Case Report

A 37-Year-Old Cold Case Identification Using Novel and Collaborative Methods

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Abstract: Cold cases are like time capsules for law enforcement. We try to open them using the methods that have been developed since any previous attempt. In this case, a young woman, Jane Doe #48, went unidentified between her death in 1971 and her exhumation and analysis in 2008. This paper details the specialties and forensic techniques used to achieve this identification. A new method using teeth to determine age and season at death is highlighted, for this was one of the first applications of the method to a real case.

Background

In 2008, the Stanislaus County Sheriff’s Office undertook a concerted effort to solve its cold cases. Detective Ken Hedrick, who had been combing through the binders of the county’s 80 cold cases, notified the coroner’s office that unlike the many cremated victims, one woman lay unidentified in a Jane Doe grave in a Patterson, CA, cemetery. Chief Deputy Coroner Kristi Herr Ah You and Sheriff Adam Christianson secured a court order and arranged for forensic anthropologist Vicki Wedel, to exhume the remains. On April 24, 2008, Dr. Wedel and the coroner’s office staff recovered the skeleton, adherent soft tissue, and hair mass of a young adult female from the grave.

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Received March 29, 2012; accepted September 4, 2012
Over the succeeding months, Sheriff Christianson coordinated the efforts of Ms. Herr Ah You, Detective Hedrick, Dr. Wedel, forensic odontologist Garry Found, forensic facial reconstruction artist Gloria Nusse, and DNA specialists at the California Department of Justice. Their combined efforts resulted in the positive identification of Jane Doe #48.

**Forensic Anthropology**

The young woman had been buried under a Jane Doe headstone in a simple wooden coffin. Earth-moving equipment excavated down to the lid of the coffin, after which the excavation was continued using hand tools. The woman had been buried in a black body bag, which had become rigid and thus cracked when it was manipulated. Water movement through the soil over the 37 years of interment had especially pooled in the areas of the hands and feet, many of the bones of which were recovered when the back dirt of the grave and the soil from under the body bag were manually screened. The bones of the hands would become important in the review of perimortem trauma. The burial interim had seen the skin of the back, shoulders, and breasts rendered to adipocere. The rest of the body was skeletonized and the bones were encased in soft mud. After they were unpacked, the remains were rinsed with warm water and allowed to dry in the fume hood. The remains were already skeletonized when recovered, except for the two pieces of adipocere, which were kept frozen at 9 °C. No bones were embedded in the adipocere, so it was not reduced.

The goals of the forensic anthropological analysis were to use the cleaned skeletal remains to determine Jane Doe #48’s biological profile (age, sex, stature, and ancestry), estimate age at death and season of death, and document any antemortem medical conditions that might be described in potentially relevant missing person’s reports or medical records. To avoid bias, Dr. Wedel did not review the autopsy report or any of the other records until her analysis was complete.

The remains represented one adult individual and all showed the same level of decomposition. The bones were devoid of grease and odor and were consistent in size and morphology, with no duplication of elements. The excavated skeleton was largely complete. Missing at the time of examination were the following elements: most of the sternum, manubrium, the medial left clavicle, the right first metacarpal, the first right proximal hand phalanx, the first left proximal hand phalanx, two interme-
diate hand phalanges, six distal hand phalanges, the left hamate, the left pisiform, the right trapezoid, the left triquetral, the left and right navicular bones, portions of the left and right innominate, three proximal pedal phalanges, six intermediate pedal phalanges, and nine distal pedal phalanges. Also missing at the time of examination were the right femur and teeth numbers 1 and 18, which had been packaged at the morgue for DNA analysis.

Pelvic characteristics indicated that the skeleton belonged to a female based on a wide greater sciatic notch, wide subpubic angle, pronounced preauricular sulci, and a wide and curved sacrum. The cranium was gracile and had typical female characteristics including a vertical forehead, sharp supraorbital margins, small mastoid processes, smooth muscle attachment markings, and slight zygomatic arches. The gonial angle was obtuse, and the mandible came to a point at gnathion.

The skull exhibited the traits of someone primarily of European American ancestry, commonly dubbed “white”. Nonmetric traits that indicated European American ancestry included narrow nasal bones, deep depression at nasion, narrow nasal aperture, pronounced nasal sill, long nasal spine, minimal facial prognathism, and angled superior and inferior orbits. Nonmetric traits that suggested Native American ancestry included mild malar prognathism and pronounced shoveling of the maxillary incisors. Metric analysis (using, for example, Fordisc 3.0) could not be used to corroborate these findings given the autopsy removal of the calotte, a postmortem radiating basilar skull fracture, and the broken zygomatic arches.

Stature was estimated using the anthropometric software ForDisc 3.0’s (University of Tennessee, Knoxville, TN) white female category. The estimate was derived based on the maximum length of the femur, which for Jane Doe #48 was 430 mm. An estimated stature of 1575 to 1650 mm (5' 2"–5' 5") was calculated based on this.

The age at death and season at death were determined using a relatively new method, dental cementum increment analysis (DCIA) [1, 2]. Dental cementum anchors teeth into their sockets via the periodontal ligament. Cementum is incrementally deposited throughout an individual’s lifespan and is not removed or remodeled, so it can potentially record a wealth of life history. When thin sections of tooth roots are examined under a microscope, the cementum layers appear as alternating dark and light bands, analogous to tree rings (Figure 1). The banding is caused
by changes in mineralization and collagen orientation, which in turn reflect the apposition rates. Physiological stresses, such as cold stress, cause an increase in calcium consumption. Reduced calcium availability interferes with cementogenesis, which results in hypomineralization and arrested growth of collagen fibers in the newly formed cementum layers [3–5]. The resulting collagen-leached zone appears opaque or black in all rotational positions under polarized light microscopy [4]. Research with comparative samples of known-age and known date-of-death individuals has demonstrated a consistent relationship between annual seasons and the formation of distinct increment types. In general, the winter or arrested cementum increment appears as an opaque or dark band. The summer or growth increment appears as a translucent or light band. A single pair consisting of one opaque and one translucent band represents one year of an individual’s life, and the complete series of bands provides a record of life history from the time of tooth eruption until death or tooth removal.

Figure 1
Transverse section of an example tooth, which is labeled to depict the various histological structures and cementum increments[2]. (Reprinted with permission from Journal of Forensic Science.)
Dental cementum increment analysis is the study of the life histories of mammals, including humans, based on the information recorded in the cementum bands [5–6]. Because cementum (1) is deposited in annual bands that (2) vary with physiological stresses (primarily seasonal) and (3) are effectively immune to normal processes of decay, DCIA can provide information on diet patterns, reproductive history, seasonality, and other aspects of life history [3, 5–8]. This information is especially valuable in archaeological and forensic contexts, where it often cannot be reliably obtained in any other way.

The simplest and most straightforward applications of DCIA are determination of age at death and season of death. DCIA age at death is determined by counting the number of band pairs, where each pair represents one year, and adding that number to the age at which the tooth erupts. Season of death is determined by examining the outermost band. The opaque band is laid down in autumn and winter (October to March) and the translucent band is formed in spring and summer (April to September). The color of the outermost band therefore constrains the season of death to a six-month window. Based on the thickness of the band, it may be possible to narrow this window to one of the four seasons.

Zooarchaeologists have long used DCIA to estimate the age and season at death in nonhuman mammals [9–11]. More recently, the method has been extended to humans. Wittwer-Backofen et al. [1] found that DCIA yields age-at-death estimates within a 2.5-year range of error. The method is starting to be applied more frequently; Huffman and Antoine [12] noted ten studies that apply DCIA to estimating age at death from human teeth.

Wedel [2] published the first study to estimate season at death in humans using DCIA. Using a sample of 112 teeth collected from an oral surgeon over the course of a year, she found that by using the color of the outermost band, the teeth could be sorted into spring/summer and autumn/winter with 99% accuracy. As in other Northern Hemisphere mammals, the teeth extracted between October and March had opaque outermost bands and those extracted between April and September had translucent bands. The sole outlier was a tooth extracted in November that had a transparent outermost increment. Because it was extracted near the beginning of autumn, it is likely that the opaque band had either not yet started forming or was too thin to recognize.
For Jane Doe #48, DCIA was performed on the left mandibular second premolar. The tooth was embedded in epoxy, sectioned, mounted to a glass slide, ground and polished, and examined under 10, 20 and 40 X magnification under polarized light. Twelve pairs of bands were present (Figure 2). The mandibular second molar erupts and is in occlusion at age 12 ± 6 months [13]. Adding the number of pairs of bands to the age of eruption of the tooth yielded an estimated age at death of 23.5 to 24.5 years, which was reported using the 2.5-year range of error from Wittwer-Backofen et al. [1] as 23.5 to 25 years ± 2.5 years. Furthermore, the translucent outermost band indicated a death in the spring or summer, which corresponded well with Jane Doe #48’s discovery in September, 1971.

![Figure 2](image)

*Transverse section of Jane Doe #48’s tooth with labeled histological structures and cementum increments: (a) external edge of tooth root; (b) spring/summer outer increment; (c) examples of spring/summer increments; (d) cementum/dentin junction.*

Jane Doe #48 sustained several wounds from sharp force trauma, and although the soft tissue present at autopsy revealed more about her final day, the trauma to the bones still merits description. The wounds evident on the bones were caused by sharp force trauma and blunt force trauma.

1. Sharp force trauma is present on the left clavicle midshaft, the sternal ends of the right ribs 3–10, and left sternal ends of ribs 2–10. These cuts are consistent with cuts made at autopsy.
2. Saw cuts are present on the frontal, parietal, and occipital bones. These cuts are consistent with cuts made at autopsy.

3. A perimortem incomplete subcondylar fracture is present on the right mandibular ramus just beneath the condyle. This trauma is consistent with what would be sustained with a blow to the right cheek/jaw.

4. An incomplete perimortem fracture is present on the internal surface of the bend of the blade of the right 2nd rib. This trauma is consistent with that sustained when in-bending compresses the ventro-lateral surface of the chest.

5. Perimortem sharp force trauma is noted on several manual phalanges. It is difficult, however, to specify exactly to which digits these phalanges belonged since several hand bones were lost postmortem with the water and mud washing into and out of the broken plastic body bag, and those present exhibit postmortem erosion of the identifying side and digit number features. Each instance of perimortem sharp force trauma is then described by type of hand bone only.

   a. One proximal hand phalanx exhibits three superficial instances of sharp force trauma to the base of the shaft. One cut is at an oblique angle to the palmar surface of the shaft, while the other two cuts are slightly more superficial and run transverse to the base of the shaft of the phalanx. These superficial cuts to the bone are consistent with those received when the hand is used in self defense.

   b. One proximal hand phalanx was severed by sharp force trauma and the distal end of the bone is missing. The cut is at an oblique angle to the bone and runs from distal to proximal and from dorsal to palmar. This type of cut would be consistent with a hand palm down being cut by a blade that is angled obliquely from proximal shaft to distal.

   c. One proximal hand phalanx exhibits a through and through cut from proximal to distal on the dorsal surface. This kind of cut is consistent with a hand palm down being cut by a blade being angled obliquely from the dorsal midshaft of the phalanx towards the palmar distal end. The distal half of the bone is missing.
d. One distal hand phalanx exhibits sharp force trauma to the palmar surface of the bone. The cut runs from proximal to distal. This type of cut is consistent with a hand being palm up while being cut with a blade that severs the tip of the digit.

The biological profile of Jane Doe #48 was therefore listed in the case report as being from a young adult female of predominately European American and possibly Native American ancestry.

At the original autopsy in 1971, Jane Doe #48’s age at death had been estimated at 15 to 25 years based on physical appearance. However, several markers on the skeleton suggested that the original estimate was too young. The third molars had erupted and were in occlusion. This is usually completed in the early 20s. The coronal, sagittal, and lambdoid sutures were already in the process of fusing. The auricular surface of the left ilium retained some billowing but had begun to form striae. These features are consistent with an age estimate of 25 to 34 years, according to Lovejoy et al. [14] The sternal end of the right clavicle was partly fused, and the bilateral iliac crests were unfused, as were several vertebral annular rings. According to Owings Webb and Suchey [15], white females with unfused medial clavicles and iliac crests average 23 to 30 years at death. Therefore, based on the developmental indices and some very mild osteoarthritis, a revised skeletal age range of 23 to 30 was submitted in the case report. As discussed above, the age estimate based on cementum bands was narrower, 23.5 to 25 years ±2.5 years.

The two most significant differences between the original 1971 autopsy report and the 2008 case report are, first, that the autopsy report made no mention of the blunt force trauma to the right mandible or the skeletal damage from the sharp force trauma (the autopsy report describes the soft tissue trauma), and second, that the original age estimate of 15 to 25 years only partially overlaps with the revised age estimates of 23 to 30 years based on skeletal markers and 23.5 to 24.5 years based on DCIA.

**Forensic Odontology**

The dental postmortem identification examination was conducted by Dr. Garry Found, on April 25, 2008, following the guidelines and standards set forth by the American Board of Forensic Odontology. First, the upper and lower jaws were
thoroughly cleaned and debrided of dirt. Postmortem digital photographs were obtained with a Cannon 20D intra-oral camera configured with a 100 mm image stabilizing macro lens plus an MX-14EX macro ring light. The postmortem forensic digital full mouth radiographic survey was obtained utilizing DEXIS digital x-ray software with the Nomad portable hand held x-ray unit and WinID3 identification software (Online Freeware, by Dr. James McGivney, St. Louis, MO) (Figure 3). A clinical postmortem visual examination was performed utilizing magnification (Orascoptic telescopes) and enhanced illumination (portable fiberoptic light source). The results were recorded using a standardized California Department of Justice form. The notations were checked and cross-checked several times before the final postmortem dental data was inputted into the dental tab of WinID3. Two teeth were removed for submission to the California Department of Justice Missing Persons DNA unit at Richmond, California, for DNA analysis.

![Figure 3](image)

*Photoradiograph of the teeth of Jane Doe #48.*

The labeled and digitized full mouth radiographs, plus a JPEG of the NCIC WinID3 form plus WinID3 odontogram were electronically submitted to the California State Department of Justice MUPS Unit (Missing and Unidentified Persons System) for inclusion into the State UID (unidentified decedent) database. Forensic postmortem reports of findings and analysis were prepared and a complete copy of all DEXIS and WinID3 files and digital photographs were submitted on CD to the Stanislaus County Coroner’s Office.

The results of the forensic dental examination showed that the human remains were completely skeletonized. There was no evidence of fractured teeth or indication of fractures to the alveolar bone surrounding the teeth. A class I normal occlusion was noted. There was no evidence of bone loss, nor associ-
ated bony evidence of periodontal disease. Multiple craze lines within the enamel observed upon fiberoptic transillumination may be associated with oral habits, such as chewing ice or other hard foods. The four wisdom teeth were fully erupted and the apices were completely closed. This wisdom tooth apical closure was the basis for establishing the lower age estimation at 18 years of age. The upper age estimation was set at 40, based on the absence of wear patterns; the pulpal morphology and other morphological characteristics were more consistent with an age of approximately 18 to 25 years. No antemortem dental x-rays or dental records were available from the postmortem dental examination in 1971.

On June 10, 2008, five potential missing or unidentified decedents (UID) hits were received for Jane Doe #48 from the California Department of Justice MUPS Unit. Four of the UIDs had National Crime Information Center (NCIC) dental records entered, whereas the fifth UID had no dental data. Review and analysis showed that three of the possible hits could be excluded. The remaining UID case with NCIC dental data merited a comparison of dental x-rays. Comparisons of the antemortem and postmortem dental x-rays of this fourth record by the California Department of Justice MUPS Unit also resulted in its exclusion as a possible hit. The lack of NCIC dental data for the fifth UID precluded a comparison. With the aid of the FBI, Jane Doe #48's supplemental dental data was inputted and peer reviewed and entered into the UID Repository on June 12, 2008.

**Forensic Facial Reconstruction**

The forensic artist, Gloria Nusse, received the skull for reconstruction with clay. As discussed above, the anthropological assessment was that the skull of Jane Doe #48 belonged to a female, age 23 to 30, of predominantly European ancestry with some nonmetric Native American traits. Because the skull had been buried in a wet grave for 37 years, the cranium displayed gross plastic distortion of the calotte, which had been removed during autopsy. In addition, the zygomatic arches were broken, as was a large piece of the squama of the right temporal bone. A large piece of the right maxilla near the canine fossa was missing. The general condition of the bone was extremely friable and flaky. Three of the teeth had been removed postmortem for testing. Given the fragile nature of the bone, a mold and a cast were needed for the reconstruction. The mold-making process can interfere with biological test results, so permission was
sought and received from the coroner to proceed with molding and casting.

A small test patch of the dermatological silicone material used for the mold indicated the need to use a mold release coating over the skull. Before its application, however, the skull needed to be reassembled. The calotte and cranium were glued using Duco brand model cement and small toothpicks to mimic the autopsy blade cuts. Although the plastic distortion prevented a perfect fit, the landmarks of the skull and the sutures were lined up. Removable artist tape was used to cover the remaining small gaps and to block off the broken areas of the temporal and maxillary bone. The orbits and nasal aperture were filled with cotton balls, clay, and tape. The skull was molded and cast (Figure 4), according to the technique published by Nusse [16]. The skull was molded using medical grade silicone and cast in dental acrylic.

The facial reconstruction was guided by data originally presented by Rhine [17] and revised by Gatliff [18] and by new data from Manhein et al. [19] The face was reconstructed using musculature and tissue depths to approximate the facial features apparent in the bones. This method is described by Taylor [20] and is illustrated in Figure 5. A central incisor missing because of dental testing was replaced by a prosthetic tooth, and the teeth were not exposed in the facial reconstruction.

After the hair sample was cleaned, color and length were determined and matched with a high-quality wig. High-quality prosthetic acrylic eyes that matched the blue color described in the police report were used. Pictures from the sheriff’s office of the clothing and jewelry worn by the decedent helped in outfitting the bust (Figure 6). Styles for hair and clothing popular in 1971 were researched for historical and anthropological accuracy. A purple animal print blouse similar to the one worn by Jane Doe #48 when she was discovered was located in a local thrift store, as was a facsimile of the earring loop found in her right ear lobe. Morgue photos of the decedent indicated she had freckles and that she had a mole on her upper right lip, and these were confirmed by the police and pathology reports. To finish the face, makeup to simulate freckles and the mole were added. The final sculpture is shown in Figure 7.
Figure 4
Photograph of skull and cast of resin of Jane Doe #48.

Figure 5
Photographs depicting the building of a forensic facial reconstruction.
Figure 6
Photograph of the hair and clothing of Jane Doe #48.

Figure 7
Photograph of the forensic facial reconstruction and of her when she was alive.
Identification and Personal History of Jane Doe #48

Following the receipt of the revised anthropological biological profile, dental analysis, and forensic facial reconstruction, the Stanislaus County Sheriff Coroner’s office held a case conference to discuss the findings and decide how to proceed. It was decided that the media would be notified and the photographs of the forensic facial reconstruction would be posted on the Doe Network (www.doenetwork.org), a website that posts profiles of unidentified persons. The story appeared on local television stations and in newspapers (Figure 7).

A Santa Cruz woman saw a news story about the exhumation of Jane Doe #48 and the new missing person’s profile and followed up on the case on the Doe Network. She had lost contact with a female cousin in 1971 who fit the description of Jane Doe #48. This informant contacted the Stanislaus County Sheriff Coroner’s Office and agreed to mtDNA analysis. On June 26, 2008, the California Department of Justice requested that additional teeth be extracted for mtDNA analysis. A positive match was achieved and the California Department of Justice confirmed the identity of Jane Doe #48, a former San Francisco State University student [21].

According to information assembled by Detective Hedrick, the Stanislaus County Sheriff Coroner’s Office, and the San Francisco Chronicle, Jane Doe #48 had grown up in Anaheim, attended Cal Poly San Luis Obispo, married young, divorced, and moved to San Francisco in 1969, when she was 21. She became a student at SFSU and participated in protests against the Vietnam War. She also had a shotgun wedding to a jailed friend to try to help his circumstances [21]. Jane Doe #48 began supporting the Black Panther Party and its more radical offshoot, the Black Liberation Army (BLA). According to Koopman [21], there is reason to believe she participated with the BLA in the August 29, 1971, slaying of Sgt. John B. Young, a police officer in the Ingleside Police Station. She is alleged to have gone into the Ingleside Police Station while wearing a wig to report her purse missing minutes after a bomb exploded at a nearby bank. She was then apparently seen shining a flashlight up the street in the middle of the afternoon. Minutes later, several black men stormed the station, fatally wounding a police sergeant and wounding a civilian aide. Jane Doe #48’s remains were found floating nearly naked in the Delta-Mendota Canal near Modesto on September 11, 1971. The coroner determined she had been dead less than 24 hours. Defense wounds to her hands indicate
she fought her attacker(s), but that they killed her with 65 stab wounds, including at least 10 fatal blows. The killer(s) tried to sever her hands, eventually failing and giving up after taking fingertips and hacking off a thumb.

The BLA took credit for the slaying of Sgt. Young in retaliation for the August 21, 1971, prison-yard slaying of Black Panther leader George Jackson, who was fleeing at the time of his death. Six men, now in their 60s, who are accused of the death of Sgt. Young, have been taken into custody and as of this writing await trial at San Quentin. Perhaps in the future one of them might shed light on the circumstances of the murder. For the informant, her cousin, and other surviving relatives, having Jane Doe #48 identified and reburied under a headstone bearing her name and the words “Forever Loved, Never Forgotten” are at least a start.

Conclusion

This case marks the first published use of DCIA in determining both age and season of death in a forensic case. Jane Doe #48 was born on August 11, 1948, and died on September 10 or 11, 1971, at the age of 23. This is within both the revised skeletal age estimate and the DCIA age estimate of 23.5 to 25 years ± 2.5 years. The season at death was also accurately predicted based on DCIA. Estimation of age at death and season at death using dental cementum increments are therefore shown to be powerful new tools to augment existing forensic methods.

Solving cold cases, opening the time capsules like this one that reveal a complicated life, often depends on the collaboration of many specialties within the criminal justice system. In this case, Detective Hedrick, the various forensic specialists, national criminal and missing persons databases, missing persons websites, and local news media were all involved in the long chain of events that started with a cold case binder and ended with the successful identification of Jane Doe #48 and the return of her remains to her surviving family.

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References


