Bitemark evidence scientific and legal considerations criminology essay

In 1992, Ray Milton Krone was sentenced to death on grounds of first degree murder when bitemarks found on the victim’s body were affirmed to be his by the State dental expert. He lost a subsequent appeal on the same grounds in 1995 and was sentenced to life imprisonment. (State v. Krone, 1995) However, in 2002, ten years after his first conviction, he was exonerated by DNA testing which by then had been acknowledged as the ‘ gold standard’ of forensic evidenceKrone’s case was but one of the number of instances where other forensic analysis, such DNA profiling, contraindicated the outcome of bitemark testimony. (Pretty & Sweet, 2010; Florida v. Dale Morris, 1997)

Bitemark evidence has been longstanding at the centre of dispute both within and between scientific and legal circles for decades. Records of false convictions and cases where opinions between dental experts differed (People v. Milone, 1976) have sparked questions on its validity and objectivity in legal proceedings and its place as an ‘ exact’ science. The 2009 report by the US National Academy of Sciences found that bitemark analysis, unlike nuclear DNA analysis, have not been ‘ able to consistently, and with a high degree of certainty, demonstrate a connection between evidence and a specific individual or source’. Prior to the report, many legal commentators and peer reviews have criticized its admissibility in court despite a lack of a good research base, appreciation of its limits and known errors and intrinsic problems with the science. (Bowers, 1996; State v. Sager, 1980)

Bitemarks are marks that are caused by the teeth but can also involve other parts of the mouth. (MacDonald, 1974) In skin, the lesion pattern be elliptical or ovoid appearing as one or two arches, involving ecchymoses, abrasions,

contusions, lacerations, indentation, erythema, avulsion and/or punctures. These reflect the size, shape, arrangement and distribution of the different classes of the teeth it was in contact with. (American Board of Forensic Odontology, 2010) Human bitemarks tend not to cause avulsion or tearing of tissue unlike bites involving carnivorous animals. (American Academy of Pediatrics, 1999) The forensic team in the USA and UK are encouraged to follow guidelines by the American Board of Forensic Odontology in the collecting and processing of bitemarks as methods described are generally accepted and valid with respect to the development of the science.

This account endeavors to explore the main contentious legal and scientific issues in bitemark evidence, from its collection to the courtroom, emphasizing on human bitemarks on skin as a large proportion of bitemark have been found on this material and ample research has been done to address the issues on imprints found on skin. It also allows for a deeper insight and focus into the topic within the project’s constraints. Salivary DNA swabbed from a bitten site will only be mentioned in brief.

The Uniqueness of the Dentition

Bitemark analysis revolves around two postulates (Bowers & Pretty, 2009; Bowers M. , 2004):

The characteristics of the anterior teeth involved in biting are unique to each individual.

The injury or mark on the bitten material is able to transfer and record this asserted uniqueness significantly enough to allow comparison.

Human teeth are arranged in a common pattern, starting from incisors at the midline, followed by canines, premolars, in the secondary dentition, and most distally, the molars; the shape of the teeth, especially the cusps or incisal edge can be defined in a bitemark. However, variation within the dentition can occur due to the predetermination by genes or influence of time and environment e. g. usage, accidents, diet, dental treatments and disease. This variation allows for the building of a ‘ dental profile’ which is specific to particular individual.

Generally, most dentists and forensic odontologists support the concept of the dentition being unique. In a web-based survey done by Pretty (2003) to gauge the general opinions among forensic odontologists, of different levels of expertise, of the main contentious areas in bitemark analysis, 91% of respondents believed that the human dentition was unique and 8% were unsure.

The question of individuality has been raised in many publications yet this area is under-researched and has to have any solid empirical support (Pretty & Sweet, A paradigm shift in the analysis of bitemarks, 2010; Beecher-Monas, 2009; Senn & Souviron, 2010). However there were a few key articles that attempted to back this assumption.

A paper by Sognnaes et al. (1983) compared bitemark patterns within each set of 5 pairs of identical twins. Overlays of test bites created by wax radiographic technique and digitally analysed. It was discovered that there were significant differences in the arrangement of the anterior teeth e. g. tooth position, occlusal arch form and rotation within the same set of twins

and it was concluded that identical twins were not identical (Sognnaes, Rawson, Gratt, & Nguyen, 1983). The authors claimed that standardizing measures were taken during the creation of these bites. Flaws that were pointed out in a review (Pretty, 2006) were:

Little insight on how standardization of test bites was carried out.

Variation in the overlays could have been due to the pressure employed in the creation of the test bite.

The paper had yet conclude if there intrinsic differences between the dentition of identical twins as the extrinsic factors e. g. different wear and tear rates or disease and treatment still account for the variation.

No indication whether these differences are detectable in a bitemark on skin.

Rawson et al. (1984) applied probability statistics to prove the uniqueness of the anterior human dentition with certitude. The 397 bitemarks in a standardized wafer were selected out of 1200 collected from forensic odontologists were selected based on the quality of the mark and the completeness of a questionnaire pertaining to the bitemark. Radiographic overlays of the anterior teeth were created and traced onto computer sheets where the angle of rotation of each tooth was calculated. The minimum numbers of tooth positions were determined as shown in Fig. 1. By product rule, the possibility of two sets of dentition having six teeth occupying the same positions, using a conservative number of 150 tooth positions, was 1 in 1. 4×1013 which exceeds the world’s population. Rawson stated that only

five teeth need to be accurately matched in order to confirm beyond reasonable doubt the source of the bitemark.

Figure 1: Possible tooth positions of the anterior teeth (Rawson et al., 1984)

Despite the authors' assertions that this proof justifies the theory of uniqueness, there were weaknesses in the methodology:

Hand-tracing overlays onto grid paper undermine the objectivity of the method and introduce subjectivity in the system.

It does not consider the effect of inter-relationship between teeth on tooth position discovered in an earlier paper (MacFarlane, MacDonald, & Sutherland, 1974).

More recently, a study using geometric morphometric analysis concluded that ' the incisal surfaces of the anterior dentition were unique' (Kieser, Bernal, Neil Waddell, & Raju, 2007) and supported the use of the product rule in Rawson et al. (1984). Another study (Bush, Bush, & Sheets, 2011) found that ' statements of dental uniqueness...in an open population are unsupportable' and deemed the used of the product rule inappropriate.

Certainly the features of the dentition would be unique if measured in very high resolution, however, what is more relevant is whether this uniqueness is observed in bitemarks on skin with sufficient detail to be associated with one set of dentition above all others. The literature mentioned above fail to go beyond attempting to establish individuality but has often been misquoted to assert bitemark individuality.

The Bitten Human Skin

Figure 2 (A, B) Two different bites on a victim’s back by the same dentition. The lower arches are further from the scale. (Sheasby & MacDonald, 2001)Human skin is a very poor bitemark registration material as the mechanism of biting its and the underlying tissues biomechanical characteristics result in high and non-uniform primary distortion and deformation in response to applied force (Pretty, 2006; Senn & Souviron, 2010; Bush, Miller, Bush, & Dorion, 2009; Sheasby & MacDonald, 2001). According to the classification of distortion suggested by Sheasby and MacDonald, distortion due to the biting action is proportional to the degree of movement which is a result of a series of movements by the biter and/or the victim. The amount of tissue taken in during the bite also affects the dimension of the bite. Every encounter is different, resulting in different bitemark patterns (Fig. 2).

Distortion is further compounded by tissue distortion which is the intrinsic variation in bitten skin. Bush (2009) succiently described skin as ‘ heterogeneous, nonlinear, visco-elastic, anisotropic…exhibiting hysteresis’. The properties of skin as a result of it’s structure vary at different anatomical sites, physiological condition, age, gender, ethnicity and thus vary between persons. Langer lines, as an outline of the arrangement of elastin and collagen fibres in the dermis contribute to anisotropy. Least distortion occur if bites are placed perpendicular to Langar lines (Fig. 3 and 4) (Bush, Miller, Bush, & Dorion, 2009). Also oedema as a result of the influx of tissue fluid into the bitten site, haemorrhage and inflammation can cause distortion (Sheasby & MacDonald, 2001).

Figure 3: Bitemark made perpendicular to tension lines (Langer lines) in loose tissue shows a decrease of angle of rotation and stretching of the arches.

Figure 4: Bitemark made parallel to tension lines showing a ‘ dragged’ appearance, constriction of the short axis of the pattern and increase in angle of rotation.

Secondary (post-biting) distortion can occur as a result of time and changes in the posture of the body from the point it was bitten. Once bitten, the physiological process of healing initiates to repair the wound on a living victim and the degradation occurs in the deceased (Sheasby & MacDonald, 2001). Depending on the severity of the bite, the wound in a living victim may eventually fade to a bruise and change colour over time and may be displaced. Tissue contraction can also occur in more severe bites which causes alterations in the pattern and loss of detail (Sheasby & MacDonald, 2001). In-vivo testing for the histopathological study of bitemarks on pigskin found that indentations are lost postmortem (Avon, Mayhall, & Wood, 2006). This brings into the question the accuracy of the 3D representations of the bitemarks produced from impressions. Livor mortis was found to obscure bitemark patterns (Avon, Mayhall, & Wood, 2006).

In most cases, upon examination, the body would have been at a different position to the one when the bite was inflicted. Distortion depends on the degree of change in body position and anatomical location and occurs in the direction of movement and affects multiple tooth marks. Some places such as the breast and arms show high postural distortion unlike the head and

neck (Sheasby & MacDonald, 2001). Table 1 shows how measurements used in bitemark analysis can change due to postural differences. The pattern on upper arm had little distortion when flexed as compared to the upper leg when flexed as well.

Location of Bite

Movement Difference

Intercanine Difference (%)

Mesial-distal Difference (%)

Angulation (%)

Shoulder

Initial bite: Arm straight at side

+5. 1

-7. 3

13 flatter

Arm flexed and medially rotated

+17. 5

-14. 0

8 flatter

Upper Arm

Initial bite: Arm straight at side

+11. 2

-5. 7

5 flatter (max); 70 flatter (mand)

Arm flexed

+13. 6

-5. 5 (max)

+5. 2 (mand)

20 flatter (max); 63 flatter (mand)

Lateral Thoracic Wall

Initial bite: Arm above head

+4. 1

-13. 5

21. 6 flatter

Arm straight at side

-8. 0

-15. 0

13 flatter

Upper Leg

Initial bite: arm straight

+13. 9

-7. 4

52. 5 flatter

Leg allowed to fall off table

-27. 9

-29. 0

25 steeper

Table 1: Changes in measurement of intercanine differences, mesial-distal differences and angulation following a change in body position after a test bite is inflicted at four different anatomical locations on a cadaver. (Adapted from Bush et al, 2009)

Even though studies have shown distortion affects the transfer of detail of the biter’s dentition, it does not refute the claim of individuality found in bitemarks on skin. Rather, it is key to establish to what degree is distortion insignificant beyond which the uniqueness of the dentition as impressed on

the skin is lost. If the degree of distortion go beyond set parameters that define the individuality of the bite pattern, then it may not be of much forensic value in identifying the biter with certainty.

In a study done by Miller et al (2009) to investigate the exclusivity of bitemarks against similarly aligned dentition and against a population sample, 100 dental stone models were catagorised into ten groups based on similar alignment patterns and a model was randomly chosen from each group and were used to impress bitemarks on unembalmed cadavers and photographed in the same position. Hollow volume overlays were produced from both the bitemarks and the models for metric and angular analysis. The bite was first compared with overlays from the rest of the group followed by the rest of the sample and examiners were asked to determine which dentitions could not be excluded as the biter.

Within the groups, the range of percentage of dentitions that could not be excluded was from 11% to 86% and in the population sample, it was 3% to 16% – a large proportion if it were the figures from an open population. However, as the sample size was very small, the inclusion of one dentition would significantly affect these percentages and within the groups, this is further amplified. Larger studies have yet to be undertaken. The authors concluded:

‘ the uniqueness of the dentition cannot be perfectly transferred to skin… similarly aligned dentitions cannot be ruled out as the biter in all cases. In addition, when comparing the entire 100-sample population of nonsimilar mal-alignments, certain dentitions could be included as the biter, thus

allowing for the possibility of exclusion of the biter and inclusion of an innocent person.' (Miller, Bush, Dorion, & Bush, 2009)

In the field, the forensic odontologist has to consider the forensic significance of the bitemark before analysis is undertaken and conclusions are drawn. Bitemarks that do not have sufficient detail are advised to be treated with caution (Pretty, 2006) and be approached in a conservative manner as to consider whether it is a bitemark in the first place (Senn & Souviron, 2010). A severity-significance scale proposed by Pretty in 2007 summarises the change in forensic significance as the bitemark progressively becomes severe. A visual index is also provided. (Fig. 5 and 6)

Figure 5: A severity-significance scale (Pretty, Development and Validation of a Human Bitemark Severity and Significance Scale, 2007)

Figure 6: Visual index for the severity-significance scale (Pretty, Development and Validation of a Human Bitemark Severity and Significance Scale, 2007)

Analysis Techniques

The techniques used, in comparing a suspected dentition to a bitemark, are important determinates on the validity of bitemark analysis (Pretty, The Barriers to Achieving an Evidence Base for Bitemark Analysis, 2006). Currently, the ABFO recognizes the following techniques (American Board of Forensic Odontology, 2010):

Overlays in

Metric Analysis

Comparison to photos of the pattern (Dental exemplars)

Direct comparison of dental casts to photographs, casts of bite patterns or resected tissue

Transillumination

Computer enhancement

Stereoscopy and macroscopy

Scanning Electron Microscopy

Video superimposition

Histology

The ABFO encourages the development of new scientifically sound methods of analysis (American Board of Forensic Odontology, 2010). Other techniques mentioned in literature included the use of reflex microscopy (Lighthelm, Coetzee, & van Niekerk, 1987), fingerprint powder (Rao & Sourivron, 1984) and more recently, 3D imaging (van der Velden, Spiessens, & Willems, 2006; Evans, Jones, & Plassmann, 2010; Blackwell, et al., 2007). With a number of methods to carry out analysis, there must be measures placed to ensure that they are equally reliable.

Overlays

Overlays remain one of the most frequently used tools for comparison analysis. 90% of odontologists

Photography

Legal Issues

Conclusions

Since bitemarks have been identified in mainly serious crimes such as homicide, rape, child and spousal abuse (Webb, Pretty, & Sweet, 2000), it therefore wields a strong hand in the outcome of justice. A high standard of forensic methodology must be responsibly taken in order to be able to pinpoint the guilty party beyond a reasonable doubt but more importantly prevent the conviction of innocents. (Pretty & Sweet, A paradigm shift in the analysis of bitemarks, 2010)

Legal References

State v. Krone, 182 Ariz, 319, 897 P. 2d 621 (1995).

Florida v. Dale Morris (Pasco County, 97-3251 CFAES, 1997)

People v. Milone, 43 Ill. App. 3d 385, 356 N. E. 2d 1350 (1976).

State v. Sager, 600 S. W. 2d 541, 556-557 (Mo. App. 1980)