# FORENSIC ODONTOLOGY:

## A HANDBOOK FOR HUMAN IDENTIFICATION

Editors:
**Anshu Nanda**
**Jaskaran Singh**

**Bentham Books**

# Forensic Odontology: A Handbook for Human Identification

Edited by

**Anshu Nanda**
*Department of Clinical Research*
*Sharda University, Greater Noida*
*U.P., India*

&

**Jaskaran Singh**
*Department of Forensic Science*
*Geeta University, Panipat*
*India*

**Forensic Odontology: A Handbook for Human Identification**

Editors: Anshu Nanda and Jaskaran Singh

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# FOREWORD

In India, crime investigation has been an evolving matter of concern for many agencies of the government primarily due to low conviction rates for many heinous crimes. The delays in the forensic investigation have also been a major concern. In some cases, it is reported that forensic labs around the country have not been able to conclusively conduct evidence-based investigations and reports, due to which cases in the judiciary have lingered for more than even 10 years.

Besides the practical utility of the tool, academically, Forensic Science is an interdisciplinary branch that is an amalgamation of concepts of many science subjects. Forensic Science works in a domain that is a combination of law enforcement and crime-fighting, making it a field of diverse possibilities, challenges and responsibilities. It has been the bedrock of every investigation around the world for solving a crime.

It is in the above context that the present book about forensic odontology caught my attention. Forensic Odontology is in a nascent stage in the country, and slowly it is being understood as a very robust tool to revolutionize crime investigation. This book is an excellent primer to the possibilities of how dental evidence should be collected, handled, examined, reasoned with, and used to scientifically strengthen the criminal investigation system.

While going through the book, I found that the Editors have made a sincere attempt to present an intelligent overview of various aspects of the subject. It fulfills the long-term need for a concise book in this evolving field. The book sieves out the conceptual knowledge and exposure of forensic odontology for medical, dental, allied and litigation purposes. One of the attractive features of the content is that it brings out the remedial measures for challenges in disaster victim identification which can prove to be very helpful in the management during times of crisis.

This book is undoubtedly appropriate and reinforces a long journey ahead to realize the value of Forensic Odontology in strengthening law enforcement agencies to boost the criminal justice system. I believe this book would also be helpful to the labs which have already been accredited by one of our Boards, *viz.* the National Board of Testing and Calibration Laboratories (NABL), and many more which would venture to increase their scope in Forensic-Biological Sciences group. I would encourage my colleagues, friends, officers and staff of NABL and forensic laboratories to use the book for understanding of this evolving field of forensic investigation in the country.

I congratulate the editors for their sincere effort and wish them all the best.

**Ravi P. Singh**
Secretary General
Quality Council of India
Bahadur Shah Zafar Marg
New Delhi, India

# PREFACE

Forensic odontology has popped up in forensic science, which deals with the collection and handling, thorough examination and corroboration in the proper criminal justice system.

Over the last few decades, forensic odontology has emerged as one of the most applauded areas of interest among the dental fraternity, who wish to gain knowledge or explore the possibilities of a career in forensic odontology with a genuine understanding of this discipline.

Written by authors that are highly knowledgeable, experienced and well-established in the field, this book provides lucid content which covers both basic and advanced components of dental forensics, beginning with anatomical attributes of the tooth, age assessment, dental anomalies and moving ahead to DNA fingerprinting from dental pulp, disaster victim identification from dentures, bite marks and oral autobiography which is a pragmatic approach in identification. This book gives an insight into all the aspects necessary to become an expert practitioner and stalwart who can provide apt evidence and explanations.

This book will benefit forensic medicine, clinical settings, litigation, disaster management, *etc*., and will help accelerate the progress in criminal justice.

We hope that the book will meet the requirements of every reader.

**Anshu Nanda**
Department of Clinical Research
Sharda University, Greater Noida
U.P., India

&

**Jaskaran Singh**
Department of Forensic Science
Geeta University
Panipat, India

# DEDICATION

*To Lord Shiva, the supreme being, the eternity, the beginning, the end!*
*To my family, the reason for my existence!!*
*To my sisters, the reason for who I am today!!!*

# List of Contributors


| | |
|---|---|
| **Aman Chowdhry** | Department of Oral Pathology, Faculty of Dentistry, Jamia Millia Islamia, New Delhi, India |
| **Archana Gaikwad** | Department of Oral Pathology, Nair Hospital Dental College, Mumbai Central, Maharashtra, India |
| **Emilio Nuzzolese** | Department of Sciences of Public Health and Pediatrics, University of Turin, Turin, Italy |
| **Ferah Rehman** | Department of Pediatric and Preventive Dentistry, Maulana Azad Institute of Dental Sciences, New Delhi, India |
| **Gyanendra Kumar** | Department of Pediatric and Preventive Dentistry, Maulana Azad Institute of Dental Sciences, New Delhi, India |
| **Hemant Sawhney** | Department of Oral Medicine & Radiology, School of Dental Sciences, Sharda University, Gautam Budh Nagar, Greater Noida, Uttar Pradesh, India |
| **Jayant Kumar Gahlot** | Department of Oral Medicine & Radiology, School of Dental Sciences, Sharda University, Greater Noida, Uttar Pradesh, India |
| **Priyanka Kapoor** | Department of Orthodontics, Faculty of Dentistry, Jamia Millia Islamia, New Delhi, India |
| **Rohan Ashok Gawali** | Department of Forensic Odontology, Maulana Azad Institute of Dental Sciences, MAMC Complex, B.S. Zafar Marg, New Delhi, India |
| **Shivani Bansal** | Department of Oral Pathology, Nair Hospital Dental College, Mumbai Central, Maharashtra, India |
| **Shilpa Malik Dutta** | Department of Oral Pathology and Microbiology, Teerthanker Mahaveer Dental College and Research Center, Moradabad, Uttar Pradesh, India |
| **Shaivya Mishra** | Forensic Odontologist, Lucknow, Uttar Pradesh, India |

# CHAPTER 1

# Anatomical Attributes of the Tooth

**Aman Chowdhry**[1,*] and **Priyanka Kapoor**[2]

[1] *Department of Oral Pathology, Faculty of Dentistry, Jamia Millia Islamia, New Delhi, India*

[2] *Department of Orthodontics, Faculty of Dentistry, Jamia Millia Islamia, New Delhi, India*

**Abstract:** Anatomical variations in the human species can be attributed to interactions between genetic influences and environmental factors. These variations also permeate dental morphology, and dental morphological traits are of value for understanding variations among populations. Dental anthropologists have cataloged this diversity, and these traits have been used in various disciplines.

To establish population-based data, both metric and nonmetric dental trait frequencies are required. These anatomical attributes have applications in forensic odontology and archaeological contexts. Both nonmetric and metric traits are being used in the fields of dental profiling (assessing age, sex and ethnicity) and bite mark analysis.

A trait that is higher in number in one population may be considered normal in the population. In contrast, if a trait is found at a low frequency, it could inadvertently be considered an anomaly. It can help in determining the relationship with ancestry, which justifies the significance of data pools of dental traits in human forensic identification.

Although numerous studies of dental anatomical landmarks and peculiarities have been carried out in search of population patterns worldwide, India has yet to establish a database for its population. This highlights the need for an area-specific, gender- and ethnicity-based database of dental traits for the population of the Indian continent, which does not exist at present.

**Keywords:** ASUDAS, Carabelli's traits, Dental identity, Disaster victim identification.

[*] **Corresponding author Aman Chowdhry:** Department of Oral Pathology, Faculty of Dentistry, Jamia Millia Islamia, New Delhi, India; E-mail: achoudhry@jmi.ac.in

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## CONCEPT AND DEFINITIONS

### Archaeology and Anthropology

- **Archaeology:** Etymological archaeology is derived from the Greek word archaiologia, where archaio means ancient and logos means study. Thus, archaeology is a branch of science to study, discover and understand skeletons and artifacts that remain left behind by humans.
- **Anthropology:** Etymologically, anthropology is derived from the word anthropos, which means man, and logos, which means study. Thus, anthropology is the branch of science that deals with learning about human and human behaviour and societies in the past and present.

### Dental Anthropology

Teeth have a wide array of variables, which are controlled by genes and the environment. The study of these morphological variations in teeth is called "dental anthropology".

### Dental Trait

Dental traits are distinguishing characteristics, peculiarities, or attributes of a tooth that can be metric and nonmetric in nature (Fig. **1**).

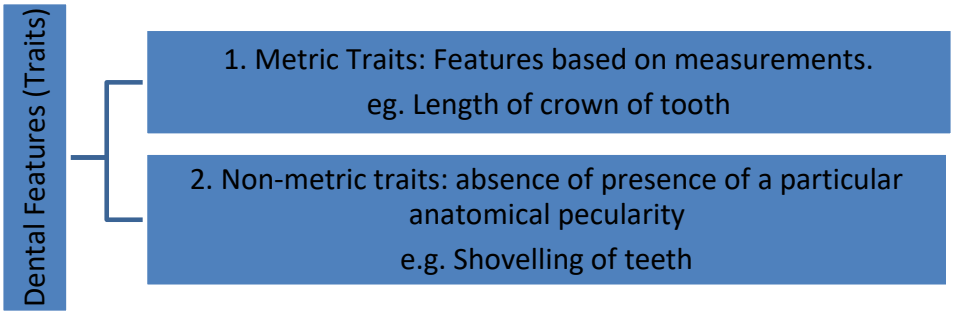


**Fig. (1).** Dental traits.

These traits help to distinguish the set, arch, class, or type of each tooth, *i.e:*

### *Set Traits (Dentition Traits)*

Difference in primary and secondary sets of dentitions.

*E.g.*, Difference in deciduous and permanent central incisors.

### *Arch Traits (Upper and Lower Teeth Traits)*

Difference in maxillary and mandibular arch teeth.

*E.g.*, Difference in permanent maxillary central incisor and mandibular central incisors.

### *Class Traits (Interclass Traits)*

Differences in four classes of teeth (Incisor, Canine, Premolar and molars).

### *Type Traits (Intraclass Traits)*

Difference in teeth within one class.

*E.g.*, Difference in central incisor and lateral incisor or difference in first and second premolars.

## Arizona State University Dental Anthropology System

ASUDAS is a standard protocol plaque crafted by Scott and Turner in 1991 for objectively scoring more than 30 morphological traits of teeth. They have suggested that unique dental traits have been formed over the years due to genetic and environmental factors that influence various populations. These traits can be consistently reproduced and gauged between observers. For consistency, plaques are utilised; this gives a visual explanation for various traits. A novel web-based application of ASUDAS (*i.e.,* rASUDAS) has been tested on osteological remains excavated from Ptuj, Eastern Slovenia [1].

## Carabelli's Trait (*Tuberculum Anomale*)

In 1842, the Cusp of Carabelli was one of the most studied traits and was first recorded by Sir George Carabelli [2]. Morphological variation appears on the lingual surface of the mesiolingual cusp of the upper molars (Fig. **2**). It presents itself as a fifth separate cusp and is less prominent if present in the upper second and third molars [3, 4]. Bhavya R *et al.* (2020) found an increased risk for caries in the Carabelli cusp in primary maxillary second molars [5].

# CHAPTER 2

# Dental Age Estimation in Forensics

**Priyanka Kapoor**[1,*] and **Aman Chowdhry**[2]

[1] *Department of Orthodontics, Faculty of Dentistry, Jamia Millia Islamia, New Delhi, India*

[2] *Department of Oral Pathology, Faculty of Dentistry, Jamia Millia Islamia, New Delhi, India*

**Abstract:** Dental age estimation is important in both comparative and reconstructive forensic identification, where chronological age is either unknown or deliberately hidden or forged due to criminal, civil or legal disputes. Age estimation is possible right from prenatal life to early postnatal, childhood, adolescent and adult age, but the methods or principles differ in implementation. While the developmental stages of teeth are important to assess age in a young life, the morphologic changes after the complete development of teeth or third molar indices become important in adulthood. This chapter classifies different methods used in dental age determination, including visual, radiographic, physical, histologic, biochemical, and morphologic changes, in different age groups and gives a diagrammatic representation for ease of understanding. The evolution of atlas/chart methods for developing teeth has been explained in detail, including the conventional Schour and Massler chart to the contemporary London atlas method. Additionally, an overview of the more objective scoring methods, including Demirjian and its modifications, comprehensive DAEcc charts, Camariere methods, *etc*., is also given. This chapter also entails the most recent advances in age estimation techniques, including 3-D CBCT/micro-CT volumetric assessments and automated age estimation programs, along with the current use of artificial intelligence (AI) in the segmentation of radiographic images of teeth for greater accuracy and automation. The comprehensiveness of this chapter is established by the inclusion of dental age estimation in special situations of craniofacial abnormalities, archeology or fossil evidence. Towards the end, it also highlights the importance of using more than one age estimation method while preparing a forensic age estimation report or in research, also mentioning the error rate in each method.

**Keywords:** Age estimation charts, Artificial intelligence, Dental age stimation, DAE, Forensics.

[*] **Corresponding author Priyanka Kapoor:** Department of Orthodontics, Faculty of Dentistry, Jamia Millia Islamia, New Delhi, India; E-mail: pkapoor@jmi.ac.in

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## CONCEPTS AND DEFINITIONS

***Forensic age estimation (FAE)*** by Ritz-Timme S, 2000 [1]: "Expertise in forensic medicine which aims to define in the most accurate way the chronological age of person of an unknown age involved in judicial or legal proceedings".

***Chronologic Age (CA):*** The difference between the individual's date of birth and a specific later date [2].

***Dental Age (DA):*** DA is the assessment of the stage of dental maturity based on calcification, mineralization, eruption and posteruption morphologic changes in tooth structure. It can also give an indication of the chronological age of the individual.

***Skeletal Age:*** It is an interpretation of skeletal maturity, primarily assessed on radiographs (hand-wrist/lateral cephalogram, knee joint, *etc*.). It can also be correlated with chronological age and dental age for age assessment of the individual.

***Striae of Retzius [3]:*** First described by Anders Ritzeus (1837), these are brown lines produced by variations in rhythmic mineralization of the enamel prism, indicating the period of enamel formation and rest. In dentin, these are called incremental lines of Von Ebner and contour lines of Owens.

## INTRODUCTION

Age can be described as an indication of the maturity of an individual. It can be measured as chronological age (CA), physical age, skeletal maturation, dental age (DA), sexual maturity and mental age. The chronological age of an individual is mandatory for distinguishing societal norms, benefits, and laws, with little variation across different countries. It is required for rendering civil matters, including voting, marriage, retirement, consent, labor laws, and criminal offenses and sentence [1]. Determination of CA worldwide is by registration of birth in national birth registries, but there is a wide divide in the proportion of registration between the developed and developing parts of the world. The latest UNICEF data (2021) for birth registration below 5 years indicate a 100% registration in North America and Western Europe, followed by 94-99% in Eastern Europe, Central Asia, Latin America and the Caribbean, while it is as low as 40% in sub-Saharan Africa [4]. Hence, with the changing current scenario worldwide, due to the increasing crime rate, natural or made disasters or population migration leading to high numbers of asylum seekers, it is important to ascertain the legal identity of an individual. In cases where it is difficult to establish the

chronological age, dental age plays an important role in this aspect. Dental age estimation (DAE) is rapidly becoming the mainstay for proven practice in forensic odontology as well as a legal medicine.

## HISTORY OF DENTAL AGE ESTIMATION

The earliest use of teeth for estimation of age dates back to approximately 175 years when the eruption status of teeth was used to determine age in cases of child labor, as the Factory Act of 1837 stated that children working in factories should have erupted second molars and between 9-12 years, they should be working only for a restricted time [5]. Additionally, adolescents in ancient Rome were considered for service based on the eruption of permanent second molars.

Various charts have been developed for the assessment of age based on developmental status and eruption of teeth. As early as 1941, the Schour and Massler chart was published, which presents different stages of deciduous and permanent teeth eruption, which was modified from the Kronfild and Logan charts and is still a standard application to date [5]. There are other authors who have supported the accuracy of age estimation by teeth during infancy and childhood, including Gorden *et al.* and Gonzales *et al.* [6, 7] However, DAE becomes a challenge once the individual reaches adulthood. There were studies in European populations that studied sex-related differences in the emergence of deciduous dentition. The pattern depicted males taking the lead in the development of the anterior dentition, while females taking the lead in the development of the posterior dentition [5].

Authors have claimed contradictory findings related to the accuracy of age estimation based on the eruption of teeth in developing children, with one author stating that it can only give an approximation of age as eruptions are subject to a wide amount of individual variations [8]. On the other hand, one author supports systematic observations for accuracy in age estimation [9], while another author states that mineralization of the deciduous crowns can accurately determine age between birth and 6 months of life, while the eruption status can determine age up to 13 months of age [10].

## IMPORTANCE OF TEETH IN AGE ESTIMATION

Teeth are important tools in forensic investigations, especially for identification and age estimation. The highly mineralized structure of teeth makes them resistant to environmental abuse, nutritional deficits, postmortem decomposition, and the ability to withstand high temperature and pressure, making them reliable entities to be studied in mass disaster situations where distortion of soft tissues or other

# CHAPTER 3

# "Dental Anomalies": A Key to Personal Identification

**Gyanendra Kumar[1,*], Shilpa Malik Dutta[2]** and **Ferah Rehman[3]**

[1] *Department of Pediatric and Preventive Dentistry, Maulana Azad Institute of Dental Sciences, New Delhi, India*

[2] *Department of Oral Pathology and Microbiology, Teerthanker Mahaveer Dental College and Research Center, Moradabad, Uttar Pradesh, India*

[3] *Department of Pediatric and Preventive Dentistry, Maulana Azad Institute of Dental Sciences, New Delhi, India*

**Abstract:** Despite the fact that the world is a lovely spot to live, violations, brutality, mishaps, and fiascos happen on a regular basis. Being that as it may, distinguishing and bringing the guilty party(s) to discipline and carrying comfort to the family members of the person in question or the deceased by recognizing the perished is the best equity we can manage, and criminological medication assumes a significant part in it. A forensic examination team might include law implementing authorities- criminological pathologists, measurable odontologists, legal anthropologists, serologists, criminalists, and different experts relying upon the conditions. Singular ID may in like manner be expected to recognize both a lost live presenting with amnesia and the liable gatherings doing incorrectly doings.

**Keywords:** Dental records, Dental anomolies, Dental identification, Dental charting.

## INTRODUCTION

Despite the fact that the world is a lovely spot to live, violations, brutality, mishaps, and fiascos happen on a regular basis. Being that as it may, distinguishing and bringing the guilty party(s) to discipline and carrying comfort to the family members of the person in question or the one who is expired by recognizing the perished is the best equity we can manage, and criminological medication assumes a significant part in it. A forensic examination team might include law implementation authorities, criminological pathologists, measurable odontologists, legal anthropologists, serologists, criminalists, and different experts

* **Corresponding author Gyanendra Kumar:** Department of Pediatric and Preventive Dentistry, Maulana Azad Institute of Dental Sciences, New Delhi, India; E-mail: gyanendrasaroj@gmail.com

relying upon the conditions. Singular ID may, in a similar manner, be expected to recognize both a lost live being presenting with amnesia and liable gatherings doing incorrectly doings.

Dental records are vital and regularly play a critical part in maintaining the individual ID of those who were visually acknowledged in the past. It is an individual from the legitimate calling, much of the time the police, who calls upon the dental specialist for the cycle of ID. The distinguishing proof of an individual is required when the body is deformed or damaged to the point of being unrecognizable because of uncouth violations, working environment and engine vehicle mishaps, flying and naval force catastrophes, natural disasters such as flood, fire, war artificial and normal mass fiascos and emergencies and in conditions where the body is unidentified and is in a deteriorated state. Dental professionals play a crucial role in forensic investigations. They consulted to distinguish the remaining body parts of those people who could not be recognized outwardly. They are frequently important for the multimember group of legal examinations. A few dental specialists and legitimate experts are much uninformed about the significance of dental archives in the distinguishing proof of obscure people at crime scene investigations. They are habitually demanded to distinguish the remaining parts of people who cannot be recognized outwardly. They are frequently essential for the multimember group of measurable examinations. A few dental specialists and legitimate experts are very oblivious to the significance of dental data in providing recognizable proof of obscure people in the speciality of criminology. There is a severe need to fill this gap [1].

At a certain point when dental designs are the wellspring of data for the distinguishing proof of an individual's remaining parts, the measurable odontologist assumes a fundamental part in the ID of the individual. Dentition is a rigid and steady special construction with diverse morphology. They are not effortlessly deteriorated as other body parts, even in the afterlife. Teeth endure even unfortunate ecological circumstances, such as fire, which makes them a believed source in the distinguishing proof interaction. Varieties fit as a fiddle, shading, location, age, wear designs, caries, periodontitis, dental rebuilding efforts, along with various prosthesis work furnishing the dentition of an individual as fingerprints [2]. The essential techniques for casualty ID include unique mark examination, near-the-dental investigation, and DNA examination. An exact positive ID might be conceivable when posthumous (PM) and ante mortem (AM) records are received from similar individuals. Without ante mortem data, the measurable group looks for elective wellsprings of reference, for example, photos and tapes for individual highlights that might be recognizable at the after-death assessment. One of the procedures utilized in these cases is skull-photograph superimposition. Recognizable proof by this strategy depends on the

coordination of the diagram and positional connections between anatomical focuses on the face and their areas on the skull [3].

## DENTAL RECORDS

A dental record is an authoritative archive that consists of all emotional and target data of the patient and is owned by specialized personnel in the field of dentistry. It consists of the patient's main grumbling, the historical backdrop of ailment and related foundational ailment, clinical assessment, dental graphs, finding, examinations, treatment done, and notes on ensuing development(s). A dental graph provides data regarding the subtleties of a relative multitude of teeth present in the oral cavity, for example, the teeth present or missing, rebuilding efforts, pathologies such as dental caries, furcation involvement, and periodontal status.

Dental graphs likewise provide data on the entire surfaces of anterior and posterior teeth individually. The dental graphs should be recorded precisely. Any blunder in diagramming might deliver the record as untuneful. Dental records should be saved for approximately 7-10 years. Exact dental records can establish a central point in recognizing an individual and have measurable applications. Guard associations recommend that every case record of treatment performed, dental investigations such as radiographs and dental casts made for analysis of the case, and correspondences be held for a very long time after the fruition of treatment. On account of children, records should be kept up until the patient is at least 25 years of age. Individualised pre-and postoperative orthodontic models should be held forever. In case there are any intermediates, they may be disposed of within 5 years.

The purpose of the Dental Record in Recognizing Obscure People and its advantages for Other Measurable Techniques is that dental records are more accessible than finger impression information bases all over the world. Likewise, distinguishing proof utilizing dental records is less tedious than finger impression or DNA-based IDs.

### Dental Charting

An indispensable tool to assist dental experts in distinguishing and outlining these dental abnormalities, an advanced “Chartbook of Dental Inconsistencies” was made utilizing a site building stage on July 31$^{st}$, 2019. The site gives succinct portrayals of restricted dental oddities on many perpetual teeth. The map book can go about as an examination material for dental understudies, an agenda for dental attendants, hygienists, or collaborators, or potentially as reference material for rehearsing dental specialists with regard to graphing dental abnormalities. The digital atlas can be obtained at http://www.theatlasofdentalanomalies.com/

# CHAPTER 4

# Dental Pulp: A Charismatic Role in DNA Fingerprinting

**Shivani Bansal**[1,*] and **Archana Gaikwad**[1]

[1] *Department of Oral Pathology, Nair Hospital Dental College, Mumbai Central, Maharashtra, India*

**Abstract:** The current advances in DNA fingerprinting have significantly revolutionized forensic odontology. DNA, the language of life, manages all cell activities, which gives unimaginable data related to health and disease. Although the medical and dental records of the patient are the gold standard in forensic identification, DNA fingerprinting has plodded along with conventional fingerprints and blooming in forensic science. Following natural mass calamities or non-natural catastrophes, when the other means of traditional identification become impossible, teeth serve as a rich source of DNA due to their resistance to physical and chemical insults. The recent techniques in the isolation of DNA, the ways of running a DNA fingerprint and their significance in identifying the truth from untruth are highlighted in the chapter.

**Keywords:** Dental pulp, DNA, DNA fingerprinting, DNA extraction, DNA analysis, Forensic dentistry, Human identification, Teeth.

## INTRODUCTION

Human identification is one of the major fields of study and research in forensic science, as it addresses the human body and aims to establish human identity. The revolution caused in 1953 by Watson and Crick, who discovered the double-helix structure of DNA, which is responsible for the genetic inheritance of human beings, led to important changes in nearly all fields of science [1].

In today's modern era, DNA analysis methods find their application in crime scene investigations, in the case of immigration eligibility, in parentage testing and in medical research. It is considered an indispensable science for achieving justice [2].

[*] **Corresponding author Shivani Bansal:** Department of Oral Pathology, Nair Hospital Dental College, Mumbai Central, Maharashtra, India; E-mail: bshivani2000@gmail.com

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DNA fingerprinting (DNA profiling/DNA typing), invented in 1985 by Professor Sir Alec Jeffreys, refers to the approach of determining an individual's DNA characteristics [3]. The nuclear DNA/genomic DNA present in the cell nucleus of the body contains genetic material from both the father and mother, while the mitochondria contain mitochondrial DNA derived from maternal genes [4].

Several biological materials may be employed for the isolation of DNA and accomplishment of laboratory tests for human identification, including bone tissue, hair bulb, biopsy sample, saliva, blood and other body tissues. It is possible to obtain DNA from virtually all human body tissues, only with variations in the quantity and quality of the DNA extracted from each tissue [5]. Teeth can withstand various insults, such as trauma, immersion, decomposition and mutilation, which make them an important source for extracting DNA [6]. Teeth do not undergo postmortem degradation and extreme changes in temperature and pressure, unlike other human tissues [7]. In comparison to the bone, teeth have high resistance to contamination because of their naturally hard mineral composition and low porosity. Hence, teeth are skeletal structures that better preserve DNA over time [8].

## HISTORIC REVIEW

In 1869, a Swiss researcher, Friedrich Miescher, discovered DNA as a distinct molecule while he was studying lymphoid cells and their composition. The structure of DNA was discovered by James Watson and Francis Crick in 1953 [9].

Until the 1980s, the science of identification of criminal cases was based only on serological analyses of protein polymorphisms, blood groups and some genetic markers. Forensic examination of biological samples started at the beginning of the twentieth century by application of the ABO blood group system in evidence related to crimes or human identification [5].

In 1985, Karry Mullis invented polymerase chain reaction (PCR) and has revolutionized molecular biology. It is the most widely used method for making exponential copies of specific DNA sections from a very small DNA sample and has become an essential tool in diagnostic medicine and scientific research. In 1991, Schwartz *et al*. conducted a study and isolated high molecular weight (HMW) DNA from teeth subjected to varying environmental conditions [12].

Swe *et al*. nd Sweet were the first to use DNA isolated from an unerupted and preserved third molar to identify a burned victim [13]. Since then, teeth have proven to be a potent source of many DNA studies in the field of forensic science.

## MOLECULAR ANATOMY OF DNA

The human genome contains 23 pairs of chromosomes consisting of long and fragile DNA molecules wrapped around histone proteins [1]. DNA has a double-helix structure consisting of a sequence of nucleotides differentiated by 4 bases (adenine, cytosine, guanine and thymine) [4]. The two DNA strands are held together by complementary binding, or hydrogen bonding, between adenine and thymine, guanine, and cytosine. Therefore, the strand in the 5-3'direction is the mirror reflection or "complementary" to the 3- 5'strand [14] (Fig. **1**).

The size and organization of the chromosomal DNA molecule are the basis for the enormous informational complexity of the human genome. There are 3 $x10^9$ paired nucleotides or base pairs (bp) in each cell [15]. DNA is condensed and packaged with histone proteins to fit into the nucleus of the cell [16]. Metaphase chromosomes are the only visible form of DNA. It is important to understand the structure and alteration of DNA to apply in basic and clinical forensic science [17].


**Fig. (1).** Double helix DNA structure. a-Sugar phosphate backbone b-Base pair, 3'- 3 prime end, 5'- 5 prime end.

# CHAPTER 5

# Dentures: A hope for Disaster Victim Identification

**Emilio Nuzzolese**[1,*]

[1] *Department of Sciences of Public Health and Pediatrics, University of Turin, Turin, Italy*

**Abstract:** All dental data offer information for a timely, cheap, and effective human identification process. Dental autopsy and dental data-analysis can be pivotal in disaster victim identification to such an extent that failure to employ odontologists can reduce additional findings and delays in the DVI process. Partial and full dentures found-alongside the remains can offer information on the dental history, the material employed, dietary and sociocultural information, and when jaws are fragmented or disarticulated, offer a possible technical response on the number of individuals involved. Particularly relevant are the printed palatal rugae in the palatal surface of the upper denture. An individual wearing one or two full dentures is obviously totally edentulous. In the upper, lower, or both jaws, family members living together will surely be aware of this circumstance. In the interview for the collection of antemortem dental data, they were asked specifically about any dental prosthetics or orthotics worn or used by the deceased. Greater emphasis should be placed on recording and archiving patients' oral health data, including material specifications of fixed and removable prosthetics, encouraging the use of digital and electronic oral health records and international collaboration in the DVIscenario, and employing teleconsultation tools.

**Keywords:** Dentures, Dental prosthetic, Dental autopsy, DVI, Forensic odontology, Identification, Mass disaster.

## INTRODUCTION

Disaster victim identification (DVI) can be divided into five phases of activity: recovery of human remains on the disaster site, a collection of postmortem data in the mortuary or temporary morgue, a collection of ante-mortem data from relatives and next-of-kin, reconciliation of postmortem and ante-mortem data and debrief [1, 2]. Visual recognition through the involvement of relatives or next of kin is not recommended and can lead to misidentifications [3, 4]. Depending on the size of the disaster, safety issues, number of victims and facilities available, a hospital could be used to host the postmortem data collection of human remains.

[*] **Corresponding author Emilio Nuzzolese:** Department of Sciences of Public Health and Pediatrics, University of Turin, Turin, Italy; E-mail: emilio.nuzzolese@unito.it

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Still, to avoid interfering with routine medical work, a temporary morgue is usually set up in a dedicated and often isolated area where DVI team members will process human remains.

Disaster victim identification (DVI) encompasses the collection of any evidence on human remains with potential identifying features. human identification process can be very challenging depending on the status and fragmentation of the human remains. Unidentified human remains are processed by experts in several fields of forensic sciences who are recruited in DVI teams, along with police personnel. The forensic specialties include pathology, anthropology, odontology, biology, and ridgeology [5]. Teeth, dental treatment and prosthetics are extremely resistant to heat, chemical, and postmortem degradation and keep identifying features that are paramount in the DVI process. Dental data collection and forensic odontological comparison are one of three primary identifiers, as they can lead to a positive identification alone or be combined with secondary identifiers [6]. For this reason, forensic odontologists can play a key role in DVI in two ways: in the initial reconstructive identification of human remains, dental autopsies and dental radiology allow the assessment of a preliminary biological profile report, which narrows the search for missing persons; in the comparative identification phase, when ante-mortem data of the victims become available, odontologists will use dental records and dental evidence to perform a comparison and achieve a positive identification.

Dental autopsy involves the inspection of jaws and teeth, the recording of the odontogram with all identifying dental data, treatments and features, and radiological imaging depending on the facilities available (generally, periapical radiographs using a portable X-Ray device). The odontogram used for forensic dental identification must not be confused with the oral health patient record, which usually records the dental formula. Infact, dental findings and evidence with the purpose of human identification are not limited to restored, missing, or present teeth but include oral pathologies, periodontal conditions, crown morphology, teeth pigmentations, teeth positions, endodontic treatments, dental implants, fixed prosthetics, and full or partial dentures [7 - 9]. A complete dental autopsy must also be performed on unidentified victims who are totally edentulous [10], as this could reveal pathologies and previous surgical treatments. Radiographs of jaws must never be forgotten during a dental autopsy. The postmortem work of forensic odontologists is, in other words, description, analysis, and interpretation of dental evidence, paying careful attention to details to supplement the biological profile with biocultural odontological information and dental history of the deceased.

## DENTURES AND POSTMORTEM DATA

Among the means used for the study of data collected during a dental autopsy, partial or full dentures found alongside the remains can offer information on the dental history, the material employed, dietary and sociocultural information, and when jaws are fragmented or disarticulated offer a possible technical response on the number of individuals involved (Fig. **1**). Particularly relevant for the identification process are the printed palatal rugae in the palatal surface of the upperdenture [11].

**Fig. (1).** Two partial dentures positioned on the upper and lower jaw, confirming through the intercuspation and occlusion the belonging to a single individual.

Partial dentures are usually manufactured using a metal frame with several anchoring elements to natural teeth or to fixed crowns. Partial or full dentures could be found broken on the disaster site. The clinical experience of a forensic odontologist enables repair using cyano-acrylic glue (Figs. **2** and **3**). Clamps of the metallic frames or placed into acrylic partial dentures allow a unique fit on one specific mouth. This can contribute to the reconstruction of the dental formula and to the identification once dental records of the victims are collected. When no information is available, the metal frame and/or the acrylic of the partial denture could also be analysed to assess the chemical composition and gather information on the possible geographical origin as well as contribute to discrimination among different manufacturers and local dental technicians' laboratories [12 and 13].

Dentures are also tailored for each patient. The upper denture with acrylic palate internally reproduces the individual's pattern of palatal rugae, which can be of forensic value in the identification of edentulous unidentified human remains [10] through rugoscopy. This suggests that odontologists, in addition to photographs (Figs. **4** and **5**), should always take impressions with alginate of the upper jaw of the unidentified cadaver when oral mucosa is still present. The need for keeping a plaster model is suggested, especially in partially or totally edentulous deceased individuals, even when no mobile prosthetics are found in the mouth (Fig. **6**).

# CHAPTER 6

# Oral Autobiography: A New Paradigm for Identification

**Rohan Ashok Gawali**[1,*] and **Shaivya Mishra**[2]

[1] *Department of Forensic Odontology, Maulana Azad Institute of Dental Sciences, MAMC Complex, B.S. Zafar Marg, New Delhi, India*

[2] *Forensic Odontologist, Lucknow, Uttar Pradesh, India*

**Abstract:** Identity is central to an individual's personality and his/her existence. The face is synonymous with identity. Identity needs to be proven in daily life transactions for security reasons. Identity (be it of the victim or the suspect) is also a paramount investigative question for which the answer is not straightforward. The orofacial region is packed with individualistic information ready to be explored in different areas, such as disasters, crimes, civil matters, and access to property (biometrics). The orofacial structures offer diverse solutions to the common questions of identity. The choice of a specific technique is governed by the circumstances that call for identification and the advantages-disadvantages of the technique.

**Keywords:** Cheiloscopy, Dental identification, Dental profiling, DNA, Dental calculus, Denture marking, Otoscopy, Paranasal sinus, Rugoscopy, Saliva, Selfie identification, Smile line, Voice analysis.

## INTRODUCTION

Identity is defined by Oxford learners' dictionary [1] as 'the characteristics, feelings, or beliefs that distinguish people from others' and 'who or what someone or something is'. Identity addresses the uniqueness of a person. Identity, albeit underrated, is the invisible thread that connects the communities and underlies all the day-to-day activities and transactions we make. It is difficult to imagine a day or a situation without a correct identity. Our mind works subconsciously to identify the people we come across daily. It is no wonder that a face is the center stage of identity.

[*] **Corresponding author Rohan Ashok Gawali:** Department of Forensic Odontology, Maulana Azad Institute of Dental Sciences, MAMC Complex, B.S. Zafar Marg, New Delhi, India; E-mail: dr.rohangawali@gmail.com

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Face and its various features allow the brain not only to identify an individual but also to assess their thinking and feelings. These features collectively form a face, *viz.* eyes, nose, ears, lips, hair, and their association with each other, determining the uniqueness of an individual. The process of identification occurs subconsciously in the fusiform face area located in the temporal cortex [2]. The facial features are fairly constant over the long term, and the brain adapts well to the slow, age-related changes in the face. Generally, our brain performs the task of identification exceptionally well. However, this process is challenged in situations of concealed identity and after the death of an individual since the features of the face (which may be distorted) do not allow the brain to assign any identity.

Due to the complex nature of the disasters and conscious efforts by the perpetrators to conceal their crimes, the victims of disasters and crime are often rendered visually unidentifiable. This poses a unique challenge in the process of investigation. Additionally, the identification of a criminal from the tiny, biologically unique evidence left at the crime scene is a routine investigative requirement. The identification of a living person also assumes extraordinary importance in matters of impersonation, espionage and surveillance. Identification is also relevant in the context of historical figures [3], archaeological sites [4] and mass graves [5]. Table **1** describes the various scenarios and the objectives of identification.

**Table 1. The need for identification.**

| Scenario | Reason for Identification |
|---|---|
| Disaster | **Closure:** To arrive at the closure of the mourning process.<br>**Humanitarian:** The rights of the dead extend to correct identification.<br>**Forensic:** To issue a death certificate to the correct person.<br>**Financial:** To execute the will, settle insurance claims, and release other death benefits.<br>**Cultural:** To perform the last rituals as per the religious beliefs.<br>**Other:** Remarriage of a spouse, *etc*. |
| Unnatural deaths, including homicide, suicide and accidental deaths | **Forensic:** Imperative step as the investigative process begins with positive identification. |
| Mass graves | **Forensic:** To detect genocide, crimes against humanity, war crimes<br>**Humanitarian:** Burial in mass graves is against the rights of the dead. Burial in identified graves honours the rights of the dead. |
| Archaeological excavation site | **Historical:** To uncover the mysteries of past. |
| High-security facilities/locations such as airports, *etc*. | **Access control:** To allow or deny access to restricted areas and properties. |
| Surveillance | **Forensic:** To detect impersonation and espionage. |

*(Table 1) cont.....*

| Scenario | Reason for Identification |
|---|---|
| Routine activities such as appearing for the examination, marking attendance, *etc*. | **Administration:** To detect impersonation and prevent cheating. |
| Government-issued documents | **Civil rights:** To ensure the correct person executes any exclusive right such as voting, driving, *etc*. |

Identification techniques are generally comparative in nature and aim to find a match between the two sets of data, *viz.* the known or K and the questioned or Q. Certain techniques are exclusively comparative in nature, *viz.* fingerprints, lip prints, ear prints and rugae pattern (although research to associate these patterns with identifying information such as sex, habits, *etc*. is underway). However, certain techniques allow more than just comparison. Techniques or parameters such as dentition, DNA, saliva, *etc*., give a lot more information even if the K (missing person or suspect) data is absent from comparing. The insight into the identity of the Q sample by the information obtained by profiling allows the investigators to narrow down the possibilities and reach a few K profiles to finally arrive at comparative identification by some or the other technique. Fig. (**1**) depicts the identification/attribution process.

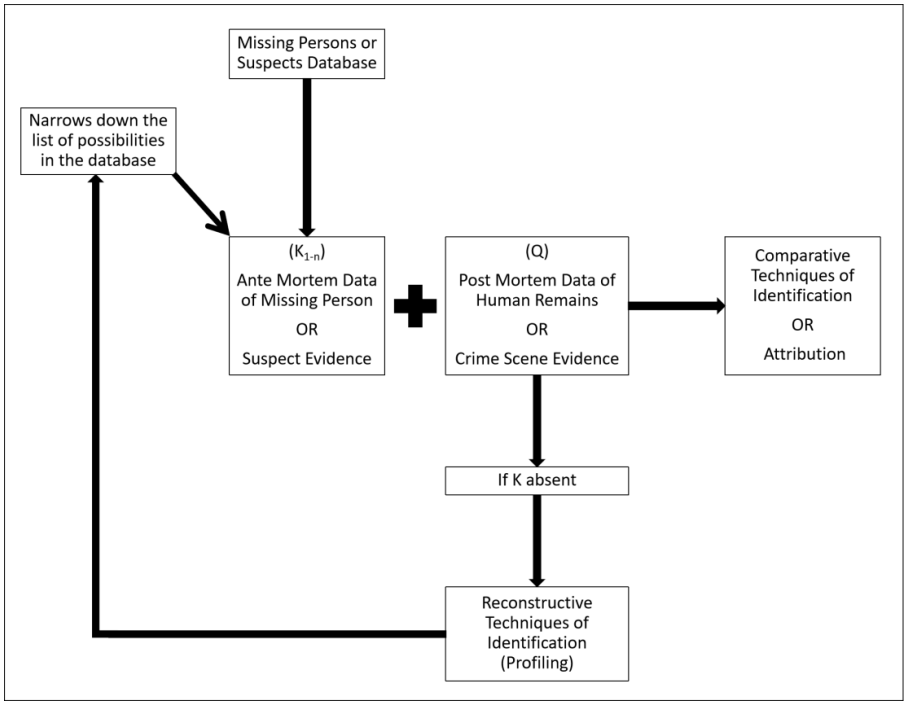


**Fig. (1).** The identification/attribution process.

# CHAPTER 7

# Bite Marks: A Pragmatic Approach in Identification

**Jayant Kumar Gahlot**[1,*] and **Hemant Sawhney**[1]

[1] *Department of Oral Medicine & Radiology, School of Dental Sciences, Sharda University, Gautam Budh Nagar, Greater Noida, Uttar Pradesh, India*

**Abstract:** Teeth can be used as a weapon when an individual tries to harm another, or can be used by the victim attempting to protect themselves from an attacker. Bite marks are a clinical representation of intraoral structures (tooth and other soft tissues) on any object by an animal or human. Bite mark assessment can play a critical role in the identification of persons in forensic-related cases. Bite marks are usually found in various crime scenes, such as sexual assault, rape, murder, cases of child abuse and during sports activities. This chapter reviews the basics of the bite mark pattern, characteristics, and significance of bite marks in forensic science to solve crimes.

**Keywords:** Bite marks, Characteristics, Dental impression, Forensic odontology, Forensic science, Forensic dentistry.

## INTRODUCTION

Someone very well gave the idiom, “A person can very well lie through their teeth”; however, the teeth can’t lie for that person. Evaluation of bite marks is based on those two mouths not being the same [1]. Bite marks are subsequently taken as a good opportunity for fingerprinting and DNA identity in forensic observations. Forensic odontology is a branch of forensic medicine, which is based on the habit of justice offered with dental evidence that has to be present in the justice courts [2]. The oldest method of investigation based on forensic science was bite marks. A bite mark is a form of patterned injury, which is the physical result of a biting action applied to skin or other material such as food or other inanimate substrates [2]. Biting is used by human beings as both offence and defense. A forensic odontologist collects documents, evaluates and compares the

* **Corresponding author Jayant Kumar Gahlot:** Department of Oral Medicine & Radiology, School of Dental Sciences, Sharda University, Gautam Budh Nagar, Greater Noida, Uttar Pradesh, India;
E-mail: jayant.kumar@sharda.ac.in

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bite mark evidence. Bite marks can be determined genuinely on any area of the human body. The fossa, neck, forearm, limbs, shoulder, nose, ear, breast, buttocks, waist, and female genitals are the most common sites.

Bite marks may be found in various offenses, such as sexual/physical assault, rape or attempt to rape, murder and child abuse. Mac Donald, in 1974, described bite marks as 'a mark caused by the teeth either alone or together with other mouth parts' [3].

## CLASSIFICATIONS OF BITE MARKS

Certain classification systems have been suggested for bite marks.

1: According to Cameron and Sims:

Based on the type of agent and materials exhibited it.

**Agent:** Human and Non-human (Animal)

**Materials:** Human skin, body, foodstuff and other materials [4].

2. Mac Donald's Classification:

This classification is based on the etiology of bite marks.

**Tooth Pressure Marks**: Marks produced by the application of tooth pressure. Most commonly produced by the incisal surface of anterior teeth (Fig. **1**).

**Fig. (1).** Rectangular incisal surface of anterior teeth on skin.

**Tongue Pressure Marks**: Tongue pressure on palatal surfaces of the teeth, cingula, or palatal rugae causes distortion of marks. These marks are due to the suckling action of the tongue.

**Tooth scrap marks**: Marks formed by the friction and scraping of teeth.

3. According to Webster's:

This is based on the penetration depth of teeth on the food materials.

**Type 1**: Fractured food item with less penetration depth. For example, hard chocolate (Fig. **2**).

**Fig. (2).** Bite mark on chocolate.

**Type 2**: Fractured food items with a remarkable depth of penetration. For example, marks on fruits [4] (Fig. **3**).

**Fig. (3).** Considerable depth of bite marks on apples.

# SUBJECT INDEX

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## Anshu Nanda

Dr Anshu Nanda is a dedicated academician and has worked as an Assistant Professor (Clinical Research) and Deputy Controller of Examinations at the School of Allied Health Sciences, Sharda University, Greater Noida, India, for more than a decade. Dr Nanda completed her Bachelor of Dental Surgery from M.J.P Rohilkhand University, Bareilly, India and Masters from Manav Bharti University, Solan, India. She served as a Program Developer and Coordinator for various academic programs, namely, Master in Clinical Research, Master in Basic Medical Subjects, Bachelor in Cardiovascular Technology, Diploma in Clinical Medical Practice, Diploma in Operation Theatre Technology, etc. Her research interests include Forensic Dentistry, Pharmacovigilance, Ethical Clinical Research, Recent Advances in Hospital Management, etc. Her scope of work is multi and interdisciplinary health and ethical areas leading to research publications in journals of repute. Apart from research publications, she also has copyrights and books to her credit. She has served as an Invited speaker and session chair for many national and international conferences. Furthermore, she is the recipient of an honored fellowship FSIESRP from the Society of Innovative Educationalist and Scientific Research Professional, Malaysia.

## Jaskaran Singh

Dr Jaskaran Singh is the Dean of Research and Head of the Forensic Science Department at the Geeta University of Panipat, India. Dr Singh is an INSPIRE fellowship holder from DST, Ministry of Science and Technology, Govt. of India. He is a Gold Medalist in his Post Graduate Program. His research interests focus on the area of emerging fields of forensic sciences and medicine, ranging from theory to practical implementation. He has conglomerated with researchers in the other disciplines of allied and health sciences. He believes in the Multi and Trans-disciplinary approach of extensive research leading to several Patents and Copyrights. He has served as a Key and Invited speaker for many National and International Conferences. Furthermore, Dr. Singh received Honorary Professorship from ISPTEC, Angola.