F4 Exploration of Bitemark Distortion in Human Skin: Effects of Size and Shape Deformation

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The goal of this presentation is to describe the extent of distortion, relative to size, in a series of bitemarks with consideration of both maxillary and mandibular teeth. In addition, the ability to predict distortion in one arch relative to the other will also be discussed.

This presentation will impact the forensic science community by exploring one of the basic premises of bitemark analysis, that of reproducible transfer of dental shape to the skin.

The biomechanical nature of skin dictates that distortion will be inevitable, as skin behaves in anisotropic, visco-elastic manner. Given these properties the question then becomes *what is the extent of distortion possible in a bitemark and is distortion with respect to one dental arch predictive of the other?*

In order to explore this deformation of skin, an approach that can statistically evaluate the range and extent of shape change associated with distortion is necessary. A well-developed method to describe shape variation between biological specimens is Landmark based Geometric Morphometric analysis (GM).

In GM, landmarks are placed on digital images. These are preserved as coordinates that describe and preserve spatial information. The landmarks can then be extracted and used to describe shape changes between specimens in a quantitative and statistical manner. Traditionally, GM methods remove scale; however, GM methods can extended to preserve size information. In forensic studies, information about size is generally important, so it was necessary to explore an approach that preserves size. Thus, a size-preserving Procrustes approach (Procrustes S-P) was used in this study, as well as the size independent approaches.

Human Subject Review Board Exemption (HSRIB) was granted for this project. Impressions of the maxillary and mandibular dentition were taken from a single volunteer. The impressions were poured in resin and mounted on a hand held vice grip instrumented with a load cell to monitor force application.

The apparatus was used to inflict 49 bites on unembalmed human cadavers. The cadavers were acquired based on availability and thus gender and age were not controlled factors in this study. Bites were made on the upper arm, lower arm, lateral thoracic wall, and upper thigh. The same examiner created all of the bites.

The resulting bites were digitally photographed with an ABFO scale in place. All photography occurred within two minutes of infliction. In order to avoid photographic distortion, the maxillary and mandibular arches were photographed separately as needed.

Landmarks were placed on the digital images with tpsDig freeware. Landmarks were placed on the mesial and distal extensions of the six anterior teeth as well as the center point of the canines. This resulted in a placement of 14 landmarks. Two additional landmarks were placed on the ABFO scale for size reference. The maxillary and mandibular dentitions were recorded separately.

The landmarks were then extracted from the images and analyzed with IMP freeware. Landmarks were also placed on digitally scanned images of the biter's maxillary and mandibular dental models as described for the bitemarks. Concurrently, a sample population of 297 paired maxillary and mandibular dental models were acquired from the University at Buffalo School of Dental Medicine. This was a sample of convenience. The models were placed on a flat bed scanner and digitally scanned and landmark placement performed. These models were used for comparison purposes to the inflicted bitemarks. Error rates were calculated by repeated measures.

Results show that scale changes appear in the upper and lower arch in a relatively independent way and are not highly correlated. This result is not surprising given the anisotropic nature of the skin. A change in arch width was the largest factor seen with regard to distortion. Variation in arch width caused by distortion in the bitemarks was roughly ten times the measurement error. Arch width variation in the bitemarks from a single dentition was compared to the population of 297 models. The bitemarks span 42% of the population range of arch widths in the mandibular dentition, and 53% of the range in the maxillary.

It was concluded that substantial size variation exists in bitemarks produced by one dentition, as characterized by arch width, as well as by more complex geometric morphometric measurements. Scale changes appear in the upper and lower in a relatively independent way and are not highly correlated. To summarize, cadaver skin produced extensive and rather unpredictable distortions in arch width for the dentition used in this study.

Forensic Science, Bitemarks, Distortion

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