Scattered Skeletal Human Remains: Search Strategy Considerations for Locating Missing Teeth

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Introduction

Positive identifications, in cases where the body is skeletonized, are resolved by dental means in the majority of cases (Haglund et al. 1987; Rothwell et al. 1989). Therefore, it is essential that recovery of teeth be maximized. Antemortem facial trauma and taphonomic processes of the postmortem interval, such as decomposition, scavenging, and dispersion of remains by animals, can serve to confound recovery of teeth. With the disappearance of the surrounding soft tissue and the periodontal ligament, teeth commonly become disassociated from their alveoli (Rothwell et al. 1989; Sperber 1986) (Figure 1). This is true for single-rooted teeth such as incisors and canines, but also holds for immature molars and premolars, and when the roots of multirooted teeth are not sufficiently splayed to lock them into their sockets. As decomposition progresses, the mandible becomes detached from the cranium, and the cranium, in turn, is disassociated from the rest of the body. This has been reported to occur early in the disarticulation sequence of animals (Toots 1965; Micozzi 1985) and humans (Haglund et al. 1990; Skinner and Lazenby 1983:13). Teeth may also be lost when either the mandible or cranium is moved. Such movement is most commonly mediated by scavengers and can occur when the body is fresh, in various stages of decomposition, or after it is completely skeletonized.

At the time a scene is processed, searchers generally do not know which teeth will be documented in antemortem records. A further complication to dental identification is that dental charting and dental radiographs may be available for only a few select teeth.

In the following six case examples, teeth were missing postmortem and not readily located at the time the body was initially discovered. These cases are analyzed in terms of decomposition, disarticulation, and dispersion. Search strategies are suggested for efficient, maximum recovery of dental remains.

Case Examples

Case 1

This 39-year-old suicidal male disappeared in July of 1986, in a rural county of Washington State. His skeletal remains were discovered in a remote wooded area in March of 1991, after a postmortem interval of 45 months. At the scene of discovery, bones and clothing, partially covered by seasonal debris, rested on the ground immediately beneath a tree limb from which hung a partially rotted rope. Skeletal elements were completely disarticulated and no soft tissue was present. The noose-end of the rope was recovered from among the jumble of bones

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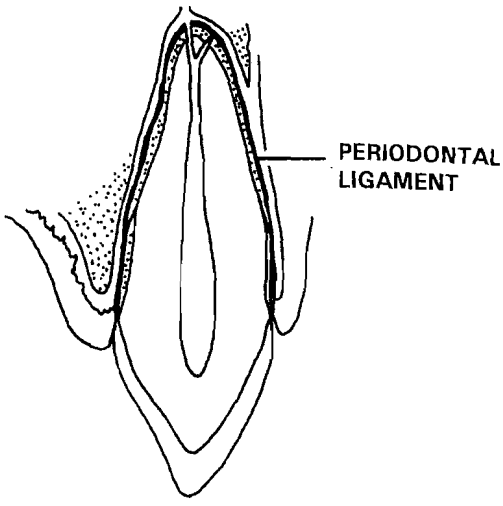

Figure 1 The periodontal ligament binds the tooth in its alveolus.

and clothing. There was no scattering of the remains, and skeletal elements revealed no evidence of animal scavenging. Scene processing and recovery were done by local law enforcement investigators. The manner and cause of death was determined to be suicide by hanging.

The skeletal remains, sawn-off branch and ligature, along with antemortem dental records of a missing individual, were sent to the author for analysis and identification. Upon examination of the maxilla and mandible, 14 teeth were missing postmortem. Where were the missing teeth?

As indicated by the presence of skeletal remains, clothing, the noose end of the rope, and the rope hanging from the tree, the original site where the remains were discovered was the location of death, decomposition, and disarticulation. Because there was no scavenging or scattering of skeletal elements, the teeth should have been recovered from among the bones and clothing, or from screening of the soil and seasonal debris, where they were collected.

Case 2

The cranium of this 14-year-old female was discovered in an evergreen forest by a pine cone hunter. The postmortem interval was 1 year. Nine maxillary teeth were missing. These included the four incisors, both canines, two premolars, and an immature left third molar (teeth 5 to 12, and 16). An initial survey of the area by police investigators and the author revealed fully disarticulated and scavenged skeletal elements, devoid of all soft tissue, and scattered over an area of approximately 300 by 150 feet (76.9 by 38.5 meters) (Figure 2A). The majority of ribs and vertebrae were clustered in anatomical disarray (Figure 2B). Associated with this area was the fully skeletonized right wrist and hand which rested in relative anatomical order. The head hair mass was located at the periphery of this cluster (Figure 2B). Where were the missing teeth?

Presence of the majority of the vertebrae and ribs, plus finding the right wrist and hand in relative anatomical order, supports the hypothesis that this location was where the body originally rested (Figure 2B). Association of the mandible with this grouping of skeletal elements indicates that the disarticulation of cranium and mandible occurred here, and that this was the main decomposition site. Based on these observations, the most likely pattern of scatter radiates from this decomposition site (Figure 2B.) The cranium was initially moved to the site where the hair mass was found and where further decomposition took place. Eventually, the cranium had been moved to the location of its discovery. Note that bones away from the location of primary decomposition are widely scattered and are not found associated with other skeletal elements to which they normally articulate. This indicates that they were

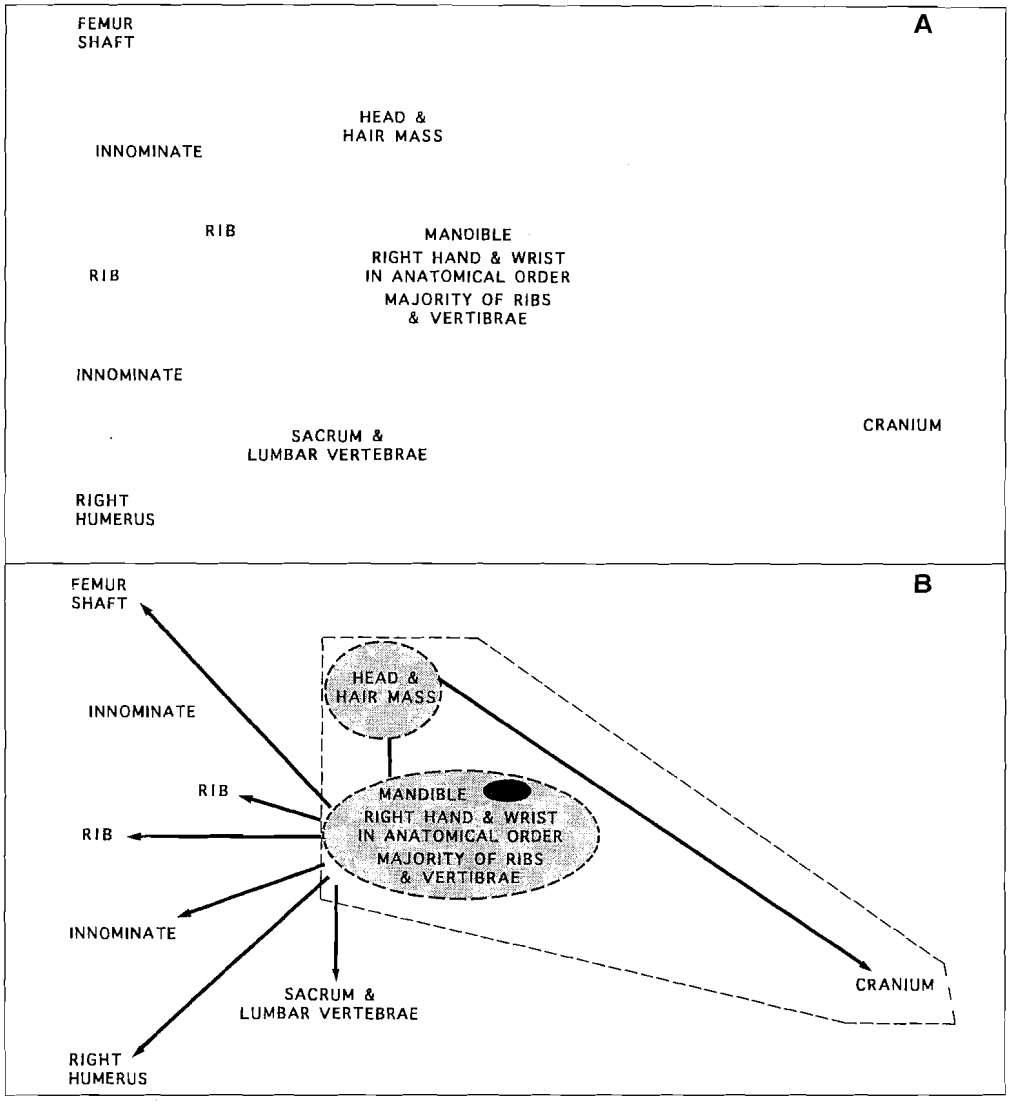

Figure 2 Case 2. (A) Associations and relative distribution of remains without interpretation. (B) Inferred scatter pattern. Shaded areas indicate primary deposition/decomposition sites. Trajectories of dispersal are indicated by arrows. Maximum potential location of disassociated teeth is indicated by dashed perimeter. Darkly shaded location indicates site where teeth were recovered.

moved from the site of decomposition **after** soft tissue had decomposed and disarticulation had occurred.

The area where the teeth are most likely located is between the site where the mandible and head–hair–mass rested. Because disarticulation had advanced enough to detach the mandible, screening for the missing maxillary teeth was initiated at the mandible's location, and that is where the teeth were located. Failure to find teeth in this area would have necessitated screening at the location of the hair mass and then the area between it and the mandible.

Case 3

This 21-year-old female's skeletal remains were found when her cranium was discovered by a moss hunter. Subsequent to her identification, it was learned she had been missing 7 years.

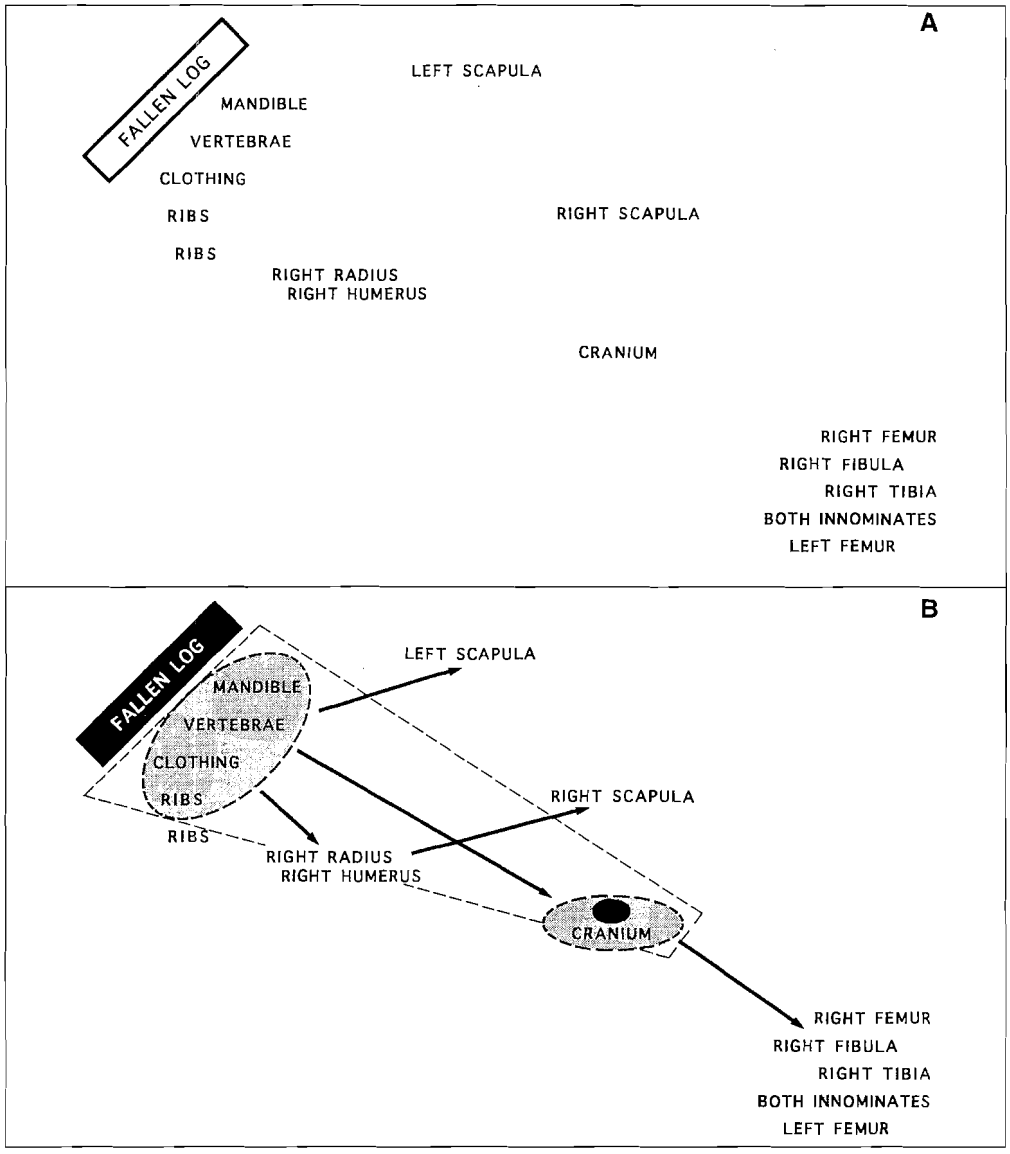

Figure 3 Case 3. [A] Associations and relative distribution of remains without interpretation. [B] Inferred scatter pattern. Shaded areas indicate primary deposition/decomposition sites. Trajectories of dispersal are indicated by arrows. Maximum potential location of disassociated teeth is indicated by dashed perimeter. Darkly shaded location indicates site where teeth were recovered.

The location of discovery was in a rural area of evergreen forest. The cranium rested in a depression created by pine needles that had fallen around it. Seven maxillary teeth including the right first, second, and third molars (teeth 1 to 3), the right lateral and central incisors, and the left central incisor (teeth 7, 8, and 9), and the left first molar (tooth 14) were missing. An initial survey of the vicinity by police investigators and the author revealed scavenged skeletal remains scattered in an east–west direction for approximately 200 feet (51.3 m) (Figure 3A). Clothing, the mandible, and the majority of ribs and vertebrae were located adjacent to a turn-around area at the westerly extreme of the scatter pattern. The cranium was located approximately at the midpoint of this scatter pattern. Along the path of scatter, and associated, were bone shafts of the right arm. At the most easterly end of the scatter was a loosely associated cluster representing shafts of the major elements of the both lower limbs

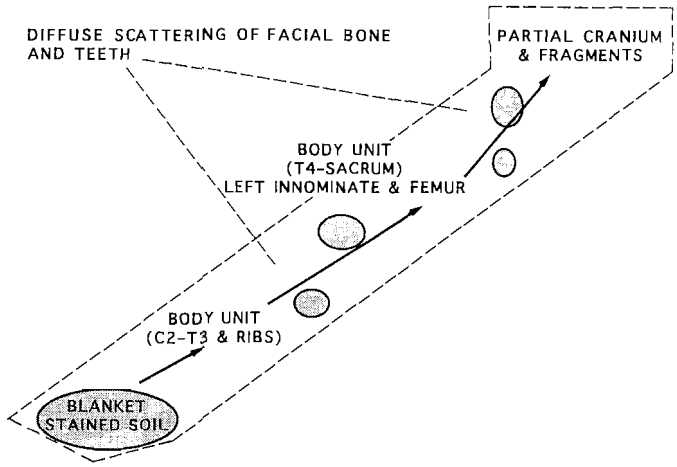

Figure 4 Case 4. Location of human remains in a case where there was extreme antemortem blunt trauma to the skull. Cranial fragments and disassociated teeth (darkly shaded areas) were dispersed along the trajectory (arrows).

including the right and left femurs, right tibia and fibula, and both innominate bones. Where were the missing teeth?

The original site of the body deposition was considered to be where clothing and major bones of the thorax were located. Dispersion of the remains took place from this location (Figure 3B). Scatter occurred before disappearance of soft tissue was complete. This can be inferred because scattered clusters of associated skeletal elements represented anatomically related bones. As observed in Figure 3B, major elements of the right arm (including shafts of the radius, humerus, and the scapula) were strewn along a trajectory, and the pelvic girdle accompanied by major bones of both lower extremities (both innominate, femora, tibiae, and fibulae) were located at the furthest extreme of scatter. The right arm plus its girdle and the lower portion of the body were initially moved as units of articulated sequences of bone. In this example it was considered most likely that the cranium was moved with the teeth still in anatomical position. Therefore, the search and screening efforts for maxillary teeth concentrated first at the location of the cranium's discovery. All were found at this location. If this strategy had failed to yield the missing teeth, the original deposition site, and then the path between it and the location of the cranium, would have been screened.

Case 4

This 22-year-old female homicide victim's remains were discovered in April, in a rural area of woods and thick underbrush, 2 months following her disappearance. Her killer had severely beaten her about the face and head. Blood and a maxillary left central and lateral incisor were found in the trunk of the suspect's vehicle. By the time the remains were discovered, much soft tissue decomposition had occurred and the remains had been scavenged and scattered by coyotes (Figure 4). The original body deposition site was marked by a blanket, clothing, and darkly stained, odor-laden soil. The extremes of scatter were marked by the decomposition site at one end and at the other end by a partial cranial vault that was absent the face from below the superior orbital margins. Two major articulated body units were present. The first body unit included the partially skeletonized and scavenged upper trunk inclusive of the second cervical vertebrae through the third thoracic vertebrae. The second body unit section included the remainder of the trunk inclusive of the fourth thoracic vertebrae through the sacrum, left innominate, and femur. All remains were located along a 240-foot (61.5 m) linear trajectory. Numerous cranial fragments were littered along this path. Where were the missing teeth?

A special circumstance complicates this case. There was extensive antemortem fragmentation of facial bones and teeth due to impact trauma to the face. Because of this and the fact that scatter took place while decomposition was in progress, cranial bone fragments, including teeth and tooth-bearing bones, were potentially scattered between the extremes from where the body was deposited and where the mandible and farthest portion of the cranium were found. Indeed, in the weeks following the initial scene processing, further searches of the area were made separately by medical examiner and law enforcement personnel and family members. All teeth were eventually recovered along the path where they had fallen away from mandible and cranium as they were moved. Careful screening of path between the original site where the body had rested to the section of cranial vault, at the time of initial scene processing, would have saved considerable time and embarrassment for law enforcement as well as unnecessary distress to surviving family members.

Case 5

This 37-year-old female was discovered approximately 120 feet (30.7 m) over the side of a steep embankment off a remote mountain road. The remains had been placed within two plastic trash bags which had apparently been disrupted when they were rolled over the embankment. The majority of viscera and muscle was absent due to insect activity and decomposition. There was exposure of the majority of bones of the skeleton, although they remained articulated by dried ligaments and skin. Integument of the head and face was mummified and relatively intact (Figure 5A, head and soft tissue). Five anterior teeth were missing from their sockets. Inspection of the oral cavity and posterior pharynx did not disclose the missing teeth, and detectives were advised to screen the area beneath the head end of the body where the teeth were presumed to have fallen. Four hours of meticulous sifting failed to yield the missing teeth. Where were the missing teeth?

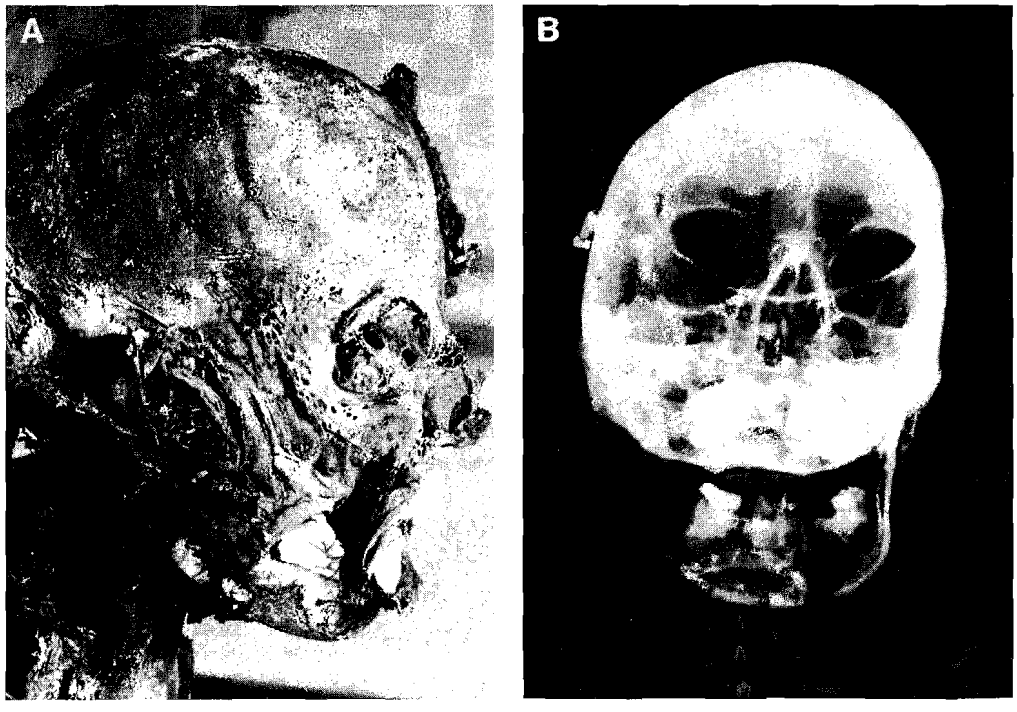

Figure 5 Case 5. (A) Desiccated soft tissue covering the majority of the head and face. (B) Postmortem radiograph showing teeth entrapped between cranium and scalp.

Since the majority of the remains were articulated and there was no scattering or traumatic damage to dentition bearing bones, it is unlikely that teeth would be anywhere but near the area of the head end of the body. Screening of this general area failed to yield the missing teeth. At time of autopsy, routine X-rays of the skull revealed the missing teeth entrapped between the scalp and the right posterior parietal bone (Figure 5B). Absence of the disassociated teeth in the oral cavity and pharynx had misled the author to suggest that missing teeth had dropped from the oral cavity to the ground. Instead, the missing teeth had fallen onto the internal surface of the cheek and then, as decomposition advanced and the scalp loosened from the skull, continued to drift into that space to finally settle in the dependent location from which they were recovered.

When the soft tissue of the oral cavity and face is intact and the rear of the oral cavity is in a dependent position, loosened teeth routinely fall back into the mouth and pharynx. Contrarily, when the mouth opening is dependent, the teeth may fall out of the oral cavity and to the ground. The position of the remains is crucial to such evaluations. Case 6 suggests that investigators should be aware that teeth may also be entrapped between soft tissue and the cranium in other locations. Therefore, it is important to assess the final and potential positions of the body in such cases.

Case 6

The cranium of this 37-year-old female was discovered by a mushroom hunter in April. She had been missing since March of the previous year. The location was adjacent to a major highway that ran through an evergreen forest. An initial survey of the area indicated several groupings of scattered skeletal elements were located along the fringe of a swamp. Scattered clusters of associated bones included: (1) the cranium and first through third cervical vertebrae; (2) a loose association of clothing, mandible, and major bones of the trunk; (3) long bone shafts of the right arm; and (4) long bone shafts of the lower extremities (Figure 6A). Much of the area was littered with downed tree trunks and growth of brush. The two central maxillary incisors were missing and four incisors were missing from the mandible. Where were the missing teeth?

The remains were fully skeletonized and scattered. Body units had been moved before complete disarticulation had taken place. At a minimum, the cranium and the three cervical vertebrae, the majority of the right arm, and the pelvis and lower extremities were moved as discrete body units. Enough disarticulation had occurred before the movement of the cranium that the mandible had already detached from the cranium. The location where the body originally rested and from which it was scattered is at the association of bones of the trunk, the mandible, and where the clothing was found. Because there is evidence that some disarticulation had occurred before disarticulation was complete, it is not possible to limit the potential area of the missing maxillary incisors any further than the area between the group of bone containing elements of the trunk and mandible and the site of the cervical vertebrae and the cranium. Sifting of this area produced the missing central incisors. Mandibular teeth were near the mandible.

Discussion

Crime scene investigators often labor under manpower, financial, and time constraints (Skinner and Lazenby 1983). It behooves them to achieve efficient scene processing, with an eye towards maximizing efforts for complete recovery of evidence and remains. This begins with an overall survey of the area to assess the locations of bones and/or other remains, associations with each other, likely scatter patterns, and location(s) where decomposition has taken place.

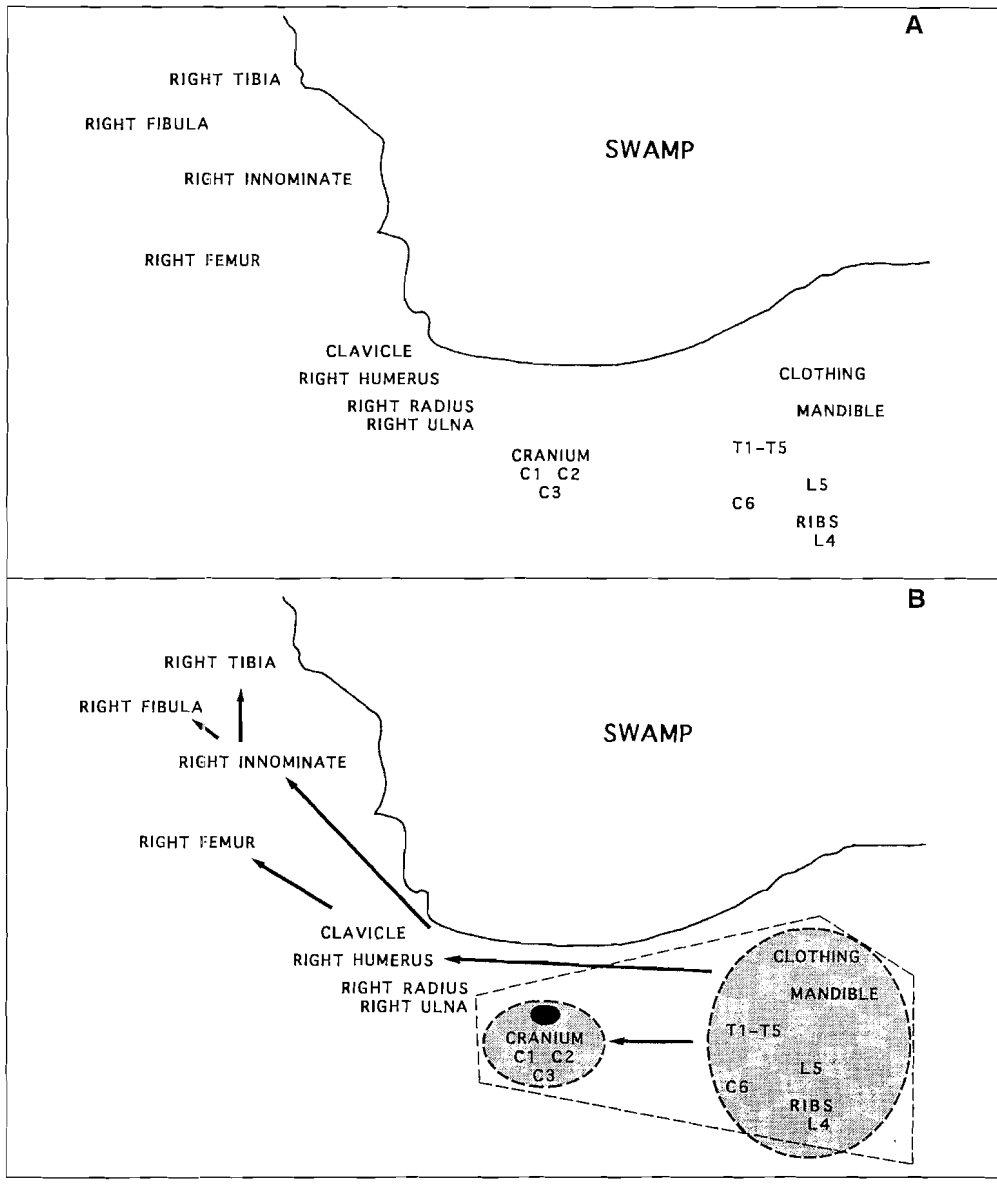

Figure 6 Case 6. (A) Associations and relative distribution of remains without interpretation. (B) Inferred scatter pattern. Shaded areas indicate primary deposition/decomposition sites. Trajectories of dispersal are indicated by arrows. Maximum potential location of disassociated teeth is indicated by dashed perimeter. Darkly shaded location indicates site where teeth were recovered.

In the above cases, recovery of missing teeth was maximized by establishing a search strategy based on answers to the following questions:

1. Are the remains scattered?
2. From where was the body scattered?
3. What is the skeletal element composition of the scattered groupings of bones?
4. What were the most likely trajectories and dispersion?
5. Are there any special circumstances that might affect disassociation of teeth or their scatter?

Considerations for answering these questions are as follows:

Are the remains scattered?

If the remains are *not* scattered (cases 1 and 5), inspection of the remains themselves or the immediate area where the remains rest is the logical location where the teeth should be found. When teeth are missing postmortem and the soft tissue of the oral cavity or face is relatively intact, with the rear of the oral cavity in a dependent position, loosened teeth routinely fall back into the mouth and pharynx. (This is also a likely area to find teeth of charred remains resting in the supine position.) Contrarily, when the mouth opening is dependent, the teeth may fall out of the oral cavity and to the ground. Case 6 suggests that investigators should be aware that teeth can also be entrapped between soft tissue and the skull in other locations.

If the remains are scattered, an initial survey of the scene will give an overview of the locations of scattered bones and artifacts. If dentition-bearing bones are scattered away from other skeletal elements or from each other (cases 2, 3, 4, and 6) it is important to establish: the time relative to the decomposition and disarticulation that the scatter took place and the location from which scattering took place (see questions 2 and 3 below).

Where was the body scattered from?

Suicide weapons, such as the rope in case 1, may mark the obvious place of death. The location of death for gunshot suicides is often marked with the location where the firearm is found. Visual signs may indicate location(s) where the remains decomposed. These include discolored areas of substrate marked by odor or discoloration from body fluid leakage, presence of insect puparium, and yellowish discoloration of low, overhanging deciduous foliage (Rodriguez 1989). Some bones are more likely to be found at the original site of decomposition than others. One survey of 23 surface-scattered remains conducted by the author suggests that associations of bones commonly located at the primary deposition include: ribs (88.2%); thoracic vertebrae (82%); lumbar vertebrae (71%); and cervical vertebrae 2 to 7 (59%) (Haglund 1991).

It should be cautioned that the site where the majority of decomposition takes place may or may not be the original site of the body's deposition. Remains, especially of subadults or nearly complete portions of adults, can be moved by medium-sized canids. This can occur more easily in open terrain, but the author is aware of an adult torso of a gunshot suicide victim being moved approximately 40 feet (10.3 m), in a swampy area of dense underbrush, by coyotes. The location of the victims backpack and the suicide weapon marked the site of death. Of course, larger carnivores such as bears (*Ursa sp.*) and cougars (*Felis concolor*) would be capable of moving complete, adult human remains.

There may be secondary sites of decomposition when a body unit with soft tissue attached is moved to another area. The head–hair mass often indicates the site where soft tissue of the scalp decomposed and may be a likely location where teeth became loosened and separated from the alveoli.

For scattered remains, what is the skeletal element composition of the scattered groupings of bones?

Are anatomically related bones associated within scattered clusters, or are anatomically unrelated bones found singly or together? The answer to this question helps to infer at what time, relative to decomposition and disarticulation, that scatter most likely took place. Parts may be removed and scattered from fresh, decomposing, or completely disarticulated remains.

Each of these states dictates potential body units that can be easily detached from the remains. Case 4 presents an obvious example of remains that were scattered while decomposition was in progress, because scattered body units remain connected by soft tissue. For fully skeletonized and scattered remains, examine the skeletal elements which compose the scattered groupings of skeletal elements. (A **group** of skeletal elements is defined as a discrete cluster of bones or bones strung along a short span of trajectory.)

For the majority of groupings, if bones were still connected by soft tissue, or represent bones of the same anatomical region, such as upper arm or forearm and hand (case 3 and 6), they were more likely transported as connected body units. These associations indicate transport took place before disarticulation was complete and that bones were connected to each other at the time of movement. Predictable body units, such as complete arms and their respective partial girdles, are commonly removed from fresh remains by medium-sized canids (Haglund et al. 1989). It is also common for major sections of lower limbs including parts of the pelvic girdle to be moved as body units (cases 4, 6, and 7). When transport takes place after decomposition/disarticulation is complete, individual bones are moved, and the resulting scatter pattern may consist of single bones or a mix of bones representing different anatomical regions. Case 3 fits this latter category.

What were the most likely trajectories of dispersion?

Between the original resting place of the remains and locations of dispersed body units or skeletal elements are the most likely paths along which skeletal elements parts traveled. This may not be a straight line. A secondary decomposition site(s) may need to be considered as in case 2. Trajectories of scattered bones (case 3) and/or artifacts may conform to animal trails or terrains (case 6) and may guide the investigator in establishing the most likely trajectories. Primary, secondary, and even tertiary resting sites may be identified and need to be taken into consideration when determining pattern of dispersion.

Are there any special circumstances that might affect disassociation of teeth or scatter?

Circumstances such as preexisting facial trauma, terrain, or purposeful dismemberment and dispersion may serve to bias the forgoing considerations. For instance, extensive impact trauma to the face in case 4 knocked out teeth, loosened others, and fractured dentition-bearing bones into many pieces. This situation complicated the mechanism of tooth loss and extended potential areas from which they might be recovered. Terrain, such as the swamp in case 6, defined a perimeter for potential search because the scavenging animals skirted the margins of the swamp and limited their trail along downed tree trunks which served as high ground to the surrounding bog. Location of teeth for purposefully dismembered and dispersed human remains is not predictable by the above means (Haglund and Reay 1993).

The above search strategy assumes surface scattering of human remains by medium-sized canids. When teeth are consumed, carried into burrows by rodents or birds, or moved by environmental factors such as water, the suggested search strategy may not apply.

Conclusion

In cases of scattered human remains, complete dentition is frequently not recovered because teeth separate from their sockets early in the decomposition process and are overlooked during scene processing. Available antemortem dental records may document only a limited number of teeth. These factors can combine to limit the information available for dental comparisons. Because identification by dental means is routine for skeletonized human remains, it is important that as many teeth as possible be recovered.

Attention to sound scene processing often yields evidence and human remains that would otherwise be overlooked. Six cases that involve fully to partially skeletonized surface remains for which teeth, not recovered at the time of the body's original discovery, are analyzed. Search strategies to locate postmortem missing teeth in outdoor, surface-scattered skeletal remains are presented. Considerations for recovery of teeth include analysis of factors such as: the status of articulation of the remains; presence or absence of scattering; associations of skeletal elements in scattered clusters of bones; determination of the primary site of disposition/decomposition; the most likely trajectory of scattering; and considerations of special circumstances such as existence of facial trauma, terrain, or purposeful dismemberment.

Acknowledgments

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