Forensic Science Anthology

Bitemark analysis: A NIST scientific foundation review

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Abstract: This report summarizes a review of the scientific foundations of bitemark analysis conducted by the National Institute of Standards and Technology (NIST). Bitemark analysis typically involves examining patterned injuries left on a victim or object at a crime scene, recognizing those injuries as bitemarks, and comparing those marks with dental impressions from a person of interest. This review specifically focuses on pattern injuries found on human skin. Over 400 sources were considered via literature searches and input from previous efforts by the National Institute of Justice Forensic Technology Center of Excellence. Our NIST review also utilized input from an October 2019 Bitemark Thinkshop organized by the Center for Statistics and Applications in Forensic Evidence (CSAFE) where experts and stakeholders associated with bitemark analysis were convened to discuss key issues. Based on this input, our study found a lack of support for three key premises of the field: 1) human dentition is unique at the individual level, 2) this uniqueness can be accurately transferred to human skin, and 3) identifying characteristics can be accurately captured and interpreted by analysis techniques. Furthermore, our review noted a lack of consensus among practitioners on the interpretation of bitemark data as well as thoughts on how to move the field forward. If the field seeks to advance, the key takeaways provided in this review are starting points for areas needing improvement, not an exhaustive list of specific shortcomings.

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Q&A

What is bitemark analysis in forensic science?

Bitemark analysis is a forensic technique that involves examining patterned injuries found on a victim or object at a crime scene, recognizing these injuries as potential bitemarks, and comparing them to dental impressions

or models from a person of interest (POI). The goal is typically to determine if a particular individual's dentition could have created the mark, with conclusions typically being "excluded" or "not excluded" as the source. This differs from using dental records for postmortem identification, which utilizes the full dentition to identify human remains.

What are the key elements or premises that bitemark analysis relies on?

Bitemark analysis fundamentally relies on three main premises:

1. **Uniqueness:** The belief that human dentition, particularly the anterior teeth, possesses characteristics unique to each individual.
2. **Transference:** The assumption that these unique dental characteristics can be accurately transferred and recorded in a bitemark on a substrate like human skin.
3. **Interpretation:** The ability of a bitemark examiner to accurately capture, analyze, and interpret the features of the bitemark to compare it to a suspect's dentition and draw reliable conclusions.

Does existing scientific evidence support the premise of the uniqueness of human dentition at the individual level?

Based on the reviewed literature, there is a lack of sufficient data to support the notion that human anterior dental patterns are unique at the individual level. While some studies have claimed to find evidence of uniqueness, critics point to issues with sample sizes, statistical methods, and a lack of population frequencies. Research has shown that similarities among dental patterns can occur more often than previously claimed, casting doubt on the idea that anterior dental patterns alone can reliably identify an individual.

How reliably do bitemarks transfer dentition characteristics to human skin?

The accurate transference of an anterior dentition pattern to human skin is significantly limited by various factors. Skin elasticity, the unevenness of the biting surface, the specific location of the bite, and movement of either the biter or the victim during the event can all cause significant distortions to the resulting bitemark. Research, including studies on cadaver models, has shown that even multiple bites from the same individual can result in marks with considerable intra-individual variation, meaning they may not appear consistent.

What challenges exist in the interpretation and analysis of bitemark data by examiners?

There are significant challenges in accurately interpreting and analyzing bitemark data. Studies have shown a widespread lack of agreement among bitemark examiners regarding fundamental assessments, such as whether an injury is indeed a human bitemark, what specific features are present, and the ultimate conclusion of excluding or not excluding a suspect. This lack of consistency and the subjective nature of traditional analysis methods like hand-traced overlays raise serious doubts about the reliability and accuracy of conclusions reached in bitemark analysis.

What limitations are associated with using human cadavers or animal skin in bitemark research?

While human cadavers and animal skin are used in bitemark research, they have important limitations. Cadaver skin loses elasticity over time and does not exhibit the inflammatory responses (swelling, bruising, healing) seen in living tissue, which can significantly distort bitemarks. Animal skin, while sometimes similar in structure, does not perfectly mimic human skin's properties. Research using these models, conducted under controlled conditions, may overestimate the accuracy achievable in real-world criminal cases where such conditions are absent and distortions are more pronounced and unpredictable.

What is the current consensus or recommended terminology for conclusions in bitemark analysis?

The American Board of Forensic Odontology (ABFO) and participants in the 2019 CSAFE Bitemark Thinkshop recommend cautious terminology when stating conclusions. Rather than using terms that imply a definite "match" or "unconditional linkage" to a single dentition, the sanctioned conclusions are limited to "excluded as having made the bitemark," "not excluded as having made the bitemark," or "inconclusive." This reflects the inherent uncertainty and subjective nature of bitemark analysis.

Have there been previous calls for more research and improvement in the scientific foundation of bitemark analysis?

Yes, there have been repeated calls for decades, dating back to at least 1960, for more empirical research and better scientific foundations for bitemark analysis. Critics and practitioners alike have highlighted the lack of data supporting key premises and the need to address reliability concerns. However, these calls have largely gone unheeded, contributing to the current lack of sufficient scientific support for the accurate use of bitemark analysis in excluding or not excluding individuals.

Glossary

AAFS: American Academy of Forensic Sciences.

ABFO: American Board of Forensic Odontology. **ASFO:** American Society of Forensic Odontology.

Bitemark Analysis: The examination of patterned marks left on a victim or object at a crime scene and comparing those marks with dental impressions from a person of interest.

Bitemark: The physical alteration or representative pattern recorded in a medium caused by the contact of teeth of a human or animal.

Class Characteristics: Features or traits that distinguish a bitemark from other pattern injuries or human dentition from non-human dentition patterns.

Dental Abrasion: Wear on teeth not caused by tooth-on-tooth contact.

Dental Arch: Arrangement or alignment of maxillary and/or mandibular teeth in the mouth.

Dental Prothesis: Artificial replacement of one or more teeth and structures.

Dentition: The arrangement of the teeth in the maxillary and mandibular arches.

Displacement: Teeth displaced toward facial/lingual aspect.

Forensic Foil: A dentition from an individual that is not a person of interest to be used as a distractor for bitemark data comparisons.

Individual Characteristics: Features or traits that distinguish one person, or their teeth, from any other.

IOFOS: International Organization for Forensic Odonto-Stomatology.

NIST: National Institute of Standards and Technology.

NRC: National Research Council.

Odontology: The use of specialized knowledge in dentistry to assist investigative agencies.

Overlays: A method for comparing a person of interest's dentition to a bitemark, often involving tracing or scanning the biting edge of the teeth and superimposing it onto an image of the bitemark.

Pattern Evidence: Markings produced when one object acts upon another object; includes fingerprints, bitemarks, and toolmarks.

PCAST: President's Council of Advisors on Science and Technology.

Position: Location of tooth in the dental arch in relation to others.

Rotation: Tooth is displaced along its longitudinal axis.

Transference: The ability of an object to leave identifying characteristics in material it contacts.

Wear Pattern: Distinctive shape or form of wear on individual teeth.

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