F6 The Role of the Skin in Bite Marks, Part I: Biomechanical Factors and Distortion

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The goal of this presentation is to investigate bite mark distortion in both size and direction with regard to mechanical and anatomical properties of the skin. Attendees will appreciate how basic biomechanical features of the skin affect the appearance of a bite mark and the degree of distortion that can result.

This presentation will impact the forensic community by beginning a knowledge base that may allow for possible quantification of bite mark distortion on human skin.

Skin is a notoriously poor recording medium. It behaves in an in- homogenous, non-linear, visco-elastic, anisotropic manner. It also exhibits hysteresis, stress relaxation and creep. This problem is compounded by the fact that these properties vary from site to site on an individual and differ with age, sex, weight, and underlying physiological conditions. Yet, a basic understanding of these properties as they relate to bite mark interpretation is essential for the forensic odontologist and it is imperative to conduct research, however daunting, in order to gain knowledge in an under- explored area.

In most areas of the body, skin is in a constant state of anisotropic tension. Anisotropy, simply defined, means that skin has different properties in different directions. Thus, skin tension is greater in one direction, the direction being dictated by skin tension lines. There are 36 tension line descriptions that exist to depict this property of human skin, and the most widely accepted are Langer lines. Tension lines not only vary between different regions on the body, but vary in different directions at a single site. They also alter with movement. Site to site variation of skin extension is dictated by the mechanical demands of each part of the body, such as articulation of joints. For example extensibility of the medial side of the thigh is relatively large to accommodate abduction of the hip while over the ventral aspects extensions are much less.

Once a force is applied, greater deformation will occur in the direction in which tension forces are the largest. Once the forces are removed, relaxation of the skin takes place, being greatest in the direction that initially had the most tension.

The load deformation relationship for skin is distinctly nonlinear. At low loads, the skin exhibits fairly extensible properties, but as the load increases, the skin becomes progressively stiffer. Therefore, during normal activity at low loads, the skin behaves elastically, however, as stress levels increase, skin exhibits elastic and viscous properties, hence the term visco- elastic. For visco-elastic materials, retraction does not occur instantaneously. It is this property that causes indentations of teeth to remain in skin for an indeterminate amount of time before rebounding. The viscous nature of the skin is primarily the result of the ground substance moving through collagen fibers in the dermis, which typically occurs late in stage II of the stress-strain curve. It is this curve that demonstrates the non-linearity of skin. Visco-elastic materials also exhibit stress relaxation and creep. Consequently, applied stress decreases with time and permanent deformation can result.

Therefore, taking all of these properties into account, the position that the victim was in at the time of the bite is extremely important as to distortional effects of the bite-mark. Work has been implemented in this direction. DeVore (1971), Harvey (1972), Barbenel (1974), and Sheasby (2001) all commented on the distortion on bite marks with regard to movement and directional variation and it is imperative that work continue on this topic.

PVS impressions were collected from an individual who was to serve as the biter. These impressions were poured in low viscosity metallographic epoxy resin under vacuum. Following complete set of the epoxy, the models were articulated and mounted onto hand held vice grips. The maximal opening of the biter was determined and the vice grips were set to not exceed this dimension. The bite pressure on the apparatus was tested and the bite force was determined to be well in the range of a human bite.

Human Subject Review Board (HSRB) exemption was applied for, and granted for cadaver use in this project. Bites were inflicted on un- embalmed human cadavers. The cadavers were stored at 4C and had no apparent tissue break down. Though the wounding effects will not be seen (bruising and edema) in cadavers, most mechanical features of skin are retained after death. Hence, transfer of the dental arch and resultant distortion can be accomplished. Each cadaver received bites in locations known to be both static and highly variable with regard to skin tension lines and also in various positions of flexion, extension, adduction, abduction, rotation, and supination.

All of the bite marks were digitally photographed with a Canon Rebel XTi 10.1 MP camera. An ABFO ruler was in place for each photograph. The images were entered into Adobe Photoshop. Metric/angular analysis was performed on each bite (Johansen and Bowers method).

The upper and lower dentition of the biter was scanned on a flatbed scanner (Hewlett Packard 6100/CT) at 300dpi resolution, the dentitions were then entered into Adobe Photoshop. Hollow volume overlays were

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constructed and metric/angular analysis was performed (Johansen and Bowers method). These were compared to all of the inflicted bites. Deviations and discrepancies between bites based on location and position were calculated.

Bite mark evidence has come under scrutiny. Therefore, it is imperative to conduct research of basic fundamental principles. Skin has been largely ignored in bite mark research, when in fact, it is an important variable. In this presentation, the importance of the biomechanical properties of the skin with relation to bite mark distortion and analysis is explored.

Bite Marks, Skin, Biomechanics