Application Of Oral Hard And Soft Tissue Structures In Sex Determination

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Abstract

Introduction- Establishment of a person's individuality is important for legal as well as humanitarian purpose and gender determination is an essential step in identifying an individual. . In forensic odontology the sum total of all the characteristics of teeth and their associated structures provide a unique totality and forms the basis for personal identification.Aims & Objectives- To investigate the accuracy of various methods employed in sex determination such as cheiloscopy, mandibular canine index and measurement of upper lip length by soft tissue cephalometric analysis.Materials & Method- The study group comprised of adults between 18- 25 years of age, who were assesed for gender identification using lip prints, mandibular canine index and upper lip length by soft tissue analysis. The results were subjected to statistical analysisResults- Mandibular Canine Index and Upper Lip Length were found to be more accurate and specific for sex determination as compared to lip prints and showed a greater co-relation. Conclusion- There is scope for use of these methods in criminal investigations, personal identification and genetic studies. Thus, dental tissues make good witnesses Although they speak softly, they never lie and they never forget.

INTRODUCTION

The moral and professional obligation of dental surgeon to mankind is not only to serve in examination, investigation, diagnosis and treatment of oral and oro-facial lesions of local origin and oral manifestations of systemic diseases, but to serve the community by their services and also render their opinion in legal matters.[1]

As dental surgeon has to actively involve in various objectives of forensic dentistry like age and sex determination, personal identification of unknown deceased person, analyzing bite marks as evidence, participating in mass disaster, studying lip prints, giving evidence in child abuse and in civil and criminal litigation, his role in personal identification and criminal investigation is very much important, as his evidence would be very much useful in law and justice.[2] Dentist's role in criminal investigation includes collection of information from bite marks, lip prints and teeth found in the crime sites like quarrel, robbery, murder and rape[3].

Establishment of a persons individuality is important, both for legal as well as humanitarian purposes. In forensic odontology the sum total of all the characteristics of teeth and their associated structures provide a unique totality and forms the basis for personal identification[3].

Usually, personal identification is made by comparing an already prepared ante mortem record which includes details of teeth, rugae pattern, any restorations, with that of post mortem records in which the investigating dental surgeon records number of teeth, teeth changes, restorations and dentures in unknown deceased persons or of a living person whose identity is required.

Recently personal identification is made by analyzing the DNA profile of deceased persons with that of their relatives DNA profile. But this procedure is sophisticated and requires long time and is not available in rural and remote parts of the town. Hence conventional methods have to be followed.[3]

Apart from the teeth and their restorations, soft tissues of oral cavity may help for personal identification. Anatomical structures like. rugae, pigmentation, lip prints, upper lip length (by cephalometric analysis) remain constantly and can be included in ante mortem records.

The aim of the present study was to investigate the accuracy of various methods employed in sex determination/ personal identification such as cheiloscopy, mandibular canine index

and soft tissue cephalometric analysis in an age group of 18 – 25 years.

MATERIALS AND METHOD

SELECTION AND GROUPINGS OF PATIENT

The subjects employed for the investigation included 50 individuals (25 males and 25 females) of ages between 18 -25 years, with Class I molar relation and overjet and overbite within normal limits. The gingiva and periodontium were healthy. There were no lesions present on the lips. An informed consent was taken from all the subjects. Each study sample was assigned a code to avoid any observer bias (blind study)

METHOD FOR COLLECTION OF LIP PRINTS

The lips of each subject were thoroughly examined clinically for any deformity, scars or abnormality and the findings were noted. If any abnormality was noticed, then such cases were excluded from the study. The lips of the subject were first cleaned thoroughly and then outlined using a sharp lip liner pencil. Lipstick was applied uniformly using lip stick applicator brushes, starting at the midline and moving laterally. The lip stick was allowed to dry for two minutes, after which an impression was made on a cellophane tape and transferred to a white bond paper. This served as a permanent record. The impression was subsequently visualized with the use of a magnifying lens. The combinations of lines and furrows and their length were noted. The lip prints obtained were coded, keeping in account the sex of the subject. At the time of analysis the sex was not disclosed.

The lip prints were classified using the classification given by Suzuki and Tsuchihashi (1970)[4]. (Figure 1)

Type I: Clear cut vertical grooves that run across the entire lips.

Type I':Similar to type I, but do not cover the entire lip.

Type II:Branched grooves (branching Y- shaped pattern).

Type III:Intersected grooves.

Type IV:Criss-cross pattern, reticular grooves

Type V:Other patterns.

For classification, the middle part of the lower lip (10mm wide) was taken as study area, as proposed by Sivapathasundaram et al[8]. Since this fragment is visible in any trace, the determination of the pattern in each segment of the lip was based on the numerical superiority of properties of the lines in this study area.

METHOD FOR DETERMINING MANDIBULAR CANINE INDEX (MCI)

Maxillary and mandibular impressions of all the samples were made with alginate and study models were prepared in dental stone. Mandibular study models were used for the analysis. On the study model the following measurements were taken for all the subjects using a digital vernier's callipers.

Mandibular canine width was measured as the greatest mesiodistal dimension of mandibular canine on either side of the jaw using a vernier calliper, and the average of this was taken(Figure2a). The intercanine distance was measured as the linear distance between the cusp tips of right and left mandibular canine(Figure2b). The observed mandibular canine width and intercanine width were subjected to statistical analysis to assess sex difference using unpaired t-test.

The observed mandibular canine index (MCI_O) was calculated using the formula below:

Figure 1

$$\text{Observed mandibular canine index (MCIo)} = \frac{\text{Average Mesio-distal crown width of mandibular canine}}{\text{Inter canine width}}$$

The standard MCI value is used as a cut- off point to differentiate males from females, which is obtained from the measurements taken from the samples by applying the following formula:

Figure 2

$$\text{Standard mandibular canine index } (MCI_S) = \frac{(\text{Mean male MCI} - \text{SD}) + (\text{Mean female MCI} + \text{SD})}{2}$$

METHOD FOR DETERMINING UPPER LIP LENGTH (ULL) USING SOFT TISSUE CEPHALOMETRICS

Lateral cephalograms were made with the teeth in centric occlusion and the lips in a relaxed contact at a focus/ object distance of 150 cm and a object receptor distance of 20 cm using a Planmeca proline ec cephalostat (Planmeca OY, 00880 Helsinki Finland). The subjects were placed in the headholder and asked to look straight ahead to establish the natural head position.

Radiographs were then traced on a standard acetate paper and a True vertical line (TVL) was established(Figure 3). The line was placed through subnasale and was perpendicular to the natural head position. The soft tissue subnasale and stomion superius were established and transferred to the TVL, the distance between which was calculated as the upper lip length.

Soft Tissue Subnasale: the point at which the columella (nasal septum) merges with the upper lip in the mid sagittal plane.

Stomion Superius: Most inferior point on the curve of the upper lip.

The average upper lip length was calculated along with standard deviation for males and females respectively. The cut point value was obtained using ROC curve (Reciever Operating Curve), the values above the cut point were taken as males and below which were females.

The results of all the three parameters were verified from the coded data collected at the beginning of the study, and a correlation between each pair of the parameters was statistically done using t test.

RESULTS

The examination of lip print patterns revealed the following observations:

No two lip prints matched with each other, thus establishing the uniqueness of the lip prints.

Type I, I' were commonly seen in females whereas Type III, IV, V were seen most commonly in males.

In the present study, 21 females were correctly recognized as females and 14 males were correctly identified as males on the basis of their lip prints (Table1)

Measurement of agreement with kappa was .4, which was not significant (Table 1)

On application of Mandibular Canine Index for sex determination the cut point for Mandibular Canine Index for sex determination was calculated at 0.27, above which were considered as males & below which were females. 22 females were correctly identified and 28 individuals were identified as males. Measurement of agreement with kappa was .88, which was highly significant (Table 2).

Reciever Operating Characteristic (ROC) analysis was conducted & ROC curve plotted. Area under curve, sensitivity & specificity at 95% confidence interval (95% CI) was obtained from ROC analysis.(Figure 4).

The Upper Lip Length analysis showed that the cut point obtained was 22.25mm, the value below which was considered for females, and above which were considered for males. Out of 50 individuals 23 were correctly identified as females and 27 were placed in male category. Measurement of agreement with kappa was .92, which was highly significant (Table 3)

Reciever Operating Characteristic (ROC) analysis was conducted & ROC curve plotted. Area under curve, sensitivity & specificity at 95% confidence interval (95% CI) was obtained from ROC analysis.(Figure 5).

On correlating mandibular canine index with upper lip length using soft tissue cephalometrics the measurement of agreement with kappa was .798 which was significant (Table 4)

On correlating lip pattern with mandibular canine index, and lip pattern with upper lip length using soft tissue cephalometrics the measurement of agreement with kappa was .381 and .335 respectively, both of which were not significant.

Figure 3

Table 1: Sex determination by Lip prints

SEX DETERMINATION BY LIP PRINT	KNOWN MALES	KNOWN FEMALES	TOTAL
Males	14	4	18
Females	11	21	32
Total	25	25	50

Symmetric Measures

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Measure of Agreement	Kappa	.400	.124	2.946	.003
N of Valid Cases		50			

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

Figure 4

Table 2: Sex determined by Mandibular Canine index

SEX DETERMINATION BY MCI	KNOWN MALES	KNOWN FEMALES	TOTAL
MALES	25	3	28
FEMALES	0	22	22
TOTAL	25	25	50

Symmetric Measures

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Measure of Agreement	Kappa	.880	.067	6.268	.000
N of Valid Cases		50			

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

Figure 5

Table 3: Sex determined by Upper Lip Length

SEX DETERMINATION BY UPPER LIP LENGTH	KNOWN MALES	KNOWN FEMALES	TOTAL
MALES	25	2	27
FEMALES	0	23	23
TOTAL	25	25	50

Symmetric Measures

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Measure of Agreement	Kappa	.920	.055	6.526	.000
N of Valid Cases		50			

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

Figure 6

Table 4: Sex determined by Mandibular Canine Index & Upper Lip Length

Sex determination by MCI & ULL	Known males	Known Females	Total
MALES	25	3	28
FEMALES	2	20	22
Total	27	23	50

Symmetric Measures

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Measure of Agreement	Kappa	.798	.086	5.648	.000
N of Valid Cases		50			

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

Figure 7

Figure 1: Classification of lip prints as given by Suzuki and Tsuchihashi

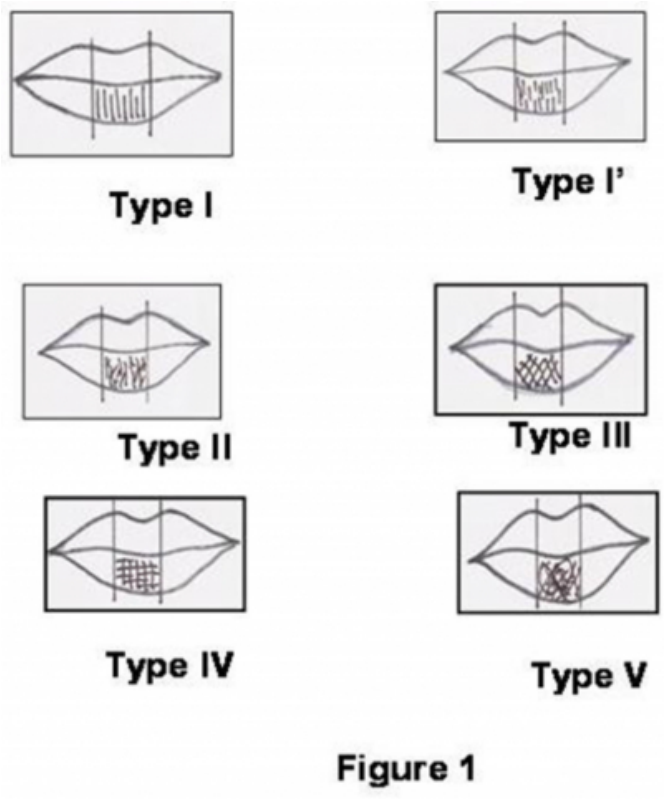


Figure 8

Figure 2: Mandibular canine width being measured as the greatest mesiodistal dimension of mandibular canine using a vernier calliper (Figure2a). The intercanine distance being measured as the linear distance between the cusp tips of right and left mandibular canine (Figure2b).

Figure 2a

Figure 2b

Figure 9

Figure 3: Establishment of a True vertical line (TVL) on radiographic tracing.

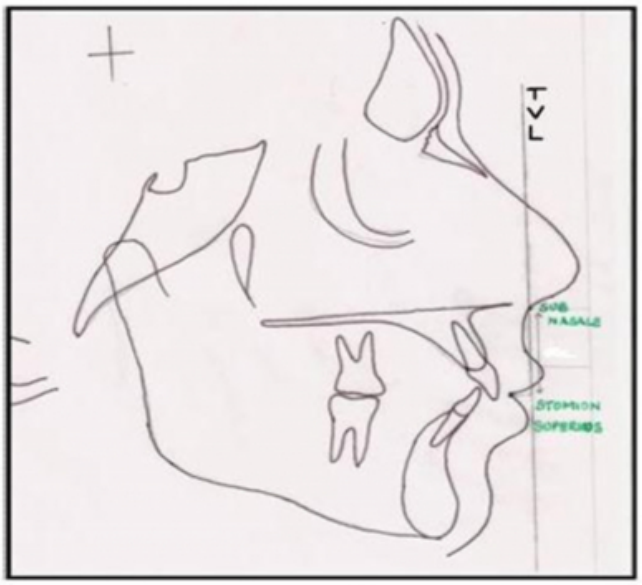


Figure 10

Figure 4: Reciever Operating Characteristic (ROC) analysis showing area under curve, sensitivity & specificity at 95% confidence interval (95% CI) of Mandibular Canine Index.

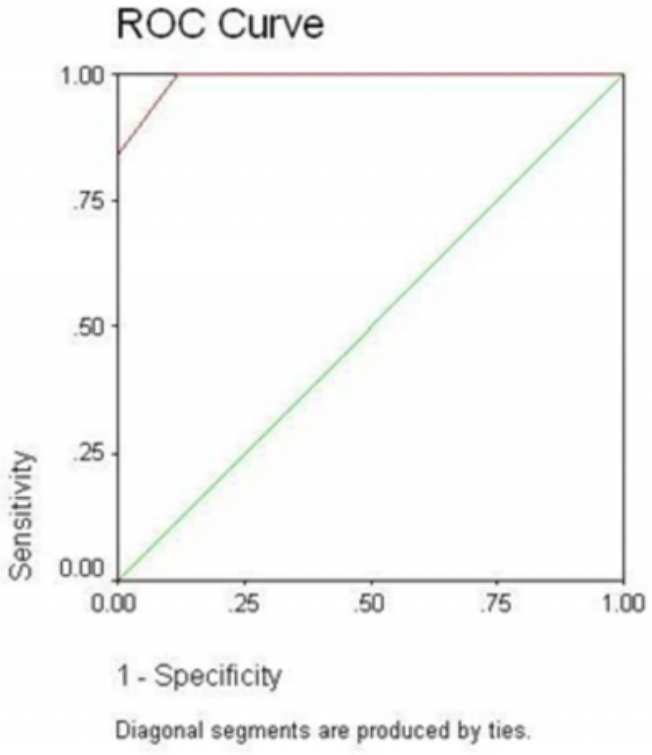
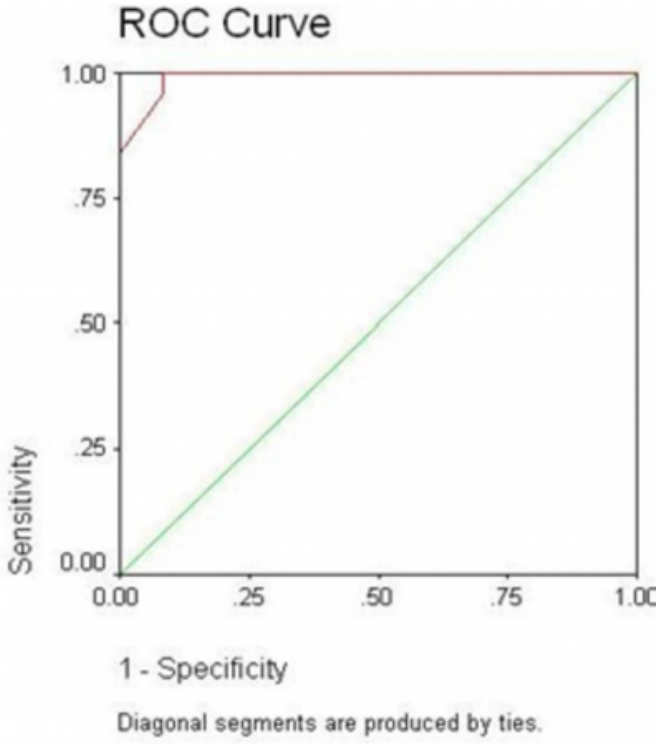


Figure 11

Figure 5: Reciever Operating Characteristic (ROC) analysis showing area under curve, sensitivity & specificity at 95% confidence interval (95% CI) of Upper Lip length .



DISCUSSION

Lip prints were first described by Fisher in 1902[4], however, it was only in 1930 that de Lille developed some studies which led to lip print use in criminology. Thomas and Van Wyk have mentioned that it was Edmond Locard, one of France's greatest criminologists, who recommended the use of lip prints in human identification[4]. Snyder in his book 'Homicide Investigation', written as early as 1950, mentions the possible use of lip prints in the identification of individuals[5]. Suzuki and Tsuchihashi proposed a classification dividing the pattern of grooves on the lip into six types[6].

In recent years, lipsticks have been developed that do not leave any visible trace after contact with surfaces such as glass, clothing, cutlery, or cigarette butts. These lip prints are characterized by their permanence and are, therefore, referred to as "persistent" lip prints. Although invisible, these prints can be lifted using materials such as aluminium powder and magnetic powder[7,8]. The edges of lips have sebaceous glands, with sweat glands in between. Thus, secretions of oil and moisture from these enable development of latent lip prints, analogous to latent finger prints[9]. Although lip prints have previously been used in a

court of law, the use is not consensual and some authors believe further evidence is needed to confirm their uniqueness.

In the past, few researchers have worked on lip prints with the idea of proving that a gender difference does exist in lip print[10]. According to a study by Sonal- Nayak[11], Type I and Type I' patterns were found to be dominant in females, while Type III and Type IV patterns are dominant in males. In a study by Sivapathasundharam et al in a population of 200 individuals, it was shown that Type III (branched groove) pattern is predominantly seen (41.33%) and least commonly seen pattern is Type IV (reticular) (10.71%)[12]. However in our study Type I' (Partial length groove) is seen as most predominant in females and Type I'(Partial length groove) and Type IV (Reticular) were most common in males and the measurement of agreement by kappa was 0.4, which was not significant.

Canines differ from other teeth with respect to survival and sex dichotomy. These differences probably are related to their function, which is different on an evolutionary basis from other teeth. In carnivores and in most primates, the chief function of the canines is not masticatory; their function is related to threat of aggression and actual aggression. Eimerl and DeVore[13] postulated that in the evolution of primates there was a transfer of aggressive function from the canines in apes to the fingers in man, and that until this transfer was complete, survival was dependent on the canines, especially those of the males. In present day humans, it is not coincidence that the mandibular canines are the teeth that show the greatest sex difference in size and in prominence and eruption age. They also are the teeth most able to survive dental disease. The human male appears to retain canines that are masculine in form, position, and development, if not in function.

The present study establishes the existence of a definite statistically significant sexual dimorphism in mandibular canines. It is consistent with the findings of Hashim and Murshid[14] who conducted a study on Saudi males and females in the age group of 13- 20 years and found that only the canines in both jaws exhibited a significant sexual difference while the other teeth did not. Similar findings were seen in studies of Andersen & Thompson[15].

Studies performed on the lower canines using the ratio between the maximum crown width and canine arc width, resulting in a mandibular canine index (MCI), have shown an ability to determine gender when performed on 384 females and 382 males of the South Indian population in the age group of 15- 21 years with an accuracy of 84.3 % in males and 87.5% in females by comparing the observed MCI with a standard MCI value[16]. In a similar study by Muller et al[17] the population involved the students enrolled in the University of Nice- Sophia Antipolis. 210 girls and 214 boys were randomly sampled. The results were found to be statistically significant. In the present study both these parameters as measured in males and females were compared and the difference was found to be statistically significant with a kappa value of 0.88 . It is the Y chromosome which intervenes most in the size of teeth by controlling the thickness of dentine, whereas the X chromosome, for a long time considered to be the chromosome responsible, only comes into play concerning the thickness of enamel[21].

Two different methods have been used in sex determination from human soft tissue. The first is the metric analysis comprising more than one measurement of tissue, and the second is the conventional visual approach where sexing relies mainly on rather intuitive recognition of some gross morphological features[18] like everted mandibular angle in males, prominent supercilary arches in females.

Literature reveals that male faces are statistically longer, with significantly greater upper lip length as compared to females. Gender differences are detected in the linear dimension subnasale - stomion superius, with the average male having a 1.54-mm-longer upper lip[19] Males have thicker soft tissue structures, increased facial length and lip length measurements, increased lower third of face, than the females.[20]

Arnett in 1999, reported an upper lip length of 24.4 ± 2.5mm and 18.49 ± 1.9mm in males and females respectively.[21] A similar study was carried out in Kuwait by Rasheed-Al Azemi in 2007, and values of 19.90 ± 2.63mm and 18.36 ± 1.88 mm were found for males and females.[22] In our study, the upper lip length in males was longer by 1.34 mm with the mean in males and females being 23.38 mm and 22.04 mm respectively. Due to high specificity with a kappa value of 0.921, this is a reliable indicator for sex determination.

A very high measurement of agreement with a Kappa value of 0.798 was observed between mandibular canine index and upper lip length, making it a highly reliable and inexpensive method for sex determination in legal cases.

The discrepancies associated with various methods are to be

weighed cautiously to make forensic odontology a more accurate, reliable, and reproducible investigatory science.

Various factors can alter lip print recording. Lip print pattern depends on whether the mouth is opened or closed. In closed mouth position lip exhibits well- defined grooves, whereas in open position the grooves are relatively ill defined and difficult to interpret. Any pathology of the lip such as mucocele or any postsurgical alteration of the lip can change the lip print pattern. Also, loss of support due to loss of anterior teeth can cause changes in lip prints. Any debris or fluid on the lip surface, application of a thick layer of lipstick, or over stretching of cellophane tape can alter lip print recording. Although lip prints are unique to an individual, when the lines are not clear, individual identification based on this trace is extremely difficult unless the trace contains more individual characteristics like scars, clefts, etc[23].

With respect to canine index, variation occurs with different geographic distributions. Controversy exists regarding the degree of sexual dimorphism between mandibular and maxillary canine teeth in different ethnic groups. Other limitations are those that only those cases that have Class I Molar relation with normal overjet & overbite can be used. Canines with caries and interproximal wear will give inaccurate results.

The inherent problem in sex determination from soft tissue is that; measurements are required to be performed in a large sample of population to establish norms which can be used as standard for a given population. As, soft tissue profiles are associated with growth and development, this method is not valid for adolescents and children. Bias can creep in due to different malocclusions, so the samples need to be grouped according to malocclusion to establish standard values. The upper lip length varies considerably in different races. Thus, experience and skill and a sound knowledge of dental anatomy and occlusion are mandatory in examining upper lip length.

Though forensic odontology has achieved giant strides in recent times, various techniques utilized in forensic odontology are abided by limitations. These limitations are to be kept when answering queries in the court of law while prosecuting an accused, because an improper conclusion can alter and shatter the dreams and lives of alleged accused too.

SUMMARY & CONCLUSION

In the present study Mandibular Canine Index and Upper Lip Length were found to be more accurate and specific for sex determination as compared to lip prints and showed a greater co-relation. Thus, there is scope for use of these methods in criminal investigations & personal identification.

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