Analysis of time-dependent changes in Bitemarks on Styrofoam sheets

Djeapragassam Parimala, Mariappan Jonathan Daniel, Subramanian Vasudevan Srinivasan, Jimsha Vannathan Kumaran

Abstract

Context: The scope of Bitemarks in forensic dentistry is widening as they help the forensic expert in identifying the perpetrator in medicolegal cases. The greatest challenge in Bitemarks analysis is the time-dependent changes produced in Bitemark patterns on various substrates at the scene of the crime. Aims: To analyze the time-dependent changes in Bitemarks on Styrofoam sheets. Settings and Design: Single centered prospective study. Materials and Methods: Twenty-five subjects were randomly chosen, and dental casts prepared. Then test bites were registered on Styrofoam sheets, overlays prepared from these test bites on subsequent days (day 1, 2, 3, 4) and checked for matching accuracy. Statistical Analysis Used: The data were analyzed using Kruskal–Wallis ANOVA to compare the overlays from dental stone cast with test bites on Styrofoam sheets on subsequent days. Results: The P value was found to be 1 which is statistically not significant implying that there were no significant time-dependent changes in the pattern of Bitemarks. Conclusions: There were no time-dependent changes in the pattern of Bitemarks on Styrofoam sheets hence they serve as better materials than Bitemarks on human skin or food substrates obtained from the scene of the crime.

Key words: Bitemarks, forensic dentistry, overlays, Styrofoam, test bites

Introduction

Bitemarks are physical alterations in a medium caused by the contact of teeth.[1] These Bitemarks are frequently found on food substances in crime scenes[2‑6] and play a pivotal role in identifying the offenders. However, these are prone to distortion because of their perishable nature.

The ABFO has suggested test bite registration media like wax sheet, Styrofoam, clay and human skin of volunteers.[1] Through this study, we analyzed the time‑dependent changes in Styrofoam as to check its reliability without distortion if found in a crime scene and its durability as a test bite registration material.

Materials and Methods

Twenty-five healthy subjects above 15 years of age were randomly chosen and after obtaining informed consent impressions of both the dental arches were made and the corresponding casts were prepared. Test bites were registered from these individuals by making them bite on Styrofoam sheets obtained from the common disposable Styrofoam plates that are commonly referred as thermocol plates [Figure 1a]. The thickness of the sheets we used was 0.2 cm and the sheets were custom made from Styrofoam plates of 9 inches diameter.

These sheets were folded and placed in the mouth such that the extension of the sheet was from canine to canine. The folded end of the Styrofoam sheets were placed inside the mouth and the free end of the sheets extending outside the mouth. Then the subjects were instructed to bite on the sheets [Figure 1b]. The sheets were removed from the mouth [Figure 1c] and unfolded so that the bite pattern was obtained in the same plane as the typical horseshoe shaped pattern facing each other as shown below [Figure 1d]. The sheets were washed in running tap water and then dried by placing against absorbent tissue paper. Then it was gently wiped off with cotton soaked in surgical spirit to disinfect the surface and air dried.

The Bitemarks thus obtained formed the base from which overlays were generated by tracing the pattern of Bitemarks on transparent sheets with a marker [Figure 2a]. The sheets were numbered on the back side for easy recognition on the subsequent days. The sheets were left at a dry place in normal room temperature, no special preservation techniques or protocols were followed. The Bitemark patterns were analyzed for time-dependent changes [Figure 3]. Overlays were generated on four subsequent days from these sheets to analyze the alteration in the pattern of Bitemarks with time elapse [Figure 2b]. A reference overlay was generated for each subject from the dental casts by tracing the incisal edges of anterior teeth with marker on a transparent sheet [Figure 2c].
The overlays thus generated on the subsequent days (day 1, 2, 3, 4) were superimposed on the reference overlay obtained from the dental cast and checked for matching accuracy [Figure 2d]. Then appropriate matching scores were assigned as 0 - no match, 1 - mild match, 2 - moderate match and 3 - excellent match.

### Results

The data obtained by checking the matching accuracy were tabulated and analyzed statistically. It was found that 16% of the cases showed moderate matching (i.e. 4 out of 25 samples had a matching accuracy score 2) and 84% showed excellent matching with the reference overlays generated from the dental casts (i.e. 21 out of 25 samples had a matching accuracy score 3). However, when comparing within the Styrofoam sheets, the matching accuracy remained the same on the four subsequent days.

Kruskal–Wallis ANOVA test was used to analyze the time-dependent changes by comparing the overlays from dental stone cast with test bites registered on Styrofoam sheets on subsequent days [Table 1]. The P value was found to be 1 which is statistically not significant implying that there were no significant changes in the pattern of Bitemarks with time elapse.

### Discussion

Bitemarks if analyzed properly not only can prove the participation of a particular person or persons in crime but also help in exonerating of the innocent.[7] In the majority of cases, qualitative evaluation of the Bitemarks is usually easier with bitten foodstuffs than human skin although it must be emphasized that certain foods make poor media for Bitemark registration.[8] Skin is a poor medium to capture marks left in it by various tools, weapons and teeth. From the time the mark is made until the case data are obtained, the skin continues to change. If the victim is alive, bruising may appear. If deceased, then post-mortem changes may occur.[9]

Among the ABFO recommended materials Styrofoam readily serves as a bite registration material. Wax sheets might need softening while clay may be tacky and needs proper manipulation. Skin known for its elastic nature make the Bitemarks fleeting. The use of skin on human volunteers, porcine skin and cadaver skin for test bite registration have also been reported in the literature. However, these materials may be disagreeable to register Bitemarks from our test subjects. Considering these ethical issues, we attempted to register Bitemarks on an inanimate material. So, in our study we used Styrofoam sheets.[3,10,11]

Rothwell et al. (2001) conducted a study to analyze the distortion in preserved Bitemark skin and stated that although some samples were dimensionally stable, there
was both contraction and expansion of Bitemark specimens, even within individual skin samples. He concluded that even standard techniques for storage and preservation of Bitemark samples will not produce reliable dimensional accuracy.[10] In our study, with Styrofoam we found that 16% of the cases showed moderate matching with the dental casts (i.e. 4 out of 25 samples had a matching accuracy score 2) and 84% showed excellent matching (i.e. 21 out of 25 samples had a matching accuracy score 3). This discrepancy occurred when there existed crowding in the dental arches with one or two teeth well above or below the incisal plane. This is suggestive of the superiority of Styrofoam over dental casts because the pattern registered on Styrofoam sheets are the result of the biting force applied which is probably the more accurate reproduction of the dynamic process of biting; whereas the reference overlay is merely traced from the static dental model.

Avon et al. (2005) studied the ageing of human Bitemarks on in-vivo models of porcine skin and stated that porcine skin exhibited similar changes like human skin. He concluded that the passage of time will result in loss of tooth depressions in human or porcine skin. The status of the tissue at the time of biting; the time elapsed between the biting and when the analysis was made; condition of the skin injured; the clarity of the marks and the site of the wound; must all be considered in determining the evidentiary value of any Bitemark.[11]

In this study, we have analyzed the time-dependent changes in Styrofoam and we found that the inter canine distance and mesio-distal width of the incisal edges obtained in the test bites on the Styrofoam sheets remained the same suggesting that there was no alteration in the pattern of Bitemark with time elapse. Stavrianos et al. (2011) in their study of Bitemarks on bitten apple to compare accuracy of two methods in Bitemark analysis have stated that they had refrigerated the apple; which could possibly be to overcome the shrinkage with time elapse.[12] In the case of fruits the water content of fruits influence the Bitemarks; the more juicy the fruit the less prominent the Bitemark.

Styrofoam comes in many thicknesses, shapes and colors. Teeth will usually imprint fairly accurately in Styrofoam, recording both class and individual characteristics. Coffee/cold drink cups are the most common form of Styrofoam bitten object. Dorion (1989) reported the use of Styrofoam as an impression media for registering and analyzing a suspect dentition.[3,13,14]

Wax and Styrofoam behave quite differently from human skin, as they undergo permanent plastic deformation under stress, unlike skin that has visco-elastic properties.[15] The problem with this method is that wax and skin are very different in consistency and require different amounts of pressure to produce a mark, and if too much force is used the wax Bitemark will most likely produce an overlay that does not reflect the real situation.[16] The use of disposable plates and cups have increased these days, and so it is possible that one may find these at the scene of the crime more interestingly with a Bitemark. In our study, Kruskal–Wallis ANOVA test was used to analyze the time-dependent changes by comparing the overlays from dental stone cast with test bites registered on Styrofoam sheets on subsequent days and the P value was found to be 1 which is statistically not significant implying that there were no significant changes in the pattern of Bitemarks with time elapse. This is possibly because of the permanent plastic deformation these sheets undergo with the biting pressure. Styrofoam forms part of the hard group of materials called thermoplastic elastomers. An elastomer will undergo an immediate, linear and reversible response to high strain to an applied force. This response has a mechanical analogy with a spring according to Hooke’s Law. Nonlinear, time-dependent irreversible response is a viscous response according to a dashpot model.[17] Research is needed in assessing the physical properties and biomaterial perspective of Styrofoam sheets and further studies with prolonged time duration is needed.

Through our study, we would like to suggest the possibility of the use of Styrofoam as a test bite registration material as an alternative to the dental casts. Bitemarks may be offensive or defensive in nature and for this reason Bitemark evidence is collected from both the victim and suspect.[18] In certain cases wherein the victim is severely injured and with restricted mouth opening Styrofoam can be used as an alternative. Identification of individuals is not always straightforward and easy especially in medicolegal cases where the individuals are either unable to give accurate answers or are purposefully misleading. Living individuals for whom identification is required are criminals attempting to elude custody, amnesia victims, comatose victims, victims of disfiguring trauma or persons requiring identity confirmation following identity theft.[19] Impression making may be difficult in special situations like in young children, mentally challenged individuals, emotionally disturbed victims of rape, child abuse, individuals with gagging, bed ridden

**Table 1: Kruskal–Wallis ANOVA comparing overlays for time-dependent changes**

| Day | n | Sum of ranks | Kruskal–Wallis test H | P level | LS |
|-----|---|--------------|----------------------|---------|----|
| 1   | 25| 1262.5       | 0.0000               | 1.0000  | NS |
| 2   | 25| 1262.5       |                      |         |    |
| 3   | 25| 1262.5       |                      |         |    |
| 4   | 25| 1262.5       |                      |         |    |

*P value 1 not significant implies that there is no changes with time elapse. LS: Level of significance; NS: Not significant; ANOVA: Analysis of variance*
individuals (who could not be positioned upright as needed for impression making), individuals with soft tissue injuries like lacerations intra orally, individuals with TMJ disorders and restricted mouth opening due to any other reason. In these conditions, Styrofoam can be used as a better alternative method in obtaining the pattern of Bitemarks as the thickness of the sheet is 2 mm only.

Styrofoam test bite registration is advantageous over the conventional dental casts because they are handy, easily available, does not require any dental materials, economical and less time consuming in overlay generation. The dental stone casts prepared are also brittle and needs special precautions during transportation, the procedural difficulties and need for a laboratory setting, impression trays, impression materials, delay due to transportation of impression to laboratory and time for setting of cast are all eliminated with the use of Styrofoam sheets. However, it is reported that in Styrofoam sheets larger the cell size more inaccurate the representation of teeth being recorded\[^{20}\] which can be overcome by the use of Styrofoam plates rather than the Styrofoam sheets as the cells are more closely packed in these plates. The limitation of using Styrofoam is that it may be charred when near direct flame hence care must be taken while transportation. Another limitation is the uniformity in color of the sheets that makes computer-assisted overlays and a photocopy method of overlay generation out of scope. However, we can overcome this limitation with a careful contrast painting. We suggest painting the Styrofoam with a contrast dark colored, flat tipped permanent marker (to and fro strokes like in shading a coin pattern on a plain paper) to make the incisal outlines of teeth in the test bite more prominent (and stay distinct as they are three dimensional registrations lying at a depth from the plane of the sheet) before preparing the overlays.

**Conclusion**

The forensic expert plays a vital role in medico legal cases where his judgment decides the fate of the individual; such an important decision should not be deceiving due to the time-dependent alterations in Bitemarks. So through our study, we conclude that Styrofoam serve as better substrates than human skin or food substances if obtained from a scene of crime as there were no time-dependent changes in the pattern of Bitemarks on Styrofoam. We envision the widespread use of Styrofoam as a test bite material in the near future as an alternative to dental casts in special conditions like trismus, bed ridden individuals etc., were no alternative methods have been suggested till date.

**References**

1. American Board of Forensic Odontology. Diplomates Reference Manual. 2013. Available from: www.abfo.org/wp.../ABFO-Reference-Manual-1-22-2013-revision.pdf. [Last accessed on 2013 Dec 15].
2. Whittaker DK, MacDonald DG. A Color Atlas of Forensic Dentistry. London: Wolfe Medical Publications; 1989.
3. Dorion RB. Bitemark Evidence. 1st ed. New York: Marcel Dekker; 2005.
4. Bernitz H, Piper SE, Solheim T, Van Niekerk PJ, Swart TJ. Comparison of bitemarks left in foodstuffs with models of the suspects’ dentitions as a means of identifying a perpetrator. J Forensic Odontostomatol 2000;18:27-31.
5. McKenna CJ, Haron MI, Brown KA, Jones AJ. Bitemarks in chocolate: A case report. J Forensic Odontostomatol 2000;18:10-4.
6. Gorea RK, Jasuja OP. Identification from bitemarks on Nakh (pear). J Indo Pac Acad Forensic Odontol 2010;1:30-3.
7. Kaur S, Krishan K, Chatterjee PM, Kanchan T. Analysis and identification of Bitemarks in forensic casework. Oral Health Dent Manag 2013;12:127-31.
8. Nambiar P, Carson G, Taylor JA, Brown KA. Identification from a bitemark in a wad of chewing gum. J Forensic Odontostomatol 2001;19:5-8.
9. Bowers CM, Bell GL, editors. Manual of Forensic Odontology. 3rd ed. Ontario: Manticore; 1997. p. 184-90.
10. Rothwell BR, Thien AV. Analysis of distortion in preserved Bitemark skin. J Forensic Sci 2001;46:573-6.
11. Avon SL, Wood RE. Porcine skin as an in-vivo model for ageing of human Bitemarks. J Forensic Odontostomatol 2005;23:30-9.
12. Stavriansos C, Vasiliadis L, Emmanouil J, Papadopoulos C. In vivo evaluation of the accuracy of two methods for the Bitemark analysis in food stuff. Res J Med Sci 2011;5:25-31.
13. Dorion RB. Styrofoam as an Impression Material. Proceedings of the 41st Annual Meeting of the American Academy of Forensic Sciences; 1989 Feb 13-18; Las Vegas, NV, Colorado Springs, CO: American Academy of Forensic Sciences; 1989.
14. Dorion RB. Bitemark Project 2000 — Objectivity. Proceedings of the 53rd Annual Meeting of the American Academy of Forensic Sciences; 2001 Feb 19-24; Seattle, WA, Colorado Springs, CO: American Academy of Forensic Sciences; 2001.
15. Bush MA, Miller RG, Bush PJ, Dorion RB. Biomechanical factors in human dermal bitemarks in a cadaver model. J Forensic Sci 2009;54:167-76.
16. Kouble RF, Craig GT. A comparison between direct and indirect methods available for human Bitemark analysis. J Forensic Sci 2004;49:111-8.
17. ElSonbati AZ. Thermoplastic Elastomers. Ch. 8. Croatia: InTech Publishers: 2012. p. 8. Available from: http://www.intechopen.com/books/thermoplastic-elastomers/thermoplastic-elastomers. [Last accessed on 2015 Feb 24].
18. Bhargava K, Bhargava D, Rastogi P, Paul M, Paul R, Jagadeesh HG, et al. Review research paper an overview of Bitemark analysis. J Indian Acad Forensic Med 2012;34:61-6.
19. Kanaparthi A, Kanaparthi R. The dental role in forensic medicine. IOSR J Pharm 2013;3:14-7.
20. Wright FD, Dalley JC. Human Bitemarks in forensic dentistry. Dent Clin North Am 2001;45:365-97.