Case Report

Charred: Forensic dental identification and scanning electron microscope

Luiz Francesquini Júnior, Viviane Ulbricht[1], Adriano Luis Martins[2], Rhonan Ferreira Silva[3], João Sarmento Pereira Neto[4], Eduardo Daruge Júnior

Departments of Social Dentistry, [1]Anatomy, [2]Biologist Supervisor – CEMI School of Dentistry of Piracicaba, State University of Campinas, [4]Department of Ortodonthic and Pediatric, School of Dentistry of Piracicaba, State University of Campinas, Campinas, SP, [3]Department of Social Dentistry, School of Dentistry of Federal University, Goiás, Brazil

Address for correspondence:
Dr. Luiz Francesquini Júnior, Department of Social Dentistry, School of Dentistry of Piracicaba, State University of Campinas, Avenida Limeira, 901, Piracicaba, SP, Brazil.
E-mail: francesq@unicamp.br

Abstract

The identification of bone and dental remains to establish identity, requested by police and judicial authorities, has increased annually because criminals have been using sophisticated methods that make this identification impractical. This study reports a murder case by charring, which creates dental and bone calcination. In 2013, a completely burned car was examined by forensic experts, containing charred, calcined human bones and teeth inside its trunk, thus an identity needed to be established. The scanning electron microscope (SEM) was used as a supporting method and indicated the presence of restorative materials, which were compatible and consistent with the chart and radiographic shots provided by the victim's dental surgeon. The SEM examination reinforced the positive identification of the alleged victim performed by comparative radiographic examinations (antemortem and postmortem) in the dental fragments found. It is a supporting method that, even though it does not establish the identity, it helps in the process of identification.

Key words: Electron microscopy, forensic anthropology, forensic odontology

Introduction

Organized crime in Brazil spares no effort to eliminate or reduce the possibility of leaving traces in the crime scene, making it difficult to identify the victims and the perpetrators. The most-used way to this end is to burn cars, places, and bodies, which generates destructive forces by heat in the human body (carbonization and/or calcination). This destructive force (heat), in most cases, is designed to consume the entire corpse, leaving only dental and bone structures and/or prosthetics.

In a study on the effect of heat in vehicles set on fire,[1] it was found that the internal temperature can reach 1832°F. As for titanium, the melting point is above 3002°F.[2]

Access this article online	
Website: www.jfds.org	Quick Response Code
DOI: 10.4103/jfo.jfds_65_18	

How to cite this article: Francesquini Júnior L, Ulbricht V, Martins AL, Silva RF, Pereira Neto JS, Daruge Júnior E. Charred: Forensic dental identification and scanning electron microscope. J Forensic Dent Sci 2018;10:164-8.

Some studies[3,4] investigated the destruction phases (carbonization) for each segment of the human body exposed to a temperature of 1256°F; the arms were carbonized after 10 min, the legs after 14 min, facial and arm bones after 15 min, ribs and skull after 20 min, tibia after 25 min, and the tights and femur were completely carbonized after 35 min.

After studying[5] the effects of high temperatures in different restorative materials (amalgam, porcelain, and ionomer) and intact teeth, exposed to temperatures of 392°F, 752°F, 1472°F, and 1832°F, they observed that intact teeth subjected to 392°F had no alterations, while ionomer showed cracks. All the materials presented marginal contraction at 752°F except for the porcelain; the intact teeth presented cracks on the crown and roots and the ionomer also presented cracks. The ionomer and the intact teeth fragmented at 1472°F, the amalgam presented cracks, and the ceramic crowns were separated in the cervical region. All the dental materials and the dental crown fragmented at 1832°F, except for the porcelain and dental root.

The restorative materials behaved in a different way depending on the time of exposure and form of incidence on the teeth (direct or not).[6] According to those authors, it is a complex task when the victim was incinerated to the point where only fragments of teeth and bones remained.

This article reports a murder case by charring that generated dental and bone calcination. The identification by the dental radiography method (primary method of identification), established by Interpol,[7] was possible by superposing the image of the calcinated root of the tooth 46, as well as measuring implants 45 and 47, which had been X-raid in life.

Case Report

In 2013, the Military Police found a car completely burned with charred, calcinated human bones and teeth, as well as fragments of glass and metal parts of the car, dental roots, and part of a maxilla with implant-/individual-fixed metal–ceramic prosthesis exposed to heat [Figure 1].

In this case, the victim's six implants did not melt, which shows that the temperature did not reach 1650°C (titanium melting point)[2]

However, the temperature may have reached 1832°F near the skull, as the roots, implants, metal–ceramic crowns, and skull bone fragments remained.

Fifteen days after the car was found by the police, the forensic odontology team of FOP/UNICAMP was asked to help identify the victim, going with the police authority to impounded vehicle yard. A new search was carried out in the burned car to find more bone and dental fragments that could have passed unnoticed in the first one. All materials present in the vehicle were "shifted" to find more evidence and/or clues that could somehow assist in the identification process. During this new perinecroscopy, two other dental implants were found with their respective prosthetic crowns, as well as other dental roots and bone fragments.

Figure 1: Dental roots and part of the maxilla with four implants

Radiographic examination

Radiographic examinations were performed in all dental fragments and implants found at the crime scene (inside the trunk), and those are arranged in anatomical position [Figure 1].

The maxilla was partially reconstructed through bone juxtaposition and complementation with wax, performing occlusal radiographic shots of it [Figure 1].

The alleged victim's dental chart was obtained from the dental surgeon who attended it in life. The chart had a panoramic [Figure 2] and two periapical radiographs and six clinical files, with tags indicating implant insertion (Emfils Ref. CRCE-4011 Ø 4.0 × 11.5 mm Lot. 005286).

Such chart could only be found because the burned car belonged to the alleged victim. With a name in hand, the radiologic clinics in the victim's supposed region of origin were asked about the records of radiographic shots and, in one of them, a dental surgeon was indicated. He, when requested, provided the documents concerning the victim's treatment.

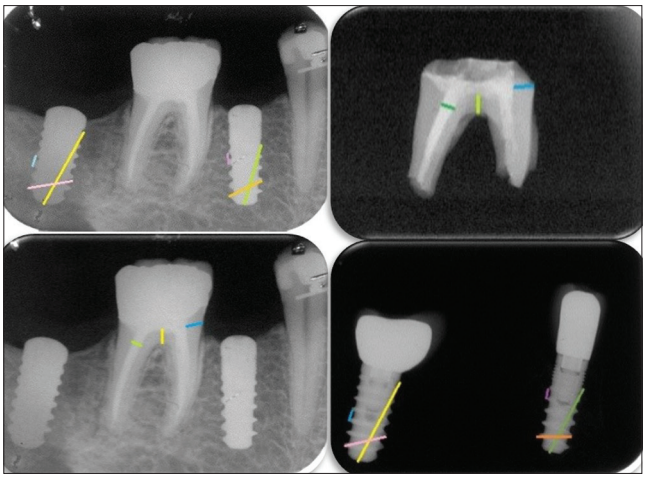

Figure 2: Antemortem and postmortem radiography with measurements

The antemortem (AM) and postmortem (PM) radiographic images of the implants 45 and 46 and teeth 46 were compared.

Using the software ImageJ® (ITK-SNAP, Pensilvânia, EUA), linear measurements were performed between implant and teeth points of the radiographs observed in Figure 3 and in Tables 1 and 2.

The radiographic shots taken in life may have a degree of distortion, which can explain the larger value of measurements obtained in AM periapical radiographs.

The transparency feature was used (in six different gradations) to verify the coincidence of the anatomical shape of part of the tooth 46 with the endodontically treated canal.

Figures 4 and 5 depict the comparative chart dental findings (AM and PM).

Scanning electron microscope as a complementary method

After examinations with radiographic images, all recovered dental materials were examined through scanning electron microscope (SEM) to prove if the existence of restorative materials in the dental fragments found corresponded to those listed in the dental work in the alleged victim's chart. After analyzing the implants found and their respective metal–ceramic crowns that survived the temperature, four anterior implants (lateral incisors 12 and 22 and central 11 and 21) and two posteriors (second premolar 45 and second molar 47), a very low quantity of calcium and phosphate was observed in the spectrum obtained through X-ray microanalysis (energy-dispersive X-ray spectroscopy [EDS]), probably from the osseointegration adhered to the implant.

In the spectrum obtained through EDS, a large amount of commercially pure titanium was observed, corresponding to the implant of the supposed victim, according to what appears in his dental chart [Figure 6].

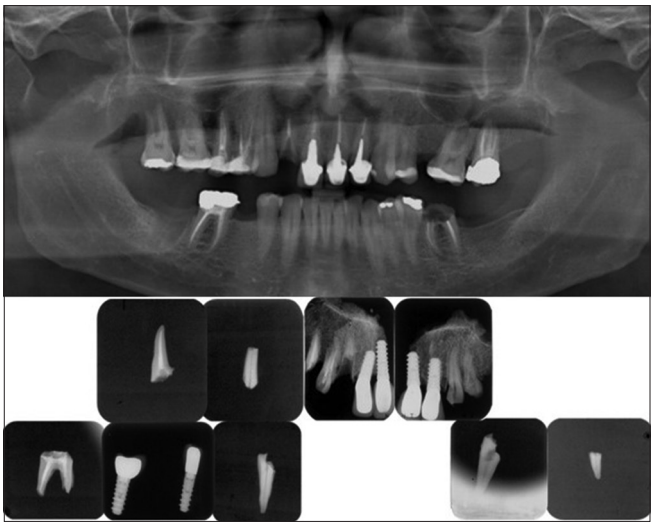

Figure 3: Panoramic radiography antemortem before implants of 2010 and postmortem radiography roots

Table 1: Linear measurements using ImageJ

Length (mm)	Antemortem	Postmortem
Implant 47 length	10.543	10.405
Implant 45 length	8.695	8.189
Distance between the threads of implant 45	1.452	1.417
Implant 47 width	4.697	4.700
Implant 45 width	4.134	4.091

Table 2: Linear measurements using ImageJ

Length (mm)	Antemortem	Postmortem
Furcation until pulp chamber	1.593	1.613
Distal channel width	0.907	0.949
Wall width of the mesial root	1.7675	1.675

The company Emfils® was contacted, which promptly provided the composition of Type 2 titanium alloy (implants made with commercially pure titanium).

In the alleged victim's chart from 2012 provided by the dental surgeon, there are tags with the implants' lot numbers, and those refer to the implants inserted in the maxilla and mandible, which were made with Type 2 alloy.

Viana[8] stated that Nobel-Biocare™ and Straumann™ were the most popular manufacturers in the world, and they used commercially pure titanium.

The use of aluminum to manufacture vehicles is quite widespread: not only small motor parts, but also wheels, body, and structures, and its melting point is 1218,2°F.[9]

Vanadium was also found in the implant's surface and, according to Figueiredo *et al*.,[10] "Vanadium originated

TOOTH	AM	PM	Outcome	SEM	
11	Dental implant with fixed metal-ceramic prothesis.	Dental implant with fixed metal-ceramic prothesis.	Coincidence	Spectrum obtained through X-Ray microanalysis characterized by EDS, discriminating the analyzed elements of the implant and metal-ceramic crown.	Coincidence
12	Dental implant with fixed metal-ceramic prothesis.	Dental implant with fixed metal-ceramic prothesis.	Coincidence	Spectrum obtained through X-Ray microanalysis characterized by EDS, discriminating the analyzed elements of the implant and metal-ceramic crown.	Coincidence
13	Resin distal restoration	Impaired. Crown very fragmented.	Impaired.		
14	Endodontic treatment, MOD amalgam restoration	Endodontic treated root Crown very fragmented.	Coincidence		
15	Endodontic treatment, MOD amalgam restoration	Endodontic treated root Crown very fragmented.	Coincidence		
16	MOD amalgam restoration	Impaired. Tooth not found.	Impaired.		
17	Occlusal amalgam restoration	Impaired. Tooth not found.	Impaired.		
18	Absent	Absent	Coincidence		
21	Dental implant with fixed metal-ceramic prothesis.	Dental implant with fixed metal-ceramic prothesis.	Coincidence	Spectrum obtained through X-Ray microanalysis characterized by EDS, discriminating the analyzed elements of the implant and metal-ceramic crown.	Coincidence
22	Dental implant with fixed metal-ceramic prothesis.	Dental implant with fixed metal-ceramic prothesis.	Coincidence	Spectrum obtained through X-Ray microanalysis characterized by EDS, discriminating the analyzed elements of the implant and metal-ceramic crown.	Coincidence
23	Resin restoration on mesial	Present. The crown was partially destroyed.	Impaired.		
24	MO amalgam restoration	Present. The crown was partially destroyed.	Impaired.		
25	Absent	Absent	Coincidence		
26	MO amalgam restoration	Impaired. Tooth not found.	Impaired.		
27	Endodontic treatment, MODVP amalgam restoration	Impaired. Tooth not found.	Impaired.		
28	Absent	Absent	Coincidence		

Legend:

AM = Dental signaling characters before death.
PM = Dental signaling characters of dead victim.
MOD = Mesial, Distal and Occlusal Restoration
OM = Occlusal and Mesial Restoration
OD = Occlusal and Distal Restoration
MODV = Occlusal, Mesial, Distal and Vestibular Restoration

Figure 4: Dental upper register antemortem

TOOTH	AM	PM	Outcome	SEM	
31	Healthy	Impaired. Tooth not found.	Impaired.		
32	Healthy	Impaired. Tooth not found.	Impaired.		
33	Healthy	Impaired. Tooth not found.	Impaired.		
34	Occlusal amalgam restoration	Impaired. Tooth not found.	Impaired.		
35	ODI amalgam restoration	Impaired. Tooth not found.	Impaired.		
36	Indication of tooth extraction, root with endodontic treatment	Absent Teeth extracted in life.	Coincidence		
37	Absent	Absent	Coincidence		
38	Absent	Absent	Coincidence		
41	Healthy	Impaired. Tooth not found.	Impaired.		
42	Healthy	Impaired. Tooth not found.	Impaired.		
43	Healthy	Impaired. Tooth not found.	Impaired.		
44	OD restauration in resin	Impaired. Tooth not found.	Impaired.		
45	Dental implant with fixed metal-ceramic prothesis.	Dental implant with fixed metal-ceramic prothesis.	Coincidence	Spectrum obtained through X-Ray microanalysis characterized by EDS, discriminating the analyzed elements of the implant and metal-ceramic crown.	Coincidence
46	Endodontic treatment, MODV amalgam restoration	Root fragment with endodontic treatment	Coincidence		
47	Dental implant with fixed metal-ceramic prothesis.	Dental implant with fixed metal-ceramic prothesis.	Coincidence	Spectrum obtained through X-Ray microanalysis characterized by EDS, discriminating the analyzed elements of the implant and metal-ceramic crown.	Coincidence
48	Absent	Absent	Coincidence		

Caption:

AM = Dental signaling characters before death.
PM = Dental signaling characters of dead victim.
MOD = Mesial, Distal and Occlusal Restoration
OM = Occlusal and Mesial Restoration
OD = Occlusal and Distal Restoration
MODV = Occlusal, Mesial, Distal and Vestibular Restoration

Figure 5: Dental upper register postmortem

from burning fossil fuels is emitted as oxides, including VO, V_2O_3, V_2O_4, and V_2O_5; however, during combustion, most of the vanadium is emitted as V_2O_5." Thus, contamination by vanadium may have occurred by the burning of fossil fuels and tires. Furthermore, remnants of restorative materials were found (resin and amalgam).

Discussion

In this study, the SEM was used which was a supporting method and indicated the presence of restorative materials compatible and consistent with the chart and radiographic shots provided by the victim's dental surgeon, as well as the composition (spectrum) of the implants found in the calcinated remains which are compatible with the type of alloy (Type 2) used in implants in 2011 and 2012.

When carbonized, teeth can suffer alteration of color, not only on restorations, but also on the enamel and cementum, including shape and volume. It can equally calcinate and fragment, which makes identification impossible.[11] This situation is referred by Bagdey *et al*.,[12] who stated that in carbonized victims, amalgam restorations presented changes (of color and texture and contraction) at all temperatures.

It should be noted that when[13] the restorative materials such as amalgam, composite resin, and glass ionomer were analyzed at high temperatures, compared with unrestored teeth, they observed visual and stereomicroscopic changes of coloration. They concluded that such modifications can help the identification process.[14]

In cases of crime with carbonized bodies, due to the high temperatures, the metals can melt (amalgam restoration, bullets, and prothesis) and the bones may calcinate, so that traces disappear, and it is impossible to determine the death cause.[4]

In this case, the temperature inside the trunk may have oscillated from 1832°F to 3002°F, as only a few bone and teeth fragments remained (including the crown, which was lost), but it did not go over 3002°F because the titanium did not melt.

The SEM examination can show details of the chemical composition of the analyzed materials, such as restorations, prosthesis, and implants, which is of great value, because it helps to confront information obtained AM with PM, especially when so little information and traces remained in the crime scene. It is a supporting method that, even though it does not establish the identity, it helps in the process of identification.

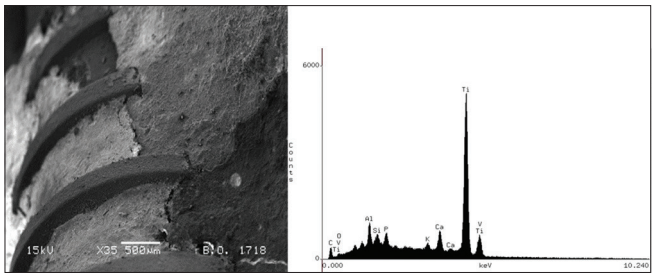

Figure 6: Electron photomicrograph, graphic of spectrum obtained through X-ray microanalysis, showing the large amount of titanium

The SEM examination performed in this case reinforced the victim's positive identification through comparative radiographic examinations (AM and PM) of the dental fragments found. The team that will work in the identification must be aware that the calcinated bone elements are fragile as well as prepared to search the crime scene to collect all dental and bone elements that can contribute to the positive identification. All available methods should be used to develop them and to enable the forensic dentist to effectively use them.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

References

1. Dehaan JD. Kirk's Fire Investigation. Publisher: Prentice Hall; 5 edition (January 25, 2002);. p. 234.
2. Berketa J, James H, Marino V. Dental implant changes following incineration. Forensic Sci Int 2011;207:50-4.
3. Richards NF. Fire investigation – Destruction of corpses. Med Sci Law 1977;17:79-82.
4. Silva RF, Pereira SD, Prado FB, Daruge E 2nd, Daruge E. Forensic odontology identification using smile photograph analysis – Case reports. J Forensic Odontostomatol 2008;26:12-7.
5. Pol CA, Ghige SK, Gosavi SR, Hazarey VK. Effects of elevated temperatures on different restorative materials: An aid to forensic identification processes. J Forensic Dent Sci 2015;7:148-52.
6. Reesu GV, Augustine J, Urs AB. Forensic considerations when dealing with incinerated human dental remains. J Forensic Leg Med 2015;29:13-7.
7. INTERPOL Disaster Victim Identification Guide: INTERPOL 2014 (Proposed Amendments: March 2014).
8. Viana "Commercial Forms of Dental Implants", Monograph presented for the title of Specialist in Dentistry, in post graduation, CIODONTO; 2010. p. 45.
9. Santos WA, Paulista CR, Pessanha DC, Erthal M Jr., Reis AC. A Brief analysis of the use of 6061 aluminum alloy in automotive bodies., XIII CIBEM –Lisboa; 2017. p. 2-8.
10. Figueiredo AM, Enzweilwe J, Sígolo JB, Camargo SP, Gumiero FC, Pavese A. Evaluation of the vanadium concentration in parks of the city of São Paulo, XIII Brazilian Congress of Geochemistry; 2011.
11. Patidar KA, Parwani R, Wanjari S. Effects of high temperature on different restorations in forensic identification: Dental samples and mandible. J Forensic Dent Sci 2010;2:37-43.
12. Bagdey SP, Moharil RB, Dive AM, Thakur S, Bodhade A, Dhobley AA. Effect of various temperatures on restored and unrestored teeth: A forensic study. J Forensic Dent Sci 2014;6:62-6.
13. Vandrangi SK, Radhika MB, Paremala K, Reshma V, Sudhakara M, Hosthor SS. Adjunctive role of dental restorations in personal identification of burnt victims. J Oral Maxillofac Pathol 2016;20:154-61.
14. Albuquerque Neto AD, Farias Neto AM, Cavalcante JR, Cavalcante DK, Sampaio TR, Costa VS. Effect of high temperatures to the oro-dental tissues and dental materials: A review. Rev Bras Odontol Leg 2015;2:89-104.