STRENGTHENING FORENSIC SCIENCE IN THE UNITED STATES

A PATH FORWARD

Committee on Identifying the Needs of the Forensic Science Community

Committee on Science, Technology, and Law
Policy and Global Affairs

Committee on Applied and Theoretical Statistics
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ing screwdrivers,[295] crowbars,[296] punches,[297] knives,[298] as well as other objects.[299] An expert's opinion is admissible even if the expert cannot testify to a positive identification.[300]

IX. Bite Mark Evidence

Bite mark analysis has been used for more than 50 years to establish a connection between a defendant and a crime.[301] The specialty developed within the field of forensic dentistry as an adjunct of dental identification, rather than originating in

295. *E.g.*, State v. Dillon, 161 N.W.2d 738, 741 (Iowa 1968) (screwdriver and nail bar fit marks on door frame); State v. Wessling, 150 N.W.2d 301 (Iowa 1967) (screwdriver); State v. Hazelwood, 498 P.2d 607, 612 (Kan. 1972) (screwdriver and imprint on window molding); State v. Wade, 465 S.W.2d 498, 499–500 (Mo. 1971) (screwdriver and pry marks on door jamb); State v. Brown, 291 S.W.2d 615, 618–19 (Mo. 1956) (crowbar and screwdriver marks on window sash and door); State v. Eickmeier, 191 N.W.2d 815, 816 (Neb. 1971) (screwdriver and marks on door).

296. *E.g.*, *Brown*, 291 S.W.2d at 618–19 (Mo. 1956) (crowbar and screwdriver marks on window sash and door); State v. Raines, 224 S.E.2d 232, 234 (N.C. Ct. App. 1976).

297. *E.g.*, State v. Montgomery, 261 P.2d 1009, 1011–12 (Kan. 1953) (punch marks on safe).

298. *E.g.*, State v. Baldwin, 12 P. 318, 324–25 (Kan. 1886) (experienced carpenters could testify that wood panel could have been cut by accused's knife); Graves v. State, 563 P.2d 646, 650 (Okla. Crim. App. 1977) (blade and knife handle matched); State v. Clark, 287 P. 18, 20 (Wash. 1930) (knife and cuts on tree branches); State v. Bernson, 700 P.2d 758, 764 (Wash. Ct. App. 1985) (knife tip comparison).

299. *E.g.*, United States v. Taylor, 334 F. Supp. 1050, 1056–57 (E.D. Pa. 1971) (impressions on stolen vehicle and impressions made by dies found in defendant's possession), *aff'd*, 469 F.2d 284 (3d Cir. 1972); State v. McClelland, 162 N.W.2d 457, 462 (Iowa 1968) (pry bar and marks on "jimmied" door); Adcock v. State, 444 P.2d 242, 243–44 (Okla. Crim. App. 1968) (tool matched pry marks on door molding); State v. Olsen, 317 P.2d 938, 940 (Or. 1957) (hammer marks on the spindle of a safe).

300. For example, in *United States v. Murphy*, 996 F.2d 94 (5th Cir. 1993), an FBI expert gave limited testimony "that the tools such as the screwdriver associated with Murphy 'could' have made the marks on the ignitions but that he could not positively attribute the marks to the tools identified with Murphy." *Id.* at 99; *see also* State v. Genrich, 928 P.2d 799, 802 (Colo. App. 1996) (upholding expert testimony that three different sets of pliers recovered from the accused's house were used to cut wire and fasten a cap found in the debris from pipe bombs: "The expert's premise, that no two tools make exactly the same mark, is not challenged by any evidence in this record. Hence, the lack of a database and points of comparison does not render the opinion inadmissible.").

Although most courts have been receptive to toolmark evidence, a notable exception was *Ramirez v. State*, 810 So. 2d 836, 849–51(Fla. 2001). In *Ramirez*, the Florida Supreme Court rejected the testimony of five experts who claimed general acceptance for a process of matching a knife with a cartilage wound in a murder victim—a type of "toolmark" comparison. Although the court applied *Frye*, it emphasized the lack of testing, the paucity of "meaningful peer review," the absence of a quantified error rate, and the lack of developed objective standards. In *Sexton v. State*, 93 S.W.3d 96 (Tex. Crim. App. 2002), an expert testified that cartridge cases from *unfired* bullets found in the appellant's apartment had distinct marks that matched fired cartridge cases found at the scene of the offense. The court ruled the testimony inadmissible: "This record qualifies Crumley as a firearms identification expert, but does not support his capacity to identify cartridge cases on the basis of magazine marks only." *Id.* at 101.

301. *See* E.H. Dinkel, *The Use of Bite Mark Evidence as an Investigative Aid*, 19 J. Forensic Sci. 535 (1973).

crime laboratories. Courts have admitted bite mark comparison evidence in homicide, rape, and child abuse cases. In virtually all the cases, the evidence was first offered by the prosecution. The typical bite mark case has involved the identification of the defendant by matching his dentition with a mark left on the victim. In several cases, however, the victim's teeth have been compared with marks on the defendant's body. One bite mark case involved dentures[302] and another braces.[303] A few cases have entailed bite impressions on foodstuff found at a crime scene: apple,[304] piece of cheese,[305] and sandwich.[306] Still other cases involved dog bites.[307]

Bite marks occur primarily in sex-related crimes, child abuse cases, and offenses involving physical altercations, such as homicide. A survey of 101 cases reported these findings: "More than one bitemark was present in 48% of all the bite cases studied. Bitemarks were found on adults in 81.3% of the cases and on children under 18 years-of-age in 16.7% of cases. Bitemarks were associated with the following types of crimes: murder, including attempted murder (53.9%), rape (20.8%), sexual assault (9.7%), child abuse (9.7%), burglary (3.3%), and kidnapping (12.6%)."[308]

A. The Technique

Bite mark identification is an offshoot of the dental identification of deceased persons, which is often used in mass disasters. Dental identification is based on the assumption that every person's dentition is unique. The human adult dentition consists of 32 teeth, each with 5 anatomic surfaces. Thus, there are 160 dental surfaces that can contain identifying characteristics. Restorations, with varying shapes, sizes, and restorative materials, may offer numerous additional points of individuality. Moreover, the number of teeth, prostheses, decay, malposition,

302. *See* Rogers v. State, 344 S.E.2d 644, 647 (Ga. 1986) ("Bite marks on one of Rogers' arms were consistent with the dentures worn by the elderly victim.").

303. *See* People v. Shaw, 664 N.E.2d 97, 101, 103 (Ill. App. Ct. 1996) (In a murder and aggravated sexual assault prosecution, the forensic odontologist opined that the mark on the defendant was caused by the orthodontic braces on the victim's teeth; "Dr. Kenney admitted that he was not a certified toolmark examiner"; no abuse of discretion to admit evidence).

304. *See* State v. Ortiz, 502 A.2d 400, 401 (Conn. 1985).

305. *See* Doyle v. State, 263 S.W.2d 779, 779 (Tex. Crim. App. 1954); Seivewright v. State, 7 P.3d 24, 26 (Wyo. 2000) ("On the basis of his comparison of the impressions from the cheese with Seivewright's dentition, Dr. Huber concluded that Seivewright was the person who bit the cheese.").

306. *See* Banks v. State, 725 So. 2d 711, 714–16 (Miss. 1997) (finding a due process violation when prosecution expert threw away sandwich after finding the accused's teeth consistent with the sandwich bite).

307. *See* Davasher v. State, 823 S.W.2d 863, 870 (Ark. 1992) (expert testified that victim's dog could be eliminated as the source of mark found on defendant); State v. Powell, 446 S.E.2d 26, 27–28 (N.C. 1994) ("A forensic odontologist testified that dental impressions taken from Bruno and Woody [accused's dogs] were compatible with some of the lacerations in the wounds pictured in scale photographs of Prevette's body.").

308. Iain A. Pretty & David J. Sweet, *Anatomical Location of Bitemarks and Associated Findings in 101 Cases from the United States*, 45 J. Forensic Sci. 812, 812 (2000).

malrotation, peculiar shapes, root canal therapy, bone patterns, bite relationship, and oral pathology may also provide identifying characteristics.[309] The courts have accepted dental identification as a means of establishing the identity of a homicide victim,[310] with some cases dating back to the nineteenth century.[311] According to one court, "it cannot be seriously disputed that a dental structure may constitute a means of identifying a deceased person . . . where there is some dental record of that person with which the structure may be compared."[312]

1. Theory of uniqueness

Identification of a suspect by matching his or her dentition with a bite mark found on the victim of a crime rests on the theory that each person's dentition is unique. However, there are significant differences between the use of forensic dental techniques to identify a decedent and the use of bite mark analysis to identify a perpetrator.[313] In 1969, when bite mark comparisons were first studied, one authority raised the following problems:

> [Bite]marks can never be taken to reproduce accurately the dental features of the originator. This is due partially to the fact that bite marks generally include only a limited number of teeth. Furthermore, the material (whether food stuff or human skin) in which the mark has been left is usually found to be a very unsatisfactory impression material with shrinkage and distortion characteristics that are unknown. Finally, these marks represent only the remaining and fixed picture of an action, the mechanism of which may vary from case to case. For instance, there is as yet no precise knowledge of the possible differences between biting off a morsel of food and using one's teeth for purposes of attack or defense.[314]

309. The identification is made by comparing the decedent's teeth with antemortem dental records, such as charts and, more importantly, radiographs.

310. *E.g.*, Wooley v. People, 367 P.2d 903, 905 (Colo. 1961) (dentist compared his patient's record with dentition of a corpse); Martin v. State, 636 N.E.2d 1268, 1272 (Ind. Ct. App. 1994) (dentist qualified to compare X rays of one of his patients with skeletal remains of murder victim and make a positive identification); Fields v. State, 322 P.2d 431, 446 (Okla. Crim. App. 1958) (murder case in which victim was burned beyond recognition).

311. *See* Commonwealth v. Webster, 59 Mass. (5 Cush.) 295, 299–300 (1850) (remains of the incinerated victim, including charred teeth and parts of a denture, were identified by the victim's dentist); Lindsay v. People, 63 N.Y. 143, 145–46 (1875).

312. People v. Mattox, 237 N.E.2d 845, 846 (Ill. App. Ct. 1968).

313. *See* Iain A. Pretty & David J. Sweet, *The Scientific Basis for Human Bitemark Analyses—A Critical Review*, 41 Sci. & Just. 85, 88 (2001) ("A distinction must be drawn from the ability of a forensic dentist to identify an individual from their dentition by using radiographs and dental records and the science of bitemark analysis.").

314. S. Keiser-Nielson, *Forensic Odontology*, 1 U. Tol. L. Rev. 633, 636 (1969); *see also* NRC Forensic Science Report, *supra* note 3, at 174 ("[B]ite 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.").

Dental identifications of decedents do not pose any of these problems; the expert can often compare all 32 teeth with X rays depicting all those teeth. However, in the typical bite mark case, all 32 teeth cannot be compared; often only 4 to 8 are biting teeth that can be compared. Similarly, all five anatomic surfaces are not engaged in biting; only the edges of the front teeth come into play. In sum, bite mark identification depends not only on the uniqueness of each person's dentition but also on "whether there is a [sufficient] representation of that uniqueness in the mark found on the skin or other inanimate object."[315]

2. Methods of comparison

Several methods of bite mark analysis have been reported. All involve three steps: (1) registration of both the bite mark and the suspect's dentition, (2) comparison of the dentition and bite mark, and (3) evaluation of the points of similarity or dissimilarity. The reproductions of the bite mark and the suspect's dentition are analyzed through a variety of methods.[316] The comparison may be either direct or indirect. A model of the suspect's teeth is used in direct comparisons; the model is compared to life-size photographs of the bite mark. Transparent overlays made from the model are used in indirect comparisons.

Although the expert's conclusions are based on objective data, the ultimate opinion regarding individuation is essentially a subjective one.[317] There is no accepted minimum number of points of identity required for a positive identification.[318] The experts who have appeared in published bite mark cases have testified to a wide range of points of similarity, from a low of eight points to a

315. Raymond D. Rawson et al., *Statistical Evidence for the Individuality of the Human Dentition*, 29 J. Forensic Sci. 252 (1984).

316. *See* David J. Sweet, *Human Bitemarks: Examination, Recovery, and Analysis*, in Manual of Forensic Odontology 162 (American Society of Forensic Odontology, 3d ed. 1997) [hereinafter ASFO Manual] ("The analytical protocol for bitemark comparison is made up of two broad categories. Firstly, the measurement of specific traits and features called a *metric analysis*, and secondly, the physical matching or comparison of the configuration and pattern of the injury called a *pattern association*."); *see also* David J. Sweet & C. Michael Bowers, *Accuracy of Bite Mark Overlays: A Comparison of Five Common Methods to Produce Exemplars from a Suspect's Dentition*, 43 J. Forensic Sci. 362, 362 (1998) ("A review of the forensic odontology literature reveals multiple techniques for overlay production. There is an absence of reliability testing or comparison of these methods to known or reference standards.").

317. *See* Roland F. Kouble & Geoffrey T. Craig, *A Comparison Between Direct and Indirect Methods Available for Human Bite Mark Analysis*, 49 J. Forensic Sci. 111, 111 (2004) ("It is important to remember that computer-generated overlays still retain an element of subjectivity, as the selection of the biting edge profiles is reliant on the operator placing the 'magic wand' onto the areas to be highlighted within the digitized image.").

318. *See* Keiser-Nielson, *supra* note 314, at 637–38; *see also* Stubbs v. State, 845 So. 2d 656, 669 (Miss. 2003) ("There is little consensus in the scientific community on the number of points which must match before any positive identification can be announced.").

high of 52 points.[319] Moreover, disagreements among experts in court appear commonplace: "Although bite mark evidence has demonstrated a high degree of acceptance, it continues to be hotly contested in 'battles of the experts.' Review of trial transcripts reveals that distortion and the interpretation of distortion is a factor in most cases."[320] Because of the subjectivity, some odontologists have argued that "bitemark evidence should only be used to exclude a suspect. This [argument] is supported by research which shows that the exclusion of non-biters within a population of suspects is extremely accurate; far more so than the positive identification of biters."[321]

3. *ABFO Guidelines*

In an attempt to develop an objective method, in 1984 the American Board of Forensic Odontology (ABFO) promulgated guidelines for bite mark analysis, including a uniform scoring system.[322] According to the drafting committee, "[t]he scoring system . . . has demonstrated a method of evaluation that produced a high degree of reliability among observers."[323] Moreover, the committee characterized "[t]he scoring guide . . . [as] the beginning of a truly scientific approach to bite mark analysis."[324] In a subsequent letter, however, the drafting committee wrote:

> While the Board's published guidelines suggest use of the scoring system, the authors' present recommendation is that all odontologists await the results of further research before relying on precise point counts in evidentiary proceedings. . . . [T]he authors believe that further research is needed regarding the quantification of bite mark evidence before precise point counts can be relied upon in court proceedings.[325]

319. *E.g.*, State v. Garrison, 585 P.2d 563, 566 (Ariz. 1978) (10 points); People v. Slone, 143 Cal. Rptr. 61, 67 (Cal. Ct. App. 1978) (10 points); People v. Milone, 356 N.E.2d 1350, 1356 (Ill. App. Ct. 1976) (29 points); State v. Sager, 600 S.W.2d 541, 564 (Mo. Ct. App. 1980) (52 points); State v. Green, 290 S.E.2d 625, 630 (N.C. 1982) (14 points); State v. Temple, 273 S.E.2d 273, 279 (N.C. 1981) (8 points); Kennedy v. State, 640 P.2d 971, 976 (Okla. Crim. App. 1982) (40 points); State v. Jones, 259 S.E.2d 120, 125 (S.C. 1979) (37 points).

320. Raymond D. Rawson et al., *Analysis of Photographic Distortion in Bite Marks: A Report of the Bite Mark Guidelines Committee*, 31 J. Forensic Sci. 1261, 1261–62 (1986). The committee noted: "[P]hotographic distortion can be very difficult to understand and interpret when viewing prints of bite marks that have been photographed from unknown angles." *Id.* at 1267.

321. Iain A. Pretty, *A Web-Based Survey of Odontologist's Opinions Concerning Bitemark Analyses*, 48 J. Forensic Sci. 1117, 1120 (2003) [hereinafter *Web-Based Survey*].

322. ABFO, *Guidelines for Bite Mark Analysis*, 112 J. Am. Dental Ass'n 383 (1986).

323. Raymond D. Rawson et al., *Reliability of the Scoring System of the American Board of Forensic Odontology for Human Bite Marks*, 31 J. Forensic Sci. 1235, 1259 (1986).

324. *Id.*

325. Letter, *Discussion of "Reliability of the Scoring System of the American Board of Forensic Odontology for Human Bite Marks,"* 33 J. Forensic Sci. 20 (1988).

B. The Empirical Record

The 2009 NRC report concluded:

> More research is needed to confirm the fundamental basis for the science of bite mark comparison. Although forensic odontologists understand the anatomy of teeth and the mechanics of biting and can retrieve sufficient information from bite marks on skin to assist in criminal investigations and provide testimony at criminal trials, the scientific basis is insufficient to conclude that bite mark comparisons can result in a conclusive match.[326]

Moreover, "[t]here is no science on the reproducibility of the different methods of analysis that lead to conclusions about the probability of a match."[327] Another passage provides: "Despite the inherent weaknesses involved in bite mark comparison, it is reasonable to assume that the process can sometimes reliably exclude suspects."[328]

Although bitemark identifications are accepted by forensic dentists, only a few empirical studies have been conducted[329] and only a small number of forensic dentists have addressed the empirical issue. In the words of one expert,

> 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 [dental] community, although the basis of this acceptance within the peer-reviewed literature is thin. Only three studies have examined the ability of odontologists to utilise bitemarks for the identification of biters, and only two studies have been performed in what could be considered a contemporary framework of attitudes and techniques.[330]

326. NRC Forensic Science Report, *supra* note 3, at 175. *See also id.* at 176. ("Although the majority of forensic odontologists are satisfied that bite marks can demonstrate sufficient detail for positive identification, no scientific studies support this assessment, and no large population studies have been conducted.").

327. *Id.* at 174.

328. *Id.* at 176.

329. *See* C. Michael Bowers, Forensic Dental Evidence: An Investigator's Handbook 189 (2004) ("As a number of legal commentators have observed, bite mark analysis has never passed through the rigorous scientific examination that is common to most sciences. The literature does not go far in disputing that claim."); Iain A. Pretty, *Unresolved Issues in Bitemark Analysis*, *in* Bitemark Evidence 547, 547 (Robert B.J. Dorion ed., 2005) ("As a general rule, case reports add little to the scientific knowledge base, and therefore, if these, along with noncritical reviews, are discarded, very little new empirical evidence has been developed in the past five years."); *id.* at 561 ("[T]he final question in the recent survey asked, 'Should an appropriately trained individual positively identify a suspect from a bitemark on skin'—70% of the respondents stated yes. However, it is the judicial system that must assess validity, reliability, and a sound scientific base for expert forensic testimony. A great deal of further research is required if odontology hopes to continue to be a generally accepted science.").

330. Iain A. Pretty, *Reliability of Bitemark Evidence*, *in* Bitemark Evidence at 543 (Robert B.J. Dorion ed., 2005).

Commentators have highlighted the following areas of controversy: "a) accuracy of the bitemark itself, b) uniqueness of the human dentition, and c) analytical techniques."[331]

One part of a 1975 study involved identification of bites made on pigskin: "Incorrect identification of the bites made on pigskin ranged from 24% incorrect identifications under ideal laboratory conditions to as high as 91% incorrect identifications when the bites were photographed 24 hours after the bites made."[332] A 1999 ABFO Workshop, "where ABFO diplomats attempted to match four bitemarks to seven dental models, resulted in 63.5% false positives."[333] A 2001 study of bites on pigskin "found false positive identifications of 11.9–22.0% for various groups of forensic odontologists (15.9% false positives for ABFO diplomats), with some ABFO diplomats faring far worse."[334] Other commentators take a more favorable view of these studies.[335]

1. DNA exonerations

In several cases, subsequent DNA testing has demonstrated the error in a prior bite mark identification. In *State v. Krone*,[336] two experienced experts concluded that the defendant had made the bite mark found on a murder victim. The defendant, however, was later exonerated through DNA testing.[337] In *Otero v. Warnick*,[338] a forensic dentist testified that the "plaintiff was the only person in the world who

331. Pretty & Sweet, *supra* note 313, at 87. Commentators had questioned the lack of research in the field as long ago as 1985. Two commentators wrote:

> There is effectively no valid documented scientific data to support the hypothesis that bite marks are demonstrably unique. Additionally, there is no documented scientific data to support the hypothesis that a latent bite mark, like a latent fingerprint, is a true and accurate reflection of this uniqueness. To the contrary, what little scientific evidence that does exist clearly supports the conclusion that crime-related bite marks are grossly distorted, inaccurate, and therefore unreliable as a method of identification.

Allen P. Wilkinson & Ronald M. Gerughty, *Bite Mark Evidence: Its Admissibility Is Hard to Swallow*, 12 W. St. U. L. Rev. 519, 560 (1985).

332. C. Michael Bowers, *Problem-Based Analysis of Bitemark Misidentifications: The Role of DNA*, 159S Forensic Sci. Int'l S104, S106 (2006) (citing D.K. Whittaker, *Some Laboratory Studies on the Accuracy of Bite Mark Comparison*, 25 Int'l Dent. J. 166 (1975)) [hereinafter *Problem-Based Analysis*].

333. Bowers, *Problem-Based Analysis*, *supra* note 332, at S106. *But see* Kristopher L. Arheart & Iain A. Pretty, *Results of the 4th ABFO Bitemark Workshop 1999*, 124 Forensic Sci. Int'l 104 (2001).

334. Bowers, *Problem-Based Analysis*, *supra* note 332, at S106 (citing Iain A. Pretty & David J. Sweet, *Digital Bitemark Overlays—An Analysis of Effectiveness*, 46 J. Forensic Sci. 1385, 1390 (2001) ("While the overall effectiveness of overlays has been established, the variation in individual performance of odontologists is of concern.")).

335. *See* Pretty, *Reliability of Bitemark Evidence*, *in* Bitemark Evidence, *supra* note 330, at 538–42.

336. 897 P.2d 621, 622, 623 (Ariz. 1995) ("The bite marks were crucial to the State's case because there was very little other evidence to suggest Krone's guilt."; "Another State dental expert, Dr. John Piakis, also said that Krone made the bite marks. . . . Dr. Rawson himself said that Krone made the bite marks. . . .").

337. *See* Mark Hansen, *The Uncertain Science of Evidence*, A.B.A. J. 49 (2005) (discussing *Krone*).

338. 614 N.W.2d 177 (Mich. Ct. App. 2000).

could have inflicted the bite marks on [the murder victim's] body. On January 30, 1995, the Detroit Police Crime Laboratory released a supplemental report that concluded that plaintiff was excluded as a possible source of DNA obtained from vaginal and rectal swabs taken from [the victim's] body."[339] In *Burke v. Town of Walpole*,[340] the expert concluded that "Burke's teeth matched the bite mark on the victim's left breast to a 'reasonable degree of scientific certainty.' That same morning . . . DNA analysis showed that Burke was excluded as the source of male DNA found in the bite mark on the victim's left breast."[341] In the future, the availability of nuclear DNA testing may reduce the need to rely on bite mark identifications.[342]

C. Case Law Development

People v. Marx (1975)[343] emerged as the leading bite mark case. After *Marx*, bite mark evidence became widely accepted.[344] By 1992, it had been introduced or noted in 193 reported cases and accepted as admissible in 35 states.[345] Some courts described bite mark comparison as a "science,"[346] and several cases took judicial notice of its validity.[347]

339. *Id.* at 178.

340. 405 F.3d 66, 73 (1st Cir. 2005).

341. *See also* Bowers, *Problem-Based Analysis*, *supra* note 332, at S104 (citing several cases involving bitemarks and DNA exonerations: *Gates*, *Bourne*, *Morris*, *Krone*, *Otero*, *Young*, and *Brewer*); Mark Hansen, *Out of the Blue*, A.B.A. 50, 51 (1996) (DNA analysis of skin taken from fingernail scrapings of the victim conclusively excluded Bourne).

342. *See* Pretty, *Web-Based Survey*, *supra* note 321, at 1119 ("The use of DNA in the assessment of bitemarks has been established for some time, although previous studies have suggested that the uptake of this technique has been slow. It is encouraging to note that nearly half of the respondents in this case have employed biological evidence in a bitemark case.").

343. 126 Cal. Rptr. 350 (Cal. Ct. App. 1975). The court in *Marx* avoided applying the *Frye* test, which requires acceptance of a novel technique by the scientific community as a prerequisite to admissibility. According to the court, the *Frye* test "finds its rational basis in the degree to which the trier of fact must accept, on faith, scientific hypotheses not capable of proof or disproof in court and not even generally accepted outside the courtroom." *Id.* at 355–56.

344. Two Australian cases, however, excluded bite mark evidence. *See* Lewis v. The Queen (1987) 29 A. Crim. R. 267 (odontological evidence was improperly relied on, in that this method has not been scientifically accepted); R v. Carroll (1985) 19 A. Crim. R. 410 ("[T]he evidence given by the three odontologist is such that it would be unsafe or dangerous to allow a verdict based upon it to stand.").

345. Steven Weigler, *Bite Mark Evidence: Forensic Odontology and the Law*, 2 Health Matrix: J.L.-Med. 303 (1992).

346. *See* People v. Marsh, 441 N.W.2d 33, 35 (Mich. Ct. App. 1989) ("the science of bite mark analysis has been extensively reviewed in other jurisdictions"); State v. Sager, 600 S.W.2d 541, 569 (Mo. Ct. App. 1980) ("an exact science").

347. *See* State v. Richards, 804 P.2d 109, 112 (Ariz. Ct. App. 1990) ("[B]ite mark evidence is admissible without a preliminary determination of reliability. . . ."); People v. Middleton, 429 N.E.2d 100, 101 (N.Y. 1981) ("The reliability of bite mark evidence as a means of identification is sufficiently

1. Specificity of opinion

In some cases, experts testified only that a bite mark was "consistent with" the defendant's teeth.[348] In other cases, they went further and opined that it is "highly probable" or "very highly probable" that the defendant made the mark.[349] In still other cases, experts made positive identifications (to the exclusion of all other persons).[350] It is not unusual to find experts disagreeing in individual cases—often over the threshold question of whether a wound was even a bite mark.[351]

established in the scientific community to make such evidence admissible in a criminal case, without separately establishing scientific reliability in each case. . . ."); State v. Armstrong, 369 S.E.2d 870, 877 (W. Va. 1988) (judicially noticing the reliability of bite mark evidence).

348. *E.g.*, Rogers v. State, 344 S.E.2d 644, 647 (Ga. 1986) ("Bite marks on one of Rogers' arms were consistent with the dentures worn by the elderly victim."); People v. Williams, 470 N.E.2d 1140, 1150 (Ill. App. Ct. 1984) ("could have"); State v. Hodgson, 512 N.W.2d 95, 98 (Minn. 1994) (en banc) (Board-certified forensic odontologist testified that "there were several similarities between the bite mark and the pattern of [the victim's] teeth, as revealed by known molds of his mouth."); State v. Routh, 568 P.2d 704, 705 (Or. Ct. App. 1977) ("similarity"); Williams v. State, 838 S.W.2d 952, 954 (Tex. Ct. App. 1992) ("One expert, a forensic odontologist, testified that Williams's dentition was consistent with the injury (bite mark) on the deceased."); State v. Warness, 893 P.2d 665, 669 (Wash. Ct. App. 1995) ("[T]he expert testified that his opinion was not conclusive, but the evidence was consistent with the alleged victim's assertion that she had bitten Warness. . . . Its probative value was therefore limited, but its relevance was not extinguished.").

349. *E.g.*, People v. Slone, 143 Cal. Rptr. 61, 67 (Cal. Ct. App. 1978); People v. Johnson, 289 N.E.2d 722, 726 (Ill. App. Ct. 1972).

350. *E.g.*, Morgan v. State, 639 So. 2d 6, 9 (Fla. 1994) ("[T]he testimony of a dental expert at trial positively matched the bite marks on the victim with Morgan's teeth."); Duboise v. State, 520 So. 2d 260, 262 (Fla. 1988) (Expert "testified at trial that within a reasonable degree of dental certainty Duboise had bitten the victim."); Brewer v. State, 725 So. 2d 106, 116 (Miss. 1998) ("Dr. West opined that Brewer's teeth inflicted the five bite mark patterns found on the body of Christine Jackson."); State v. Schaefer, 855 S.W.2d 504, 506 (Mo. Ct. App. 1993) ("[A] forensic dentist testified that the bite marks on Schaefer's shoulder matched victim's dental impression, and concluded that victim caused the marks."); State v. Lyons, 924 P.2d 802, 804 (Or. 1996) (forensic odontologist "had no doubt that the wax models were made from the same person whose teeth marks appeared on the victim's body"); State v. Cazes, 875 S.W.2d 253, 258 (Tenn. 1994) (A forensic odontologist "concluded to a reasonable degree of dental certainty that Cazes' teeth had made the bite marks on the victim's body at or about the time of her death.").

351. *E.g.*, Ege v. Yukins, 380 F. Supp. 2d 852, 878 (E.D. Mich. 2005) ("[T]he defense attempted to rebut Dr. Warnick's testimony with the testimony of other experts who opined that the mark on the victim's cheek was the result of *livor mortis* and was not a bite mark at all."); Czapleski v. Woodward, No. C-90-0847 MHP, 1991 U.S. Dist. LEXIS 12567, at *3–4 (N.D. Cal. Aug. 30, 1991) (dentist's initial report concluded that "bite" marks found on child were consistent with dental impressions of mother; several experts later established that the marks on child's body were postmortem abrasion marks and not bite marks); Kinney v. State, 868 S.W.2d 463, 464–65 (Ark. 1994) (disagreement that marks were human bite marks); People v. Noguera, 842 P.2d 1160, 1165 n.1 (Cal. 1992) ("At trial, extensive testimony by forensic ondontologists [sic] was presented by both sides, pro and con, as to whether the wounds were human bite marks and, if so, when they were inflicted."); State v. Duncan, 802 So. 2d 533, 553 (La. 2001) ("Both defense experts testified that these marks on the victim's body were not bite marks."); Stubbs v. State, 845 So. 2d 656, 668 (Miss. 2003) ("Dr. Galvez denied the impressions found on Williams were the results of bite marks.").

2. *Post*-Daubert *cases*

Although some commentators questioned the underlying basis for the technique after *Daubert*,[352] courts have continued to admit the evidence.[353]

X. Microscopic Hair Evidence

The first reported use of forensic hair analysis occurred more than 150 years ago in 1861 in Germany.[354] The first published American opinion was an 1882 Wisconsin decision, *Knoll v. State*.[355] Based on a microscopic comparison, the expert testified that the hair samples shared a common source. Hair and the closely related fiber analysis played a prominent role in two of the most famous twentieth-century American prosecutions: Ted Bundy in Florida and Wayne Williams, the alleged Atlanta child killer.[356] Although hair comparison evidence has been judicially accepted for decades, it is another forensic identification discipline that is being reappraised today.

A. The Technique

Generally, after assessing whether a sample is a hair and not a fiber, an analyst may be able to determine: (1) whether the hair is of human or animal origin, (2) the part of the body that the hair came from, (3) whether the hair has been dyed, (4) whether the hair was pulled or fell out as a result of natural causes or disease,[357] and (5) whether the hair was cut or crushed.[358]

352. *See* Pretty & Sweet, *supra* note 313, at 86 ("Despite the continued acceptance of bitemark evidence in European, Oceanic and North American Courts the fundamental scientific basis for bitemark analysis has never been established.").

353. *See* State v. Timmendequas, 737 A.2d 55, 114 (N.J. 1999) ("Judicial opinion from other jurisdictions establish that bite-mark analysis has gained general acceptance and therefore is reliable. Over thirty states considering such evidence have found it admissible and no state has rejected bite-mark evidence as unreliable.") (citations omitted); *Stubbs*, 845 So. 2d at 670; Howard v. State, 853 So. 2d 781, 795–96 (Miss. 2003); Seivewright v. State, 7 P.3d 24, 30 (Wyo. 2000) ("Given the wide acceptance of bite mark identification testimony and Seivewright's failure to present evidence challenging the methodology, we find no abuse of discretion in the district court's refusal to hold an evidentiary hearing to analyze Dr. Huber's testimony.").

354. E. James Crocker, *Trace Evidence*, *in* Forensic Evidence in Canada 259, 265 (1991) (the analyst was Rudolf Virchow, a Berliner).

355. 12 N.W. 369 (Wis. 1882).

356. Edward J. Imwinkelried, *Forensic Hair Analysis: The Case Against the Underemployment of Scientific Evidence*, 39 Wash. & Lee L. Rev. 41, 43 (1982).

357. *See* Delaware v. Fensterer, 474 U.S. 15, 16–17 (1985) (FBI analyst testified hair found at a murder scene had been forcibly removed.).

358. *See* 2 Giannelli & Imwinkelried, *supra* note 177, § 24-2.