Review Article

Forensic Identification of Charred Human Remains Using Dental Remnants: A Review of Methods and Temperature Ranges (400-800°C)

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Abstract

Establishing the identity of a person is important in the field of forensic odontology. This field can be helpful in identifying charred corpses in cases involving intense heat. Bones and body tissues can be extremely damaged due to heat, in such cases dental records have become a reliable source of identification. Dental Identification of charred human remains begins with the examination of dental features such as teeth anatomy, morphology, dental implants, oral health, restorations, fillings, dental anomalies and overall dental structure. These features remain resistant to extreme heat and can thus be compared with that of the ante-mortem records. When the postmortem and ante-mortem records match a successful identification is done. Dental features may also be damaged and become less effective for identification when temperatures rise above a particular range. In order to help with the identification of charred human remains, this research intends to give forensic experts a clear understanding of the circumstances in which dental records can be used by examining the effects of extreme temperature within the 400–800°C range. By gaining insights into this particular range and its effects on dental tissues and records gives forensic experts a chance to solve complex cases involving burned corpses.

Key Words: Charred remains, Dental records, forensic odontology, restorations, dental implants

Introduction

Just like fingerprints or snowflakes, there are no two teeth that are alike. Not even identical twins have the same teeth. As teeth are specific to every individual, they are often used as an identifier (Manjunath, 2008)[1]. Burned skeletal remains can result from a variety of incidents, such as train and airplane accidents, suicides, and terrorist acts. These events produce severe damage on human remains. In such cases, forensic experts mostly rely on evidences that are unaffected post charring. Teeth are exceptional in that they can withstand extremely high temperatures.

Dental remains such as teeth are often more resilient to the effects of fire compared to other skeletal remains. Due to the high exposure to

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temperature different aspects of dental remnants are being affected. Teeth might get discolored as a result of exposure to intense heat. A fire's intense heat might result in teeth cracking or breaking. This may be particularly true if there are dental issues that already exist, like cavities or dental restorations that may compromise the tooth structure. Although enamel is very heat-resistant, enamel can be harmed by prolonged exposure to extreme heat. The pulp and dentin of the teeth both contain trace amounts of organic material. When heat is exposed to this organic material the internal structure of the tooth gets affected. Dental restorations can be lost when dental fillings, like amalgam or composite resin, melt or disintegrate under hot temperatures. Heat-induced alterations can cause the surface of teeth to become rough or uneven and can also cause a reduction in the overall size of the teeth.

Forensic experts face severe challenges in personal identification of the extremely charred bodies. Intense heat causes bones and body tissues to be severely damaged making it practically impossible to use traditional identifying techniques. In such cases dental records have become a reliable and strong substitute that offer a special way to confirm positive identifications. The teeth are the least destructible part of the body and may remain more or less intact for many years beyond death. In addition, because of their stability in a biological sense, and because during their formation disease may affect the hard tissues of the teeth themselves, they contain information about the physiological and pathological events in the life of the individual which remain as markers within the hard tissues of the teeth (Whittaker, 1995)[2].

Forensic Dentistry employs ante-mortem dental data and records in order to compare them with other post-mortem information through using the registers within patient's dental file (Frari, 2008)[3],which comprises all documentation regarding to dental treatment, including: anamnesis, treatment planning, executed procedures, complementary examinations, radiographs, photographs, dental casts, prescriptions, receipts, certificates, among others(Silva, 2011)[4].With comparing these records with that of the charred remains it can be used in age estimation, sex determination and dental anomalies that can be helpful in personal identification.

When other techniques, including DNA analysis, are rendered impracticable by prolonged exposure to high temperatures, dental tissues—including teeth and dental fillings—become essential for forensic identification. Even dental structures have their limitations, too. Dental features may also be damaged and become less effective for identification when temperatures rise above this range. In order to help with the identification of charred human remains, this research intends to give forensic experts a clear understanding of the circumstances in which dental records may or cannot be used by examining the effects of extreme temperature within the 400–800°C range.

Methodology

Materials and Methods

AIM FOR RESEARCH

The main aim of this study is to explore methods within which dental records prove to be a reliable means of identifying human remains that have been exposed to temperatures ranging from 400 to 800°C.

DATA COLLECTION

In this review, we meticulously compiled insights from a wide array of scholarly sources to evaluate methods and temperature ranges (400-800°C) used in forensically identifying charred human remains through dental remnants. Our data collection involved reviewing over 50 articles from diverse web resources and books pertinent to the subject.

DISCUSSION

Dental remains such as teeth are often more resilient to the effects of fire compared to other skeletal remains. Due to the high exposure to temperature different aspects of dental remnants are being affected. Teeth might get discolored as a result of exposure to intense heat. An intense heat might result in teeth cracking or breaking if there are already existing dental issues such as cavities or dental restorations. Enamel being heat-resistant, can only be harmed by continuous exposure to extreme heat. The pulp and dentin of the teeth both contain trace amounts of organic material. When heat is exposed to this organic material the internal structure of the tooth gets affected. Dental restorations can be lost when dental fillings, like amalgam or composite resin, melt or disintegrate under hot temperatures. Surface of the teeth will become rough or uneven and reduction in the overall size of the teeth can be observed when teeth is exposed to extreme temperature.

DENTAL PULP:

The dental pulp is the innermost layer of the tooth and it contains blood vessels and nerves that are used for defense, sensitivity, and nourishment. Sex of the individual can be determined based on the morphology of canines. Apart from this method, it can also be determined by using X and Y chromosomes in the cells which are inactive. X chromatin in its inactivated form is present as a mass against the nuclear membrane in females is known as Barr body as it was first named by Barr and Bertem (1949). These Barr bodies are present in 40% of females who are considered as chromatin positive and absent in males who are considered as chromatin negative. Similar to X chromosome, Y chromosome (F bodies) can also be studied for sex determination of males. Both X and Y chromosomes are found to be present during interphase of the cell cycle (Patel, 2020)[5].At 400°C, the root tips of the teeth will show brownish discoloration. The teeth will be brittle and it will be difficult to extract pulp. The amount of pulpal tissue that could be extirpated was also being minimal. Histological analysis of male teeth will show disorganized collagenous matrix with hypocellularity. The few fibroblasts that are present will lack Barr chromatin condensation. The female teeth will show similar features such as hypocellularity and disorganized collagenous stroma, but the fibroblasts will show the presence of peripheral nuclear chromatin condensation. At 600°C, the roots were burnt. At 800°C, the entire tooth will be burnt and the crowns will break away from the roots (Reddy, 2017)[6].

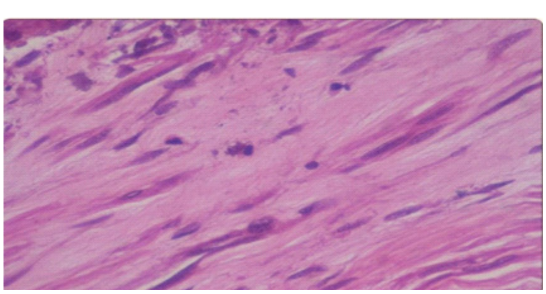


Figure 1: Female pulpal tissue at 4000c shows the presence of Barr chromatin in the nuclear periphery.

Sourced From: (Reddy, 2017)

ENAMEL AND CEMENTUM

Dental enamel is the hardest substance in the human body and serves as the wear-resistant outer layer of the dental crown**.** It forms an insulating barrier that protects the tooth from physical, thermal, and chemical forces that would otherwise be injurious to the vital tissue in the underlying dental pulp (Lacruz, 2017)[7].

Dental cementum is a living tissue that continues to grow throughout life. It is the calcified material that covers the outside of the tooth root, and provides the attachment site for the periodontal ligaments which hold the tooth to the alveolar bone within the socket. It can be used for age estimation by calculating the average age of emergence of the tooth to the number of dark and light line pairs counted (Emily Hammerl, 2012)[8].

a. Enamel- At 400°C, numerous crazing lines can be seen and it will be more pronounced at the level of cementoenamel junction. Crazing pattern and cracks will develop and multiply with the rise in temperature, leading to chequered look of the enamel at 600°C. . At 800°C a few zones with a molten appearance can be noted, which appears shrunken and smaller as the temperature rise (Pol, 2014)[9].

b. Cementum- At 400°C, numerous crazing lines can be seen and it will be more pronounced at the level of cementoenamel junction. At 600°C, crazing pattern and cracks will develop and multiply over cementum with some zones revealing the underlying dentine. Teeth will continue to crack near the cementoenamel junction, leading to a honeycomb appearance at these zones at 800°C (Pol, 2014) [9].

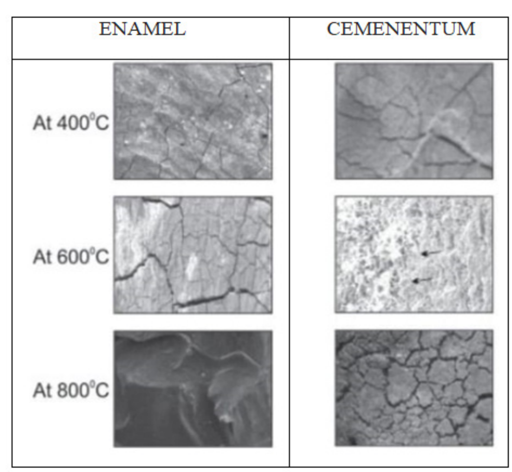


Figure 2: Scanning electron microscope(SEM) analysis of healthy unrestored teeth at magnification x1000.
Sourced from: (Pol, 2014)

DENTINE

Dentine is a layer of material that lies underneath the enamel.Dentin is formed from odontoblasts found in the outermost layer of the dental pulp.The dentin is covered by the enamel at the crown of the tooth, the portion that is visible in the mouth. They extend from the pulp outwards toward the outer enamel at the tooth's crown and the cementum at the tooth's base, all arranged in a radial pattern around the pulp. At 400°C, dentine a will reveal a slightly crazed pattern. At 600°C, will dentine show reduced diameter of dentinal tubules, which is a sign of elevation in temperature. At 800 ° C, debris can be noted covering the dentinal tubules (Pol, 2014)[9].

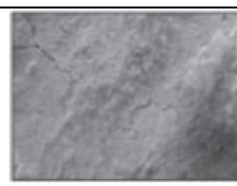
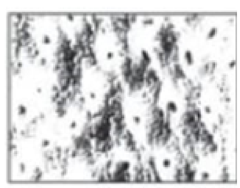
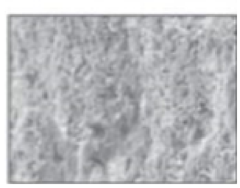
DENTINE	
At 400°C	
At 600°C	
At 800°C	

Figure 3: Scanning electron microscope(SEM) analysis of healthy unrestored teeth at magnification x1000.

Sourced from: (Pol, 2014)

AMELOGLYPHICS

Dental enamel is the highly mineralized tissue in the human body and resists post mortem degradation. Tooth prints are the enamel rod end patterns on tooth surface (Manjunath, 2008)[1]. The tooth prints are unique, exhibiting dissimilarity both between teeth of different individuals and of the same individual. This uniqueness of the tooth print could be used as a valuable tool in forensic science for personal identification (Bharanidharan, 2014)[10]. Tooth prints obtained from each tooth are unique, exhibiting dissimilarity both between teeth of different individuals and of the same individual. Tooth prints can be obtained at temperatures as high as 750° C (Juneja, 2016)[11].

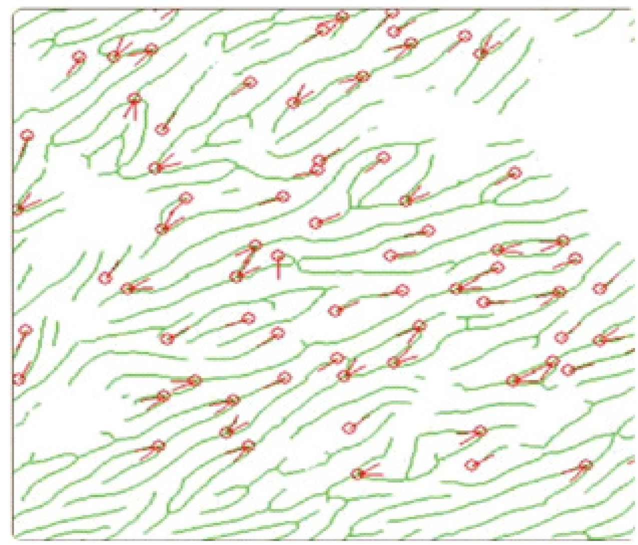


Figure 4: processed image of tooth print minutae points using Verifinger standard SDK version 5.0

Sourced from: (Juneja, 2016)

UNRESTORED TEETH

The term 'unrestored teeth' refers to teeth that have experienced no dental restoration treatments or procedures to replace or to restore a lost or decaying tooth. In cases where indispensable means of identification are lost due to fire or other disasters, partially burnt teeth can give precious information similar as bite mark identification, dental attestation and age identification. Unburned remains can be linked by their unique dental anomalies and characteristics, which aid in the identification of the departed existent. At 400° C, the color of the root will change to steel gray or black while that of the crown remains light brown. Stereomicroscope will show extension of the micro fractures from the root or appearance of new ones on the surface of the crown as well. At 600°C, the crown will be shattered into pieces while the root will be intact, and black in color. Stereo microscopic view shows numerous minute fractures on the root surface. At 800°C a drastic change in color of the root can be seen, which will turn to opaque white. The exposed dentin of the root continues to be dark gray. Stereomicroscope shows vertical cracks on the chalky white root (Bagdey, 2014)[12].

Figure 5: Unrestored tooth at 600o C: macroscopic evaluation shows black discoloration of the whole tooth, a shattered part of the crown and detachment of the enamel.

Sourced from: (Bagdey, 2014)

RESTORED TEETH

Dental restorations such as implants and dental fillings are commonly seen in individuals. Restored teeth are those that have undergone restoration procedures to replace or restore damaged teeth. These are used to maintain teeth structure, appearance and its function. Commonly used restoration materials are amalgam, glass ionomer cement and composite. Identifying these features and type of restoration, location of placement can help identify the deceased

a. Amalgam restorations-At 400°C the crown will show slight retraction of the amalgam filling from the light brown to black color crown and further retraction of the amalgam filling and loss of marginal seal can be seen when viewed under the stereomicroscope. At 600°C,the tooth will shatter, but the filling will be intact. Stereomicroscopic view will show fractures on the filling though the shape of the filling is maintained. At 800 °C the filling remains in place with an intact shape on the portion of the crown that is left. Exposed portion of the dentin is bluish white. Stereomicroscopic view shows cracks on the filling and loss of marginal seal (Bagdey, 2014)[12].

b. Glass ionomer cement restoration- At 400°C the filling will show a change in color to light brown. The root will appear charred due to carbonization. At 600°C, loss of superficial portion of the crown structure will be seen along with a portion of the filling. The root remains charcoal black in color. Stereomicroscope shows deep fracture lines along the length. At 800°C only a portion of the crown structure along with the filling will remain. The filling will remain intact within the crown, which had turned opaque white. Stereomicroscope shows loss of distinction between the anatomical crown and the root (Bagdey, 2014)[12].

c. Composite restorations- At 400°C macroscopic cracks and carbonization can be observed. Higher temperature intervals (>500°C) were not addressed because at this level the fragmentation process starts hampering further observations of the interaction and interface of the dental restorations and the tooth cavity (Conde, 2019)[13].

Temperature	Amalgam	Glass Ionomer Cement	Composite
400°c			
600°c			

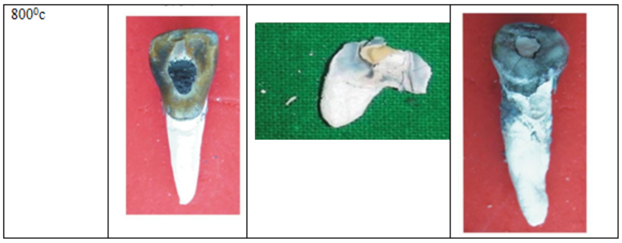


Figure 7: Amalgam restoration and composite restoration when viewed macroscopically. And glass ionomer cement restoration viewed under stereomicroscope (42)

Sourced From: (Bagdey, 2014)(Vázquez, 2012)

ROOT CANAL

When a tooth's pulp—the innermost portion of the tooth—becomes injured or infected, it can be treated and saved via a root canal. An endodontist or dentist performs a root canal by extracting infected or damaged pulp, cleaning and disinfecting the tooth's interior, and then filling and sealing it. Dental records that include information regarding root canals may be a vital piece of evidence in determining the deceased's identity. When the condition of the remains compromises other means of identification, this information can be very helpful in forensic investigations. At 400°Tooth remains intact but voids can be seen in postmortem radiographs. At 600 C, scorched (partially burned) appearance can be seen and radio graphically honey-comb appearance can be seen in obturating material. At 800° C, tooth will become charred and softening of obturating material occurs which will cover the irregularities of root canal if present (Chandra, 2019)[14].

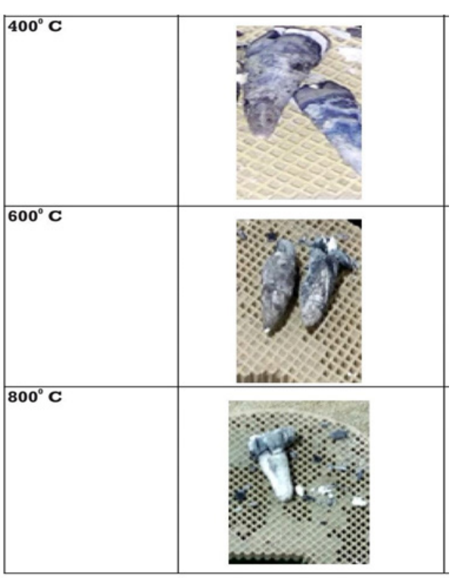


Figure 8: Morphological changes

Sourced From: (Chandra, 2019)

Conclusion

Comparing post-mortem dental records with ante-mortem dental records is a reliable source of information in identifying charred human remains. By doing a step by step examination, such as macroscopic inspection in order to know about the color change, radiographic examination to know about endodontic treatments, restorations and root curvatures and specialized technologies such as Scanning electron microscope(SEM) can be used to know the surface changes in the hard tissues and also aids in the extraction of the necessary data even after intense heat exposure. There is a possibility to identify the person through their teeth patterns even after death using modern software's such as Verifinger standard SDK version 5.0 and it can also be used in order to differentiate between male and female enamel rod patterns. However, it is important to note that there are certain limitations when dental remnants are exposed to temperature greater than 800°C. As teeth being more resistant than other skeletal remains, they can still suffer discoloration, cracking, and destruction when exposed to high heat but restorations, dental anomalies, enamel rod patterns and morphological anatomy of teeth are some features that are unique to individuals and can help in identifying charred human remains. Thus, dental records found to be more reliable source of partial personal identification in charred bodies.

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