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Effect of various temperatures on restored and unrestored teeth: A forensic study

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Abstract

Background: In large scale disasters associated with fire the damage caused by heat can make medico legal identification of human remains difficult. Teeth, restorations, and prostheses all of which are resistant to quite high temperatures and can be used as aids in identification process. **Aim:** Aim of the study was to investigate the macroscopic and microscopic changes of teeth and several dental filling materials exposed to a range of high temperature (200-800°C). Dental restorations include filling materials, crown, and bridges. **Materials and Methods:** Restored and unrestored teeth were placed in a furnace and heated at a rate of 30°C/min and the effects of the predetermined temperatures 200, 400, 600, and 800°C were observed. Macroscopic and stereo microscope findings were observed. **Results:** Our results showed that teeth and restorative materials resist higher temperatures than theoretically predicted and that even when a restoration is lost because of detachment or change of state, its ante-mortem presence can be confirmed and detected by stereo microscopic examination of the residual cavity. **Conclusion:** We further conclude that a reasonably reliable estimation of the temperature of exposure can be made from an analysis of the teeth and restorative materials.

Key words: Dental identification, forensic odontology, stereo microscope

Introduction

Various events can lead to burned skeletal remains, which may include transport accidents such as aircraft and rail; suicides; and terrorist attacks.[1] These events may display variable results on human remains.[1] Conventional methods of identification such as visual identification and fingerprints have been rendered redundant in cases where the body is burnt beyond recognition. Teeth and bones have the good fortune of surviving really high temperatures.[2] Teeth and the restorative material used as cavity fillings have an astonishing ability to resist extreme conditions of heat and cold. This quality can be attributed to the protection offered from the surrounding orofacial structures such as the buccal mucosa and the labial mucosa.[2] Studying the effect of heat on teeth and the restorations would help ascertain the temperature reached by the fire, if an accelerator was used and whether the blaze was the cause of death or the victim was dead prior to the fire. This would be highly pivotal in cases where skeletal remains are recovered. Additional information obtained from the available restorative material after a fire enhances the possibility of a positive identification.[3]

The aim of this study was to find out the effect of heat on the teeth and the different restorations and their resistance to this extreme state. Apart from gross examination of the teeth, a stereomicroscopic study was carried out to study the finer details post exposure to fire.

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Materials and Methods

Eighty sound teeth, extracted for periodontal or orthodontic reasons were disinfected in a 5% sodium hypochlorite solution for 2 h and stored in sodium chloride 0.9% solution at room temperature for up to 1 month, and they were randomly divided into different groups.

Group 1: 20 Unrestored teeth
Group II: 20 Amalgam restored teeth
Group III: 20 Glass ionomer restored teeth
Group IV: 20 Zinc oxide eugenol restored teeth.

After restoration all samples were stored in a 0.9% sodium chloride solution at room temperature for 1 month before further tests. Each specimen was placed in a custom made tray made of dental investment material and the samples were then exposed to direct heat in an oven at four different temperatures viz; 200°C, 400°C, 600°C, and 800°C, with an increment rate of 30°C/min. The number of samples and controls exposed to each target temperature is reported. As soon as each target temperature was reached, the samples were removed from the oven and allowed to cool to room temperature. The samples were then examined both macroscopically and with a stereo-microscope.

Results

The effects of high temperatures on teeth were overtly observed for the change of color and the intactness of the restorations. The macroscopic and stereomicroscopic findings for both restored as well as un-restored teeth were as follows:

Un-restored teeth

200°C: The color of the crown and root changed from yellowish white to light brown. [Figure 1] Stereomicroscope showed the appearance of micro cracks or fractures on the root.

400°C: The color of the root had changed to steel gray or black while that of the crown remained light brown. Stereomicroscope showed extension of the micro fractures from the root or appearance of new ones on the surface of the crown as well.

600°C: The crown had shattered into pieces while the root was intact, and black in color. [Figure 2] Stereo microscopic view showed numerous minute micro fractures on the root surface.

800°C: A drastic change in color of the root was seen, which turned to opaque white. The exposed dentin of the root still remained dark gray. Stereomicroscope showed vertical cracks on the chalky white root.

Restored teeth

Amalgam restorations

200°C: The crown showed slight retraction of the amalgam filling from the light brown to black colored crown. Stereomicroscopic view showed bubbles on the surface of the filling indicating evaporation of mercury.

400°C: The findings were similar to those at 200°C with further retraction of the amalgam filling and loss of marginal seal seen with the stereomicroscope [Figures 3 and 4].

600°C: The tooth was shattered, but the filling was intact. Stereomicroscopic view showed fractures on the filling though the shape of the filling was maintained.

800°C: The filling remained in place with an intact shape on the portion of the crown that was left. Exposed portion of the dentin was bluish white. Stereomicroscopic view showed cracks on the filling and loss of marginal seal.

Zinc-oxide eugenol fillings

200°C: The color of the root had turned dark brown whereas the color of the filling showed areas that had turned light brown. The filling was extruded from the cavity.

400°C: The color of the crown was light brown whereas the root was turned to dark grey to charcoal black as did the color of the filling. Stereomicroscopic view showed extrusion of the restoration. Portions of the filling had broken off, and loss of marginal seal was observed. Deep cracks and fissures were seen on the surface of the left over filling.

600°C: The crown was carbonized and completely shattered into pieces, but the outline of the filling was noticeable. The cross-section of the filling shows no change in the color [Figure 5]. Stereo microscopically the color of the root had turned to dark brown to black and showed deep fracture lines.

800°C: The filling was lost as the crown was shattered completely and root was intact. Exposed dentin showed a bluish grey hue. A deep vertical fracture was seen along the length of the root. Stereomicroscopic view showed minute fracture lines on the root, which had turned to opaque white.

Glass ionomer cement restoration

200°C: The restoration had extruded from the crown, which showed a slight change in color to light brown. A loss of marginal seal was seen upon examination with a stereomicroscope.

400°C: The filling showed a change in color to light brown as was the color of the crown. The root appeared charred due to carbonization.

600°C: Loss of superficial portion of the crown structure was seen along with a portion of the filling. The root remained charcoal black in color. Stereomicroscope showed deep fracture lines along the length [Figure 6].

800°C: Only a portion of the crown structure along with the filling remained. The filling remained intact within the crown, which had turned opaque white as had the root [Figure 7]. Stereomicroscope showed a loss of distinction between the anatomical crown and the root.

Discussion

Most of the microscopic studies of enamel showed structural changes at 800°C, whereas dentin showed changes at a comparatively lower temperature of 600°C.[1] These changes are the result of the physiochemical properties of the material and their nature. Even with these changes, individual components like amalgam residues are identifiable even at temperatures more than 1000°C.[4] The change in the color, hue of the restoration and their external appearance are the most commonly observed findings in an incinerated tooth.[2,5] Teeth are amazingly resistant to heat if it is subjected to it gradually, but if heated severely the tooth may disintegrate; else they may resist temperatures unto 1200°C.[6] Care must be exercised while handling the burnt teeth and methods to reinforce the singed remains must be carried out so as to prevent them from disintegration. Fragmentation is the most important complication of burned human remains.[1]

According to the Gustafson, no major changes are observed in teeth and fillings below 200°C. Hence, the study commenced at a temperature of 200°C and above. The greatest disparity in the effect of high temperatures on restorations is seen in amalgam fillings.[6] Pink pigments due to Copper oxides and a golden thread due to mercuric oxide vapors that were seen in other studies were absent in this study.[6] The difference in the composition of amalgam and an inconsistency in the percentages of mercury, silver, and copper found in amalgam available in different parts of the world may be responsible for this discrepancy.[5] Some fillings of Amalgam have been reported to resist temperatures as high as 870°C.[2] The contraction of the restoration and loss of marginal seal was due to

Figure 1: Unrestored tooth at 200°C: Macroscopically evident change of color, tending to yellow, brown, of both the root and the crown

Figure 2: Unrestored tooth at 600°C: macroscopic evaluation showed black discoloration of the whole tooth, a shattered part of the crown and detachment of the enamel

Figure 3: Amalgam restoration at 400°C: macroscopically fillings were in place, although both showed the same phenomenon noted at 200°C, that is the presence of bubbles on the surface

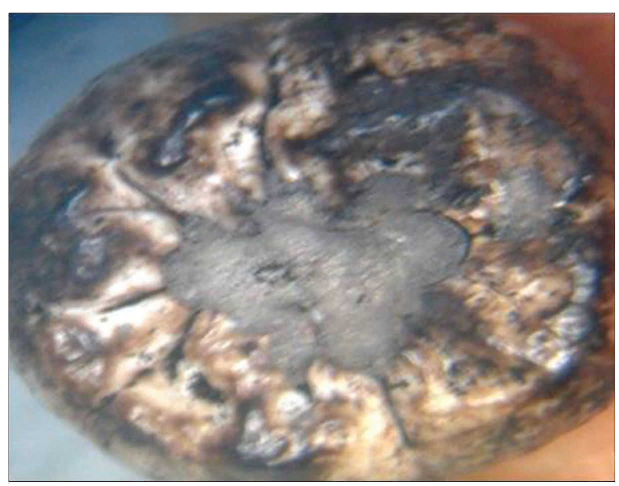

Figure 4: Amalgam restoration at 400°C: retraction of the amalgam filling and loss of marginal seal seen with the stereomicroscope

Figure 5: Zinc oxide eugenol at 600: macroscopically dark gray with cracks and dimensional contraction by loss of water, agglomerated particles of zinc

Figure 6: Glass ionomer restoration at 600°C: Stereomicroscope showed deep fracture lines along the length

Figure 7: Glass ionomer restoration at 800°C: macroscopically only a portion of the crown structure along with the filling remained. The filling remained intact within the crown which had turned opaque white as had the root

evaporation of mercury and loss of organic matrix.[6] The bubbles observed on the surface of the restoration were due to evaporation of mercury.[6] Gold Inlays are known to resemble amalgam fillings because of the deposited vapor of mercury on it.[2]

Phosphate linings are known to resist fire very well, and are usually found at the bottom of the cavity when the amalgam filling is dislodged.[2] This could not be verified in this study, since, the amalgam filling was intact and in its place even at a temperature as high as 800°C.

The charred appearance of the tooth indicates sudden and quick carbonization of the tooth and its conversion into solid carbon as any biomaterial does on exposure to high temperatures.[2] The teeth used in this study were specifically restored post extraction; hence, the time elapsed since the fillings were carried out and the teeth incinerated could not be considered. In real time, there may be a time gap between the restorations carried out on the teeth and the incineration of the body. The amalgam and glass ionomer restorations were intact even at a temperature of 800°C. This is in accordance to other similar studies carried out.[4] The reason for it could be the mechanical retention factors made during cavity preparation.[4] Restored teeth appeared to show cracks and fissures at lower temperatures than un-restored teeth. This may be due to the alteration in the structural integrity of the tooth during cavity preparation.[7]

Contrarily to amalgam, zinc oxide eugenol filling showed extrusion indicating expansion of the filling instead of marginal contraction. In incinerated remains tooth colored fillings are the most difficult to identify macroscopically, but the use of a stereomicroscope simplifies the task.[8] The stereomicroscope can also be used to differentiate the gold fillings with amalgam residue on them from actual amalgam fillings and to detect the presence of a root canal filling after an explosion of the crown of the tooth.[8]

Teeth like bones have been known to react in a predictable manner when subjected to natural elements such as fire, earth, and water. This study was performed on extracted teeth; hence, exact results may not be obtained when a body is subjected to an intensive heat source. Nonetheless, valuable information was obtained regarding the predictability of effects. The effects produced depend upon variables, such as the intensity of heat, protection of surrounding tissue, duration of exposure to the heat, presence of an accelerator, and the medium used to extinguish the fire.[4,7] Absence of these variables may have caused an early evaporation of organic components with subsequent shattering or explosion of the crown around 800°C.[4,7] Thus, the teeth are known to survive higher temperatures than those mentioned in this study. The effect of heat on teeth in reality is further complicated by the duration of exposure to high temperatures.

Conclusion

In this study, the teeth were subjected to a single, limited, and controlled exposure to heat. We conclude that the possible temperature of exposure can be estimated by analyzing the changes in the teeth and their restorations, though, further studies on other materials used in the restoration of decayed or missing teeth such as acrylic, porcelain, and stainless steel are required.

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