## F23 Statistical Shape Analysis of Bitemark Distortion in Human Skin

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The goal of this presentation is to explore the range of distortion possible in bitemarks created on human skin using shape measurement tools coupled with multivariate statistical analysis.

This presentation will impact the forensic science community by addressing one of the two fundamental principles of bitemark analysis, that is, transferability of the shape of the human dentition to skin.

Distortion in a bitemark in human skin is unavoidable. What is poorly understood is the extent of distortion that is possible. Skin is a less than optimal recording medium as it undergoes visco-elastic, anisotropic non-linear response to stress. Prior studies have shown that these factors create a situation in which the deformation will show both intra- and inter-arch variation in multiple bites, even if all are created with the same dentition. However, these studies employed a metric approach.

Traditional methods of exploring this problem have used metric measurements in an attempt to quantify mesial to distal, intercanine, and angulation differences of the teeth. Nonetheless, metric measurements provide no overall description of shape changes. Nor do they provide any formal statistical analysis with regard to biological form.

A well-established statistical shape method used to describe biological form is Geometric Morphometic analysis (GM). GM

methods allow for a quantitative analysis of shape by capturing the geometry of morphological structures of interest and preserving this information through statistical analysis.

Shape information can be visualized by plotting landmark positions in Procrustes distance superimposition. Procrustes distance is a measure of the closeness in shape of Procrustes superimposed specimens and is recognized as a general-purpose measure of specimen similarity in the geometric morphometrics framework. Procrustes distances can be used to summarize variations in populations, express the degree of similarity of individual specimens, means of populations, or to search for matches between bitemarks and dentition.

Among the tools available for statistical analysis is Principal Component Analysis (PCA) with which the principal variations of shape can be plotted and visualized. This allows for determination of which shape aspect is responsible for the most variation. Canonical Variates Analysis (CVA) can also be used to determine if shape information can distinguish between different categories of data.

Thus, the use of shape change analysis software allows a multivariate statistical approach to explore one of the principal tenets of bitemark analysis; *transfer of the dentition to skin.*

All necessary Human Subject Institutional Review Board (HSIRB) procedures were completed and exemption was granted. Eighty-nine bitemarks were created on unembalmed cadavers. The cadavers were stored at 4°C and allowed to come to room temperature prior to bite infliction. The bites were created both perpendicular and parallel to skin tension lines. Bitemarks were also created in wax for comparative purposes.

For bitemark infliction, a single dentition was used. The dentition of a volunteer was impressed with polyvinylsiloxane and then poured in light viscosity metallographic epoxy resin. The models were mounted on a hand-held vice grip. The opening diameter was set to 40mm (opening diameter of the volunteer).

Each bite was photographed with a #2 ABFO scale in place. Landmark points were placed on each digital image that described the mesial to distal endpoints, intercanine and angulation of each of the 6 anterior teeth with freeware. Landmark points were also placed on the ABFO scale as an internal reference. Intra operator error threshold was also calculated. Following landmark data point extraction, statistical analysis was completed with another freeware program.

PCA, CVA, and Procrustes distance was determined, and used to demonstrate the non-equality of measured images of the dentition, wax impressions, as well as the range of distortion of bitemarks in skin. In addition the bitemarks were compared to a population of 410 dental models to determine the closest match. Results showed that none of the bitemarks matched the dentition that caused them within measurement error and that two unrelated dentitions matched more closely.

The data presented will allow the forensic community to understand the range of distortion possible in bitemarks created on human skin.

**Bitemarks, Bitemark Research, Skin Distortion**

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