other disasters in the future. It can only be hoped that international efforts are made to encourage the keeping of good dental records and the marking of dentures which is a view that has been expressed from other disasters that have occurred in recent times.[7]

Progress to date

Forensic odontology is well recognized as regularly making a significant contribution to positive identifications in mass fatality incidents. The value and accuracy of dental evidence is acknowledged in the Interpol Disaster Victim Identification Guide[8] where it is noted that if dentistry can provide a confirming identification, this can be regarded as a stand alone identification, not requiring additional contributing evidence from other scientific disciplines. Numerous authors[9-12] have reported the contribution of forensic odontology to the identification process in mass disasters, with contributions ranging from 22 - 100% of identifications in a number of disasters.

Recent advances in DNA technology and capabilities have led many to speculate that traditional methods of identification will be superseded, and ultimately rendered redundant. Sole identification via DNA has been employed in a number of recent disasters, including the Kaprun Cable car fire disaster.[13-15] In actuality, the majority of major incidents use a combination of all available identification techniques to confirm the identity of the deceased.[10, 12, 16, 17]

By 11 May 2005, 1,474 bodies had been identified through the formal processes of the Identification Board. The vast majority of these were identified by dental comparison. Table 1 shows the distribution of identifications by primary identifier. This indicates that odontology had provided 1,163 (79%) of these identifications, and contributed in part to another 125 (8%). Overall, odontology has played a role in 87% of identifications

Also observable is the low level of identifications confirmed by the other major identifiers, fingerprints and DNA. Fingerprints had contributed to 129 (9%) of identifications as sole identifier, and made a contribution to an additional 109 (7.3%) identifications. To this date, DNA had confirmed only seven (0.5%) of identifications. It is reasonable to assume that these disciplines will contribute to more identifications as the process continues. Reviews of identifications at future dates should indicate a more even distribution of the contribution of the different primary identifiers.

The significant contribution of odontology, particularly early in the identification process is consistent with findings in other disasters.[17] The merit of forensic odontology as a valuable tool in the identification process in mass disasters is reinforced by the statistics of confirmed identifications completed by the Thai Tsunami Victim Identification Commission. There is no evidence to support the utilisation of

single methods of identification where large numbers of victims, from various countries, are involved.

PHASE 5: DEBRIEF

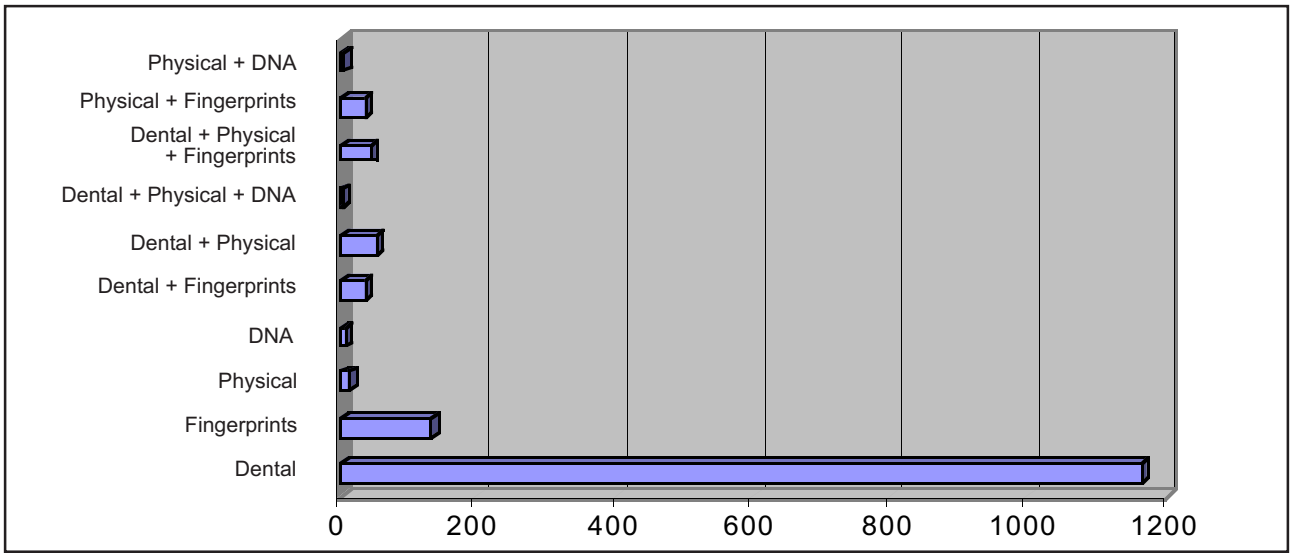
The debrief phase of the DVI process involves examination of work practices to establish the efficiency and effectiveness of the DVI response and to identify any positive or negative aspects that enhance or impede the response.[4] In addition to the official Thai Tsunami Victim Identification debrief, there must be discussion of the role of odontologists in this disaster at upcoming meetings such as IAFS and AAFS.

Obvious areas for discussion include:

1. The desirability, from the outset, to co-operate with local community leaders to accommodate local religious and cultural issues that may not be immediately apparent to overseas visitors, such as display of national flags without the corresponding host flag.
2. Standard Operating Procedures for international incidents. It is clear that standards of postmortem examination, and quality assurance checks, have been irregular, in spite of standard operating procedures. A number of national identification teams included dentists with minimal experience in both the theory and practice of identification work. Language difficulties have also contributed to problems. These issues need to be addressed at national levels; a major disaster is not the place to learn the theory of DVI.
3. Use of English for all data entry, as recommended by Interpol. There were numerous instances of antemortem and postmortem F1 and F2 forms not completed in English. Written descriptors (form F2 sections 87 and 88), potentially extremely useful sources of information, were often left blank. In future the need for some details in these sections could be emphasised.
4. Consistent rostering of odontologists from different countries to allow a steady daily work load. On some days there were a lot of dentists available and on other days only a few dentists were present.
5. Recognition of the requirements of original antemortem data. Each country of origin should appoint one or two trained forensic dentists to collate all antemortem records and to transcribe these to an acceptable standard prior to forwarding them to another country. There were instances of reluctance or refusal by treating dentists to supply original records. Such instances may be considered reportable to the Dental Board of the particular country.
6. Data file management. Numerous files mysteriously disappeared/reappeared.
7. The use and effectiveness of the PlassData™ computer program.

The Canadian team experienced a remarkable situation during the response, which may be regarded as an example of “disaster tourism“. A retired dentist from Vancouver who lives near Phuket was able to insert himself into the response. He dropped the names of Canadian odontologists to gain access through the fairly loose security checkpoints. Since this dentist had no previous DVI training, problems that reflected poorly on the rest of the team ensued. The dentist’s personality caused considerable stress

Table 1: Identified bodies by primary evidence as at 11 May 2005. (Total bodies identified 1,474).



and embarrassment to the team. The dentist developed a relationship with family members of a missing Canadian that came to the site and this caused numerous concerns and problems. Eventually Interpol personnel removed him from the site. This highlights the stringent need for team security and the use of fully-qualified odontologists.

Prior to the tsunami disaster, forensic odontology in Thailand had played a relatively minor role in the forensic sciences and was not considered to be of importance, comparing with other dental clinical subjects. The subject is allotted only two to three hours in a six-year undergraduate dental curriculum and does not appear in any post-graduate dental program. National standards or guidelines for forensic odontology had never been established. This disaster has increased awareness and highlighted the importance of forensic odontology in the Thai dental profession. They are determined to use this crisis as a chance to develop knowledge, experience and skill in forensic odontology and raise standards to an international level by development of a national protocol on forensic odontology and promotion of postgraduate study for specialised dentists in this area.

The Boxing Day Tsunami is the largest single event ever requiring a modern DVI response and the early days of the operation were a vast learning curve for all concerned. The fact that so many lessons were available and for the most part learnt, will stand the forensic dental community in good stead for any future operations. Never before have so many nations from different parts of the globe come together in one single operation and the term “Global Citizenship” has taken on a new meaning.

As a final comment, we have introduced a new word to DVI experts. All those who have been involved in this incident will recognize this word. “Manky” will from now on be associated with dirty, smelly work conditions, and a reminder of a job that had to be done in Thailand.

ACKNOWLEDGEMENTS

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Thanks to all who have provided photographs for publication.

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LETTER TO THE LIVING

Barham J.R. Ferguso*n*
12 January 2005

Hello my friend from distant lands.
I see you without my eyes and
Still you look upon my face as
Though I am watching you.
I feel your touch without my senses
And still you treat my body with
Unbridled kindness.
I hear you even though I am
Without ears, and still you speak
Softly to me as you do your work.
I know I am not what I used to be,
But please remember me as I was.
You may mourn my passing but
You must not be saddened by it.
As my life began, so must it end.
Know that your work for me,
My family and my country will
Never be forgotten.
Know that your smile throughout
Adversity lifts my spirits, as well as
Those of your friends and others
Around you. Always live your life
As though it may end at anytime,
For it is then that you will truly live.
My eternal Love and Blessings.

The unknown dead.

DVI SYSTEM INTERNATIONAL: SOFTWARE ASSISTING IN THE THAI TSUNAMI VICTIM IDENTIFICATION PROCESS

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ABSTRACT
DVI System International is software that operates on the PC-Windows platform. 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. Following the Thai Tsunami Disaster of 26 December 2004, Interpol recommended that its member country Thailand use DVI System International software, as it is one of the few internationally approved systems. This paper focuses on the concepts upon which the dental forms, F1 and F2, of the DVI System International are designed, describes how it works and some of the adjustments implemented during the ongoing Thai Tsunami Victim Identification process.
(J Forensic Odontostomatol 2005;23:19-25)

Key words: software, identification, DVI, forensic odontology, Thai Tsunami

INTRODUCTION
Modern technology offers means of processing and transmitting data that can significantly expedite identification procedures. Following the natural disaster that took place on 26 December 2004, the Interpol organization recommended that its member country Thailand use the DVI System International software, as it is one of few internationally approved systems in data handling and matching of missing persons to unidentified human remains. The software is based on the Interpol Disaster Victim Identification (DVI) form[1] that has particular advantages when victims of several nationalities are involved, as in the disaster in question. The forms consist of two sets of data sheets: a yellow form set for recording latest known data concerning a missing person; and a pink form set for recording all findings concerning a dead body. The yellow and pink forms have sections recording the same type of data: C forms contain technical descriptions on effects (clothing, jewellery, documents etc.); D forms contain physical characteristics; E forms contain medical information; F forms dental information; G form any further information that may assist in identification. Furthermore A forms in the yellow form contain personal data of a possible victim or missing person while B forms in the pink form are the report on the recovery of the body from the site.

This paper focuses on the concepts upon which the dental forms, F1 and F2, of the DVI System International are designed, and describes how the system works and some of the continuous adjustments and improvements implemented during the ongoing Thai Tsunami Victim Identification (TTVI) process.

HISTORY
Denmark has taken an active role in the DVI form set developed by a working party established by the Interpol Standing Committee on Disaster Victim Identification. It was, in fact, one of the Committees co-founders, forensic odontologist, Soren Keiser-Nielsen (deceased), who, assisted by police inspector, Gunnar Johnsen, designed this international form in 1988. Since then the DVI forms have been continually reviewed and revised by the Missing and Wanted Persons Search Squad of the Danish Police Force in close collaboration with Interpol's Standing Committee on DVI. The first and second electronic versions of the Interpol DVI form, known as DVI/IDDONT System (DOS) and DVI System (Windows), were designed and developed in the early and mid 1990s by the Danish DVI Group in cooperation with Plass Data Software A/S. These software programs were based on standards and complied with the Interpol guide for DVI, the Interpol DVI form set, search and comparison methods, dental standards for nomenclatures and tooth numbering. Progress in design and development of the DVI System, taking into account the experience acquired, has currently been presented to Interpol Standing Committee members. The software has finally been tested and approved by Interpol. The

software used in the TTVI process is the latest version known as DVI System International (commonly referred to in Thailand as Plass Data™). This System has been developed in Delphi and data are stored in a Microsoft SQL database* to comply with updated requirements for computer assisted DVI including exchange of data with external systems via XML-files.

FUNCTION OVERVIEW

DVI System International operates on the PC-Windows* platform and all functionalities of the system can be selected from the menu in the main window (Fig.1). The form-selector toolbars below the menu bar are used to open individual pages in the antemortem and postmortem forms sets. With an active antemortem case, all buttons in the post-mortem toolbar are disabled and vice-versa. The case selector toolbar manages open cases and displays the currently active case. Provided the active case is a search case, a search button is enabled on the bar and executes a form search upon activation. True images of the individual form pages are displayed in the windows workspace and entering of data is performed in these form windows.

*Microsoft Corporation, Redmond, WA, USA

Online Case Manager

The software opens with the *Online Case Manager* (Fig.2). As needed, this manager may be opened from the file menu. The case lists can be filtered by entering text or by selecting sex, case kind or case state. The targeted case is loaded by a double click of the line. A panel of buttons allows the user to choose between different tasks: create a new ante-mortem or postmortem case; edit or delete an existing case; change the number of an existing case; search for cases; import or export cases (XML files); print DVI forms with case data; print case list.

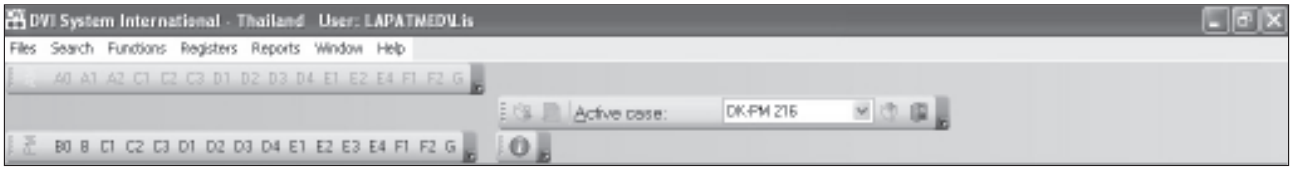

Fig.1: *Main menu bar and toolbar area*

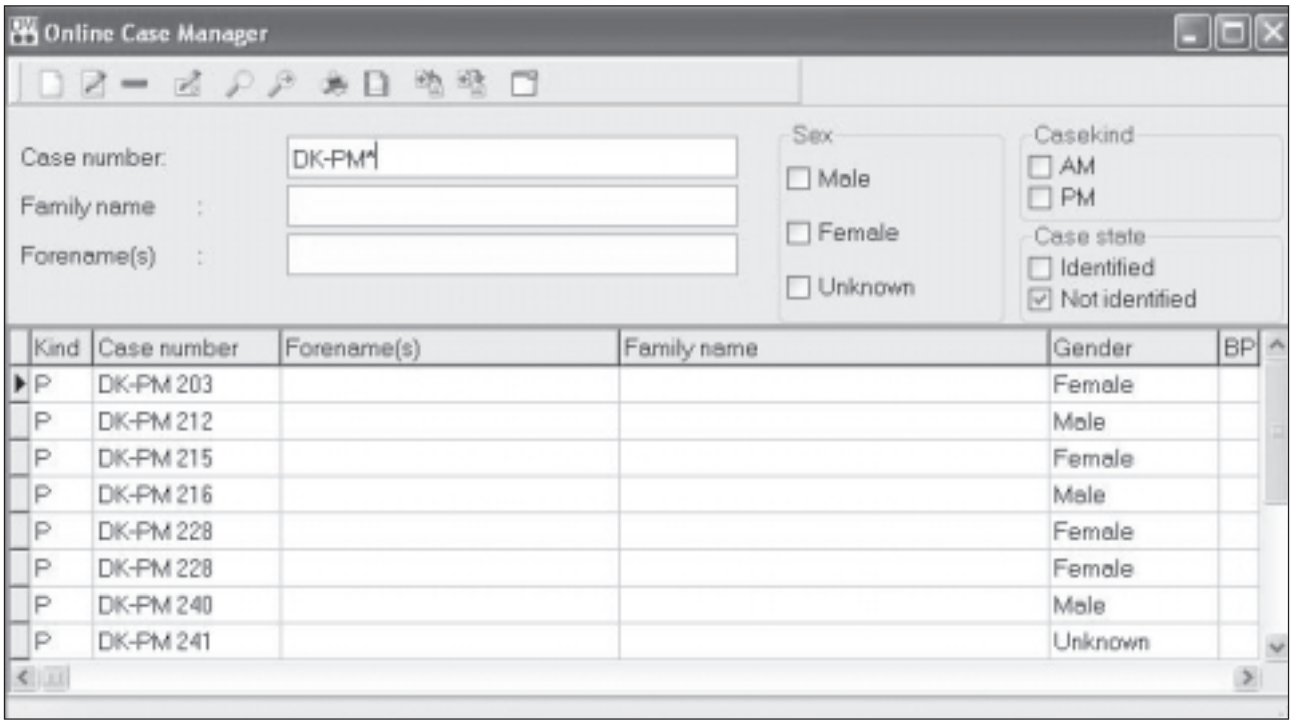

Fig.2: *Online Case Manager filtered by Case kind*

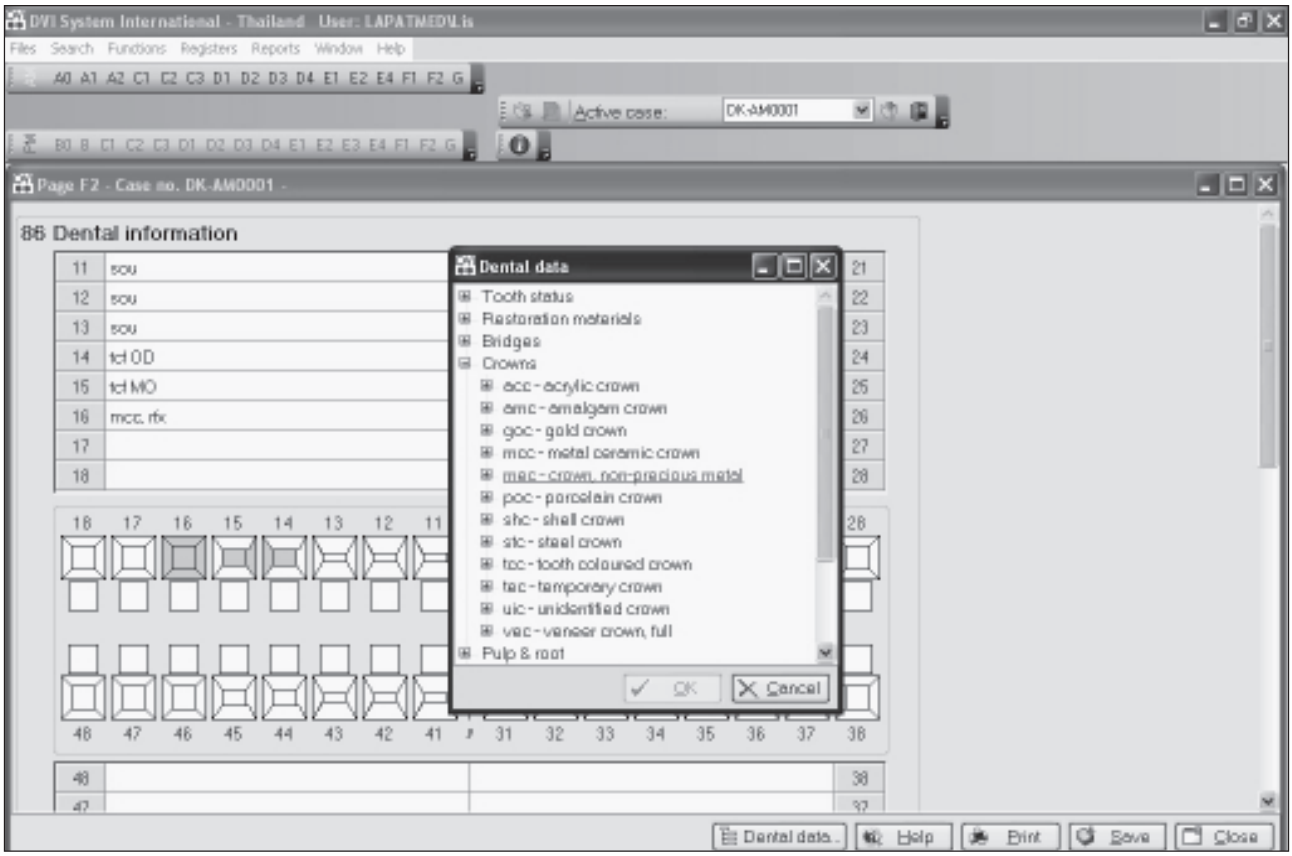

Fig.3: *Main window with display of dental antemortem page F2. The Dental data register has been activated with display of a subdirectory for crowns to assist entry of sys code in text field*

DENTAL DATA ENTRY

Antemortem/Postmortem form F1

The most import information to be entered on the yellow antemortem form F1 is data on the dentist or institution (present and past) that the missing person has visited for examination or treatment. The pink postmortem form F1 is mainly for description of the condition of the dead body using cross-off boxes and text field. On both F1 forms the *Officer* e.g. the forensic odontologist has to fill in appropriate data e.g. name, institution and phone number.

Antemortem/Postmortem form F2

Tooth nomenclature/numbering

The FDI two-digit system is by default the tooth numbering system. This system is among the favoured worldwide numbering systems and makes visual sense, cognitive sense and computer sense. In the individual user settings it is possible to choose between FDI, Universal or Haderup tooth nomenclature. When forms are viewed with a different setting, all registrations are automatically translated. The tooth number is by default the permanent dentition but the user may change the numbering to reflect a mixed or primary dentition by double clicking the tooth number. This operation will also change the tooth number in the odontogram.

Sys codes

Fields for entering dental findings (field 86) will accept the codes from the *Dental data* register. This restriction is made to ensure uniformity and provide comparable antemortem and postmortem data of major importance in the searching mode. Entry of system (sys) codes is made easy by access to the register either by right clicking in the data field or clicking the Dental data button in the bottom pane. This operation will bring up a dialog from where to select the relevant sys code and click the OK button (Fig.3). The sys code is automatically transferred to the tooth field as is its graphic presentation in the odontogram. The colours associated with the sys codes are specified in the Dental data register. Free text in a tooth field can be entered by adding a quotation mark followed by the text. Free text is not displayed graphically in the odontogram but can be search for in the free text search mode. An extra square per tooth has been added to the odontogram. Clicking the square bring up a dialog with a panel of symbols that may further characterize the tooth

(Fig.4). The symbol is selected by marking followed by clicking the OK bottom. At present one symbol only is accepted per square.

The sys codes and associated sys text is based on English terminology. To make visual sense all codes comprise three letters: one word designations: three first letters (e.g. ede for edentulous); two word designations: two first letters of the first word and first letter of the second word or the opposite, if the first letter of the second word is reserved – see below (e.g. dio for distal occlusion; cfr for crown fracture); three word designations: the first letter of the three words (e.g. fud for full upper denture). For dental restorations, the first two letters of the material form the first and second letters in the code, followed by the restoration type (f for fillings, i for inlay, c for crown, p for pontic, b for bridge, d for denture). These latter third letters are the so-called reserved letters, implying that they cannot appear as the third letter in any other code within the *Dental data* register. Sys codes applicable to restoration of one or more surfaces (f, i) will require entering of the actual surfaces by capitals (O, M, D, V or L). The user may indicate that a filling covers only part of a surface by adding a star e.g. *VG for vestibular gingival filling. If uncertain on type of treatment the code tre for treatment is to be selected. System codes with x or v as the third letter imply observations seen on x-ray or visible on clinical examination, respectively. Two materials/ conditions per surface are allowed e.g. two surface/ tooth codes or one surface code and one tooth code. A sys code should be entered in each text field to indicate that all teeth have been taken into consideration; if nothing is known about a tooth the code non for no information should be entered into the antemortem F2 field. The code pre for present is to be selected if only part of tooth is seen on an antemortem radiograph. When printing the dental forms, the user may choose between sys codes, sys text or sys codes without graphics on F2.

Observations on anatomic variations, oral pathology, malocclusion etc. can be entered within field 87 and 88 either as sys codes/text or free text. This information may subsequently be targeted with the form search or free text search mode. Digital photographs and radiographs of teeth and the body as a whole can be imported and linked to field 89 on the F2 form. Field 89 will show the number of photos available on the system.

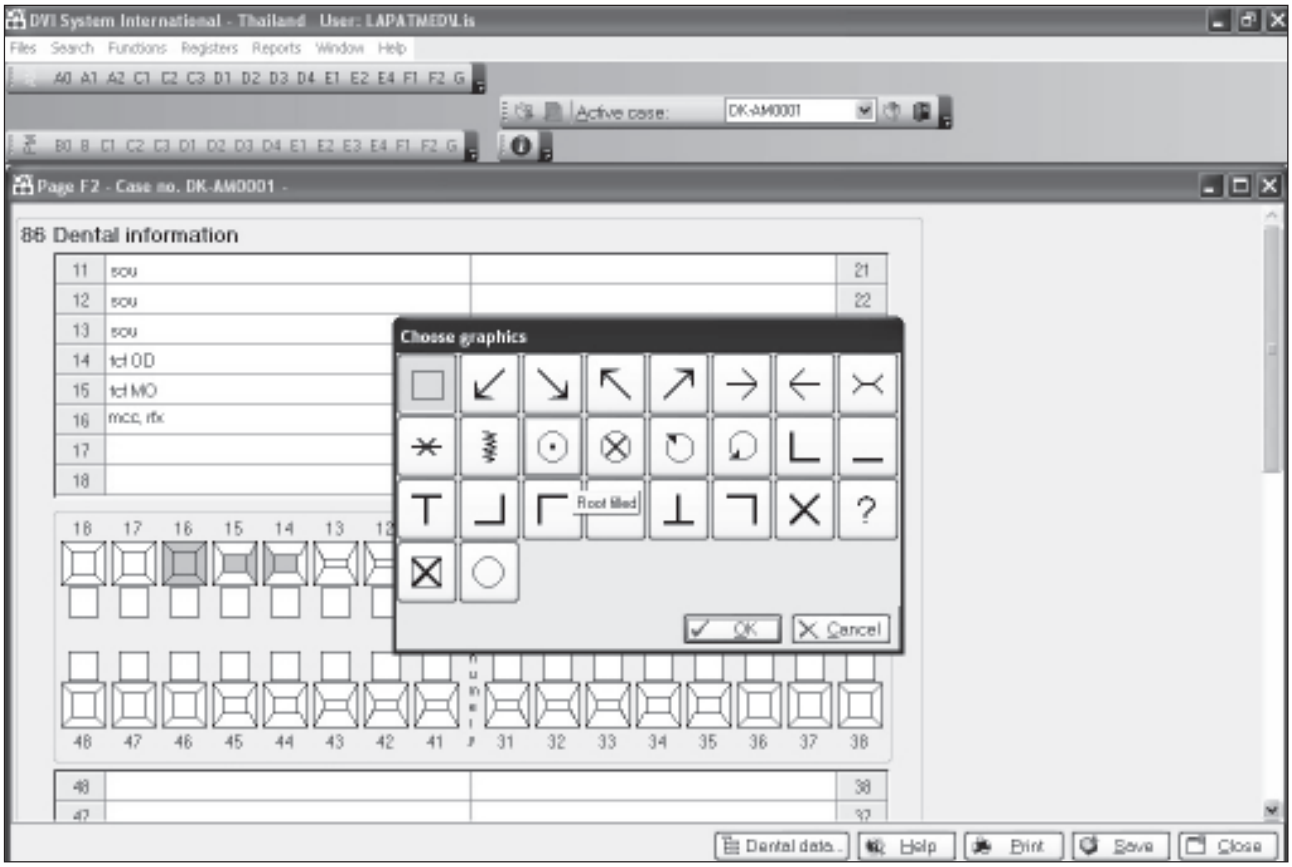

Fig.4: *Dialog with symbols to be selected for entering in squares of the odontogram*

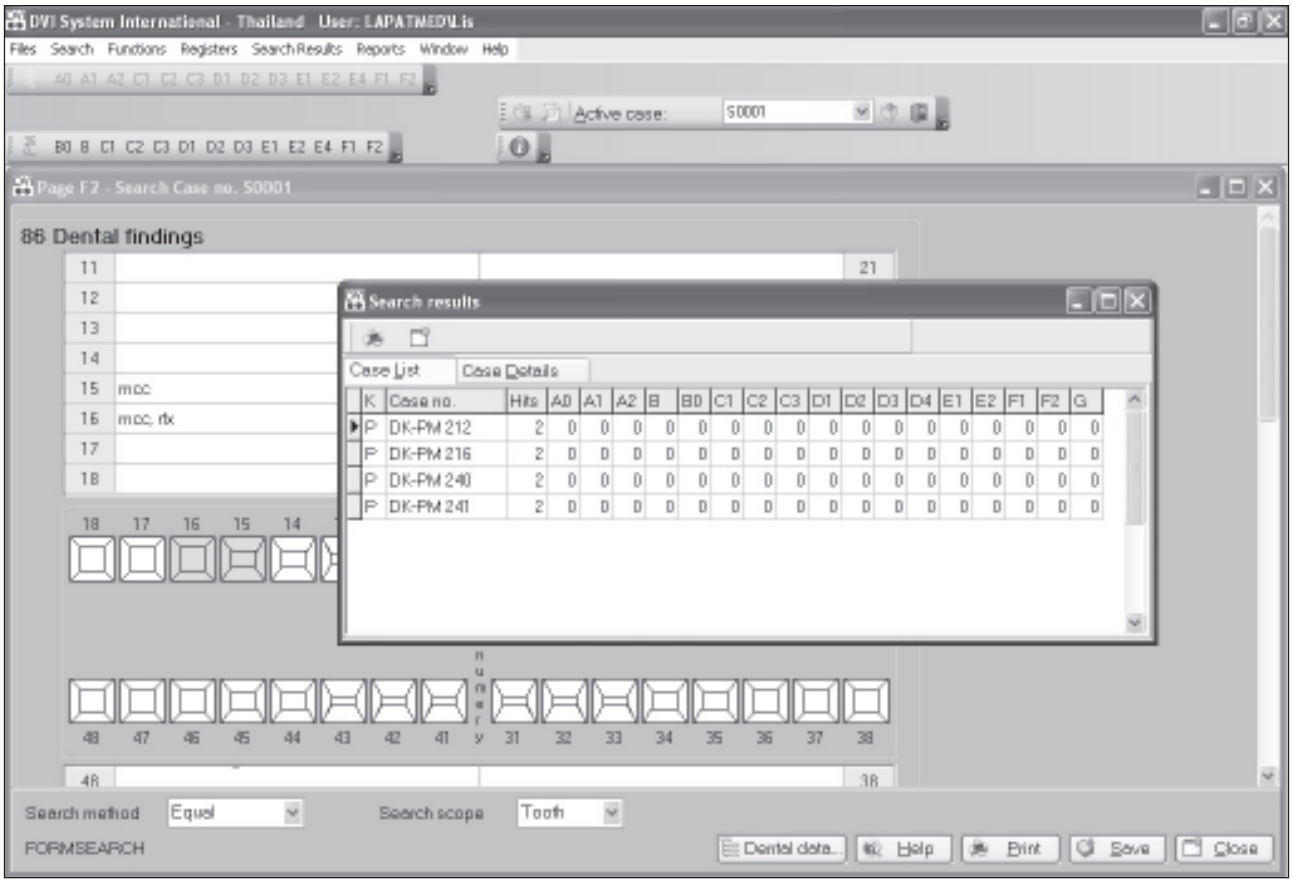

Fig.5: *Main frame with display of form search and corresponding search results. The search provides no hit on the dental page F2 but two hits that refer to sex and case state to be displayed if clicking Case details*

SEARCH FACILITIES

The search functions are aimed at making searches to display the most probable candidates for match to be reviewed by simultaneous comparison of antemortem/postmortem forms on the screen or manually on printouts. Searching can be performed in both the postmortem and antemortem databases. There are four search modes to facilitate cases to be found and matched e.g. fast search, free text search, form search and with active case. These modes can be selected in the search menu. Irrespective of search mode the search result window will display *Case List* with details on number of hits (e.g. match of any parameter) and their position in the form set (Fig.5). The corresponding case is loaded and made the active case by double clicking the line. Before doing so the user can choose to activate *Case detail* and double-click a detail line for display of both case and form.

The *Fast search* forms a rational sorting tool. This search mode brings up a dialog from where to specify a search on common parameters (gender, age interval, height, weight, build, hair colour, eye colour or case ID-state). The search can be performed against either antemortem and postmortem cases by clicking the actual button in the bottom pane. *Free text search* allows natural language searches to be carried out across all information in the antemortem or postmortem databases. This search mode brings up a window for entering the text. Before running the search the user is asked to select the gender to be included (all, female and unknown or male and unknown).

The *Form search* brings up a dialog e.g. *New antemortem or postmortem Search Case* to be given *Case No* and *Disaster* characteristics before becoming the active case (Fig.5). An empty F2 form for entering search criteria in the field/s can subsequently be activated by clicking the appropriate button in the toolbar. In field 86 the search is made by the input of a sys code, or rather combinations of codes, that reflect dental patterns of missing, restored and unrestored teeth. Before running the search case the user is advised to select items in the *Search method*

and *Search scope* that will influence the reliability of the search results. Activating the search scope menu in the bottom pane will display: tooth, quadrant, jaw or dentition as the matching parameter; the search method menu will display: specific, equal, equal to or less (in antemortem search), or equal to or more (in postmortem search). Specific search implies that only cases with fully identical sys code(s) will be included in the search result whereas treatments/conditions of similar weight will be displayed provided equal search is requested. Before the search is activated a window appears in which to select gender characteristics. The weightening system designed match antemortem and postmortem sys codes is based on a hierarchical system reflecting progressive disease and treatment modalities of the individual tooth: weights 0-1 for tooth without disease; weight 2 for tooth with disease (caries); weights 3-6 for tooth with disease and treatment; weight 7 for tooth missing; weights 7-10 for tooth missing and with treatment. The two materials/conditions allowed per surface, as described in the section on dental data entry, form the basis for the match tooth by tooth in the form search mode. When entering sys codes in field 86 it is therefore mandatory to enter codes by priority in accordance with appropriate tooth characteristics.

When clicking search mode 'With Active Case' in the menu the active case is transformed into a search case of the opposite kind (antemortem to postmortem and vice-versa). This mode is considered less appropriate for matching dental data due to inconsistency in record keeping and the possible time frame between antemortem and postmortem recording.

OTHER FUNCTIONS

Simultaneous display of comparable antemortem and postmortem pages in the same window is performed as part of a Microsoft Office Word* function, whereas similar display of digital photos

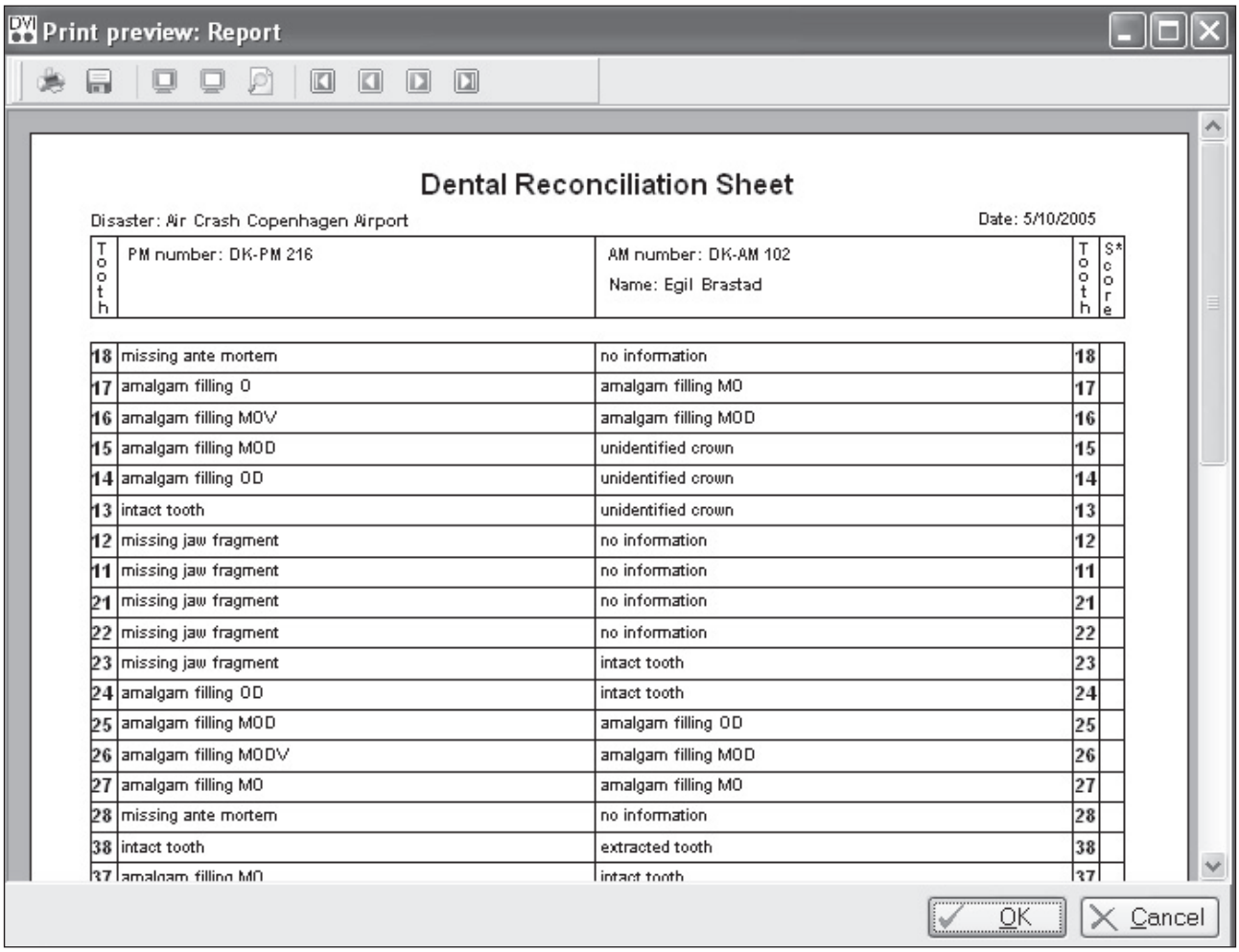

Fig.6: *Window form area with display of Dental Reconciliation Sheet*

and radiographs is at hand using the Microsoft Office Picture Manager*. Simultaneous display of photos and radiographs, as well as the possibility of having several photos open at a time, was implemented during the TTVI process.

A *Dental reconciliation sheet* with simultaneous display of dental field text tooth by tooth for selected antemortem and postmortem cases can be supplied by activating this task in the *Reports* menu (Fig.6). Updated reports that comply with the Interpol recommendations e.g. case lists, comparison lists, and ID-lists can further be selected from this menu from where also disaster statistics and instant supply of empty DVI forms are among the choices. Program language and print language is by default English but a change in the users interface is possible by selecting another language either in *Preferences* or in the individual *user* settings. Such changes may be useful when preparing translations before transmission of form data to another country. Settings for printing in the form may be conducted in the Interpol languages or in any other languages in which the DVI form has been made available electronically (Albanian, Croatian, Danish, Dutch, English, Finnish, French, German, Icelandic, Italian, Norwegian, Spanish, and Swedish). Before the TTVI process DVI professionals in Austria, Belgium, Denmark, France, Iceland, Netherlands, Norway, Sweden, and Switzerland were among the users of the DVI System International.

COMMENTS

The identification work after the Tsunami in Thailand has definitely been a great challenge for the DVI community and DVI System International. So far this software has assisted in mass disasters with casualty numbers of up to a few hundred. The lessons learnt during the TTVI await results of quality assurance of both the procedures and the staff at work. Until then a few comments based on my experience achieved from work at sites (1A, 1B and 2) and in the Information Management Centre. The inter-individual and intra-individual differences in practice and competency between forensic odontologists from a diversity of countries will inevitably result in a large variation in the way the sys codes are used. Such an obstacle could be surmounted by filtering, e.g. reducing, the number of sys codes to be used. Though providing a great number of sys codes a few new codes (jew for jewellery; une for unerupted) were indeed added to DVI System International during the TTVI process. This ongoing process has highlighted the needs for a review and revision of sys codes, in particular those characterizing stages in mineralizing teeth. In the form search mode measures could be taken to compensate for possible inconsistency in entering of dental antemortem/postmortem. For example, display of a temporary cross off dialog in field 87 to secure storage of important information (crowns, bridges, edentulous, etc.) for use in the search function. Such functionality was at hand in a previous version, the DVI System. In a future version, the System might be capable of handling translations (national/regional/state codes and text) for all supported languages. Such functionality was at hand in the previous version (DVI System) that did allow a country to apply its own codes. The person in charge could define optional national codes as well as full text to be used to a given number of system codes and during transmission of dental forms to other countries, the codes of a particular country was translated via the sys codes to those of another country. The searching possibilities and capacity are further issues to be reviewed and possibly revised. The search facilities were twice improved, in mid February and in April, by implementation of an additional identity match program designed and developed by Jens Heidmann, Denmark, and working in parallel with the established modes. It remains for further analyses of the identification match progression data to decide whether sorting algorithm of this later program or other types of algorithms should be incorporated in a future version of DVI System International.

ETHICAL NOTIFICATION

The author has no commercial interest in the program but has expressed the wish that the DVI System International will be applied as wide as possible, in order to make international cooperation more effective.

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ANALYSIS OF RUGAE IN BURN VICTIMS AND CADAVERS TO SIMULATE RUGAE IDENTIFICATION IN CASES OF INCINERATION AND DECOMPOSITION

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ABSTRACT

The most challenging situations in Forensic Odonto-Stomatology are mass disasters, where the forensic dentist is usually confronted with charred human remains or heavily decomposed or fragmented bodies. This article determines the extent of preservation of palatal rugae for use as an alternative identification tool in such situations, using a study group comprising burn victims and cadavers simulating forensic cases of incineration and decomposition. The thermal effects and the decomposition changes on the palatal rugae of burn victims with panfacial third degree burns and human cadavers in storage were respectively assessed and graded on a new scale. Ninety three percent of burn victims and 77% of human cadavers had Grade 0 changes (normal). When changes were noted, they were less pronounced than the generalized body involvement of burns in burn victims and the generalized body decomposition of human cadavers.

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Key words: palatal rugae, forensic identification, burn victims, human cadavers

INTRODUCTION

Nowadays deaths due to high-speed transportation accidents and acts of terrorism are on the rise and identification of these victims is a major goal of forensic science.[1] Methods of identification commonly employed are visual identification, fingerprint and dental records comparison and DNA profiling. Although DNA profiling is accurate, it is expensive and time consuming for use in large populations.[2] Visual identification and fingerprints are limited by postmortem changes associated with time, temperature and humidity[3] but dental tissues have been shown to withstand these conditions.[4-8] Among the oral tissues palatal rugae are permanent, unique to each individual and can establish identity through discrimination.[9,10] Palatal rugae, due to their internal position, are protected from trauma and high temperatures by lips, cheek, tongue and buccal pad of fat teeth and bone and do not demonstrate age-related changes.[11,12] In spite of these merits, rugae have not often been used as a widespread forensic tool. This study throws light on the usefulness of rugae in forensic situations of incineration and decomposition.

MATERIALS AND METHODS

Study groups

Two study groups were formed simulating conditions found at mass disasters. One group consisted of thirty burn victims and the other consisted of thirty human cadavers. Both males and females aged 18-65, of south Indian Dravidian ethnicity, and either dentate or partial dentate with no missing teeth in the anterior maxilla were examined.

Burn victims

Burn victims treated at the Department of Burns, Kilpauk Medical College Hospital, Chennai for pan facial third degree burns (full thickness burns characterised by multicoloured denatured layers, dry and insensitive to pain involving skin, subcutaneous tissues, adnexal structures and nerves which usually requires skin grafting) were selected to assess the influence of fire on changes to palatal rugae. All subjects were examined within 72 hours of the accident (following emergency treatment). The cause of the fire producing the injuries was not considered. Burn victims were clinically assessed and the condition of the palatal rugae was graded based on the degree of thermal effects observed.

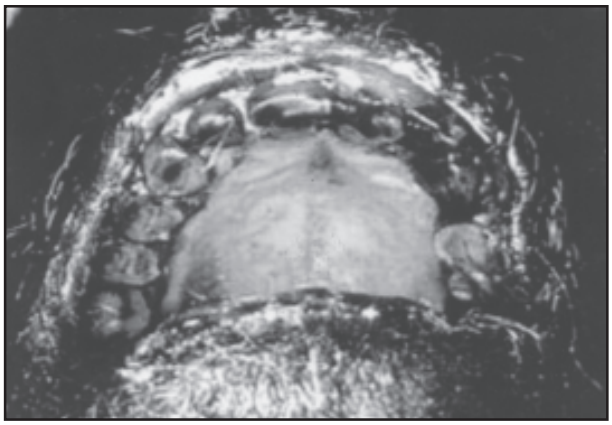

Fig.1: *Palatal rugae of a burn victim- Grade 0*

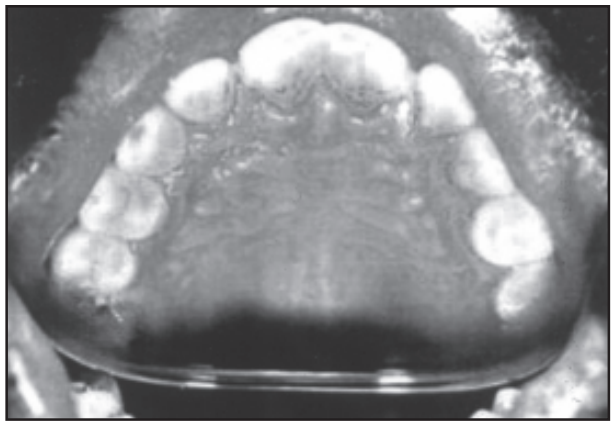

Fig.2: *Palatal rugae of a human cadaver-Grade 1*

Grade 0: Mucosa pink in colour. Palatal rugae unaltered.
Grade 1: Inflammation of mucosa with mild erythema and oedema. Rugae clearly identifiable.
Grade 2: Erythematous mucosa with bullae and ulcerations. Rugae faintly identifiable.
Grade 3: Blistered and necrosed mucosa. Blotchy-red appearance. Rugae not identifiable.

Changes observed in the rugae were compared with the percentage of total body surface involved with burns (TBSA) classified using the 'Rule of Nine', in which body regions are grouped as a multiple of 9% of the total (ie 9% - head, neck and each arm**,** 18% - anterior trunk, posterior trunk and each leg, 1% - palms and genitals) to provide an easy estimation of the extent of the surface area of the burns.[13]

Human cadavers

Human cadavers stored in the mortuary of the Institute of Forensic Medicine, Madras Medical College Hospital, were selected to assess the preservation of palatal rugae after death. Cadavers were stored in the mortuary at temperature of 5° Celsius and relative humidity of 30-40% within 12 hours of autopsy and kept for a minimum period of 7 days. Condition of the palatal rugae was assessed clinically in the cadavers and graded based on the changes observed on the eighth day.

Grade 0: Mucosa pink in colour. Palatal rugae clearly identifiable.
Grade 1: Mucosa blanched. Drying of oral cavity. Rugae identifiable.
Grade 2: Mucosa oedematous. Tissues slip over the rugae. Rugae faintly identifiable.
Grade 3: Swelling and necrosis of mucosa. Rugae not identifiable. Fungal growth was not ascertained.

The stage of decomposition of each cadaver, as described by Clark et al.,[14] was assessed.

Stage I: Early putrid odour, lividity fixed, rigor waning.
Stage II: Intensive livor, no rigor, early skin slippage, drying of lips and fingers.
Stage III: Prominent haemolysis, skin slip easily, tissues soft and slick.
Stage IV: Early body swelling, discolouration of head, bullae formation.

These stages were then compared with the condition of the palatal rugae in each body.

Photographic records of burn victims and cadavers were taken using a Canon SLR Camera* with 35-80 standard zoom and flash guide No.1**.** A palatal mirror was used to obtain adequate opening and exposure of rugae in photographs. Figure 1 shows rugae of a burns victim and Figure 2 show rugae of a cadaver.

*Canon Inc, Tokyo, Japan

Table 1: *Thermal effects in palatal rugae among panfacial third-degree burn victims*

Grade	Burn Victims Number
Grade 0	28
Grade 1	0
Grade 2	2
Grade 3	0

Table 2: *Comparison of thermal changes observed in rugae with the total body surface area (TBSA) involved in burns*

%BURNS (TBSA)	Rugae Changes	Burn Victims
50-59	Grade 0	2
60-69	Grade 0	19
70-79	Grade 0	5
80-89	Grade 0	2
	Grade 2	2

Table 3: *Decomposition changes in palatal rugae among the human cadavers in storage*

Grade	Cadavers Number
Grade 0	23
Grade 1	2
Grade 2	3
Grade 3	2

Table 4: *Comparison of observed changes in rugae with the stages of body decomposition of cadavers in storage*

Body Decomposition	Rugae Changes	Cadavers
Stage II	Grade 0	8
Stage III	Grade 0	15
	Grade 1	2
	Grade 2	1
Stage IV	Grade 2	2
	Grade 3	2

RESULTS

Grade 0 thermal effects in 28 subjects and Grade 2 thermal effects in two subjects were noted in the palatal rugae of burn victims (Table 1). The thermal effects in the palatal rugae of burn victims were compared to the extent of generalised body involvement with burns. Of the subjects with Grade 0 thermal effects in their palatal rugae: two subjects had 50-59% burns to total body surface area (TBSA), 19 subjects had 60-69% burns TBSA, five subjects had 70-79% burns TBSA and two subjects had 80-89% burns TBSA. The two subjects with Grade 2 thermal effects in their palatal rugae had 80-89% burns TBSA (Table 2).

The palatal rugae of the human cadavers in storage showed Grade 0 changes in 23 cadavers, Grade 1 changes in two cadavers, Grade 2 changes in three cadavers and Grade 3 changes in two cadavers (Table 3).

The decomposition changes in the palatal rugae of cadavers were compared to the extent of generalised body decomposition, of the 23 cadavers with Grade 0 decomposition changes in their palatal rugae, eight cadavers were in Stage II and 15 cadavers were in Stage III body decomposition respectively. Two cadavers with Grade 1 decomposition changes in their palatal rugae were in Stage III body decomposition. Of the cadavers with Grade 2 decomposition changes in their palatal rugae, one cadaver was in Stage III and two cadavers were in Stage IV body decomposition respectively. Two cadavers with Grade 3 decomposition changes in their palatal rugae were in Stage IV body decomposition (Table 4).

DISCUSSION

Although there are many studies[2, 4-8] regarding identification of human remains using the dentition, literature reports of usage of palatal rugae for identification purposes are scarce**.** This study was planned to evaluate the retention of palatal rugae morphology under conditions simulating those found in mass disasters and to utilize this anatomical landmark for identification in such situations.

Palatal rugae were normal in 93% of the subjects sustaining pan facial third degree burns due to accidental fire. No changes were observed in the colour or surface anatomy in the palatal rugae of 77% of the human cadavers in storage. It is evident from this study that rugae are not markedly affected in survivors by the intensity of the fire and highlight the ability of palatal rugae to resist decomposition

changes for up to seven days after death under ideal conditions of storage in mortuary.

This study had its limitations in not considering the cause of death that might influence the rate of decomposition in cadavers and the variations of inter-investigator and intra-investigator assessments in grading the clinical condition of the palatal rugae of the subjects of the study group. The grading systems proposed need further testing. The effect of dentures influencing thermal changes on the palatal rugae of subjects involved in accidental fire also needs to be studied.

Comparisons of alterations in the palatal rugae with the generalized body conditions of incineration and decomposition of subjects of this study group provide an insight to the extent of possible palatal changes in real forensic situations. However further studies involving large number of individuals and extended periods after death in real forensic situations immediately after mass disasters are needed to substantiate the findings of this study and verify the usefulness of palatal rugae as a tool for forensic identification in such situations.

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