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Effects of Elevated Temperature in Forensic Endodontics: A Comparative Review

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Abstract

Forensic science is the art of identifying, evaluating and presenting evidences in the Court of law. The branch of endodontics plays a vital role in aiding the investigative procedures. The advances in biomaterials that are used and the evolution of radiographic and imaging techniques help in identifying the similarities and differences between ante-mortem and post-mortem evidences. Fire constitutes a major contribution in the mode of disasters or during cremation or mass accidents. There are various studies that compare the effect of heat and the alterations that occur in dental tissues and materials. This paper reviews on a comparative scale various in vitro studies and review articles on the basis of the effect of high temperature on endodontic materials and dental tissues.

Keywords: Biomaterials, Forensic Odontology, Incineration, Imaging Techniques

Introduction

Forensic Odontology also referred to as Forensic Dentistry is the specialty of dentistry that comprise of maintaining dental records, identifying human remains, evaluating and presenting the dental evidences appropriately during legal proceedings that could either be civil or criminal with interest of justice[1]. The characteristic features of the dental tissues are that it sustains various environmental conditions and hence plays a vital role in the forensic identification process over decades[2].

Recent advances in the field of biomaterials and the evolution of various imaging modalities aid in the forensic personal identification. The remnants of dental tissues are considered as concrete evidence during a postmortem when there is lack of fingerprint records[3]. Fire is considered as one of the major cause of morbidity and hence, identifying the deceased person becomes the challenge for the forensic team especially when the victims are due to automobile accidents or aircraft crashes that result in complete carbonization of the soft tissues[4].

An endodontically treated tooth or a restored tooth imparts more information rather than a tooth that is non-treated. The identification of fire victims poses as a challenge in personal identification during forensic analysis in comparison to other sources of morbidity. This review paper discusses the various changes that occur in dental tissues as well as in the dental materials that are used in restoration and root canal treatment when subjected to heat at elevated temperatures.

Methods

Hand searching of articles and review papers were done. Only in vitro studies were considered that analyzed the effect of high temperature on dental tissues or dental materials used in endodontic restoration. The review also compared the modality used in assessing the alterations that occurred at various levels of heat administration. Most of the studies were performed at temperatures ranging from 200°C to 1200°C at intervals of 200°C, 400°C, 800°C, 600°C, 1000°C and 1200°C for a standard time of 15 mins.

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Table 1. Changes in dental tissues

Temperature in °C	Enamel	Dentin	Cementum
200°C	• Loss of brightness • Crown reveals a brownish hue with a whitish incisal edge • Cusps change into white color	• Reveals a brownish hue	• Loss of brightness
400°C	• Reveals darker enamel • Cracks	• Reveals a blackish hue	• Turns darker in brown colour • Longitudinal cracks
600°C	• Brownish hue	• Grayish hue	• Longer and deeper cracks
800°C	• Turns Grayish colour • Incisal edge reveals chalky white appearance	• Black streaks observed along the tubules	• Chalk like whitish hue
1000°C	• Fragmentation • Complete loss of enamel	• White dentin appearance	• Appears white and completely incinerated

Table 2. Changes in restorative materials

Temperature in °C	Silver Amalgam	Composite	Glass Ionomer Cement
200°C	• Marginal malalignment • Surface roughness	• Marginal retraction • No macroscopic changes	• Intact but gets separated
400°C	• Darkening of material • Superficial cracks	• Light brown hue • Loss of Marginal integrity • Superficial cracks	• Intact but gets separated
600°C	• Turns black • Loss of morphological characters	• Whitish hue	• Difficult to observe
800°C	• Silver bullets	• Chalky white hue	• Difficult to observe
1000°C	• Dislodgement • fragmentation	• Dislodged	• Difficult to observe

Table 3. Changes in endodontic materials

Temperature in °C	Zinc Oxide Eugenol	Gutta Percha cones	Crowns
200°C	• Remain unchanged between GP points	• Maintains original color • Melted in consistency	• No change
400°C	• Whitish hue	• Black colored with white streaks	• Black spots observed
800°C	• Chalk like whitish hue	• Chalk-like whitish hue	• Dullness observed • Darker
>1000°C	• Undifferentiated from dentin due to incineration	• Completely incinerated	• Dullness observed • Loss of glazed texture • Darker in colour • Porous in nature

Results

The comparison of the in-vitro studies revealed similar descriptions with difference in certain details. Some of the studies concentrated in analyzing the different imaging modalities such as CBCT, Micro-CT [5], other than digital images or naked eye evaluation[6] to obtain better detailing of the characteristics observed and also to rule out disagreement in the observations. Microscopic evaluations such as histological interpretations, stereomicroscopic analysis and SEM analysis were also utilized in assessing the alterations subjected to high temperatures[7,8].

Discussion

The influence of heat on dental tissues is given utmost importance due to the increasing rate of morbidity caused due to fire. Hence, evaluating the various features that are presented by the dental tissues and materials subjected to heat are currently the trend in forensic analysis. Norrlander classified the burns that occur in the body into five categories such as superficial burns, destroyed epidermis areas, destruction of the epidermis and dermis and necrosis areas in underlying tissues, total destruction of the skin and deep tissues and lastly burned remains[9]. The various temperature ranges are considered due to the simulating exposure of fire accidents that include house fires that occur around 649°C[10], gas leak accident at around 800°C to 1000°C, cremation at around 760°C to 983°C[11], petrol combustion occurs between 800°C to 1100°C[12].

Changes in Dental Tissues

Enamel comprises of increased concentration of inorganic components that result in desiccation when exposed to high levels of heat resulting in loss of matrix.

These consequences to lack of brightness, and occurrence of cracks in the enamel surface[6]. The change in color yellowish white to brown then continued to black was attributed to the carbonization or the incineration of the inner dentin surface as it comprises of more organic constituent[7,13].

The intensity of the cracks is well identified when it is observed using Stereomicroscopy[15]. The crown portion of the tooth results in fragmentation when compared to the root when exposed to high temperatures denoting that delicate property of calcinated teeth[7,12].

Changes in Dental Materials

In amalgam it was observed that at temperatures of 200°C to 400°C there was roughness on the surface due to nodule formation attributed to mercury evaporation process and denoted the appearance as "Silver Bullets" due to the surface porosities[6].

As stated to Vazquez et al., the change in color of the coronal tooth structure was observed that were restored with amalgam restorations. They were categorized into pink color pigmentation, reddish brown or brownish golden attributing to oxidation of copper or interaction of mercury vapors to copper or silver oxide[6,15]. In recent years the usage of amalgam as a restorative material has been limited due to esthetic awareness. Glass ionomer cements reveal dislodgment at temperatures above 600°C and reveal marginal contraction at lower temperatures[7]. which is attributed to the material thickness[6].

Composites are widely used as post endodontic restoration due to the esthetic value and the durability of the material. It has been evaluated that composite withstand heat to a greater extent as compared to other restorative materials. The color change results due to the effect of carbonization on the acrylic matrix[6] and also the occurrence of cracks were observed. The loss of matrix that comprises of organic content results in marginal contraction that was assessed using RVG[16]. It was also assessed in a study by Kiran *et al.* that above 500°C the fluorescence property is lost in the organic content and above 900°C the inorganic component also loses the fluorescence[17].

Changes in Endodontic Materials

The materials that are used in filling the root canals are invariably protected by the presence of the crown or the post endodontic restoration. Zinc oxide eugenol cements or sealers remain unchanged at lower temperatures and at higher temperatures resemble the features of dentin that is incinerated[6]. Gutta percha cones are materials that are soft, thermo-plastic in nature and withstand heat to a great extent[6]. They show very less shrinkage when assessed by CBCT. Also at 800°C voids are observed demonstrative

of "honeycomb" appearance[5,18]. All ceramic crowns offer maximum resistance to heat exposure. They are characterized with overflow of ceramic and loss of texture and glaze when subjected to 1200°C[19]. In addition to these materials the presence of separated files can be detected with the surface characteristics or the presence of posts can aid in forensic assessment.

Conclusion

The presence of various materials used in the field of endodontics has played an essential role in personal identification in forensic investigations. When there are fatalities due to fire the dental records give utmost accuracy in determining forensic analysis. All the studies in this review show similar characteristics when the materials are subjected to high temperature. The composite material is evaluated as a consistent material and endodontically treated teeth can be assessed by novel imaging methods instead of photography for accuracy. Hence the dental records maintained at hospitals, clinics, peripheral centres and health centres must be duly maintained to help in forensic science.

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