Teeth as Forensic Evidence: Pioneering Odontological Methods of Human Identification in Algeria.

Chawki Bisker and Ammar Teboul.

***Abstract*— Forensic odontology is a reliable approach for human identification during mass disasters and investigations involving the discovery of skeletons, carbonized human remains, and mummies. This branch of forensic science relies on estimative and comparative methods to identify the deceased. It is often employed at disaster scenes and during cadaver examinations to document the post-mortem dental status. Additionally, it is used in conjunction with forensic anthropology when dealing with human skeletal remains.**

Forensic odontology has proven vital to forensic investigations and human identification during disasters, particularly in countries prone to natural disasters or those that have experienced colonialism or armed conflicts.

The Forensic Anthropology Laboratory of the Algerian National Institute of Criminalistics and Criminology is the first Algerian laboratory to be accredited in forensic odontology, in 2019, it has adopted forensic odontology as a rapid and economical means of victim identification, alongside forensic anthropology, DNA analysis, and fingerprint analysis, capitalizing on the high resistance of teeth to biotic and abiotic agents.

Laboratory odontological analysis involves regionally validated methods for sex and age estimation, as well as the comparison of ante-mortem data with post-mortem evidence to establish positive identification. Bite mark comparison is also part of the process. Forensic odontology provides valuable information that complements forensic anthropology regarding human identification and the reconstruction of death scenarios. Consequently, it aids in identifying the deceased and supplying the court with essential technical elements for informed judgments.

***Keywords*— Human identification; forensic science; forensic odontology; forensic anthropology; Bite mark; disaster victims identification.**

I. INTRODUCTION

Every year, thousands of victims from natural disasters remain unidentified [1], leaving families in anguish and uncertainty. What happens to these lost identities? In our rapidly changing world, the moral and legal obligation to identify human remains has never been more critical. The priority in such cases is to conduct swift and accurate victim identification to uphold the deceased's rights. Various forensic techniques, including visual recognition, fingerprints, and DNA analysis, are employed based on international guidelines such as INTERPOL's Disaster Victims Identification guide [6]. However, identification can be challenging [8] in cases involving dry skeletal remains or severely decomposed bodies, necessitating the use of forensic anthropology [52], and forensic odontology methods.

The Algerian National Institute of Criminalistics and Criminology (NICC), through its Forensic anthropology Laboratory and Disaster Victim Identification unit specializes in identifying disaster victims and decomposed human remains recovered from crime scenes and archeological sites using locally validated forensic anthropology and odontology methods. The NICC is the first laboratory accredited by the Algerian Accreditation body (ALGERAC), under ISO/IEC 17020:2010 standards and the fourth accredited by ANSI National Accreditation Board (ANAB) in 2019 [51],enhancing its credibility.

In Algeria, stomato-odontological casework is performed by experienced dentists as per Executive order 09-393 of November 24, 2009 [7]. Forensic scientists and odontologists conduct forensic odontological casework to identify disaster victims and human skeletal remains following quality assurance recommendations from the International Organization for Forensic Odonto-Stomatology (IOFOS) [9].

This paper provides an overview forensic odontology practices at NICC and explores its vital role in ensuring that every victim receives the dignity they deserve.

II. BASE REQUIREMENT

Forensic odontology methods are rapid and economical due to the high resistance of teeth to the biotic and abiotic factors affecting decomposition [2, 11].Ensuring reliable results is crucial; thus, establishing quality management systems [14], using regionally validated methods aligned with international guidelines is essential to maintain proficiency and minimize errors.

During forensic odontology casework, narrowing down missing persons helps direct investigations. Establishing a dental chart (odontogram) should include records of dentition type (deciduous, permanent or mixed),individual tooth characteristics (wear, fractures, ante or post-mortem missing teeth), and tooth tint and position. This information can be recorded as a handwritten notes or digital charts [13].

Teeth are classified according to international standards set during the 58th session of the International Dental Federation (IDF) in October 1970, which are used in the International Criminal Police Organization (ICPO) guides. A dental chart serves as a standard evidence source for body identification [13]; photographs documenting teeth from various angles are also essential for future reference and should include an occlusal view of both teeth arcades, a vestibular view of the dental occlusion (front, right and left profile) [18].

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III. HUMAN IDENTIFICATION

Human identification involves searching for forensic clues that are compared against physical characteristics of the deceased. Identifying victims is crucial for investigators as it aids in directing their inquiries [18, 21].

A. Forensic odontology at the NICC

The NICC's Forensic Anthropology Laboratory handles bones and mummies from various sites; teeth can help estimate sex and age at death. All laboratory methods have been validated on samples from the Algerian population. Age estimation techniques based on tooth maturation (Schour and Massler, 1941) [17] and degeneration (Lamendin, 1992) [4], have been accredited under ISO/IEC 17020 since 2019. Regular international proficiency tests are conducted.

Forensic odontology methods estimate age in over 5% of the adults skeletons processed in the laboratory and about 60% of non-adult skeletons, depending on bone availability. Anthropological methods for sex estimation (Klales 2012; Walker 2008) and age estimation (Suchey-Brooks 1990) are preferred for sex and age-at-death estimation on the Algerian population due to their accuracy during validation, while sex is determined by odontological methods in very few cases.

B. Disaster victims identification (DVI) unit:

Disaster victims' identification is a multidisciplinary task [39] that involves in situ intervention during which the DVI unit will search for, record and recover human remains, exhibits and property. Subsequently, the human remains will be processed, examined and stored in a mortuary until formal identification and release by the magistrate.

DVI requires coordination among experts from various fields [6, 37] including forensic pathologists, geneticists (forensic biologists), fingerprint experts, forensic anthropologists and forensic odontologists. These experts work alongside crime scene technicians and other professionals.

Forensic odontology plays a vital role in identifying victims of mass-disasters due to its cost-effectiveness [37, 38] and efficiency. The NICC's multidisciplinary DVI unit includes forensic odontologists responsible for securing dental materials on-site and recording post-mortem dental statuses [10, 36].

C. Comparative odontology:

This approach is based on the comparison of post-mortem data collected from cadavers or skeletons with ante-mortem medical records, family testimonies and information collected as outlined in INTERPOL's guide [6]. Comparative odontology is used for disaster victims' identification in closed sites or indoors disasters; it is most effective when up-to-date ante-mortem medical records exist [30], which makes it mainly applicable when health systems allow the storage of patients' medical records. In addition, the practice of having family health practitioners facilitates the recovery of recent ante-mortem medical records in a timely manner.

In some countries, electronic patient medical records are kept by dentist practices and can be used to retrieve recent ante-mortem data for dental comparison and therefore identification of the deceased. Nonetheless, these records are kept separetely and might not be up-to-date within all practices hence the need for a unified network for electronic medical records.

In some regions where medical records are not consistently maintained or laws do not allow it [47, 48], comparative identification may not be feasible; thus, estimative identification methods may be utilized.

D. Estimative odontology:

Estimative odontological identification aims to gather sufficient information from teeth characteristics to estimate age and sex with varying precision. It may also provide insights into the deceased's profession, diet, and habits.

1) Age estimation:

Teeth play a critical role in age estimation [22]; recent literature indicates that age estimation using teeth is more accurate than using bones [22, 23]. By analyzing dental development patterns, forensic professionals can provide valuable age information about unidentified bodies [49], assisting investigators in narrowing down their search for potential matches and guiding their investigations. Based on the age (adult, non-adult) of the deceased two different analytical processes might be used.

1.1 Non-adult age estimation:

Age estimation of dead or living people is crucial to investigations. The Algerian legislation ensures the protection of children from exploitation and crimes related to begging, homelessness, exposition to danger and human trafficking [24, 25], hence the importance of age estimation in cases such as child adoption and identification of under-age children [26].

Accurate age estimation by means of anthropological methods such as epiphysis fusion and long bones' length is challenging, hence the use of dental development stages as key indicators for age estimation in children and adolescents. Root formation in permanent teeth typically completes around the age of 18, allowing for age estimation between 16-22 years [27].

Dental age estimation methods involve assessing the development of specific teeth and comparing them to established dental growth diagrams. X-rays, specifically panoramic radiographs, are frequently used to examine dental structures. The stage of tooth development, tooth eruption sequence, and the closure of growth-related apical structures help forensic odontologists estimate the chronological age of non-adult individuals [17, 28, and 50].

In children, dental age estimation can be performed using atlas-style methods, based on diagrams representing the eruption patterns of developing teeth or methods relying on incremental staging of developing teeth. A method based on the diagram of Schour and Massler (1941) and the atlases of Ubelaker (1978, 1989) and AlQahtani et al. (2010) is used at the NICC for teeth that are still in their alveoli. This method showed no sex discrimination during validation on Algerian samples.

1.2 Adult age estimation:

Estimating adult dental age is more complex since all teeth formation aspects are complete. Methods focus on physiological changes like dental wear [12], secondary dentine apposition [29], cement apposition on roots, and radicular resorption [30], which varies based on individual factors, geographical position, standard of living and diet.

Various methods have been used for age estimation, each focusing on different dental features. The Lamendin (1992) method significantly improved Gustafson's original technique [16] by assessing root transparency variations (T) and periodontal recession (P);it uses physical measurement of dental translucence, periodontitis and root height on the labial aspect of the tooth.

A method based on Lamendin (1992) has been validated at the NICC, on a sample of modern Algerian population in which age varied between 20 and 73 years, with results indicating its adequacy for estimating adult age-at-death.

2) Sex estimation:

While skeletal variations indicate biological sex differences, few studies have explored sexual-odontometric variations. Fronty (1978) measured lateral mandibular canine and incisive crowns to demonstrate sexual dimorphism [19], while Bequain (1985) focused on dental roots measurement for assessing sexual dimorphism in maxillary canines [20].

E. Teeth as specimen for DNA analysis.

DNA analysis is a powerful tool for human identification during mass disasters when other methods fail. This efficient approach relies on ante-mortem data collected from direct primary DNA sources like blood and hair samples, direct secondary sources including toothbrushes and clothing, and indirect DNA reference samples from biological relatives [49]. DNA can be extracted and subsequently analyzed from a variety of biological specimens such as body tissues and bones [33, 35]. Post-mortem specimens undergo sequential degradation through autolysis and bacterial action [31, 32] including production of DNA degrading enzymes (DNase) [15]. Dental specimens are particularly rich in DNA and durable compared to bones or decomposed tissues [34], making them preferable for DNA extraction in over 59% of the skeletal remains processed at the NICC.

IV. BITE MARKS ANALYSIS.

Bite marks are patterns resulting from contact between teeth and surfaces [3];analyzing dental impressions left at a crime scene or on victims' bodies can link suspects to crimes [40, 46]. Despite its subjective nature making it complex [45], bite mark analysis has been successfully used in criminal cases as additional evidence. Judicially accepted guidelines [42], adopted by the American Board of Forensic odontology since 1984 [41, 43] support this practice.

The NICC's first bite mark analysis dates back to 2012, when a suspect was linked to a murder through bite mark evidence on a victim's body. However, challenges remain due to the discipline's controversies surrounding bite mark comparison [44].

V. CONCLUSIONS

Forensic odontology is crucial for human identification, especially when other techniques like DNA and Fingerprints are unfeasible. Successful identification relies on available ante-mortem dental records and accurate post-mortem data collection; therefore, it is recommended that dentists maintain detailed, up-to-date patient records. Estimative methods can help construct biological profiles of deceased individuals while bite mark analysis offers potential investigative leads despite its challenges. The main obstacle for experts is effectively utilizing all available evidence to assist magistrates in making informed judgments.

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