ORIGINAL RESEARCH

Structural And Shadowgraphic Stories Of Burnt Teeth And An Insight On How To Handle Fragile Forensic Evidence

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ABSTRACT
One of the most resistant structures to heat in body is teeth. With increase in its forensic demand it is becoming an irrefutable evidence for the experts. Along its use in identification of victims, its use in narrating the circumstances of what caused the fire are increasing. **Aim:** The aim of this study was to evaluate the morphologic and radiographic features in teeth exposed high temperatures and how to handle them. **Method:** A total of 48 extracted permanent teeth were exposed to heat in digital furnace at five different temperatures (100, 300, 500, 700, 800 and 900°C). Before and after each exposure macroscopic and radiographic appearances were evaluated and the differences were recorded. **Results:** The colour changes noted were typical light yellow colour, yellowish brown, black, greyish brown, bluish grey and neutral white. Radiographic evaluation revealed intact teeth at 100°C and 300ºC, fissures at 500ºC along with separation of enamel and dentin with fractures running in enamel and dentin at 700, 800 and 900ºC with longitudinal and transverse cracks in root observed at 900°C. **Conclusion:** Macroscopic alterations occurring in teeth due to high temperatures may provide useful information about conditions at time of fire and based on colour changes how to handle fragile dental evidence.
Keywords: Teeth; Forensic odontology; Temperature; Identification; Radiographs.

INTRODUCTION

The interpretation of burnt human cadavers from airline accidents, automobile accidents, bombings, or wrongful cremation is an uphill task.(1) Fire one of the most common cause of deaths involving complete destruction of the evidence resulting in insufficient proof on how things would have gone wrong. Importance of evidence collection one can assume from famous cases all around the globe. Fire can be involved in homicides, suicides(2), and accidental death, with different results on human remains(3) and can be used in attempts to destroy forensic evidence in criminal cases.(4) At these high temperatures one cannot expect charred soft tissues to be of any value as forensic evidence. So, hard tissues of our body becomes depending constants to act as an evidence and among these two that is bone and teeth, teeth are of special importance as these often survive severe fires because of their highly resistant composition and also because they are protected by the soft and hard tissues (maxilla and mandible) of the face.(4-8)

Teeth being the hardest structure of the human body when exposed to thermal stress can throw light not only on the identification of the individuals but also on some circumstances of the fire.(9) Alterations in the external appearance of burnt teeth can provide details about their fragility and recovery, trauma history, structural changes, DNA degradation and on the temperature to which they were exposed.(10) In this background the study was undertaken to analyse the changes in teeth at various temperatures.

The aim of this study was to evaluate the gross morphological change in teeth subjected to specific temperatures (100, 300, 500, 700, 800 and 900°C) for specific duration and with an attempt to focus on evidence collection of such teeth. The study also aims to evaluate and compare the radiographic features of teeth exposed to high temperatures.

MATERIALS AND METHODS

A total of 48 (forty eight) permanent teeth excluding controls were studied: - 24 Anteriors and 24 Posteriors. The samples were divided into six equal groups of eight teeth each and kept for exposing at required set of temperatures that is 100,300,500,700,800 and 900 ºC. Eight teeth were left unheated as a control group. The control samples were kept separately and thus not exposed to the experimental procedures. All the teeth studied were extracted for orthodontic or periodontal purpose, without any cavities, restorations, endodontic treatments and malformations. After extraction, each tooth was rinsed with saline water to remove blood deposits and salivary coating. The teeth were then stored in 10% formalin. Formalin (10% concentration) was used as the storage medium as it is an effective disinfectant and sterilizing agent for extracted teeth without altering their hardness.(11) The 6 groups were radiographed using SKANRAY Radiovisiography machine for better resolution of radiographic images.

Teeth were heated in a P300 ivoclar vivadent furnace (Germany) at temperatures of 100, 300, 500, 700, 800 and 900 ºC; apart from previous studies the temperature range of 800 was included instead of going up to 1000ºC as the average temperature reached in open air cremation is up to 900ºC.(12)The furnace chamber was preheated to the required temperature, and the corresponding group of teeth, placed in separate crucibles or fire resistant cotton, was then heated at required temperatures for a period of 30 minutes; the teeth were then removed and allowed to cool down to room temperature. After each heat exposure, the teeth were radiographed. The resulting radiographic and morphological changes concerning the teeth before and after exposure to high temperatures were recorded.

After exposure to experimental temperatures, each individual tooth was examined under a 2.5x magnification loupe and stereomicroscope. Crazing and fissure patterns on the surface of teeth were studied and generalized observations were made regarding the depth of fissures and the fragment size in disintegrated samples. The teeth were also examined to determine the temperature at which the enamel shell gets separated from underlying coronal dentin. The most important thing in our study which probably not mentioned in other studies is how the teeth were radiographed as they were so brittle. In our study after removing the teeth from the furnace the morphological changes were noted and molten wax was poured to stabilize the broken fragments and later heated again for just 30 seconds with a lighter to remove the wax for stereomicroscopic examination and later the burnt tooth was embedded in wax blocks for radiographic examination. Wax was chosen for embedding as it will not have much of change in radiographic details in comparison to other conventional methods.

RESULTS

All the teeth exposed to high temperatures showed different morphologic and radiographic appearances. At 100°C all the teeth were intact with pale to light yellow colour. The crown retained its morphology and no appreciable changes were noticed radiographically (Figure 1 and 2).

Figure 1: Morphological alterations in burnt teeth at various temperatures

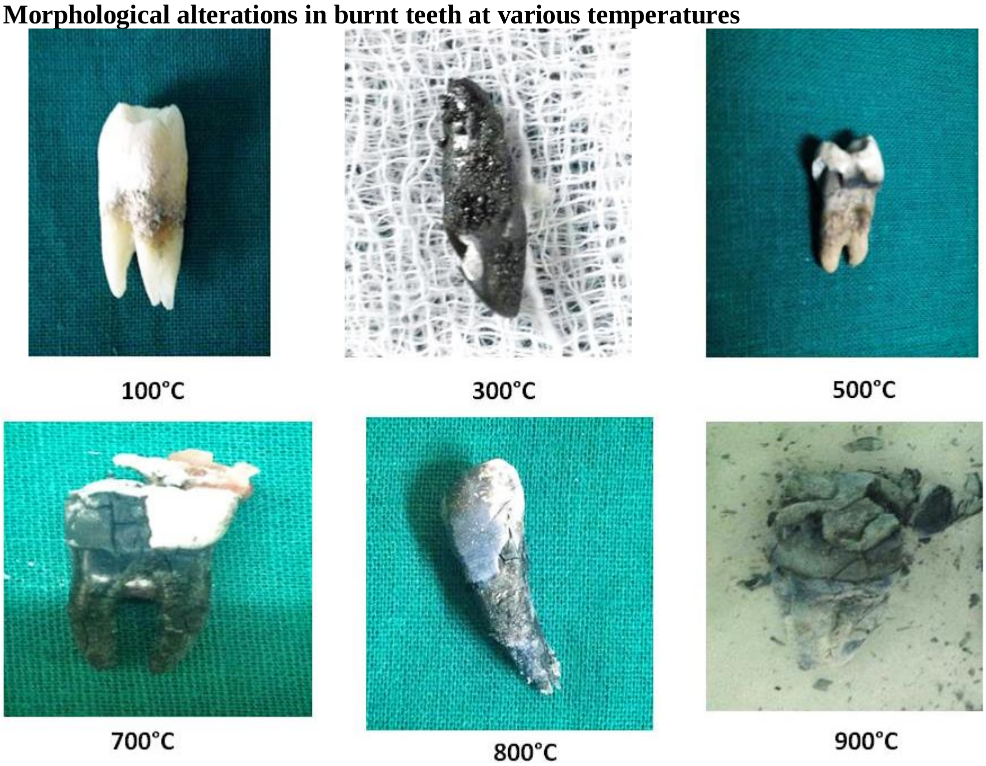
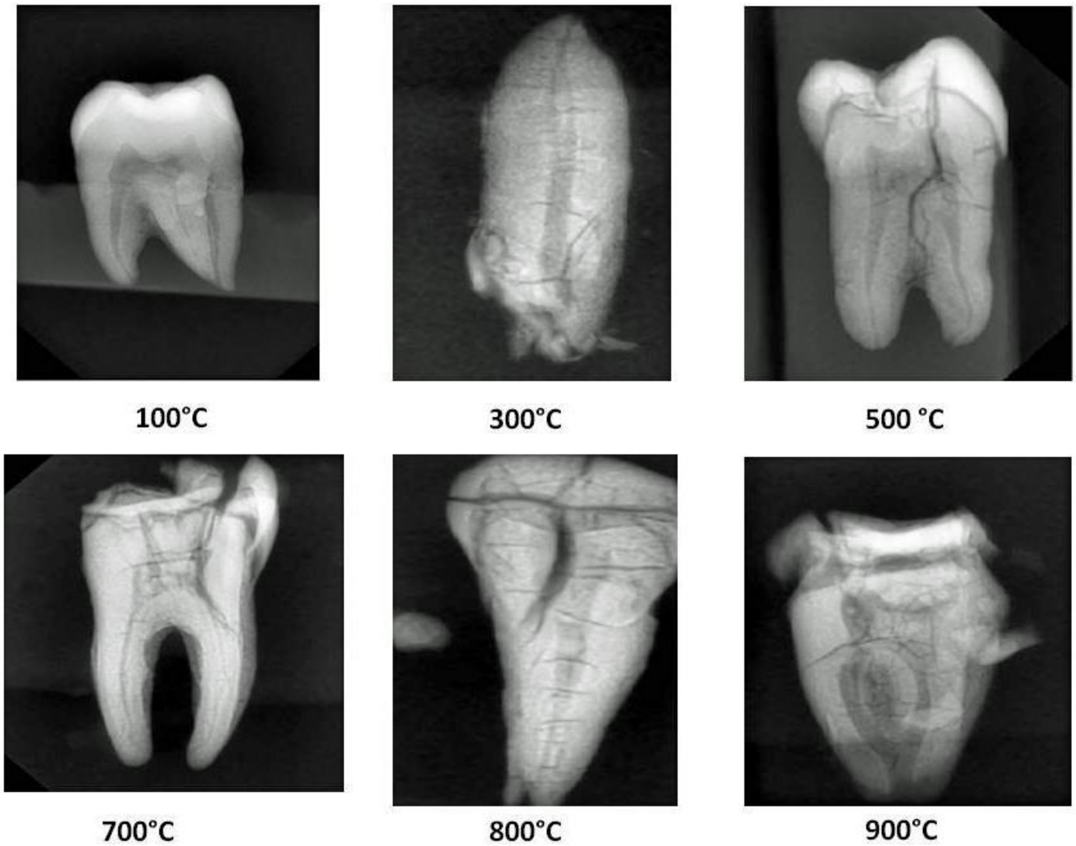


Figure 2: Radiographical changes in burnt teeth at various temperatures



At 300°C teeth showed dark greyish change in colour on crown and root ranging from a patch to total discolouration. All the teeth were intact but radiographically fissures observed running across the tooth surface. Grossly we can say the teeth resembled like clinical appearance of neurofibromatosis or sand bubbles Figure 1 and 2).

On exposure to 500°C, all the teeth showed crown with light to dark bluish grey colour. The colour of roots turned to greyish brown colour. At 500°C and above tooth lustre was lost. Many teeth were disintegrated into fragments at 500°C. The burnt tooth samples resembled as if giving a crown (prosthesis) over a reduced tooth. The radiographic evaluation revealed fractures between enamel, dentin and extending within dentin (Figure 1 and 2).

The colour of all the teeth were turned to light to dark bluish grey colour at 700°C. All the teeth specimens disintegrated into small fragments. Radiographically presence of many fractures between enamel and dentin were noted. At 800°C the bluish colour was more pronounced resembling the inner bluish tinge of feather of peacock.

At 900°C teeth were going towards neutral white colour with bluish colour being present in patches over the tooth. Teeth showed presence of large fractures spreading through the dentin and crushed crown was observed radiographically (Figure 1 and 2). All these changes are represented in Table 1.

Table 1: Morphologic and radiographic changes observed in teeth exposed to high temperatures for 30 minutes.

SI NO.	SAMPLE SIZE	TEMPERATURE AND DURATION	MORPHOLOGICAL CHANGES (COLOUR)	RADIOGRAPHICAL CHANGES
1	8	100ºC – 30MINS	Pale to light yellow	No change.
2	8	300ºC – 30MINS	Crown -Yellowish brown to Very dark grey. Root - Shiny black.	Fissures running across the tooth surface
3	8	500ºC – 30MINS	Crown- light to dark greyish. Root – yellowish brown.	Cracks between enamel/dentin and Within dentin.
4	8	700ºC – 30MINS	Light to dark bluish grey within the discolouration	Fracture of crown and cracks running till pulp chamber
			More bluish areas than black	Fracture of crown and cracks

5	8	800ºC – 30MINS		running till pulp chamber
6	8	900ºC – 30MINS	Neutral white with Light bluish gray	Large fractures damaging the whole tooth structure.

DISCUSSION

A great deal of effort goes into identifying the victim, in case of forensic identification of the body in burnt cases. One of the methods of identification in forensic odontology is to examine the burned bodies (13) and noting the fine clues given by them but as soft tissues cannot be of much help due to their less resistance to fire so the dependence comes on hard tissues. Dental identification is one of the most reliable and frequently applied methods of identification, because of which forensic odontology has emerged as a separate branch. (14)

The teeth are protected from physical and thermal insults by the peri-oral musculature, lips and tongue. When exposed to fire, the soft tissues dehydrate and retract, thereby exposing the anterior teeth. As a result, the anterior teeth exhibit more thermal damage than the posterior teeth, which are protected by the tongue and buccal musculature.(15)Though bones are also hard tissue components of our body protected by soft tissues, but their mineral composition is less by roughly 25-30% as compared to the outer covering of teeth that is enamel which also makes teeth more resistant to fires along with the facts that teeth are protected by bones as well the root portions of teeth are inside sockets of bone.(16)

The teeth, though most resistant to fire, can become brittle and fragile when subjected to increased temperature. Burnt teeth are difficult to handle and reconstructing them for purpose of post-mortem radiography and dental charting is an uphill task.(17) Knowledge about morphology and brittleness of burnt teeth can, therefore, can assist forensic investigators to appropriately handle fragile dental tissues and enabling them to study the teeth. The purpose of the present study was to analyse thermally induced macroscopic and radiographic alterations.

In a burns victim, therefore, the thermal damage observed in anterior teeth exceeds the damage in posterior teeth.(15)The consequence of this differential damage is that estimation of temperature becomes complex due to the absence of uniformity in the structural changes in the hard tissues. In this study, this factor along with variables present in in-vivo conditions was not taken into account and the teeth were introduced into the oven at the experimental temperatures to simulate a thermal shock that would be induced by a fire; after 30 minutes exposure they were removed.

We noted that colour of the teeth was the most important predictor of tooth fragility and this finding concurs with the previous studies which suggest that blackened teeth are less fragile in comparison with remains that are grey, bluish or white in colour. (15) In this study, colour changes varied from light yellow colour, yellowish brown, greyish brown passing through bluish grey and then neutral white at 900ºC relating directly to the level of carbonization and incineration of teeth. All these changes were also described by Gunther and Schmidt-quoted by Rotzscher., Merlati et al., Muller et al., Merlati, Danesino et al., and Bagdey et al. (13,18-21) Good care must be taken while collecting the evidence as teeth which are looking intact might be so brittle that while picking up with fingers or tweezers they may break. So an estimation based on the colour should be made how to collect the evidence directly by finger, tweezers or pouring molten wax.

Another important decision which can be made after collecting the burnt tooth specimens is which kind of technique should be used to extract the DNA from the tooth as DNA extraction studies indicate that the nuclear DNA can be extracted only from tooth which has survived temperatures up to 300 degree centigrade, above that only mitochondrial DNA can be extracted up to 700 ºC (22) so an assumption based on morphological and radiographic alterations should be made to avoid spillage of precious time and money over other non-useful techniques.

From the results, it is observed that teeth were not strongly affected by the temperature exposure till 300°C. Above 300°C the radiographic changes observed cracks between enamel and dentin, fractures between enamel-dentin and within dentin, large fractures spreading through the dentin and crushing of crown starting at 700°C up to 900°C. A similar observation has been reported by Savio et al. (23)

The colour of bone fragments affected by high temperatures is a reflection of oxygen availability, duration and temperature. Colour changes in teeth are similar to those documented in bone.(1) At initial temperatures the organic components begin to carbonize and as the temperature rises the carbonates begin to disappear resulting in black or dark grey colour depending on the duration of the heat exposure. At high temperatures of 800ºC or more, bone becomes "calcined" and the colour changes to blue-grey or white. (24) Similar type of observations is seen in our study.

Our team didn't weigh the tooth before and after incineration as the melting point of minerals calcium and phosphate is very high and organic component of the tooth is very less so the changes in weight of the tooth will be very minimal and probably might not lead to conclusive results.

CONCLUSION

Morphologic and shadow graphic details noticed in burnt teeth will provide valuable information about the temperature and duration of exposure to fire and most importantly on how to handle the fragile evidence. It can also aid in understanding the circumstances surrounding the fire. This study can help the forensic investigators in approaching the scene in a systematic planned manner so that it could prove to be the best useful evidence for identification of those who are extensively burned.

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