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Analysis of Distortion in Preserved Bite Mark Skin

REFERENCE: Rothwell BR, Thien AV. Analysis of distortion in preserved bite mark skin. J Forensic Sci 2001;46(3):573–576.

ABSTRACT: In addition to other methods for conservation of bite mark evidence, preservation of actual skin from deceased victims is often suggested. This study was undertaken to analyze the dimensional stability of such specimens. Utilizing a prefabricated template, marks approximating "bites" were made in postmortem skin of Miniature Hanford pigs, producing imprints with distinct margins and indentations. Tissue samples were stored in 10% formalin after affixing an acrylic support ring with cyanoacrylate adhesive and sutures. Measurements of the six tooth mark analogues and cross-arch dimensions were taken at intervals of up to 38 days.

Data from these measurements indicate a wide range of amount and type of distortion in preserved tissue. Although some samples were dimensionally stable, there was both contraction and expansion of bite mark specimens, even within individual skin samples. It appears that standard techniques for storage and preservation of bite mark samples will not produce reliable dimensional accuracy.

KEYWORDS: forensic science, bites—human, forensic—odontology, dentistry, forensic—pathology

Bite mark evidence has assumed a growing standing as an important segment of forensic science. Over the last three decades, bite mark evidence has moved from virtual nonexistence to a position of relative frequency in cases involving forensic evidence (1). Similarly, the sophistication and technical proficiency utilized in the analysis of bite mark evidence have improved dramatically. The application of photographic techniques are widely recognized as a critical means of evidence preservation, and there has been substantial improvement in the consistency and reproducibility of such photographs (2,3). The use of standardized photographic scales in conjunction with stabilized color and black and white photographs has allowed the production of life-size reproductions for direct comparison with tooth models and imprints (4).

Considerable attention has been paid to the myriad methods of comparison of the bite mark in skin to the dentition of possible perpetrators. Various templates, comparison devices, and techniques have been espoused (5–7). Most of these employ correlation between photographic representations, but some use actual skin samples (8). Most recently, studies have shown that templates produced by computer programs from scanned photographs are the most reliable means of comparison (9). While photographs have the advantage of relative permanence, they are two-dimensional representations of three-dimensional objects. Because of this inherent limitation, many experts recommend preservation of actual bite mark skin samples when practical. Although skin preservation has been advocated, the specific use of these samples has not been well delineated. The literature is not very clear on this issue, but since the apparent objective of the recommended process is to stabilize the tissue, it is likely that forensic odontologists will endeavor to perform some sort of metric analysis of the skin marks at some future date (10). In individual case presentations, forensic odontologists have stated that preserved samples were measured after storage. In addition, one author describes transillumination of this preserved skin to demonstrate features otherwise difficult to visualize (11,12).

Generally accepted methods of preservation include the placement of tissue support devices and adhesion to surrounding tissue with cyanoacrylate cement and circumferential skin sutures (13). This supposedly allows for the dissection of tissue samples maintaining the three-dimensional features of the original tissue prior to placement in fixative and preservative solutions.

The purpose of this study was to assess one aspect of that method of tissue preservation: the dimensional stability of the bite mark samples. The reliability of the metric analysis of such skin samples following storage for finite periods of time was assessed by standard measurement techniques.

Methods

Deceased Miniature Hanford pigs were used to harvest skin samples for this study. The animals had been used for another anatomical study requiring the removal of the heads, and the freshly killed carcasses were made available for this investigation of bite mark imprints. Experimental imprints approximating bite marks were made in the skin of the pig carcasses using a standardized tooth arch analog template applied in a static fashion with a support and weight platform on top (Fig. 1). The tooth arch analog template was fabricated from clear plastic stock and milled aluminum to standard dimensions approximating the size of average adult teeth in the anterior region (Fig. 2). It was designed to be equivalent to the canine-to-canine portion of the adult maxillary arch. In preliminary trials, it was determined that clear, precise imprints could be predictably produced by using a force of 6.8 kg for 3 min.

Using the device in this fashion, experimental bite imprints were produced in the skin of the pig carcasses in selected sites of smooth flat topography. Immediately afterward, tissue support rings were fabricated from acrylic resin dental tray material (Formatray®, L.D. Caulk) and adapted to the surrounding tissue contours. These were then affixed to the skin with cyanoacrylate cement and four circumferential subdermal 00 black silk sutures (Fig. 3). The cyanoacrylate cement was allowed to set at room temperature for 1 h, and the skin samples with affixed support rings were removed by means of sharp dissection and removal of underlying subdermal tissues. The resultant samples were of uniform thickness and were then immersed in a 10% formalin solution and refrigerated at 25°C.

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Received 24 April 2000; and in revised form 20 June 2000; accepted 28 July 2000.

FIG. 1—*Bite registration device.*

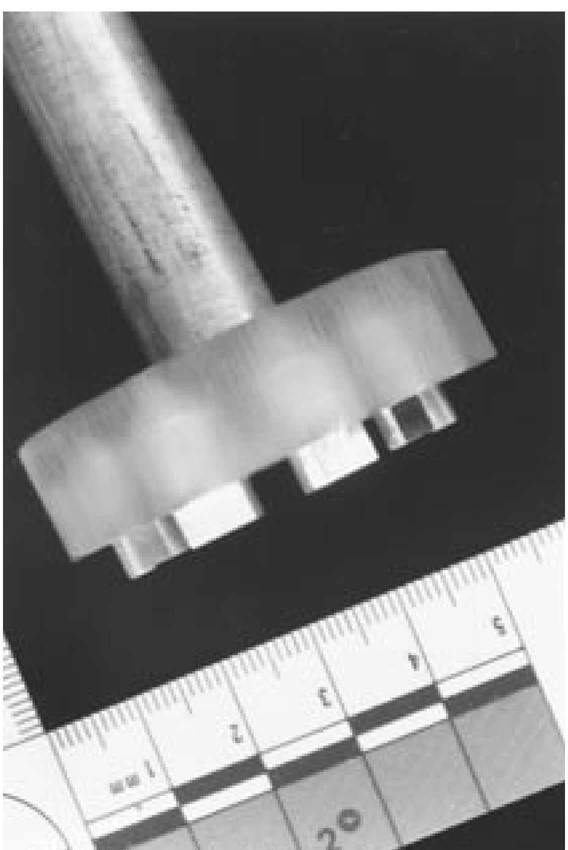


FIG. 2—*Tooth arch analog.*

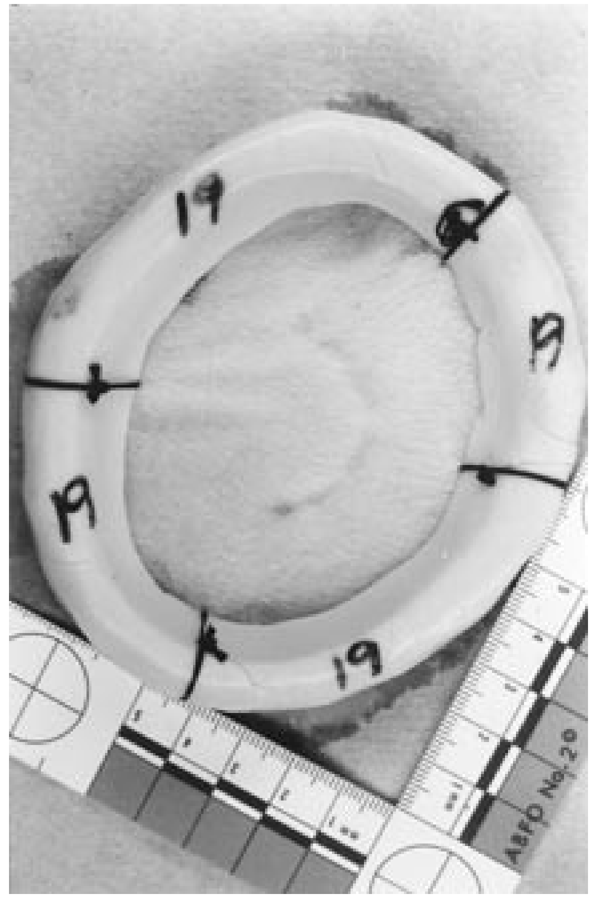


FIG. 3—*Experimental bite with support ring in place.*

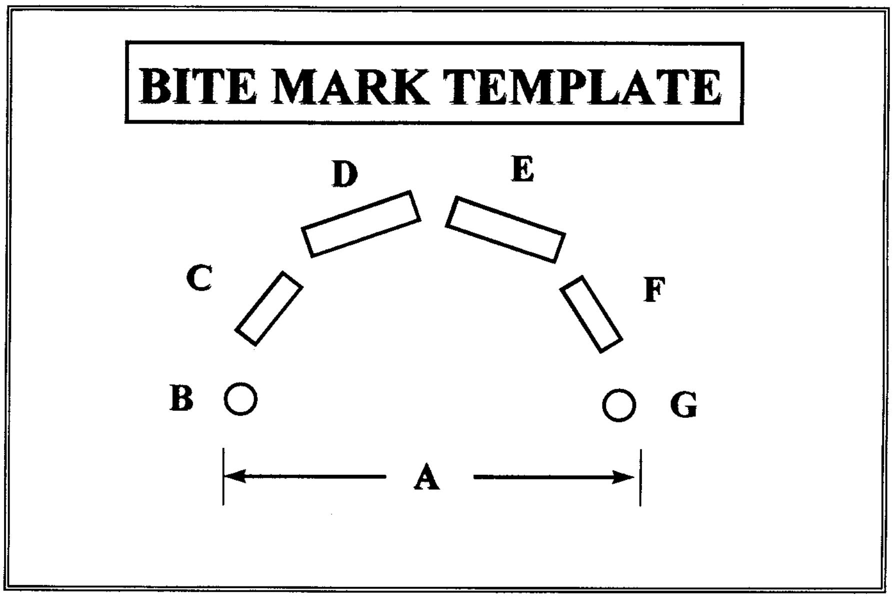
At selected intervals up to 38 days, specimens were carefully removed from storage and the imprints measured by two independent investigators utilizing calipers and Boley gage under × 2.5 magnification. Measurements were made of the cross-arch dimension and of each of the individual tooth analog imprints (Table 1). The data obtained were tabulated for each of the 24 samples and comparisons made to assess dimensional stability. The changes were assessed using the t-test and paired two sample for means as described in the results section.

Results

The measurements of the skin were taken at the time of excision of the skin (T_0) and at intervals up to 38 days (T_{12}). Although the bite mark samples were measured several times during the 38-day period, it was decided, for simplicity, to report only the values at T_0 and T_{12}. Twenty-four skin samples were assessed over the experimental period; however, several samples demonstrated enough tissue distortion that one or more individual measurements were not possible at T_{12}. In addition, storage in formalin altered the skin coloration and produced a bleaching effect that also made the measurements more challenging. Only those measurements in which accurate assessments were possible were reported.

Measurements were made by each of the two examiners at each interval. The two measurements were averaged to produce a mean value. The difference between the measurements made by the two examiners was small, with a mean difference of 0.02 to 0.13 mm at

TABLE 1—*Diagram and dimensions of template.*



MEASUREMENT	SIZE	REPRESENTING
A	36 mm	Maxillary Arch Width at Canines
B	3 mm	Canine Imprint
C	6 mm	Lateral Incisor, Mesial-Distal Width
D	8 mm	Central Incisor, Mesial-Distal Width
E	8 mm	Central Incisor, Mesial-Distal Width
F	6 mm	Lateral Incisor, Mesial-Distal Width
G	3 mm	Canine Imprint

T_0 and 0.01 to 0.10 mm at T_{12}. Thus, it was felt reasonable to compare the mean measurements in the final data analysis.

Skin samples demonstrated a wide range of type and extent of dimensional distortion. The measurements showed considerable change in dimension in both absolute terms and in the range of change. The measurements showed both expansion and contraction, sometimes even in the same individual sample. The change in dimension for each measure after 38 days of storage was tabulated along with the range of change, with negative numbers indicating tissue shrinkage. The data for T_0 and T_{12} were assessed statistically by means of the paired two-tail *t*-test for means and the standard deviation and value of *p* calculated for each of the seven individual measurements. This information is summarized in Table 2.

TABLE 2—*Mean dimensional change* T_0–T_{12}.

Measure	Change	Range	Standard Deviation	*p*
A	0.23 mm	−0.8 to + 1.05	0.48	0.027
B	0.27 mm	−0.05 to + 0.6	0.24	<0.01
C	0.09 mm	−0.25 to + 0.45	0.24	0.135
D	0.25 mm	−0.1 to + 0.65	0.29	0.022
E	0.13 mm	−0.55 to + 0.95	0.34	0.136
F	0.06 mm	−0.75 to + 0.80	0.48	0.625
G	0.19 mm	−0.25 to + 0.40	0.24	<0.01

There was a significant change in dimension for most measures during the experimental period. It was also noted that the magnitude of the changes increased with increasing periods of storage in the formalin. In addition, other distortion factors in the indentations themselves and changes in skin coloration made measurements difficult and in some cases virtually impossible.

Discussion

The experimental "bites" made in this study are not directly analogous to those seen in the majority of cases investigated in human skin bite marks. These were more distinct and more precise in initial placement than most actual tooth marks. In addition, the skin was excised relatively soon after placement, which should contribute to the stability on storage. In spite of these positive factors, the samples in this study demonstrated significant changes in dimension even when stored for the relatively short study period. Longer periods of time appeared to lead to increased distortion.

These results bring into question the value of attempting to preserve excised skin for later metric analysis. Because the distortion resulted in contraction as well as expansion, there was not even a consistent change that could be considered in any future measurements. In addition to the distortion, tissue became visibly more pale and the depth of indentations diminished so as to complicate measurements. The imprints in these samples were made postmortem, and although they were more distinct than many actual bite marks, it is possible that bites made before death in reactive tissue would be less susceptible to such changes upon preservation. Based upon this particular situation, it would appear that measurements after tissue excision and storage under these conditions is not accurate and that direct comparisons with the dentition of suspected biters are inherently flawed.

These effects make the production of standardized, consistent photographs of presumed bite marks even more important as a means of preserving evidence and size relationships. Although there are some inherent flaws in photography, it is probably more dimensionally stable than this form of skin preservation. Though not considered in this particular study, it was also noted that the dimensions of the marks at T_0 was in most cases different from the actual dimensions of the tooth analogues. This points out one of the inherent flaws in the accurate representation of bite marks in skin. There may be other uses for preserving skin samples, but metric analysis and comparisons do not appear to be viable.

Acknowledgment

This project was partially supported by the University of Washington Dental Alumni.

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