RESEARCH ARTICLE

COMPARISON AND ANALYSIS OF BITE MARKS USING WAX IMPRESSION, RADIOPAQUE AND COMPUTER ASSISTED METHODS - A FORENSIC STUDY

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Manuscript Info	Abstract
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Aim: To evaluate the best method of overlay generation out of three methods i.e.,wax impression, Radiopaque and computer assisted method.

Material and methods: 50 randomly selected casts from departments of prosthodontics and orthodontics in DivyaJyoticollege of dental sciences and research, Modinagar, Ghaziabad were used to compare three commonly used two dimensional overlay generation methods in bite mark analysis. Overlay production was done by wax impression, Radiopaque and Computer assisted methods. Finally, the overlays obtained by each method were compared**.**

Results: Chi-square test was used for comparison of wax impression, Radiopaque and computer assisted overlay generation methods,the scores obtained being highest in case of computer assisted overlays, thus making it the best method of overlay generation out of three methods.

Conclusion: we conclude that the method of computer assisted overlay generation is the best method among the three methods used in our study.

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Introduction:-

Forensic odontology is a branch of dentistry, which in the interest of justice, deals with the proper handling and examination of dental evidence, and also with proper evaluation and presentation of dental findings. The term 'forensic' is derived from the Latin word forensis, which means 'pertaining to the forum' and 'odontology' refers to the study of teeth.[1]Forensic odontology has played a vital role in the identification of individuals whose bodies have been mutilated due to fire accidents, mass disasters, sexual assaults and so on. The various approaches employed in forensic dentistry include bite marks, saliva, teeth, rugoscopy, tooth prints, cheiloscopy, photographic study, dental casts, molecular methods and radiographs.[2]Teeth are often used as weapons when one person attacks another (or) when a victim tries to ward off an assailant. It is relatively simple to record the evidence from the injury and the teeth for comparison of the shapes, sizes & pattern that are present.[3]

ABFO defines bite-marks as "a pattern left in an object or tissue by the dental structures of an animal or human, "Mac Donald described it as a mark caused by the teeth either alone or in combination with other mouth parts. Hence a bite mark shows unique pattern of an individual's teeth, also it can help in excluding suspects to whom the mark does not belong to.[4]

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Three predominant mechanisms associated with production of bite marks are; tooth pressure, tongue pressure and tooth scrape. Tooth pressure marks are caused by direct pressure application by incisal edges of anterior teeth /occlusal edges of posterior teeth. Severity of bite mark depends upon duration, degree of force applied and degree of movement between tooth and tissue. Clinical presentation of tooth pressure indicates pale areas representingincisal edges and bruising that representincisal margins. Tongue pressure is caused when the material taken into mouth is pressed by tongue against teeth/ palatal rugae and distinctive marks are present due to tongue sucking/ thrusting. Tooth scrape is caused by teeth scrapingagainst tooth surface commonly involving the anterior teeth. Clinical presentation can be in the form of scratches and abrasions. Scratches and abrasions that indicate irregularity and peculiarity of incisal edges are useful in identification.[5]The human dentition is unique. Occlusal (bite surface) profiles of all people are different from each other. There is just a smallhypervariation that occurs in the dentition which is unique. This hypervariation can be used to create a dental occlusal profile database. This has its drawbacks. It is not constant throughout life as compared to DNA which is constant. To overcome this concern, the dental records of suspects can be routinely updated with a bite registration taken every year or so. This is also a new area and a lot of research has to be done in this field.[7]

Material and Methods:-
In this present study, the bite mark overlays generated by three methods i.e. hand tracing from wax impression method, radiopaque wax impression method, computerassisted method was conducted to determine the most accurate bite mark overlay fabrication technique.

The sample size for this study comprised of 50 randomly selected casts from departments of prosthodontics and orthodontics in DivyaJyoti college of dental sciences and research , Modinagar, Ghaziabad to compare the three commonly used two-dimensional overlay generation methods in bite mark analysis.50 randomly selected casts from departments were divided in to 3 groups
1. Group A – The overlay generated by wax impression method
2. Group B – The overlay degenerated by radiopaque wax impression method.
3. Group C – The overlay generated by computer-assisted method

In the present study three methods were used for analysis of bite marks. It includes wax impression (manual method), Radiopaque wax impression method andComputer assisted method

In theWax impression method, the study casts arepressed into a single wafer of modelling wax sheet to produce shallow impression of the biting surfaces of the six upper and six lower anterior teeth. A sheet of transparency film is thenplaced over the wax sheet and the perimeter of each of the shallow depressions caused by teeth of interest ishand traced using fine tipped black pen. InRadiopaque wax impression method, the shallow impressions of the biting surfaces of anterior teeth are produced as described by wax impression method and then a small quantity ofradiopaque restorative material, i.eZnoeugenol cement is sequentially added to the individual tooth impressions using a thin hairbrush (Camlin hairbrush size 0) andis allowed to set for approximately 5-10 minutes.. A radiographic image isproduced on an intraoral dental X-ray machine by allowing the central ray directed at 90 degreeto the wax sheet surface. After this, the film isprocessed, the bite marks appearas white teeth marks in a dark black background and tracing of bite marks is done on transparent sheet. In the Computerassisted method, the study models are scanned with the biting edges of the dental model over the glass plate of the scanner. The images are analysed usingAdobe photoshop software version 7.0. The outlines of the biting edges are reproduced using pencil tool in the software. The images obtainedare thenprinted on transparent sheet. Thus, three overlays aremade for one set of dental model. The three overlays corresponding to a set of dental model are placed directly over the biting edges one by one for matching and assigned one out of the four values (0-3) with "0" assigned to no matching and "3" assigned to excellent matching

Scoring Criteria For Matching
According to ABFO (American Board OF Forensic Odontology) scoring system for Bite marks , following is the scoring criteria;

0	No matching (no teeth edge match the impression)
1	Slight matching (one to two teeth match the impression)
2	Moderate (probable) matching (three to four teeth match the impression)
3	Excellent (distinctive) matching (five to six teeth match the impression)

Results and Observation:-

The data for the present study was entered in the Microsoft Excel 2007 and analyzed using the SPSS statistical software 23.0 Version. The intergroup comparison for the difference of frequency scores between three independent groups was done using the Chi square test

Chi Square Test

Chi-square is a statistical test commonly used to compare observed data with data we would expect to obtain according to a specific hypothesis. This test is commonly used to test association of variables in two-way tables, where the assumed model of independence is evaluated against the observed data. In general, the **chi-square test statistic** is of the form

$$X^2 = \sum \frac{(\text{observed} - \text{expected})^2}{\text{expected}}$$

.

Scoring was done by three observers. The three observers included in the study were:
1. Post graduate student from the department of oral and maxillofacial pathology and microbiology
2. Senior lecturer in the department of oral and maxillofacial pathology and microbiology
3. Forensic odontologist

Overall percentage of positive matching for wax impression method was 64%,for radiopaque was 74%and for computer assisted method was 82%. The interobserver variation was highly significant for wax impression method, significant for radiopaque wax impression method and was not found to be significant for computer assisted method .it suggests thatin wax impression technique, observers had less agreement and there was more interobserver variability. Second observer had better positive matching than the other two observers

Table 1:- Scoring By Observer –I In Impression Wax In Maxilla And Mandible

	Score 0	Score 1	Score 2
Maxillary	5	35	10
	10%	70%	20%
Mandibular	0	35	15
	.0%	70.0%	30.0%

Table 1: shows using impression wax method , maximum score was score1 (about70%) i.e out of six teeth , one to two teeth from the generated overlays match with the bite marks as per observer I

Table 2:- Scoring By Observer –IIIn Impression Wax In Maxilla And Mandible.

	Score 0	Score 1	Score 2
Maxillary	5	31	14
	10%	62%	28%
Mandibular	1	31	18
	2%	62.0%	36.0%

Table 2: The table represents the maximum scoring obtained by radiopaque impression wax method as per observer II is score 1 for both maxilla and mandible (62% each)

Table 3:- Scoring By Observer –IIIIn Impression Wax In Maxilla And Mandible.

	Score 0	Score 1	Score 2
Maxillary	3	37	10
	6%	74%	20%
Mandibular	5	35	10
	10%	70.0%	20.0%

Table 3 : represents that the maximum score obtained by observer III in impression wax method is score 1 being 74% in maxilla and 70% in mandible respectively

Table 4:- Scoring By Observer -I In Radiopaque Wax In Maxilla And Mandible.

	Score 1	Score 2	Score 3
Maxillary	30	18	02
	60%	36%	4%
Mandibular	22	28	00
	44.0%	56.0%	00.0%

Table 4 : shows that maximum score using radiopaque wax impression method is score 1 (60%) for maxillary cast i.e one to two teeth match and score 2 (56%) in case of mandibular cast i.e three to four teeth from generated overlays match with the cast

Table 5:- Scoring By Observer-IIIn Radiopaque Wax In Maxilla And Mandible.

	Score 1	Score 2	Score 3
Maxillary	21	27	02
	42%	54%	4%
Mandibular	18	32	00
	36%	64.0%	00.0%

Table 5 : represents that the maximum score obtained by radiopaque wax impression method is score 2 with (54%) in maxilla and (64%) in mandible i.e three to four teeth from generated overlays match with the cast as per observer II

Table 3:- Scoring By Observer –IIIIn Impression Wax In Maxilla And Mandible.

	Score 0	Score 1	Score 2
Maxillary	3	37	10
	6%	74%	20%
Mandibular	5	35	10
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Table 6:- Scoring By Observer- IIIIn Radiopaque Wax In Maxilla And Mandible.

	Score 1	Score 2	Score 3
Maxillary	27	22	01
	54%	44%	2%

Mandibular	14	36	00
	28%	72.0%	00.0%

Table 6: represents that the maximum score obtained by observer III in radiopaque wax impression method is score 1 (54%) in maxillary cast and score 2 (72%) in mandibular cast

Table 7:- Scoring By Observer- I In Computer Assisted Method In Maxilla And Mandible.

	Score 1	Score 2	Score 3
Maxillary	3	40	07
	6%	80%	14%
Mandibular	0	28	22
	.0%	56.0%	44.0%

Table 7: The table shows the maximum score by computer assisted method as per observer I is score 2 (80%) in case of maxillary cast and 56% in case of mandibular cast

Table 8:- Scoring By Observer- II In Computer Assisted Method In Maxilla And Mandible.

	Score 1	Score 2	Score 3
Maxillary	2	33	15
	4%	66%	30%
Mandibular	01	32	17
	2.0%	64.0%	34.0%

Table 8:represents that as per observer II the maximum score obtained by computer assisted method is score 2 being 66% in maxilla and 64% in mandible respectively

Table 9:- Scoring By Observer -III In Computer Assisted Method In Maxilla And Mandible.

	Score 1	Score 2	Score 3
Maxillary	03	30	17
	6%	60%	34%
Mandibular	0	31	19
	0.0%	62.0%	38.0%

Table 9:represents the maximum score obtained by observer III by computer assisted method is score 2 (60%) in maxilla and score 3 (38%) in mandible respectively

Discussion:-

The present study shows that the Maximum scoring using wax impression method in maxilla and mandiblewas score 1 by observer I(table1), score 1 by observer II(table 2) andscore 1 by observer III(table 3)..Similar results were obtained by**SarithaMaloth et al (2011)**andthey concluded thathand tracing methodsfrom either wax impressions of teeth or directly from study casts, because of low scoringaredetermined to be inaccurate and subjective[8]

Maximum scoring using radiopaque wax impression method in maxilla and mandible was score 1 as per observer I(table 4), score 2as per observer II(table 5) and score 1 in maxilla and score 2 in mandible as per observer III(table 6).Similar results were obtained by**NiluferGev P etal (2017)** and they concluded thatof the two hand tracing methods, radiopaque wax impression method showed scoring values more than wax impression method andwas better than the wax impression method for overlay generation[9]

Maximum scoring using computer assisted method in maxilla and mandible was score 2 as per observer I (table 7), score 2 as per observer II(table 8) and score 2 as per observer III(table 9)..Similar results were obtained by **Nima et al (2017)** where the %age of excellent matching was observed in 40% of apple samples, 6.6% of eggplant samples and 66.6% of chocolate samplesby computer assisted method[10]

The results of the present study showed that as per all the three observers, scoring was maximum in computer assisted method followed by radiopaque wax impression method and then wax impression method. All the three observers stated that on comparison between three different methods (inter group comparison), computer assisted methodwas best of the three methods. The interobserver agreement was found to be maximum in computer assisted method followed by radiopaque and then wax impression method, thus the computer overlay had a greater

percentage of positive matching and also a greater value indicating a higher examiner reliability when compared to other methods. Based on the results it is interpreted that the subjective variationin computerized overlay was less in comparison to other overlay analysis suggesting that the computerized overlay is more reliable and accurate than the other methods. Limitations of the study areSmall sample size and assesment of bite mark evidence made on humans requires additional investigation with development of sophisticated software with superior specificity as a tool to aid in justice.

Conclusion:-

The results of the present study showed that as per all the three observers, scoring was maximum in computer assisted method followed by radiopaque wax impression method and then wax impression method. All the three observers stated that on comparison between three different methods (inter group comparison), computer assisted method was best of the three methods. The interobserver agreement was found to be maximum in computer assisted method followed by radiopaque and then wax impression method, thus the computer overlay had a greater percentage of positive matching and also a greater value indicating a higher examiner reliability when compared to other methods. Based on the results it is interpreted that the subjective variationin computerized overlay was less in comparison to other overlay analysis suggesting that the computerized overlay is more reliable and accurate than the other methods. Limitations of the study areSmall sample size and assesment of bite mark evidence made on humans requires additional investigation with development of sophisticated software with superior specificity as a tool to aid in justice.

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