



NATIONAL SCIENCE AND TECHNOLOGY COUNCIL, COMMITTEE ON SCIENCE
SUBCOMMITTEE ON FORENSIC SCIENCE

Leading the federal effort to strengthen forensic science in the United States

Human Bitemarks, NAS Report and *Daubert*

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January 12, 2011

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“Bitemark Analysis: The Good, the Bad and the Ugly”

Dr. David Senn, D-ABFO

In Newsletter of the *American
Society of Forensic Odontology*

Winter, 2007 edition

Bitemarks

- No database to quantify bitemarks or human dentition
- No ability to establish numerical probabilities
- No ability to research biting in living human skin

Bitemark Analysis

- Method of comparing tooth patterns left in skin and other inanimate objects to the teeth of a population of suspected biters
- One of the most controversial of all forensic scientific investigations

Bitemark Analysis

- There is definite subjectivity in bitemark analysis
- This interpretative property of the science has lead to questions about the validity, accuracy and reliability of bitemark analysis
- National Academy of Science (NAS) report 2009

Bitemark Analysis

- Determine injury represents a bitemark
- Design and perform tests to evaluate the bitemark against a population of suspected biters
- Analysis leads to a preliminary opinion
- Re-Examination by independent second opinion
- Case Report

Bitemark Analysis: Scientific Methodology

- Hypothesis
- Testing design
- Testing methods
- Analysis of tests
- Opinion based on the testing

Dynamics of Biting

- Biting is not a static event
- Biting dynamics lead to different appearances of the bitemarks created by the same biter in cases involving multiple bitemarks

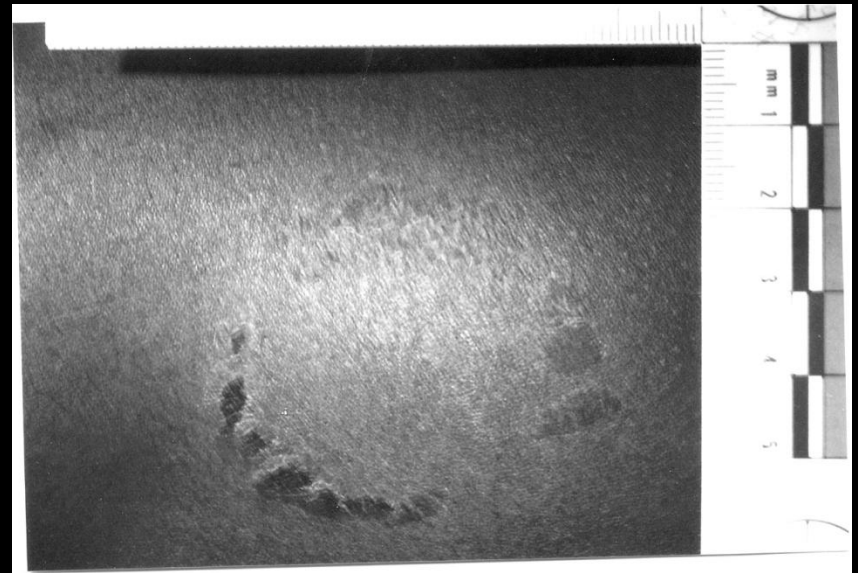
4 of more than 30 bitemarks from attack



Same biter causing all injuries at the same incident

Bitemarks

- Teeth may leave imprints when they bite something
- The imprints left during the biting may link to a specific biter



Bitemarks

- The object bitten typically will distort, particularly if the biting is in skin



Bitemark Patterns

- Movement during biting by either/both the biter and the object bitten can distort the recorded tooth patterns
- This pattern of distortion often complicates the interpretation of the pattern as related to a biter



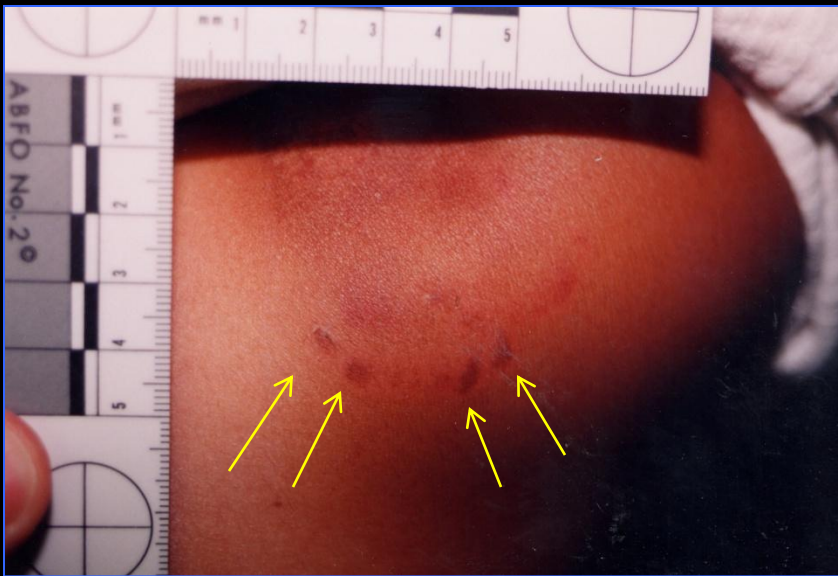
Objects other than skin are sometimes bitten, which can also record bitemarks. This presentation only discusses bitemarks in human skin.

Bitemark Patterns

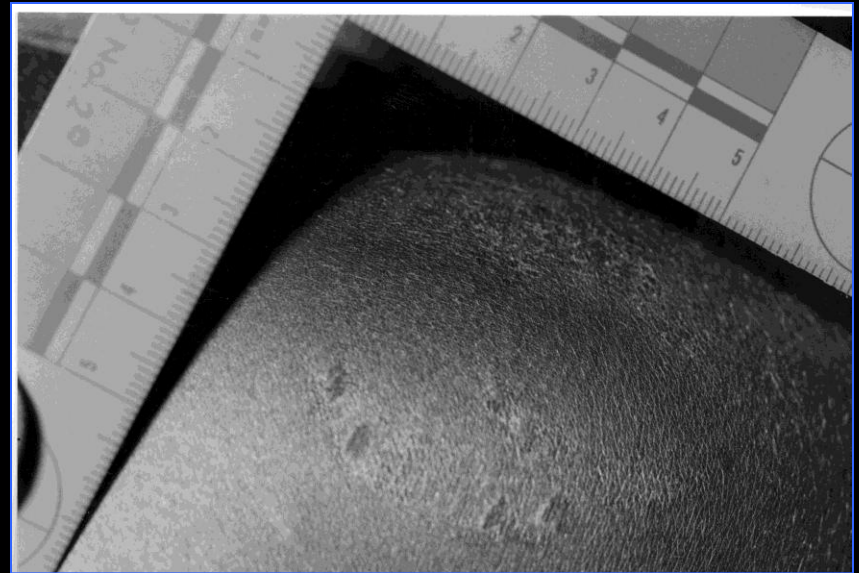
- Front teeth usually register first when biting. Depending on their length, some will touch the bitten object before others
- After the first tooth penetrates a defined distance, the next tooth will begin to mark
- Subsequent teeth follow with the biting depending on their height and position



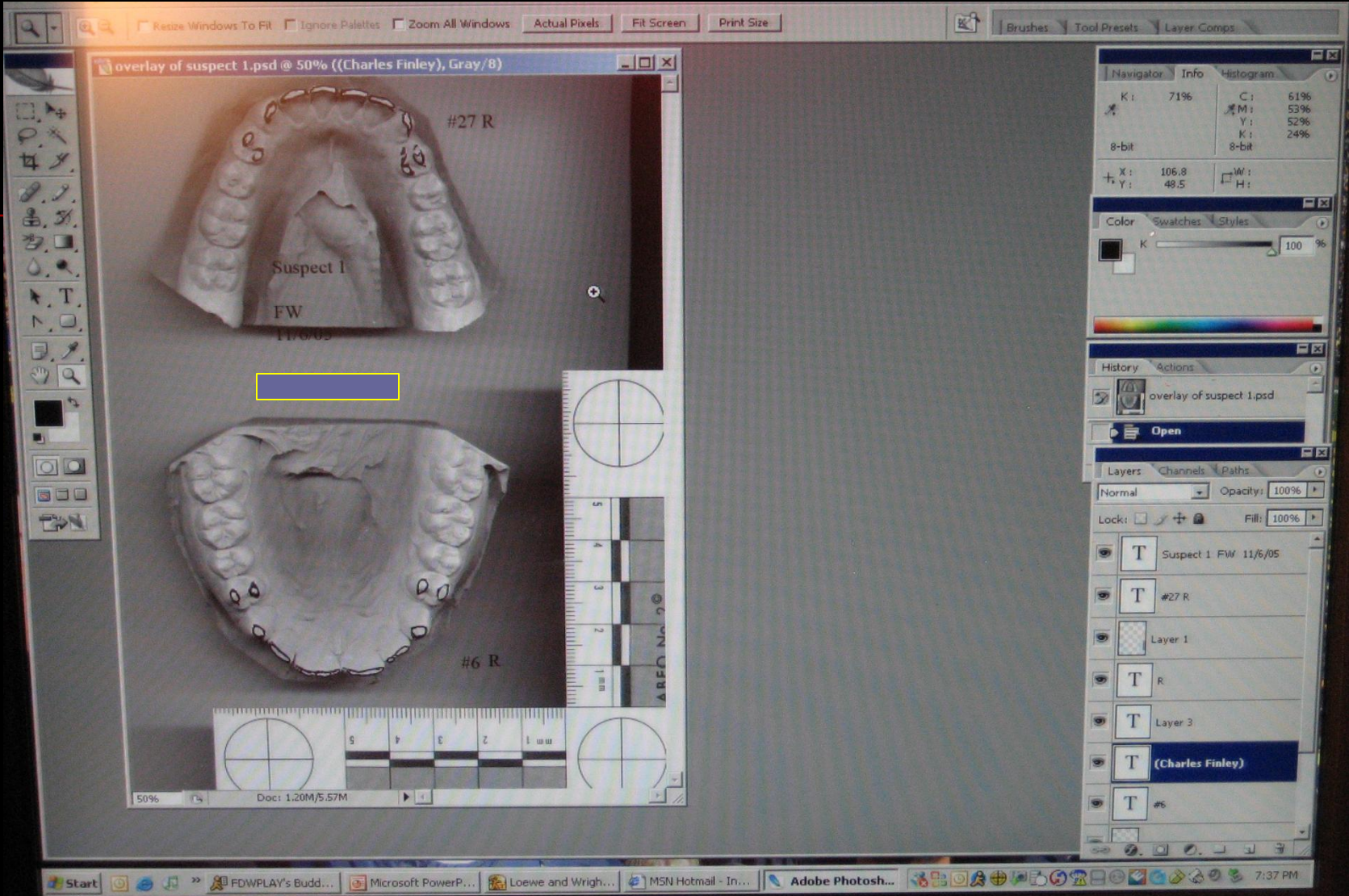
Bruising differences from teeth at different heights



Color photograph taken day of bite- heavy markings of lateral incisors and canines; faint markings of the central incisors



UV photograph taken 8 days after the bite showing all six lower anterior teeth are present



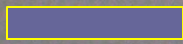
overlay of suspect 1.psd @ 50% ((Charles Finley), Gray/8)

#27 R

Suspect 1

FW

11/6/05



#6 R

50% Doc: 1.20M/5.57M

Navigator Info Histogram

K: 7196 C: 6196
M: 5396 Y: 5296
K: 2496
8-bit 8-bit

X: 106.8 W:
Y: 48.5 H:

Color Swatches Styles

K 100%

History Actions

overlay of suspect 1.psd

Open

Layers Channels Paths

Normal Opacity: 100%

Lock: Fill: 100%

T Suspect 1 FW 11/6/05

T #27 R

Layer 1

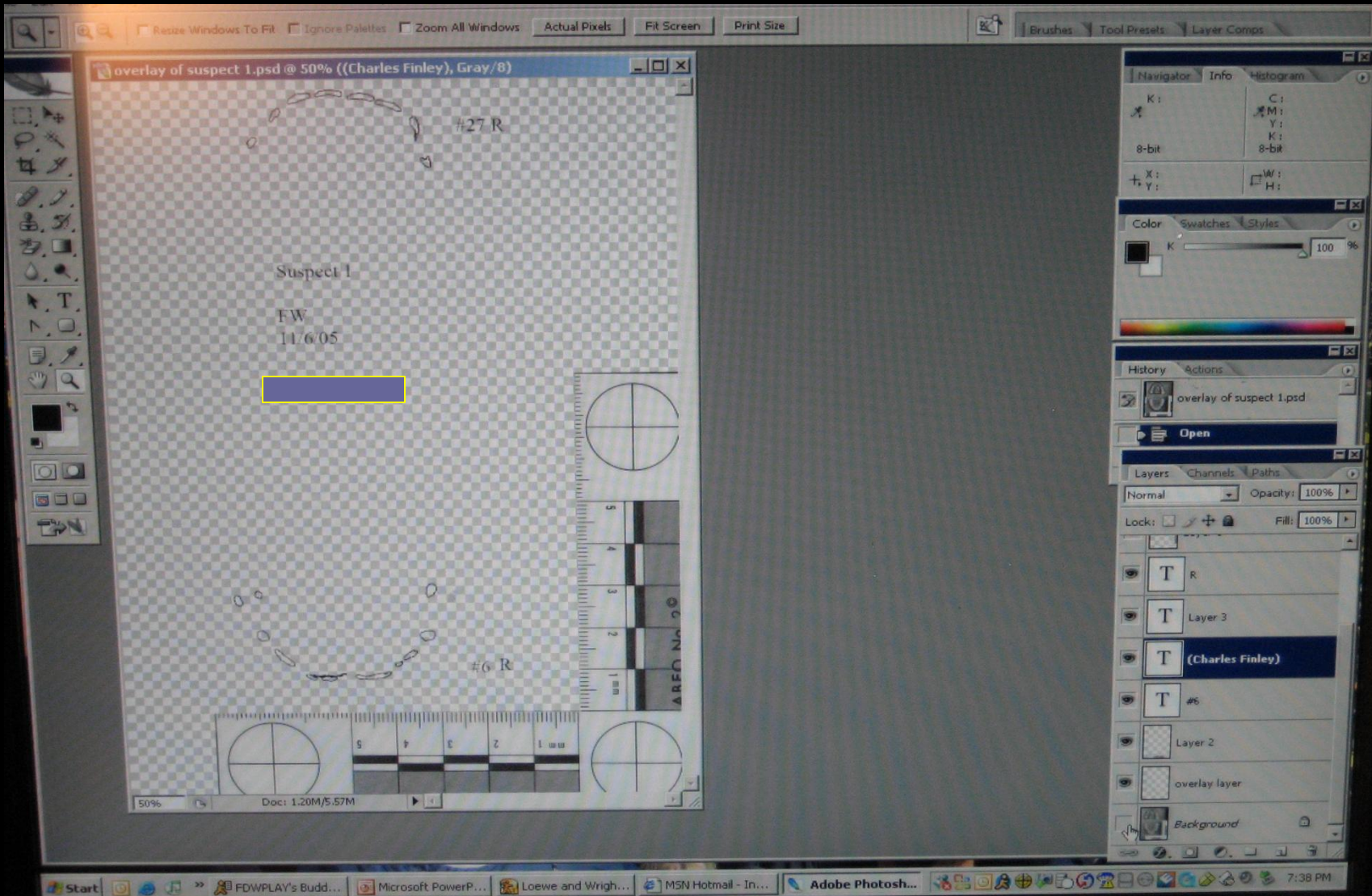
T R

T Layer 3

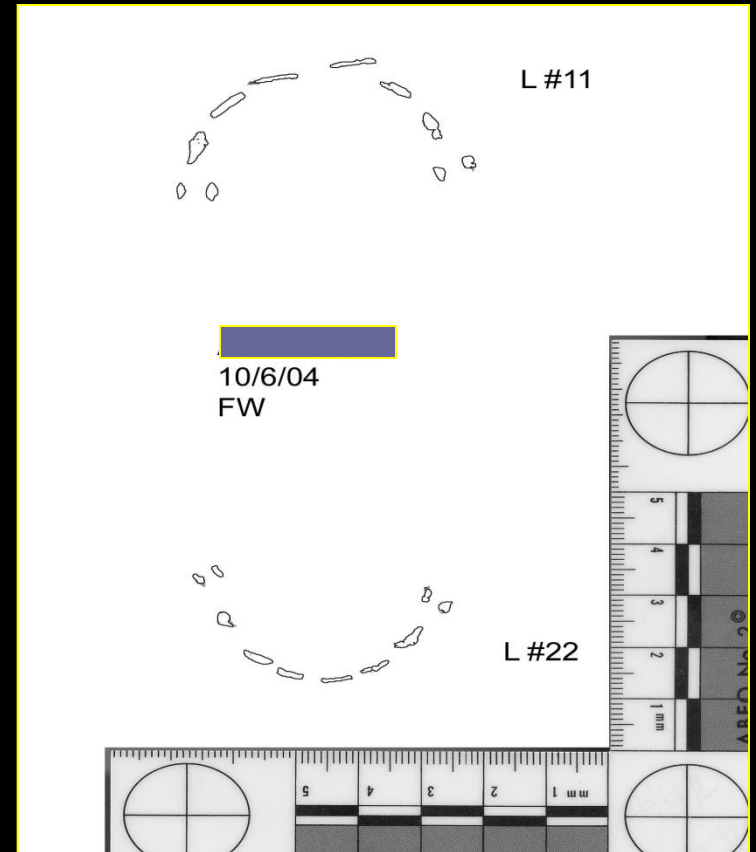
T (Charles Finley)

T #6

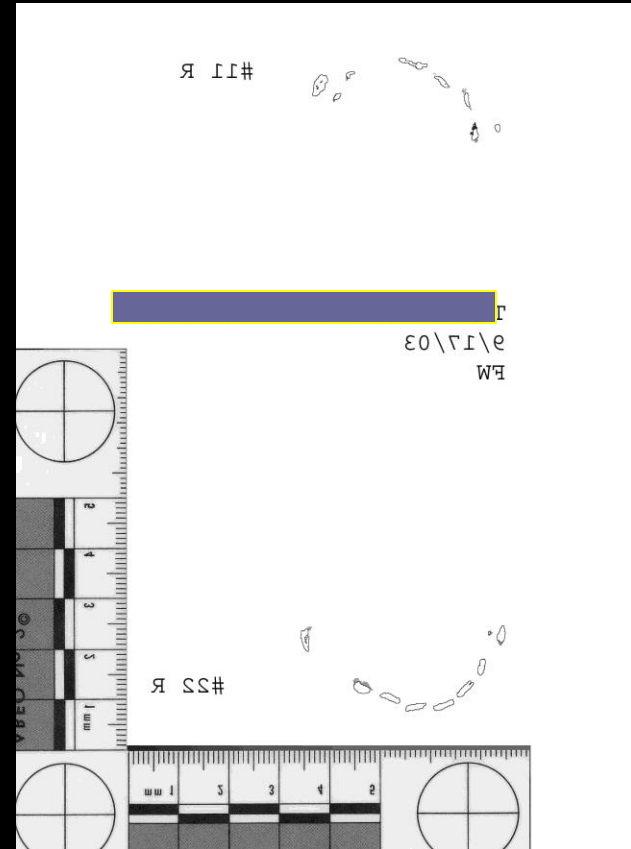
Start FDWPLAY's Budd... Microsoft PowerP... Loewe and Wri... MSN Hotmail - In... Adobe Photosh... 7:37 PM



Models and the overlay



Wax bite and overlay

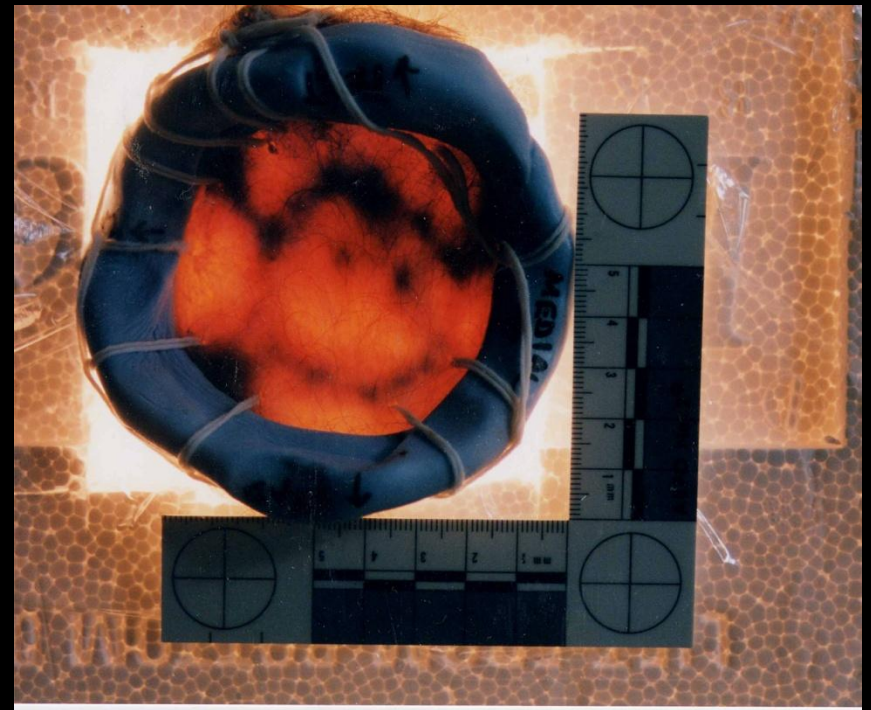
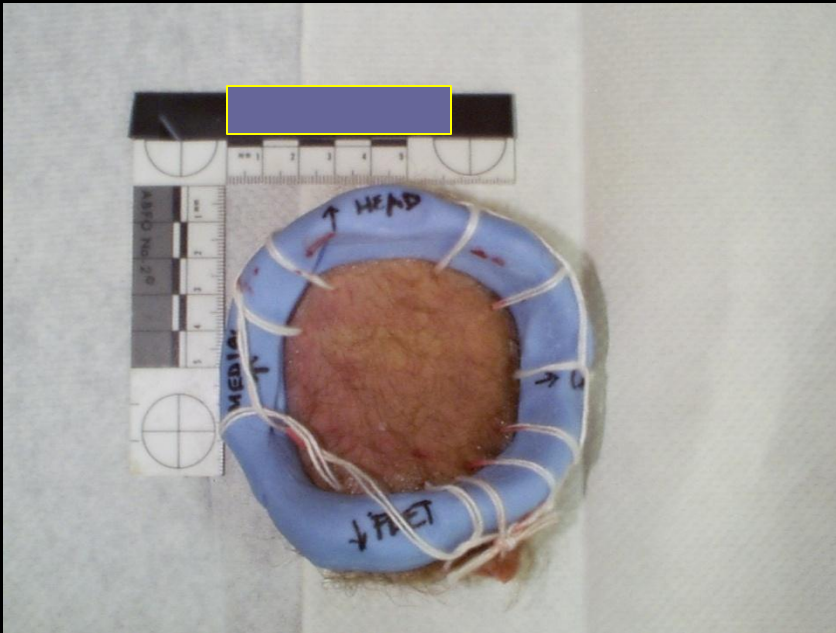


(Overlay intentionally flipped horizontally)

Transillumination

- The resected tissue is examined using a light source that is shined through the excised tissue from the deepest sub-dermal regions toward the outer skin layer

Transillumination



Photography

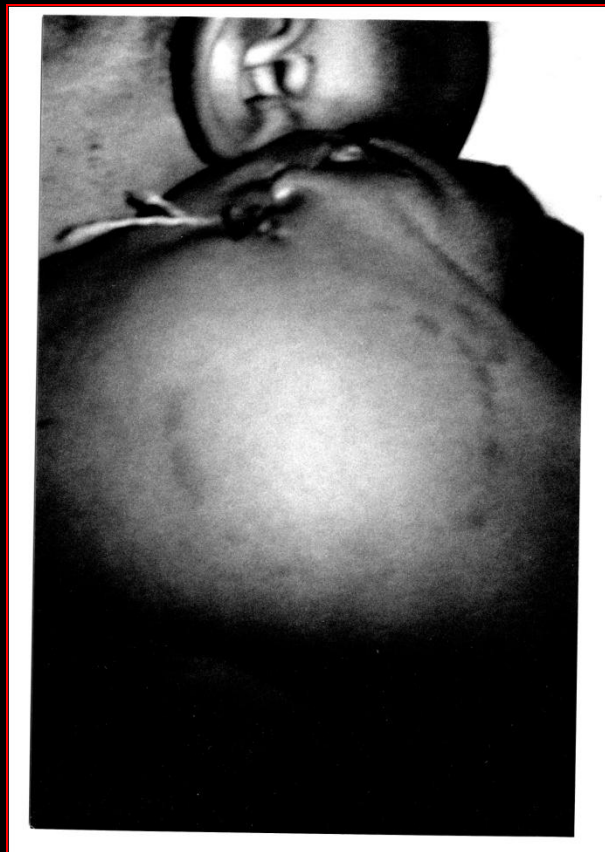


Color and black & white visible light photos



Digitally enhanced
Black & white
Visible light photo

Digital Imaging and Enhancement



Digitally enhanced
ALI of shoulder



Black & white visible light
photograph

ABFO Bitemark Terminology

Terms Indicating Degree of Confidence That an Injury is a Bitemark:

Bitemark - Teeth created the pattern; other possibilities were considered and excluded.

- *criteria*: pattern conclusively illustrates a) classic features. b) all the characteristics, or c) typical class characteristics of dental arches and human teeth in proper arrangement so that it is recognizable as an impression of the human dentition.

Suggestive – The pattern is suggestive of a bitemark, but there is insufficient evidence to reach a definitive conclusion at this time.

- *criteria*: general shape and size are present but distinctive features such as tooth marks are missing, incomplete or distorted or a few marks resembling tooth marks are present but the arch configuration is missing.

Not a bitemark – Teeth did not create the pattern.

ABFO Bitemark Terminology

Descriptions and Terms Used to Relate Bitemark to the Suspected Biter:

DESCRIPTORS TO INDICATE SIMILARITIES BETWEEN A BITEMARK AND A PERSON'S DENTITION:

Biter

Probable biter

Cannot Exclude

Exclusion

Inconclusive

Bitemark Analysis: Basis

- Collective sets of teeth have visually different arrangements
- In an ideal world, the patterns left by teeth in biting should relate to only one individual
- In the real world, it can be more difficult to differentiate similar sets of dentitions
- Bitemark evidence best used as adjunctive evidence or as a potential source of biter DNA

Bitemark Analysis

- Most bitemarks analyzed are in human skin
- In an open population of suspected biters, little scientific evidence exists to say with any degree of certainty that the skin will record details of the biter's teeth in such a way that a single suspected biter could reliably be identified

Bitemark Analysis

- A closed population of suspected biters with *similar dentitions* could not be discriminately separated in analysis with a bitemark in skin, even with a bitemark deemed to be of high forensic evidentiary value
- Bitemarks in skin lacking *individual* characteristics of the biter's teeth should not be used in bitemark analysis

Bitemark Analysis

- Bitemarks of high evidentiary value in a closed population of suspected biters ($n=2$ or 3), each of whom present with significantly different dentitions, may be analyzed for discriminate inclusion/exclusion of a specific biter

Suspect B



Suspect A



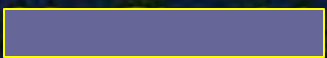


Suspect A

Upper Teeth

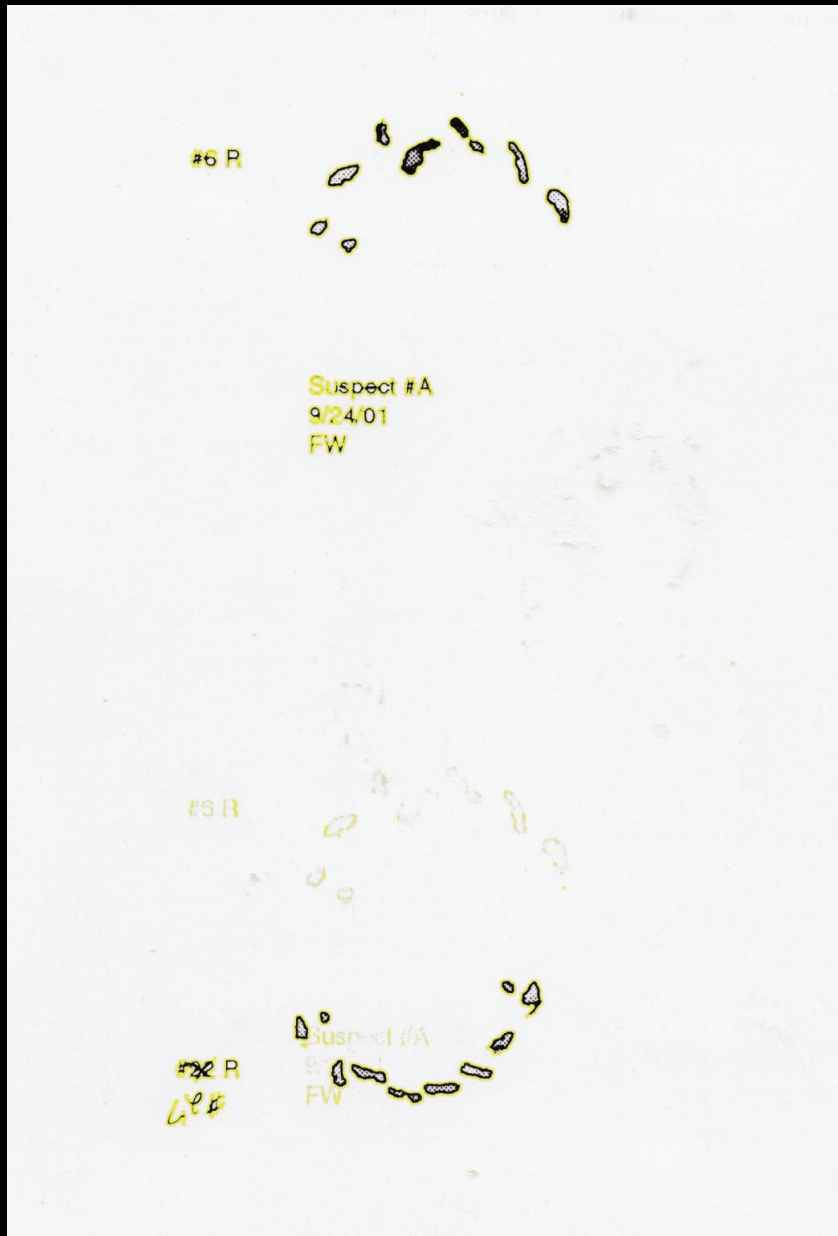
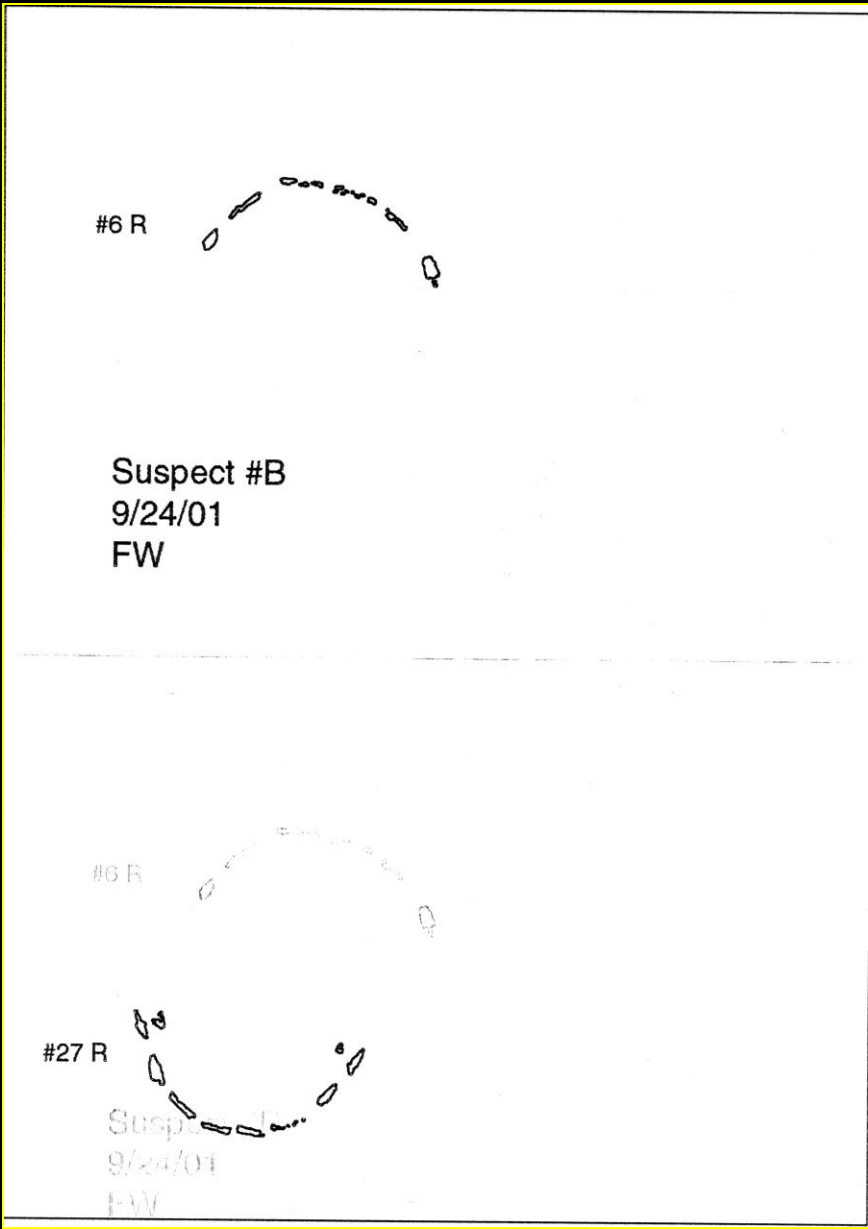


Suspect B



Upper Teeth

Profoundly different suspected biters' teeth



Bitemark Analysis and the NAS report

- “There is no evident reason why rigorous, systematic research would be infeasible”

Comment:

- *However, it is not possible to experimentally reproduce bitemark circumstances such as violent altercations*

Spectrum of Bitemarks

In human skin

Witnessed bite through clothing



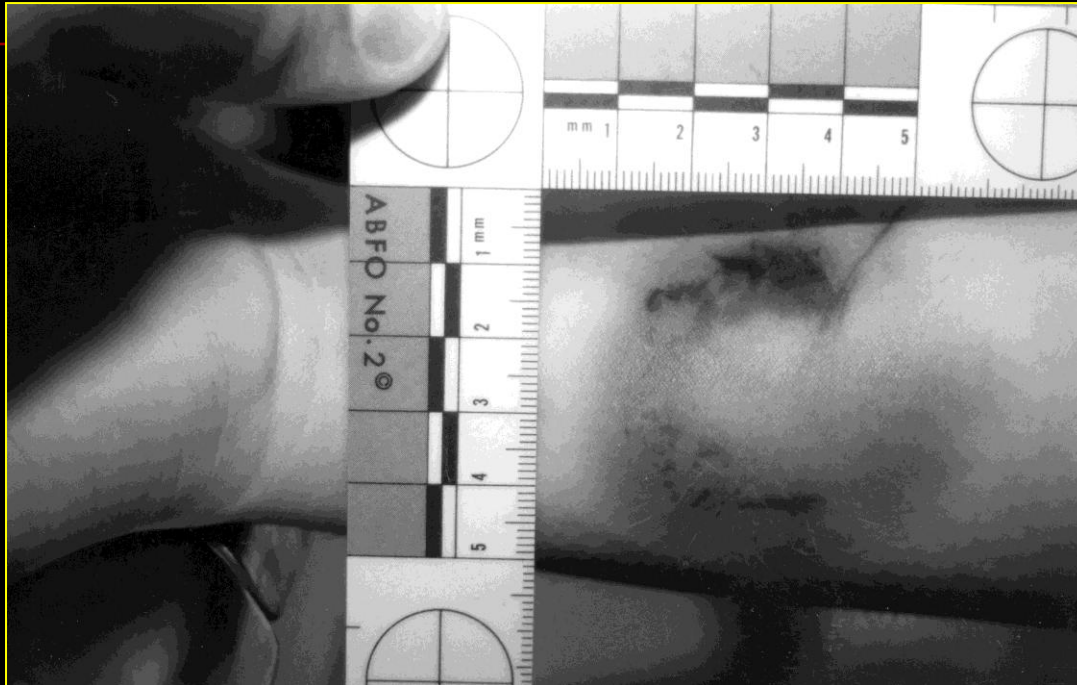
No evidentiary value in bitemark analysis

Healed bitemark



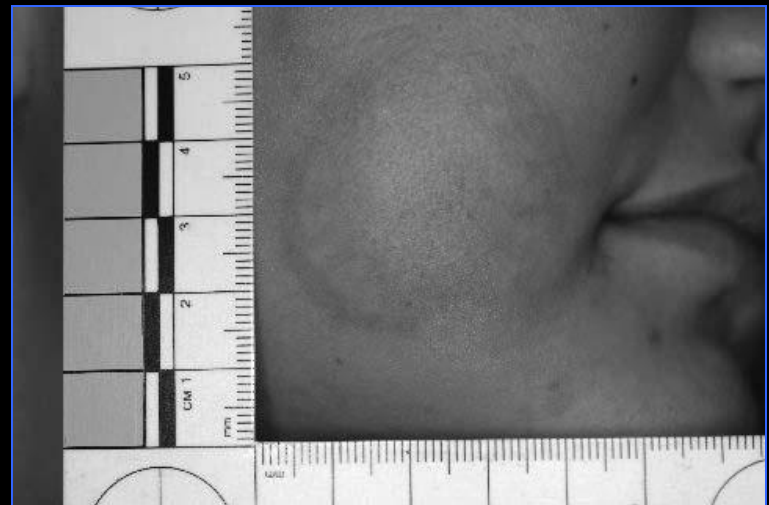
No evidentiary value in bitemark analysis

Badly distorted bitemark in fatty skin



No evidentiary value in bitemark analysis

Diffuse bitemark



No evidentiary value in bitemark analysis

Bite mark with individual and class characteristics



Higher evidentiary value that could be useful in bite mark analysis

Child versus Adult bitemark



Child on child biting

Child on Child Biting

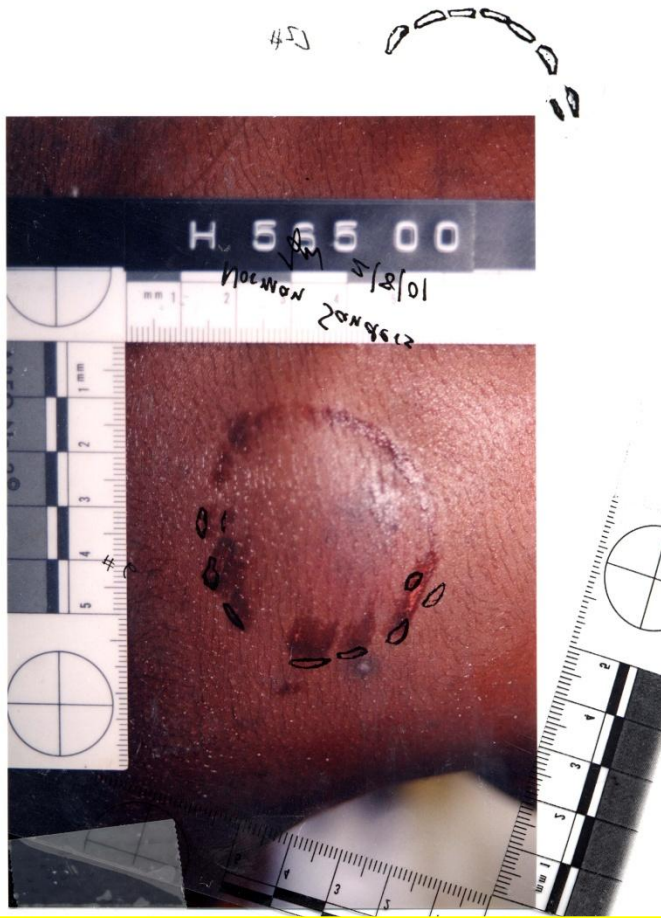




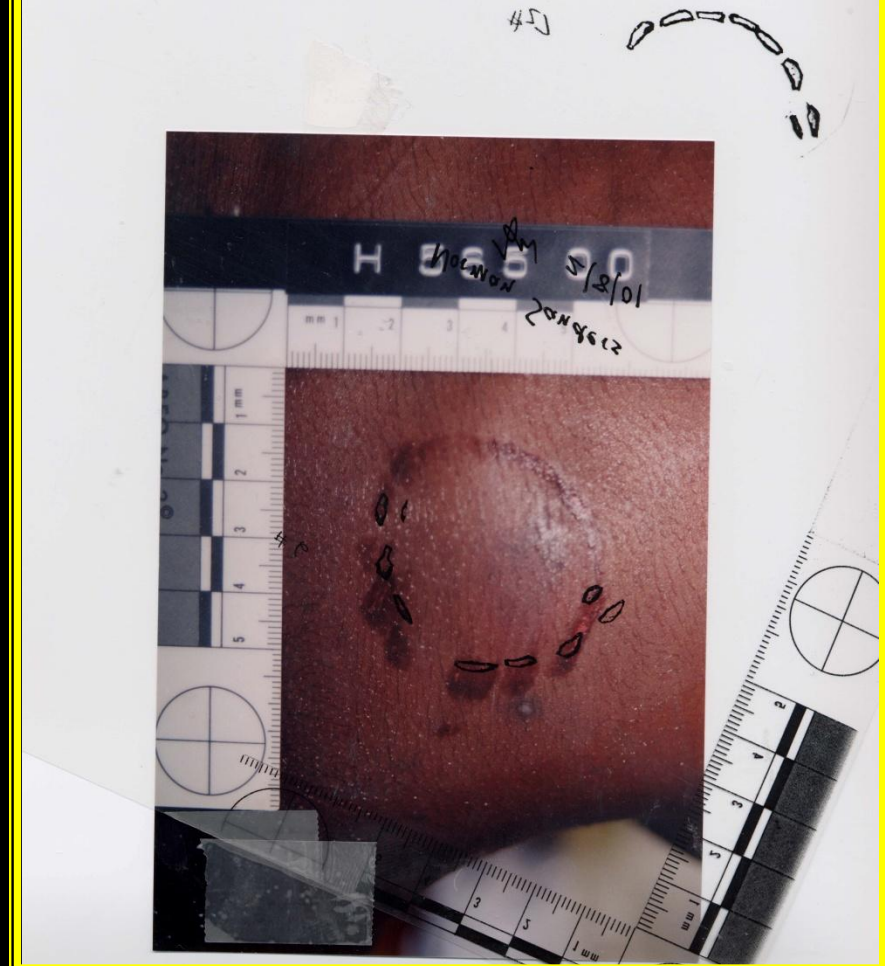








Teeth position at start of biting



Teeth position at conclusion of biting



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Leading the federal effort to strengthen forensic science in the United States

The NAS Report- Bitemark Analysis- --- *Daubert* Expert Presentation

January 12, 2011

Definition of *Science*

- *World English Dictionary* definition:

- *...the knowledge so obtained or the practice of obtaining it; any body of knowledge organized in a systematic manner; skill or technique*

- *Science Dictionary* definition:

- *...the investigation of natural phenomena through observation, theoretical explanation, and experimentation, or the knowledge produced by such investigation*

Definition of *Science*

- “...the concerted human effort to understand, or better understand...how the natural world works...It is done through observation of natural phenomena, and/or through experimentation that *tries to simulate natural processes under controlled conditions* (emphasis added)

Source: www.gly.uga.edu

Perhaps better said:

- “Science is the belief in the ignorance of experts” - Richard Feynman, Nobel Prize winning physicist 1999
- “A true scientist is bored by knowledge; it is the assault on ignorance that motivates him” -Matt Ridley, *Genome- the autobiography of a species in 23 chapters*, pg. 271

-regarding science....

- “(Scientists) may have a high level of confidence if there’s abundant evidence, but they won’t ever claim absolute Truth or absolute certainty”

Source: www.gly.uga.edu

Bitemark Analysis as Science

- Based on the definitions of *science*, bitemark analysis fits well, with one notable exception:
 - *Experimental testing*:
 - it is not possible to experimentally create and recreate bitemarks in unanaesthetized living human skin for research purposes.

Daubert and Bitemark Analysis

NAS Report regarding Bitemark Analysis
2009

“Daubert Trilogy” vs. Daubert: Federal Rules of Evidence 702

- Removing the concerns some have regarding bitemark analysis as pure “science”, indulge the use of the “Daubert Trilogy”, which includes *Daubert v Merrill Dow Pharmaceuticals*; *Kuhmo Tire Co v Carmichael* and *GE v Joiner*
- Will better focus the discussion on bitemark analysis and expert testimony

Daubert Trilogy

- Applies to scientific, technical or other specialized knowledge regarding expert witness testimony

Relevant Factors of *Daubert*

- Evidence based on a testable theory
- Subjected to peer review and publication
- Known or potential error rate
- Standards and controls concerning its operation
- Is the underlying science generally accepted by a relevant scientific community

Relevant Factors of *Daubert*

- skin recording bitemarks
- uniqueness of the dentition

From the NAS report

Evidence based on a testable theory

Ability of human skin to accurately record bitemark

- Research on the reaction of skin to biting using human cadaver skin and living porcine skin

(not living human skin)

Research Centers

McGill University, Montreal

2004



QUEBEC
PROVINCIAL
POLICE
IDENTIFICATION
UNIT



Laboratoire
de sciences judiciaires
et de médecine légale

Sécurité publique
Québec

Research using anesthetized porcine skin

University at Buffalo, The State University of New York



*Research using
cadaver skin*

Peer Reviewed research- Skin

***Mary A. Bush,¹ D.D.S.; Raymond G. Miller,¹ D.D.S.; Peter J. Bush,¹ B.S.;
and Robert B. J. Dorion,² D.D.S.

Biomechanical Factors in Human Dermal Bitemarks in a Cadaver Model*

J Forensic Sci, January 2009, Vol. 54, No. 1
doi: 10.1111/j.1556-4029.2008.00908.x
Available online at: www.blackwell-synergy.com

***Mary A. Bush,¹ D.D.S.; Howard I. Cooper,² D.D.S.; and Robert B. J. Dorion,³ D.D.S.

Inquiry into the Scientific Basis for Bitemark Profiling and Arbitrary Distortion Compensation

J Forensic Sci, July 2010, Vol. 55, No. 4
doi: 10.1111/j.1556-4029.2010.01394.x
Available online at: interscience.wiley.com

***Sylvain Desranleau,¹ D.M.D. and Robert B. J. Dorion,² D.D.S.

Bite Marks: Physical Properties of Ring Adhesion to Skin—Phase 1*

J Forensic Sci, 2010
doi: 10.1111/j.1556-4029.2010.01604.x
Available online at: onlinelibrary.wiley.com

Raymond G. Miller,¹D.D.S.; Peter J. Bush,¹B.S.; Robert B. J. Dorion,²D.D.S.;
and Mary A. Bush,¹D.D.S.

Uniqueness of the Dentition as Impressed in Human Skin: A Cadaver Model*

J Forensic Sci, July 2009, Vol. 54, No. 4
doi: 10.1111/j.1556-4029.2009.01076.x
Available online at: www.blackwell-synergy.com

Mary A. Bush,¹D.D.S.; Kyle Thorsrud,¹B.S.; Raymond G. Miller,¹D.D.S.; Robert B. J.
Dorion,²D.D.S.; and Peter J. Bush,¹B.S.

The Response of Skin to Applied Stress: Investigation of Bitemark Distortion in a Cadaver Model*

J Forensic Sci, January 2010, Vol. 55, No. 1
doi: 10.1111/j.1556-4029.2009.01235.x
Available online at: interscience.wiley.com

Mathematical matching of a dentition to bitemarks: Use and evaluation of affine methods

H. David Sheets ^a, Mary A. Bush ^{b,*}

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^b Laboratory for Forensic Odontology Research, School of Dental Medicine,
SUNY at Buffalo, B1 Squire Hall, S. Campus, Buffalo, NY 14214, USA

NAS Report: bitemarks in skin

- “Unfortunately, bite marks on the skin will change over time and can be distorted by the elasticity of the skin, the unevenness of the surface bite, and swelling and healing. These features may severely limit the validity of forensic odontology. Also, some practical difficulties, such as distortions in photographs and changes over time in the dentition of suspects, may limit the accuracy of the results.” (5-35)

NAS Report: bitemarks in skin

- “The ability of the dentition, if unique, to transfer a unique pattern to human skin and the ability of the skin to maintain that uniqueness has not been scientifically established.¹²⁹
 - i. The ability to analyze and interpret the scope or extent of distortion of bitemark patterns on human skin has not been demonstrated.
 - ii. The effect of distortion on different comparison techniques is not fully understood and therefore has not been quantified.”

NAS Report: bitemarks in skin

■ Comments:

- If the bitemark in skin possesses both distinct individual and class characteristics (high quality bitemark) AND if the population of suspected biters is small (say $n=2$ or 3) AND if each suspected biter has a dentition that is visibly and notably different for each other, it would be possible to establish biter identity

NAS Report: bitemarks in skin

■ Comments:

- Research of biting in living human skin is impractical for medical, legal and ethical considerations at this time
- Identification of the biter should be restricted to only those cases that meet the criteria as previously noted- bitemarks with distinct individual and class characteristics, small/closed population of suspected biters, each of whom has distinctly different dentitions

NAS Report: regarding bitemarks and bitemark analysis in skin

- “...it is reasonable to assume that the process can sometimes reliably exclude suspects.” (5-37)
- “The ability of the dentition, if unique, to transfer a unique pattern to human skin...has not be scientifically established” (5-37)

NAS Report: bitemarks in skin

■ conflict

- If skin doesn't accurately record tooth position in bitemarks, then neither biter inclusion nor exclusion should be possible. (That's not what the NAS report says.)

Comment:

There are high quality bitemarks that they can be reliably used in bitemark analysis for inclusion or exclusion

NAS Report: bitemarks in skin

- Comment (continued)
 - In an open population of suspected biters, bitemark analysis opinions should not be rendered.

Evidence Based on a Testable Theory

Uniqueness of the human dentition

- Research on the arrangement, shape and position of the six upper and lower anterior teeth in two- and three- dimensions

Arrangement of the Anterior Human Teeth

- The 2D and 3D databases are being compiled to examine the positions of each of the anterior human teeth individually and collectively
- It is hoped that they will one day be searchable to create a “dental lineup” of suspected biters’ dentition to use in bitemark analysis

Jules A. Kieser,¹ Ph.D.; Valeria Bernal,² Ph.D.; John Neil Waddell,¹ M.Dip. Tech.; and Shilpa Raju,¹ BDS

The Uniqueness of the Human Anterior Dentition: A Geometric Morphometric Analysis

J Forensic Sci, May 2007, Vol. 52, No. 3

doi:10.1111/j.1556-4029.2007.00403.x

Available online at: www.blackwell-synergy.com

Int J Legal Med

DOI 10.1007/s00414-010-0507-8

ORIGINAL ARTICLE

Similarity and match rates of the human dentition in three dimensions: relevance to bitemark analysis

Mary A. Bush · Peter J. Bush · H. David Sheets

Forensic Science International journal www.elsevier.com/locate/forsciint:
Review article

Uniqueness in the forensic identification sciences—Fact or fiction?

Mark Page, Jane Taylor ^{*}, Matt Blenkin University of Newcastle, School of Health Sciences, Australia Contents

A R TICLEINFO Article history: Received 24March2010 Received inrevisedform30July2010 Accepted
4August2010 Available onlinexxx

Statistical Evidence for the Similarity of the Human Dentition

Journal:	<i>Journal of Forensic Sciences</i>
Manuscript ID:	JOFS-09-488.R1
Manuscript Type:	Paper
Date Submitted by the Author:	
Complete List of Authors:	Bush, Mary; SUNY at Buffalo School of Dental Medicine, Laboratory for Forensic Odontology Research Bush, Peter; SUNY at Buffalo, Laboratory for Forensic Odontology Research Sheets, H; Canisius College, Physics
Keywords:	forensic science, forensic odontology, bitemarks, bitemark research, statistics, dental uniqueness

NAS Report: uniqueness of the human dentition



- **Comments:**

- Using high quality bitemarks with a small/closed population of suspected biters who have dentitions are notably dissimilar, the uniqueness of the human dentition in large population-based studies is irrelevant

NAS Report: uniqueness of the human dentition

- The databases being constructed mapping the anterior dentitions of human teeth in 2D and 3D will be a significant aid in creating a dental lineup of similar dentitions, increasing the accuracy, validity and reliability of the bitemark analysis
- In cases where only one potential biter is identified by investigators, creating a dental lineup will prove invaluable

Relevant Factors of *Daubert*

- Evidence based on a testable theory 
- Subjected to peer review and publication 
- Known or potential error rate
- Are there standards and controls concerning its operation
- Is the underlying science generally accepted by a relevant scientific community

Relevant Factors of *Daubert*

- Known or potential error rate

Known or potential error rate

- **Comments:**
 - False positive or false negative errors should be near zero with high quality bitemarks and closed population of biters who have different dentitions
 - Working with an open population and less than ideal bitemark evidence will lead to an undeterminable error rate

Known or potential error rate

- Operator bias
 - Blinded case review (“second opinion”)
- Failure to follow prescribed methodology
 - Independent of operator bias

Relevant Factors of *Daubert*

- Maintaining Standards and Controls

Maintaining Standards and Controls:

- ABFO Guidelines and Standards on Bitemark Analysis, Bitemark Terminology and Bitemark Report Writing
- ABFO Recertification Examination
- ABFO Peer Review (motion pending)
- ABFO Bitemark Proficiency testing (in development)
- ABFO Bitemark subspecialty designation??

Relevant Factors of Daubert

- Is the underlying science generally accepted by a relevant scientific community

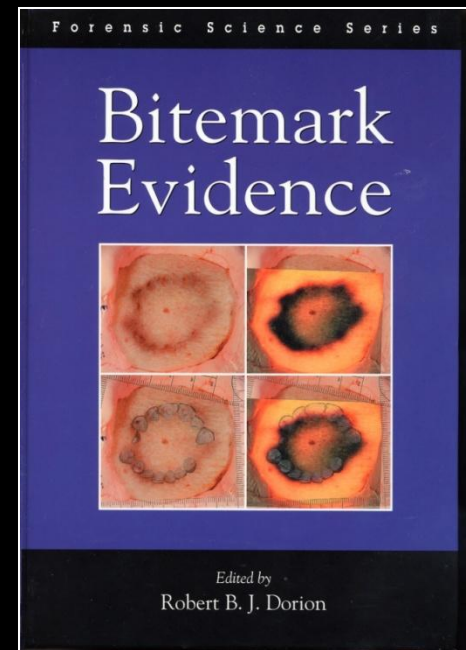
General acceptance by a relevant scientific community

■ Comments:

- Expert testimony in bitemark analysis has been accepted by the courts for decades
- In *Forensic Dentistry, 2nd edition*, edited by Senn and Stimson, pages 411-421 list some 250 cited federal and state appeals decisions upholding bitemark analysis

- “The research suggests that bitemark evidence, at least that which is used to identify biters, is a potentially valid and reliable methodology. It is generally accepted within the scientific community
”
...

Iain Pretty in *Bitemark Evidence*, 1st edition,
edited by Dorion, pg 543

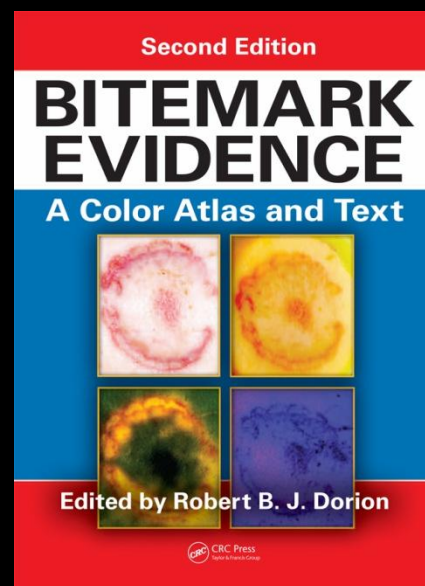


1st Edition, 2005

(2nd Edition out week of
January 11, 2011)

Prominent chapters in the
2nd Edition involving
Daubert and bitemark
analysis:

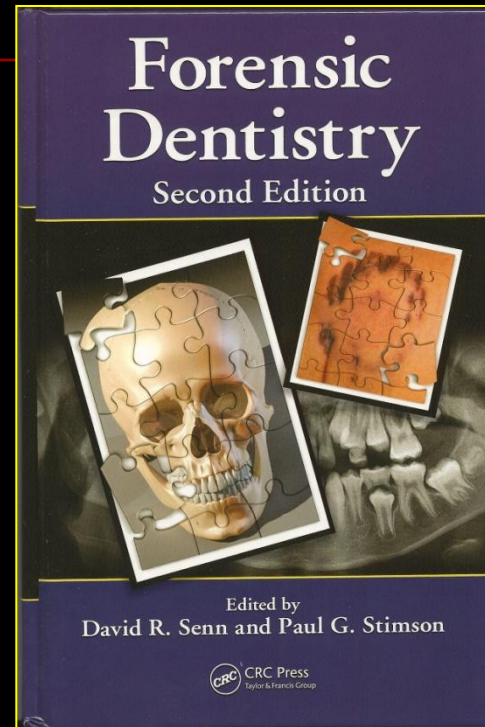
-Chapters 20, 21, 22, 23,
29 and 34



2nd Edition

-Chapter 14: Bitemarks

-Appendix: US Federal
and State Court Cases
of Interest in Forensic
Odontology



Bitemark Analysis Comments

- There is a place in forensic science for bitemark analysis
- The best use of bitemark analysis is adjunctive evidence in any given case

Comments on the NAS report

■ Bitemarks and DNA

- It would be most beneficial if DNA could be recovered from human bitemarks and added to the list of possible evidence to use in a case
- Great care must be exercised to be certain that source of the DNA and its interaction with the bitemark is well established

Comments on the NAS report

- Some of the citations used in the NAS report appear to have based on the 1999 ABFO Bitemark Workshop #4 being represented as a “proficiency test”. It was not. A Position Paper on the intention of ABFO Bitemark Workshop #4 was published in 2003 by the ABFO clearing stating the workshop was not a proficiency test, thus no conclusions regarding proficiency could be gleaned

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- I wish to acknowledge Drs. David Senn, Robert BJ Dorion, Roger Metcalf and Robert Barsley for their help with this presentation