

A comparative assessment of bite marks in analyzing the overlay generation using styrofoam sheet and modeling wax with the dental casts as one of the adjuncts for archiving the forensic records: An *in vivo* study

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Abstract

Introduction: Bite mark evidence is unique to an individual and plays an important role in the legal system. There has always been the need to develop newer materials for bite mark analysis that will have excellent reproducibility as well as reliability.

Aim: The present study aimed to evaluate the efficacy of styrofoam sheets and modeling wax with time-dependent changes when compared to the routine dental cast models.

Materials and Methods: The present study included thirty volunteers and their bite marks were taken on the styrofoam and wax sheet materials that were traced on the transparent sheet and evaluation of the bite marks on the two materials were carried out at an interval of 1 day for 3 alternate days and grades were given, respectively. ANOVA test and *t*-test were used for statistical analysis.

Results: The comparison between the styrofoam sheet and wax sheet with the dental cast on day 1 proved to be excellent materials for reproducibility, but from day 3 onward, the styrofoam sheet showed changes in bite registered area; whereas wax sheet maintained its registered dimensions.

Conclusion: The study concludes that bite mark registration on styrofoam and wax sheet had excellent reproducibility on day 1, which makes these two materials advantageous in bite mark registration and overlay generation on the same day, whereas on day 3 and day 5, the styrofoam sheet showed changes with respect to bite registration and overlay generation, which questions the reliability of the styrofoam sheet for long-term record keeping when compared with the modeling wax.

Keywords: Bite registering materials, forensic odontology, record maintenance, reproducibility, time-dependent changes

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INTRODUCTION

Forensic odontologists are the experts in identifying the suspect by studying the various aspects of the dentition

which are as specific and unique to an individual as the fingerprints, and in criminology, personal identification is

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the most important criteria.^[1,2] Any feature in the human identification that stands out from normality becomes an important tool to point out toward the suspect.^[3] In all judicial cases, experts must explain the technology and its limitations and report statistical analysis results to allow probabilistic conclusions to be drawn.^[4]

Bite marks are unique to an individual; they are different even in identical twins.^[5] Therefore, bite mark evidence plays a pivotal role in many legal systems. Bite mark analysis has been advancing since long and seems like there is no end. In developing and underdeveloped countries, where the latest technology is a bit expensive to incorporate in the forensic department to analyze bite marks, in such situations, look out for materials which are easily available and economical becomes obligatory.

The American board of forensic odontology has recommended test bite registration media such as clay, wax sheet, styrofoam sheet and human skin of volunteers.^[6] Dorion reported the use of styrofoam as an impression media for registering and analyzing a suspect dentition. It is important to develop a valid method of analyzing bite marks with materials which are reliable, inexpensive, less bulky and easy to manipulate.^[7] Styrofoam sheet produced excellent indentations of the teeth as biting forces were applied. It can be used as a better adjunctive material in obtaining the pattern of bite marks as the thickness of the sheet is 2 mm only,^[8] with better bite reproducibility.

Dental cast study model is the most accurate for collecting evidence for human bite mark identification.^[7] In this study, an attempt was being made to compare overlay generation on styrofoam sheet and modeling wax, respectively, and to assess for an alternative material to be used in routine forensic practice.

MATERIALS AND METHODS

The study was carried out in the Department of Prosthodontics. In the study, 30 healthy controls above 15 years of age were randomly chosen; among them, 11 (36.7%) were males and 19 (63.3%) were females; the mean age of individuals was 18.33 ± 0.61 ; after obtaining informed consent, impressions of both the dental arches were made and the corresponding dental casts were prepared [Figure 1]. Simultaneously, bite marks were registered on styrofoam sheet and modeling wax from premolar to premolar.

Test bite registration: Styrofoam sheet

Test bite registration was done on styrofoam sheet obtained from the common disposable styrofoam plates.

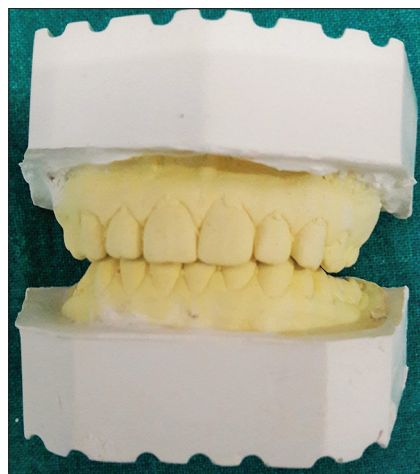


Figure 1: Dental casts prepared

The sheet thickness used was 0.2 cm which was cut into a triangle shape. The styrofoam sheets were piled with a thicker sheet of 0.4 cm thickness in between for bite registration [Figure 2]. Then, the broader end of the triangle of the piled sheet was placed in the mouth from premolar to premolar and the narrow end extended outside the mouth. The individuals were instructed to bite into the sheet with a limited force such that bite does not tear the sheet and bite marks were registered on styrofoam sheet [Figure 3]. After the bite was registered, the sheet was washed with tap water and left to dry for 5–10 min and the surface was wiped with spirit and cotton to disinfect the surface. The sheets were immediately numbered for recognition and matching with the cast. Overlay generation was done using transparent sheets and markers on the same day. Then, the sheets were preserved for the next tracing on day 3 (i.e., alternate day) and day 5.

Test bite registration: Modeling Wax Sheet

Test bite marks were registered on modeling wax sheet [Figure 4] by placing a cardboard in between the folded sheet so that when the sheet is opened, it should have horseshoe shape. Both the materials were handled at room temperature to rule out any temperature-dependent changes.

Overlay generation

Tracing was done on transparent sheet using a magnifying lens [Figure 5] with marker pens for both styrofoam sheets and wax sheet for 3 alternate days [Figure 6], that is, on day 1 (on the day impression was made); then, the materials on which bite was registered were kept at room temperature for 1 day and then tracing was done on day 3. Then, on day 5, tracing was again done in the same manner as it was on the previous days.



Figure 2: The styrofoam sheet cut and piled for bite registration

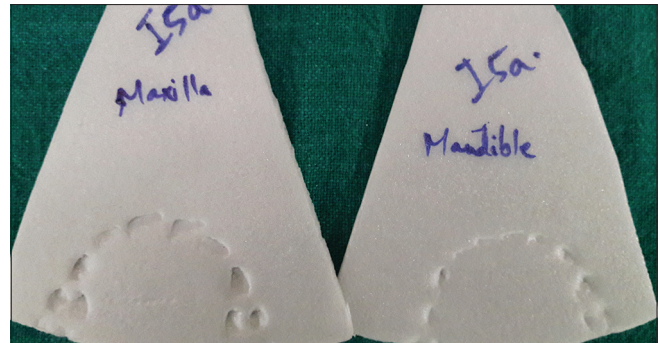


Figure 3: The bite marks were registered on styrofoam sheet



Figure 4: The bite marks were registered on modeling wax sheet

Grades assigned

The transparent sheets were then used to compare with the dental cast (standard). Blinding was done to exclude examiner bias. The findings were graded based on the criteria mentioned below as suggested by Parimala *et al.*^[9] with slight modifications: 0 – no matching, 1 – some teeth matching, 2 – arch form matching with some teeth (modified) and 3 – excellent matching.

RESULTS AND OBSERVATIONS

The data were obtained by checking the matching accuracy which were tabulated and analyzed statistically. It was observed that overlay generation on modeling wax showed excellent matching by 100% of the cases



Figure 5: Tracing was done on transparent sheets using magnifying lens

(i.e., 30 out of 30 samples had matching accuracy of score 3) that remained same on the 3 alternate days when compared with the maxillary and mandibular dental cast.

It was also observed that the overlay generation of the maxillary teeth on styrofoam sheet when compared to dental cast showed excellent matching by 100% cases (i.e., 30 out of 30 samples had matching accuracy of score 3) on the 1st day. About 66.7% showed excellent matching (i.e., 20 out of 30 samples had a matching accuracy of score 3) and 33.3% of the cases showed moderate matching (i.e., 10 out of 30 samples had a matching accuracy of score 2) on the 3rd day. It was observed that 43.3% of the cases showed excellent matching (i.e., 14 out of 30 samples had matching accuracy of score 3), 46.7% showed moderate matching (i.e., 14 out of 30 samples had a matching accuracy of score 2) and 10% of the cases showed some teeth matching (i.e., 3 out of 30 samples had a matching accuracy of score 1) on the 5th day, indicating the changes in the styrofoam sheet with time elapse.

Similarly, the overlay generation of mandibular teeth on styrofoam sheet showed excellent matching observed in

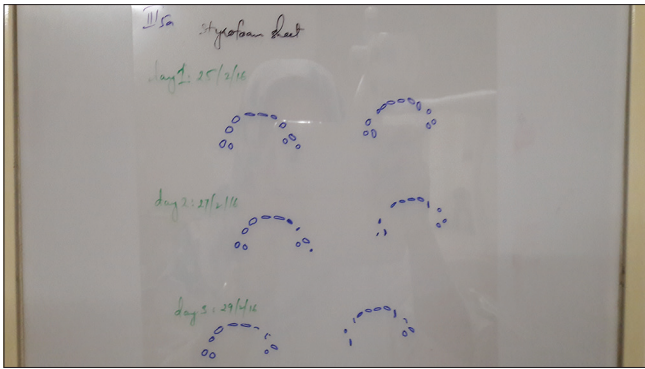


Figure 6: Tracing was done on 3 consecutive days on transparent sheet

100% of the cases (i.e., 30 out of 30 samples had matching accuracy of score 3) on the 1st day. However, with time elapse, 56.7% showed excellent matching (i.e., 17 out of 30 samples had a matching accuracy of score 3) and 43.3% of the cases showed moderate matching (i.e., 13 out of 30 samples had a matching accuracy of score 2) on the 3rd day. Moreover, it was observed that 36.7% of the cases showed excellent matching (i.e., 11 out of 30 samples had matching accuracy of score 3), 53.3% showed moderate matching (i.e., 16 out of 30 samples had a matching accuracy of score 2) and 10% of the cases showed some teeth matching (i.e., 3 out of 30 samples had a matching accuracy of score 1) on the 5th day.

ANOVA test was used to analyze the time-dependent changes by comparing the test bite registered on the modeling wax and styrofoam sheet with dental cast on 3 alternate days which is represented in Tables 1-3.

Unpaired *t*-test was applied to compare two materials, that is, modeling wax and styrofoam sheet to find which material is significantly better which is tabulated in Tables 4 and 5.

Line diagram representation shows changes in the modeling wax with dental cast and changes in styrofoam sheet with dental cast with time elapse in both maxillary and mandibular overlay generations on 3 alternate days as shown in Graphs 1 and 2, respectively.

DISCUSSION

Bite marks can prove the participation of a particular person or persons in crime and preclude the innocent when proper investigation is attempted by collecting all the evidences at the crime scene.^[10] Bite mark evidence is collected from both the victim and suspect as the marks made on the skin can be assaultive or resistive.^[11] Skin is the site most common for bite marks and is also a poor medium for identification due to the tendency of skin to regenerate. When the victim is alive the bitemark undergoes bruising and subsequently heal after sometime, but in deceased

Table 1: Comparing overlays for time dependent changes in modelling wax with dental cast for maxillary and mandibular arches

Day	n	Sum of scores	ANOVA result		
			ANOVA test F	P	Significance
1	30	90	0.000	1.00	NS
3	30	90			
5	30	90			

P value 1 not significant implies that there is no changes with time elapse; NS: Not significant; There is no statistically significance difference of scores (no changes) with time elapse

Table 2: Comparing overlays for time-dependent changes in styrofoam sheet with dental cast for maxillary arch

Day	n	Sum of scores	ANOVA result		
			ANOVA test F	P	Significance
1	30	90	15.0	0.000	HS
3	30	80			
5	30	70			

P value is 0.000 highly significant implies that there is changes with time elapse; HS: Highly significant. There is statistically significance difference of scores (significant changes) with time elapse

Table 3: Comparing overlays for time-dependent changes in styrofoam sheet with dental cast for mandibular arch

Day	n	Sum of scores	ANOVA result		
			ANOVA test F	P	Significance
1	30	90	18.445	0.000	HS
3	30	77			
5	30	68			

P value is 0.000 highly significant implies that there is changes with time elapse; HS: Highly significant; There is statistically significance difference of scores (significant changes) with time elapse

victims, the bitemark moves from its original site.^[12] Skin has viscoelastic properties and may undergo permanent plastic deformation;^[13] the uses of more resilient and structurally stable materials are recommended in practice. Considering these properties of the materials, the wax sheet and styrofoam sheets have been used in this study for bite registration.

The use of styrofoam as an impression media for bite registration was proposed by Dorion in 1989.^[7] Parimala *et al.* in their study concluded that there were no time-dependent changes in the pattern of bite marks on styrofoam sheet.^[9] In this study, we analyzed the time-dependent changes in styrofoam and wax and compared it with the dental cast (standard). Wax sheet showed good reproducibility and a reliable material throughout the study whereas styrofoam sheet showed changes from day 3 onward.

It was observed in various studies that due to different consistency of wax and styrofoam, they require different amounts of pressure to produce a mark, and if too much

Table 4: Comparison of changes in modelling wax with dental cast and changes in styrofoam sheet with dental cast for maxillary in different time period

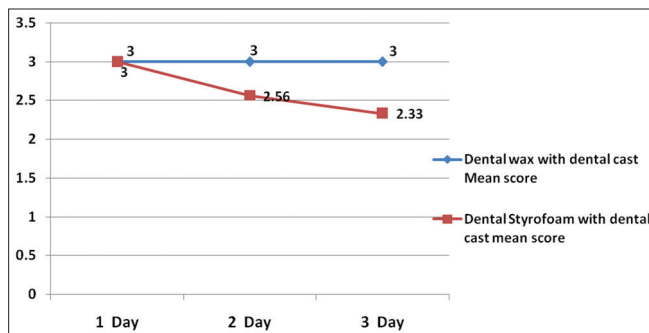
Day	Mean±SD		t-test result	P	Significance
	Dental wax with dental cast mean scores	Styrofoam with dental cast mean scores			
1 st day	3.0±0.0	3.0±0.0	t=0.0	1.00	NS
3 rd day	3.0±0.0	2.56±0.48	t=3.81	0.001	HS
5 th day	3.0±0.0	2.33±0.66	t=5.53	0.000	HS

NS: Not significant; HS: Highly significant. There is statistically highly significant difference of scores (significant changes) between two materials on 3rd and 5th day with time elapse. But there is no statistically significant difference of scores (no changes) on 1st day with time elapse in bite registered by maxillary teeth

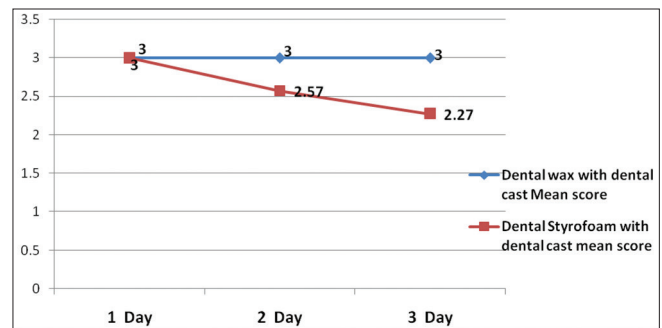
Table 5: Comparison of changes in modeling wax with dental cast and changes in styrofoam sheet with dental cast for mandibular in different time period

Day	Mean±SD		t	P	Significance
	Dental wax with dental cast mean scores	Styrofoam with dental cast mean scores			
1 st day	3.0±0.0	3.0±0.0	t=0.0	1.00	NS
3 rd day	3.0±0.0	2.56±0.48	t=4.71	0.000	HS
5 th day	3.0±0.0	2.33±0.66	t=6.28	0.000	HS

NS: Not significant; HS: Highly significant. There is statistically highly significant difference of scores (significant changes) between two materials on 3rd and 5th day with time elapse. But there is no statistically significant difference of scores (no changes) on 1st day in bite marks registered by mandibular teeth



Graph 1: Line diagram represents changes in the Dental wax with dental cast and changes in styrofoam with dental cast with time elapse (maxillary teeth)



Graph 2: Line diagram represents changes in the Dental wax with dental cast and changes in styrofoam with dental cast with time elapse (mandibular teeth)

force is used, the bite mark will most likely produce an overlay that does not reflect the real dentition of the individual.^[14] While registering the bite on styrofoam, it was observed that if there is crowding, one or more teeth are well above or below the incisal plane and surprising lack of compatibility was observed.^[8] In such cases, careful inspection of the individual's dentition was made and they were guided while bite marks were being registered so that excessive forces are avoided.

In this study, on day 1, the overlay which was generated and matched with the cast showed that both wax and styrofoam sheet served as excellent materials, but on day 3, the styrofoam sheet showed changes such as rounded borders of the site of indentation; these results were in contrast with the study conducted by Parimala *et al.* who concluded saying that styrofoam sheet is a stable material and did not change with time.^[9]

In this study, the infraerupted anterior teeth showed that the indentations were not deep but were good enough to show site of tooth and morphology of the biting tooth on both materials. Wax did not show any changes at that site throughout the study. Perhaps, on day 1, all the indentations were very well appreciated and the tracing obtained from styrofoam showed all the teeth involved in the registration of bite. On day 3, the styrofoam sheet bounced back leaving behind a small depression at the same site which was recorded as a dot on tracing sheet. On day 5, the small depression also vanished and hence nothing was recorded on the tracing sheet. Therefore, grades given were based on arch form and few teeth which were matching.

Styrofoam is made up of polystyrene, which has low tensile and flexural properties which probably leads to the drawbacks of this material.^[15] Since styrofoam sheet had good reproducibility on day 1, it is advisable by this study

to record the overlay generation on the same day which will bring out the usefulness of this material, as based on our findings on day 3 and day 5, styrofoam sheet showed changes.

Wax sheet is easily available in dental clinics and dental depots which will be beneficial in registering bite marks at room temperature as it was found to be stable as observed in this study on days 1, 3 and 5 when compared to styrofoam sheet which showed changes on days 3 and 5.

CONCLUSION

Styrofoam sheet and modeling wax both have promising reproducibility for bite registrations. The observations in this study show that styrofoam sheet has the best reproducibility on day 1 and thus make us understand the importance of filing the information as soon as we receive it. For the purpose of future reference, photographs of the traced sheet and bite registered on materials should be saved. Styrofoam sheet and wax sheet are advantageous in bite registration as they are easily available, handy, do not require any manipulation, are economical and they also have the property of being resilient.

To conclude:

1. Styrofoam sheet and modeling wax, both, serve excellent and promising reproducibility on day 1 for bite registration and for immediate forensic records such as photographs, tracings and permanent cast preparation
2. Styrofoam sheet serves as the best material compared to modeling wax for immediate analysis, i.e., within 24 h of investigation
3. Modeling wax sheet can be used as a reliable material for future analysis owing to its less distortive properties, i.e., after 48 and 72 h, respectively, when compared with styrofoam sheet for long-term archiving of forensic records and also for its easy availability and cost.

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Conflicts of interest

There are no conflicts of interest.

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