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Analysis of Photographic Distortion in Bite Marks: A Report of the Bite Mark Guidelines Committee

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ABSTRACT: Some degree of distortion is found in all bite marks. That distortion can be caused by photographic methods of recording the mark, by the dynamics of the bite, or by artifaction. All types of distortion complicate the process of matching marks to dentition, thus making it important to understand the distortion and, if possible, correct or allow for it. A method of analyzing photographically distorted bite patterns is presented, future research directions are suggested, and evidence-gathering standards are stressed.

KEYWORDS: odontology, bite marks, photography, distortion, analysis and standards

Forensic odontologists have long recognized that the human dentition is unique in its morphology and alignment [*1-4*], and numerous methods of bite mark analysis have been presented [*5-8*]. Extensive investigation and numerous forensic science cases have led to a high degree of acceptance of bite mark testimony in the courtroom, with 192 cases cited in the legal literature at the time of this writing. The authors are not aware of any case where bite mark testimony has not been allowed.

Although bite mark evidence has demonstrated a high degree of acceptance, it continues

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to be hotly contested in "battles of the experts." Review of trial transcripts reveals that distortion and the interpretation of distortion is a factor in most cases.

Forensic odontologists have dealt with distortion of bite marks in various ways [*4,9–11*], and some authors have suggested methods of classifying tissue or recording evidence to minimize the detrimental effects [*12*]. Distortion may be caused primarily by the nature of skin [*12,13*], or by the dynamics of the bite [*14*], or it may be produced photographically while documenting evidence [*15*].

Members and committees of the American Academy of Forensic Sciences and the American Board of Forensic Odontology (ABFO) have prioritized and studied the major concerns in bite mark analysis and testimony. Those items considered most important for the development of scientifically founded standards are: uniqueness, consistency, and accuracy in matching; methods for evidence collection and analysis; classification of tissue; and analysis of distorted marks. Expertise of the forensic science examiner, as demonstrated by certification and experience, is also an important factor.

This report presents the work of the American Board of Forensic Odontology Bite Mark Standards Committee in establishing the basic principles of photographic distortion analysis.

Methods and Materials

The authors felt that it was important to understand photographic distortion, including methods of compensation, before an accurate study of the potentially more complicated subject of tissue distortion could be attempted. To accurately study photographic distortion, a 2- by 4-ft (0.6-by 1.2-m) comparison table was designed and constructed with two video cameras located directly above 15- by 15-in. (38- by 38-cm) white Plexiglas® surfaces (Fig. 1). The surfaces were wired for independent illumination so that lighting could be directed from above or below the photographed subjects.

The standardized hypothetical bite mark of the Bite Mark Standards Committee of the American Board of Forensic Odontology (Bite 1) [*16*] (Fig. 2) was used for comparison. This bite mark was developed by the committee as part of a series of bite marks to test the currently accepted bite mark scoring system. It comprises the imprints of twelve anterior teeth arranged consistently, with the average arch form determined from a general population sampling [*2*].

The hypothetical bite was placed upon one comparison surface and transilluminated for accurate tracing. The outlined tracing was then used to represent the dentition and was placed on the other comparison surface. The video images were then photographed and superimposed using Sony® model 1800 single tube cameras with 6:1 macro zoom lenses and a Crosspoint latch® model 6112 high industrial grade video mixer with automatic drive interface and four simultaneous functions.

The superimposed image was then observed and analyzed on flat and curved surfaces under different known photographic angles to determine the degree of distortion produced. When the bite mark and the dentition are viewed on identical surfaces from identical angles, the images superimpose perfectly.

Results and Discussion

Figure 2 demonstrates the high degree of correlation or match between the standardized bite mark and dentition when photographed at a 90° angle or perpendicular to the surface of the bite. There is no discernable distortion, and this represents the ideal photographic angle for evidence collection. The degree of correlation represents a match with a high degree of dental certainty and would demonstrate an exceptionally high score with the American Board of Forensic Odontology Scoring System (95 to 100 points) [*17*].

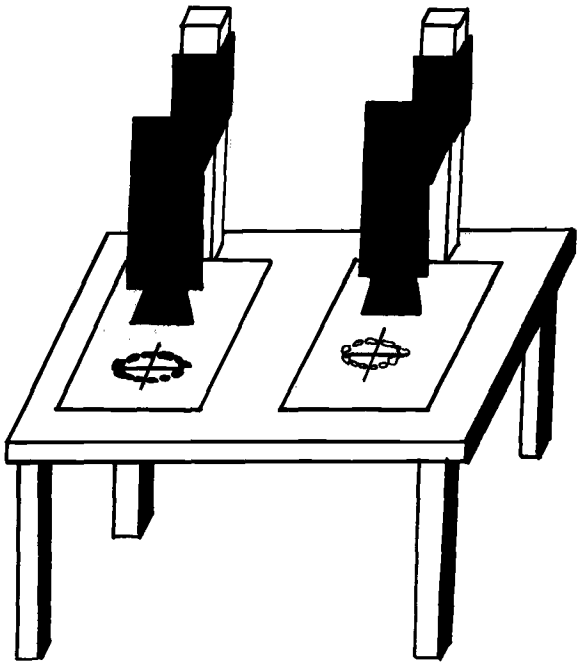

FIG. 1—*Comparison table constructed with video cameras located above comparison objects. Images are routed through a mixer to accomplish superimposition.*

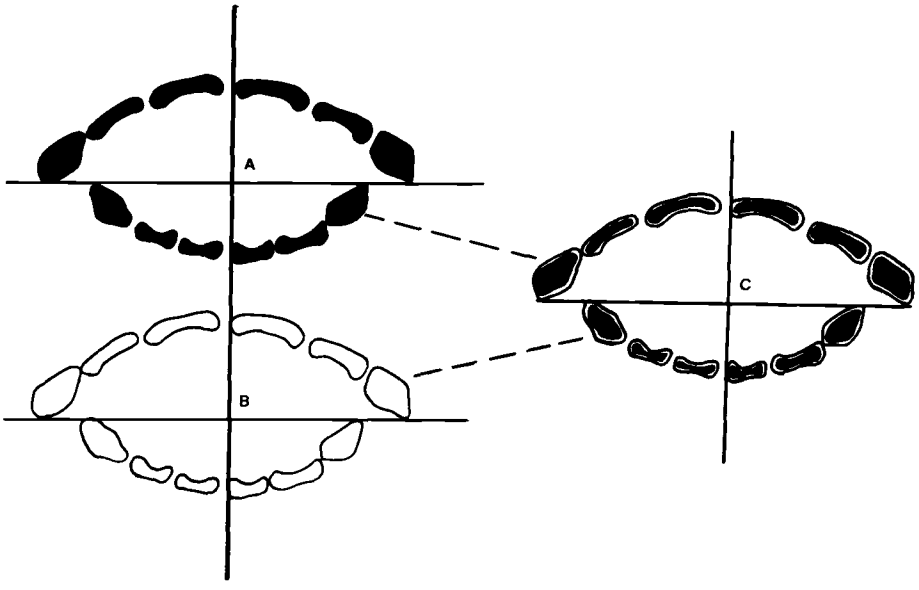

FIG. 2—(a) *Hypothetical Bite Mark Standard One.* (b) *Hypothetical Dentition Standard One.* (c) *Graphic representation of comparison or superimposition of Bite Mark Standard One and Dentition Standard One.*

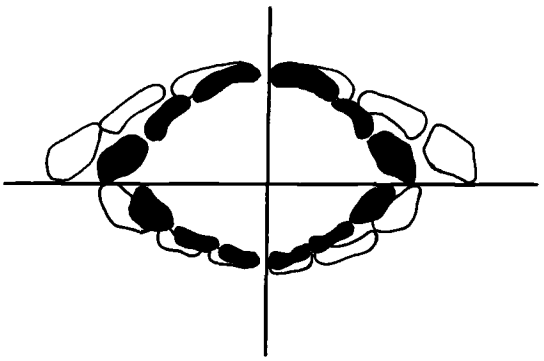

FIG. 3—*Eliptically distorted mark produced by photographing from a 45° side angle.*

Figure 3 demonstrates the shortened, eliptically distorted mark produced by photographing at a 45° angle from the side of the bite mark which is compared to the dentition. The distortion produced must be considered a simple case of distortion in one plane and is similar to what odontologists have seen on many occasions. The comparison does not appear to represent a very precise match in the sense of using overlays, and yet it is known that the match would be exact if the bite mark had been viewed from the correct angle. The ABFO scoring guide allows for this type of distortion, and a score in the range of 60 to 80 would still be considered as indicating a probable match. This type of distortion has resulted in extensive courtroom dispute with some odontologists standing firm that there is not a match.

Figure 4 demonstrates the addition of a circular scale to allow determination of the camera angle. Using the formula described by Stimson after Hyzer [*18*], (angle = Cos − major axis/minor axis), it is found that the camera angle is accurately identifiable through the measurement of minor and major axis dimensions of the circle and simple trigonometric calculation. The known photographic angle will then allow for the mathematical correction

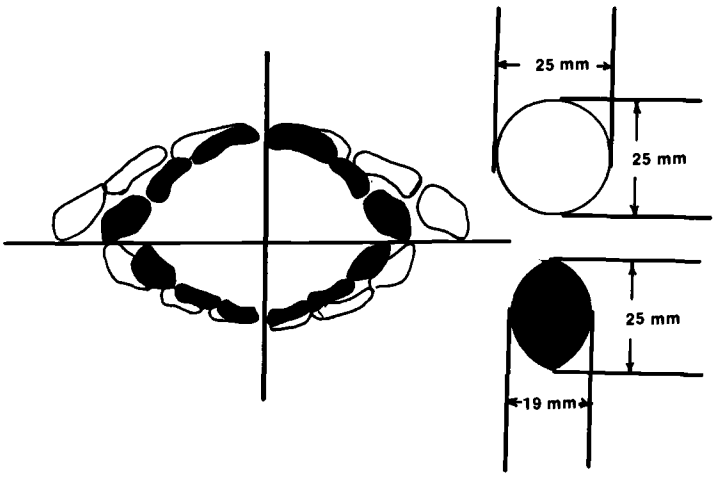

FIG. 4—*Demonstration of a circular-scale distortion in the case of a 45° photographic side angle.*

of distorted patterns analyzed by computers or the simple adjustment of viewing angle when superimposing teeth and marks for comparison or rating.

Figure 5 demonstrates the flattened-arch distortion caused by photographing from a 45° angle from the top or bottom arch. Although the mark and dentition are known to match, there are significant distortions that could lead to the conclusion that they do not. However, it is significant to note that the ABFO scoring system still yields a high score in the 70 to 80 range and should aid the odontologist in concluding that there is a probable match.

Figure 6 demonstrates a more complicated photographic distortion produced when the camera is oriented at 45° to the flat plane from a direction halfway between the x axis and the y axis. The bite mark is distorted in two ways so that only two quadrants will superimpose. Again, this mark and dentition are known to match perfectly under identical photographic angles, but significant problems have been introduced by improper angulation. Although the ABFO point count still yields a high score based on numerous similarities that still remain, possible discrepancies must now be evaluated. For example, the labiolingual relationships of the central incisors no longer match. When viewing an actual unknown case this type of distortion leads to the question of whether this is a real discrepancy, or whether it is an artifactual distortion.

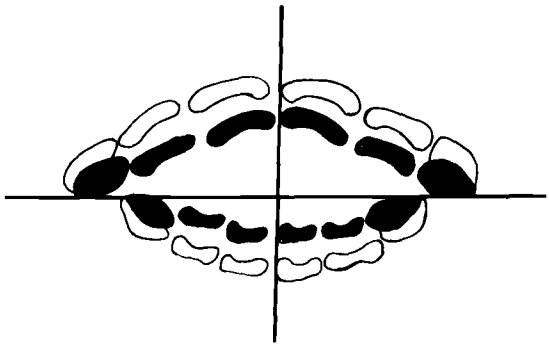

FIG. 5—*Flattened arch distortion caused by photographing the mark at 45° from the top or the bottom of the mark.*

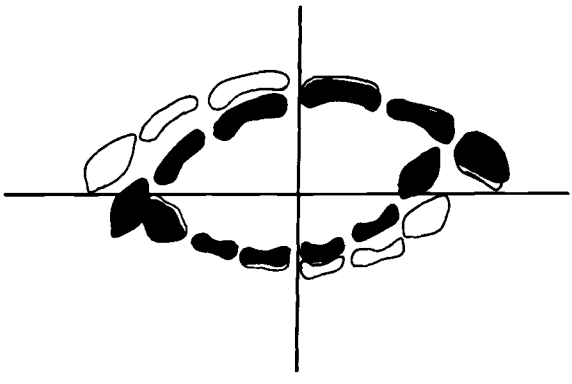

FIG. 6—*Complicated photographic distortion caused by photographing the mark at 45° from the surface and halfway between the* x *axis and the* y *axis (explained in the text).*

There have been many actual cases where individual quadrants will match, but there is an overall distortion when comparing entire arches. This phenomenon has caused some experts to advocate a quadrant approach to analysis. They seem to have discovered through experience that meaningful conclusions can be drawn in this way because of the discrete morphological points of comparison. However, the present authors have not been able to find any written description, nor have they heard any presentation at scientific meetings that would account for the distortion or allow for the correction of that distortion.

Certain distortions may be demonstrated that appear to negate a match even though the objects are known to be identical. The Bite Mark Guidelines Committee found this type of distortion in their study of experimentally produced bites on a large dog and were unable to explain it at the time [*16*]. This photographic distortion now appears to be totally compensable if the proper scale is included for photographic angle reference.

The Guidelines Committee recommends the use of a scale with a circle of known size. The circle allows appropriate superimposition angles to be set for comparison purposes.

Figure 7 demonstrates the lack of photographic distortion produced when a bite mark is photographed at a 90° angle to the center of the hypothetical bite mark which is placed on a curved surface. The curved surface had a measured radius of 11 cm and approximates many areas of the body, such as an upper arm, leg, or neck.

Most bite mark experts instinctively feel and recommend that photographs should be taken perpendicular to the mark of each arch when the mark is found on a curved surface. This study tends to indicate that a curved surface that will allow visualization of the entire mark has a surface angle too small to produce significant distortion. This is a very important point. It may be photographically insignificant whether the bite mark is on an arm or breast, because when photographs are made at right angles to the flat plane, distortion created around those curved surfaces is indiscernable. This essentially disproves the argument that great inaccuracy is introduced when we study a two-1-dimensional representation of a three-dimensional object. Unless we are dealing with animal bites that are of a much greater size than the human bite, the angle of curvature appears to be insignificant. This statement can only be made if the entire bite can be visualized from one direction. If the curvature is so great as to obscure part of the bite, then the surface angle is large enough to cause significant distortion and multiple photographs will have to be taken.

This study provides further evidence of the importance of photographic distortion. The recommendation of this Committee is to photograph at a 90° angle or perpendicular to the

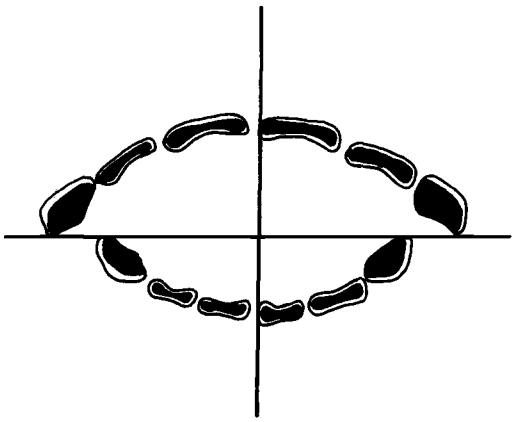

FIG. 7—*Graphic representation of the apparent lack of photographic distortion produced when photographing a mark on a curved surface.*

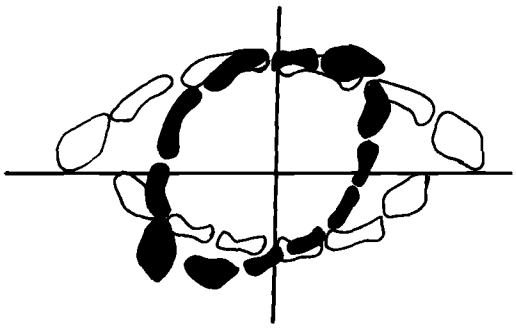

FIG. 8—*Demonstration of the complicated distortion produced when a bite mark on a curved surface is photographed at 45° from the surface halfway between the* x *axis and the* y *axis (see text).*

center of the bite. There should be a circular scale included, to permit accurate calculation of the photographic angle and to allow correction for any distortion caused by improper angulation.

Figure 8 demonstrates the very complicated distortion produced when a bite mark on a curved surface is photographed at 45° to the surface (at the center of the bite) and halfway between the x axis and the y axis. The inclusion of a circular scale, however, allows the readjustment of angles to correct for the photographic distortion. If the roundness of the circular scale is reestablished in the superimposition process, then the distortion in the bite mark is also corrected. That correction may be accomplished with the type of video equipment described in this paper, by computer graphics, or possibly through manual methods such as with an adjustable photographic table or adjustable easel in the darkroom. It is important to note that those adjustments are not inappropriate and improper attempts to match a mark, but solid scientific moves to correct identifiable distortion. The circular scales should always be used as a reference point. If the circles match, then there can be a high degree of confidence in the accuracy of the images being compared. If those images match then there can be a high degree of confidence in the accuracy of the match. If they do not match after angle correction, then dynamic tissue distortion or mismatch must be considered.

Summary and Conclusions

The important new findings demonstrated by this study can be enumerated. First, curvature of the body does not produce significant photographic distortion. Other Committee experiments have demonstrated dynamic tissue distortion caused by biting on curved surfaces and those findings will be described in the future, but photographic distortion is not a problem in those cases where the entire mark can be observed from one viewing angle.

Second, photographic distortion can be very difficult to understand and interpret when viewing prints of bite marks that have been photographed from unknown angles. Although the ABFO point system of evaluating bite marks allows for a certain amount of distortion, a proper understanding, and where possible, correction of distortion is essential for meaningful and accurate comparisons.

Third, it is suggested that the odontologist place a circular scale in the photograph to permit calculation of photographic angle, and to allow for proper corrections of viewing angle before comparisons are made. A comparison of scientifically and accurately corrected bite marks to dentition will give the most accurate, and therefore the most reliable, result.

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