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# EVALUATION OF MORPHOLOGIC AND RADIOGRAPHIC CHANGES IN TEETH WHEN SUBJECTED TO HIGH TEMPERATURES: AN IN-VITRO STUDY

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## ABSTRACT:

**Aim**: The aim of this ‘‘in vitro’’ study was to evaluate the morphologic and radiographic changes in teeth when subjected to high temperatures.

**Methods:** A total of 324 freshly extracted permanent teeth were exposed to heat in an Unident digital muffle furnace for six different temperatures (100, 300, 500, 700, 900 and 1000°C). Before and after each exposure, periapical radiographs of all the teeth were taken. The morphologic and radiographic appearances of all the teeth before and after exposure to heat were evaluated.

**Results**: Our observation showed that as the temperatures increased the enamel, dentin and cementum changed to a neutral white colour. The results of radiographic examination showed that enamel and dentine were fragmented at 700°C onwords and longitudinal & transverse cracks of root were observed at 900 and $1000^0$C.

**Conclusion:** Morphologic and radiographic alterations caused by incineration may provide useful information about the temperature and duration of exposure to fire.It aid in understanding the circumstances surrounding the fire.

**Key words**: Forensic science; Forensic odontology; Identification; Radiographs; High temperatures.

## INTRODUCTION:

As we enter a new millennium society is facing fresh challenges in every conceivable area. Despite leaps in modern technology medical breakthroughs and the geographical changes that the last century has brought, crime still persists in all aspects of our live.[1]

Forensic dentistry as defined by Keiser-Neilson in 1970 as the branch of forensic medicine which in the interest of justice deals with the proper handling and examination of dental evidence and with the proper evaluation and presentation of dental findings.[2]

A precise understanding of morphologic and radiographic changes in teeth subjected to high temperatures is of great importance in forensic medicine. The type and severity of structural

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damage provide valuable clues in fire and criminal investigations, especially when only dental evidence remains.[3]

Radiology results in important information in the dental practice and it is considered definitive evidence in court or identification cases.[4-5]

Teeth have the highest resistance to most environmental effects like fire, desiccation, and decomposition. Teeth survive most natural disasters and provide a positive, personal identification of an otherwise unrecognizable body. Teeth exposed to high temperatures have the potential to not only aid in identification, but also in understanding the circumstances surrounding the fire.[6-7]

Teeth are the components of the body that often survive severe fires because of their high resistant composition and also because they are protected by the soft and hard tissues of the face and other elements.[7-8]

From experimental literature, macroscopic color variations of unrestored teeth could be related to the temperature rise and time of application. It was relieved that the temperature levels and the combustion time were inversely proportional to the rate of color changes.[9]

Color changes from light yellow to bluish-white, passing through brown, were pointed out also by Merlati et al and Muller et al, when unrestored teeth are exposed to temperatures in the range of 150-1150 °C.[10-11]

All of the currently available literature on incinerated teeth has been conducted for macroscopic and microscopic changes. The apparent lack of data on heat related morphologic and radiographic changes in teeth subjected to high temperature thus necessitates this type of experimental study.

The aim of this study was to evaluate and compare the gross morphological and radiographical changes in teeth when subjected to specific range of temperatures (100, 300, 500, 700, 900 and 1000°C) for specific duration of time (30 min).

## MATERIALS AND METHODS:

A total of 324 freshly extracted permanent teeth were studied; 108 anteriors, 108 premolars and 108 molars. The control samples were kept separately and thus not exposed to the experimental temperatures. All the teeth analyzed were extracted for orthodontic and periodontal purpose, without any cavities, restorations, endodontic treatments and congenital malformations.

Following extraction each tooth was rinsed with saline water to remove blood deposits and salivary coating. The teeth were then stored in 10% formalin for 15 days. Formalin (10% concentration) was used as the storage medium for the teeth becauseit is an effective disinfecting and sterilizing agent for

extracted teeth without altering their hardness.

All the teeth were equally divided into 6 groups according to temperatures of exposure, 100°C, 300°C, 500°C, 700°C, 900$^0$C and 1000°C (Graph 1).

Then, periapical radiographs of all the samples were recorded before exposure to high temperatures using the following procedure: KODAK Dental Intraoral E-Speed Film, with Bio-Medicare 1070D Machine at 65Kvp, 10 mA and exposure time of 0.5 seconds with the long cone paralleling technique, finally KODAK Dental X-Ray Developer and Fixer were used.

The 6 groups of samples were exposed to high temperatures using an Unident digital muffle furnace (fig.1) at experimental temperatures starting at 100°C up to a maximum of 1000°C. The teeth were placed in a porcelain stub inside the furnace and exposed to a high experimental range of temperatures. Once placed in the furnace, the teeth were exposed to high temperature for a period of 30 minutes; the teeth were then removed and allowed to cool to room temperature.

After each heat exposure the teeth were radiographed in the same way as described previously. The resulting radioghaphic and morphologic differences concerning the samples before and after exposure to high temperatures were recorded and listed.

## RESULTS:

All the teeth exposed to different experimental temperatures showed different morphologic and radiographic appearances. All the teeth were intact with pale to light yellow colour at 100°C. The crown retained its surface. At 100°C no appreciable changes were noticed radiographically. At 300°C teeth showed light grey with dark grey patches on crown and yellowish brown coloured roots. All the teeth were intact but radiographically fissures observed between enamel and dentin.

After 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 loss of surface luster was noted. Many teeth were disintegrated into fragments at 500°C. The radiographic evaluation pointed out fractures between enamel, dentin and extending within dentin.

The colour of all the teeth were turned to light to dark bluish grey colour at 700°C. All the teeth specimens were disintegrated into small fragments. Radiographically presence of many fractures between enamel and dentin.

At 900$^0$C and 1000°C teeth showed Neutral white colour with Light bluish gray and Light greenish gray patches. Teeth showed presence of large fractures spreading through the dentin and crown crushing were observed radiographically (Fig.2) were noted. The results of morphologic and radiographic evaluation are outlined in Table 1,

according to temperatures and exposure time.

## DISCUSSION:

Forensic odontology or forensic dentistry is the application of dental knowledge to those criminal and civil laws that are enforced by police agencies in the criminal justice system.[12]

The Holy Scripture (bible) says 'Hate evil, love good and maintain justice in courts` in reality the judicial system seeks the ardent help of forensic science especially the forensic odontologist to provide dental expertise in courts and legal systems in the administration of law.[13]

In forensic odontology a great deal of effort goes into identifying the victim. One method of identification in forensic odontology is to examine the burned bodies and their fine traces, as well as to examine the resistance of teeth to high temperature.[14] Dental identification is one of the most reliable and frequently applied methods of identification and forensic odontology is a specialty in itself. 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.[14-15]

Andersen et al. (1995) classified six grades of fire injuries to teeth and jaws: (0) no injury (1) injury to anterior teeth (2) injury to anterior and posterior teeth (unilaterally) (3) injury to anterior and posterior teeth (bilaterally) (4) fragments of jaw bone including teeth roots and (5) no dental remains.[16]

It was found that the colour of the teeth was the most important indicator of their relative fragility. This confirms previous research which suggests that blackened teeth are less fragile in comparison with remains that are grey or white in colour. In our study the teeth mainly showed morphological changes from light yellow colour, yellowish brown, greyish brown passing through bluish grey, which turned completely neutral white at 1000°C. This is directly related to the level of carbonization and incineration of teeth. All of these changes were also described by Merlati et al.[10], Gunther and Schdmidt-quoted by Rotzscher.[12], Muller et al.[11], Merlati, Danesino et al.[17] and Bagdey et al.[18] & Karkhanis et al.[19] & Priyanka et al.[20], Michael A. Sandholzer et al.[21] Thus, small fragments of teeth can be identified from the burn remains and a reliable estimation of the temperature of exposure can be made. It was found that at lower temperatures the teeth fragmented into large particles and at higher temperature teeth disintegrated into numerous smaller particles. A similar observation has been reported by Karkhanis et al.[19]

From the results of our study, it is observed that teeth were not strongly affected by the temperature exposure till 100°C. Above 300°C the radiographic changes observed were a progressive formation of fissures between enamel and dentin, fractures between enamel-

dentin and within dentin, large fractures spreading through the dentin and crown crushing at $900^0$ C & $1000^0$ C. The radiographic properties of the roots were available for the analysis till the 1000°C. Our study results were similar with study done by Merlati et al , Rotzscher et al , Muller et al , Savio C et al and Bagdey et al , Priyanka et al , M. A. Sandholzer et al , Shekhawat et al.[22] , Pol, et al.[23], Verónica Parra et al.[24] , Lucero Vázquez et al.[25]

The colour of bone fragments affected by high temperatures is a function of oxygen availability, duration and temperature. Colour changes in teeth are similar to those documented in bone.[26]

At initial temperatures the organic components begin to carbonize then at higher temperatures as carbonation is completed and the carbonates begin to disappear resulting in black or dark grey colour depending 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.[27] A similar type of colour changes can be observed in teeth at different temperatures as seen in our study.

To conclude that the teeth when exposed to increasing range of temperatures, the morphologic changes takes place like change in colour, luster and intactness at crown and root. They also develop cracks, fissures and lose its structural integrity. These changes were well observed and documented in our study. Our study was an in vitro experimental observation.

In our study, once the predetermined temperatures were reached, the teeth were removed from the furnace and allowed to cool at room temperature. The controlled increment of temperature and careful handling of the specimens allowed us to observe the morphology of the tissues, a view highlighted by Fereira et al.[6] in 2008. We agree with Moreno et al.[9] who observed that in reality many other factors may complicate the effect of fire, such as the time of exposure to fire, the type of fire, the source of fire, the speed of increase in temperature and the material used to extinguish the fire.

It was interesting to note that the experimental conditions have some limitations as our study did not accurately represent the real life scenario of a fire, explosion, etc. Our study also did not take into account other possible variables present in reality, such as protection from direct exposure provided by structures such as hard and soft tissues surrounding the teeth present in the mouth.

## CONCLUSION:

Morphologic and radiographic alterations caused by fire may provide useful information about the temperature and duration of exposure to fire. It can also aid in understanding the circumstances surrounding the fire. It can be concluded that dental evidences may provide clues to solve the mystery

in fire investigations as dental structures are the last to be destroyed under extreme conditions.

Hence, our study in future can imprint the importance of the preplanned and systematic approach toward the preservation of charred dentition, as at times it could prove to be the best evidence for identification of those who are extensively burned.

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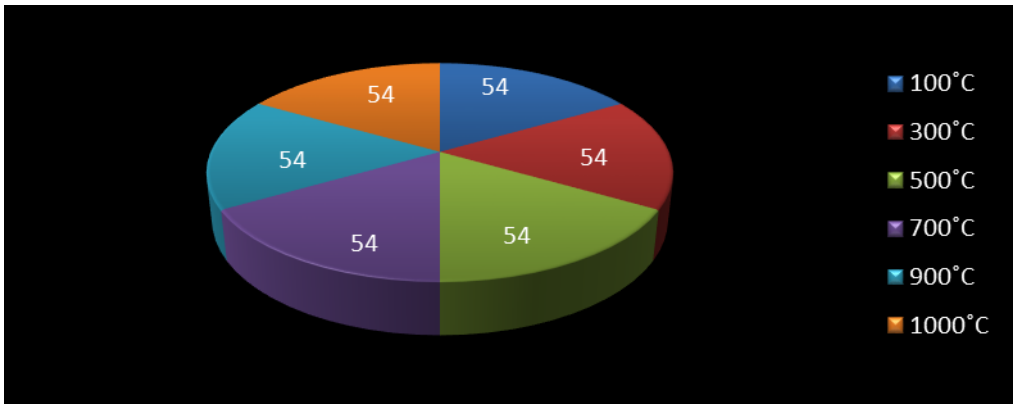
## FIGURES AND GRAPH:




Graph 1: Distribution of sample size according to various temperatures

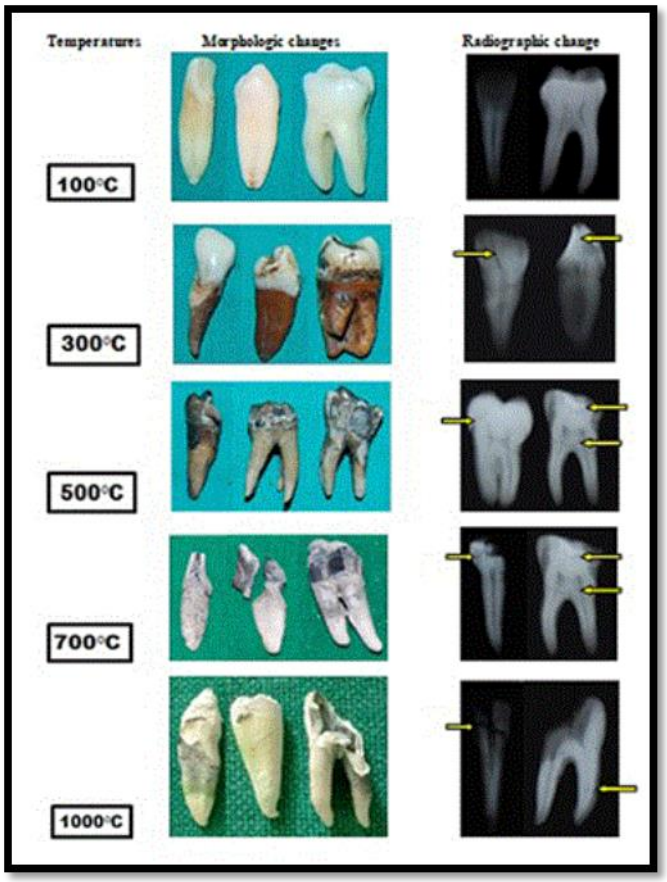



**Figure 1:**

Colour plate: Morphologic and Radiographic changes observed in teeth exposed to high temperatures for 30 minutes.

**Figure 2:** Unident muffle furnace

**TABLE:**

| Sr. No | Temperature in degrees centigrade | Duration in minutes | Sample Size | Morphologic changes | Radiographic Changes |
|---|---|---|---|---|---|
| 1 | 100 | 30 | 54 | Pale to light yellow<br>retained surface luster | No appreciable changes |
| 2 | 300 | 30 | 54 | Light gray with dark gray patches<br>Roots - Yellowish brown | Fissures between enamel and dentin |
| 3 | 500 | 30 | 54 | Enamel –Light to Dark bluish gray Patches<br>Roots - Grayish brown<br>Loss of surface luster | Fractures between enamel/dentin and within dentin |
| 4 | 700 | 30 | 54 | Light bluish gray to Dark bluish gray<br>Disintegration into small fragments | Fractures between enamel/dentin and within dentin |
| 5 | 900 | 30 | 54 | The colour of teeth changed to be natural white with bluish grey patches, fragmentation of roots were noticed | shows large fracture line spreading through dentin along with multiple fractures of roots and crown crushing |
| 6 | 1000 | 30 | 54 | Neutral white colour with Light bluish gray And Light greenish gray patches | Large fractures spreading through dentine dentin along with multiple fractures of roots and crown crushing |

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