FURTHER STUDY OF RESTORED AND UN-RESTORED TEETH SUBJECTED TO HIGH TEMPERATURES

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ABSTRACT

Forensic dentistry has been shown to be of fundamental importance in medico-legal investigations aimed at identifying human remains involving high temperature incidents because dental remains and prosthetic devices are resistant to quite high thermal change. In this project we studied teeth containing class I and V amalgam and composite fillings and compared them to un-restored teeth when exposed to high temperatures.

Twenty five un-restored teeth, 25 teeth with class I amalgam restorations, 25 teeth with class V amalgam restorations and 25 teeth with class I composite fillings were placed in a furnace and heated at a rate of 30°C/min. The effects at the predetermined temperatures 200, 400, 600, 800, 1000 and 1100°C were examined macroscopically and then observed microscopically by means of a stereomicroscope. Our observations showed that the class I amalgam restorations at the different temperature levels remained in place, maintaining their shape despite disintegration of the crowns, whilst the class I composite restorations remained in place but in an altered shape. Comparing restored with un-restored teeth we observed different responses in crown disintegration at the different temperature levels.

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INTRODUCTION

In events involving exposure of a human body to high temperatures, the damage caused by the heat can make medico-legal identification of human remains difficult. Of all skeletal remains, the teeth are the components that often best survive fire because of their particularly resistant composition and because they are protected by the soft tissues of the face and occasionally other elements, such as a crash-helmet, which may be present.[1]

In such situations, forensic odontology has been shown to be of fundamental importance because dental remains and prosthetic devices are resistant to quite high temperatures and can be used as aids in the identification process. Teeth and dental interventions have a large number of features that alone, or in combination, can contribute to a positive identification.[2]

Most of the features of damage to the oral tissues and dental restorations can be observed directly by the naked eye but additional microscopic investigation, either optical or electronic, is very useful in studying the finer details of the dental tissues, the surfaces involved in dental treatment and any distinguishing traits in the restorative materials present. The same is true for prosthetic devices. Therefore, the changes observed in the specimens allow a reasonably reliable estimate of the temperatures to which they have been exposed and the characteristics of the original state prior to heating. This was demonstrated in our previous study [3], which was in agreement with Carr *et al*.[4] and Muller *et al.*[5]

Our earlier study[3] showed that some prosthetic devices and restorative materials seem to resist higher temperatures than theoretically predicted. Even when a restoration is lost because of detachment or change of state, its ante-mortem presence

Table 1: Restoration dimensions

Restoration Type	Material	Tooth	Dimensions (mm)
Class I	Amalgam	Molar	5 x 3 x 3
Class I	Composite	Molar	5 x 3 x 3
Class I	Amalgam	Premolar	3 x 3 x 2
Class I	Composite	Premolar	3 x 3 x 2
Class I	Composite	Incisor	3 x 2 x 2
Class V	Amalgam	Molar	3 x 2 x 1
Class V	Amalgam	Premolar	3 x 2 x 1

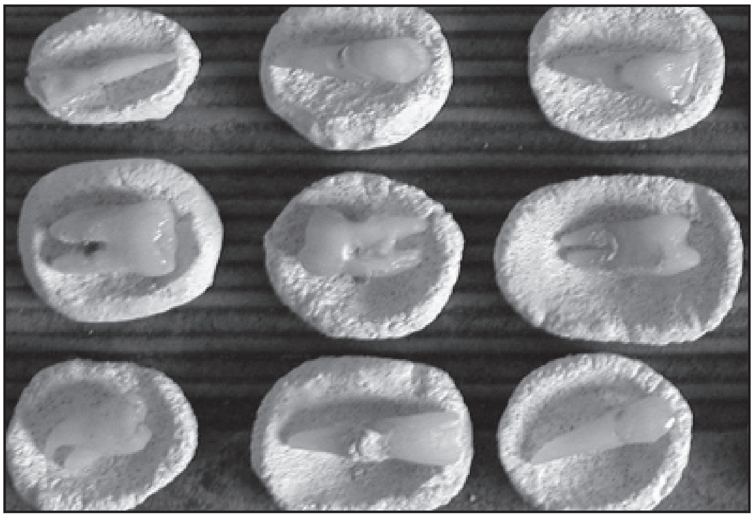

Fig 1: *Individual custom-made trays*

Table 2: *Number of samples and controls exposed to each target temperature*

°C	Class I amalgam	Class V amalgam	Class I composite	Un-restored
200	4	4	4	4
400	4	4	4	4
600	4	4	4	4
800	4	4	4	4
1000	4	4	4	4
1100	5	5	5	5

can often be detected and confirmed by examination of the morphology of the surfaces showing the residual cavities. However, after exposure to the highest temperatures, the samples become brittle and difficult to manage both by the direct handling and/or by tools (tweezers, etc.).[3]

Following these earlier observations and with the aim of contributing to useful knowledge in identifying victims involved in fires, we considered it important to carry out a further study to learn more about the variations in morphology of teeth with class I and V amalgam and composite restorations compared to un-restored teeth when exposed to a wide range of temperatures. In order to avoid the problems in the handling of the brittle samples, we used a special tray/container for each specimen made of an investment material.

**Dispersalloy©, Caulk-Dentsply, Milford DE, USA*
†Optibond© and Herculite© HRV, Kerr, Orange CA, USA
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§ECF 44, Eurocem S.r.l., Milan, It
¶Carl Zeiss Italy, Milan, Italy

MATERIALS AND METHODS:

One hundred sound teeth, extracted for periodontal reasons, disinfected in a 5% sodium hypochlorite solution for one hour and stored in a sodium chloride 0.9% solution at room temperature for up to one month, were randomly divided into two groups.

Group 1 consisted of 75 teeth which were restored following accepted procedures and manufacturers' instructions. The restorations were: 25 class I and 25 class V amalgam fillings* and 25 class I composite fillings with adhesive system application.† Table 1 shows the approximate dimensions of the restorations. Group 2 consisted of 25 un-restored teeth as a control group. After restoration all samples were stored in a 0.9 % sodium chloride solution at room temperature for one month before further tests.

Each specimen was placed in a custom made tray made of dental investment material‡ (Fig.1) and the samples were then exposed to direct heat in an oven§ at six different temperatures: 200-400-600-800-1000-1100 °C, reached at the increment rate of 30°C/minute. The number of samples and controls exposed to each target temperature is reported in Table 2. As soon as each target temperature was reached, the samples were removed from the oven and allowed to cool to room temperature. The exposure to heat for each set of specimens was the same as our last study[3] i.e. 6.66 minutes to reach 200°C; 13.33 minutes to reach 400°C; 20 minutes to reach 600°C; 26.66 minutes to reach 800°C; 33.33 minutes to reach 1000°C and 36.66 minutes to reach 1100°C. About 10 seconds was required to remove the specimens from the oven.

The samples were then examined both macroscopically and with a stereo-microscope¶ and data recorded.

RESULTS

1. Un-restored teeth:
   At each temperature stage the appearance of un-restored teeth was identical to those in our previous study. [3]

2. Restored teeth:
   200°C: all the fillings showed an unchanged marginal seal (Fig. 2). Microscopically (20 X) we detected a slight shrinkage of the fillings. The

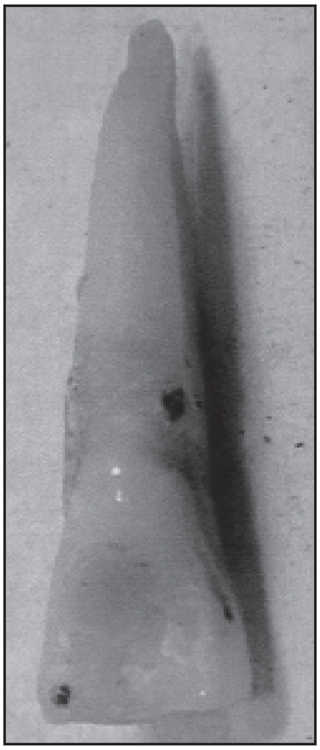

Fig.2: *Class I composite filling after exposure up to 200 °C*

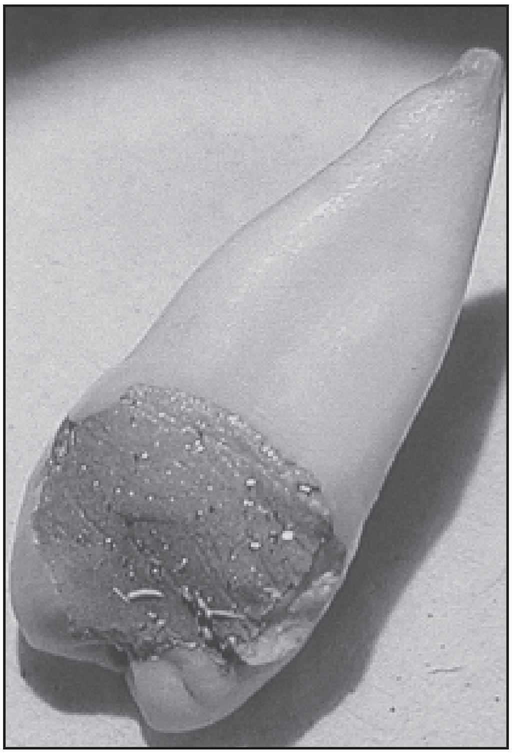

Fig.3: *Class I amalgam filling after exposure up to 200 °C*

amalgam bubbled on the surfaces indicating separation and subsequent evaporation of mercury (Fig. 3).

400°C: the amalgam fillings were in place, but showing the same phenomenon already found at 200°C. The enamel of all the samples showed fractures and the teeth were black because of the carbonisation process. The composite fillings also were black, probably due to the combustion products from the acrylic matrix. Cracks had spread over most of the composite material (Fig. 4).

600°C: macroscopically the samples were greyish, the crowns were disintegrated and the enamel fragments were detached. There were deep cracks in the roots but the fillings were in place and maintaining their shape. The composites were chalky white (Fig. 5). After handling, the crowns disintegrated completely but the fillings remained intact, maintaining both shape and dimensions.

800°C: the colour of the roots surfaces was chalky white, the crowns were greyish and there was cracking and separation between enamel and dentine as well as between dentine and fillings, while the roots remained whole. In the samples in which the crowns were intact, we observed a large fissure between dental tissues and fillings (Fig.6), while, in the samples in which the crowns were broken off, the fillings remained whole and maintained their shape. The composite fillings displayed a chalky white colour (Fig.7) with the inside surface of the fragments being blue-grey.

1000°C: the crowns of the specimens restored with amalgam had completely disintegrated but the fillings were in place and maintained their shape. The fragments of the teeth and the roots were chalky white with pinkish spots (Fig.8). Some of the crowns of teeth restored with composite resin had disintegrated, in others the fillings remained in place but in an altered shape. In both situations the colour of the composite was bright white (Fig.9) and the specimens broke at first touch.

1100°C: macroscopically, the samples fractured into chalky white and grey fragments. Where the roots were still covered by cementum there was pink staining. The amalgam restorations were still in place but partially altered in shape. The composite material was still present in some samples, although severely altered in shape and displaying a shiny white colour (Fig.10).

DISCUSSION AND CONCLUSIONS

The results of this study are identical with our previous observations with respect to un-restored teeth exposed to high temperatures. However, teeth used in this study were restored specifically, allowing uniform cavity dimensions. This contrasts with our previous study in which extracted teeth with existing restorations were used. We applied the same experimental procedures used in our first study,[3] with

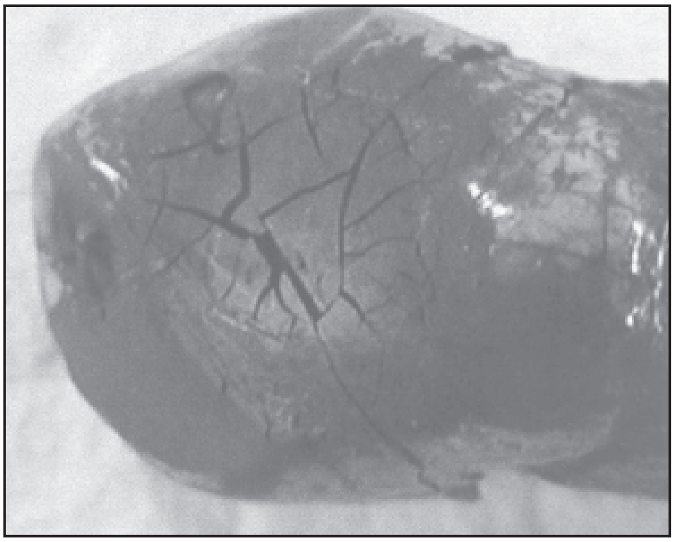

Fig.4: *Class I composite filling after exposure up to 400 °C*

improved handling and storage procedures for the samples during the thermal test. The use of a custom tray for each specimen allowed easier examination of individual teeth. Our results show the different responses of restored teeth compared to un-restored when subject to high temperature.

For the current samples containing restorations we were able to distinguish between amalgam and composite fillings despite the crown disintegration. Amalgam restorations at the different temperature levels kept their place and maintained shape, and amalgam residue was not found far from the specimens in a molten state as happened in the our first study. This was probably due to the better experimental conditions and the use of the special trays.

The composite restorations all remained in place after thermal exposure up to 1100°C. At 200°C the composite fillings were unchanged in shape, dimension and colour, which may have resulted in difficulty in detection macroscopically[6] but we observed that they could easily be identified by a stereomicroscope from the defective restoration/tooth interface.

Mechanical retention factors in the fillings contributed to post-fire retention. In our first study[3] using Class V composites we found no restorations in place after exposure to 400°C whereas in this study Class I composites, with appropriate retention, were retained at all temperatures tested.

Restored teeth appeared to show cracks and crown shattering at lower temperatures compared with un-restored teeth. This may be a result of alteration to the structural integrity of the tissue due to cavity preparation.

In our opinion, most of the identifiable characteristics of interest

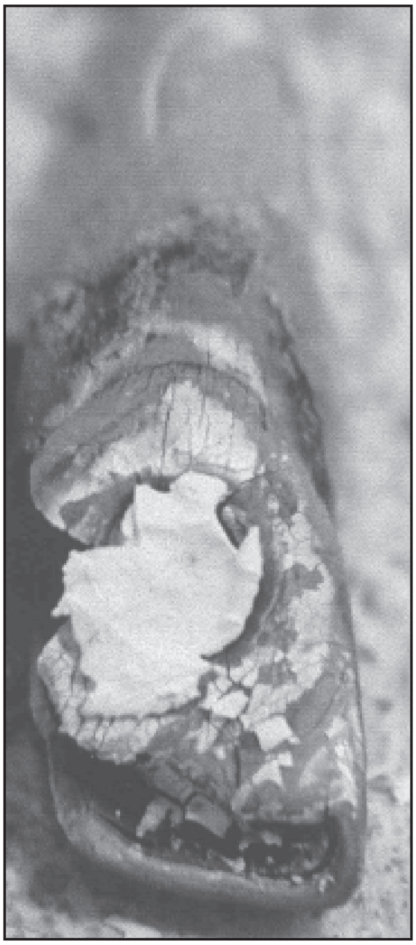

Fig.5: *Class I composite filling after exposure to heat up to 600 °C*

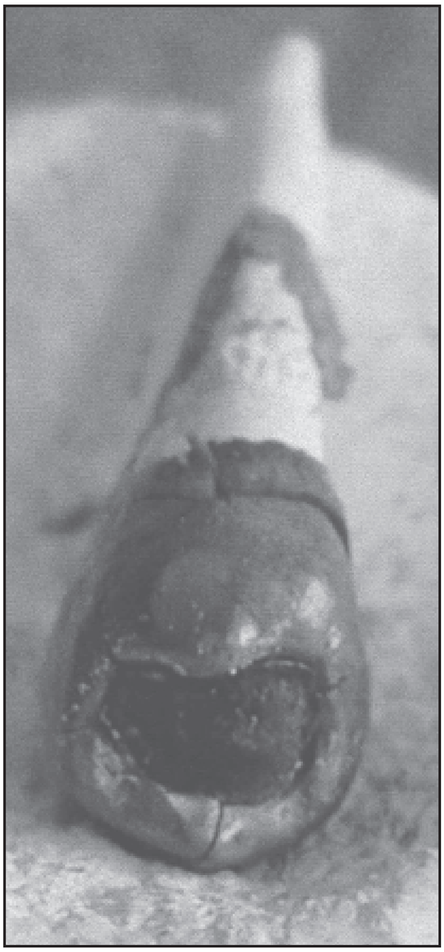

Fig.6: *Class I amalgam filling after exposure up to 800 °C*

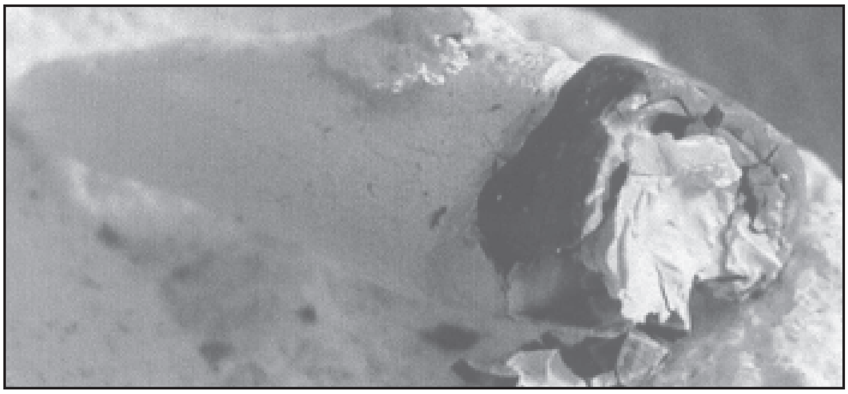

Fig.7: *Class I composite filling after exposure up to 800 °C*

are recognisable by macroscopic observation and need only be investigated further by microscopic analysis when more clarification of details is required.

Our study did not take into account possible variables present in reality such as the protection provided by the soft and hard tissues surrounding dental elements and/or dental appliances present in the mouth. Such structures protect the teeth from direct exposure to fire that would otherwise produce an early catastrophic evaporation of the organic component with consequent separation of the crowns. In our experiments such a phenomenon was observed above 800°C.

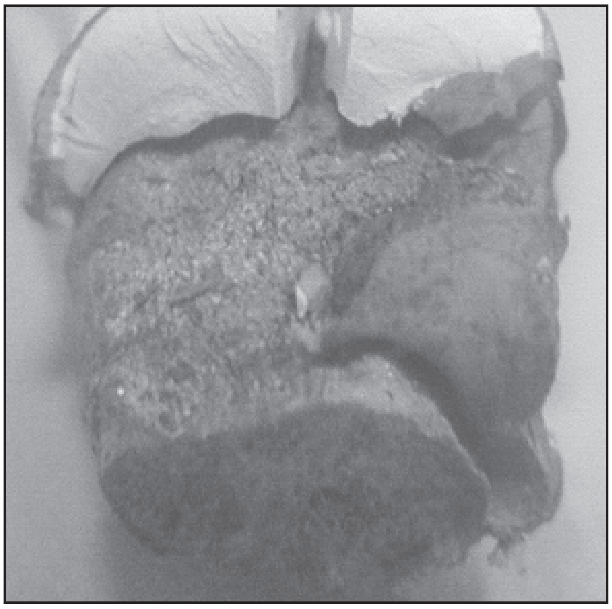

Fig.8: *Class I amalgam filling after exposure up to 1000 °C*

In our experiments, once the pre-determined temperatures were reached, the samples were removed from the oven and allowed to cool at room temperature. The materials were therefore subjected to only one controlled and limited thermal shock. In reality many factors may further complicate the effect of the fire on the tissues and materials such as the time of exposure to the fire, the type of fire, the speed of increase in temperature as well as the substances used to the extinguish the fire. All of these factors need to be considered in evaluating the specimens for forensic analysis.

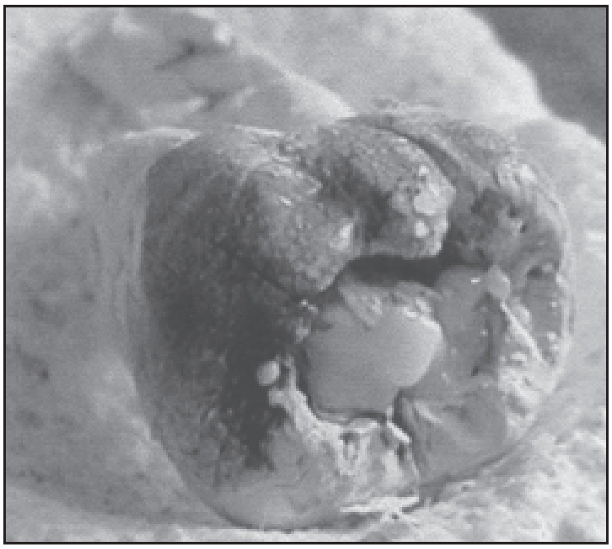

Fig.9: *Class I composite filling after exposure up to 1000 °C*

Fig.10: *Class I composite filling after exposure up to 1100 °C*

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