



Clinical Implications of Dental Injury Analysis in Forensic Odontology: A Review Article

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Received: February 16, 2024; Accepted: August 31, 2024; Published online: September 13, 2024

Abstract: Dental trauma is a common occurrence in forensic investigations and may provide important clues about the amount of damages and when they occurred, both of which are vital in court cases. Forensic pathologists and dentists work hand in hand to assess and diagnose oral injuries accurately, which is crucial for those who are alive and those who have passed away. In order to guarantee accurate forensic results, the need of standardizing procedures used in dental trauma analysis, such as clinical and radiographic tests, and the need of thorough documentation are very crucial. The many kinds of dental injuries, their causes, and how forensic applications help to identify victims and piece together are very important to be discussed. This article provides a comprehensive overview of the importance of dental injury analysis, procedures and their implications in various cases within the scope of forensic odontology for efficient practice, highlighting the vital role of forensic odontology in medico-legal investigations via an in-depth review of the existing literature.

Keywords: dental trauma; forensic odontologist; clinical examination; radiographic assessment; legal context

Introduction

Dental injuries resulting from physical trauma are often seen in the area of forensic science. Their occurrence varies according on characteristics such as the age, gender, place of origin, and socioeconomic position of the victims.¹ The frequency of dental trauma is greatest among school-age children, however, it starts to grow from the age of one when children begin to walk for the first time.² The prevalence of these injuries is rising due to the growing number of individuals engaging in contact sports.^{3,4} It is not known how many people really get traumatic dental injuries, despite the fact that they do occur with a reasonable level of frequency. This is due to the fact that the person who has been traumatized does not usually seek out the specialized medical treatment needed. On the other hand, there are certain instances of acute oral damage that are not detected because they do not exhibit any signs, such as subjective or objective symptoms.⁵

Mechanical factors induce dental trauma most often followed by physical and chemical agents. Dental injuries may be caused by trauma, compression, falls, or iatrogenic factors. The central incisors, located in the anterior maxillary area, are more vulnerable to direct injuries from impacts. Indirect injuries may occur when the mandible touches the upper arch. Coronal fractures in the posterior dental arch and coronal-radicular fracture, condyles, and symphysis may ensue.⁶ Dental trauma may be produced by misalignment, protrusion, degeneration, decay, restorations, crown-and-root restorations, long-term gum disease, and seizures. Teeth injuries may harm the tooth's hard structure, pulp cavity, periodontal structures, or soft tissues, leading to tooth loss. Endodontic therapy may cause vertical fractures. These fractures may be produced by dental hard tissue loss, enamel degradation, and iatrogenic causes.³ After a thorough investigation of stressed teeth, developmental abnormalities were found in the permanent teeth that followed the primary teeth. After the most major event, the teeth were severely damaged.⁷

Identification of traumatic dental lesions in corpses has great relevance in forensic practice. Analysis of dental injuries is important in the forensic aspect because this analysis can be one of the common threads in case identification. The influence of dental injury analysis can be implied in living and deceased victims, such as identification of estimated age, identification of signs of abuse in the orofacial area, such as fractures, lacerations, and bruises, and postmortem identification by comparing antemortem and postmortem dental records in the form of bite mark analysis.

Classification of traumatic dental injuries

Andreasen and Andreasen describe traumatic dental injuries using a WHO-recommended approach. The WHO's classification of dental injuries is as follows (Figure 1): 1) damage to hard tooth tissue and pulp; 2) damage to hard tooth tissue, pulp, and alveolar bone; and 3) damage to the periodontal tissue. Damage to hard tooth tissue and pulp consists of crown fracture (enamel infraction), an imperfect fracture in the enamel without losing the tooth structure in a horizontal or vertical direction; uncomplicated crown fracture, a fracture that only affects the enamel layer; uncomplicated crown fracture, which is a fracture in the tooth crown that only affects the enamel and dentin without involving the pulp; and complicated crown fracture that affects the enamel, dentin, and pulp.⁸

Damage to hard tooth tissue, pulp, and alveolar bone consists of crown-root fracture, which is a fracture that affects the enamel, dentin, and cementum. Crown-root fractures involving tissue are also called complicated crown-root fractures, and crown-root fractures that do not include pulp tissue are called uncomplicated crown-root fractures; root fractures, namely fractures that affect dentin, cementum, and pulp without involving the enamel layer; tooth socket wall fractures, namely alveolar bone fractures involving the labial or lingual socket wall, limited by the facial or lingual part of the socket wall; alveolar process fractures, namely fractures that affect the alveolar process with or without involving the alveolar socket of the tooth; and mandibular or maxillary corpus fractures namely fractures in the mandibular or maxillary corpus involving the alveolar process, with or without involving the tooth socket.⁸

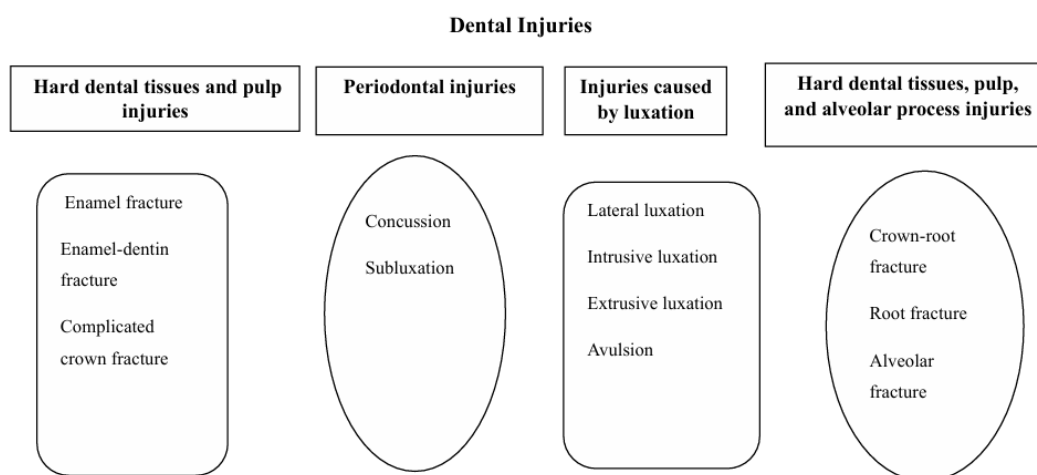


Figure 1. Classification of types of injuries based on the area and cause of injury. Abbott, 2022⁸

Damage to the periodontal tissue consists of concussion, a trauma that affects the supporting tissues of the teeth which causes the teeth to be more sensitive to pressure and percussion without any loosening or change in position of the teeth; subluxation, which is tooth loosening without any change in position of the teeth due to trauma to the supporting tissues of the teeth; extrusion luxation (partial displacement), which is the release of part of the tooth out of its socket. Extrusion causes the crown of the tooth to look longer; luxation, which is a change in the position of the tooth that occurs due to the movement of the tooth towards the labial, palatal, or lateral, this causes damage or fracture to the alveolar socket of the tooth. Tooth trauma that causes lateral luxation causes the crown to move toward the palatal; intrusion luxation, which is the movement of the tooth into the alveolar bone, which can cause damage or fracture of the alveolar socket. Intrusion luxation causes the crown of the tooth to look shorter; and laceration (lost or extrarticulation) which is the movement of the entire tooth out of the socket.⁸

Examination of dento-alveolar cases

Examinations of dento-alveolar cases consist of clinical examination, supporting examination, and assessment of the severity of trauma occurs in forensic practise. General dentists can establish a diagnosis through clinical examination based on the etiology and clinical appearance of living patients. Meanwhile, forensic doctors can handle and perform clinical and supporting examinations on living and dead patients.

Clinical examination

Dento-alveolar trauma is common and can result in tooth displacement, fractures, bone crushing, and soft tissue injuries. Current literature provides guidelines, procedures, and documentation for trauma first aid, patient examination, treatment planning decisions, and informing traumatized patients of their treatment options and prognosis.⁹⁻¹¹ The severity of tooth damage increases when two types of traumas occur simultaneously, such as developed roots, subluxation injuries, or concussions, if their crowns break simultaneously, leading to pulp necrosis and infection.¹²

Supporting examination

Clinicians can use several supporting examinations in analyzing dental injuries. Supporting examinations that can be performed are histological examination, clinical photo examination, and radiographic examination. Histological examination can be performed on deceased victims to identify the patient's age, cause of trauma, or the patient's peri-mortem condition. Clinical photo

examination can be performed on both living and deceased victims. This examination is performed to identify the victim and match it with the clinical examination. Radiographic examination is performed on both living and deceased victims. Clinicians should evaluate patients and determine the necessary two-dimensional radiographs, using standard angulations and projections. Early radiographs are crucial for comparisons during tests. Film holders should ensure uniformity and repeatability. A single periapical radiograph should focus on the upper jaw's central incisors, maxilla's right lateral incisors, and left lateral incisors. A radiation specialist's x-ray is also recommended. Periapical radiographs should match the mandible's centrals. Further radiographs may be needed for mandibular tooth destruction.¹³⁻¹⁵ Cone beam computed tomography (CBCT) can be used to better understand root fractures, crown/root fractures, and lateral luxation. The 3D imaging, if accessible, may be helpful in certain injuries. Before subjecting a patient to ionizing radiations, it is important to determine whether the picture will alter the injury's treatment.¹⁶

Assessment of the severity of trauma occurs in forensic practise

The assessment of the severity of trauma can be done by forensic odontology. The duration of medical treatment for a trauma victim's recovery is determined by factors such as the anatomic and functional effects of the injuries, the need for specialized care, and the clinical course of the injury in forensic practice, indicating the total treatment time.¹⁷ The Romanian Criminal Code governs assault and wounding, with Articles 193 and 194 defining offenses. Courts consider traumatic mechanisms and recovery time for victims, with severe punishments for violent criminals. Medical treatment, hospitalization, sick, and complete recovery days are distinct, determined by individual injury severity. Collaboration between forensic pathologists and dentists is crucial for accurate assessment of dental injuries.³ The dentist's professional duty involves conducting an examination, which the forensic pathologist relies on during a criminal investigation. They estimate the patient's recovery time and address other concerns, while thoroughly examining and analyzing all dental records within their expertise.¹⁸ To evaluate the severity of dental trauma in living victims, there are several steps, as follows: 1) Assess the extent of the injuries, documenting them using medical records, photographs, and witness statements; 2) Determine the necessary treatment, considering the impact of delayed or inadequate treatment; 3) Calculate losses and expenses, including medical bills, lost wages, travel, prescription costs, and other related expenses; 4) Assess the psychological impact of the dental injuries, including trauma, anxiety, or depression; 5) Use case law and judicial guidelines to determine appropriate compensation; 6) Consult with dental and medical experts for detailed assessments of the injuries and required treatment; and 7) Negotiate compensation using evidence and expert assessments, considering the long-term impact on the victim's quality of life and overall well-being.¹⁹

Determining the patient's age based on teeth can be done whether the victim is alive or dead. An integral aspect of the identification procedure should include age estimate, a branch of forensic science, particularly in cases when details about the dead are lacking.²⁰ The main way to determine age for younger people is by dental estimation of chronological age, since there are small differences in tooth formation and eruption across individuals. This can be done because there are small differences in tooth formation and eruption between individuals. From around four months after conception until the first few years of adulthood, when all of the permanent teeth have grown in, there is a regular and predictable pattern to the development of the human dentition.²¹ Chronological age analysis of teeth from the sequence of tooth eruption can be determined through radiography examination. Radiography methods assess pulp health by observing mineralization phases, considering root and crown development, eruption stage, and mixed primary and adult teeth. Sensitivity tests measure pulp health by measuring brain activity but may be inaccurate due to temporary neural response or lack of differentiation of A-delta nerve fibers in baby teeth. Pulse oximetry quantifies real blood flow, confirming pulp vitality. Both tests are essential for assessing pulp health and ensuring proper functioning so that the age of the victim can be determined.^{22,23,24,25}

Determination of patient age in adults or deceased victims can use the Gustafson method, which is a tooth analysis of six stages; degree of attrition, amount of secondary dentin, position of gingival attachment, degree of root resorption, transparency of root dentin and thickness of cementum. The Gustafson method can be seen based on histological examination. This method is taken from incisor teeth, with a standard error of ± 4.5 years, but has high accuracy in identifying age.^{22,24,25}

Scale for measuring the severity of traumatic dental injury (TDI) can be done by a forensic odontologist. Trauma involving the dento-alveolar region is a frequent occurrence which can result in the fracture and displacement of teeth, crushing, and/or fracturing of bone, and soft tissue injuries including contusions, abrasions, and lacerations. Available current literature provides protocols, methods, and documentation for the clinical assessment of TDI, trauma first aid, patient examination, factors that affect treatment planning decisions, and the importance of communicating treatment options and prognosis to traumatized patients. The TDIs are utilized in forensics to estimate hospitalization duration for serious injuries, classifying injuries, determining recovery days, and detailing any ramifications, including permanent ones like handicap.²⁶ The TDI guidelines based on International Association of Dental Traumatology (IADT) explain that TDI is carried out by several examinations, such as clinical examination, pulp sensitivity and vitality examination, clinical photo examination, and radiographic examination. In living victims, based on these examinations, clinicians can take treatment measures such as stabilization, repositioning, or endodontic treatment. In deceased victims, this can be an analysis of the cause of a case.

Assessing Victim's Dental Trauma

Assessing victim's dental trauma can be done by a forensic odontologist. The identification of traumatic dental lesions on both living and dead victims is of great relevance within the area of forensic practice. This is because it plays a critical role in determining both the mode of trauma and the cause of death.^{27,28} In living victims, clinicians can determine the type of trauma that occurred to the victim, the cause of the trauma, and the time of the trauma. Trauma that can occur in living victims is physical abuse, non-abusive dental trauma, child abuse, rape, bitemarks in some cases. In deceased victims, clinicians can determine the time of trauma, the mechanism of trauma, and the victim's skeletal analysis. Concerning timing of trauma, an accurate trauma analysis is essential to ascertain whether injuries are related to the individual's life or the circumstances surrounding their death. Antemortem trauma can indicate past injuries, while perimortem trauma may relate to the cause of death. Postmortem damage, on the other hand, is not associated with the death event. In mechanism of trauma, understanding the biomechanical principles behind the observed trauma can help forensic experts diagnose the type of injury and its potential cause. This involves analyzing the characteristics of the skeletal damage, which can vary based on the type of trauma inflicted. The mechanism of trauma can estimate whether the victim died from sharp objects, blunt objects, high velocity projectile trauma, or thermal trauma. Related to skeletal analysis, the examination of skeletal remains can yield valuable information for coroners or medical examiners, aiding in the determination of the manner and cause of death. Forensic anthropologists and odontologists play a critical role in this analysis, as they can provide insights into the nature of the injuries and their implications for the investigation.^{27,28}

The methodology for analyzing dental injuries has several stages, as follows; 1) Visual examination: observing and documenting the condition of the teeth and associated structures, including the presence of cracks, fractures, or other damage; 2) Imaging: using imaging techniques such as X-rays to obtain a clearer picture of the injuries within the teeth and jaw; 3) Histological analysis: in some cases, analysis of dental tissue can be performed to assess signs of healing or infection.²⁹ The challenge in analyzing dental injuries is that distinguishing between perimortem, and postmortem injuries can be difficult, especially if the damage occurs in teeth that have already undergone decomposition. Therefore, the analysis must be carried out carefully and in the right context to avoid misdiagnosis.³⁰

Role of Forensic Odontologist

A forensic odontologist is involved in every step of identifying deceased victims as well as identifying violence against living victims, to determine the nature of the crime.³¹ Forensic science and the legal system generally agree that teeth may be used for positive identification purposes. A forensic odontology expertise and team-based approach are crucial for successful forensic investigations. They assist law enforcement by analyzing dental evidence in various scenarios, including dental forensic examination, forensic analysis, and dental remains analysis.³²

Dental forensic examination involves assessing and analyzing damage to teeth, jaws, and oral tissues from abuse, assault, mass disasters, and crime-related incidents. Forensic analysis scrutinizes markings to potentially identify the offender, while dental remains analysis helps identify unknown individuals or corpses.³³ Forensic odontologists are professionals who use dental evidence to identify signs of abuse, identify deceased individuals, estimate their age, analyze bite marks, and respond to mass disasters. They identify signs of abuse in the oro-facial region, such as fractures, lacerations, and bruises, and report findings to authorities. They also perform postmortem identification by comparing ante-mortem and post-mortem dental records. Age estimation is crucial, as they can estimate a deceased individual's age based on dental development and eruption patterns. Bite mark analysis helps identify perpetrators of violent crimes by comparing victim's bite marks with suspects' dental structures. They also assist in disaster response efforts, providing expertise in diagnosis, monitoring, referral, decontamination, infection control, surveillance, and notification.¹⁹ Forensic odontology is a crucial method for identifying human remains based on dental trauma. It involves examining teeth to assess the nature and extent of trauma, using unique tooth class characteristics, identifying dental pathology and anomalies, and comparing the recovered evidence with ante-mortem records. The forensic odontologist can also determine the victim's biological profile, such as age, sex, race/ethnicity, occupation, and habits. However, limitations and challenges exist, such as the difficulty in identifying victims without ante-mortem records and the inability to confirm identity in all cases.³⁴

Forensic odontologists identify nameless cadavers, providing families with evidence for court use. This process ensures access to the deceased person's body in time for funerals and provides insight into their death. This helps replace uncertainty with more accurate information, despite potential distress. The identification process ensures that families have access to the deceased person's body, allowing for a more accurate understanding of their death.³⁵

Significance of identification

Dental hard tissues are resistant to decay, fire, and natural disasters, making them often the only remnants after burial. Forensic dentistry has become crucial in medicolegal matters since the late 1890s, focusing on forensic analysis of human remains, legal proceedings concerning professional error, and bite-mark assessment in cases of abuse, particularly child abuse. Human dentition is often compared to a fingerprint due to its unique characteristics, and the physiological variation of teeth and treatment effects are recorded throughout their lifetime.³⁶

Conclusion

Dental injury analysis helps to determine the cause and mechanism of injury, estimate when the injury occurred, pattern of injury, and type and intensity of the trauma. This is important in criminal investigations to match the time of the incident with other evidence. There are several challenges in dental injury analysis, including soft tissue degradation, tooth fragmentation, and limited dental records. Overall, dental injury analysis in forensic odontology is an important tool that helps in the process of forensic identification and criminal investigation. A systematic and detailed approach can provide valuable information to solve forensic cases.

Conflict of Interest

The authors declare no conflict of interest in this study.

Authors' contributions

All authors made equal contributions to the writing of the manuscript.

Acknowledgements

The acknowledgement is extended to Universitas Indonesia for the facilities provided, from the library to collecting data.

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