Review Article

Forensic odontology as a humanitarian tool

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Abstract

Humanitarian forensic action is the application of skills of forensic science in a conflicts or disasters as a humanitarian action. Forensic odontologist promote forensic odontology and forensic science principles to caseworks with the purpose of preventing human right violation by human identification, age estimation and where ever dental evidence is involved. Forensic odontologist is involved in all phases of disaster victim identification. According to Disaster Victim Identification Guide, if a positive match is found using dental identification it can be trusted as a standalone identifier. Dental structures are well protected and the hardest structure of the body. They resist decomposition and high temperatures and are the last one to disintegrate after death. Dental hard tissue provide abundant information in disaster victim identification, missing and unidentified persons, child abuse and neglect, domestic violence and sexual abuse with bite mark evidence, age estimation of unaccompanied minors, border control and human trafficking. The present article highlights the role of forensic odontologist in human identification for the purpose of preventing human rights violation.

Keywords: Forensic odontology, humanitarian forensic action, humanitarian, human identification, Humanitarian tool

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INTRODUCTION

Humanitarian forensic action (HFA) is the application of the knowledge and skills of forensic medicine and science to humanitarian actions, especially following conflicts or disasters.[1] The term HFA was first coined by the International Committee of the Red Cross (ICRC) and is defined as the "application of forensic science to humanitarian activities." Humanitarian action itself is defined by the ICRC as a range of activities of that seek to alleviate human suffering and protect the dignity of all victims.[2,3]

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The word forensic is derived from the ancient Roman "forum" the home of the law courts – and means "relating to the law." As closely related, there has been a humanitarian character to forensic medicine and related sciences.[1] Article 6 of the Universal Declaration of Human Rights states that every person has the right to be recognized.[4]

The identification of a person is required when the body is disfigured or mutilated beyond recognition as a result of barbaric crimes, motor vehicle accidents, aviation and navy disasters, wars, fire, flood, manmade and natural mass disasters and when the body is in unrecognizable,

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decomposed state.[5] In such situations, forensic anthropology, fingerprinting, forensic odontology (FO), radiology and DNA typing can be used for victim identification.[6] The identification of a person by means of dental identification is one of the most reliable methods as teeth and dental structures may survive postmortem (PM).[7]

The active participation of forensic odontologists in all phases of human identification and responding to the new challenges with approaches to identification may make FO a humanitarian tool.

PAST EVENTS OF VICTIM IDENTIFICATION

Luntz L and Luntz P presented a case 1972 in which Warren was killed and was buried by the British. Later, Warren was identified by Paul Evere by the ivory denture work which he had done for Warren. This was thought to be the first case of identification by a dentist.[8] Sansare and Dayal were the first in India to report forensic dental identification in 1995. They reviewed and stated that M. Raja Jayachandra Rathore was identified using false anterior teeth, who died in 1191 on the battlefield.[9] The late President of Pakistan, General Zia-ul-Haq died in the year 1988 in a plane crash due to an explosion. He was identified from his dentition. The late Indian Prime Minister Mr. Rajiv Gandhi was assassinated in a terrorist attack in 1991 and was also identified from his dentition.[10] In 1897, a fire in a charity bazaar resulted in 126 deaths in Paris. Here, antemortem (AM) dental records were compared with PM dental records for identification of the dead. This was the first dental identification in a mass disaster.[11] In a systemic review by Prajapati *et al.* of the 20 mass disasters, 17 involved the use of FO for victim identification. All victims were identified using FO in the Kentucky air crash. The highest percentage of victims was identified using FO was in the Newark air crash followed by the Nepal air crash, the France air crash, the Australian bushfire and the Estonia ferry disaster. In contrast, lower percentages of victim identification were observed following the Japan tsunami and the Nigeria air crash. In the Croatia train and air crash accidents, FO was exclusively used in combination with other identification methods for the identification of the victims.[6]

DISASTER VICTIM IDENTIFICATION PROCESS

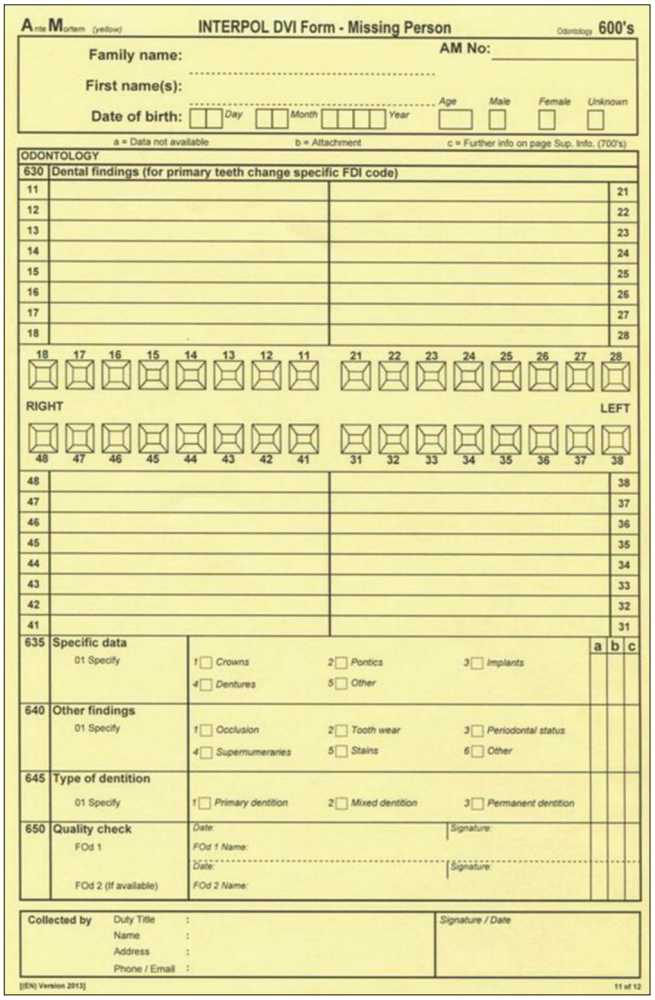
A forensic investigation team may involve law enforcement officials, forensic pathologists, forensic odontologists, forensic anthropologists, serologists, criminalists and other specialists depending on the circumstances.[5] The identification process will involve recovery, AM PM and identification teams.[7]

Recovery team

The recovery team collect evidence such as bodies, body parts, personal property and record their findings accurately.[12] Body numbering is done according to Interpol guidelines and has to be followed by all teams to avoid errors. Forensic odontologist should be a part of this team and has to look for dental evidence at the site to avoid, destruction of the dental substances during transportation to the mortuary.[7]

Ante mortem team

The work of the AM team begins with eliciting missing person's lists. It is obtained through the missing person's family members and health-care provider. A forensic odontologist is assigned in AM team who will allocate the dental AM data and material after the missing person's dentist has been contacted by the local police. Available materials such as dental records, X rays, computed tomography (CT) scans, dental model and full face photographs must be collected and are transcribed onto


INTERPOL DVI Form - Missing Person

Ante Mortem (yellow) — Odontology 600's

Family name: AM No:

First name(s):

Date of birth: Day Month Year Age Male Female Unknown

a = Data not available b = Attachment c = Further info on page Sup. Info. (700's)

ODONTOLOGY

630 Dental findings (for primary teeth change specific FDI code)

11 12 13 14 15 16 17 18 | 21 22 23 24 25 26 27 28

18 17 16 15 14 13 12 11 21 22 23 24 25 26 27 28

RIGHT LEFT

48 47 46 45 44 43 42 41 31 32 33 34 35 36 37 38

48 47 46 45 44 43 42 41 | 38 37 36 35 34 33 32 31

635 Specific data — 01 Specify — 1 Crowns 2 Pontics 3 Implants 4 Dentures 5 Other — a b c

640 Other findings — 01 Specify — 1 Occlusion 2 Tooth wear 3 Periodontal status 4 Supernumeraries 5 Stains 6 Other

645 Type of dentition — 01 Specify — 1 Primary dentition 2 Mixed dentition 3 Permanent dentition

650 Quality check — FOd 1 — Date: Signature: FOd 1 Name: — FOd 2 (If available) — Date: Signature: FOd 2 Name:

Collected by — Duty Title : Name : Address : Phone / Email : — Signature / Date

[EN] Version 2013] 11 of 12

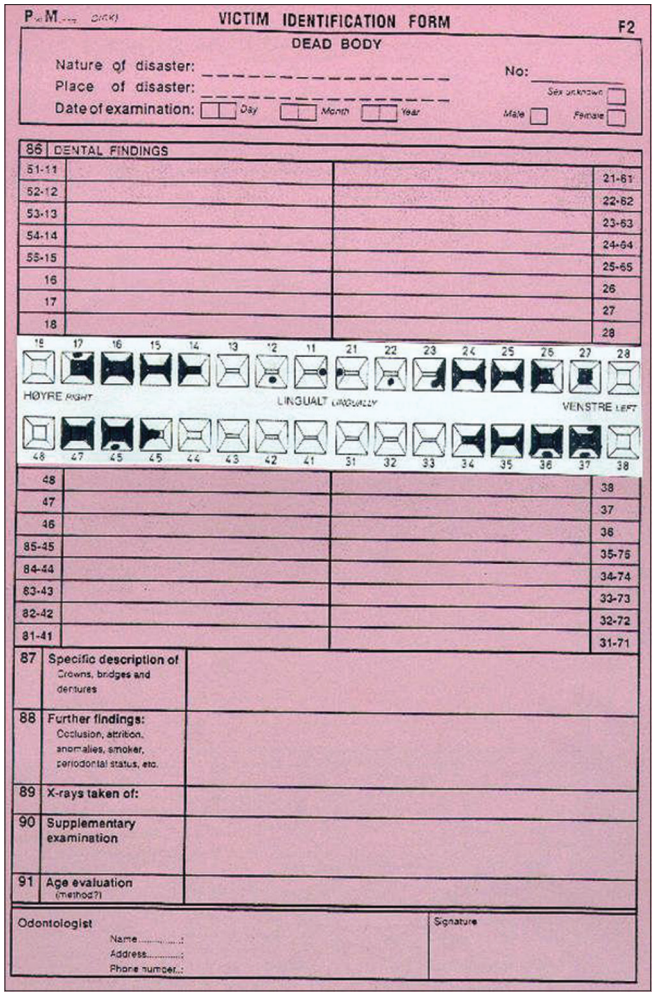
Figure 1: Ante mortem form

the AM F1/F2 Interpol form [Figure 1]. The personal, medical and dental record obtained from the specialists is entered into a central computer system: disaster victim identification (DVI) System International or WinID or DAVID or other software available. The AM fingerprints recorded are received along with this and are scanned into the automated fingerprint identification system.[13]

Postmortem or mortuary team

In the mortuary, the body is examined by a multidisciplinary team of specialists (fingerprint experts, policemen, pathologists, odontologists and DNA experts), who will register their findings on the pink PM Interpol forms.

The first step in the PM examination starts with finger/palm print analysis followed by the extensive external description. During the next step, the pathologist starts the external and internal description of the body. Later, Forensic odontologist carries out dental examination. A detailed description of the dentition and surrounding structure, the fillings and materials and the presence of prosthetic work will be made and registered on the PM F1/F2 Interpols form [Figure 2]. As dental pulp material is a good source for DNA analysis, two vital teeth (canines/premolars) can be extracted and sent to the forensic DNA laboratories.[7]


VICTIM IDENTIFICATION FORM

F2

DEAD BODY

Nature of disaster:

Place of disaster:

Date of examination: Day Month Year

No:

Sex unknown

Male

Female

86 DENTAL FINDINGS

51-11			21-61
52-12			22-62
53-13			23-63
54-14			24-64
55-15			25-65
16			26
17			27
18			28

18 17 16 15 14 13 12 11 21 22 23 24 25 26 27 28

HØYRE RIGHT LINGUALT LINGUALLY VENSTRE LEFT

48 47 46 45 44 43 42 41 31 32 33 34 35 36 37 38

48			38
47			37
46			36
85-45			35-75
84-44			34-74
83-43			33-73
82-42			32-72
81-41			31-71

87	Specific description of Crowns, bridges and dentures	
88	Further findings: Occlusion, attrition, anomalies, smoker, periodontal status, etc.	
89	X-rays taken of:	
90	Supplementary examination	
91	Age evaluation (method?)	

Odontologist

Name.....:

Address.....:

Phone number.:

Signature

Figure 2: Postmortem form

Identification team

The identification center handles and compares AM and PM documents forwarded from the AM and PM files unit, in these sections missing persons AM, PM, fingerprint, dental, DNA analysis reconciliation takes place and the transcription of the AM and PM documents. Results obtained from the specialized section are fed back to the identification files.[13]

According to the DVI Guide: Interpol 2009, the primary methods of personal identification are fingerprint analysis, comparative dental analysis and DNA analysis. It also states that accurate positive identification may be possible when the PM and the AM dental records obtained are from the same person. The Interpol DVI Guide mentions that if a positive match is found using dental identification, it can be trusted as a stand-alone identifier.[12]

DENTAL IDENTIFICATION

Dental identification has always played a key role in natural and manmade disaster situations. Because of the lack of a comprehensive fingerprint database, dental identification continues to be crucial.[14]

According to the American Board of FO, identification reports can be:

a. Positive identification - records that match with no discrepancies
b. Possible identification - AM and PM records that have consistent features but there is doubt in the quality of evidence
c. Insufficient evidence - without sufficient evidence to arrive at a conclusion and
d. Exclusion - records that clearly do not match.

Dental identification is performed by two means:

- To examine previous dental records of the person suspected as deceased and look for these dental characteristics in the deceased person for similarity and confirmation
- PM dental profiling is done if there is no previous dental records that will give clues to narrow the search required for AM materials to identify the deceased person.[15]

DENTAL RECORD

It is a legal document that contains all subjective and objective information about the patient.[16] The dental chart should be recorded accurately. It gives information about the details of all the teeth present in the mouth, such as the teeth present or absent, restorations, pathologies such as caries, furcation involvement, root pieces and periodontal health.[17] Every dentist has the legal obligation to maintain an accurate legible dental record to his/her patient.[18] An electronic or computer-generated dental record has the advantage of easy handling, transfer and feasibility of rapid communication in forensic cases related to identification.

AM records, such as case history sheet containing dental chart, written notes, study casts, full mouth impressions, dental radiographs and high-quality photographs, can be used in the positive identification of the deceased when compared with PM findings.[5] AM dental records are particularly helpful in mass disasters.[19]

The procedures for collecting dental records should conform to the relevant laws of the state. While releasing the records, all legal protocols should be maintained and the deviation of which may prove disastrous.[5] In case of mass disasters, the "Disaster victim register" process is required. AM forms (yellow color) and PM forms (pink color) should be filled separately for later comparison.[20] The electronic version of this form is called the "DVI System International" software program developed by Plass Data (Plass Data Software A/S, Taastrup Moellevej 12A, 4300 Holbaek, Denmark) that may help to identify the victim manifest.[21]

POSTMORTEM DENTAL PROFILING

PM dental profiling is done when the tentative identity of a person is not available and therefore AM records cannot be obtained. Such situations arise when the remains are grossly decomposed and found in unrelated location. The aim of PM dental profiling is to narrow the search to a small population of individuals.[22] Dental profile constitutes a group of individual characteristics related to the hard and soft tissue. They help in the estimation of age, sex, race, socioeconomic status, personal habits, systemic health, occupation and dietary status of the person.[23]

Table 1: Age estimation methods

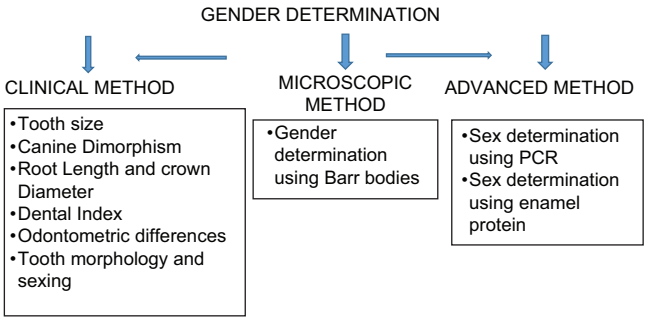
AGE ESTIMATION		
CLINICAL BIOCHEMICAL		RADIOGRAPHIC
Eruption Sequence	•Appearance of tooth germ •Degree of mineralization of various teeth •Degree of crown and root completion •Degree of root resorption of deciduous teeth. •Open apex •Pulp to tooth ratio •Volume of pulp chamber and root canals •Third molar eruption	•C14 levels •Racemization of dentin

Sex determination

Sex determination is the first step in human identification by a forensic investigator. Forensic odontologist can assist in sex determination by using information of the dental and skeletal remains.[24] Various features of teeth such as morphology, crown size and root length are characteristics of males and females. Since teeth can resist PM destruction, it can be used as a valuable tool in human identification. Various methods were used to determine gender in human identification[25] [Table 1].

Tooth size is a valuable tool that predicts the sex of an individual.[26] Certain dental indices such as incisor Index, mandibular canine index (MCI) and Crown Index have been derived from the linear measurements of the teeth that show sexual dimorphism in the teeth.[27] Studies show significant differences in crown dimensions of male and female teeth. Mandibular canine show the greatest dimensional differences with large teeth in males than in females. Incisors, premolars, first and second molars also have significant differences.[24] Crown diameters and combinations of root lengths are also used for sex determination. Singh *et al*. in a study found that the intercanine distance, right canine width, left canine width, right MCI and left MCI was found to be significantly higher in males than females.[28] Nonmetric features such as a distal accessory ridge, Carabelli's trait of upper molars, shovelling of upper central incisor, number of cusp in mandibular first molar can be used in sex determination. The distal accessory ridge in canine is more pronounced in male compared to female. Female exhibit lesser number of cusp in the mandibular first molar compared to male (distobuccal or distal cusp).[29] The size of the crown and Carabelli's tubercle to be greater in males.[30] A recent method of sex determination is the presence of bar bodies in the pulp of the teeth.[27] Reddy *et al*. in a study found that At 100°C, 200°C 400°C, the female cells showed fibroblasts with peripheral Barr chromatin condensation, whereas the males lacked Barr chromatin though they also showed a fibrovascular connective tissue stroma.[31] DNA from pulp tissue is used for sex determination using polymerase chain reaction (PCR).[27] Sivagami *et al*. obtained 100% success in determining the sex of the individual by preparing DNA from 2000 teeth

Table 2: Gender determination methods



by ultrasonication, and subsequent PCR amplification.[32] AMELOGENIN or AMEL, a human enamel protein has a different pattern in males and females. AMEL genes, in males, is located on chromosome X and on chromosome Y whereas females have two identical ALEL genes seen on X chromosome.[33]

Age estimation

Age estimation is one of the essential tools in identifying a person. Since the dental maturity is not affected by nutritional and endocrine status dental age can be used as a tool for identification.[34] Various methods are involved in the age estimation in human identification [Table 2].

Dentition is used to estimate age in three groups namely prenatal, natal and postnatal period, children and adolescents and adults. The age estimation is done in neonatal period for purpose like infanticide. Maceration, CT scan, dry weight of teeth and neonatal line are used in estimating the age of neonates.[35] In children and young adults, age estimation is done by clinical methods such as eruption sequence, radiographic methods such as Schoulr and Masslers method, Moorer, Fanning and Hunt method, Demirijian, Goldstein and Taners method and Nolla's technique.[36] The eruption of third molars is of great importance to distinguish juveniles and adults.[37] In adults, regressive alteration of teeth, periodontal status like attachment loss, dentin translucency histologic changes like incremental lines of cementum, radiographic assessment like root resorption, cementum apposition at the apex helps in age estimation.[35] Gustafson developed a method of age estimation from a single tooth which utilizes various stages of regressive changes in the teeth such as occlusal attrition, coronary secondary formation, loss of periodontal attachment, cementum apposition, amount of apical resorption and the transparency of the root.[38] Kvaal *et al*. developed a method to calculate age in adults. In this pulp to tooth ratio with volumes calculates the age.[39] Harris and Nortjé gave five stages of third molar development based on the root formation. This may help in the estimation of individuals age.[40] According to recent research, tooth cementum angulation may be used more reliably than other methods for age estimation.[41] Amino acid racemization is also used to determine age. As there is increased conversion of L – aspartic acids to D – aspartic acid with age in enamel, dentine and cementum, the D/L ratio can be used to estimate age.[42]

Race determination

Race can be determined by morphological characteristics of teeth confirmed by numerous dental anthropological studies. Caucasians have a characteristically high prevalence of Carabelli cusp, reduced number of dental cusps and simplification of the fissure system. A high prevalence of shovelled incisors, complex fissure system with no reduction in the number of dental cusps is seen in Asians. The black races neither have a high degree of Carabelli cusp prevalence, nor the shovelled incisors; however, they have a complex fissure system and the usual number of cusps on the teeth.[43]

Assessment of socioeconomic status, personal habits, oral health status and occupation

A victim with poorly maintained teeth, great number of caries, old and inadequate fillings, prosthetic replacements fabricated from cheap materials, is known to a person of a low-income status. On the other hand, esthetically pleasant, and the teeth treated, with high-quality fillings, dental implants, orthodontic appliances may point to a person of a high-income status.

Personal habits such as smoking, use of oral hygiene products may cause defects in dental hard tissues. Open bite crossbite and protruded incisors may indicate numerous inappropriate habits in children. PM dental data that includes Amelogenesis imperfecta, Dentinogenesis imperfect, oral manifestation of scurvy, erosive changes due to bulimia/anorexia may have a great importance when it comes to comparison with dental data which were recorded during life can be helpful in determining the identity of the individual. In certain profession, it is possible to find dental defects characteristic of particular profession. Such defects are mostly seen in upper and lower incisal edge of incisors commonly in glass blowers, shoemakers and musicians who play wind instruments. High caries index, tooth wear, erosive changes in hard tissue may be correlated with high consumption of carbohydrate, hard food and nuts and carbonated beverages respectively may aid in the reconstruction of dietary habits of an individual helping in identification.[23]

FORENSIC ODONTOLOGIST: AS A HUMANITARIAN

Forensic odontologist plays an active role in all phases of the victim identification process.[7] The use of teeth in personal identification is well accepted in the forensic science and in the court of law.[27] The role of forensic odontologist and a multidisciplinary approach are important in the following sections for the best outcome of the forensic analysis.

Border control

In defence force, the active participation against cross-border terrorism at the national boundaries with the neighboring countries many soldiers become martyrs and the body cannot be identified due to burns or other disorientation. In this situation, Forensic Odontologist might help in identification by comparing the dental record collected before the commencement of his/her service.[44]

Human trafficking

Human trafficking is the second largest criminal activity in the world and it is a growing crime. Victims of human trafficking frequently come into contact with health care professions owing to injuries and illness, but also because of safe and confidential environment they offer. Dental professionals can contribute to the identification, assistance and protection of trafficked persons, as well offering forensic services to assist the police investigation to identify crimes and find the criminal organization behind them.[45]

Mass disaster

In the recent time, the incidence of mass disasters has increased many folds due to the expansion of travel facilities, an increase in unusual natural conditions.[6] In this scenario, Forensic Odontologist can alone make a victim identified.

Identification of nameless cadavers

The identification of nameless cadavers by forensic odontologist can provide evidence to the families which may be used in court, and ensuring that the body is available to the family for the funeral. It also helps to understand that what happened to the deceased, so that corrosive uncertainty about this is replaced by something closer to the truth, as terrible as that might be.[1]

Speedup disaster victim identification process

DVI is a demanding task and can be successfully completed by proper planning and executing with forensic tools and key experts.[7] Forensic Odontologist can play an important role in victim identification in mass disasters across the world and speed up DVI process.[6]

CONCLUSION

Teeth and jaws provide a huge amount of information in the field of DVI, age estimation of unaccompanied minors, missing and unidentified persons, child abuse and neglect, domestic violence and sexual abuse. Forensic odontologist and oral health professionals can promote FO for the purpose of preventing human rights violation through the application of best practice in human identification. Human identification without complete PM assessment can lead to delayed identification and represents a violation of human rights and international humanitarian Law.

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Conflicts of interest

There are no conflicts of interest.

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