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Reliability of the Scoring System of the American Board of Forensic Odontology for Human Bite Marks

REFERENCE: Rawson, R. D., Vale, G. L., Sperber, N. D., Herschaft, E. E., and Yfantis, A., **"Reliability of the Scoring System of the American Board of Forensic Odontology for Human Bite Marks,"** *Journal of Forensic Sciences*, JFSCA, Vol. 31, No. 4, Oct. 1986, pp. 1235-1260.

ABSTRACT: In 1981, the Bite mark Standards Committee of the American Academy of Forensic Sciences and the American Board of Forensic Odontology developed a method of scoring bite mark comparisons in an attempt to standardize a scientific approach to bite mark analysis. The various methods of determining the validity of the scoring guide are presented with statistical data generated from scores reported by recognized forensic science experts.

KEYWORDS: odontology, bite marks, comparative analyses, analysis, comparison and standards

Although bite mark comparison techniques have been described as being as valid as fingerprints [*1*] there are some who have suggested a waiting period before their use, until standards have been described and scientifically validated [*2*]. Hale [*3*] suggested that bite mark evidence should be excluded from the courtroom because of the lack of scientific reliability, and because significant courtroom duels between respected dental experts have raised the possibility of the failure of bite mark evidence according to the Frye standard. The high

Received for publication 2 Dec. 1985; revised manuscript received 26 Feb. 1986; accepted for publication 4 March 1986.

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degree of uniqueness of human dentition has been demonstrated by Keiser-Nielsen [4], Rawson [5], and Sognnaes [6]. Establishment of this fact has allowed forensic odontologists to concentrate on determining the match between a dentition and the impression or bruising left on skin or other materials. Today it can be safely stated that if the correlation is high between the features of a dentition and those of a bite mark then there can be an assurance that no other set of teeth could have caused the mark. The question faced today is whether the degree of correlation between teeth and teeth marks can be determined reliably.

Few experimental studies have been carried out to determine the reliability of comparison techniques of bite marks in food or skin. One study [7] has demonstrated that the dentition which produced test bites in wax is easily recognized with a high degree of reliability by forensic dentists. However, experimental bite marks produced in pigskin demonstrate a much lower degree of reliability on the part of investigators in being able to determine the dentition causing the mark. Dinkle [8] indicated that there is no generally accepted approach to the evaluation of bite marks, and Butler [9] stressed the need of better systems for evaluation and classification of bite marks.

The purpose of the series of investigations reported in this paper was to determine the reliability of the system for evaluation of bite marks in human skin that was proposed by the Guidelines Committee of the American Board of Forensic Odontology and reported to the Odontology Section of the American Academy of Forensic Sciences [10].

Methods and Materials

A large dog was anesthetized in the animal facility of the University of Southern California according to accepted techniques for the handling of large animals for experimental purposes. The skin over its legs, back, and abdomen was shaved and a series of experimentally produced bite marks were created. Eight sets of dentition representing different types of arch shapes, tooth patterns, and bite classification were mounted on simple hinge axis articulators. Each set of dentition was pressed into the tissue and the arch held closed with large wood working clamps for 60 s. The marks produced were all well detailed and noticeable at the time of photography. The technique was not developed to determine the dynamics of tissue damage versus biting pressure, but merely to produce a consistent bite pattern, reproducible in future experiments. Photographs of the bite marks were then sent with eight sets of unidentified models to seven forensic odontologists for determination of the proper matches. One investigator was able to match all eight sets of models correctly to the bite marks they had caused. The average reliability or accuracy in correctly matching bite marks to the dentition was 66%. Although this test was small and scientifically incomplete, the results prompted some concern. There was a clear suggestion that there was not a universal ability to make adequate comparisons. Some widely experienced odontologists were not able to describe adequately their approach to evaluation in such a way that it could be reproduced by others. The members of the committee recognized that a common rating or scoring method was needed so that investigators could more accurately and consistently describe bite mark patterns and compare them to a dentition.

As part of the guidelines, which are published in a separate paper, the Guidelines Committee formulated a system of scoring each bite according to the overall arch size, shape, and tooth position within the arch [10] (Fig. 1).

The scoring system was developed with the basic premise that there should be a high point value allowed for unusual and unique features. Usual or ordinary features, although important, should not carry the same weight. The size and shape of the dental arch as reflected in the bite mark thus has point value, but not high point value unless the arch is significantly distinctive. Tooth position likewise has a weighted value and becomes particularly significant if it is unique or significantly distinctive. An average arch with well-aligned teeth is not as important an indicator of individuality as an arch with a tooth or teeth significantly out of

ABFO SCORING SHEET FOR BITE MARK ANALYSIS

(Important: Use only with scoring guide, score only *reliable* information)

Case Name: _____

Features Analyzed	No. of Points	SCORE Max.	SCORE Mand.	Discrepancy (if any)
GROSS				
1. All teeth in mark present in suspect's mouth	*One per arch			
2. Size of arches consistent	*One per arch			
3. Shape of arches consistent	*One per arch			
TOOTH POSITION				
4. Tooth and tooth mark in same labiolingual position	*One per tooth			
5. Tooth and mark in same rotational position (whether rotated or normal)	*One per tooth			
6. Vertical position of tooth re. occlusal plane matches depth of mark (use *only in unusual case*)	One per matching tooth			
7. Spacing between adjacent marking edges	*One per space			
INTRADENTAL FEATURES				
8. Mesiodistal width of tooth matches mark *(use only if individual tooth is clearly marked)*	*One per tooth			
9. Labiolingual width of tooth matches mark OR attrition of edge matches mark	**Three per tooth			
10. Distinctive curvature of tooth incisal edge matches mark *(use only in unusual case)*	Three per tooth			
11. Other distinctive features (fractured teeth, unusual anatomy)	Three per tooth			
MISCELLANEOUS				
12. Suspect has one edentulous arch and this is reflected in bite mark	Three			
	Total, each arch:			
	Grand Total:			

*Three points if feature is significantly distinctive.

**Only in case permitting accurate measurement.

_____

Signature *Date*

2/20/84 Committee on Bite Mark Guidelines
Raymond Rawson; Norman Sperber; Gerald Vale, Chairman

FIG. 1—*Copy of the scoring sheet recommended by the American Board of Forensic Odontology.*

normal alignment. Intradental features or discrete morphological characteristics tend to be weighted more heavily. A talon cusp or shoveling characteristic becomes more predictive of identity than average morphologic characteristics. Thus, a truly unique tooth in an unusual position has a very high evidence value and this is reflected in the scoring system.

The scoring system stressed that the investigator evaluate the bite mark and the suspected dentition causing the mark by their usual method. This instruction allowed for all types of individual techniques such as: overlays, measurements, scanning electron microscopy, en-

hancement, one to one, three to one, or computer analysis. Once the bite mark study was completed, the investigators were asked to make their comparison using the new scoring system.

For the present evaluation of the scoring system, three hypothetical cases were prepared to demonstrate three possible situations (Figs. 2 to 4). Figure 2 demonstrates an ideal match where all teeth match the mark identically. It was designed to produce the highest point value and represents the perfect match. Figure 3 demonstrates a situation where six teeth out of the twelve match the mark identically and two quadrants, containing six teeth total, were distorted in size or position so as to be a significant mismatch. This second case was designed to produce a mid-range score. Figure 4 demonstrates a situation with no teeth matching. All quadrants were distorted in size, all individual teeth were distorted in appearance and size. The case was not designed to produce a zero score. Position, size, or appearance did not match, but there were some common features between the dentition and the mark. For example, the same number of teeth were represented in the mark and the dentition.

The hypothetical bite marks were presented to 21 members of the Odontology Section of the American Academy of Forensic Sciences for evaluation and the data were collected and analyzed.

The next phase of the verification of the scoring guide consisted of the preparation of four actual cases that were known to be matches. These cases are represented in Figs. 5 to 8 and are bite mark cases where the perpetrator was known. Figure 5 is a demonstration of a bite mark considered as excellent for comparison purposes. A comparison with a bite of this quality would produce a high degree of confidence in the match, and was chosen to test the higher point values of the scoring system. Figure 6 displays some distortion, but most odon-

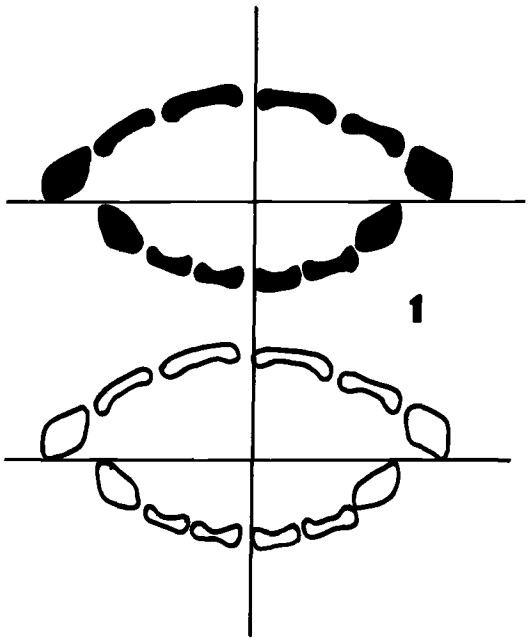


FIG. 2—*Hypothetical bite mark and dentition for comparison. The bite mark is represented by the solid color teeth and the dentition is represented by the outlined teeth. Bite 1 is the ideal match of twelve teeth.*

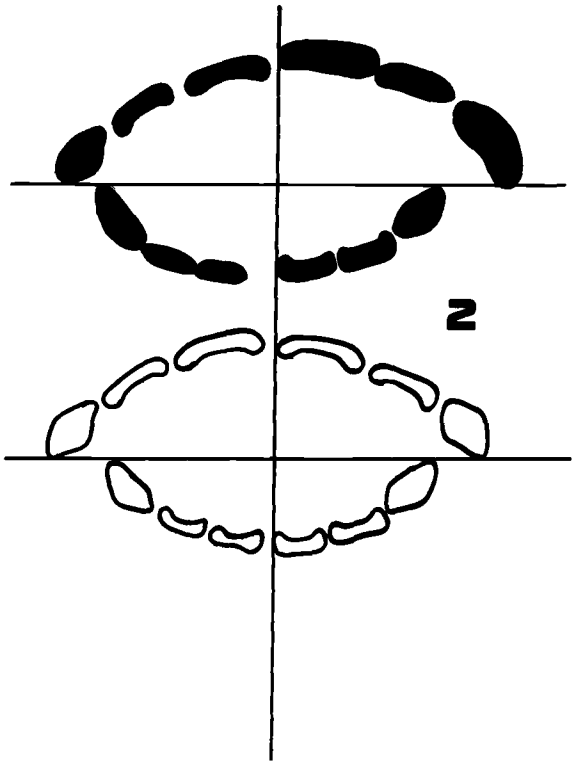


FIG. 3—*Same as Fig. 2, except that Bite 2 is a half match or only six teeth match the bite mark.*

tologists would probably agree that it contains enough information to produce a good match. Figure 7 displays distortion and unclear marks. An extensive analysis is required to determine the degree of suitability for match and many odontologists would consider it as having poor evidentiary value. Figure 8 is a bite mark with insufficient data to produce any confidence in matching to the dentition. All cases were known to match the dentition shown, but showed various degrees of difficulty in matching.

A full set of photographs of the four bite marks and four sets of models were clearly identified and sent to 100 forensic odontologists for rating by the guidelines and rating sheet. Since this was a scoring and not an identification exercise, the participants were told which sets of dentition matched each mark. Their scores should thus accurately establish the range of comparability of different investigators evaluating the same situation. All materials were sent with postage paid and precanceled return envelopes to avoid error associated with fear of investigator identification. The returned data were then analyzed.

A final test of the system consisted of producing a series of 24 experimental bite marks on living human skin in various locations. The bites were produced with the aid of a set of plastic models selected to demonstrate various curvatures, spaces, and individual morphological characteristics. The plastic models were mounted on a pair of lock pliers (Vice Grip®) and the maximum tolerable biting pressure was exerted for 30 s.

Each mark was photographed and subjected to evaluation and scoring by experienced forensic odontologists after thorough training in the use of the scoring system. The scores were then subjected to computer analysis for determination of consistency, reliability, and predictive value.

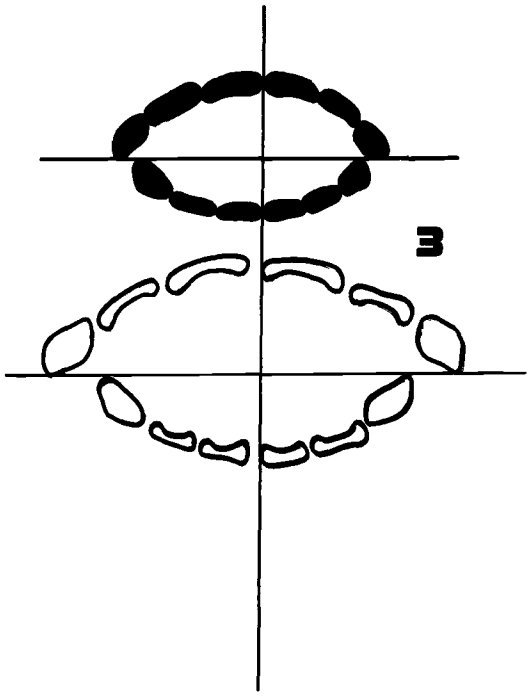


FIG. 4—*Same as Fig. 2, except that Bite 3 does not match between the teeth and the mark.*

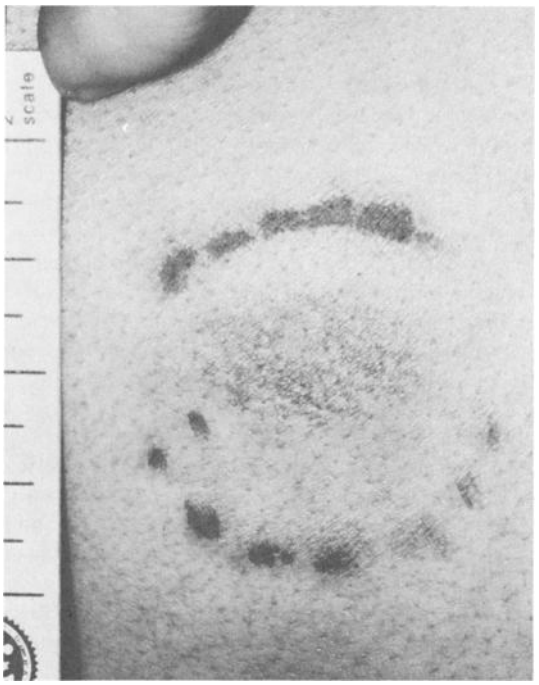


FIG. 5—*Actual bite mark used for matching—excellent bite mark.*

FIG. 6—*Actual bite mark used for matching—some distortion, but still an excellent bite mark.*

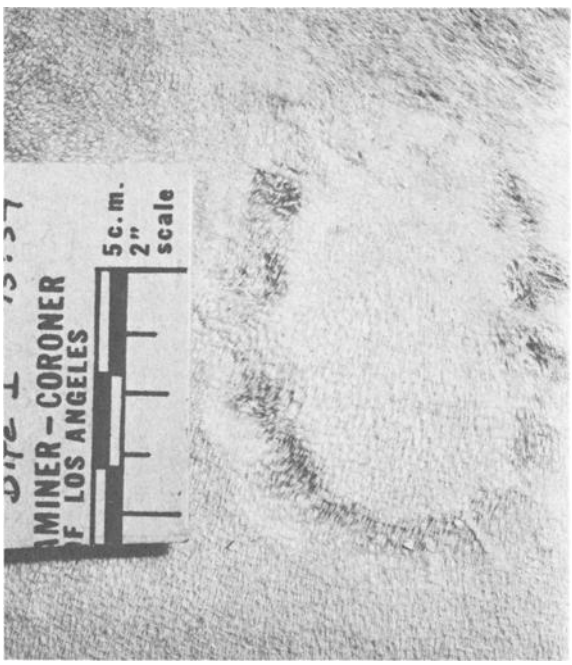


FIG. 7—*Actual bite mark used for matching—distorted and unclear mark.*

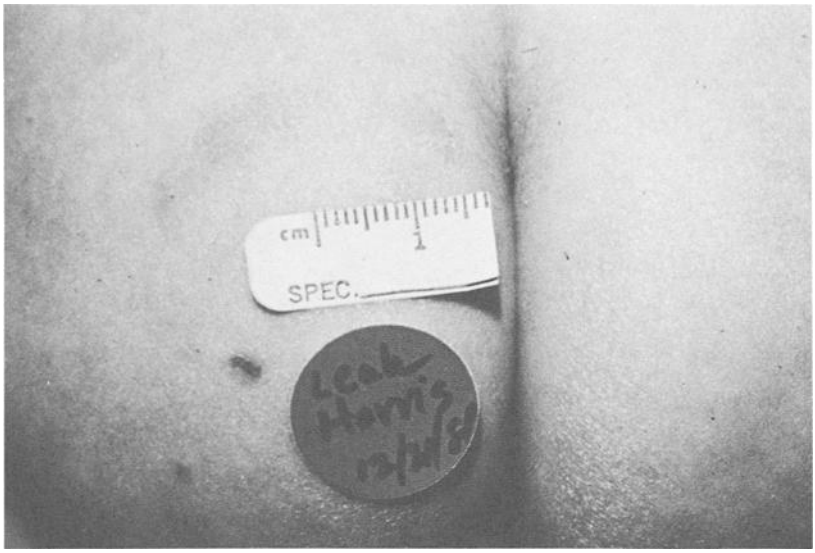


FIG. 8—*Actual bite mark used for matching—poor quality bite mark. See text for explanation.*

Results

The scores recorded for the three hypothetical bite marks are shown in Fig. 9. The results indicate that there was a high degree of consistency in determining the degree of match by twenty-one dental experts. The grouping of scores suggest a clear discrimination between a perfect match of twelve teeth and a match of only six teeth or the complete lack of a match. Ninety-five percent confidence levels and mean scores that were plotted for each of the bites demonstrate a straight line relationship between the degree of match and the mean score value (Fig. 10).

Of the larger sample size sent to a hundred odontologists and consisting of the actual bite marks, fifty-two of the sets were returned with the scoring completed on varying numbers as a result of breakage in transit. Forty-one sets were complete in their information and scoring. The completed scoring sheets were used to complete the final statistical analysis.

The data for all bites were analyzed with the help of the Statistical Package for the Social Sciences (SPSS) version 8.3 [*11*]. The data for each bite were analyzed separately, the distribution of each of the variables or questions was determined, and the following statistics were produced for each: average, mean, standard deviation, correlation coefficient, 95% confidence values for the true mean, estimated communality, Eigen value, percent of variable, cumulative percent, factor matrix, varimax rotated factor matrix, after rotation with Kaiser normalization, transformation matrix, and factor score coefficients. The complex statistical results were abbreviated for this paper, but are available on request.

The questions on the scoring guide (Fig. 1) were listed as variables and numbered in order of occurrence on the score sheet for simplification in computer processing. The first question, "All teeth in mark present in suspect's mouth?," was listed as Variable 1, and so forth. The responses to Bite 1 (Fig. 2) demonstrate that the answers corresponding to Variables 1,2,3,4,5,8, and 9 are consistent except for the response of the twelfth person, which is erratic. Variable 7 is more fluctuant and Variables 6 and 10 are very difficult to estimate. A histogram for each one of these variables is given in Fig. 11 with the exception of Variables 6 and 10 which are very unstable.

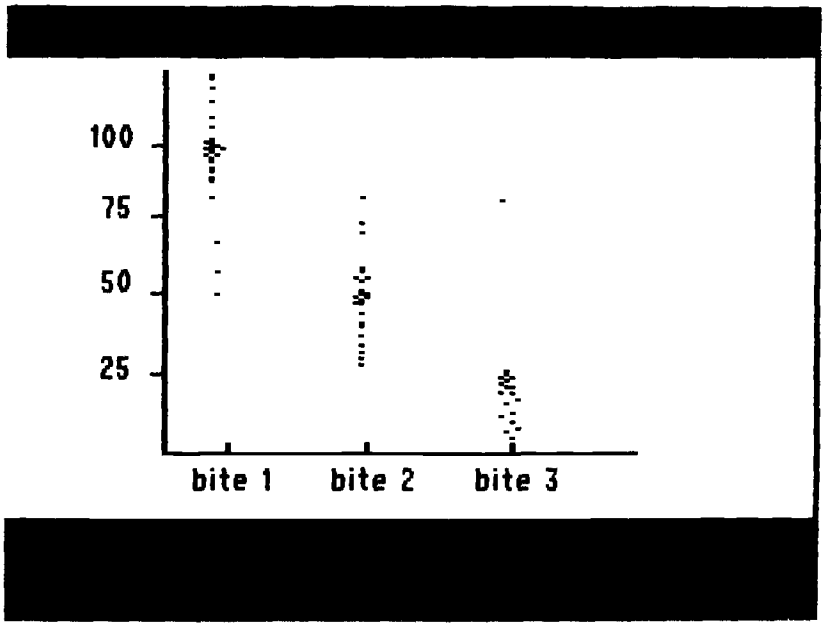


FIG. 9—*Distribution of scores for the three hypothetical bites demonstrating the discrimination of different types of bites.*

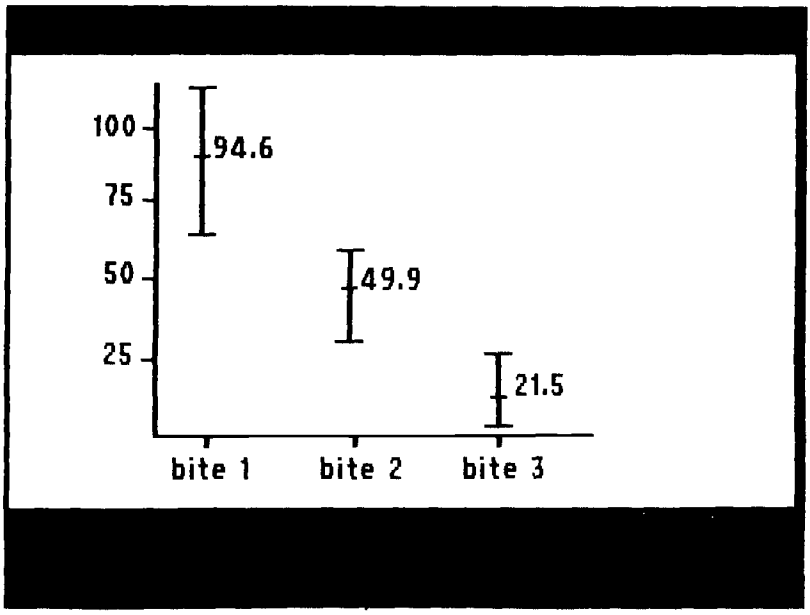


FIG. 10—*Ninety percent confidence values and mean score values for each hypothetical bite demonstrating a direct proportion between score and degree of match.*

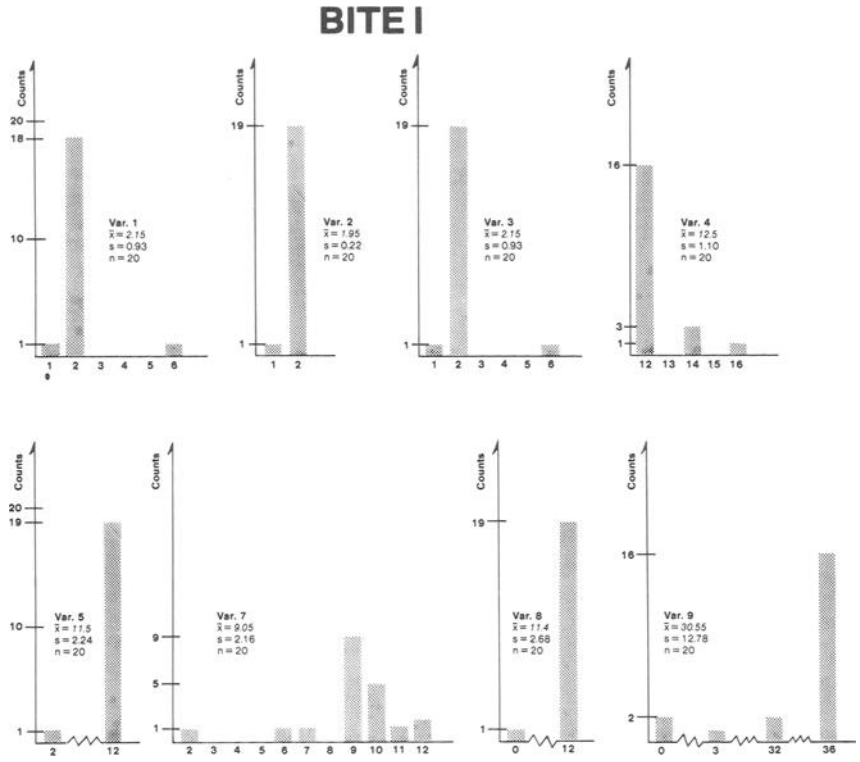


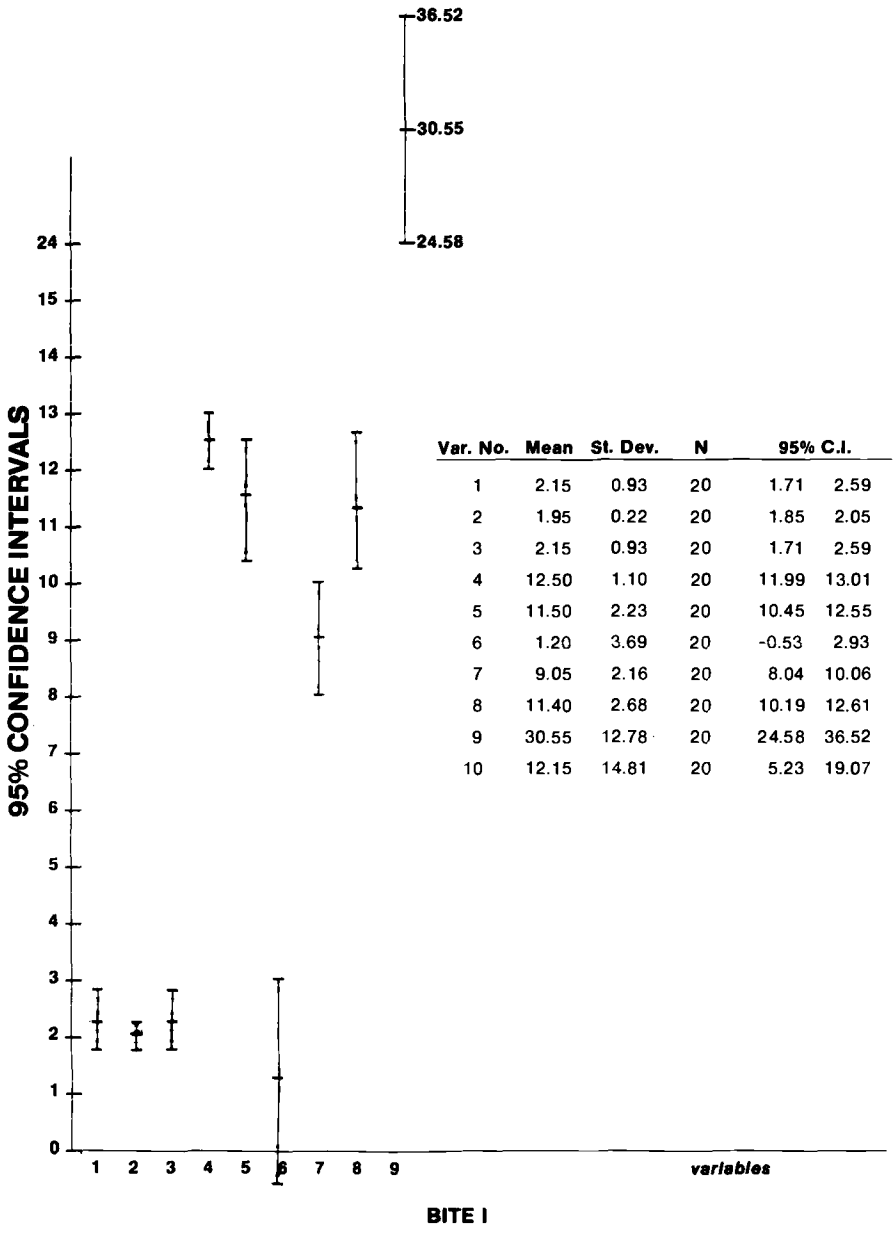
FIG. 11—*Histogram for each of the variables evaluated for Bite 1 (Fig. 2).*

The correlation between:

Variables 1 and 3 is 1,
Variables 1 and 4 is 0.74,
Variables 1 and 5 is −0.97,
Variables 3 and 4 is 0.74,
Variables 3 and 5 is −0.97,
Variables 4 and 5 is −0.75, and
Variables 8 and 9 is 0.56.

All of these correlations are highly significant. Especially the first one that indicates an identical or exactly proportional behavior of the two variables. Those areas of high correlation correspond to a high percentage of the respondents "seeing" the same thing. Variables with a lower correlation indicate an uncertainty on the part of the participating dentist and variables with a very poor correlation indicate the inability to "see" certain features. Some variables were more useful in determining the presence of a match, suggesting that the questionnaire might be trimmed down to fewer questions. However, there were some variables that correlated well in the cases difficult to match and these may actually be an indication of the lack of match just as other variables may indicate a high level of "seeing" ability.

Ninety-five percent confidence interval values were prepared for each of the variable scores. These are presented in Fig. 12 with the average score, standard deviation, number of respondents, and 95% confidence interval for each true mean score. The confidence values demonstrate that with a probability or confidence of 95%, the true value is within the speci-



Var. No.	Mean	St. Dev.	N	95% C.I.	
1	2.15	0.93	20	1.71	2.59
2	1.95	0.22	20	1.85	2.05
3	2.15	0.93	20	1.71	2.59
4	12.50	1.10	20	11.99	13.01
5	11.50	2.23	20	10.45	12.55
6	1.20	3.69	20	-0.53	2.93
7	9.05	2.16	20	8.04	10.06
8	11.40	2.68	20	10.19	12.61
9	30.55	12.78	20	24.58	36.52
10	12.15	14.81	20	5.23	19.07

FIG. 12—*Ninety-five percent confidence intervals given for each of the variables (questions) evaluated for Bite 1 (Fig. 2).*

fied limits. If these confidence limits are narrow for a variable, then that implies that the experts were very close to each other and this variable has demonstrated a high "seeing ability."

The responses to Bite 2 (Fig. 3) are seen in Fig. 13 and indicate that Variable 1 is very consistent while Variables 2,3,4,5,7,8, and 9 have distributions with big variances. It is thus

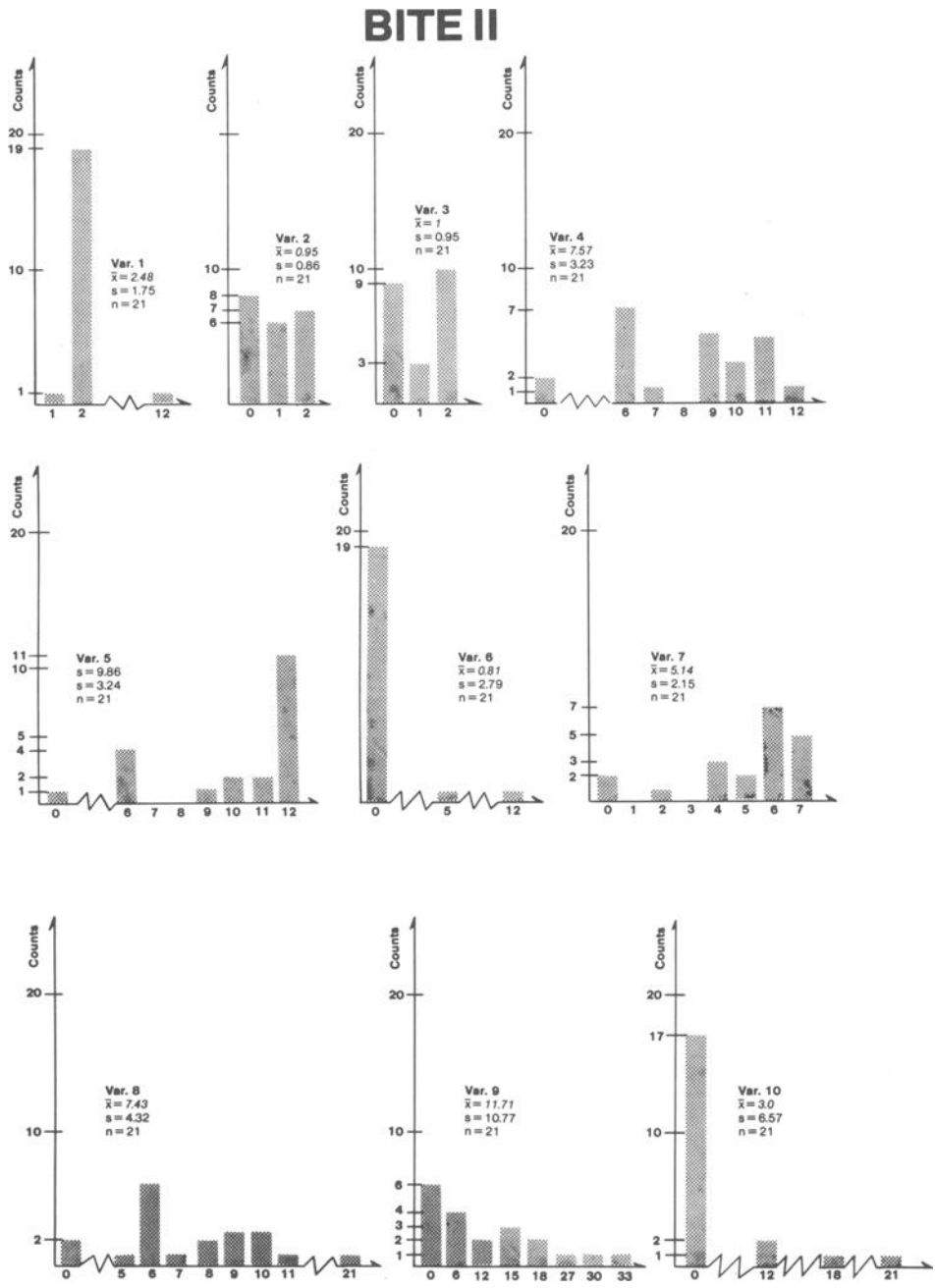


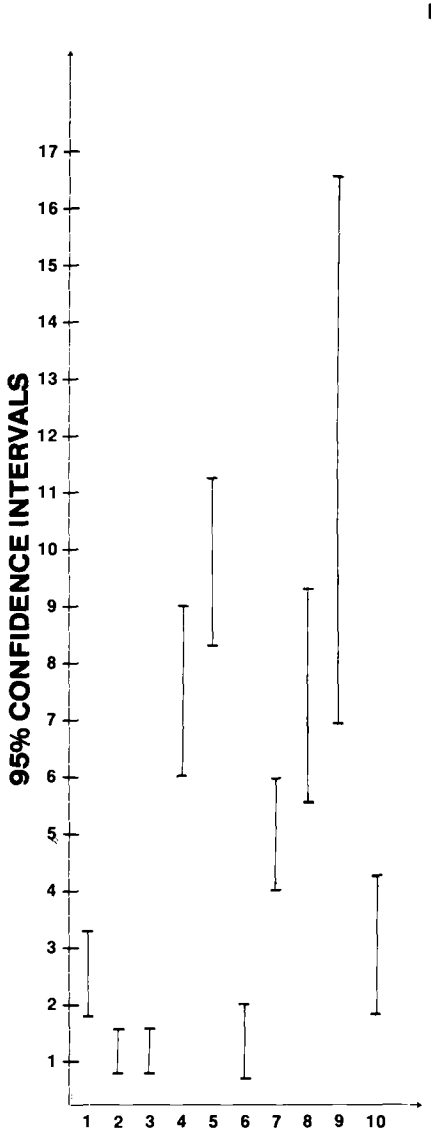
FIG. 13—*Histogram for each of the variables evaluated for Bite 2 (Fig. 3).*

difficult for the true value to be estimated. Variable 6 has a high frequency of zeros making it difficult to be detected.

The correlation between:

Variables 1 with 8 is 0.7,
Variables 2 with 3 is 0.5,
Variables 2 with 5 is 0.5,
Variables 4 with 5 is 0.6, and
Variables 5 with 7 is 0.7.

All are highly significant.



Var. No.	Average	St. Dev.	N	95% C.I. for the True Mean	
1	2.48	1.75	21	1.68	3.28
2	0.95	0.86	21	0.56	1.34
3	1.0	0.95	21	0.57	1.43
4	7.57	3.23	21	6.10	9.04
5	9.85	3.24	21	8.38	11.33
6	0.81	2.79	21	0.46	2.08
7	5.14	2.15	21	4.16	6.12
8	7.43	4.32	21	5.46	9.40
9	11.71	10.77	21	6.81	16.61
10	3.00	6.57	21	1.57	4.43

FIG. 14—*Ninety-five percent confidence intervals given for each of the variables evaluated for Bite 2 (Fig. 3).*

The 95% confidence interval values are shown in Fig. 14.

Analysis of the data from Bite 3 (Fig. 4) shown in Fig. 15 indicates that only the answer to Variable 1 is consistent. Variables 2,3,4,5,6,7,8, and 9 have many zeros as responses and are very difficult to be measured. This indicates a definite lack of match, although in the case of Variable 3, one half of the dentists seem to be consistent while the other half might not have a good understanding of the question.

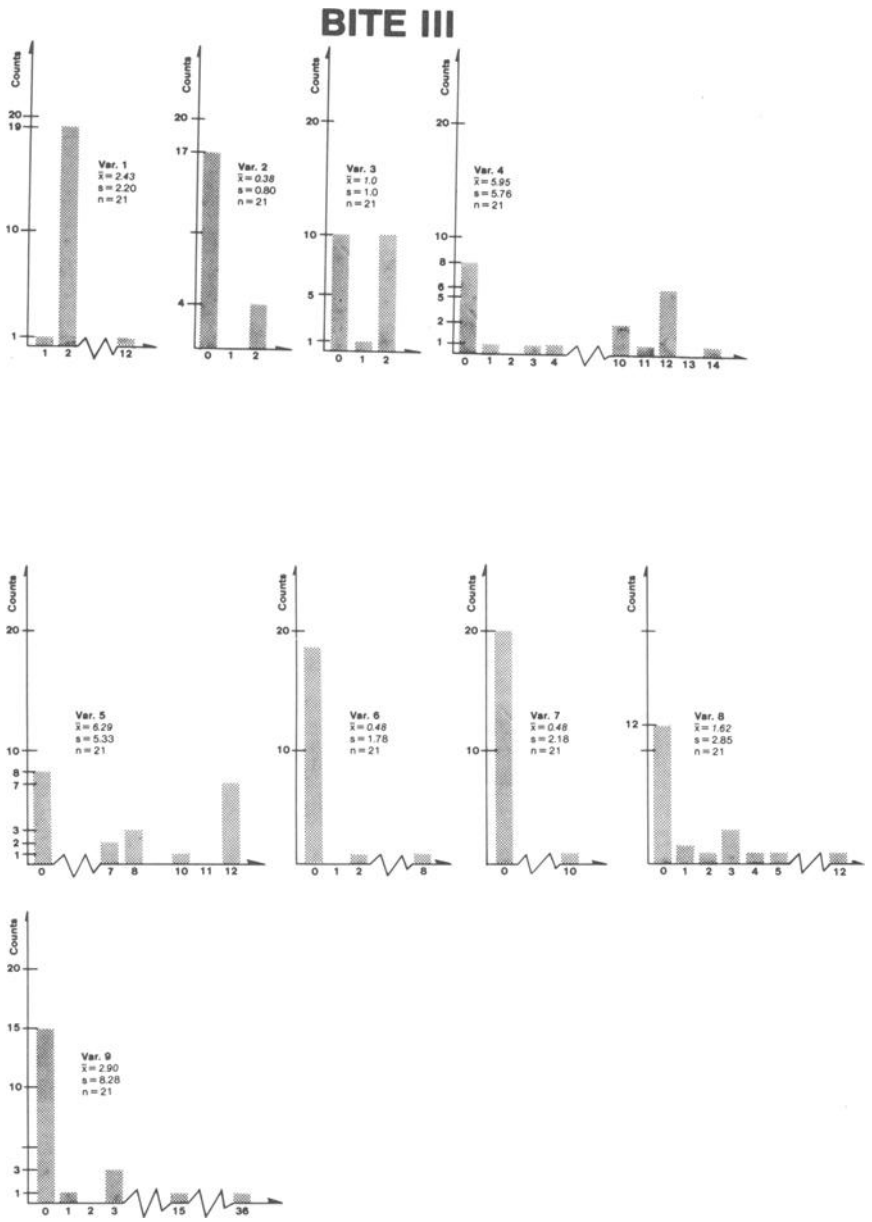


FIG. 15—*Histogram for each of the variables evaluated for Bite 3 (Fig. 4).*

The 95% confidence intervals indicate those questions that were interpreted in the same way by the majority of dental experts (Fig. 16).

Analysis of data for Bite 4 (Fig. 5) demonstrated in Fig. 17, indicates that the answers corresponding to Variables 1 and 2 are very consistent. The correlation between the two Variables is 0.9 and they have very similar behavior. Variable 3 is also very consistent while Variables 4,5, and 8 are very fluctuant and thus difficult to estimate. Variables 6,7,9, and 10 have many zeros as responses which implies that many odontologists have difficulty in detecting the existence of a matching feature in those questions.

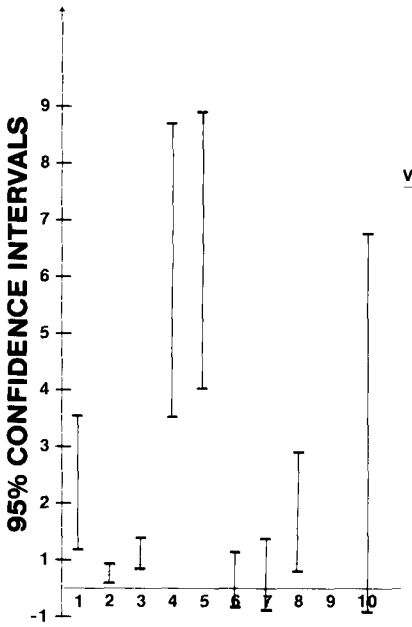
The correlation between:

Variables 1 and 2 is 0.9,
Variables 1 and 3 is 0.5,
Variables 2 and 3 is 0.4, and
Variables 4 and 5 is 0.6.

They are all significantly greater than zero.

Figure 18 gives the 95% confidence intervals for Bite 4 (Fig. 5).

Analysis of data for Bite 5 (Fig. 6) as seen in Fig. 19, indicates that Variable 1 is very consistent, and although Variables 2 and 3 have some spread, the probability of estimating



Var. No.	Mean	St. Dev.	N	95% Confidence Intervals	
1	2.43	2.20	21	1.43	3.43
2	0.38	0.80	21	0.01	0.75
3	1.00	1.00	21	0.55	1.45
4	5.95	5.76	21	3.33	8.57
5	6.29	5.33	21	3.86	8.72
6	0.48	1.78	21	-0.33	1.29
7	0.48	2.18	21	-0.51	1.47
8	1.62	2.85	21	0.32	2.92
9	2.90	8.28	21	-0.86	6.67

FIG. 16—*Ninety-five percent confidence intervals given for each of the variables evaluated for Bite 3 (Fig. 4).*

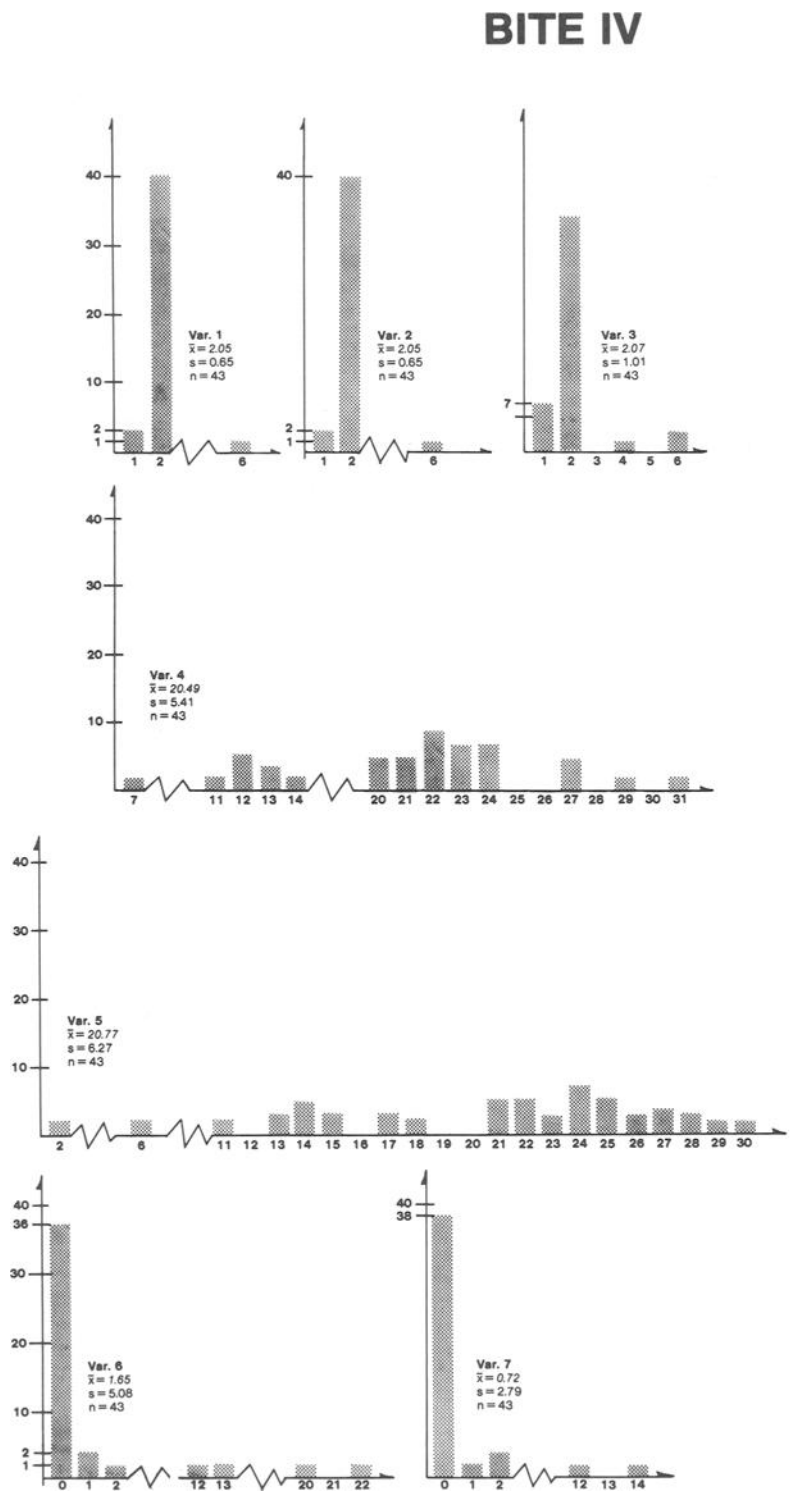


FIG. 17—*Histogram for each of the variables evaluated for Bite 4 (Fig. 5).*

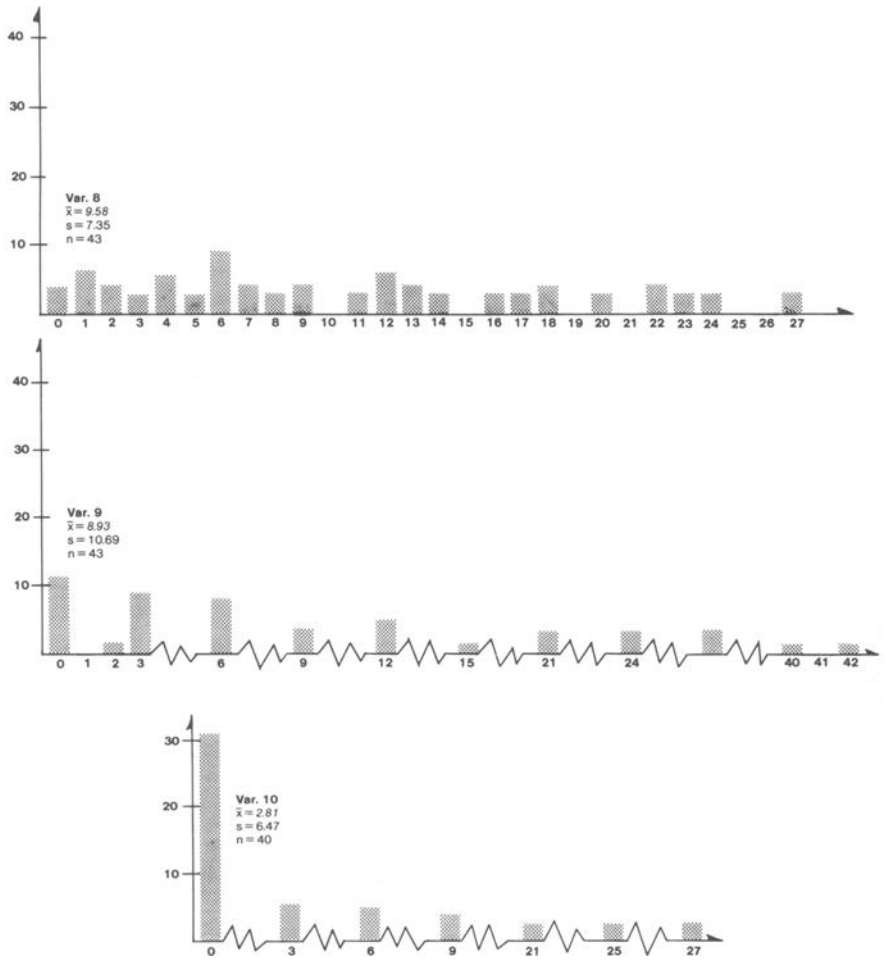


FIG. 17—*Continued.*

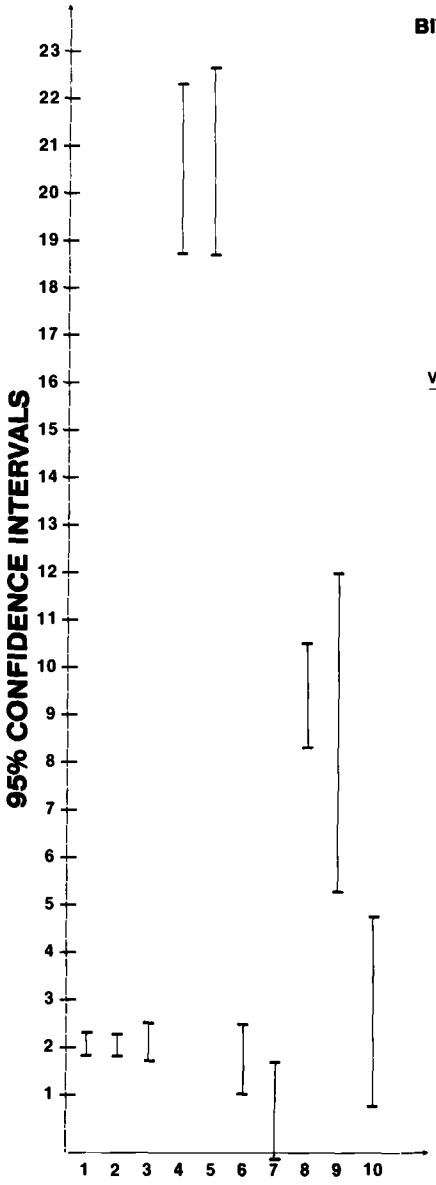
the correct value is 27/41 and 21/41, respectively. The spread indicates a confusion between allowing one or two points for those particular features. This type of indecision is typical of a distorted or blurred feature that is understood by some investigators and not understood by others. The 95% confidence intervals shown in Fig. 20 indicate a high degree of consistency with 95% of the odontologists being within one point or less of the design or predicted value. Variables 4 and 5 have distributions with big spreads while Variables 6,7,8,9, and 10 are difficult to be detected.

The correlation between:

Variables 2 and 3 is 0.6, and
Variables 4 and 5 is 0.5

and these are significantly higher than zero.

Analysis of data from Bite 6 (Fig. 7) is shown in Fig. 21 and demonstrates that Variable 2 is very consistent. In Variables 1 and 3, 2 is the value with the maximum likelihood. Variables 4 and 5 have distributions with big variances, and Variables 6,7,8,9, and 10 are very



Var. No.	Average	St. Dev.	N	95% C.I. for the True Mean	
1	2.05	0.65	43	1.84	2.24
2	2.05	0.65	43	1.84	2.24
3	2.07	1.01	43	1.76	2.38
4	20.49	5.41	43	18.82	22.15
5	20.77	6.27	43	18.84	22.70
6	1.65	5.08	43	0.88	2.42
7	0.72	2.79	43	-0.14	1.58
8	9.58	7.35	43	8.46	10.70
9	8.93	10.69	43	5.64	12.22
10	2.81	6.47	43	0.82	4.8

FIG. 18—*Ninety-five percent confidence intervals given for each of the variables evaluated for Bite 4 (Fig. 5).*

difficult to be detected since most of the reported values are 0. The correlation between Variables 4 and 5 is 0.8 and is significantly positive.

The 95% confidence intervals are given in Fig. 22.

Analysis of data from Bite 7 (Fig. 8) is demonstrated in Fig. 23 and indicates that Variables 1,2, and 3 have distributions with small variances while Variables 4 and 5 have distributions with big variances. Variables 6,7,8,9, and 10 have many zeros which implies that the items addressed in those questions are difficult to be detected or nonexistent. The 95% con-

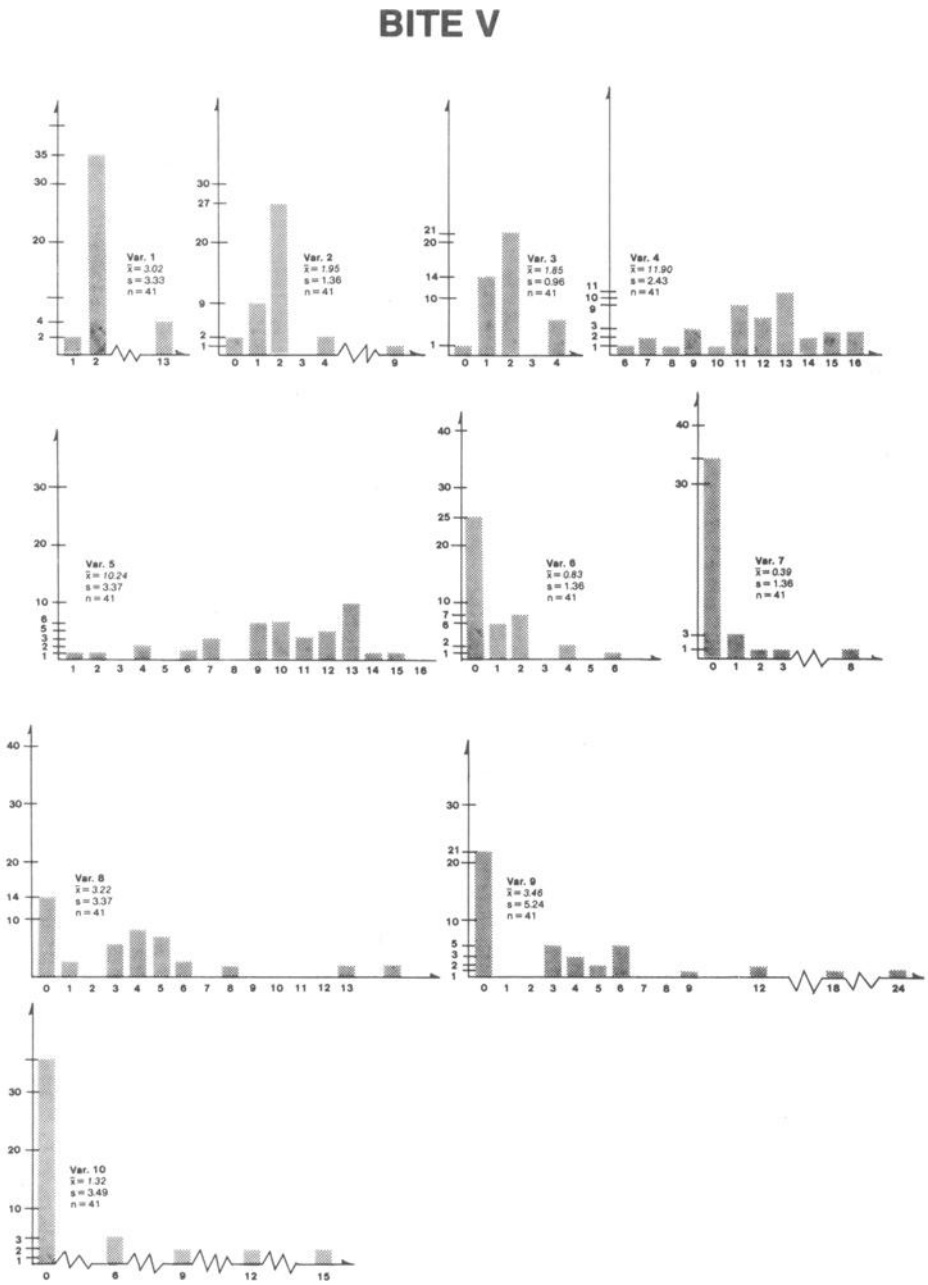
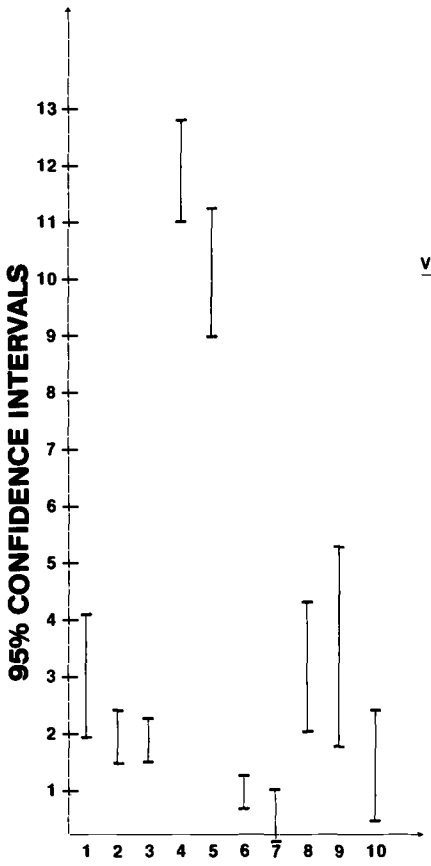


FIG. 19—*Histogram for each of the variables evaluated for Bite 5 (Fig. 6).*



Var. No.	Average	St. Dev.	N	95% C.I. for the True Mean	
1	3.02	3.33	41	1.97	4.07
2	1.95	1.36	41	1.52	2.38
3	1.85	0.96	41	1.55	2.16
4	11.90	2.43	41	11.13	12.67
5	10.24	3.37	41	9.18	11.30
6	0.83	1.36	41	0.40	1.26
7	0.39	1.36	41	-0.04	0.82
8	3.22	3.37	41	2.16	4.28
9	3.46	5.24	41	1.81	5.11
10	1.32	3.49	41	0.22	2.42

FIG. 20—*Ninety-five percent confidence intervals given for each of the variables evaluated for Bite 5 (Fig. 6).*

fidence intervals as shown in Fig. 24 indicate that there is a highly consistent response from the odontologists and suggests a high degree of confidence in the lack of a match.

The mean scores for bite mark Examples 4 through 7 (Figs. 5 to 8) are compared to those of the hypothetical bites (Examples 1 to 3) in Fig. 25. The actual bite mark cases were selected to fall within the scores produced by the hypothetical or idealized bite marks. When compared graphically, they do fall within the range that was predicted by the investigators.

The final scoring data of 24 marks produced on living human skin were subjected to statistical analysis. The mean scores and 90% confidence values are presented in Fig. 26 and demonstrate a consistent predictive value. The marks were scored by different groups of odontologists with 40% of the marks being scored more than once by the same individual. Of the examiners, 90% scored the bites a second time within plus or minus 2 points, thus demonstrating an extremely high confidence level or reliability in seeing and describing the same thing at different times. The information gained from this set of 24 bite marks will be presented in more detail in another paper.

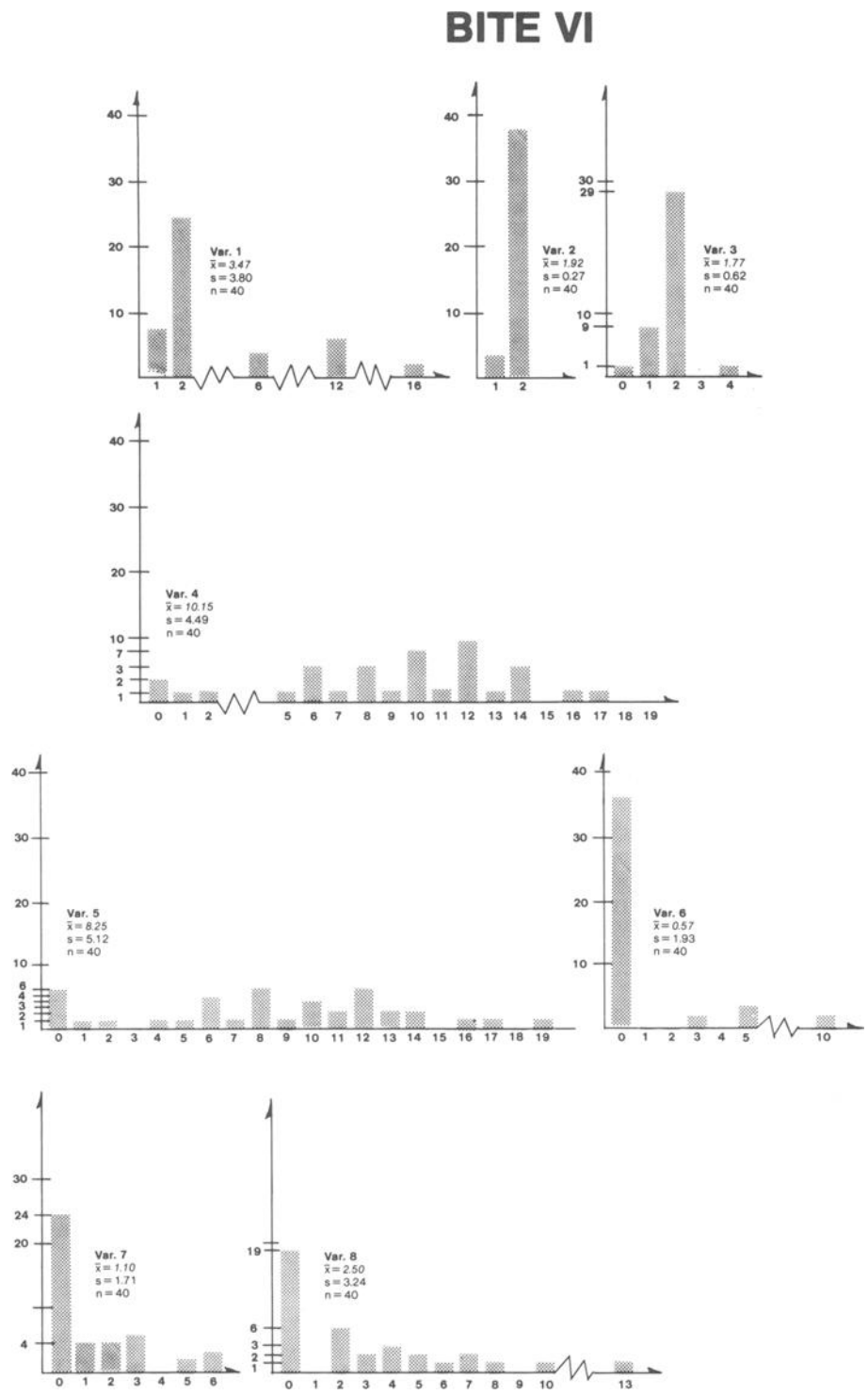
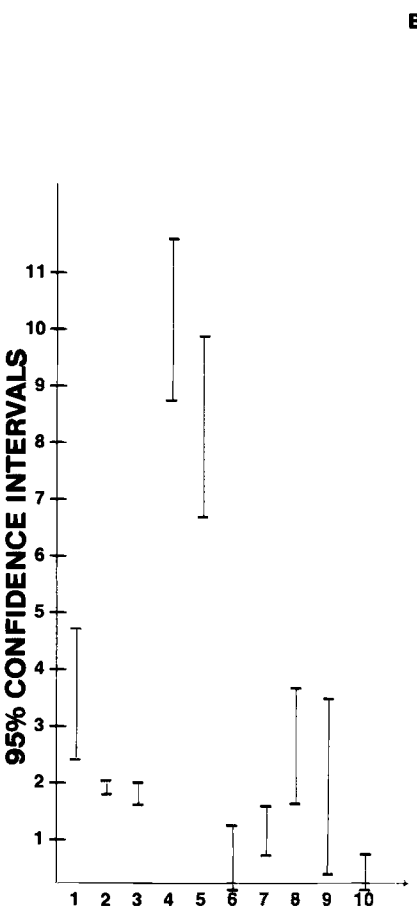


FIG. 21—*Histogram for each of the variables evaluated for Bite 6 (Fig. 7).*



Var. No.	Mean	St. Dev.	N	95% Confidence Intervals for the Mean	
1	3.47	3.80	40	2.25	4.69
2	1.92	0.27	40	1.84	2.01
3	1.77	0.62	40	1.57	1.97
4	10.15	4.49	40	8.67	11.58
5	8.25	5.12	40	6.61	9.89
6	0.57	1.93	40	-0.05	1.19
7	1.10	1.71	40	0.56	1.64
8	2.50	3.24	40	1.47	3.53
9	1.57	4.95	40	0.008	3.14
10	0.22	1.05	40	-0.11	0.56

FIG. 22—*Ninety-five percent confidence intervals given for each of the variables evaluated for Bite 6 (Fig. 7).*

Conclusions

Comparison of bite marks to dentition is a procedure commonly encountered in the field of criminal justice. Bite mark evidence is often an important part of the courtroom proceeding and it is absolutely essential that the statements made in that setting are accurate and technically well founded. A need for guidelines, common language, and an evaluating system capable of consistent and reproducible values has become apparent.

Every bite mark analysis may not result in a record of the individual characteristics of the teeth or arch form which is useful for identification. All marks evaluated in this study were consistent with the causing dentitions, but they could not all be tied positively to them on the basis of available evidence. Some dynamic distortions were produced when bites were attempted on curved surfaces, but they were recorded and analyzed and will be the subject of another paper.

The scoring system presented in this paper has demonstrated a method of evaluation that produced a high degree of reliability among observers. In addition, it demonstrated the abil-

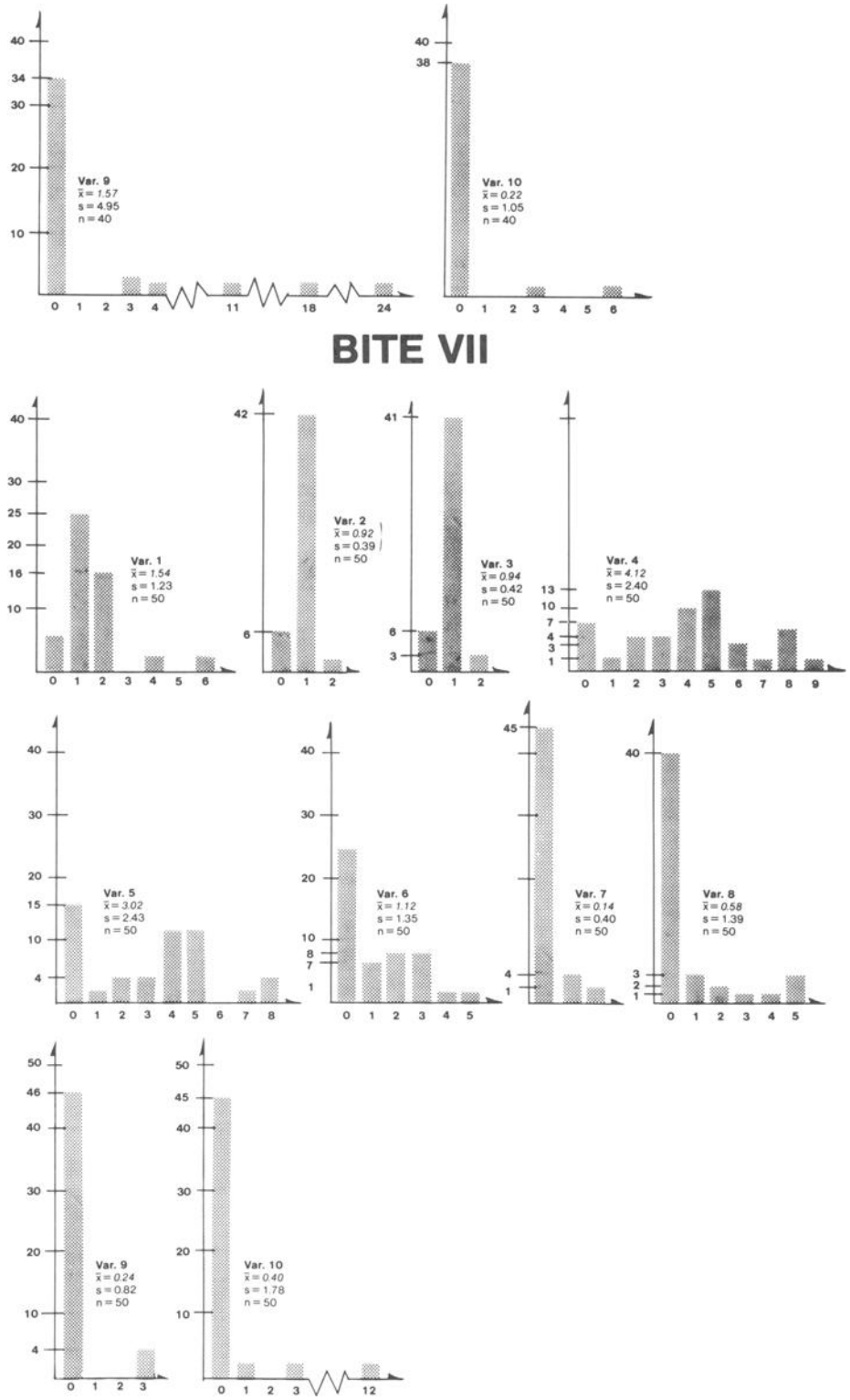
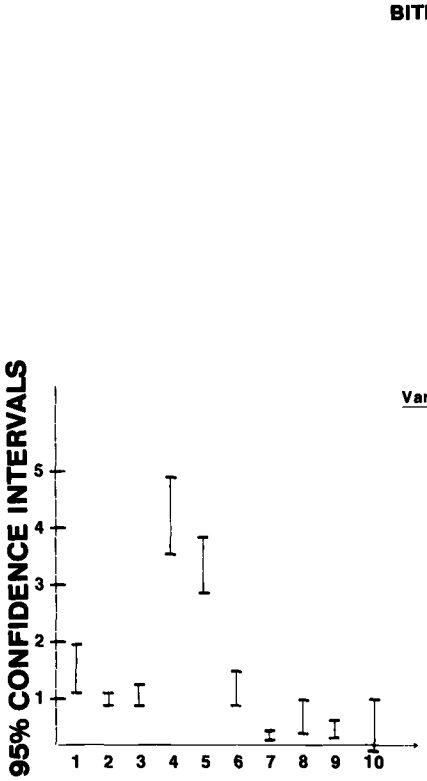


FIG. 23—*Histogram for each of the variables evaluated for Bite 7 (Fig. 8).*



Var. No.	Mean	St. Dev.	N	95% Confidence Intervals	
1	1.54	1.23	50	1.19	1.89
2	0.92	0.39	50	0.81	1.03
3	0.94	0.42	50	0.82	1.06
4	4.12	2.40	50	3.44	4.80
5	3.02	2.43	50	2.33	3.71
6	1.12	1.35	50	0.74	1.50
7	0.14	0.40	50	0.02	0.25
8	0.58	1.39	50	0.38	0.78
9	0.24	0.82	50	0.01	0.47
10	0.40	1.78	50	0.1	0.9

FIG. 24—*Ninety-five percent confidence intervals given for each of the variables evaluated for Bite 7 (Fig. 8).*

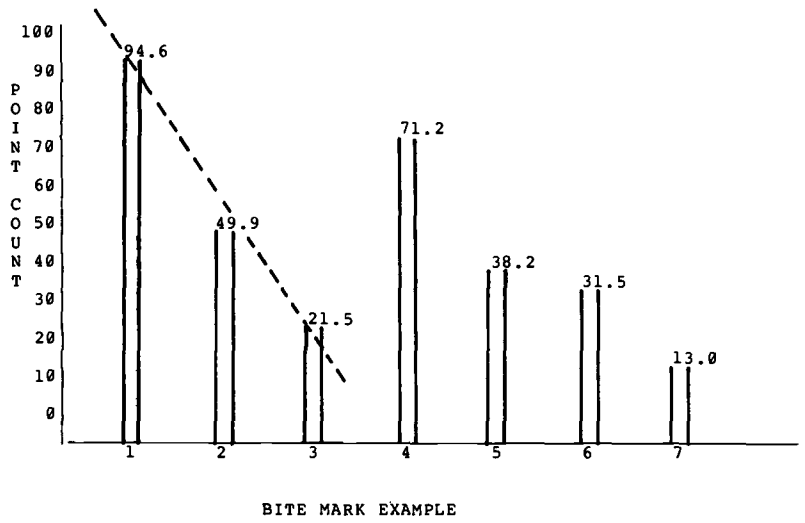


FIG. 25—*Comparison of the mean scores of the hypothetical or ideal bite marks (1,2, and 3) with four actual cases (4,5,6, and 7).*

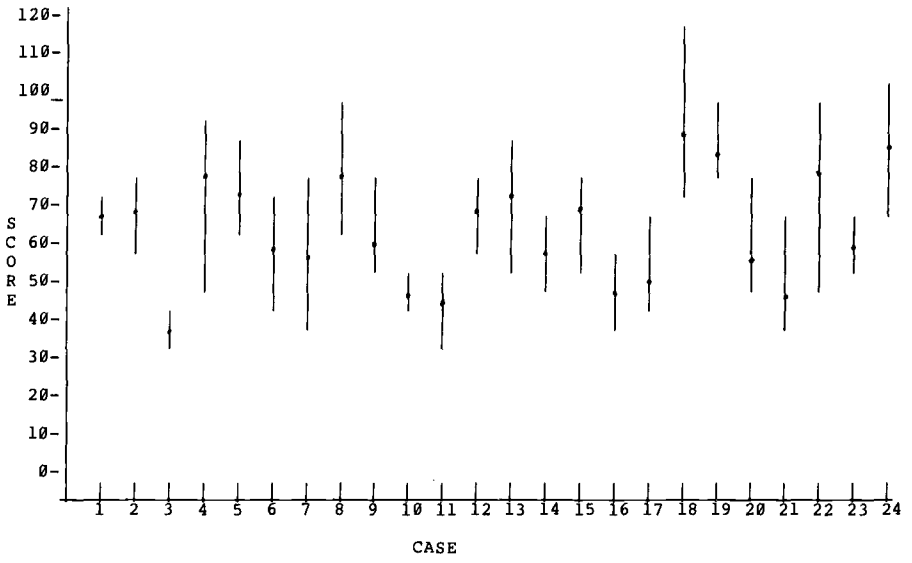


FIG. 26—*Range, 90% confidence values, and mean scores of bites produced on living human skin demonstrating the high level of reliability associated with the scoring guide.*

ity to discriminate between different degrees of match. If the score is above a certain value then there is a high confidence level that there is a match that could not have been produced by any other set of dentition. Further, if the bite mark is compared or evaluated by a group of forensic dentists and there is a corresponding high degree of consistency, then there is an extremely high confidence level in the conclusion of identity. The authors agree with Ligthelm and de Wet [*12*] that there is a greater strength in certainty if a positive identification is confirmed by more than one qualified dental forensic scientist.

The scoring guide evaluated here is the beginning of a truly scientific approach to bite mark analysis. It lends itself to computerization and modification as our understanding progresses. The availability of such a scoring system and the adoption of guidelines or standards places a new responsibility on the forensic scientist. It is essential that proper training be provided for all those who will use the system.

References

[*1*] Gladfelter, I. A., *Dental Evidence*, Charles C Thomas, Springfield, IL, 1975, p. 23.

[*2*] Sopher, I. M., *Forensic Dentistry*, Charles C Thomas, Springfield, IL, 1976, p. 140.

[*3*] Hales, A., "Admissibility of Bite Mark Evidence," *Southern California Law Review*, Vol. 51, No. 309, March 1978, pp. 323-327.

[*4*] Keiser-Nielson, S., *Person Identification by Means of the Teeth*, John Wright & Sons, Bristol, England, 1980, pp. 59-72.

[*5*] Rawson, R. D., Ommen, R. K., Kinard, G., Johnson, J., and Yfantis, A., "Statistical Evidence for the Individuality of the Human Dentition," *Journal of Forensic Sciences*, Vol. 29, No. 1, Jan. 1984, pp. 245-253.

[*6*] Sognnaes, R. F., Rawson, R. D., Gratt, B. M., and Nauyen, B. N., "Computer Comparison of Bitemark Patterns in Identical Twins," *Journal of the American Dental Association*, Vol. 105, No. 9, Sept. 1982, pp. 449-452.

[*7*] Whittaker, D. K., "Some Laboratory Studies on the Accuracy of Bite Mark Comparison," *International Journal of Forensic Dentistry*, Vol. 25, No. 3, Sept. 1975, pp. 166-171.

[8] Dinkel, E. H., "The Use of Bite Mark Evidence as an Investigative Aid," *Journal of Forensic Sciences*, Vol. 19, No. 3, July 1974, pp. 535-547.
[9] Butler, O. H., "The Value of Bite Mark Evidence," *International Journal of Forensic Dentistry*, Vol. 1, No. 1, Jan. 1973, pp. 23-24.
[10] American Board of Forensic Odontology, "Guidelines for Bite Mark Analysis," *Journal of the American Dental Association*, Vol. 112, No. 3, March, 1986, pp. 383-386.
[11] Nie, N. H., Hull, C. H., Jenkins, J. G., and Bent, D. H., *Statistical Package for the Social Sciences*, 2nd ed., McGraw-Hill, New York, 1975, pp. 1-673.
[12] Ligthelm, A. J. and de Wet, F. A., Registration of Bite Marks: A Preliminary Report, *The Journal of Forensic Odonto-Stomatology*, Vol. 1, No. 1, Jan. 1983, pp. 19-26.

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