CASE REPORT

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Computerized Axial Tomography as an Aid in Bite Mark Analysis: A Case Report

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ABSTRACT: A case is presented to demonstrate the use of computerized axial tomography (CAT) to develop precise registration of incisal edges for comparison to bite marks. Emphasis is drawn to the availability of CAT Scanning equipment and the importance of understanding its use as an adjunct or alternative to already accepted methods of incisal registration.

KEYWORDS: odontology, bite marks, tomography, computerized axial tomographic scan, computerized tomographic scan, computerized tomography, computer aided tomography, computerized axial tomography, dentistry

Bite mark evidence has a long and interesting history leading to its acceptance in the legal and scientific community [*1-3*]. Early recognition of the uniqueness of the human dentition is evidenced by references predating fingerprints by several hundred years [*1*].

The establishment of professional organizations with guidelines for the recording and analysis of this important evidence [*4*] and the citation of over 70 appellate decisions [*5,6*] in favor of bite mark comparison procedures since 1954 indicate the solid foundation of this field. Hundreds of scientific papers discussing the methods and materials associated with bite mark analysis are indicative of the importance placed upon proper manipulation of materials and interpretation of evidence.

Bite mark comparison procedures consist of an evaluation of the degree of similarity in two different pieces of evidence: the dentition of the suspect and the marks left on skin or other inanimate objects by teeth.

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There are various methods of comparison that are equally reliable and adaptable to the scoring guidelines accepted by the American Board of Forensic Odontology.

Many investigators will compare specific areas of interest in the bite mark to the part of the tooth causing the mark through means of indirect comparison, for example, placing a photograph of the mark next to a set of models of the teeth and referring back and forth until a determination is made. Others will work directly, one to one, by trying to fit a model of the teeth into the depressions made during biting or over the bruise caused by the bite. Still others will overlay a photograph of the bite mark with a photograph or tracing of the biting edges of the teeth in either one-to-one or three-to-one magnification. This last technique is well suited to video overlay techniques where the image of the teeth can be dissolved and resolved over the tooth mark in an attempt to visualize the degree of similarity.

All comparison procedures depend upon accurate representations of the biting edges of the teeth for valid comparison.

There are numerous methods of incisal registration such as placing a sheet of clear acetate on the incisal surfaces and carefully tracing the outline of the teeth for direct comparison purposes. The incisal edges can also be photographed and the resultant transparent images used for direct overlay comparison. Another precise technique for incisal registration consists of impressing the teeth into wax. The indentations in wax are then radiographed after being filled with zinc dust, silver particles, or barium sulfate. The radiographic image is then used for direct overlay comparison or computer study [7].

This paper describes the application of computerized axial tomographic scanning (CAT scanning) to give precise registration of the incisal edges of teeth for comparison purposes. It does not attempt to found a new science or establish a new standard, but rather to illustrate another example of a well-founded science being applied to the field of forensic odontology.

Case Report

On 4 June 1984, a severely battered 15-month-old female infant was brought into the Emergency Room of the Redding California Memorial Hospital (Fig. 1). The child was near death with contusions and abrasions covering her face and neck and burns between her eyes, on her nose, and in the vaginal area. In addition, there were petechial hemorrhages and contusions on both upper extremities consistent with human bite marks.

FIG. 1—*Badly battered infant with extensive injury including bite marks.*

Personnel of the Redding Police Department began an investigation which included an examination by a forensic odontologist.

Investigation

After examination of the infant, it was determined that the marks on the arms were, indeed, well-defined human bite marks (Fig. 2). Numerous photographs were taken in both black-and-white and color. The investigation of the bite marks continued as outlined in the "Guidelines for Bite Mark Analysis" presented by the American Board of Forensic Odontology [*4*].

The police investigators identified only two possible suspects with access to the infant: the mother and the stepfather.

Impressions of the mother's dentition were voluntarily given, and those of the stepfather were obtained by way of a court order. Both suspects cooperated completely. Two sets of master casts were constructed for each suspect.

Comparison Procedures

Many forensic odontologists prepare wax exemplars of bite marks for comparison. The wax tooth impressions are filled with a radiopaque material as previously described and radiographed. The incisal edge pattern is thus registered on a transparency that can be placed directly over the photographic image of the injury for comparison purposes or enlarged photographically for further study. One disadvantage of the wax bite method is that it demonstrates the incisal edge to one specific depth. If other depths are needed for comparison, new bites have to be taken in thicker material.

Rawson [*8*] suggested a tomographic approach to incisal registration by imbedding the stone model of suspect dentition in stone or plastic of another color and then sectioning at precise intervals. The result is difficult to obtain, but it does give a third-dimensional aspect to the comparison by determination of the longest teeth.

The present study was designed to determine if computerized axial tomographic scanning technology would produce a simplified method of precise incisal registration without the need of numerous wax bites or destructive sectioning of the master cast.

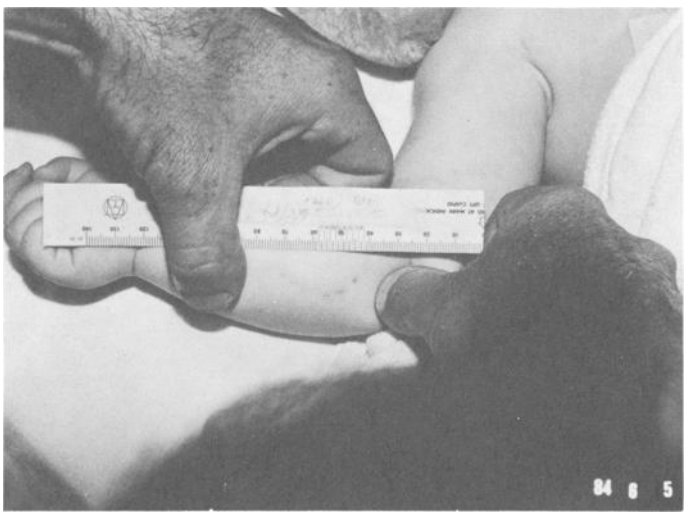

FIG. 2—*Example of the well-defined bite mark on infant's arm.*

Computerized Axial Tomography

Master models were placed in the head holder of the G.E. 9800 computerized tomographic (CAT) scanner. The teeth were oriented as if the suspects were in a supine position, head first in the CAT gantry opening (Figs. 3 and 4).

Laser alignment lights inherent to the 9800 system were used to center the teeth in the gantry. Both horizontal and vertical alignment were obtained using the following specific points on the teeth. The vertical laser was directed through the midline of the mandibular

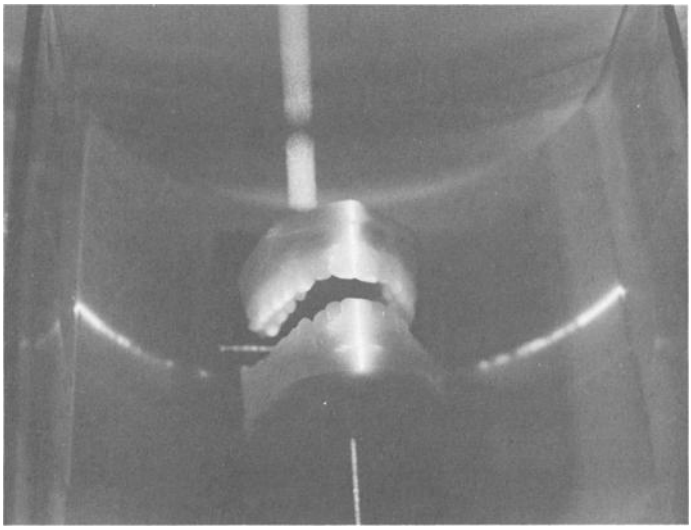

FIG. 3—*Laser orientation of master models in the CAT scanner. The laser grid is oriented between the central incisors on the* y *axis with the* x *axis touching the cusp tips.*

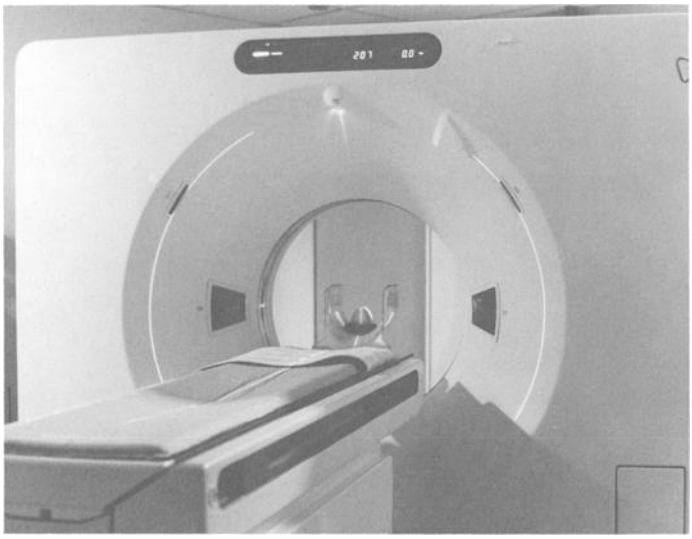

FIG. 4—*Orientation is as though the suspect were in a normal supine position for scanning.*

and maxillary central incisors and the horizontal laser was allowed to just touch the incisal edges of the cuspids (Fig. 5). Once the teeth were aligned in their proper anatomic position, a "scout" scan was performed with the X-ray beam directed at 0°, to give an anterior posterior projected image. This image, or scout film, was used to prescribe precisely the intended axial cuts to be performed.

The scanning aperature was set to 1.5 mm and the gantry programmed to move in an apical direction at 0.5-mm increments. Low kilovoltage and milliamperage settings were used to provide adequate contrast in the image of the plaster cast.

Hard copy transparencies were produced using the CT/T camera designed for the CAT scanner according to the "Black Bone" mode inherent to the 9800 system. Proper magnification factors were verified using a direct overlay technique to determine accuracy of representation of the master cast. The magnification factor used with the 9800 system is 1.35 to produce precise one-to-one camera films.

The end product is a 14- by 17-in. (35.5- by 43-cm) transparency with several axial images of the teeth at various depths and at precisely one-to-one image size (Fig. 6). A centimetre scale is visible on all axial images so that precise measurement is easy to confirm. Scout views were also produced showing the exact level and number of axial projections.

Discussion and Conclusions

The CAT scan of models in this case produced precise registrations that allowed determination of which of the two dentitions produced the bite marks. Precision was verified by direct overlay and direct measurement. The photographs of wounds and the CAT scan of teeth were prepared for presentation by using a video overlay technique that is beyond the scope of this paper, but the accuracy was ensured by standard overlay procedures (Fig. 7).

The precise nature of the registrations allows confidence in determination of degree of match when there is a high degree of correlation between tooth and wound pattern. Current statistics on the uniqueness of the human dentition have already been developed for a match of center point of tooth print or ± 1 mm and an angle which is $\pm 5°$. These parameters are well within the limits of observer capability [7].

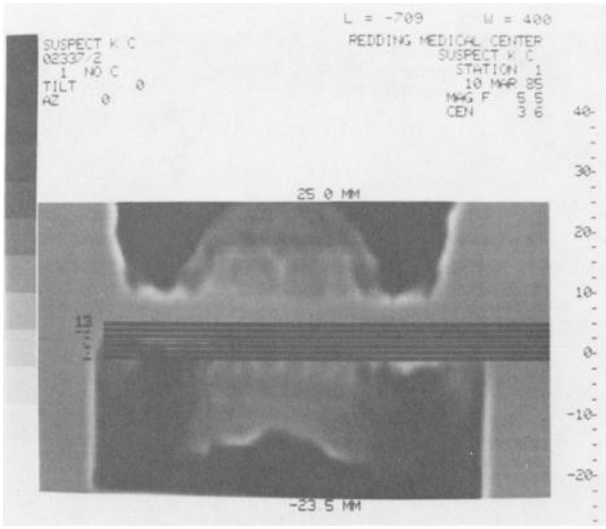

FIG. 5—*Cathode ray screen view of model orientation. The horizontal plane is just touching the cusp tips of the canines. This is an individual 0.5-mm tomographic section as indicated by horizontal numbered lines on Scout view image.*

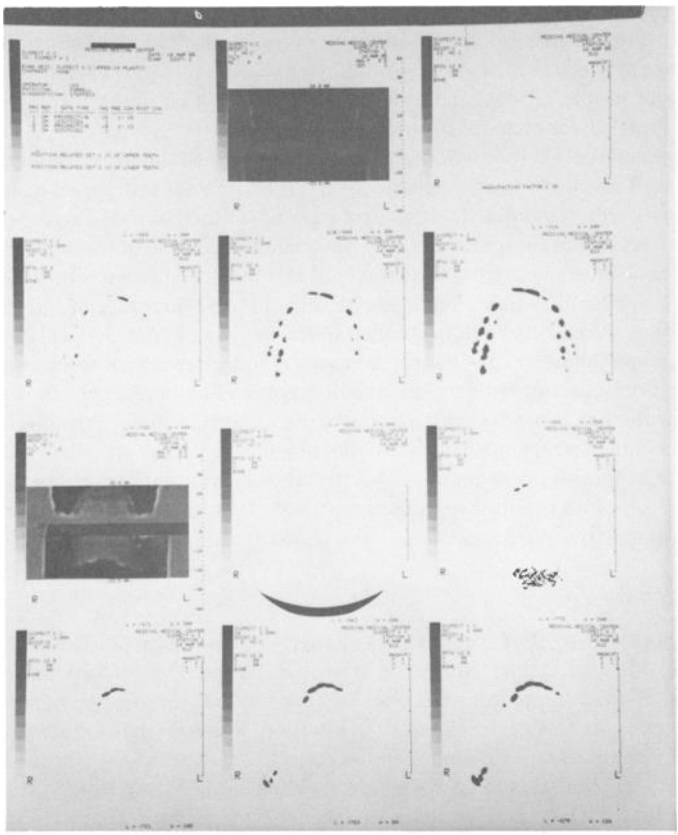

FIG. 6—*Transparency, 14 by 17 in. (35.5 by 43 cm), demonstrating the incisal and axial registration (tooth print) of teeth at prescribed 0.5-mm intervals.*

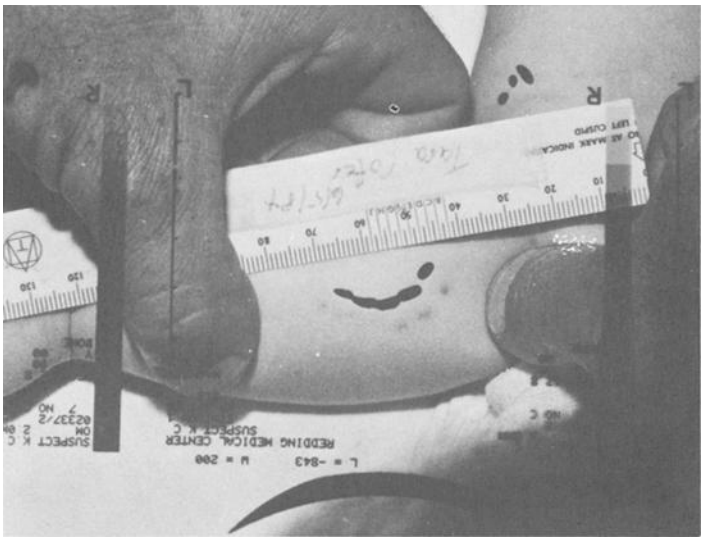

FIG. 7—*Overlay of CAT scan produced tooth prints held close to photograph of wound patterns, demonstrating similarities.*

This method appears to produce a clear registration that can easily be used in comparison procedures, thus allowing determinations to be made in difficult cases with similar dentitions because of the accuracy of the procedure. The availability of CAT scanning equipment in most major hospitals opens the possibility of use of this equipment at minimal cost by all interested forensic odontologists.

It is suggested that the validation of new comparison techniques is simplified by the significant time and scientific proof available for the fundamental techniques of comparison. Rigerous proofs were essential for the first case of comparison of fingerprints because it founded the science of comparison. Once the science of comparison was shown to be valid, it was much easier to demonstrate the validity of bite mark comparison because of reliance on established science. The new techniques described in the literature of bite marks are often demonstrations of new technology applied to the science of comparison [*9*].

As an example, photography has served as the standard means of comparing two features. If a comparison is attempted between a radiograph and a photograph, the burden is simply to demonstrate that the radiograph is an accurate representation of the original object. The comparison is then accomplished by identical methods.

The clearcut images of the incisal edges in this case prompt the authors to suggest a careful comparison of all occlusal registration procedures to determine the most useful procedures for comparison purposes.

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