Inner-canthal distance in bite mark analysis

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Introduction:

A bite mark has been described as a pattern created by dentitions of humans or animals and associated structures in any substance capable of being marked by these means [1]. Bites can occur on both the victim and suspect, the teeth are used as weapon by the aggressor and in self-defense by the victim [2]. It is estimated that the contemporary history of bite marks began with Sorup. In 1924, Sorup used transparent paper on which biting edges of a suspect's dentition were made to equate images of a bite mark with life-size [3]. Bite mark recognition is based on a dentition 's identity and is used to assign a bite mark to a suspect. One can exactly match the bite marks to the accused biter's dentition [4]. The inner canthal distance (Fig.1) is defined as the distance between the medial angles of the palpebral fissures [5]. In 2002 Abdullah suggested a method for measuring the width of the central incisor from the inner canthal point. The ICD was found to be greater than the combined width of maxillary central incisors. Thus the ICD was multiplied by 0.618. the resultant product was then divided by 2 to obtain the width of a single central incisor. FCIW = ICD/2 x 0.618[6]. In a study conducted in south India, as in the European population, the ICD and the golden proportion are reliable predictors for determining the width of the central maxillary incisors also present in the South Indian population. Bite marks most often appear as elliptical or round areas of contusion or abrasion, occasionally with associated indentations. [7] The verification of a set of bite marks with that of an individual's dentition involves the analysis and measurement of size, shape and position of the individual teeth. The forensic aspect of this analysis comes into play when it is applied to identify teeth marks left on food or in criminal cases when the victim bites the assailant in self-defense or when such marks are seen on the victim as left by the assailant in cases like sexual assault [8].

The study has been conducted with the aim to illustrate a novel approach done by applying Inner Canthal Distance, as to aid in the determination of the width of the central incisor of a potential suspect or victim using the mesiodistal dimensions of a maxillary central incisor.

Materials and Methods:

The study was conducted among 30 students, 15 males and 15 females, between the age of 18 and 35 years, with no facial or dental deformity were selected. The purpose and procedures regarding the study were explained to all participants and an informed consent was obtained from them. All the subjects had full complement of teeth with no history of orthodontic treatment, crowding, diastema, morphological deformity or any form of restorations. The subject was seated in a relaxed, upright position during examination to ensure selection criteria mentioned above.

Central incisor width:

The width of the incisor was measured by asking the subject to bite into a sheet of tough modeling wax. The measurement of the incisor width was taken as the distance between the disto-proximal surface of the indentation to the mesio-proximal surface on the indentation of the maxillary right central incisor on the modeling wax.

Inner canthal distance measurement:

Subjects were seated with their heads supported in an upright position and they looked straight. The sterilized caliper was placed against the forehead and lowered toward the eyes. The calipers' arms were positioned in such a way that they were in gentle contact with the medial angle of eye palpebral fissures. The soft tissues have taken care not to compress. The distance between these two anatomical landmarks was recorded as ICD, ICD was measured two times for each subject by the same operator. Average value was taken to avoid intraoperator observational errors.

The common ratio of geometric progression are 0.618 and 1.618.Any decreasing function is multiplied by 0.618 and increasing function by 1.618 to get the next result. As the inner canthal distance was greater than the combined widths of the maxillary central incisors, it was multiplied by 0.618. The resultant product was divided by 2 to obtain the width of a single central incisor. The formula may be expressed as follows: FCIW = ICD/2x0.618 where FCIW is the calculated width of a central incisor in the maxillary. The calculated width was compared with the calculated central width from the wax bite measurement for each subject.

The data obtained was tabulated and analyzed using Statistical Package for Social Sciences, Version 16 (SPSS). Based on these values, the mean and standard deviation (SD) were calculated. The P value of 0.05 or less was considered as statistically significant.

Agreement with Pearson's Correlation Coefficient (Pearson r) was evaluated between measured from wax bite and determined central incisor widths from innercanthal distance.

A t-test was used to find the statistical significance between measured and calculated values of CIW for male and female subjects separately.

Results:

Table 1 shows the mean values and SD for the inner canthal distance, Incisal width of Central Incisor measured from Wax bite and calculated Incisal width of Central Incisor from ICD from all patients were 31.90 ±3.13, 8.32±1.29 and 9.86±0.97 respectively.

Table 2 shows the male innercanthal gap as 31.6±3.18, and 32.1±3.16 for female. Incisal width of Central Incisor measured from Wax bite for male and female are 8.61±1.14 and 8.03±1.39 respectively. Calculated Incisal widths of Central Incisor from ICD are 9.78±0.98 and 9.93±0.98 respectively.

Table 3 illustrates the observations and statistical calculations done for Pearson's Correlation Coefficient (r) the Incisal width of Central Incisor measured from wax bite, Calculated Width of Central Incisor from ICD and the Inner Canthal Distance in all patients.

From the Table 3 and figure 1, the correlation between Incisal width of Central Incisor measured from wax bite, Calculated Width of Central Incisor from ICD and the Inner Canthal Distance in all patients was inferred to have a good positive correlation with a Pearson correlation coefficient of 0.544** and 1.000** respectively. The results are highly statistically significant.

Table 4 and figure 2 and 3 shows the r between the Incisal width of Central Incisor measured from Wax bite, Calculated Incisal width of Central Incisor from Inner Canthal Distance (ICD) and the Innercanthal distance in males and females separately.

The result showed a good positive correlation between Incisal width of Central Incisor measured from Wax bite, Calculated Incisal width of Central Incisor from Inner Canthal Distance (ICD) and the Innercanthal distance in both male and female patient, with greater correlation between Incisal width of Central Incisor measured from Wax bite and the inner canthal distance in male patient (r = .752**) compared with female patient (r = .443) [figure 3]. Calculated Incisal width of Central Incisor from Inner Canthal Distance (ICD) and the Innercanthal distance showed an positive correlation between the two.

	N	Mean	Std. Deviation
Innercanthal Distance (ICD)	30	31.90	±3.13
Incisal width of Central Incisor measured from Wax bite(IWWB)	30	8.32	±1.29
Calculated Incisal width of Central Incisor from ICD(IWICD)	30	9.86	±0.97

Table 1: The mean values and standard deviation for the upper incisal width measured from Wax bite and calculated from ICD

Gender	N	Mean	Standard Deviation
Inner canthal distance			
Male	15	31.6	±3.18
Female	15	32.1	±3.16
Incisal width of Central Incisor measured from Wax bite(IWWB)			
Male	15	8.61	±1.14
Female	15	8.03	±1.39
Calculated Incisal width of Central Incisor from ICD(IWICD)			
Male	15	9.78	±0.98
Female	15	9.93	±0.98

Table 2: The mean values and standard deviation for the width of upper central incisors and Inner Canthal for both male and female patients

Pearson Correlation

Innercanthal distance	p value Sig. (2-tailed)	
Incisal width of Central Incisor measured from Wax bite (IWWB)	0.544**	.002
Calculated Incisal width of Central Incisor from Inner Canthal Distance (IWICD)	1.000**	.000

**. Correlation is significant at the 0.01 level (2-tailed).

Table 3: Observations and statistical calculations done for pearson's correlation coefficient (r) between the Incisal width of Central Incisor measured from wax bite, Calculated Width of Central Incisor from ICD and the Inner Canthal Distance in all patients

Sex	Innercanthal Distance	p value Sig. (2-tailed)
Female		
Incisal width of Central Incisor measured from Wax bite	.443	.098
Calculated Incisal width of Central Incisor from Inner Canthal Distance (ICD)	1.000**	.000
Male		
Incisal width of Central Incisor measured from Wax bite	.752**	.001
Calculated Incisal width of Central Incisor from Inner Canthal Distance (ICD)	1.000**	.000

**. Correlation is significant at the 0.01 level (2-tailed).

Table 4: Correlation Coefficient (r) between the Incisal width of Central Incisor measured from Wax bite, Calculated Incisal width of Central Incisor from Inner Canthal Distance (ICD) and the Innercanthal distance in males and females separately

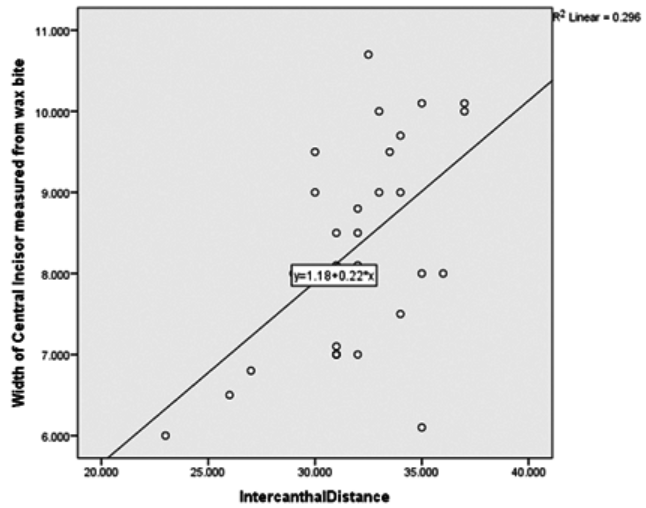

Figure 1: Graphical representation of the Incisal width of Central Incisor measured from Wax bite and the Innercanthal Distance of the study population

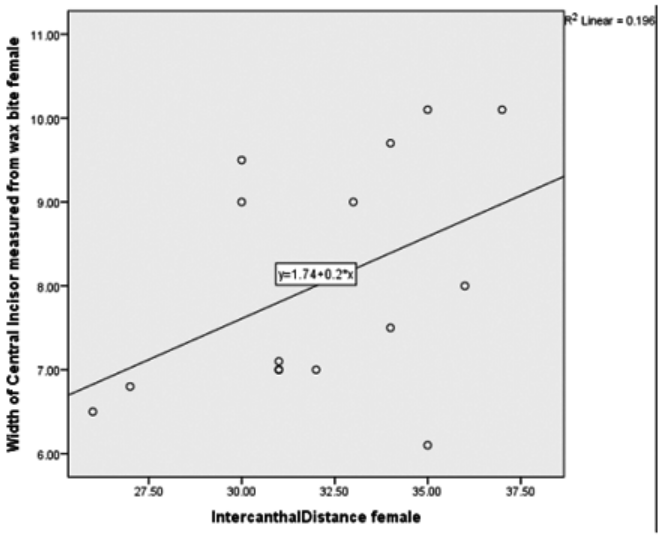

Figure 2: The correlation between the Incisal width of Central Incisor measured from Wax bite and the Innercanthal Distance in both males and females in the study population (Scatterplot) DISCUSSION:

Bite mark analysis has continued to prove its worth as an invaluable tool in forensics.[9] The landmark case that brought the importance of bite marks into public focus was the case of the serial killer Ted Bundy, where the discovery of a bite left by him on his victim played a crucial role in securing his conviction.[10] The process of comparing bite marks with a suspect's dentition includes analysis and measurement of size, shape and position of the individual teeth.[11] Because of the uniqueness of teeth size and shape, marks left behind from a bite can be used for identification purposes. It has been estimated by use of computer that there were over two billion possibilities in the charting of adult dentition.[12,13] This would therefore rule out the possibility of two adults having exactly the identical dentition. [14]And hence the theory of uniqueness is a strong point used in the analysis of bite marks to convince the court of law that a dentition in one individual is different from other human dentition.[15]

This study attempts to showcase the usefulness of applying Innercanthal distance as an adjuvant to support and aid in bite analysis. Laestadius stated that the ICD is reached by the age of 1 year in 78 per cent of adults, after which growth in this region is slow as compared to outer orbital dimension.[16]According to Epker and Fish,these values are established by 6–8 years of age and do not change significantly after this time.[16] This stable landmark can be identified, located and measured accurately.[18]

Study conducted by Md. Abdullah proved that ICD is a reliable guideline for selecting width of maxillary central incisor but in Arab population.[18] Study conducted by the George et al the ICD and the golden proportion are reliable predictors for determining the width of the maxillary central incisors in the south Indian population also.[19] Our study reinforces the findings that ICD is reliable predictor for width of the maxillary central incisors measured by wax bite and calculated from the ICD.

In our study mean values and SD for the inner canthal distance, Incisal width of Central Incisor measured from Wax bite and calculated Incisal width of Central Incisor from ICD from all subjects were 31.90 ±3.13, 8.32±1.29, and 9.86±0.97 respectively. A similar result was seen in George et al study which ICD was reported to be 32,59±2,19, 30,77±2,16 for males and females and 10,08±0,67 and 9,51±0,66 respectively.[19]Bali et al reported a mean inner cantal distance of 29,85±1,47 mm and 27,46±2,1 mm respectively for male and female subjects. The mean maxillary central incisor width of male and female subjects was 9.18±0.51mm and 8.42±0.40mm, respectively.[20] Gender based difference in mesiodistal width of central incisor was reported by previous investigators like Cesario et al.,[21] Lavellea,[22] and Md. Abdullah.[18]

The correlation between Incisal width of Central Incisor measured from wax bite, Calculated Width of Central Incisor from ICD and the Inner Canthal Distance in all patients was inferred to have a good positive correlation with a Pearson correlation coefficient of 0.544** and 1.000** respectively. This means that ICD can be utilized as an adjunct in the victim identification.

One of the limitations of study is ethnic differences exist between different populations,[23,24] universal application of the previous research work is possible only when it is studied in all populations.[24,25]

Conclusion:

Examination of the bite mark alone will not lead to a culpable verdict, although it will provide the potential to remove a suspect from a crime if the results do not match. Inner Canthal Distance attempts to utilize the measurements obtained in the bite analysis and further elucidate information regarding the individual. Based on these results we propose the use of Inner Canthal Distance as a method to supplement the evidence provided by bite mark analysis and increase its value as a forensic tool.

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