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ORIGINAL ARTICLE

Adjunctive role of dental restorations in personal identification of burnt victims

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ABSTRACT

Background: Fire remains one of the major causes of morbidity and mortality throughout the world and identification of a body from the fatal fire remains a daunting task. Several forensic cases involve interpretation of burnt human bodies from airline and automobile accidents, bombings and unlawful cremation. Fire is also involved in homicides, suicides, accidental death, arson and in attempts to destroy forensic evidence in criminal cases. Soft tissue destruction from fire can be so extensive that conventional methods of identification may be impossible. However, teeth survive even high temperatures due to their resistant composition and so, obviously, the restorative material housed in the teeth are even more secure and can yield valuable information in personal identification. **Aim:** To assess the usefulness of most common restorations in personal identification in burnt cases**. Materials and Methods:** The study was conducted on 40 extracted teeth which were divided into four groups (Group 1 - Unrestored teeth, Group 2 - Amalgam restored, Group 3 - Glass ionomer restored and Group 4 - Composite resin restored teeth. The effect of incineration at 200°C, 400°C, 600°C, 800°C, 1000°C for 15 min at each target temperature followed by subsequent cooling was studied. **Results:** Amalgam restoration was resistant and intact even at 1000°C, whereas GIC and composite restoration are identifiable till 600°C, the residual cavity preparation leaves a clue for narrowing down the spectrum of identification.

Key words: Burn-out furnace, fire, personal identification, restorative material, stereomicroscope

INTRODUCTION

"Forensic odontology is a branch of dentistry which deals with the proper handling and examination of dental evidence and the proper evaluation and presentation of dental findings in the interest of justice." Forensic odontology has been included as a specialty in the broad arena of Forensic Sciences.[1]

Human identification has always been of utmost importance in society. It has been proposed that a human was definitively identified through dental comparison in ancient history itself. In 1st century BC, when Agrippina, mother of Roman emperor Nero, made a covert financial contract to murder Lollia Paulina. To ensure that the contract had actually been completed, Agrippina ordered that Paulina's head be brought to her. The affirmation of identification was made based on dental anomalies and peculiar alignments of Paulina's teeth.[2]

Identification of unknown individuals is of supreme importance in medico-legal cases to resolve criminal investigations, insurance settlements, issue of death certificates, remarriage, for proper burial and for grief resolution of family and friends.

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Currently, accepted forms of scientific human identification include fingerprints, dental comparison and DNA analysis. Thus, human identification by forensic odontological analysis is a well-established and reliable method.[2,3]

Personal identification from soft tissue is very difficult or even impossible in cases of putrefaction, mummification and severe burning. In such cases, hard tissues such as bones and teeth become the only materials on which a forensic investigator can bank on for precise identification.[4]

What is the rationale behind tooth as an aid in forensic identification?

1. Human dentition comprises of incisors, canines, premolars and molars that vary in shape, size and interspaces between the teeth among different individuals. Arrangement of teeth in different oral cavities are unique in each individual. On the other hand, every tooth possesses a set of unique characteristics called "tooth class characteristics" which form the basis of identification
2. Dental restorations, dental anomalies and pathologies also help in precise identification[1]
3. Teeth are protected from physical and thermal injuries by peri-oral musculature, cheeks, lips and tongue[5]
4. The highly mineralized composition, especially the outer enamel-renders the tooth most indestructible component of the human body and are resistant to putrefaction, mummification and severe burning
5. Teeth are biologically stable and contain information about the physiological and pathological events in the life of individual which remain as markers within the hard tissues of teeth. For example, young individuals taking tetracycline as tooth enamel is being formed will possess discolored striations in the clinical crown which are irreversible. Blunt root apices may indicate that individual underwent orthodontic treatment[2,6]
6. The risk of contamination with modern human or environmental DNA is less in teeth due to reduced porosity of teeth compared to bone.[7]

Teeth survive most natural disasters and provide a positive, personal identification of an otherwise unrecognizable body. Teeth and dental structures are durable under extreme conditions of prolonged, high temperatures. Maximum temperatures in human crematoria range around 950–1000°C, it has been recorded that temperatures within burning motor vehicles reach 1000°C.[8] Teeth can withstand about 650°C without appreciable loss of structures. Crowns with restorations survive even higher temperatures, about 1000°C or more as the prepared filling area may act as a vent to release pressure which otherwise would shatter due to increase in pressure in matrix of enamel and dentin as moisture evaporates.[2,9]

Although newer dental materials are appearing in the market with ever expanding frequency, the usefulness of traditional restorative materials has not been eliminated. When exposed to high temperatures, they retain a number of their original characteristics and react in a predictable manner which are often unique and offer a possibility of accurate and legally acceptable identification.[6]

Aims and objectives

1. To identify macroscopic changes of all the incinerated samples
   - By assessing tooth-restoration interface and surface changes of incinerated restored teeth using stereomicroscope
   - By assessing volumetric changes of the restoration in incinerated restored teeth
   - By assessing surface changes of unrestored teeth using stereomicroscope.
2. To assess the usefulness of restorations in personal identification.

MATERIALS AND METHODS

Teeth sampling and preparation

40 teeth (molars) which were extracted for various reasons were disinfected in 5% sodium hypochlorite solution for 2 hours. Conventional class I cavity preparation was done on occlusal surface of 30 molars and were filled with 3 very commonly used restorative materials, i.e. $N = 10$ of amalgam restorations $N = 10$ of glass ionomer (GC gold label glass ionomer 2) restorations. $N = 10$ of Composite resin (Filtek Supreme Plus 3M ESPE) restorations. Last set of teeth were left unrestored ($N = 10$ of control teeth).

Experimental conditions for fire simulation

All the teeth were mounted with phosphate bonded investment material to withstand temperatures in the range of 1000°C.

Each group consisting of unrestored teeth, composite restored teeth glass ionomer cement (GIC) restored teeth and amalgam restored teeth were subjected to 200°C, 400°C, 600°C, 800°C, 1000°C temperatures in a burn-out furnace [Figure 1] for 15 min and subsequently allowed to cool to room temperature.

Macroscopic analysis

All the samples were evaluated using the criteria as mentioned before and documented by taking photographs using Powershot Canon SX 40 h digital camera and photomicrographs at

Figure 1: Photograph showing Burnout furnace

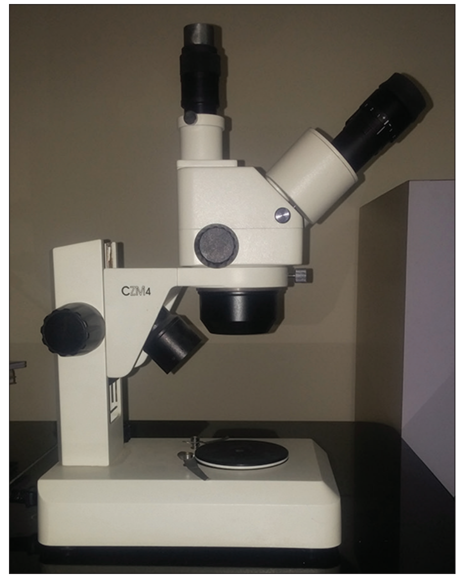

Figure 2: Photograph showing stereomicroscope

20X magnification using KYOWA CZM4 stereomicroscope [Figure 2].

Crucial considerations

Similar studies were conducted by different professionals but keeping in mind the minor drawbacks in these studies we have followed a strict protocol and have formulated crucial considerations which are as follows:

- Teeth were subjected to the particular target temperature for 15 min and then the temperature was brought down and finally allowed to cool to room temperature-simulating real life accidents
- Teeth were mounted to simulate alveolar housing
- Phosphate bonded investment material was used as mounting medium to prevent the disintegration of the mold at high temperatures in the range of (1000°C)
- Each set of teeth which were to be exposed at a particular target temperature were placed one at a time.(Not all teeth were placed in furnace once)
- Posterior teeth were only used in the study uniformly -as they tend to be better preserved than anterior teeth due to their size and the heat protection offered by adjacent tissues.

OBSERVATIONS AND RESULTS

The effect of increasing temperatures on the unrestored teeth was observed mainly in the form of color change, ranging from brown and black to grayish white. At the highest temperature they showed an ashy appearance and shattering.

On varying temperatures composite resin showed color change from off white to white. At higher temperatures they appeared chalky white. Shrinkage of restoration and loss of marginal seal were consistent.

GIC mainly showed discoloration ranging from marble white to chalky white and at higher temperatures to dark brown cracks and loss of marginal seal was a consistent finding.

Sliver amalgam initially showed granularity, loss of marginal seal, the restoration was intact even at 1000^{0}C [Figures 3-7].

The results were tabulated in detail as presented in Tables 1 to 5.

DISCUSSION

In large scale disasters associated with fire the damage caused by heat can make medico-legal identification of human remains difficult. Teeth and restorations lodged in teeth are resistant to quite high temperatures can be used as aids in the identification process. In this study, the behavior and morphology of restored and unrestored teeth exposed to a range of high temperatures was studied.

Factors such as the protection offered by the soft tissues, the rapid increase in temperature or fast cooling due to fire extinguishing agents and the presence of contaminants have not been taken into account in this study, although they might have important effects on dental tissues.[10]

The main macroscopic feature of unrestored burned tooth is the gradual change in surface color, generally ascribed to the loss of organic content.[10] Teeth exposed to lower temperatures and/or durations of heat tend to be dark black or brown in color. As temperature and/or duration increases, teeth turn blue–gray, then bleak and chalky white. This is known as calcination. At this stage, most of the protein and water have burned and evaporated

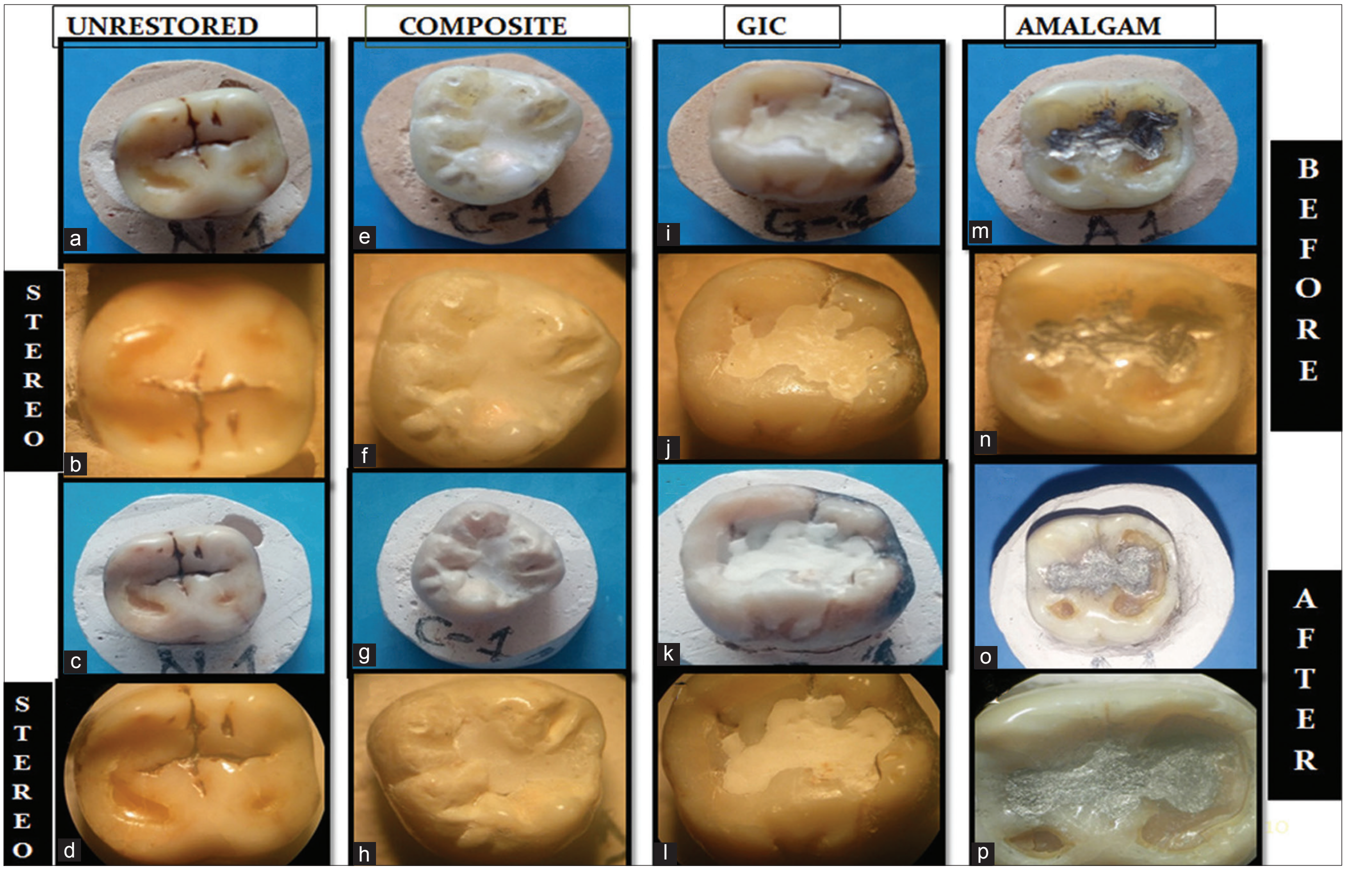

Figure 3: Visual and stereomicroscopic changes (x20) observed in the teeth at 200°C. (a and c) Unrestored tooth before and after exposure, respectively (b and d) Stereomicrographs of unrestored tooth before and after exposure, respectively. (e and g) Composite restored tooth before and after exposure, respectively. (f and h) Stereomicrographs of composite restored tooth before and after exposure, respectively. (i and k) Showing photographs of glass ionomer cement unrestored tooth before and after exposure, respectively. (j and l) Stereomicrographs of glass ionomer cement restored tooth before and after exposure, respectively. (m and o) Amalgam unrestored tooth before and after exposure, respectively. (n and p) Stereomicrographs of amalgam restored tooth before and after exposure, respectively

Table 1: Effects on different restorative materials at 200°C

Type of restoration	Time (min)	Effect
Unrestored tooth	15	Color changed from yellowish white to light brown.
Composite resin restored	15	Color of restoration changed from off white to white. Loss of marginal seal which is more obvious with SM.
Glass ionomer cement restored	15	Color changed from marble white to chalky white. Slight extrusion of restoration. Loss of marginal seal.
Amalgam restored	15	Surface of restoration depicted granularity. Spherical globules were noticed with stereomicroscope.

SM: Stereomicroscope

Table 2: Effects on different restorative materials at 400°C

Type of restoration	Time (min)	Effect
Unrestored tooth	15	Color of crown turned to light brown. Microfractures could be noticed on crown through SM.
Composite resin restored	15	Obvious retraction of restoration from cavity margins. Restoration appears to shrink towards the floor of cavity.
Glass ionomer cement restored	15	Color of restoration changed to dark brown. Obvious loss of marginal seal.
Amalgam restored	15	Surface of restoration showed granularity. Loss of marginal seal could be appreciated with SM.

SM: Stereomicroscope

and all that remains are the inorganic materials. Crowns tend to fracture along cusp margins where they are thinnest. Enamel tends to fall off the tooth almost intact as the underlying dentin shrinks more due to its greater organic content.[11]

In our study, unrestored tooth showed resistance till 600°C without appreciable loss of structures correlating with various studies and standard literature.[2] With increase in temperature outer shell tends to shatter and the color of crown turned chalky white and multiple cracks were

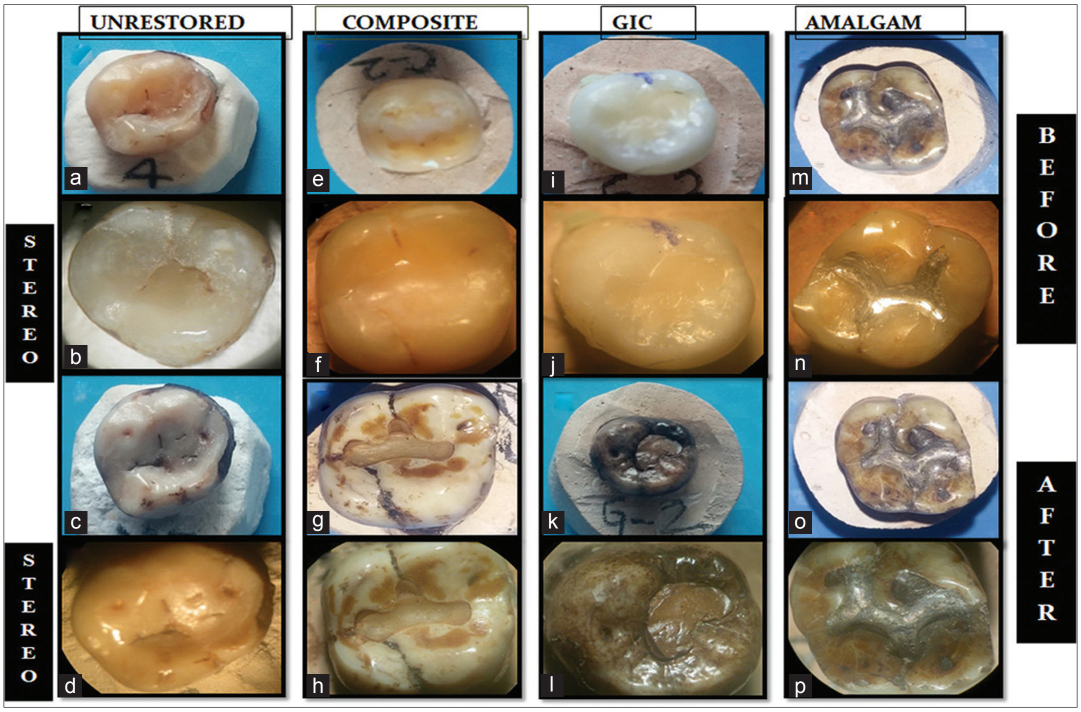

Figure 4: Visual and stereomicroscope changes (×20) at 400°C. (a and c) Unrestored tooth before and after exposure, respectively. (b and d) Stereomicrographs of unrestored tooth before and after exposure, respectively. (e and g) Composite restored tooth before and after exposure, respectively. (f and h) Stereomicrographs of composite restored tooth before and after exposure, respectively. (i and k) Glass ionomer cement unrestored tooth before and after exposure, respectively. (j and l) Stereomicrographs of glass ionomer cement restored tooth before and after exposure, respectively. (m and o) Amalgam unrestored tooth before and after exposure, respectively. (n and p) Stereomicrographs of amalgam restored tooth before and after exposure, respectively

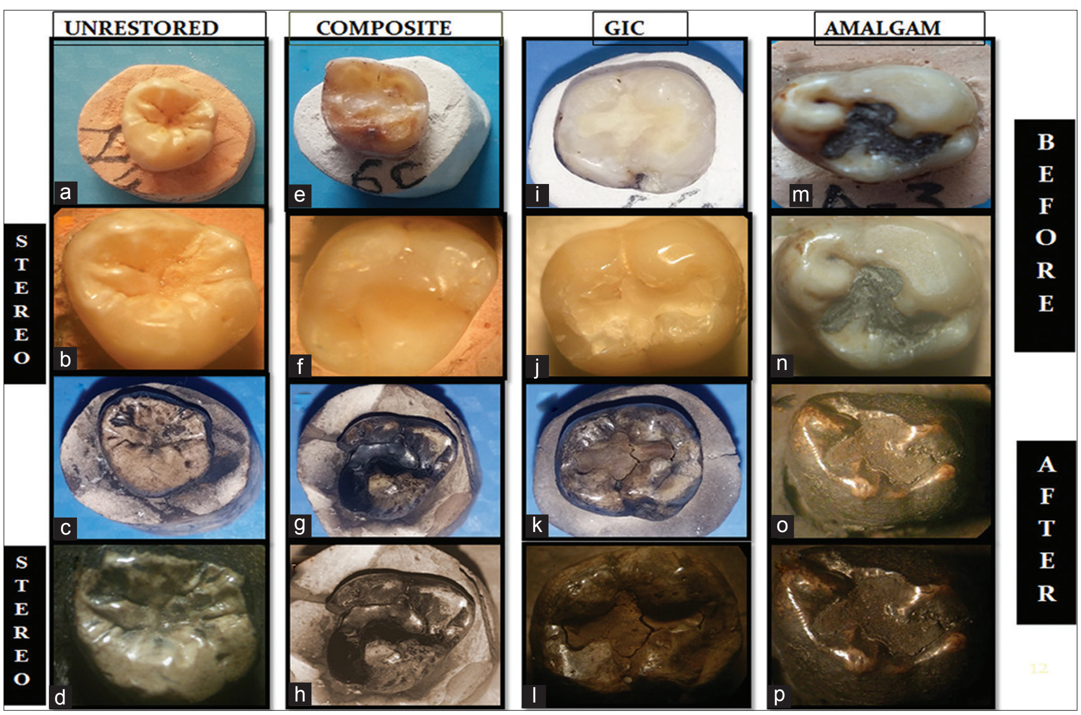

Figure 5: Visual and stereomicroscope changes (×20) at 600°C. (a and c) Unrestored tooth before and after exposure, respectively. (b and d) Stereomicrographs of unrestored tooth before and after exposure, respectively. (e and g) Composite restored tooth before and after exposure, respectively. (f and h) Stereomicrographs of composite restored tooth before and after exposure, respectively. (i and k) Glass ionomer cement unrestored tooth before and after exposure, respectively. (j and l) Stereomicrographs of Glass ionomer cement restored tooth before and after exposure, respectively. (m and o) Amalgam unrestored tooth before and after exposure, respectively. (n and p) Stereomicrographs of amalgam restored tooth before and after exposure, respectively

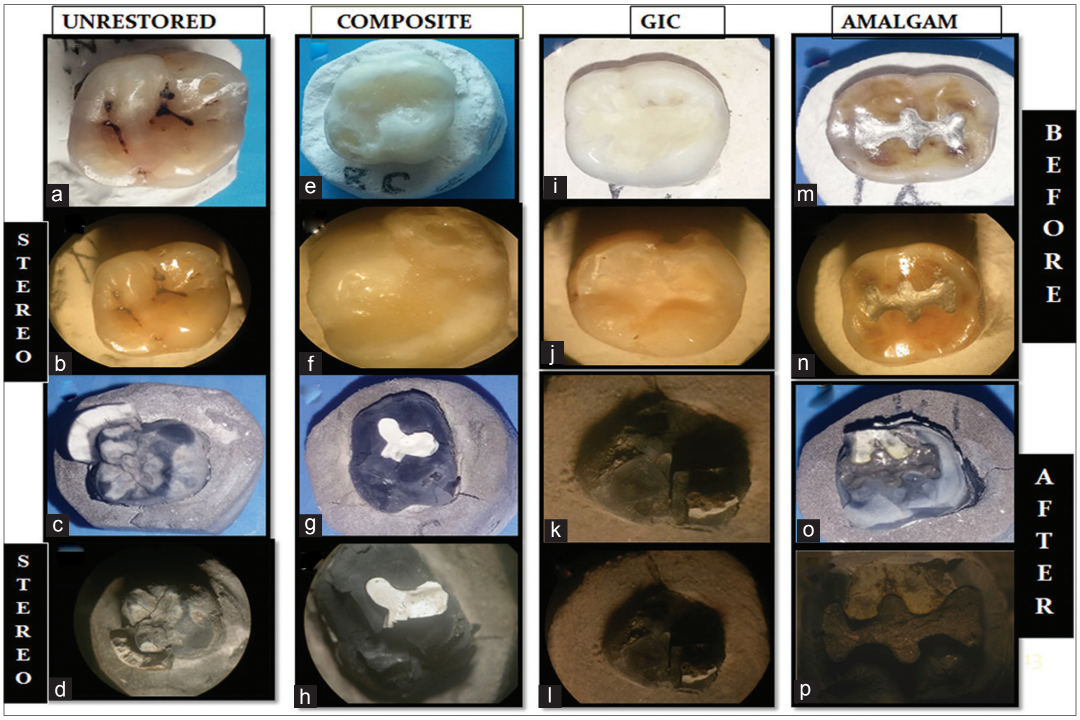

Figure 6: Visual and stereomicroscope changes (at ×20) at 800°C. (a and c) Unrestored tooth before and after exposure, respectively. (b and d) Stereomicrographs of unrestored tooth before and after exposure, respectively. (e and g) Composite restored tooth before and after exposure, respectively. (f and h) Stereomicrographs of composite restored tooth before and after exposure, respectively. (i and k) Glass ionomer cement unrestored tooth before and after exposure, respectively. (j and l) Stereomicrographs of glass ionomer cement restored tooth before and after exposure, respectively. (m and o) Amalgam unrestored tooth before and after exposure, respectively. (n and p) Stereomicrographs of amalgam restored tooth before and after exposure, respectively

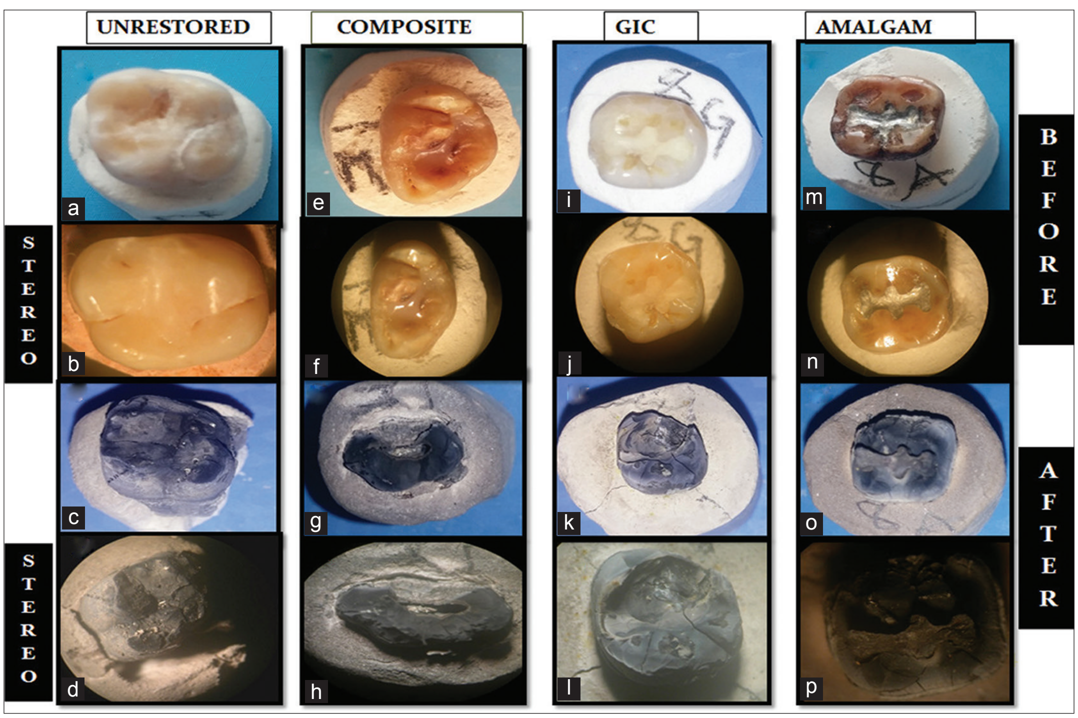

Figure 7: Visual and stereomicroscope changes (at ×20) at 1000°C. (a and c) Unrestored tooth before and after exposure, respectively. (b and d) Stereomicrographs of unrestored tooth before and after exposure, respectively. (e and g) Composite restored tooth before and after exposure, respectively. (f and h) Stereomicrographs of composite restored tooth before and after exposure, respectively. (i and k) Glass ionomer cement unrestored tooth before and after exposure, respectively. (j and l) Stereomicrographs of glass ionomer cement restored tooth before and after exposure, respectively. (m and o) amalgam unrestored tooth before and after exposure, respectively. (n and p) Stereomicrographs of amalgam restored tooth before and after exposure respectively

Table 3: Effects on different restorative materials at 600°C

Type of restoration	Time (min)	Effect
Unrestored tooth	15	Color of crown changed to dark brown to black. Micro fracture are obvious.
Composite resin restored	15	Color changed to black so was the color of crown. Crown is fractured at one margin. There is a consistent loss of marginal seal all around.
Glass ionomer cement restored	15	Color changed to dark brown. Loss of marginal seal was more pronounced. Cracks are seen on the surface of restoration.
Amalgam restored	15	Tooth surface is completely charred. Restoration surface is rough, coarse with discontinuous margins.

Table 4: Effects on different restorative materials at 800°C

Type of restoration	Time (min)	Effect
Unrestored tooth	15	Outer shell of crown shattered to pieces, The redundant crown surface is chalky white in color. Multiple cracks are visible with naked eye. The surface of crown is friable.
Composite resin restored	15	Most part of the crown is shattered. Portion of restoration is seen which is chalky white.
Glass ionomer cement restored	15	Maximal part of crown is shattered. The restoration is dislodged, keen observation with stereomicroscope revealed remnants of restoration.
Amalgam restored	15	Most part of the crown was shattered. The restoration was intact and gentle swabbing of the surface revealed shiny and granular surface.

Table 5: Effects on different restorative materials at 1000°C

Type of restoration	Time (min)	Effect
Unrestored tooth	15	Enamel separated in the form of a skull cap and residual crown appeared grayish white in color with multiple cracks on tooth surface. Surface of crown is extremely friable.
Composite resin restored	15	Restoration was completely dislodged and only redundant cavity preparation could be appreciated.
Glass ionomer cement restored	15	Restoration was completely dislodged and redundant cavity could be appreciated. Careful observation with stereomicroscope revealed remnants of restoration.
Amalgam restored	15	Entire crown was shattered. Restoration was intact.

noticed which is quiet comparable to the studies conducted by Patidar *et al*.[12]

Even at low temperatures at 200°C and 400°C there were appreciable color changes, At 600°C the composite resin changed to a grayish black, possibly due to combustion of the acrylic matrix,[13] a chalky white color was observed at 800°C. At all temperatures composite fillings typically showed considerable volumetric contraction. At above 600°C although maximal part of crown was crushed, the composite resin fillings were in place maintaining some shape till 800°C. At 1000°C temperatures, the restoration was dislodged whereas the studies conducted by Moreno *et al*. showed intact restoration even above 1000°C.[14] The residual cavity and remnants of restoration gives a clue to narrow the spectrum of identification.

Our study portrayed that teeth restored with GIC showed discoloration, loss of marginal seal, cracks till 600°C. At temperatures above 600°C, the restoration was displaced whereas in the studies conducted by Bagdey *et al*. the restoration was intact till 800°C.[15] The redundant cavity leaves a good clue to identify the type of restoration.

Amalgam exhibited globule formation at temperatures as low as 200°C which might be due to alloy dissociation, where the mercury evaporates from the alloy conglomerate.[12] Contraction and the loss of marginal seal was due to evaporation of mercury and loss of organic matrix.[15] Savio *et al*. studied the effect of high temperatures on the amalgam restorations and noticed that they were in place maintaining the shape till 1000°C,[16] correlating exactly with our present study.

CONCLUSION

Forensic dental identification of burnt victims is often a daunting task. Teeth and dental restorative materials housed in teeth can aid as valuable adjunctive or may aid directly in identification of burnt victims.

Periodic dental examination and dental record maintenance should be made mandatory for sound oral health which also aids in forensic identification.

Within the boundaries of our experimental research, we overcame some drawbacks of previous studies and we showed that our observations brought up some interesting considerations which help the identification processes in burnt victims. We will focus to improve our experimental procedures even more to simulate real life conditions.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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