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Reconstruction of Root Morphology in Skeletonized Remains with Postmortem Dental Loss

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ABSTRACT: A reversible technique is presented in which the root morphology of missing teeth in skeletonized human remains can be reconstructed for the purpose of radiographic comparison and postmortem identification. In this technique, which is based upon pilot studies with skeletonized mandibles of archival remains, the alveolar socket walls are sealed with a coat of cyanoacrylate cement and injected with a mixture of vinyl polysiloxane and barium sulfate. Radiographs are produced with the radiopaque mixture in place, which highlights the antemortem morphology of the roots. Subsequently, the impression material is removed, resulting in no gross alteration of the evidence. The radiographs made with this technique, as well as the impressions, can be stored for later use at a trial or pending the discovery of antemortem dental evidence.

KEYWORDS: odontology, postmortem dental loss, root morphology, human identification, X-ray analysis

The analysis of dental evidence in skeletonized human remains can be complicated by postmortem tooth loss, which occurs following degeneration of the periodontal soft tissues. Although the statistical basis for identication by dental characteristics has been well established [*1,2,3*], postmortem loss of the teeth may confound traditional approaches. The only dental evidence remaining may be that obtained from the empty alveolar sockets. If the bone is well preserved, it may be possible to determine areas of previous extractions [*4*] and periodontal pathology, as well as tooth alignment and angulation. Radiographically, the lamina dura may be discernible and furnish a feature for comparison with antemortem films if they portray the tooth roots. Indeed, the radiographic comparison of root structures is increasingly becoming a necessity, reflecting a general reduction in the number of victims with dental restorations. Unfortunately, the outlines of the sockets are sometimes unclear, and certain details may be difficult to interpret. In recognition of the problems associated with postmortem tooth loss, a method was sought that would help the investigator to regain some of the missing evidence for radiographic comparison. Specifically, could a radiopaque material be placed in the empty sockets which would enhance the odontologist's ability to determine the antemortem shape of the roots? The purpose of this paper is to describe a reversible method with which the root morphology of teeth lost postmortem can be reconstructed for purposes of radiographic comparison.

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Materials

The equipment used in the development of this technique included rubber gloves, a soft bristle toothbrush, cyanoacrylate cement, butyl acetate cement, barium sulfate suspension, compressed air, a table spoon, low-viscosity vinyl polysiloxane impression material (Reprosil, L. D. Caulk), an injection syringe, a mixing pad with a spatula, and a plastic instrument. All radiographs were produced on a standard dental X-ray unit at 10 mA, 70 kV peak, and 18/60 s, using periapical film (size 2).

A decision was made that the filling material of choice should be radiopaque, removable, readily available, and capable of accurately reproducing the socket architecture. A combination of vinyl polysiloxane and barium sulfate suspension was selected to meet these criteria. Vinyl polysiloxanes are considered to be highly accurate dental impression materials with excellent elastic recovery and low permanent deformation [*5*]. They produce impressions with long-term stability and acceptable tear strength [*5,6*] at a moderate cost [*7*]. Barium sulfate, on the other hand, is a commercially available compound commonly used in the radiographic imaging of the gastrointestinal tract. This material is inert, radiopaque, and water insoluble [*8,9*].

Methods

The technique described in this paper was developed using the mandibles of unknown Asian Mongoloids from the archives of the U.S. Army Central Identification Laboratory, in Hawaii. All the specimens contained from 6 to 16 adult teeth. The dentition and periodontium were without gross pathology, although mild to moderate occlusal attrition was evident on most of the posterior teeth. Some cortical bone loss was noted in the areas of canine prominence and was attributable to postmortem erosion.

Initial radiographs were produced with all the teeth in place, representing *antemortem* dental films (Figs. 1*a* and 2*a*). Next, the teeth were removed to simulate a specimen

FIG. 1*a*—*Right posterior mandible with teeth in situ, simulating an antemortem radiograph. The arrows indicate concavities on the inner aspects of the mesial and distal roots (compared with Figs. 1b and 1c).*

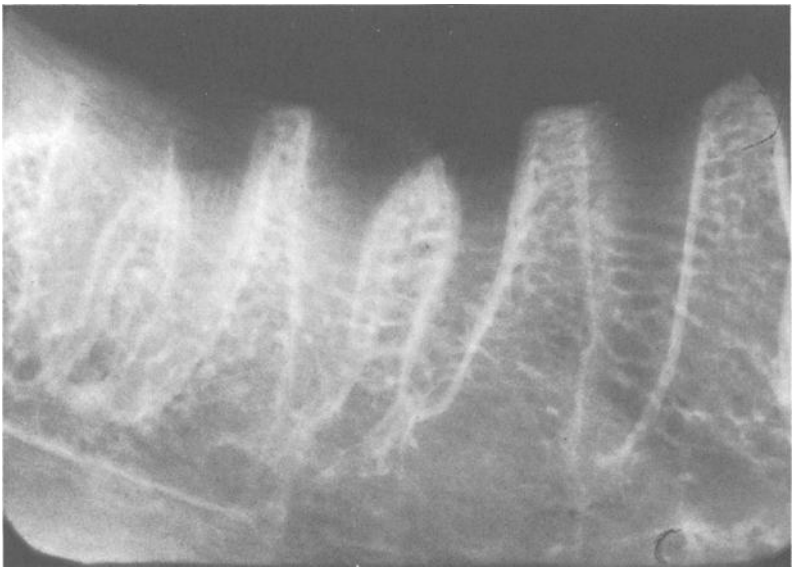

FIG. 1*b*—*Right posterior mandible with teeth missing, simulating postmortem evidence. Note the apparent mesial curve of the second molar distal root (compare with Figs. 1a and 1c).*

exhibiting postmortem dental loss. This was achieved by immersing the mandible in tap water for 3 to 10 min, followed by careful facial-lingual luxation of the individual teeth by hand. No grossly detectable change in morphology occurred in either the teeth or the bone as a result of this procedure. A second set of radiographs, representing the *postmortem* films, was produced of the empty alveolar sockets (Figs. 1*b* and 2*b*).

Early testing with injection of vinyl polysiloxane and barium sulfate into the empty alveolar sockets provided satisfactory radiographic results (Figs. 1*c* and 2*c*), but difficulty was encountered in removing the impression afterwards. The vinyl polysiloxane had flowed into the numerous nutrient canals in the alveolar walls and was locked in place. Various separating media applied to the sockets prior to injection proved unsatisfactory until a single coat of cyanoacrylate cement was tried. Subsequently, multiple impressions were produced and removed easily. From these experiences, a complete protocol was developed and is described in its entirety below.

Description of the Technique

Upon receipt of the specimen, the alveolar bone is radiographed and photographed prior to cleaning. Loose or fractured fragments of bone that can be placed in their natural locations should be stabilized with a reversible adhesive. Butyl acetate has been the author's choice because of its clear, inconspicuous appearance, radiolucent character, and solubility in acetone.

The alveolar sockets are carefully debrided with a soft bristle brush, wooden toothpicks, and warm water. Following debridement, the alveolar bone should be radiographed again to reevaluate the definition of the socket outline. If the lamina dura is distinct, further

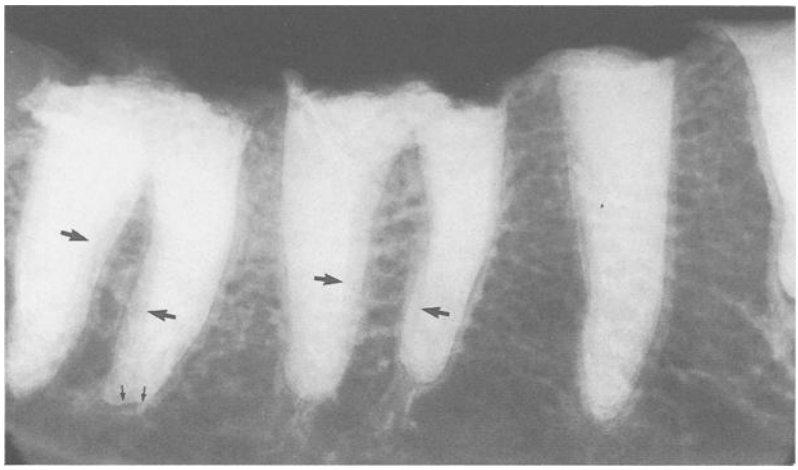

FIG. 1c—*Right posterior mandible with barium sulfate reconstruction of antemortem root morphology. The larger arrows indicate the contours on the inner aspect of the roots (compare with Figs. 1*a *and 1*b*). Note the spillage of impression material at the crestal bone on the distal aspects of the first and second molars. The smaller arrows at the mesial root of the second molar indicate incomplete apical filling (compare with Fig. 1*a*).*

FIG. 2a—*Anterior mandible with teeth in situ, simulating an antemortem radiograph. The arrows indicate significant trabecular bone patterns (compare with Figs. 2*b *and 2*c*).*

FIG. 2b—*Anterior mandible with teeth missing, simulating postmortem evidence.*

FIG. 2c—*Anterior mandible with barium sulfate reconstruction of antemortem root morphology. Note the extrusion of impression material into the alveolar bone at the apex of the left central incisor. The right lateral and central incisors exhibit incomplete apical filling by the impression material, as is indicated by the black arrows (compare with Fig. 2a).*

enhancement may not be necessary. However, if the determination is made that radiographic enhancement could be beneficial, the following six steps are recommended:

1. *Final Debridement*—Allow the alveolar bone to air dry and blow any loose debris from the socket with compressed air. Eye protection should be worn to safeguard from "blow-back" of material into the operator's face during this and subsequent steps.

2. *Sealing*—This procedure closes the nutrient canals in the alveolar socket wall, which might otherwise prevent removal of the impression material. Drop cyanoacrylate cement around the crestal edge of the socket, coating all the walls, and allowing the cement to flow into the periapical area. The slight darkening and sheen that accompanies this process will permit determination of which areas have been coated. Make sure that the entire socket is covered, using a penlight to view hidden areas if necessary. For the extreme apical areas that cannot be directly observed, place drops of cement as far apically as is visible and then blow gently with compressed air. The liquid cyanoacrylate will be forced to the bottom of the socket, and any excess will escape through the alveolar cribriform plate and into the marrow spaces.

3. *Mixture*—Allow the cyanoacrylate to dry thoroughly. Mix the vinyl polysiloxane according to the manufacturer's instructions and add one heaping tablespoon (18–25 cc) of Barium sulfate oral suspension for every two "lines" of impression material.

4. *Injection*—Load the syringe with the mixture and insert the tip as far as possible into the socket. Proceed slowly with the injection until the material has flowed up and past the syringe tip, gradually withdrawing the syringe. The material should flow beyond the upper limits of the socket. Allow the material to set completely and then recontour the excess with a scalpel blade.

5. *Radiographs*—Retake the radiographs utilizing the same settings and angulations as those used in the original films. Evaluate the radiographs for obvious voids or insufficient fill of the periapical areas.

6. *Impression*—Remove the impressions from each socket by gently teasing the cone of material out with a spoon excavator, curette, or plastic instrument (Fig. 3). Examine the impressions for any obvious blebs or overextensions. Clinical judgment must be used to determine which anatomical irregularities are artifactual and which are true representations of the root morphology.

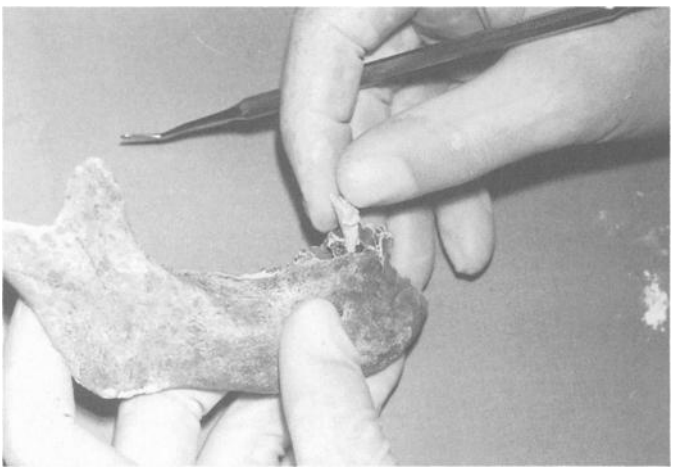

FIG. 3—*Removal and examination of the root impression.*

Results

Examination of the photographs in Figs. 1*a* through 1*c* and 2*a* through 2*c* reveal subtleties of root morphology apparent in the enhanced radiographs which are not easily seen in the postmortem films. The second molar distal root socket is indistinct and appears to curve to the mesial in Fig. 1*b*. With enhancement, in Fig. 1*c*, it becomes clear that the root actually turns toward the distal. The thin alveolar bone in the anterior mandible, shown in Fig. 2*b*, makes determination of the radicular anatomy difficult. The use of radiopaque impression media in Fig. 2*c* not only confirms the socket outline but also establishes relational landmarks for comparison with the trabecular patterns indicated by the small black arrows in Fig. 2*a*. The three-dimensional appearance of some roots is not lost in the enhancement process. Notice the contours of the inner aspects of the mesial and distal roots of the mandibular first and second molars in Fig. 1*a*. This appearance is not well maintained with the loss of dentition, in Fig. 1*b*, but is recaptured in Fig. 1*c*.

Some potential problems associated with the use of this technique are noted as well. For example, failure to obtain a complete periapical seal with the cyanoacrylate cement may result in extrusion of impression material into the surrounding alveolar bone. Figure 2*c* illustrates such an occurrence in association with the left central incisor. Removal of this material without damaging the bone is unlikely. Similar spillage may occur around the crestal bone, as seen on the distal aspect of the second molar in Fig. 1*c*. This area, however, is easily accessible and the excess material can be removed.

An incomplete periapical fill poses a different problem. Note the periapical areas of the right central and lateral incisors in Fig. 2*c* and the mesial root of the second molar in Fig. 1*c*. These voids may have been caused by residual debris in the apices, by pooling of cyanoacrylate cement, or by poor flow of the impression material.

Discussion

In view of the complications incurred in the development of this technique, the following precautions are suggested:

A lack of socket integrity may cause extrusion of the impression material—Severe loss in the continuity of the alveolar walls, whether caused antemortem, postmortem, or perimortem, may contraindicate the use of this technique or require its modification. Thorough evaluation of the condition of the alveolar bone in each case is recommended to determine which sockets, if any, are suitable for the impression technique. If the damage is focal, selective enhancement of individual sockets or portions of sockets may still be beneficial. Injection of the vinyl polysiloxane should be limited to the areas of the bone judged to be a reliable representation of the antemortem socket morphology.

Failure to completely debride the socket may compromise the accuracy of the impression—A penlight may be necessary to observe the deeper areas to ensure thorough debridement. An endodontic file or other radiopaque probe can be placed in the socket apex and radiographed to evaluate the extent of debridement in areas inaccessible to direct inspection.

Repeated sealing with cyanoacrylate cement can result in false socket depth—The sealing procedure should be conducted only once, even if all the walls are not completely covered. It was found that a hardened first layer of cyanoacrylate cement at the periapex tended to pool subsequent coats and resulted in an artifactual *shortening* of the socket depth.

The barium/vinyl polysiloxane ratio should be adjusted to fit the situation—The radiopacity of the impression appears to be directly proportional to the amount of barium

sulfate incorporated into the vinyl polysiloxane. The addition of the powder, however, stiffens the consistency of the mix and reduces its injectability. Some experimentation may be necessary to determine the ratio that provides the best radiographic image, yet maintains a reasonable flow and working time. Vinyl polysiloxane was chosen on the basis of its highly regarded performance in the clinical practice of dentistry. However, the physical properties that justified its selection may be significantly affected by the addition of barium powder. Further investigation is necessary before conclusions concerning the specific accuracy, elasticity, or flow of this combination of materials can be offered.

Material found outside the limits of the socket may distort its radiographic appearance—Particular attention should be paid to cutting back spillage that occurs in areas of cortical erosion or periodontal defects. Failure to remove this excess can produce a false increase in the radiographic width of the antemortem socket.

Impressions of the sockets can be repeated as many times as necessary to ensure accurate representation of the socket morphology—If the accuracy of the impression in a particularly contorted area is in question, injection of light-body impression material can be conducted without the addition of barium sulfate. This test is based upon the assumption that deleting the barium results in a less viscous material, which will fill in details more efficiently. The morphology of this second impression is then compared with the first radiopaque cone to ascertain the completeness and accuracy of the fill.

Conclusions

A simple, inexpensive, and reversible technique has been presented in which the root morphology of postmortem missing teeth in skeletonized human remains can be reconstructed for the purpose of radiographic comparison and postmortem identification. All items in the recommended armamentarium are readily transportable, commercially accessible, and not cost-prohibitive. The technical aspects of the procedure are easily within the capabilities of the odontologist and can be performed in a laboratory, operatory, or mortuary environment. Repeated impressions and radiographs can be produced without causing gross alterations to the jaws. Once the radiographic evaluation is completed, the impression material can be removed, leaving only a thin veneer of cyanoacrylate in the alveolar socket.

The sockets within a skeletonized jaw will vary in condition and thus in their capacity to demonstrate significant and accurate morphology. Although some caution should be exercised when radiographic comparisons are conducted with reconstructed dental evidence, each case should be evaluated independently. The author believes that the selective use of this technique will allow the reconstruction and documentation of valuable dental evidence that might otherwise be unavailable for evaluation.

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