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EVALUATION OF THE ACCURACY, PRECISION AND VALIDITY OF HYDROPHILIC VINYL POLYSILOXANE IMPRESSION MATERIAL FOR BITE MARK ANALYSIS

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ABSTRACT

The present study was undertaken to assess the accuracy, precision and validity of hydrophilic Vinyl Poly Siloxane [VPS] impression material for bite mark documentation and analysis. Medium body VPS impressions of maxillary and mandibular anterior teeth among thirty subjects were taken and dental stone casts prepared. Hollow volume overlays were made and metric analysis was done using advanced imaging software like Adobe Photoshop - 9 and Image J. These values were compared to the measurements taken from bite mark impressions of the same 30 individuals on wax wafers using light body VPS material. The mean differences in the parameters measured by the different techniques were compared using Intra Class Correlation Coefficients [ICCC]. Additionally validity parameters such as sensitivity, specificity, positive and negative predictive value were computed.

Keywords: Forensic science, forensic odontology, bite marks, Vinyl Poly Siloxane impression material, hollow volume overlays, metric analysis

INTRODUCTION

Bite marks may be one of the physical and biological evidences left by criminals at the site of criminal act. Bite marks found at crime scenes show an array of angled indentations, abrasions, micro lacerations and contusions (Bernitz et al., 2006). The bites may be inflicted as a result of differing degrees of anger, revenge, sexual frustration, wrath, righteous indignation, and punishment (Webb et al., 2002). Suspects can be physically linked to or exonerated from crime scenes through fingerprints, DNA

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samples and bite marks (Bender et al., 2000). The validity of DNA evidence is, however, regularly challenged, and the role of bite marks as substantive evidence is thus of great importance. Bite mark identification is based on the individuality of a dentition, which is used to match a bite mark to a suspected perpetrator. The most important step in bite mark analysis is to recognize a patterned injury as a human bite mark (Sperry and Campbell, 1990; Lighthelm and Van Niekerk, 1994) followed by pattern association and metric analysis of the bite mark (Bernitz and Johanna, 2008). Making impression of the bite marks is an important method to preserve bite mark evidence. Impressions should be taken of the surface of the bite mark whenever it appears that this may provide useful information. A variety of impression materials like silicon rubbers and polyether has been suggested for making impressions. VPS impression material is the most widely used impression material in restorative as well as prosthetic dentistry and are reported to have better elasticity and dimensional stability in comparison to polyethers (Chee and Donovan, 1992).

But the accuracy of VPS impression material in bite mark documentation and analysis is not well documented as the literature search reveals very few studies. Improvements in accuracy and dimensional stability, surface quality, elastic recovery, flow flexibility, hydrophilicity and tear-strength should make VPS impression material an ideal medium for bite mark documentation also. Hence, this study is undertaken to assess the accuracy, precision and validity of hydrophilic VPS impression material for bite mark documentation and analysis.

MATERIAL AND METHODS

Thirty subjects with a complete set of natural upper and lower anterior teeth between the age group of 15 and 30 years, were included in the study after obtaining their informed consent. 18 subjects were male and 12 were female [Table 1]. Subjects with orthodontic appliances, intraoral prosthesis, impaired mouth opening, periodontal and gingival abnormalities, developmental tooth anomalies and severe wasting diseases were excluded from the study.

Positive replica of the upper and lower anterior teeth of all subjects were prepared using medium-body hydrophilic VPS impression material [Reprosil, Dentsply, Caulk] and dental stone.

Table 1: Subjects included in the study

	No. of subjects	Mean age ± standard deviation (in years)
Male	18	25 ± 6
Female	12	23 ± 8

Wax wafers were used to record the bite of anterior teeth in these individuals similar to the technique used by Rawson et al. (1984). Pink dental modeling wax No. 2, measuring 90 mm x 160 mm and 1.5 mm thickness but were first folded double and again folded around a cardboard measuring 55 mm x 115 mm and 0.15 mm thick, giving a total thickness of 6.15 mm. On the remaining cardboard, a label was applied and glued for recording the unique number, age, gender, Angle's classification, midline deviation, cross bites if present, rotations and any other additional information (Bernitz et al., 2006). The bites were taken around midday, between 10:00 AM and 3:00 PM, when the ambient temperature was higher during the summer months, as the wax is warmer and therefore easier to work with. The bites were taken at the central point of the wax wafers.

Following this, light body impression material was syringed in to the bite marks on the wax wafers. For support for the impression material, clear dental acrylic was used.

Incisal edges of teeth from the die stone models as well as VPS impressions were highlighted using permanent marker, for clarity during bite mark analysis. These highlighted incisal edges of all the die stone models and VPS impressions were scanned using a flat bed scanner [Astra 3600] along

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with American Board of Forensic Odontology [ABFO] scale No. 2 to rule out any geometrical distortion while scanning and stored with proper labeling for identification [Figures 1, 2].

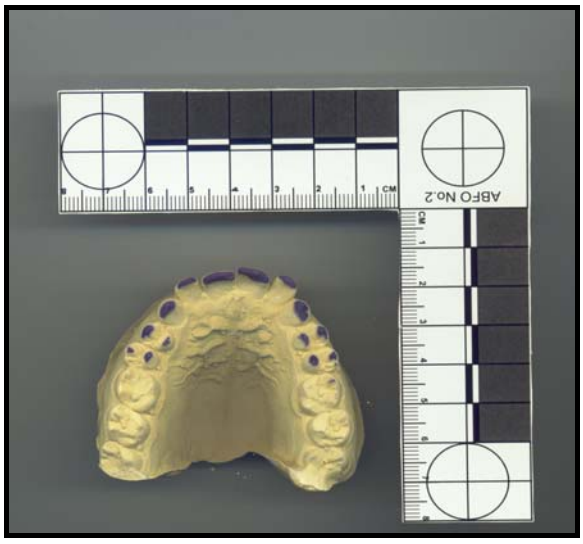

Figure 1: Scanned image of stone cast with American Board of Forensic Odontology scale No. 2 using flat bed scanner

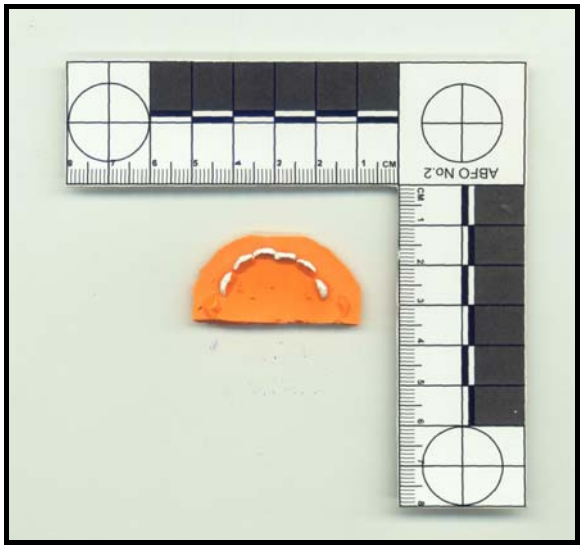

Figure 2: Scanned image of VPS impression with American Board of Forensic Odontology scale No. 2 using flat bed scanner

Overlays of these scanned highlighted incisal edges of the anterior teeth from stone model and VPS impressions were prepared using computer image-processing software, the Adobe Photoshop 9 ‘‘magic wand’’ tool (Johansen and Bowers, 2003) [Figures 3, 4]. Following this, metric analysis was carried out using features available in the “Image J” software, an image processing computer program available from the National Institutes of Health (Metcalf, 2008). Values obtained from stone models were considered as reference values and compared to values from VPS impression [Table 2].

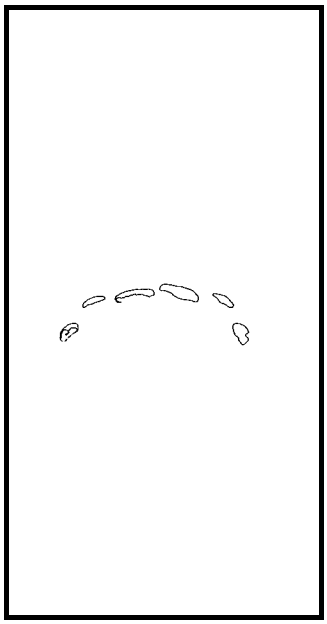

Figure 3: Hollow volume overlay of the incisal edges of stone cast shown in Figure 1

The subjects were numbered from 1 to 30 and the scores obtained from metric analysis were assigned to them. A comparison was made between the values obtained from stone casts and VPS impressions respectively. Those subjects in whom the values closely resembled were designated as “*Metric match*” and others in whom the values did not closely resemble, were designated as *“Metric non match”*.

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Table 2: Descriptive statistics for stone casts and VPS impressions

Variable	Minimum	Maximum	Mean	Standard Deviation
Maxillary cast surface area	0.037	0.095	0.061	0.015
Maxillary impression surface area	0.034	0.086	0.057	0.015
Maxillary cast perimeter	2.934	5.646	4.376	0.749
Maxillary impression perimeter	2.926	5.642	4.347	0.740
Mandibular cast surface area	0.029	0.073	0.046	0.011
Mandibular impression surface area	0.026	0.068	0.042	0.011
Mandibular cast perimeter	2.634	4.886	3.732	0.601
Mandibular impression perimeter	2.628	4.881	3.728	0.605

RESULTS

In statistics, intraclass correlation coefficients [ICC] is a descriptive statistic that can be used when quantitative measurements are made on units that are organized into groups. It describes how strongly units in the same group resemble each other. While it is viewed as a type of correlation, it operates on data structured as groups, rather than data structured as paired observations. ICC was used to compare the mean differences among various parameters like surface areas and perimeters of stone casts and VPS impressions [Table 3]. Difference was observed between the mean and standard deviation [SD] of maxillary cast surface area [MCSA] and maxillary impression surface area [MISA], maxillary cast perimeter [MCPM] and maxillary impression perimeter [MIPM], mandibular cast surface area [DCSA] and mandibular impression surface area [DISA] and mandibular cast perimeter [DCPM] and mandibular impression perimeter [DIPM]. This difference was found to be statistically significant using ICC at p-value less than 0.05.

Table 3: Comparison between the Mean and Standard Deviation of surface areas and perimeters of stone casts and VPS impressions using Intra Class Correlation Coefficient [ICC] test

Variable	Mean and Standard Deviation	ICC	p-value
Maxillary cast surface area	0.06 (0.01)	0.994	0.000
Maxillary impression surface area	0.05 (0.01)		
Maxillary cast perimeter	4.37 (0.74)	0.998	0.000
Maxillary impression perimeter	4.34 (0.73)		
Mandibular cast surface area	0.04 (0.01)	0.991	0.000
Mandibular impression surface area	0.04 (0.01)		
Mandibular cast perimeter	3.73 (0.60)	0.993	0.000
Mandibular impression perimeter	3.72 (0.60)		

n = 30 [ICC test]

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Additionally validity parameters such as sensitivity, specificity, positive predictive value and negative predictive value were computed. The sensitivity and specificity were obtained comparing *visual observation* with the acceptable standard as *metric + visual observation* using "*table of two*". The sensitivity obtained was 100 % and the specificity was 25 %. Sensitivity measures the proportion of actual positives which are correctly identified. Hence a sensitivity of 100 % means that the test recognizes all actual positives, which are the persons who truly made the bite marks. Specificity measures the proportion of negatives which are correctly identified. Hence a low specificity of 25 % means that the test may have more "false positive" results. Positive predictive accuracy in terms of VPS impressions was found to be 66.6 %, which implies a fairly high degree of accuracy for this method.

DISCUSSION

Once it has been established that the mark is in fact a human bite mark, a multidimensional pattern-associated analysis of every feature present in the mark is required. Bernitz has shown that a small degree of warping and shrinkage will not affect the pattern-associated analysis of the bite mark. The examiner will never know the exact position of the victim during the biting process, but the relationship of the dental features in a bite mark will remain constant, making bite mark analysis possible. It is required to demonstrate that the tooth marks present on the victim's body and the suspect's dentition show similar dental features present in the same position, in relation to the same teeth, in the same shaped arches and have similar size ratios (Bernitz and Johanna, 2008).

Impressions should be taken of the surface of the bite mark whenever it appears that this may provide useful information. During the biting process, the incisal surfaces of the teeth produce a characteristic bite pattern. Hence, the impression material used to record the case should accurately record the area and perimeter of incisal surfaces, tooth rotations, alignment and position of teeth in the arch. A variety of impression materials like silicon rubbers and polyether has been suggested for impression making. Hydrophilic VPS impression material is reported to have better elasticity and dimensional stability compared to other impression materials. It can be efficiently used for bite marks documentation and analysis as it provides sufficient elastic recovery upon removal from undercuts and interproximal spaces under tensile and compressive stresses and minimizes distortion and tears (Martinez et al., 2001). Distortion on removal from undercuts is virtually non-existent, because these materials exhibit the lowest strain in compression values. Moreover these are the most dimensionally stable of all the existing impression materials. No volatile reaction by product like hydrogen gas is released in the recently introduced products containing palladium, which acts as a hydrogen gas scavenger. This hydrogen gas can produce bubbles on the stone cast surface if poured immediately after VPS impression making. Hence hydrophilic VPS materials have a good compatibility with gypsum products for pouring the casts. Newer VPS impression materials have been designed to facilitate the balance of properties by enhancing precision in challenging clinical scenarios to minimize clinical problems such as voids, bubbles, pulls, and tears. These materials are labeled as hydrophilic or hydrophilized VPS, due to the addition of surfactants for better wettability (Rupp et al., 2005). Handling any of these materials is easy and they clean up well without staining. They reach final set depending upon the temperature situations. If the body is cold, as seen in cadavers preserved at lower temperatures, the setting time will be prolonged and if temperature is warm, the setting time will accelerate. Hence the setting time must be tested before the final impression on any area of the body away from the bitten area (Kirkland et al., 1987).

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Metric analysis is a method of establishing approximate numerical values which can be used in weighing the selected dental features like surface area and perimeter according to the relevant population statistics. It is important to realize that when comparing the measurements of the suspect's dentition with the tooth marks present on the skin of the victim, an exact match will seldom be found. A conclusion of ''absolute certainty'' should never be given, but of ''possible degree of certainty/possible identification'' would be more appropriate in bite mark cases (Bernitz and Johanna, 2008).

In our study, the ICCC for the difference between mean and SD of MCPM and MIPM was 0.998, between MCSA and MISA was 0.994, between DCPM and DIPM was 0.993 and between DCSA and DISA was 0.991, which indicates this difference to be statistically significant at the p-value less than 0.05. Further using values obtained from stone casts as the reference, the high sensitivity of 100 % through measures of validity indicates that VPS impression material can be used along with clinical pattern-association with high success rate for screening of the suspects. A low specifity of 25 % indicate that possible identification of the victims can be done only after taking other evidences into consideration to avoid the false positive results. Positive predictive accuracy of 66.6 % for VPS impression material indicates a fairly high degree of accuracy. The findings and results of our study are in accordance to Pretty and Sweet, who had used the term "highest level of forensic significance" which in effect does not imply "absolute certainty" (Pretty and Sweet, 2006). Three-dimensional (3D) comparative analysis of bite marks with the help of evolving technologies using laser scanners and comparative softwares is possible now. The availability, understanding and implementation of these advanced technologies require professional guidance, which can be obtained in required cases.

CONCLUSION

VPS impression material can be used effectively in forensic odontology for bite marks documentation and analysis. But as the sample size is small and representative of only a small population group, we recommend that bigger scientific studies may be further carried out.

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REFERENCES

Bender K, Schneider PM, Rittner C. Application of mt DNA sequence analysis in forensic casework for the identification of human remains. Forensic Sci Int 2000;113: 103–7.

Bernitz H, Johanna HO. An integrated technique for the analysis of skin bite marks. J Forensic Sci 2008;53:194-8.

Bernitz H, Heerden W, Solheim T, Owen J. A technique to capture, analyze and quantify anterior tooth rotations for application in court cases involving tooth marks. J Forensic Sci 2006;51:624-9.

Chee WW, Donovan TE. Polyvinyl siloxane impression materials: a review of properties and techniques. J Prosthet Dent 1992;68:728-32.

Johansen RJ, Bowers CM. Digital analysis of bitemark evidence. 2nd ed. Santa Barbara, CA: Forensic Imaging Services, 2003.

Kirkland G, Tatum RC, Soni NN, Perez RS. Forensic dentistry: solving the mysteries of identification. Gen Dent 1987;35:120.

Ligthelm AJ, Van Niekerk PJ. Comparative review of bite mark cases from Pretoria, South Africa. J Forensic Odontostomatol 1994;12:23–9.

Martinez J, Combe E, Pesun I. Rheological properties of vinyl polysiloxane impression pastes. Dent Mater 2001;17:471-6.

Metcalf RD. Yet another method for marking incisal edges of teeth for bite mark analysis. J Forensic Sci 2008;53:426-9.

Pretty I, Sweet D. The judicial view of bite marks within the United States criminal justice system. J Forensic Odontostomatol 2006;24:1-11.

Rawson RD, Ommen RK, Kinard G, Johnson J, Yfantis A. Statistical evidence for the individuality of the human dentition. J Forensic Sci 1984;29:245–53.

Rupp F, Axmann D, Jacobi A, Groten M, Geis GJ. Hydrophilicity of elastomeric non-aqueous impression materials during setting. Dent Mater 2005;21:94-102.

Sperry K, Campbell HR. An elliptical incised wound of the breast misinterpreted as a bite mark. J Forensic Sci 1990;35:1226–35.

Webb DA, Sweet D, Hinman DL, Pretty IA. Forensic implications of biting behavior: a conceptually underdeveloped area of investigation. J Forensic Sci 2002;47:103–6.