

Scorching effects of heat on extracted teeth - A forensic view

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Abstract

Context: Fire investigation is the multidisciplinary basis of the exploration, which involves investigations concerning the origin of fire, its cause as well as the identification of victims. At times, victim identification in fire disasters becomes nearly impossible owing to complete destruction of soft tissues. In such circumstances, teeth may prove to be of value since they are extremely hard. A precise understanding of physical and histological changes in teeth subjected to high temperature can provide valuable clues in fire and crime investigations, when dental evidence remains.

Aim: The main aim and objective of the study was to investigate structural damage in freshly extracted teeth to heating, at different temperatures for a certain length of time in the laboratory. **Settings and Design:** Fifty-four freshly extracted teeth of different age groups had been subjected to different temperatures for a period of 15 minutes in the laboratory furnace. Physical and microscopic findings were correlated to the temperature. **Materials and Methods:** Freshly extracted 54 permanent teeth of different age groups were collected and were subjected to temperatures of 100°C, 300°C, and 600°C. Teeth were then examined for any physical changes such as change in color, texture, or morphology that occurred. Then the teeth were subjected for decalcification following which the tissues were kept for routine processing and were embedded in paraffin wax. Sections of 4 µm thickness were made and stained in hematoxylin and eosin (H and E) to correlate the microscopic findings to the temperature. **Statistical Analysis:** Physical and microscopic findings were correlated to the temperature. **Results:** Microscopic examination revealed definite histological patterns, which were explicitly seen at a particular temperature. The samples showed cracks and charring of the tooth structure with microscopic findings such as widening of dentinal tubules and altered histological staining. **Conclusion:** Evaluation of incinerated dental remains may provide additional forensic investigative avenues in victim identification because of the consistency of morphological changes, the histological patterns at temperatures that are commonly encountered in common domestic fires.

Key words: Forensic fire investigation, heat, histological patterns

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Introduction

Among many investigating procedures, fire investigation poses a challenging aspect as it involves investigations concerning the origin of fire, its cause, and the identification of the victims. In fire accidents, victim identification becomes nearly impossible owing to complete destruction of soft tissues. In such circumstances dental evidences may provide a clue to solve the mystery of victim identification,

since dental structures are the last to get destroyed under extreme conditions, be it temperature, acid, or putrefaction.^[1,2] The reason being that they are extremely hard and are encased both hard and soft tissue casing.^[1]

A precise understanding of physical and histological changes in teeth subjected to high temperature can provide valuable clues in fire and crime investigations, when dental evidence remains.^[3] Few studies have been found in literature regarding the physical and histological changes in teeth subjected to high temperatures. Hence the present study was undertaken to investigate structural damage in freshly extracted teeth to heating, at different temperatures for a certain period of time in the laboratory and; physical and microscopic findings were correlated to the temperature.

Materials and Methods

Freshly extracted 54 permanent teeth were collected and fixed in 10% formalin. After extraction, the individual teeth were debrided with a solution of 3% hydrogen peroxide, rinsed thoroughly with tap water and fixed in 10% formalin. The teeth collected were categorized according to the age of the patient. Group A comprised of teeth from patients aged less than 30 years, group B comprised teeth from patients aged between 30 and 45 years, and group C comprised teeth from patients aged above 45 years. Each group included 18 teeth – 6 anteriors, 6 premolars, and 6 molars. From each group, 2 anteriors, 2 premolars and 2 molars were subjected to a specific temperature.

Exclusion criteria

The teeth that were restored, teeth having a history of endodontic treatment, and grossly decayed teeth, which had very little hard tissue left, were excluded.

A custom made steel tray that could withstand high temperatures with loops around it was used to keep the teeth in the upright position in the furnace [Figure 1]. The tray with teeth in position was placed in the furnace and was subjected to a specified temperature for 15 minutes, followed by gradual cooling to room temperature. The temperatures specified were 100°C, 300°C, and 600°C. The heating process involved gradual heating of teeth to the specified temperature, and holding the temperature for 15 minutes, followed by gradual cooling to room temperature.^[1]

Teeth were then examined for any physical changes that occurred. These changes included change in color, texture, or morphology. After a thorough physical examination, teeth were placed in 10% formal formic acid for decalcification following fixation in 10% formalin. The decalcification fluid was changed every day, and the teeth were observed and documented for any significant physical changes during the process. Sponginess of dentin was considered to be the end-point of decalcification. Following complete and

careful decalcification the tissues were kept for routine processing and were embedded in paraffin wax. Sections of 4 µm thickness were made and stained with hematoxylin and eosin (H and E).

Results

From all the three groups, the enamel caps of the teeth separated out from the underlying supporting dentin along the dentino-enamel junction before enamel could completely decalcify. So enamel was not present for histologic examination. Microscopic evaluation of specimens revealed fragmented tooth sections with identifiable dentin, pulpal remnants, and cementum.

With increase in temperature, the teeth progressively became fragile and difficult to handle. At the temperature of 600°C, teeth from all the three groups were disintegrated completely as soon as they were put in 10% formal formic acid for decalcification. Therefore, processing and sectioning of these teeth could not be carried out. Teeth subjected to lower temperatures, that is, at 100°C and 300°C demonstrated a trend during the decalcification procedure where the teeth from group A decalcified faster when compared with group B.

At 100°C, there were no significant changes in the morphology of the teeth in all the groups. On examination of the H and E stained sections, it was noticed that the stainability of the tissues reduced progressively with increase in temperature. At 100°C dentin and pulp were visualized clearly as they took up eosin stain [Figure 2]. Dentin demonstrated uniform widening of the tubules that could be appreciated better in the cross-section of dentinal tubules [Figure 3]. Dentin showed cohesion of dentinal tubules with splitting between the clusters giving rise to “wicker basket pattern” in few areas [Figure 4].

At 300°C, there were significant changes in the morphology of the teeth in all the groups where the root color changed from cream to brownish black [Figure 5] and the enamel came out like a cap during decalcification process. The soft tissues appeared yellow through dentin and cementum could be visualized clearly as taking up eosin stain. Dentin demonstrated irregular dilatations of tubules, that could be visualized in both longitudinal and cross-sections of dentin giving rise to a pattern referred “vapor bubble pattern” [Figure 6]. Another interesting finding was the presence of uniform splitting along the transverse axis of dentinal tubules. Histological changes perceived at 300°C included brown appearance of dentin and cementum with inability to differentiate between these two structures. At this temperature dentin showed uniform widening of tubules along with “wicker basket pattern” in many areas [Figure 4].



Figure 1: Custom made tray with loops and teeth fitted in the loops in upright position, which were to be placed in furnace

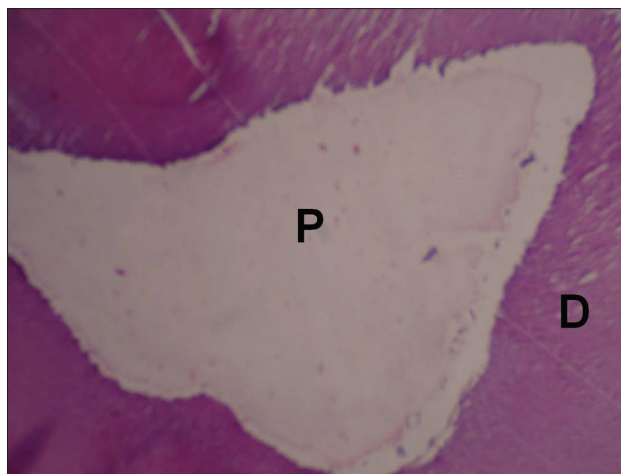


Figure 2: Photomicrograph showing dentin along with pulp tissue (H and E, x4) (D - Dentin; P - Pulp tissue)

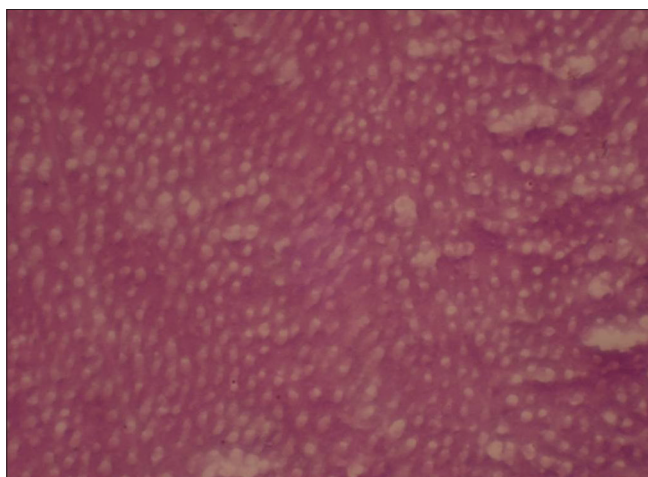


Figure 3: Photomicrograph showing widening of the dentinal tubules (H and E; x10)

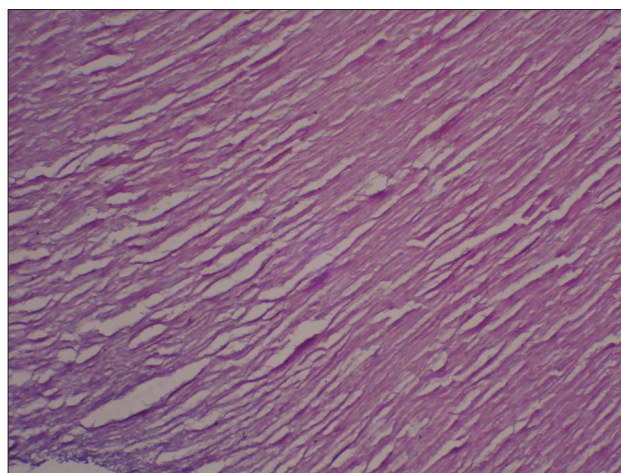


Figure 4: Photomicrograph showing cohesion of dentinal tubules with splitting between the clusters giving rise to "wicker basket pattern" (H and E, x10)



Figure 5: At 300°C temperature the root color changed from creamy yellow to brownish black

Teeth subjected to 600°C temperature appeared charred and were ineffectual for histological study as they disintegrated completely during decalcification [Figure 7].

Discussion

Fire investigation is the multidisciplinary basis of the exploration, which involves investigations concerning the origin of fire, its cause as well as the identification of victims. At times, victim identification in fire disasters becomes nearly impossible owing to complete destruction

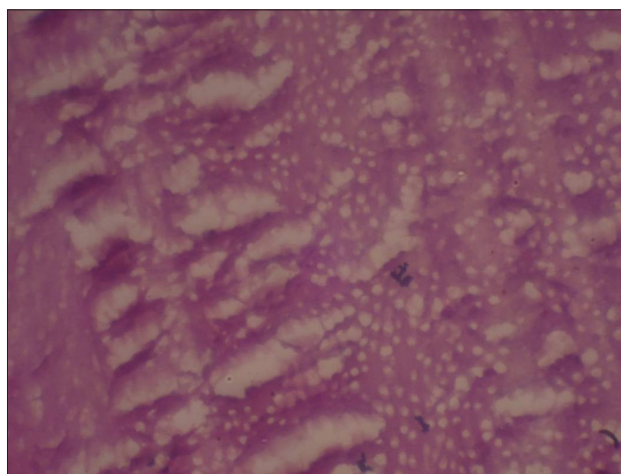


Figure 6: Photomicrograph showing intratubular water vapor bubbles referring to "vapor bubble pattern" (H and E, x10)

of soft tissues. In such circumstances dental remains may prove to be of value since they are extremely hard and resist



Figure 7: (a) At 600°C temperature teeth appeared charred and (b) disintegrated completely during decalcification

temperatures to a certain extent. A precise understanding of physical and histological changes in teeth subjected to high temperature can provide valuable clues in fire and crime investigations, when dental evidence remains.^[1-3]

Historically teeth and dental materials have been studied to aid the identification process of human remains. The study of incinerated teeth, including their histology, is an important part of forensic fire investigation where investigators have mainly used the unique nature of teeth to identify victims. However, morphologic and microscopic tissue alterations caused by incineration may provide useful information about the temperature and duration of exposure to fire. The establishment of forensic odontology is a unique discipline that has been attributed to Dr. Oscar Amoedo (Father of Forensic Odontology) who identified the victims of fire accident in Paris, France in 1897. Controlled laboratory incineration of teeth and their histologic evaluation have the potential to create valuable data for these dental tissues.^[4,5]

Norrlander classified body burns into five categories: (1) Superficial burns; (2) destroyed epidermis areas; (3) destruction of the epidermis, dermis, and necrotic areas in the underlying tissues; (4) total destruction of the skin and deep tissue; and (5) burned remains.^[6] Teeth are considered to be the most indestructible components of the human body and they have the highest resistance to most environmental effects like fire, desiccation, and decomposition, the reason being their structure and composition. Considering the above facts the present study was aimed to investigate structural damage in freshly extracted teeth to heating, at different temperatures for a certain length of time in laboratory.

In the present study, at 100°C, H and E stained sections dentin demonstrated uniform widening of the tubules and showed cohesion of dentinal tubules with splitting between the clusters giving rise to “wicker basket pattern” in few areas. At 300°C, dentin demonstrated irregular dilatations of tubules giving rise to a pattern referred “vapor bubble pattern” along with “wicker basket pattern” in many areas. Teeth subjected to 600°C temperature disintegrated completely during decalcification and were ineffectual for histological study.

Teeth with stand considerable amount of heat due to their highest resistance to most of the environmental effects like fire, desiccation, and decomposition, the reason being their structure and composition where enamel is made up of 96% inorganic, whereas dentin is composed of 76% inorganic, and 20% organic component, mainly type 1 collagen. The collagen in dentin is stabilized by the inorganic content against any thermal denaturation and shrinkage to a certain extent. At higher temperatures, the collagen is destroyed leaving behind inorganic component, which is lost during decalcification. The higher the temperature the more is the destruction of collagen framework and more is the disintegration of tissue in decalcification fluid.^[1,7,8]

In the present study, the widening of dentinal tubules was seen at 100°C temperature that can be attributed due to the heat leading to the formation of intratubular water vapor, which in turn caused widening of dentinal tubules. Similar changes may be seen even at any temperature between 100°C and 300°C. Though temperature below 300°C is not encountered in cases of fire disasters or crimes, the study of teeth heated to this temperature may reveal some interesting observations.

Wicker basket pattern was seen at 100°C in few areas and at 300°C in many areas, which could appear due to loss of inorganic matrix from decalcification, shrinkage due to drying, and incineration and consequent loss of intertubular organic matrix. The presence of uniform splitting along the transverse axis of dentinal tubules at a distance of 15-20 μm was consistent with the distance between incremental lines of Von Ebner seen in dentin. This finding emphasized the fact that incremental lines indeed are the weakest areas in the hard tissues. There was faster decalcification of younger teeth when compared with older teeth in the present study, which could be due to the fact that inorganic content of younger teeth is lesser when compared with older teeth, as inorganic content increases with age.^[7]

Conclusion

Evaluation of incinerated dental remains may provide additional forensic investigative avenues in victim

identification because of the consistency of morphological changes, the histological patterns at temperatures that are commonly encountered in common domestic fires. A larger sample size, more temperatures and variables like caries, restorations, root canal-treated teeth, and implants will provide a more reliable data for practical implications.^[9-12]

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