TECHNICAL NOTE

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Photographic Techniques of Concern in Metric Bite Mark Analysis

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ABSTRACT: In bite mark analysis concern is expressed for the need to improve the precision in photographic evidence collection procedures. The use of a rigid ruler (which meets federal specifications) for scale, proper camera positioning in relation to the scale, and a method to evaluate the distortion in a two-dimensional print that records a three-dimensional object is suggested. Disregarding these factors makes metric bite mark analysis inappropriate.

KEYWORDS: odontology, bite marks, photography, metric, nonmetric, scale, parrallelism, distortion

Historically, photographs of a bite mark are the major, if not only, evidence available for analysis. The photographer recording the marks has frequently been someone other than a trained forensic odontologist. A photographer's degree of skill, concern for detail, and understanding of the photograph's ultimate use will determine the analytical value of his photograph. Forensic odontology must improve protocols and techniques considered ideal in bite mark photography.

The terms metric and nonmetric analysis are used in anthropology[2] and are suitable for use in bite mark nomenclature. Nonmetric analysis of bite mark evidence would be the associative comparison of class and individual characteristics contained in the mark and a suspect's dentition. Metric analysis of bite mark evidence would be the absolute comparison using physical measurements of class and individual characteristics contained within the mark and a suspect's dentition. Analysis of photographic bite mark evidence demands the inclusion of a scale in the photograph and historically tends to include both metric and nonmetric analysis irrespective of the scale's own accuracy or any photographic distortions involved.

Scale

Inclusion of a scale in photographic evidence is required for two purposes. One is to establish a relative size to the item photographed, giving an observer perspective. The second is to allow

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[2]Mike Finnegan, personal communication, Kansas State University, Manhattan, KS, 1981.

accurate enlargement to achieve life size (or multiples thereof) prints. It is for the latter use that an accurate rule is mandatory to enable metric bite mark analysis. The ruler used should be rigid to enable positive total parallelism between it and the camera film plane. It should comply with accepted metrologic principles exemplified by the federal specifications for rigid measuring rules.[3] In part they indicate:

> The ruler should be one piece, without joints, made of tool steel and properly hardened, tempered, ground, and finished to minimize reflection. The scale's opposite faces and opposite longitudinal edge surface should be ground parallel; the opposite transverse edge surfaces should be similarly ground, at right angles to the faces and longitudinal edge surfaces.

For precision use, particularly in photographic enlarging, the quality of the graduating marks is a very important consideration (Fig. 1). The graduations should be machine cut or acid etched with a relatively narrow width, uniform throughout their length. The graduations should continue to one edge of the scale and be easily identified (see Fig. 2).

It is reasonable that the accuracy requirements of the rule should be determined by the average individual's ability to read it using readily available optical aids. Metrologists indicate that:

> When using a seven power eyeloop, the average person should be able to read the graduated intervals of 0.01 inch on a six inch steel rule to an uncertainty of ± 0.005 inch. An experienced individual should achieve an uncertainty between ±0.001 to ±0.002 inch. A 15 cm scale graduate in 0.5 mm increments should be read to an uncertainty to ± 0.1 mm uncertainty by an experienced observer.[4]

When you consider that photographic bite mark analysis frequently use ×3 or 5 enlargements and the dental profession commonly uses optical loops up to four power, it is suitable that the graduations not exceed the error of ±0.0508 mm (±0.002 in.) between any two graduations, nonaccumulative indicated in Federal specifications.[3]

The question might be asked, "Why is ruler accuracy important when the ruler used in evidence collection can also be used in photographic analytical procedures?" (Fig. 3). Pro-

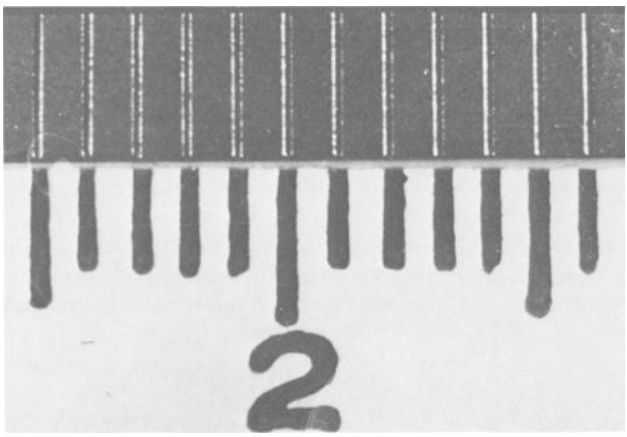

FIG. 1—*Comparison of certified graduations to those on a common printed plastic ruler.*

[3]Federal Specification GGG-R-701F, 5 April 1967, obtainable from General Services Administration, Specifications Branch, Bldg. 197, Washington Navy Yard, Washington, DC 20407.

[4]C. D. Tucker, personal communication, Dimensional Metrology Group, Automated Production Technology Division, Center for Manufacturing Engineering, National Bureau of Standards.

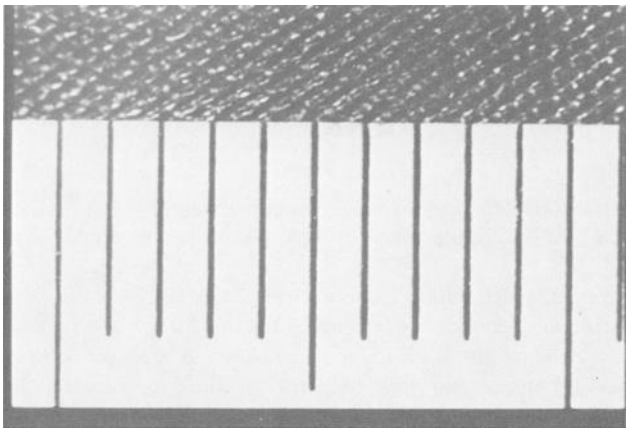

FIG. 2—*Uniform graduations of certified ruler at* × *14.*

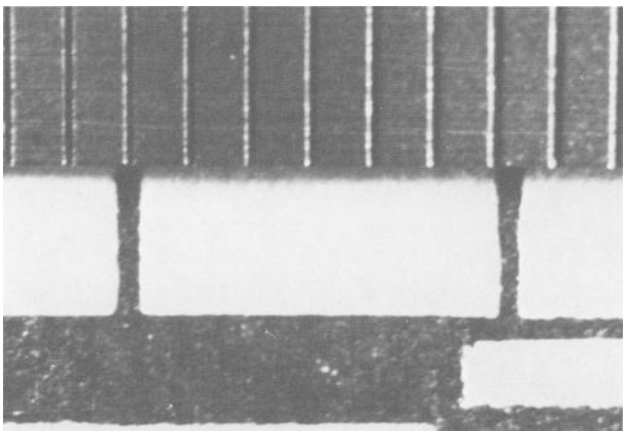

FIG. 3—*Certified rule demonstrates inaccuracy of a paper case card-type rule.*

viding that the graduation markings on the ruler are uniform in quality and the ruler is truly rigid and damage resistant, the same graduations are used each time a comparison is made and only if life-size prints are required, the results could have a high degree of acceptance. Problems occur when several technicians or examiners separated by geographical distances are to develop and analyze the material. An accurate enlargement is impossible unless the evidentiary rule is certified accurate or is calibrated for error factors. A study by individuals isolated from those who collected the evidence would be difficult or impossible. This approach should be considered a second best with concurrent deficiencies.

For ease of use, storage, and stabilization during use, the ruler should probably be 6 in. or 15 cm in length. Such rulers meeting the aforementioned criteria are available at a moderate cost through machinist supply outlets. Several manufacturers[5] provide high quality models in various graduation configurations.

Certification of accuracy using either state or federal specifications can be accomplished by a

[5]Brown and Sharpe Mfg. Co., Precision Park, North Kingstown, RI 02852; L. S. Starrett Co., Athol, MA 01331; and Mitutoyo, Japan.

metrology laboratory having standards traceable to the Bureau of Standards. Most state governments have a metrology laboratory, and in the private sector, such services are available to the aerospace, aircraft, machine tool, or similar industries. Certification would increase the court acceptance of the ruler used for photographic scale.

Parallelism

When the camera's film plane and the scale are not parallel, error is introduced in the photographic negative and its resultant prints. A simple test of this distortion illustrates the point (Fig. 4).

Using certified rulers, a high quality camera system,[6] Kodak® Panatomic film, a small bubble level, a protractor, and a copy stand, evaluations of the distortion were made when the film plane and ruler were divergent by 5, 10, 15, 20, 30, and 40°. A certified inch ruler graduated in hundreths was elevated on one end while the other remained in contact with the copy stand platform. A certified metric ruler was positioned parallel with the copy stand platform at the same general elevation of the 51-mm (2 in.) graduation on the inch ruler. The metric ruler was held in position with modeling clay. The camera was positioned above this arrangement with its film plane parallel to the metric ruler and the copy stand platform. Using a protractor, the indicated angles between the two rulers were arranged and ×2 photographic prints were produced at each angle. The distance between the 51- and 76-mm (2- and 3-in.) graduations were measured in each print and the results tabulated (Table 1). Because of the limited sampling, this information should not be used for interpolation of other work.

It is evident that lack of parallelism can introduce serious error. In photographic bite mark evidence collection the camera's film plane and the ruler used for scale should be stabilized and parallel for maximum accuracy.

Distortion

Measurable distortion occurs when recording a curved object on a flat film plane.

As illustrated by Fig. 5, it is apparent that measurements taken off a flat photographic print

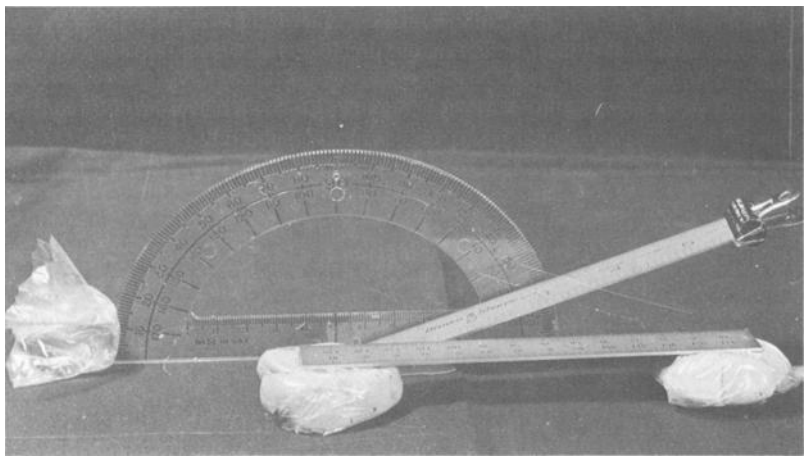

FIG. 4—*Arrangement used in parallelism test.*

[6]Fifty-five millimetre Micro-Nikkor lens, Nikkormat El Camera Bldg.

TABLE 1—*Distance between the 51- and 76-mm (2- and 3-in.) graduations were measured in each print and the results tabulated.*

Distance Measured Between 2- and 3-in. Graduations (Should Be 2 in. at ×2)		Error at 1 : 1
5°	1.995 in.	0.0025 in. = 0.0635 mm
10°	1.985 in.	0.0075 in. = 0.1905 mm
15°	1.965 in.	0.0175 in. = 0.4445 mm
20°	1.915 in.	0.0425 in. = 1.0795 mm
30°	1.780 in.	0.1050 in. = 2.6670 mm
40°	1.565 in.	0.2175 in. = 5.5245 mm

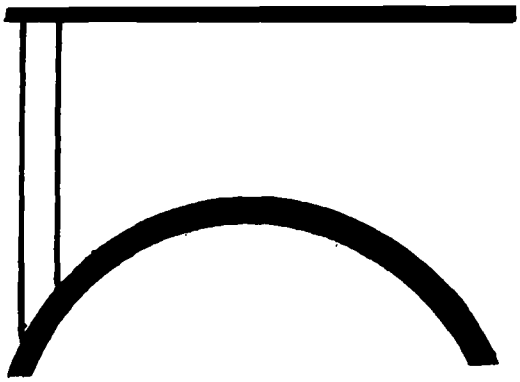

FIG. 5—*Inaccuracy in recording a curved surface on a flat film plane.*

depicting a curved surface would be inaccurate. To evaluate this distortion, a technique has been developed using an acceptable three-dimensional model of the bitten area (Fig. 6).

A standard of a thin, uniformly dimensioned pliable metal strip such as orthodontic banding material[7] is positioned and stabilized on the model crossing the highest point of contour and extending down in two directions to an elevation below all teeth marks. Reference marks are made on the band material corresponding to marks made on the model allowing future verification of measurement locations. Later explanations can be facilitated by indicating the teeth marks on the model before photography. The prepared model is placed on the copy stand platform and a scale meeting forementioned criteria is positioned parallel to the film plane adjacent to the metal strip level with the highest part of contour. The scale is stabilized with modeling clay. Using a fine grained black-and-white film, an exposure is made with a camera, lens, and framing similar to that used in the evidenciary photograph. A three or five multiple enlarged print is produced. Using the known widths of the banding material at the reference points, calculations are easily made determining the distortions incurred. If required, standards can be placed by each individual tooth mark on the model and the procedure repeated, thereby obtaining precise information concerning each mark's dimensional measurements. The usefulness of this information certainly suggests a need for three-dimensional models of the bitten area in each case.

[7]Unitek Corp.

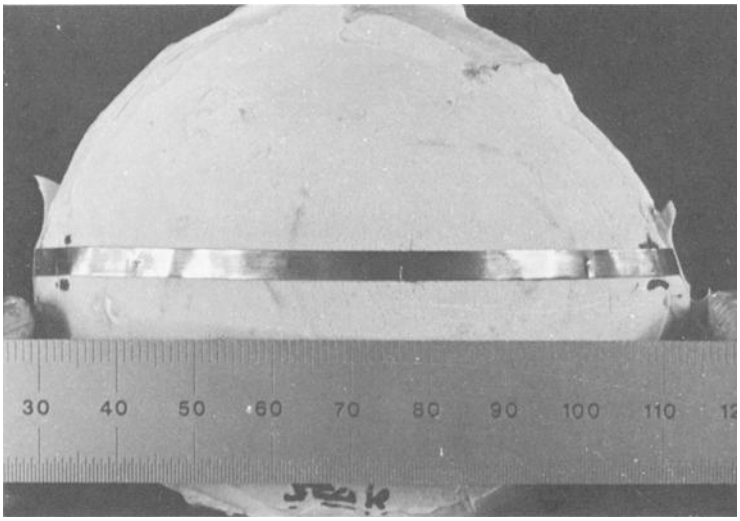

FIG. 6—*Arrangement on stone model to measure distortion as described in text.*

Summary

Conscious attention to details can enhance the analytical value of photographic bite mark evidence. The terms metric and nonmetric bite mark analysis were introduced and defined. Camera-subject stabilization allowing film plane-scale parallelism, the accuracy of the scale itself, and photograph of a curved surface with resultant distortion were discussed with appropriate recommendations. These factors should be considered in the type of analysis used by the forensic odontologist as well as the level of opinion he renders. The sophisticated analytical bite mark techniques are only as valid as the precision used in the collection of bite mark evidence examined. Without precise evidence collection, positive identifications can and should be challenged when metric analysis is used.

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