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Assessment of the Visual And Radiographic Changes in Teeth Subjected to High Temperatures : A Forensic Study

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Abstract:- The aim of the study was to assess the visual and radiographic changes in teeth subjected to various high temperatures.

An in-vitro observational study was conducted on 45 extracted teeth in the Department of Oral Medicine & Radiology, Sri Sai College Of Dental Surgery, Vikarabad. A burnout furnace was used for heating the teeth. The teeth were then categorized into three groups based on the degree of thermal stress, subjected to (150 º C, 450 º C and 950 º C). The teeth were then visually and radiographically analyzed for any changes. Teeth samples with caries, fractures and restorations were excluded from the study.

The visual changes appreciated were development of cracks, crazing lines at 150º C, to progressive discoloration at 450º C, followed by fractures of crowns and roots at 950º C. The radiographic changes appreciated at 150 º C were not so appreciable, radiographic fissures were seen between enamel and dentin at 450 º C to large factures spreading through the dentin and crown en bloc fractures at 950 º C.

Keywords:- *Temperature, In-Vitro, Thermal Stress, Extracted Teeth.*

I. INTRODUCTION

In the field of natural and man-made disasters, fire has played a predominant role. Fire survey is an interdisciplinary approach which involves examining the source of fire, its cause as well as the identification of victims.[1]

A clear understanding of visual and radiographic changes in teeth subjected to high temperatures is of great importance in forensic odontology. The type and extent of structural damage may provide valuable avenues in fire investigations, particularly when only dental evidence remains.[2]

Teeth are highly resistant to decomposition and organic decay attributed to its high mineral content when compared to the soft tissues. Enamel which is the hardest substance in the human body, protects the underlying tissues from the thermal insults it is subjected to.[3] Teeth are considered to be the most durable organs in the human body. Teeth can persist long after other skeletal remnants which have undergone decomposition and biologic degradation by factors such as fires.[4, 5]

The visual and radiographic evaluation of the dental remains provides a significant aspect in the forensic identification process, particularly after an exposure to fire. As there is a paucity of studies in literature concerning this subject, hence the present study was undertaken to investigate the visual and radiographic changes in extracted teeth that were subjected to high temperatures for a certain period of time in a laboratory setting; visual and radiographic changes were correlated to the temperature.

The aim of this "in-vitro" study was to evaluate the visual and radiographic changes in extracted teeth subjected to high temperatures.

II. MATERIALS AND METHODS

A. Study Protocol

An in-vitro observational study was conducted on 45 extracted teeth in the Department of Oral Medicine & Radiology, Sri Sai College Of Dental Surgery, Vikarabad.

B. Materials

The total sample was divided into 3 groups i.e., Group A, Group B and Group C. Group A consisted of 15 teeth from patients aged 15 – 30 years. Group B consisted of 15 teeth from patients aged 31 – 45 years and Group C consisted of 15 teeth from patients aged 45 years and above.

Each group was tagged with a unique identification number which denoted the age group and the temperature to which they were subjected.

The first five specimens of each group (A1-A5, B1-B5 and C1-C5) were exposed to a temperature of 150 º C, the second set (A6-A10, B6-B10 and C6-C10) to 450 º C and the third set (A11-A15, B11-B15 and C11-C15) to 950 º C.

➢ *Exclusion Criteria*

Teeth samples with fractures, caries and restorations were excluded from the study.

C. Methodology

The teeth were washed under running tap water, any soft tissue residue and deposits were removed using an ultrasonic scaler followed by disinfection using 3% hydrogen peroxide (H_2O_2) and stored in labeled containers according to the age group with 0.9% normal saline solution.

All the teeth were photographed and then mounted on high strength dental stone and placed inside a burnout furnace (Vita Vacuum 40T furnace) which was preheated to 100 º C for 15 minutes. After being subjected to heat the teeth were removed and allowed to cool down to room temperature followed by demounting. Then, photographs were taken and radiographs were obtained using KODAK Dental Intraaoral E – Speed Film, with Intraskan Dc machine. The exposure parameters were 70 Kvp, 10 mA and exposure time of 0.5 seconds with the long cone paralleling technique. These x – ray films were processed with the dental x – ray developer and fixer.

The resulting visual and radiographic changes concerning the samples after exposure to heat were assessed and recorded.

III. OBSERVATIONS AND RESULTS

A. Visual Changes

➢ *Changes seen in the coronal portion of teeth*

The colour changes after thermal exposure were similar for a particular temperature regardless of the age group. The colour of enamel changed from pale to a light brown discolouration at 150º C. No loss of translucency of enamel was seen in group A and B subjected to 150º C while loss of surface translucency was seen in group C subjected to 150º C. For the teeth subjected to 450º C and 950º C loss of translucency was seen in all the groups (Tables 1, 2 & 3).

Charring of the crowns was a constant finding of all teeth subjected to 450º C and 950º C irrespective of the age. At 150º C, surface cracks were seen in the coronal portion of the teeth in groups A and B and fractures involving the crown were seen in group C. The intensity of fractures increases at 450 º C to more extensive fractures of the crown at 950º C in all the groups (Tables 1, 2 & 3).

Varying degrees of disintegration of the crown structure were seen at 950º C and 450º C in groups A and B respectively (Tables 1& 2).

B. Radiographic Changes

Teeth from groups A and B showed small areas of fractures and fracture lines in the crowns of teeth involving enamel while teeth from group C did not show any evident radiographic changes at 150º C(Tables 1, 2 & 3).

Fractures involving crown and apical one – third of the root are seen in group A exposed to 450º C. The fracture lines increased in number leading to complete separation of crowns from the roots of teeth in groups B and C at 450º C(Tables 1, 2 & 3).

Obliteration of root canals was seen in groups A and B with large fracture lines involving the crowns and roots at 950º C and large fractures involving the crown enbloc were seen in teeth from group C at 950º C.(Tables 1, 2 & 3).

IV. DISCUSSION

The natural teeth are the most durable organs in the human bodies. Teeth can persist long after other skeletal structures have undergone organic decay or destruction by factors such as fires because enamel is the hardest mineralized substance that provides protection to dentin and pulp.[5,6]

The first accounted case of dental identification in which a great number of victims lost their lives occurred in Paris in 1897. A fire in the charity bazar resulted in the death of 126 individuals for which dental identification was used. Doctor Oscar Amoedo also regarded as the Father of Forensic Odontology published a paper “The role of dentist in the identification of the victims of catastrophe of the Bazar de Le charite, Paris on 4th May 1898.”[5,1,2]

In the present study, it was found that the color of the teeth was the most important indicator of relative fragility of the teeth. This confirms results of previous research which suggest that blackened teeth are less fragile when compared to teeth that are grey or neutral white in color. According to the results of the present study, the teeth showed color changes ranging from pale to light brown in group A at 150 º C, light brown to greyish discoloration in group B at 150 º C, dark brown to grey discoloration with greyish hue in group B at 450 º C. Charring of the crowns was another finding seen in group A at 450 º C and 950 º C whereas charring of crowns in group B and C was seen at 950 º C. From the above findings we can say that the colour change is directly proportional to the level of incineration of the teeth. Similar changes were described by Savio et al, Merlati et al and Fassina et al.[7] According to Beach et al, among temperature and duration, temperature as a variable appears to be more important while assessing the tooth colour.[8,13]

The fore mentioned colour changes are in agreement with the results of the study carried out by Endris and Berrsche (1985) who stated that the progression in colour change of teeth subjected to incineration at various temperatures was similar to the colour changes in bones subjected to high temperatures. The teeth first turned brown and later black, grey and eventually neutral white. Other studies done by Muller et al., 1998; Myers et al., 1999; Schmidt et al., 2005 also stated similar findings.[8]

As per G.V.Reesu et al, colour change may be due to the heat that may denature the bonds within the collagen molecules which causes the collagen to take a more haphazard arrangement that in turn affects the absorption of the visible light spectra.[9]

According to Delattre, the teeth of victims of burn show four phases. They are:

- They may remain intact.
- May show superficial discolouration.
- Become charred.
- May be burned and might burst apart.[3]

One of the most important finding in the dental tissues is the chipping of enamel in the cervical region leading to detachment of the crown from the rest of the tooth. This finding is attributed to the fact that dentin has high organic content and water content of about 12% which causes contraction due to dehydration whereas enamel has high inorganic content(96%). Therefore, when the tissue is subjected to high temperatures it loses its water content along with the collagen matrix leading to contraction due to which fissures, cracks or fractures appear.[10] These findings are concurrent with the studies done by Merlati et al and Savio et al.[7] According to Harsanyi in 1975, at 300 º C the evaporating water in cementum results in lifting of the tissue from the underlying dentin.[11,12]

The coronal dentin of the teeth from group C in the present study was more resilient when compared to the teeth in group A and B attributed to the fact that the teeth of elderly people contain sclerotic dentin due to occlusion of the dentinal tubules. This sclerotic dentin is hypermineralized due to increase in the mineral content and decrease in the organic content which is responsible for increased strength of the teeth of elderly people. Other factors like increased density of crystallite structure in the sclerotic dentin further strengthens the sclerotic dentin to withstand thermal insults. It can be concluded that the age factor and the type of dentition may also influence the heat – induced changes in the teeth. These findings are concurrent with the study done by George et al.[3]

Obliteration of the root canals was seen in the teeth from groups A and B at 950 º C, this finding was not reviewed in other studies. According to G.V.Reesu et al, 500 º C is the maximum temperature upto which the root canals are reported to have a normal appearance without narrowing.[9]

Incidence of radiolucent lines in the coronal portion was maximum upto 46.67% in group A and upto 33.33% in groups B and C. These findings are depicted as increase in number as well as the width of radiolucent lines from lower to higher temperatures.

It is evident from the present study that at specific temperatures specific patterns like color change, formation of craze lines, cracks, fissures and fractures can give an insight to estimate or predict the fire temperature ranges during investigating procedures like differentiating house fires from violent fire accidents such as atomic bomb explosions. Our study did not take into consideration in vivo conditions, other variables like restored teeth, teeth in deciduous dentition.

Future studies with larger sample size and simulation of soft tissues is anticipated.

FIGURES AND TABLES

Temperature (º C)	*Holding Time*	*Visual changes*	*Radiographic changes*
150	15 min	1. Pale to light brown discoloration. 2. Fine cracks are seen in the crown. 3. No loss of translucency of enamel.	1. Small areas of fractures involving crown are seen.
450	15 min	1. Charring of crowns. 2. Loss of transluceny. 3. Crown fractures	1. Fractures involving crown and apical ⅓rd of the root seen.
950	15 min	1. Charring of crowns. 2. Disintegration of crowns - voids of diameter approx. 0.3 cm.	1. Obliteration of root canals. 2. Large fractures of crown.

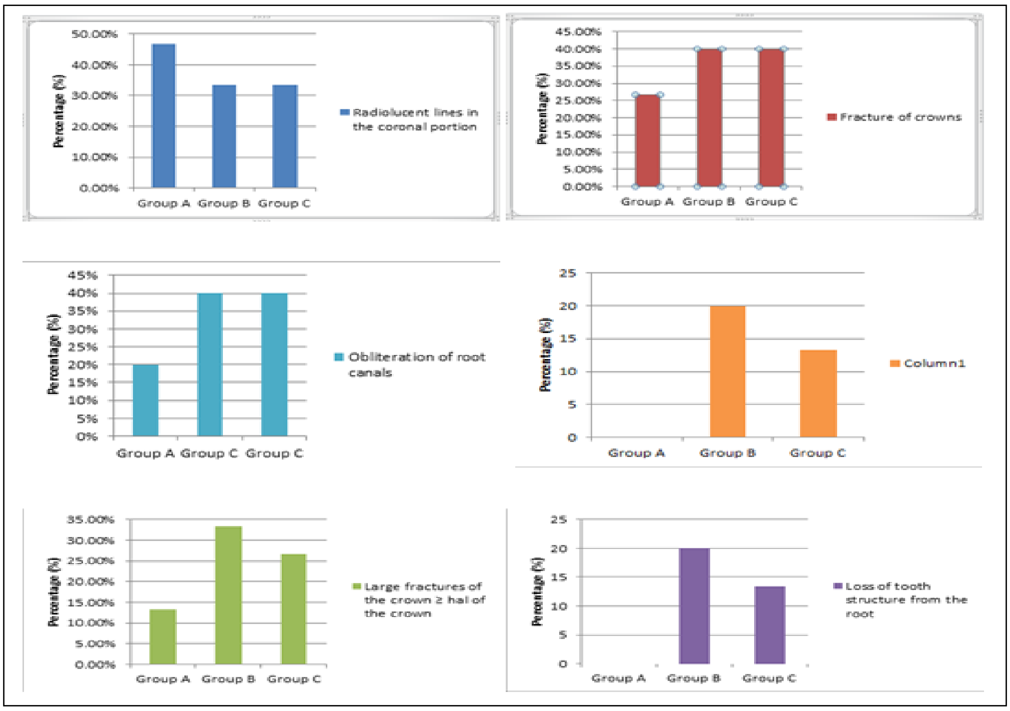
Table 1:- Visual and Radiographic Changes Seen in Extracted Teeth of Group A at Different Temperatures.

Temperature (° C)	*Holding Time*	*Visual changes*	*Radiographic changes*
150	15 min	1. Light brown to grey discoloration on the crowns. 2. 2. Surface cracks are seen.	1. Fractures involving enamel are seen.
450	15 min	1. Dark brown to grey discoloration with greyish hue is seen in the crowns. 2. Large cracks are seen in the crown portions. 3. Disintegration of crowns - voids of diameter approx. 0.5 cm seen in the crowns.	1. Large fractures involving the whole crown are seen.
950	15 min	1. Charring of teeth seen. 2. Large fractures involving crown and root are seen.	1. Large fractures involving crown and root are seen. 2. Obliteration of root canals also seen.

Table 2:- Visual and radiographic changes seen in extracted teeth of Group B at different temperatures.

Temperature (° C)	*Holding Time*	*Visual changes*	*Radiographic changes*
150	15 min	1. Pale brown to greyish discoloration in crown. 2. Loss of surface translucency. 3. Fractures involving crown.	1. No evident radiographic changes.
450	15 min	1. Grey to black discoloration of crowns seen. 2. Extensive fractures involving crown are seen.	1. Extensive fractures involving the crown are seen.
950	15 min	1. Charring of tooth structure seen. 2. Extensive fractures involving crown and root.	1. Large fractures involving crown en bloc.

Table 3:- Visual and radiographic changes seen in extracted teeth of Group C at different temperatures.



Graph 1: Percentage of radiolucent lines in coronal portion.
Graph 2: Percentage of fracture of crowns.
Graph 3: Percentage of obliteration of root canals.
Graph 4: Percentage of crown enbloc fractures.
Graph 5: Percentage of large fractures of crown ≥ half of the crown.
Graph 6: Percentage of loss of tooth structure from the root.

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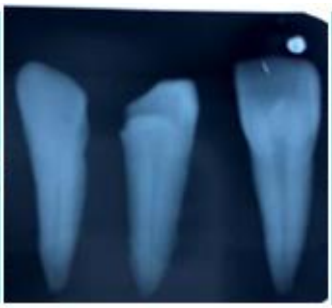


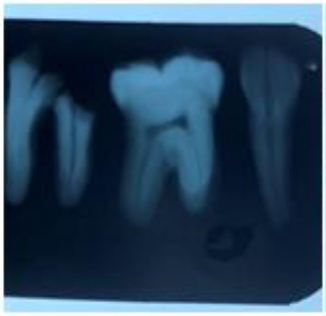

Figure 1: Photograph of teeth prior to heat exposure (Table 1).
Figure 2: Photograph of an IOPA of the teeth (Figure 1) after heat exposure (Table 1).
Figure 3: Photograph of teeth prior to heat exposure (Table 2).
Figure 4: Photograph of the same teeth (Figure 3) after heat exposure. Notice the colour change and fracture of coronal aspect (Table 2).
Figure 5: Photograph of an IOPA of teeth (Figure 4) after exposure to heat. Notice the fracture of the coronal aspect and a fracture line running through the furcation area (denoted by arrow) (Table 2).
Figure 6: Photograph of teeth prior to exposure to heat (Table 3).
Figure 7: Photograph of teeth showing charring of the crown and fracture involving more than half of the crown (denoted by arrow) (Table 3).

V. CONCLUSION

Forensic dental identification of the victims of fire accidents is often a challenging task. Mass disasters such as natural calamities, fire accidents, bomb explosions increase the mortality rates for human beings. In such cases teeth often serve as the sole means of human identification as is evident from the history. In the present study, we assessed the visual and radiographic changes seen in teeth after being subjected to varying degrees of temperature. Such a study is very useful in predicting the range of temperature to which the victim had been burnt and also to determine the type of fire accident that may have occurred. From the results drawn from the present study, it can be concluded that dental evidence may serve as important avenues of forensic and medicolegal investigations.

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