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Post-mortem dental profiling in Palu earthquake and tsunami victims—procedures and limitations

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ABSTRACT

On 28 September 2018, an earthquake hit Central Celebes, triggering a tsunami, liquefaction and a landslide. There were approximately 2,256 victims and 1,309 people remain missing. The dry tropical climate combined with seawater exposure made bodies enter a putrefaction state rapidly, and visual identification was not possible. Obtaining any dental antemortem data was almost impossible due to the flood and earthquake destroying most of the healthcare building. Hence, a dental profiling procedure was conducted. Dental charting and age estimation were carried out and photographs were taken. Dental charting and photographs were done in line with the Interpol guide's standards. Performing a multiple dental age estimation method was not feasible. Clinical age estimation methods were mandatory due to their reliability and short time consumption for Palu victim identification. In children and sub-adult dental age estimation, gingival and alveolar clinical eruption helped to determine their approximate dental age. In adults, root translucency was measured using the American Board of Forensic Odontologists' (ABFO) No. 2 scale with the Bang and Ramm (1970) method. Dental age estimation with multiple measurement parameters or radiographs was not preferable during this mass disaster due to their time consumption and the overwhelming number of dead bodies.

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Introduction

Palu is a chartered city on the Indonesian island of Celebes or also known as Sulawesi. It is the capital of the Central Celebes province. Positioned between mountain ridges, the climate in Palu is usually dry. Palu is situated over three tectonic plates and has a high earthquake and seismic rate. Palu bay's long and narrow geographical position provokes a high threat for tsunamis[1]. On 28 September 2018, an earthquake hit Central Celebes (7.4 magnitude), located 26 km north of Donggala, triggering a tsunami, liquefaction, and a landslide. The National Board for Disaster Management (Badan Penanggulangan Bencana Indonesia) reported that, on 21 October 2018, there were approximately 2256 victims and 1309 people remain missing.

Major disasters involving a massive number of fatalities raise questions about victim identification. It is essential for the victims that the bodies are handled with respect and the dead are identified so that survivors know what happened to their missing relatives.

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Legally, a death certificate needs to be issued. Furthermore, local citizen health is also a problem as there is a risk for people becoming afraid of diseases and epidemics spreading from the many unburied and decaying bodies. To avoid this risk, the identification of victims is preferably carried out within a short timeframe and bodies need to be buried quickly.[2]

Palu has a dry tropical climate, leading to tissue decomposing rapidly. Combined with seawater exposure from the tsunami, the bodies' decomposition rate was rapid and could not be visually identified.[3,4] In this situation, odontological aspects were essential in both the antemortem (AM) and post-mortem (PM) examinations.[5] However, obtaining any dental AM data was almost impossible due to the flood and earthquake destroying most of the healthcare building. Additionally, only a small portion of the Indonesian population has a comprehensive dental record which could be useful in victim identification. When a comparison between AM and PM data is not available, PM dental profiling is conducted.

The author was aware that the number of identified victims aided with dental profiling was not reported and cannot be disclosed. This paper served as an insight into how a dental profile was created during a mass disaster situation with multiple limitations.

Post-mortem dental profiling procedure

PM dental profiling aims to collect dental data and images and the estimated age of the victim, hence creating a limit in the AM population pool's data.[6] Even though a positive dental identification could not be achieved due to the lack of AM data, this procedure allows for a more focused search by excluding data external to the dental profile. The data collected included dental charts, photographs, and dental age estimation.

Dental charting was conducted using Interpol's standard guidelines, utilizing Interpol PM forms and Interpol standard abbreviations. Each tooth was specified using the World Dental Federation's (FDI) notation. FDI notation lists each tooth by dividing the mouth into four quadrants: starting from the upper right (quadrant 1) to the upper left (quadrant 2), lower right (quadrant 3), and lower left (quadrant 4). Within each quadrant, the tooth is numbered from 1 to 8 in adult dentition, starting from the midline and moving backwards.[7] Distinctive features such as caries, missing teeth, and restorations were the focus of this procedure. Interpol suggests that multiple dental radiograph images should be taken during the examination.[8] However, this was not feasible to obtain due to logistical and human resource issues.

Dental photographs were taken using a digital single-lens reflex camera paired with a 100 mm macro lens and a ring light system. Photographs were taken using the ABFO No. 2 scale in line with Interpol's guidelines for PM photographic documentation.[8]

Age estimation methods rely heavily on data availability during the examination.[9] Due to the situations in the field, most of the dental age estimation methods could not be performed. Age estimation method was divided into three age categories based on tooth development, children (0–15.99 years old), sub-adults (16–23.99 years old) and adults (above 24 years old) with each group utilizing one dental age estimation method.[10]

In children and sub-adults, age estimation relied on the eruption status of each tooth which was compared in approximation to gingival[11] and alveolar eruption timing.[12] In adults, Bang and Ramm's (1970) root translucency method on whole extracted tooth was

used due to its short time consumption. Any available loose or extracted single-rooted teeth can be used with a preference for the teeth from the upper right anterior quadrant. Furthermore, the root translucency was measured using ABFO No. 2 scale and calculated using the provided formula based on the length of root translucency whether it is above or below 9 mm.[13]

Discussion

In forensic odontology, the uniqueness of human dentitions is the basis of the victim's identification process. This is done by comparing AM and PM data using Interpol forms and abbreviations. Although there were almost no AM data to compare, the dental profile helped to ascribe the uniqueness of the victim's dentitions to their family, including their face profile and tooth position and how often the victim went to the dentist.[14] This uniqueness is defined by many parameters and is only proven if all possible related parameters are compared between dentitions.[15] Bush et al. studied similarities in human dentition, and it was assumed through simulations that no matches were found between individual samples.[16] This proves that dental uniqueness has a significant part to play in victim identification.

Forensic dental photography was performed to preserve the details of the victims with photographs. This process may involve a combination of colour photographs, black-and-white photographs, and lighting systems. A standard Interpol method includes capturing orientation photographs to be able to examine the case after the victim's body is buried.[8] For measurement and scale purposes, ABFO developed a two-legged (right-angled) scale, known as the ABFO No. 2 scale, which is used by crime-scene photographers (Figure 1). This scale is useful during digital measurement to convert the pixel scale to a centimetre scale, and a circle of 2 cm helps to reduce distortion in a photograph.

Age estimation is of great importance for the victims' dental profiles, and utilizing teeth as an age estimation parameter is reliable because it survives inhumation well and shows less variability than skeletal age.[12] Moreover, dental age estimation is scientifically based on proven parameters, and calculations are mandatory and not based on assumptions.[17]

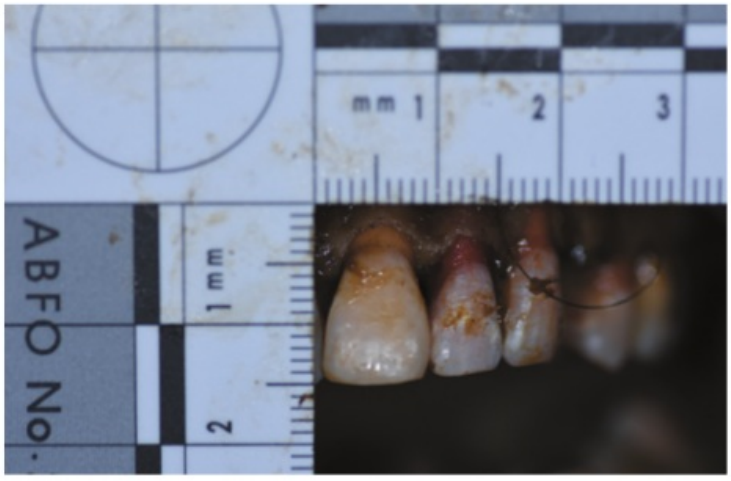

Figure 1. Detailed anterior view of the upper maxillary region with ABFO No. 2 Scale.

Dental age estimation differs between children, sub-adults, and adults. In children and sub-adults, tooth development is better than other developmental parameters available for age estimation up until the person reaches fully developed dentition.[18] This method typically employs a method described by the researcher to register the observed status' development and convert it to an age estimation through a different formula. After reaching fully developed dentition in adulthood, the parameter for age estimation is forms of tooth morphology changes, including attrition, root translucency, tooth cementum annulation, and the apposition of secondary dentin.[19]

Most of the dental age estimation methods rely on radiological evidence and measurements. Staging systems and ratio measurement methods need radiograph images to be taken, and under these circumstances, taking radiographic images was not possible due to the number of bodies and the limited number of experts present in the field. Those morphological methods considered took time to prepare due to each tooth needing to be sectioned labio-lingually.[19,20]. Due to these circumstances, many dental age estimation methods were not feasible

In children and sub-adults, approximate dental age estimation using tooth eruption timing was performed. Furthermore, two instances of the eruption status were used in the examination. Alveolar eruption timing was used when the gingival tissue had already decomposed (Figure 2)[12] and, in contrast, gingival eruption timing from Haaviko (1970) was used when the soft tissue was still intact.[11] However, Kjær (2015) stated that eruption timing differs in each individual due to multiple factors.[21] Therefore, dental age estimation using tooth eruption needs to be taken carefully. In this case, the victim's latest erupted tooth was taken to minimize errors between the initial eruption and its further growth.

In adults, the root translucency method by Bang and Ramm (1970) was used due to its simple measurement method, minimum time consumption, and it could be done without extensive training.[13] This method is differentiated by the length of root translucency, how the tooth is prepared and different tooth positions. The root translucency was separated by different regression model considering its length, whether it was shorter than or equal to 9 mm or longer than 9 mm. Tooth with shorter than or equal to 9 mm root translucency requires different regression model from teeth with root translucency longer than 9 mm.[13] Furthermore, this method can be applied both in whole and sectioned teeth. In this case, we used an extracted whole tooth with a preference of tooth from the upper right anterior quadrant.

This regression model was tested by Tang et al. and showed similar or even better results when compared to other methods.[22] The average deviation was 6.47 years, with 19 individuals estimated within 10 years of their known age and 14 individuals estimated within 5 years of their known age.[22,23] This method helps to make the dental age estimation procedure faster but still scientifically acceptable. Care has to be taken to measure the value to the total length of the translucent zone present, and boundaries between opaque and translucent dentin are irregular, making the evaluation less subjective.[22,24]

Root translucency was photographed and an analogue measurement using ABFO No. 2 length was used (Figure 3). This approach was initially used by Bang and Ramm before digital processing software became widespread.[13,25] Furthermore, a different approach, using semi-automatic digital measurement, was used by Acharya et al. A tooth was placed adjacent to the ABFO No. 2 scales on a flat-bed scanner and scanned under a resolution of

Figure 2. Lower right third molar observed with alveolar eruption due to gingival tissue already decayed. Comparison to London Atlas (2010) resulting in an estimation of 16.5 years old.

600 dpi, then processed through Adobe Photoshop 7.[23] This image analysis method creates a permanent archive of each collection, which is useful for off-site analysis.

Another age estimation method that is preferable to use is dental wear.[26] However, this method depends on specific sample populations and age groups and creates an unreliable measurement in a specific age range or different population.[27] Dental wear is affected by external factors. Bartlett et al. studied its relationship with dietary habits and found that tooth wear was statistically significant in terms of dietary habits which is highly varied in every population.[28] Seligman et al. studied the prevalence of multiple factors associated with dental attrition. It was reported that dental wear scores did not differ significantly between age groups (Males: $p < 0.06$ and females: $p < 0.07$).[29] Faillace et al. suggested that each method utilizing dental wear needs to be recalibrated for different populations.[30] These problems made age estimation using dental wear unfeasible for Palu victims, as the method needs further adaptation to a specific population.

Conclusion

A reliable and scientifically proven identification method is mandatory and should not be established based on assumptions, even in a mass disaster situation. Aside from dental charting and forensic dental photography, age estimation methods with multiple

Figure 3. Root translucency was seen on a maxillary central incisor. The length of the translucent part was measured and calculated using the appointed formula by Bang and Ramm (1970). The estimated age was 48.704 years old, with a standard deviation of 10.42 years old. RT = Root Translucency.

requirements, such as radiographic images, were not possible during the Palu identification process due to their time consumption, the limited number of available experts, and the overwhelming number of dead bodies. Hence, utilizing a clinical age estimation method was considered helpful in this situation.

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Disclosure statement

No potential conflict of interest was reported by the author.

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