F12 The Response of Skin to Applied Stress: The Influence of Force per Unit Area in Bite Mark Analysis

Mary A. Bush, DDS, SUNY at Buffalo, B1 Squire Hall, 3435 Main Street, Buffalo, NY 14214; Raymond G. Miller, DDS*, 122 Covington Road, Buffalo, NY 14216; Robert B.J. Dorion, DDS, 1 Place Ville- Marie, Suite 11238, Montreal, QE H3B 3Y1, CANADA; and Peter J. Bush, BS, Laboratory for Forensic Odontology Research, School of Dental Medicine, SUNY at Buffalo, B1 Squire Hall, South Campus, Buffalo, NY 14214*

After attending this presentation, attendees will see the response of skin to applied stress during bite mark infliction.

This presentation will impact the forensic community by investigating how skin deforms during application of stress, allowing for appreciation of distortional properties of skin.

Distortion is inevitable in a bite mark. Knowledge of how distortion arises is important for the forensic odontologist. How skin deforms in response to the applied stress of a bite is dictated by the biomechanical properties of skin coupled with the 3-dimensional properties of the skin and teeth.

There are many factors that influence how a bite distorts the skin. They can be summarized into two main categories: those associated with the biter and those associated with the victim. Some of the variables associated with the biter include maximum anterior bite force, tooth arrangement, sharpness, and the manner at which the bite is made. These variables can be controlled in an experimental situation.

The more complicated set of variables are associated with the victim, mainly the biomechanical properties of the skin and underlying substrate. Skin is complex due to its non-linear behavior in response to stress. Stress is the force per unit area of a material in response to a load. Stress is generated in skin from the bite pressure on individual teeth causing the skin to go into tension. In skin, the level of stress generated from a bite is directly related to the applied bite pressure, the rate of application, percent elongation, and the rate at which the supporting tissue dissipates the load. These factors will directly influence when the skin reaches its elastic limit.

As skin strains, its properties change. At low stresses, the skin is fairly elastic. As stress increases, the skin becomes viscous, hence causing the skin to stiffen. When the skin stiffens, further elongation is limited. Since stress is expressed as force per unit area, as the contact area of the dentition is reduced, stress applied locally to the skin increases. Given the same biting force, a dentition with fewer teeth will inflict more stress on the skin. This property has the possibility of influencing the appearance of the dentition once impressed on skin.

Human Subject Review Board exemption was granted for this project. Bites were inflicted on unembalmed cadavers after the passage of rigor mortis on naked skin. The cadavers were stored at 4ºC, allowed to warm to room temperature and any condensation on the skin was removed.

Polyvinylsiloxane (PVS) impressions were taken of an individual with an average class I dentition who served as the biter. The PVS impressions, upper and lower dentition, were poured under vacuum in low viscosity metallographic epoxy resin.

Multiple sets of epoxy models of the biter were created. One set had a complete dentition. In the other sets, the teeth were systematically removed in order to vary the contact surface area.

A custom biting apparatus was fabricated. This device articulated the teeth into maximum intercuspation. The maxillary member had an integrated force transducer to allow for constant monitoring of the applied bite force. The bite force was generated by a clamping mechanism to provide for a steady, controlled application of bite force. The force transducer was connected by USB cable to a PC and the controlling software allowed visualization of the force application rate and maximum force attained.

The results were photographed with an ABFO ruler in place and the distortion was assessed. This was accomplished via metric/angular measurements (Johansen and Bowers method) and hollow volume overlay comparison (Johansen and Bowers). Each photo was sized 1:1 and analyzed with image editing software. Each set of models was scanned on a flatbed scanner, sized 1:1, hollow volume overlays were constructed and metric/angular measurements were again obtained. The area of the biting dentition was calculated with image analysis software.

Altering one single dentition allowed for comparative study of how the force per unit area (stress) relates to a bite mark, as well as how the biomechanical properties of skin alter at the moment of tooth contact, thus allowing investigation of how distortion arises. This allows for an understanding of the dynamics of the juxtaposition of the dentition with the skin in bite mark analysis.

Bite Marks, Bite Mark Research, Skin

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