F10 A Geometric Analysis of the Inherent Inaccuracies Found in Linear Measurement of Curved Bite Mark Surfaces

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The Forensic Odontologist must be capable of presenting evidentiary accurate measurements and documenting such measurement by photographic and/or digital images. This presentation will explore the extent of the inaccuracies found in recording measurements utilizing the ABFO #2 ruler on hypothetical curved surfaces.

This presentation will impact the forensic science community by making suggestions for minimizing such inaccuracies.

The Forensic Odontologist relies on highly accurate measurements to facilitate evidentiary quality bite mark analysis. Reasonably accurate Alginate or the more stable and accurate polyether or polyvinyl siloxane impression materials are capable of producing measurement friendly dental stone study models. All these measurements are usually taken in a flat plane linear environment. For example the inter-canine cusp measurement is accomplished by simply placing the standard ABFO #2 ruler across the model and recording the appropriate dimension. Such data accurately translates to photographs (both film and/or digital) through specialized scanning techniques and photo processing software. The resultant images are generally accepted as evidence in litigation. Analysis of the bite mark is more problematic. Bite marks by their very nature are subject to either in vivo healing or postmortem decomposition. Elastomeric impressions, methacrylate tissue excision techniques, and specialized 1:1 close-up photographs or digital images all serve to preserve the bite mark as evidence. Measurement problems occur because bite marks are rarely made in a truly flat plane environment. It is the natural curves of the human body that lends itself to exhibiting a bite mark that has been made around a curved surface. If one should photograph the bite mark with the #2 ruler in view all objects are in a two dimensional posture and all measurements taken of a curved surface with a straight ruler with have some inherent inaccuracies. It is this inaccuracy that this paper will address.

Methodology for this analysis is based on the geometric relationships present between a straight ruler and a curved body part. If, for example, one considers a ruler resting on an arm in cross section the geometric shapes represented here are a straight line drawn tangent to a circle. It is obvious that the measurement on the line from the point of tangency towards the periphery would by nature be shorter that the arc length circumscribed by the resultant curve of the circle. It is this difference that will be calculated to determine if it is significant.

The #2 ruler is marked in 5 centimeter divisions with millimeter markings therefore all measurements will be in millimeters. Incremental measurements were made for each angular degree from the center of the circle. Both the arc length and the tangential distance from the origin to a point formed by the intersection of a line drawn from the extended radius perpendicular to the tangent will be calculated and compared. An Excel spreadsheet was created to perform the numerous calculations. Five columns were established: “θ” – the angle of the radius in degrees, “Arc Length in mm”, “Tangent Length in mm”, “Error in mm”, and “% Error”. If one should envision the focal plane of a camera to be placed above and parallel to the tangent line the resultant photographic image would not show anything passed the 90^{o} arc. Recognizing that it is only this “quarter circle” that is being analyzed, calculations were made for “θ” values of 1 through 90 in one degree increments.

Initial results verified the known geometric relationship between the arc length and the tangent length as evidenced by the constant % Error fixed at 36.31%. The results also show significant differences in mm measurements as θ increases. A one degree deviation from the perpendicular results in an arc length (the arm and embedded bite mark) of 0.87mm and a tangent length (the ruler) of 0.56mm with an error of 0.317mm. While 0.3+mm error may not be significant at that level, a fifteen degree angulation results in a 4.75mm error on a 13.8mm arc length (arm & bite mark) with an 8.33mm tangent length (ruler). As one would expect the greatest discrepancy occurs at 90^{o}. Here an error of 28.5mm is seen. These measurements are accurate only for a perfect circle. In vivo measurements will more likely be taken on some elliptical form. If the greater diameter of the ellipse is perpendicular to the tangent then a proportionately greater error is seen. In the case of the lesser diameter being perpendicular to the tangent the resultant circumference would present a flatter and arguably more accurate measurable surface.

This analysis suggests that measurements along a curved surface should be made by rotating the ABFO #2 ruler along the arc or by using some flexible measuring device.

Measurement, Inaccuracies, Bite Mark

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