CASE REPORT

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SEM Analysis of Incinerated Teeth As an Aid to Positive Identification

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ABSTRACT: Tooth crown and root fragments from a crime scene in which the remains were purposefully cremated, crushed and scattered were analyzed using a scanning electron microscope (SEM) in order to aid the identification process. The SEM was used to confirm the presence of parallel striations in tooth enamel and dentine as a means of determining past dental restoration. In the case presented, incinerated tooth fragments of determined type and position were subjected to SEM analysis, and ascertained to have had previous dental work that matched antemortem dental records of a missing person.

KEYWORDS: odontology, microscopy, positive identification, human identification, forensic anthropology

Identification of remains from some forensic contexts may require a comparison of postmortem and antemortem dental records. In cases of mass disasters, or any situation in which features are unrecognizable, this technique has proved to be highly reliable [*1–3*]. By necessity, dental comparison requires well preserved dental remains and access to antemortem dental records. Problems arise when dental records either cannot be located or the individual has never sought dental treatment. In some instances the situation may be somewhat reversed; the dental records are available, and of the highest quality, yet, the dental remains recovered from the scene are damaged to such an extent that many of the recognizable features of prior dental work are not evident. In one extreme example, a scanning electron microscope (SEM) was used to identify highly charred materials as dental tissues [*4*]. This case report details the use of an SEM to identify the position and type of dental restoration on tooth root and crown fragments subjected to high temperatures, purposeful crushing and scattering. This technique, coupled with other forms of morphological information, resulted in a positive identification.

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TABLE 1—*Identification of incinerated teeth according to type and position.*

Evidence #	Tooth Identification
1. 158 (8)	Upper Right Central Incisor Crown and Partial Root
2. 93 (9)	Upper Right First Premolar Root and Crown Dentine
3. 158 (10)	Upper Right Second Premolar Half Crown[a]
4. 136 (11)	Upper Right First Molar Root and Crown Dentine
5. 16 (12)	Upper Right Second Molar Root and Crown Dentine
6. 16 (19)	Upper Left First Premolar Root and Crown Dentine[a]
7. 158 (18)	Upper Left First Molar Root and Crown Dentine
8. 167 (15)	Lower Right First Molar Root and Crown Dentine
9. 167 (14)	Lower Right Second Molar Root and Crown Dentine
10. 158 (13)	Lower Right Third Molar Root and Crown Dentine
11. 93 (7)	Lower Left Central Incisor Partial Root and Crown Dentine
12. 167 (16)	Lower Left First Molar Root and Alveolus Fragment
13. 158 (17)	Lower Left Second Molar Root and Crown Dentine

[a]Indicates that the tooth was subjected to SEM analysis.

The Crime Scene

In early September of 1992 the author was contacted by the Sudbury Regional Police Service (SRPS) to examine an area of charred material discovered in and around a stone block and concrete fire pit behind a suburban home in the city of Sudbury, Ontario. The police had responded to enquiries by family and co-workers as to the whereabouts of a 48-year-old man who had not been heard from for several weeks. The missing man's

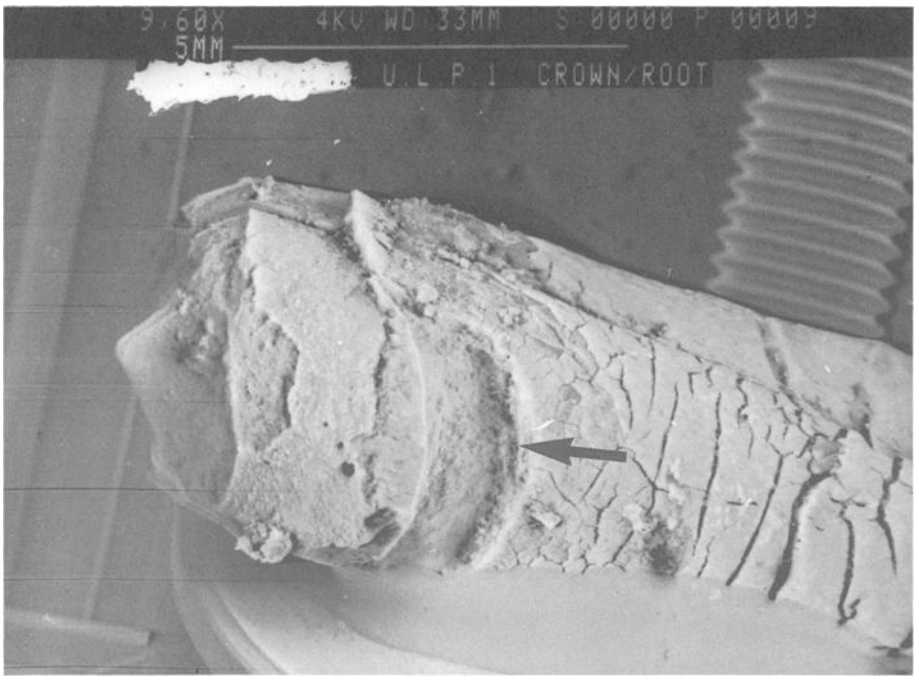

FIG. 1—*Scanning electron micrograph of tooth 16(19), upper left first premolar. Arrow indicates crescent-shaped indentation.*

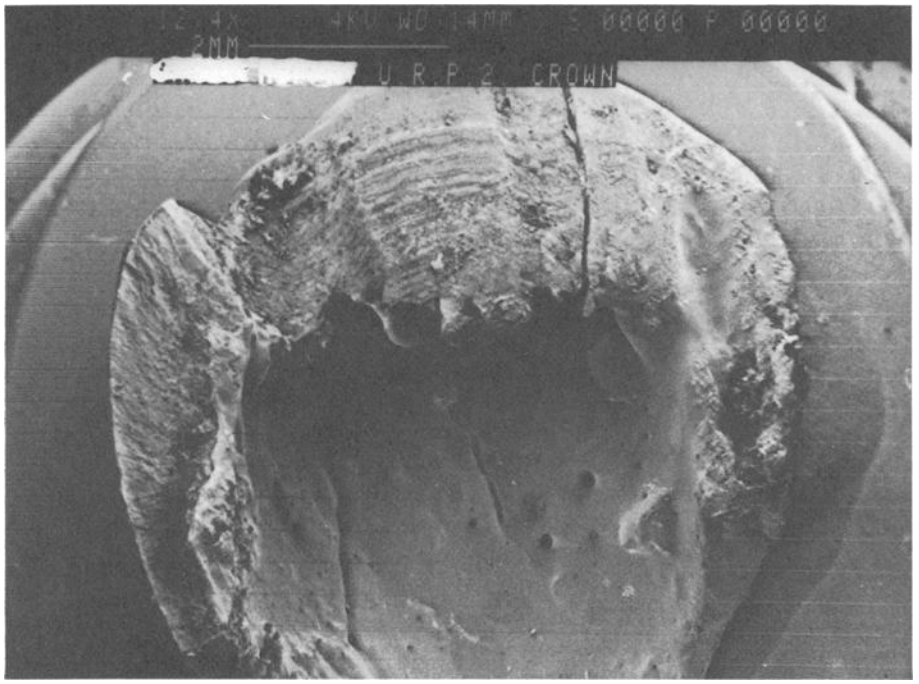

FIG. 2—*Scanning electron micrograph of tooth 158(10), upper right second premolar showing surface suspected of indicating evidence of previous dental drilling. Heat-induced fractures resulted in the mesial and distal margins.*

duties as a traveling dental equipment salesman explained why no inquiries were made any sooner.

It was evident to the author that commingled with the ash and charred wood (which included a charred creosoted railway tie) that many bone fragments, with heat-induced fractures and evidence of purposeful crushing and scattering, were widely dispersed across a 9 square metre area. The presence of the largest bone fragment, an almost complete adult occipital bone in the fire pit, immediately confirmed the presence of human remains. At the request of the police the author worked with the identification branch of the SRPS in the systematic recovery and subsequent analysis of the remains. Standard forensic archaeological technique was used in the recording of the context of each fragment of bone and tooth recovered. To be sure no tooth fragments were missing, the ash was sifted using screens with a 1 mm mesh. If it were not for this practice, the dental remains would not have been recovered to the extent they were.

Inventory of Elements Present

The inventory was conducted in order to identify each bone and tooth fragment as to its type and location in the body. Due to the extreme fragmentation of the cremated remains it was not possible to ascribe each fragment to its anatomical position. However, it is significant to note that the inventory was consistent with one individual and that all regions of the body were represented without duplication. In addition, the mass of the bone and tooth remains was consistent with one adult individual.

The tooth fragments were identified as to their type and position. This process was

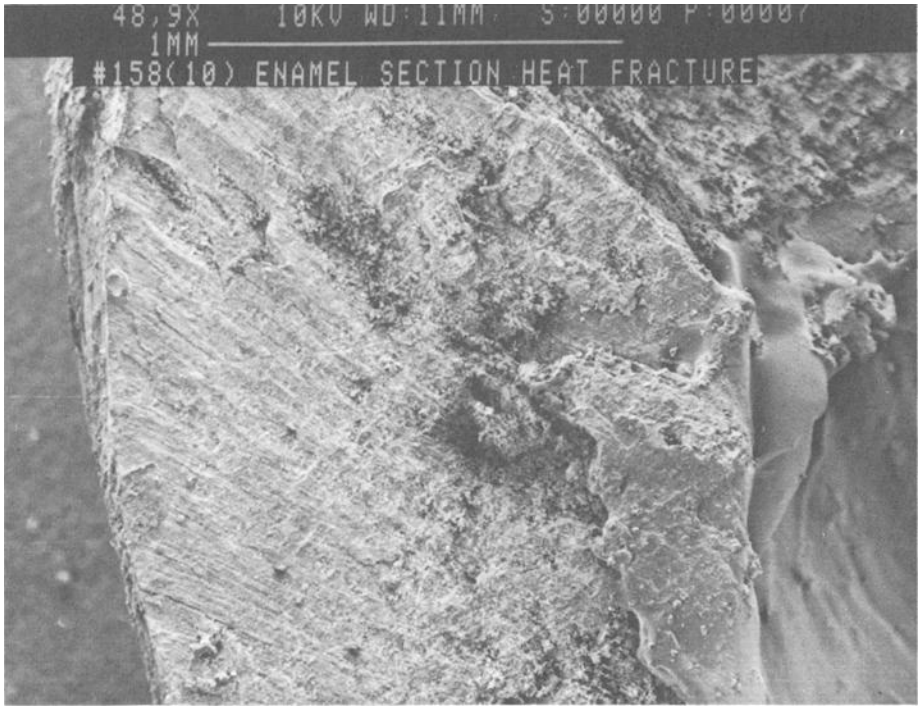

FIG. 3—*Scanning electron micrograph of mesial heat-induced fracture surface of 158(10).*

hampered because the crowns of all teeth, save one, had separated from their respective roots, and in many cases were themselves fragmented. Table 1 lists the identified teeth with their evidence numbers and a brief description.

Examination for Evidence of Dental Restoration

Of the teeth that were identified to type and position, only one was certain to have had dental restorative work. Three additional teeth were thought to have had some evidence of dental intervention.

Evidence number 158(8) is identified as the upper right central incisor. This is the only tooth recovered to have a complete crown with a fragmentary root. The reason for that is that the crown is a porcelain replacement anchored to a cast post still preserved.

The left and right upper first premolars (evidence numbers 16(19) and 93(9), respectively) have a crescent-shaped indentation on the cemento-enamel junction of the buccal surface on each tooth in the exact same position and also a regular appearance (Fig. 1). These characteristics indicate that they are likely not artifacts of the intense heat of incineration. If this area were prepared for a filling, that was subsequently lost due to prolonged exposure to intense heat, then parallel striations from the dental drill would be present on the exposed surface. Using an SEM would permit a detailed examination of these striations. Only one of these teeth, #16(19), was selected for analysis because the corresponding right tooth has the identical indentation.

Another tooth suspected of having dental work is an incomplete crown of enamel, consistent with the upper right second premolar (#158(10)). This specimen is character-

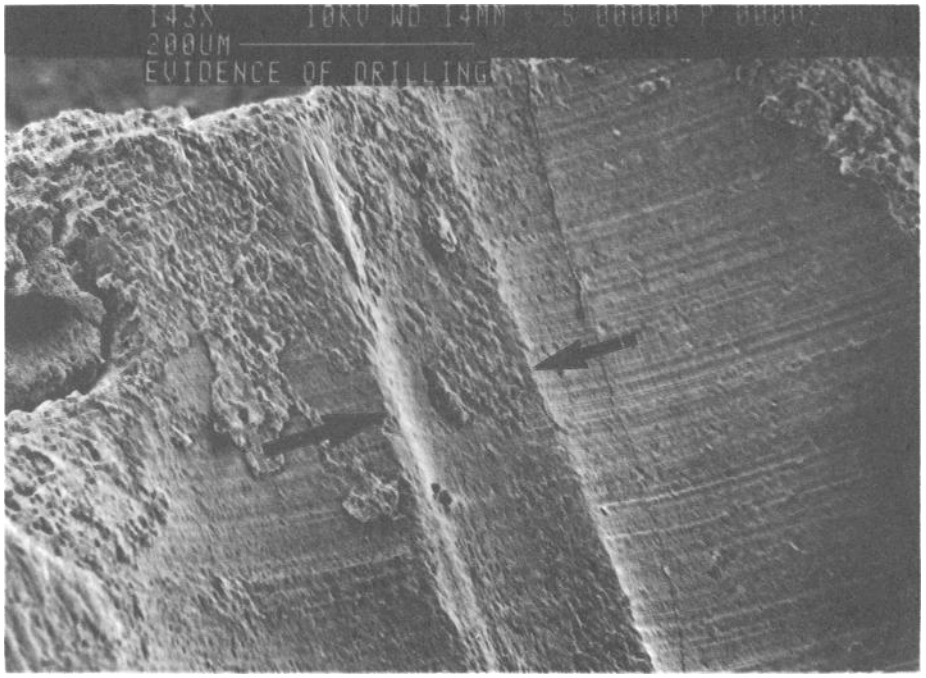

FIG. 4—*Scanning electron micrograph of drill striations and bore marks on enamel of the crown with dislodged amalgam. Arrows indicate margins of bore markings.*

ized by the presence of only the buccal half of the crown. This included the buccal surface and approximately half the mesial and distal surfaces. The occlusal surface on the buccal side of the tooth is incomplete. No filling amalgam is present. In fact, no amalgam is associated with any tooth recovered from the crime scene. The exposed edge of enamel at the occlusal surface has an undulating surface, which contrasts with the jagged enamel border at the mesial and distal ends of this specimen (Fig. 2). The undulating surface was subjected to further investigation with the SEM.

SEM Analysis

Very little was required in the way of sample preparation of the specimens for SEM analysis. The intense heat of the fire acted to desiccate the specimens to such an extent that no further fixation or dehydration was required. The preparation of the specimens followed a course similar to that of a previous study [*4*]. Each specimen was mounted on aluminum stubs using silver paint. After the silver paint dried, each specimen was coated with 75 to 100 nm of gold-palladium in an Anatech Hummer VII sputter system. The actual thickness depends on the condition of each specimen. The SEM used to view and photograph the specimens was a Cambridge Stereoscan 120. The accelerating voltage, magnification factor and scale are recorded on each micrograph.

Two controls were used as a basis for comparison. The first control used was a portion of the fire-cracked enamel from specimen 158(10) (Fig. 3). This was done to ensure that tooth enamel with no evidence of dental restoration did not exhibit any striations that may be misinterpreted. Conversely, a clinically extracted tooth with an occlusal amalgam filling was sectioned and the filling manually dislodged. This was done to determine if

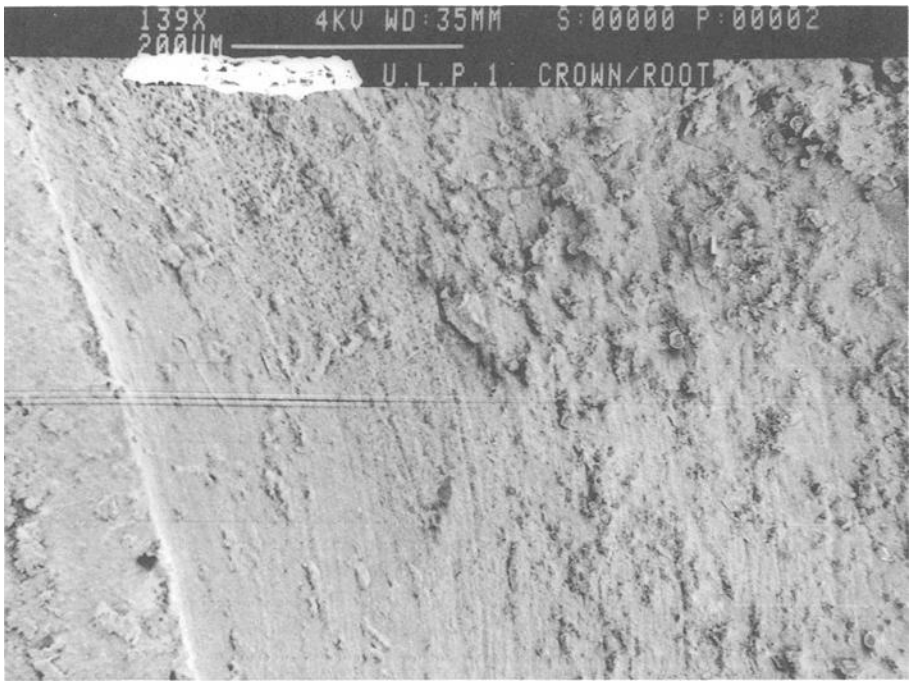

FIG. 5—*Detailed scanning electron micrograph showing parallel striations within the crescent-shaped indentation on tooth 16(19).*

the proposed drilling striations were evident in a "fresh" tooth (Fig. 4). Both of these specimens were prepared as previously outlined above.

The section of fire-cracked enamel (Fig. 3) did not exhibit any evidence of striations attributed to a dental drill. The clinically extracted tooth with the dislodged filling did exhibit the parallel striations in the enamel indicative of a dental drillbit (Fig. 4).

Although the crescent-shaped indentation of the right and left upper first premolars is not consistent with a heat-induced artifact, it was felt that this should be confirmed by SEM examination. A detailed view of the crescent-shaped region shows curved parallel striations that cannot be dentinal tubules (Fig. 5). Therefore, previous restorative work is confirmed on this tooth.

The crown of the upper right second premolar (Fig. 2), has not only clear drilling striations but also individual bore marks (Fig. 6).

Comparison to Antemortem Dental Records

Any one similarity of the incinerated teeth to the dental records is *not* sufficient to conclude a positive identification. However, several consistencies evidenced by the SEM analysis have been established. The left and right upper first premolars have been confirmed to have had fillings in the buccal CEJ. This is consistent with the antemortem radiographs (Fig. 7) and written dental records. The porcelain fillings described match the form and position of those confirmed by SEM analysis.

The upper right second premolar crown with evidence of a previous occlusal filling is also consistent with the antemortem radiographs (Fig. 7). In fact, this is the only

FIG. 6—*Detailed scanning electron micrograph of drill striations and individual bore marks on charred enamel of tooth 158(10). Arrow indicates margin of bore mark.*

premolar in the dental records to have ever had an occlusal filling. Again, a match for site and position is confirmed.

Recall that the upper right central incisor recovered from the crime scene is characterized by an artificial crown attached to a post. Although not subjected to SEM analysis, it is important to note that this tooth is entirely consistent with the antemortem dental records. In fact, the decedent's dentist claimed to recognize this tooth. This would be somewhat unusual, if it had not been for the fact that the decedent was a dental equipment and supplies sales representative and made regular calls to his own dentist.

One final piece of evidence confirmed identity. The lower right first molar has no crown enamel present due to the incineration. However, the root and the crown's underlying dentine are well preserved. The surface that is oriented toward the occlusal surface has four characteristic projections of dentine that would appear in a radiograph as only two adjacent peaks. These projections match perfectly those evident on the antemortem radiograph. Taken in conjunction, the evidence leads to a positive identification of the cremated remains as that of the dental equipment salesman who had been missing approximately three weeks.

Summation

Although dental remains that have been incinerated, to the point where their fillings have melted away, and have been highly fragmented by intense heat and mechanical forces, the fragments may harbor useful information. The SEM can be of use in at least identifying the presence, type and position of dental restoration. It should be stressed that evidence of this type, on its own, should not be the sole basis for a positive iden-

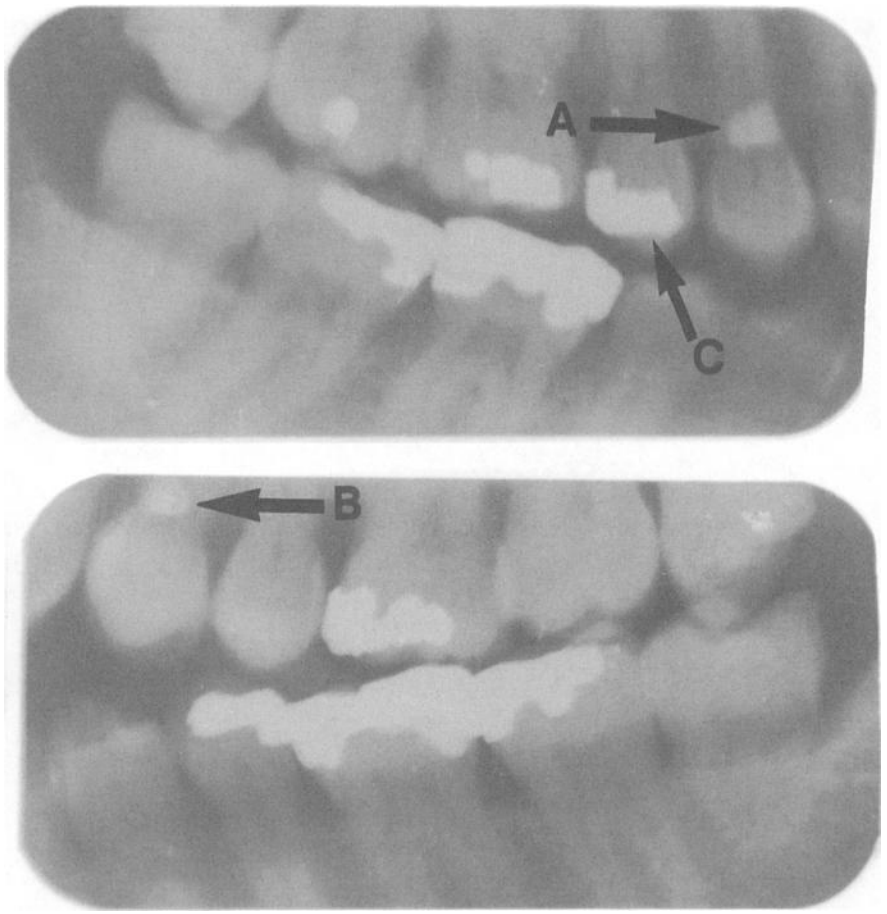

FIG. 7—*Right* (top) *and left* (bottom) *bitewing antemortem radiographs. Arrows* A *and* B *indicate the buccal CEJ porcelain fillings of the right and left upper first premolars, respectively. Arrow* C *indicates occlusal amalgam filling of the upper right second premolar.*

tification, but be a further indicator of identity. Used as one of several indicators SEM analysis may enhance the identification process.

In the case presented, the suspect, upon being confronted with the evidence, confirmed the identification of the decedent and confessed to intentionally cremating the remains.

Acknowledgments

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