Tattoo Study of Skin Distortions

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Abstract

The evidentiary value of bitemarks has been previously linked to that of fingerprints. We think that skin distortions would have an impact on the reliability of bitemark interpretation. The existing tattoos on 16 participating volunteers were substituted for bitemarks. Tattoos were photographed using an ABFO (American Board of Forensic Odontology) #2 reference scale, and measurements were taken at multiple locations. Changes in body position were photographed at each location. A representative maxillary arch width measurement of 40 mm was used for comparison. Maximum distortions of 52.5% and 76.3% were observed along the horizontal and vertical axes, respectively. Observed distortions were found to be nonuniform; therefore, the implication is that, skin distortions preclude the use of bitemarks for identifications.

Keywords: Forensic Odontology; Bitemarks; Tattoo; Skin Distortion

Background

The analysis of human bitemarks, whether on skin or other mediums, has been compared to tool mark analysis. In the formation of a bitemark, teeth can be used as a “tool” to scrape, crush, and pinch [1]. Human dentition is said to be unique to an individual, much like DNA and fingerprints [2]. In their study of human dentition, Rawson, et al. [2], examined 397 dental arches and determined maxillary arch widths to range between 21.3 mm and 41.0 mm. A related study examined maxillary anterior tooth widths and found that central incisors had maximum widths measuring 9.10 mm to 9.24 mm [3].

Devore and Harvey recognized that although human dentition may be unique, bitemarks made on malleable mediums, such as human skin, are not replicable [4,5]. Wood, et al. [6], acknowledged that distortions precluded the usefulness of bitemarks as “dental fingerprints”. Findings by Bernitz, et al [7], suggest that bitemarks are readily identifiable and therefore useful in identifications [7]. Skin distortions during and after any bite [8]. During a physical altercation, skin will stretch and distort as victims alter their body position while fighting for their release. Accurate positioning for pattern measurements is critical, but precise methods have not been determined. After an assault, bitemarks on living tissue can experience inflammation and hemorrhaging [9,10]. In addition to distortion introduced by positional changes and tissue reactions, suction and tongue thrusting could also contribute to the final appearance of the bite [5].

A bruise by definition is a “contusion usually producing a hematoma without rupture of the skin” [11]. Bitemarks produce hematomas that manifest with various degrees of organization and discoloration below the epidermis or outer skin layer. Tattoos similarly result in discolorations below the epidermis. We studied tattoos because they produce identifiable colored marks placed below the epithelial skin layer, and we compared the results with those found in previous surface studies to determine the reliability of bitemarks. Tattoos offer the added benefit of being relatively stable when compared with subcutaneous hematomas that break down and are subject to gravitational factors.

In Devore’s 1971 study and Lewis and Marroquin’s 2015 study, an inked stamp was placed on the surface of living human tissue as a representative bitemark to successfully show significant positional distortions [4,12].

Bitemark analysis has recently been scrutinized for its dependence on interpretation and its inability hold up to rigorous scientific examination [9,13-15]. False identifications have been reported to have an error rate of up to 91% [16]. DNA testing has been used to overturn convictions based on bitemark evidence. Notable examples of overturned cases based on bitemark evidence include: Willie Jackson in Louisiana, Ray Krone in Arizona, Calvin Washington in Texas, James O’Donnell in New York, Dan Young in Illinois, and most recently the case of Steven Mark Chaney in Texas [16,17]. Recently, the Texas Forensic Science Commission made the recommendation that bitemark identification can no longer be used in criminal trials [18]. Despite this recommendation, forensic odontologists continue to use bitemarks to provide identifications within the judicial system. Failed identifications suggest the need to modify measurement systems utilized for bitemark analysis to meet legal requirements.

Materials and Methods

Sixteen volunteers, 11 male and 5 female, between the ages of 18 and 50 were provided with consent documents and questionnaires. Questionnaires, completed anonymously, were intended to collect data including sex, age, weight, and height. The 16 subjects were assigned sequential numbers. Existing tattoos located on the upper arm, forearm, wrist, and torso were photographed in a relaxed standing position (Position A). Position A was considered the control. Position B required participants to alter their body position from the initial position A. Positions C and D similarly involved a change in body position by flexing or rotating the body part with the existing tattoo; no positions were duplicated.

An effort was made to follow the suggested American Board of Forensic Odontology (ABFO) guidelines for photographing bitemarks [19]. At each position, a plane parallel photograph of the tattoo was taken with an ABFO #2 scale used for reference. All photographs were taken with a Canon 5D Mark II digital camera with a 24-105 mm lens. Images were processed with Adobe® Lightroom 5 photo imaging software.

Each examiner independently established 40 mm horizontal and vertical reference points on the tattoos in position A. These same points were measured and recorded for positions B, C, and D. Position A measurements were compared with each subsequent position. Distortion percentages were calculated by dividing metric differences between the control position of 40 mm and the subsequent non-control positions.
Results

Figure 1 shows sample upper arm photographs representing positional changes of the tattoos. Initial measurements of 40 mm were made in both the horizontal and vertical directions for all tattoos. Position D resulted in distortion measurements of 10 mm and 11 mm.

Figure 2 represents upper arm measurements of the 11 tattoo specimens. The upper arm distortions ranged between 0 mm and 21 mm. The average upper arm horizontal and vertical distortions were 5.04 mm and 5.11 mm.

Figure 3 is a representative sample of a forearm tattoo. Position A represents the control position, and position B represents a corresponding positional change. Position B resulted in distortion measurements of 10 mm and 4 mm.

Measurements of the three forearm specimens are presented in figure 4. The forearm distortions ranged between 2 mm and 10 mm.

Figure 5 is a representative sample of a wrist tattoo. Figure 5(a) is a photo of the relaxed tattoo position. Figure 5(b) is a representative positional change. Position C resulted in distortions as high as 14 mm with flexion of the wrist. Wrist measurements for the two wrist specimens are plotted in figure 6. Wrist distortions range between 0 mm and 14 mm with average distortions of 3.44 mm and 6.50 mm horizontally and vertically.

The average distortions were found to be 4.33 mm horizontally and 4.00 mm vertically.

Figure 5 is a representative sample of a wrist tattoo. Figure 5(a) is a photo of the relaxed tattoo position. Figure 5(b) is a representative positional change. Position C resulted in distortions as high as 14 mm with flexion of the wrist. Wrist measurements for the two wrist specimens are plotted in figure 6. Wrist distortions range between 0 mm and 14 mm with average distortions of 3.44 mm and 6.50 mm horizontally and vertically.

The anterior torso sample photograph in figure 7(a) represents the control position, whereas figures 7(b) and 7(c) represent two alternate positions. Position B resulted in distortions of 16 mm and 18 mm. Similarly, position C resulted in distortions of 16 mm and 17 mm.

All measurements for the five anterior torso tattoo specimens...
are displayed in figure 8. The anterior torso distortions ranged between 1 mm and 30.5 mm, with average distortions of 5.84 mm in the horizontal direction and 10.28 mm in the vertical.

Posterior torso data is similarly presented. Figure 9(a) and 9(b) show the control position along with a corresponding positional change. The position shown in figure 9(b) resulted in distortions of 5 mm and 10 mm.

Horizontal and vertical measurements for the three posterior torso tattoo specimens are shown in figure 10. The posterior torso distortions ranged between 1 mm and 13 mm, with average distortions of 6.33 mm and 7.00 mm horizontally and vertically.

Intra-operator error was found to be 0.5 mm for both examiners. Inter-operator error was not determined. Each examiner worked independently on separate measurements. However, reported distortions from both examiners were compared and reported values were found to be consistent.

Discussion

This tattoo study demonstrates subepithelial human skin distortion with positional changes. Tattoos are stable subcutaneous marks versus bitemarks, which present as hematomas, which break down and are subject to gravitational factors. The results of the current study are consistent with previous internal and external bitemark studies [4,9,10,12].

In the current study, distortions were most significant at the upper arm and anterior torso locations. Visible musculature contributed to the distortions identified as seen in the photographs. Wrist distortions were impacted by skin creases causing the tattoo to be compressed by 14 mm. Tattoos on the anterior torso experienced substantial distortions, up to 76.3%, impacted by individual participant flexibility. Moderate distortions up to 32.5%
were seen in tattoos located on the posterior torso. Tattoos located at the wrist also experienced distortions of up to 35%, which were attributed to joint flexibility. Forearm distortions had a maximum of 25%. Underlying anatomy, body position, and movement significantly impacted observed tattoo distortions. Bernitz stated that “a small degree of warping and shrinking” would occur that would not affect patterns associated with the analysis of a bite park [7]. This tattoo study refutes those claims.

The uniqueness of human dentition has previously been shown to distort on skin in both stamp and cadaver studies. Similar distortions have been identified utilizing subcutaneous tattoos. Studies using human cadaver skin found distortions of 60% and 80% [9,10]. Stamp studies identified linear surface distortions of 41.9% and 60% [4,12]. This tattoo study identified distortion percentages of 52.5% on the horizontal plane and 76.3% on the vertical plane. Bitemark distortions would be anticipated to be greater as a result of pain response movements, hematological breakdown, and gravitational factors.

Tattoo patterns evaluated in the current study consistently presented nonuniform horizontal and vertical distortions with positional changes. The maximum distortion measured was 30.5 mm, or more than three times larger than an average central incisor measuring approximately 9 mm [3].

The authors acknowledge the limitations of this study as a result of sample size. The results identify distortions at specific locations and may not be representative of distortions on other areas of the body. Additionally, the study focused on changes in a representative arch width, not individual tooth width or angularity. A statistical analysis of the data is not included as no definitive conclusions can be drawn from the statistical analysis of the small sample size used in this preliminary study. The authors plan further research to verify the consistency of the results with previous studies. Future studies should include distortion analysis at additional body locations in addition to the possible effects of a victim’s age and weight on distortion potential.

Conclusion

Surface distortion studies and this subepithelial tattoo study identify significant skin distortions. Positional change distortions were noted to be associated with the musculature and flexibility of participants along with the location of tattoo patterns limiting the evidentiary value of bitemarks. This study, along with previous studies, limits the evidentiary value of bitemarks when the initial injury position is unknown. DNA evidence is collected from bitemark locations and should remain the gold standard. Surface distortions indicate aggressive behavioral patterns.

References


