TONELINE BITE MARK PHOTOGRAPHY

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Executive Summary

Abstract

In bite mark analyses, the initial photograph is critical for the collection and presentation of evidence. A high contrast film technique previously primarily used in the graphic art field, has been refined and applied to forensic odontology. The process, called *toneline*, reduces the interpretational bias of the investigator and yields a transparent overlay with a photographic outline of the bite mark that can be directly compared with models of the suspect's teeth.

Introduction

From the onset of human hostility man has used his teeth as a weapon to bite his victims. Teeth have also been used as a means of defense. It has long been recognized that bite marks are unique and can be attributed to specific individuals. In fact, a recent study has established dental uniqueness beyond a reasonable doubt [2] and that even the dentition of identical twins is not identical [3].

A *bite mark* is defined as the mark created by teeth, either alone or in combination with other oral structures [4]. They are found on virtually all areas of the body, with more than one bite occuring in 40% of the instances [5]. These marks are now accepted as evidence in courts of law. Life and death decisions can hinge upon the accuracy with which such evidence is interpreted. Courts have admitted bite mark evidence in several different types of cases, "No reported case has rejected bite mark evidence. Indeed, its acceptance is so well established that the New York Court of appeals has held that its validity need not be proved in every case."[7]

At present there are several methods of analyzing bite marks. Photographing, tracing, or making models are the most common methods of examination and study. Regardless of the method of analysis used, photographs of the bite mark are always included, enlarged to life-size dimensions for comparison with models of the suspect's teeth. We undertook the present study to find a method of isolating useful photographic information while initially recording evidence.

Current photographic methods involve continuous tone (black-and-white or color) prints or slides [8]. Reference scales, rulers, or an ABFO #2 [9, 10] are frequently included in the photographic exhibit to show size and proportion. By selectively controlling photography of the original image, we hope to improve the contrast between bite mark discoloration and

surrounding tissues. The resultant high contrast negatives can be used to generate graphic toneline images of the bite mark perimeter.

Toneline (sometimes called a line print) is a relatively common, high contrast technique which yields a thin black outline of the photographed subject, often resembling a pen-and-ink sketch [11]. It is a method which can prove useful to photographers and odontologists in documenting and analyzing the evidence in unbiased fashion. We believe that the technique can be applied to any injury, mark, or pattern resulting in skin discoloration.

Accordingly, our investigation concentrated on the search for the optimum negatives for enlarging onto lithographic film in order to achieve a black "pen-and-ink" line around the bite mark. We also wanted to demonstrate the subjective qualities of currently accepted examination methodology.

Methods

Our research involved fourteen (14) bite marks. Five (5) were self-inflicted by a researcher due to a lack of timely coroner's cases. Nine (9) were present on four (4) decedents.

All fourteen bite marks were initially recorded in conventional fashion on 35 mm. Kodak Vericolor III Professional film. 1 : 1 enlargements on 5 x 7 inch Kodak Ektacolor Plus paper were made of each injury.

Methodology devoted exclusively to refining toneline technique for bitemark application was complex and evolved as our findings confirmed or negated our approach.

It is necessary to understand that a toneline film positive is the result of a continuous-tone film negative, a lithographic film positive , and a lithographic film negative. Accordingly, refining the toneline technique required investigation and controls at two of four involved steps:

1. The initial panchromatic film negative, and
2. The toneline film positive.

All of our photographic supplies (film, paper, developer, filters, etc.) were manufactured by the Eastman Kodak Company. The equipment necessary for our methodology is straightforward, minimal and easily available to any law enforcement agency with access to a darkroom.

When an original continuous-tone negative is enlarged onto lithographic film (in our project, Kodalith), properties within the film convert all intermediate gray tones present on the negative into either white (clear) or black [11]. The point at which one gray becomes black while another becomes white is called the *tonal break* . By varying exposure and development times, we have limited control over the point at which tonal breaks occur.

Unfortunately, lithographic film is very easily over- or underexposed, and controlling tonal breaks is difficult. Our efforts, therefore, were concentrated on separating the gray middle tones on the original continuous-tone negative. Continuous-tone films have significantly reduced compression of tones, and image contrast can be more easily controlled by varying film exposure, developer, development time, and selective filtration of incoming light [13, 14]. Characteristic curves (or H&D curves) [14] demonstrate lithographic (Kodalith) and continuous-tone (PLUS-X) film's differing responses to exposure and development.

To begin our research, bite marks were photographed with four rolls of each of the following film types; T-MAX 100, T-MAX 400, TRI-X Pan, PLUS-X Pan, PANATOMIC-X, AND Technical Pan. The focusing ring on the camera lens was taped so that subject-to-image distance was constant at two feet. Each roll of film was exposed identically, with consideration given to flash recharge time [13].

The various film types were processed in four different developers (D-19, Technidol LC, T-MAX, and HC-110 (dil. B)) at the manufacturer's recommended developing times at 68° F.. In some cases film/developer combinations were not specified, so development times were extrapolated.

Throughout the film and developer investigation, negatives were visually inspected, contact printed, and enlarged 1:1 onto 4 x 5 inch Kodalith film. Kodalith film positives at a variety of exposures were examined, and those clearly isolating the bite mark from the surrounding skin were contact printed (emulsion-to-emulsion) onto another sheet of Kodalith . All Kodalith film was processed in Kodalith developer (1:3) at 70° F. for 2 $^{3}/_{4}$ minutes. Once a dry Kodalith positive and negative were obtained, they were carefully registered and taped together with silver mylar photographic tape (base-to-base). When viewed from perpendicular to the film plane no light should pass through. Finally, second contact prints were made at varying exposures. During exposure the film must be rotated uniformly so that light passes through all of the tonal breaks. Exposing the film is best done with a point light source. For economy and availability we used a 200 watt bulb. Variations in the angle of bulb placement were explored and we found our results most useful when the bulb was placed six feet from the film at a 45° angle above the film plane. Our exposure times varied from 10 to 40 seconds depending on

film densities.

After processing the last sheet of Kodalith, we now had a toneline film positive of the photographed bite mark. We later used these with models of the suspect's teeth for direct comparison.

In order to demonstrate examiner bias, color prints of four bitemarks were given to four different individuals for tracing. For our purposes, we chose people of different occupations (secretary, police officer, artist, and dentist). They were each given the same photographs, four sheets of ortho tracing acetate, and a #2 pencil. They were instructed only to carefully trace the perimeter of each bite mark. No time limit was specified. The tracings were later compared with photographs and with one another.

Results

Our research produced 716 panchromatic film negatives (51 per bite mark), 463 orthographic film positives (33 per bite mark), 67 orthographic film negatives (5 per bite mark), and 23 toneline film positives (2 per bite mark). We met our goal of establishing a repeatable combination of film, developer, development time, exposure, and filtration for toneline examination of bite marks. We also were able to successfully demonstrate examiner bias in the currently accepted methods used routinely by forensic odontologists.

We found the film of choice to be Kodak Technical Pan panchomatic film. When processed in D-19 developer it exhibited excellent separation of tones in and around the bite mark. We found it best to increase development time approximately 20% in the D-19. We have also found that at times T-MAX 100 worked reasonably well as a film substitute and HC-110 (dil. B) can be used in place of D-19 if D-19 cannot be obtained. We call attention to the fact that T-MAX 100 and HC-110 are *not as effective* and should be used *only* if Technical Pan or D-19 are not available.

Figure 1 is our recommended procedure for photographing and processing a bite mark. We offer four different developer/film combinations, with our strongest recommendations first and the other combinations following in order of decreasing effectiveness (combinations in the gray area of the chart). As seen in ***Figure 1***, we recommend a minimum of ten exposures (five with and five without a #58 filter). We had hoped to develop a two or three exposure procedure but found the differences in skin tonality of decedents dictated a wider bracketed range. Because of differences in the equipment of the Cuyahoga County Coroner's Office and that of other darkrooms, further bracketing may be initially required.

Our results varied as to whether or not to use a contrast control filter. In some cases there were no significant differences in tone separation, in others it was quite noticeable. We concluded that for our purposes the #58 Green Tricolor was best suited for isolating the red discoloration associated with bite marks from the surrounding intact skin.

We found that when enlarging onto Kodalith film, our times were between .5 and 6 seconds at *f*/4.5. Contact printing times were approximately 6 seconds, and the contact printing times for generating a toneline film positive were between 10 and 40 seconds depending on film density.

Our final six bite marks on four coroner's cases were photographed using our previously recommended procedure. Of those, five (83%) yielded useful toneline overlays. "Useful toneline overlays" varied from bite mark to bite mark. When the toneline procedure fails, it does so totally, providing no usable visual information.

Our procedure seems to work better on black skin than white skin although our only bite marks on whites were on living "victims" inasmuch as we had no non-black coroner's cases.

The portion of our study dedicated to demonstrating the subjectivity of current dental examination methods is quite convincing. The tracings made by our four volunteers were compared with one another, a toneline film positive, and a photograph of the traced bite mark . All four tracings were relatively accurate, and a general outline of the teeth was drawn by each observer.

Evaluation was based on detail, shape, size, and the selection of marks that were traced. In all four bite marks the most accurate tracings were produced by the artist who was best able to look at the photographs and record minute subtleties in a mark. The dentist was also able to trace the bite marks accurately, yet his drawings lacked the details present on the artist's renderings and on the toneline film positives. The retired police officer recorded only basic shapes while the secretary sometimes missed basic shapes entirely.

When the four tracings were superimposed, an excellent impression of the mark materialized. Differences in tracings appeared as well. Methods of identifying a tooth varied from simply drawing a square to sketching three independent circles. These subtleties in a mark can be crucial. All four participants drew various teeth at dissimilar angles. Alone, this factor of the alignment of the teeth in the arch could exclude a prime suspect or include an otherwise innocent individual.

The significance is not the *degree* of disparity between tracings. The fact that there *are* differences, regardless of the extent, is sufficient to illustrate examiner bias.

FILM	EXPOSURE WITHOUT # 58					EXPOSURE WITH #58					DEVELOPER	DEVELOPMENT TIME	TEMP.
	f/32		22		16	16		11		8			
TECH	X	X	X	X	X	X	X	X	X	X	D-19	5 minutes	68
TECH	X	X	X	X	X	X	X	X	X	X	HC-110	7.25 minutes	68
T-MAX	X	X	X	X	X	X	X	X	X	X	D-19	5.75 minutes	68
T-MAX	X	X	X	X	X	X	X	X	X	X	HC-110	8.5 minutes	68

A. Expose Tecnical Pan film using exposures listed above (abbreviated as *TECH*). Process negatives at recommended development time in D-19.

B. Enlarge image from Technical Pan film onto Kodalith at 1 : 1 (exposure times vary from .5 to 6 seconds at f/4.5 with a 95 mm. lens. Process on Kodalith (1 : 3) developer for 2.75 minutes at 70 degrees F..

C. Contact print Kodalith positive onto another sheet of Kodalith film (emulsion-to-emulsion).

D. Contact print registered Kodalith positive and negative (base-to-base) onto a third sheet of Kodalith, rotating film during exposure.

Figure 1. Procedure for producing toneline film positives. All Kodalith should be processed as described in B..

Conversely, toneline film positives *photographically* document tonal breaks. Artistic ability, knowledge of dental anatomy, and personal bias do not influence the result.

Discussion

From the outset it is important to point out that we wanted to develop a method that was portable and inexpensive, thus permitting any facility with a camera and a darkroom the opportunity to use this technique. Although we suspect that better results are possible with studio lighting, we utilized a camera-mounted flash to increase use. Furthermore, we wished to eliminate or minimize the human element. More convincing and better results are possible by using manipulative techniques such as "dodging" and "burning"; however, such manipulation would reintroduce subjective interpretation that we wanted to eliminate.

Throughout the course of our investigation, we encountered two situations that mandated departure from stated research intent. The first was abandoning the notion of an apparatus exclusively dedicated to generating a toneline film positive. The reasons for this decision were threefold: 1. The need of a machine for duplicating our results ran contrary to our desire to make this technique widely available.

2. Our research demonstrated minor changes in line weight on the toneline film positive when the angle of incidence of the light source with the film plane was varied. We strongly recommend against using angles of 75° - 90°. At these steep angles, the relative opacity of the registered Kodalith positive and negative tends to break up the continuous lines associated with the perimeter of marks.

3. Our research showed widely varying exposure times but all exposures were greater than 10 seconds. We feel that exposure time accuracy of .1 second and equipment constructed for that purpose create an unnecessary expense.

Our second departure from written intent was the decision to generate toneline film positives on film in overlay format. The reasoning is that a print would reintroduce tracing and examiner bias.

We believe both of these decisions are significant in that they result in the development a technique that is simple, easily duplicated, affordable, and immediately accessible.

Our technique does not resolve all the problems, but it does make the analysis unbiased since the bite mark itself, as recorded by the camera, is placed over the model, allowing one to peer at the teeth that could have made the mark.

Suggestions

With our study completed, we have discovered four areas that require further consideration:

1. The first is concerned with alternative lighting. We believe that by using a studio arrangement with more than one flash, better results are possible. One of our technical problems is that because of the greatly increased contrast and near axial lighting, shadows become very dark. At times, the shadows occurring on the body obscured portions of the bite mark. There is a

relationship between the partial loss of the bite mark and the differences in radii of bitten surfaces. A bite mark on a child's ankle suffered greater image loss than a bite mark on an adult's neck. We did not focus our attention on this variable because of time constraints and because it generally conflicted with our desires to develop a portable method.

2. A second area deserving attention is evaluating the Ultraviolet spectral response of various films. West has been able to photograph bite marks 59 days after the time of infliction [24]. Perhaps the combination of his research and our toneline technique might yield toneline film positives of bite marks 1 $^1/_2$ to 2 months old.

3. A third, less promising suggestion for future work would be exploring the use of Agfa's Agfacontour film [25]. The emulsion of Agfacontour film is partly solarized and exposure to a normal subject produces an outline of areas of equal density. Due to the lack of availability of this film in the Cleveland area, we were not able to explore its possible application. This film does not generate a sharp line but rather a band of equal densities. The film also has high base fog, slow speed, and lacks the exposure latitude of Technical Pan film. If, however, these characteristics can be tolerated or overcome, it may save several steps currently utilized in our procedure.

4. A fourth and most interesting area to us for future study would be the combination of the toneline technique and descriptive geometry. We believe it is possible to import a toneline drawing into AutoCAD® computer-aided design software and use drafting knowledge and technology to correct for distortions created when the three dimensional bitemark is transferred to the two dimensional plane of the film. While we found Havel's ABFO#2 [22] very useful in establishing scale and the angle at which the bitemark is photographed, it does nothing to correct for the curvature of the flesh on which it rests. CAD software will allow for the electronic *unwrapping* of the bite mark so that it appears on the surface of a plane rather than that of a cylinder, sphere, or cone.

Conclusion

Our studies have shown that toneline photography can outline a bite mark. Moreover, the procedure is inexpensive. It has already proven itself to be a valuable tool in a child abuse case where it has been accepted in evidence (Leonard Bradley Sr. vs. State of Ohio). The toneline photograph along with the already accepted procedure of drawing the mark on an acetate overlay allowed the judge to come to the decision that the defendent had made the bites. However, there are problems with it inasmuch as there is a loss of detail in shadows and the technique doesn't always work. It *is* a powerful tool which can be easily duplicated by following our procedure. Its value lies in its ease of implementation as well as its aid to a judge and/or a jury.

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