

Bite Marks Analysis Using Computer Assisted Hand Tracing Overlay Method

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ARTICLE INFO

Article Type:
Original Article

Article History:
Received: 19 Nov 2015
Revised: 23 Nov 2015
Accepted: 9 Dec 2015

Keywords:
Bite Mark
Computer Assisted Method
Bite Mark Analysis
Hand Tracing Method

ABSTRACT

Background: In recent years, crime rate has been increased. The aim of this study was to evaluate the computer assisted hand tracing overlay method for bite mark analysis.

Methods: Impressions of both, maxillary as well as mandibular arches of 50 consenting volunteers were taken and dentition casts were prepared. Tracing by hand was manually done, and computer assisted overlay comparison was carried out.

Results: Out of 2500 cross matches, expected result should have been 50 true positives and 2450 true negatives. In our study there were 38 true positive, 2406 true negatives, 44 false positive and 12 false negative matches in maxillary comparison, 44 true positive, 2424 true negatives, 26 false positive and 6 false negative matches in mandibular comparison and 31 true positive, 2446 true negatives, 4 false positive and 19 false negative matches when complete dentition (maxillary and mandibular) comparison was done. Hence this method showed significantly high false positive and true negative cases.

Conclusion: We conclude that this computer assisted hand tracing overlay method for bite mark analysis helps in arriving at an exclusion rather than inclusion type of identification, owing to its high true negative cases.

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► *Implication for health policy/practice/research/medical education: Bite Marks Analysis Using Computer Assisted Hand Tracing Overlay Method*

► *Please cite this paper as: V. Tarvadi P, Manipady Sh, Shetty M. Bite Marks Analysis Using Computer Assisted Hand Tracing Overlay Method. International Journal of Medical Toxicology and Forensic Medicine. 2016; 6(2): 83-7.*

1. Introduction:

In recent years, crime rate especially the sexual crime has been increased. Evaluating sexual crimes has never been an easy task due to various reasons, and delay reporting. Bite mark analysis has a significant role in the sexual crime evaluation. Bite Mark is a mark made by the teeth either alone or in

combination with other mouth parts (1). Bite mark analysis is based on the human dentition which has unique characteristic features that an individual possess (2, 3). Based on this, its use in identification as a reliable tool has been accepted legally but controversy persists scientifically (4).

Since 1950, bite marks have played a significant role in legal cases. Bite marks are commonly caused by the anterior six teeth, namely central and lateral incisors, and canines. The individual characteristics of these teeth and their arrangement play a vital role in bite mark analysis (5). The bite mark

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collection and its analysis has always been a challenging task. With latest technologies and importance of bite marks as evidence in testimony, there is a need for precise, accurate and reproducible methods for bite mark analysis. There are various methods of bite mark analysis like metric (measurements), microscopic, pattern, three dimensional and computer assisted method (5).

Bite marks depend upon various factors like age of the victim, agent causing the bite (animal, human, insect), anatomical location of the bite, skin type, and the force applied during the bite (2). Owing to its elasticity, skin is a poor registration material for the skin marks resulting from any external force acting on it (3, 6). There may be stretching of the skin during the bite, and pressure marks on the skin fade away rapidly. As a result of this, by the time the victim is examined, either the bite mark has faded away or the bite mark is not in the same shape as it was when freshly bit. A delay in recording the bitemark may result in loss of an evidence. Hence the bite marks need to be collected at the earliest, effectively by photography (3). The present study aims to evaluate the computer assisted hand tracing overlay method for bite mark analysis.

2. Materials and Methods:

The research was conducted at a Medical College, Mangalore. Informed consent of 50 volunteers was taken. Before biting, the volunteers were requested to clean their left forearm with soap and water, and allow it to air dry. The volunteers are instructed to bite the forearm on its frontal aspect, with pressure sufficient enough to cause mark but not to injure themselves.

Bite Mark Photography

Photography of the bite mark sample from live human volunteers was taken before the bite marks faded away. The bite mark is photographed with bitemark standard reference scale – ABFO No. 2 placed adjacent to the bite mark (7). Scale is used in the photography so that it can be restored to its actual size during computer analysis. Care must be taken not to cover any portion of the bite mark by the scale. The scale

should be in the same plane as that of the bite mark in order to have better accuracy. The camera lens should be in perpendicular direction to minimize angular distortion. The dental impressions of the volunteers were collected from the neighbouring dental college. Hand tracing overlay was prepared from the dental impressions of the volunteers.

Hand tracing overlay

Bite marks are commonly caused by the anterior six teeth, namely central and lateral incisors, and canines. A transparent sheet is placed over the biting edge of the dentition cast, and using fine tipped pen the perimeter of the biting surface are marked (as depicted in figure1). Both the mandibular and maxillary casts were traced on to the transparent sheets (as depicted in figure 2).

There are totally 12 parameters, namely 12 anterior teeth (6 maxillary and 6 mandibular). The photograph of the dental impression and the scan of the hand tracing overlay were subjected to analysis using Computer software Adobe Photoshop 7. Computer images of the bite mark cast photograph and the hand tracing overlay were brought to similar size (image size 1:1). Using Magic wand tool, image of the hand traced biting edges of the teeth is selected. The selected image is moved over the photograph for comparison. The image of hand tracing of maxillary teeth dentition cast is laid over the photograph of the maxillary teeth bite mark for comparison. Similarly images of mandibular teeth are compared. Pattern and alignment of teeth are compared. Depending on the match the results are tabulated. Using this procedure, images of all the 50 hand tracing overlays are individually compared with each bite mark photograph.

Analysis is carried out in three phases:

Phase I – Comparison of maxillary teeth

Phase II – Comparison of Mandibular teeth

Phase III- Comparison of complete (mandibular and maxillary together) dentition

Statistical analysis

Statistical software SPSS 16 was used.

Ethical clearance by the Institutional Ethical Committee has been taken.

3. Results:

Out of 2500 cross matches, expected result should have been 50 true positives and 2450 true negatives. In our study there were 38 true positive, 2406 true negatives, 44 false positive, and 12 false negative matches in maxillary comparison. In mandibular comparison 44 true positive, 2424 true negatives, 26 false positive, and 6 false negative matches. In complete dentition comparison (maxillary and mandibular) 31 true positive, 2446 true negatives, 4 false positive, and 19 false negative matches were observed (as depicted in table 1).

The statistical analysis revealed the low sensitive value and high specific value in all three comparisons. This proves that the hand tracing method is less reliable for positive identification but more reliable in negative or exclusion identification. Also the low false positive rate and relatively higher false negative rate conforms the result. The variable positive predictive value but of lower value signifies less reliability of the method. The high end negative predictive value signifies that the hand tracing method is useful in proving negative identification. This has been supported even by the statistical Fisher's Exact test wherein the p value has been less than 0.001 in all the three comparisons.

4. Discussion:

Every individual has a unique dentine feature (2, 3). The dental identification is based on presence or absence of tooth, size of tooth, the pattern and alignment of teeth, the angle rotation, treatment or filling done, crown, supernumerary teeth and etc. Technology with time has grown leaps and bounds, and it has elevated the precision and accuracy of scientific methods. Advanced technology can be effectively put into use in bite mark analysis towards developing it into a reliable tool of identification.

In our study, using computer assisted hand tracing overlay method; we compared the three phases statistically and observed that the specificity of complete dentition (99.8%) was highest among all three. We also found that the false positive rate was the least (0.2%) and the positive predictive value was



Fig. 1. A transparent sheet is placed over the biting edge of the dentition cast.

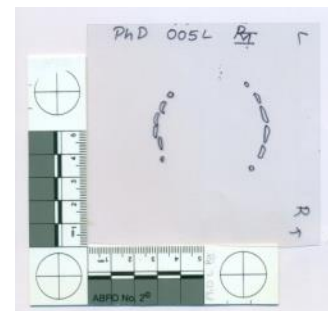


Fig. 2. Mandibular and maxillary casts.

highest (88.6%) in complete dentition as compared to the individual match. Hence we concluded that among all three comparisons using hand tracing method, the order of reliability in descending order would be, complete dentition followed by mandibular and then maxillary. The observations of all three phases showed negative predictive value being above 99% which goes in favour of identification by exclusion.

The statistical analysis of the result showed that, the computer assisted method is reliable which is in similar to the result by the Mihir Khatri *et al*, study (8). With the p value being less than 0.001 the reliability of hand tracing overlay method did prove to be reliable unlike the study conducted by Sweet *et al*, where in the authors showed that hand tracing method is an unreliable method (9). The statistical analysis also revealed that hand tracing method cannot be used for positive identification of the biter but can be used as a tool for excluding subjects. But this should be carried out with caution considering the associated observer bias. Maloth and Ganapathy in their study had similarly concluded that due to subjective error and observer bias, hand tracing method in bite mark analysis is to be avoided (10).

Table 1: Comparison of Maxillary, Mandibular and Complete dentition.

	Maxillary matches		Mandibular matches		Both Maxillary and Mandibular matches	
	Observed	Expected	Observed	Expected	Observed	Expected
True Positive Cases	38	50	44	50	31	50
False Positive Cases	44	0	26	0	4	0
True Negative Cases	2406	2450	2424	2450	2446	2450
False Negative Cases	12	0	6	0	19	0
Sensitivity	0.76		0.88		0.62	
Specificity	0.982		0.989		0.998	
False Positive Rate	0.018		0.011		0.002	
False Negative Rate	0.24		0.12		0.38	
Positive Predictive value	0.463		0.629		0.886	
Negative Predictive value	0.995		0.998		0.992	
Fisher's Exact test	<0.001		<0.001		<0.001	
P value	<0.001		<0.001		<0.001	

5. Conclusion:

Studies on bite mark analysis on human body using hand tracing method have been sparse. The hand tracing method has proved to be useful as an exclusion test. While examining probable biters for a given bite mark, hand tracing method is suitable in excluding the non-biters. This computer assisted hand tracing overlay method is not useful in proving the probable or the possible biter which could be attributed to elasticity and diverse response of skin to bites among individuals. With bite mark analysis gaining importance and the fact that an improper testimony can lead to injustice, it is very important for a forensic expert to be cautious while giving opinion on bite mark analysis. Effective bitemark recording methods must be developed to establish bite marks as a reliable tool of identification. Extensive researches need to be done on hand tracing method in bitemark analysis considering the variable factors which affect the result.

6. Acknowledgements:

This article is a part of PhD Thesis Project.

We would like to thank and acknowledge the study volunteers, Statistician Mr Sanaland, Prof (Dr) Chethan Hegde with his team of prosthodontics to whom we are indebted for helping us in conducting this study.

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