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Correlative study on lip prints, fingerprints, and mandibular intercanine distance for gender determination

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Abstract

Context: "Identity" is a set of physical characteristics, functional or psychic, normal or pathological, that defines an individual. Identification of an individual is a crucial and an exigent task in forensic investigation. **Aims:** The aim of the present pilot study was to investigate the accuracy of various methods employed in gender determination such as lip prints, mandibular canine index (MCI), fingerprints, and correlation between them. **Subjects and Methods:** The pilot study group consisted of 300 samples aged between 18 and 25 years. Lip prints, fingerprints, and impressions of lower mandibular arches were collected. **Statistical Analysis Used:** The results were analyzed using Chi-square test for lip prints and fingerprints with an independent sample *t*-test for the MCI. Intergroup comparison between the parameters was analyzed by ANNOVA test. **Results:** Type II lip print pattern and loop pattern of fingerprints were the predominant patterns in both males and females, and mesiodistal width of right MCI has greater sexual dimorphism than left MCI. **Conclusions:** Although lip prints, fingerprints, and MCI had their own specifications, correlation of the three parameters did not show any significance.

Key words: Cheiloscopy, finger prints, mandibular canines, gender, patterns

Introduction

Identification of an individual is an important and challenging task in the forensic investigation.[1] It is important for legal as well as for humanitarian purposes. Gender determination is an essential step in the identification of an individual.[2] Positive identification of living or deceased humans using distinctive traits is a cornerstone in the field of forensics. The uniqueness of patterns and subtle distinction between the traits help in establishing the true nature of facts.[3] Although DNA comparison and fingerprint analysis are the most common techniques employed to ensure fast and secure identification, there are certain circumstances related to the scene of the crime, where other supplemental aids such as lip prints, bite marks, dental identification, and palatal rugae patterns become essential. Human identification involves the combination of different procedures for individualizing a person.[4]

The dentition is considered as a useful adjunct in gender determination as teeth are resistant to postmortem

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destruction and fragmentation.[5] Their ability to survive fire and bacterial decomposition makes them a valuable aid in the forensic identification. "Sexual dimorphism" refers to those differences in size, shape, and appearance between males and females that can be applied to dental identification as no two mouths are alike. Of all the teeth in the human dentition, mandibular canines exhibit greater sexual dimorphism and considered as "key teeth" for personal identification.[6]

The theory of uniqueness is a strong point used in the analysis of fingerprints. Fingerprint evidence is the most reliable and acceptable evidence for the identification of an individual in the court of law.[7] "Dermatoglyphics" refers to epidermal ridges present on the palm, sole, fingers, and toes."[8] Every individual has an unique fingerprint pattern, and based on genetic characters of each individual, it remains unchanged throughout life.[9]

One of the most emerging methods of human identification, which originates from criminal and forensic practice, is recognition of lip prints.[10] The wrinkles and grooves on the labial mucosa form a characteristic pattern known as "lip prints," the study of which is referred to as cheiloscopy. Lip prints are considered unique to an individual and analogous to fingerprints.[11]

The study was designed with the prime objective of determining the most common lip print and fingerprint patterns among males and females, sexual dimorphism of mandibular canines, and if there is any correlation existing between these parameters for gender determination.

Subjects and Methods

Study sample

A study sample comprised of 300 students (150 males and 150 females) aged between 18 and 25 years were selected, following inclusion and exclusion criteria. Informed consent was taken from all the study subjects, along with the institutional ethical committee approval. Cheiloscopy, fingerprint analysis, and mandibular canine index (MCI) were performed in each student to investigate the accuracy in gender determination.

For cheiloscopy

The materials used were a red or brown-colored lipstick,

Figure 1: Method of applying lip prints with ear bud

Figure 2: Recording lip prints with cellophane tape

Figure 3: Type I lip pattern

Figure 4: Type-I' lip print

ear bud, cellophane tape, thin bond paper, magnifying lens, and pen/pencil for labeling the individual details.

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. Lips of the subjects were cleaned, and they were asked to open the mouth where lipstick was applied in a single motion [Figure 1]. Subjects were asked to gently rub the lips together to spread the lipstick evenly, and then, they made a lip impression in the normal rest position of the lips, by dabbing it in the center first and then pressing it uniformly toward the corners of the lips [Figure 2]. Care was taken to avoid sliding of the lips so as to prevent smudging of the print over the entire area of the red part of the lips. After 2 min, a lip impression was made on a strip of cellophane tape. The cellophane strip was then stuck to the white paper for permanent record purpose, and then, the recorded lip prints were visualized utilizing magnifying lens. Because of numerically superiority of properties of the lines in the middle part of the lower lip (10 mm wide)[12] and almost visible in any trace, this fragment was selected for the study area. In this study, we followed the classification of patterns of lines on the lips given by Tsuchihashi.[13]

- Type I: Clear-cut vertical grooves that run across the entire lip [Figure 3]
- Type I': Similar to Type I but does not cover the entire lip [Figure 4]
- Type II: Branched grooves (Y-shaped pattern) [Figure 5]
- Type III: Intersecting [Figure 6]
- Type IV: Crisscross patterns, reticular grooves [Figure 7]
- Type V: Undetermined [Figure 8].

For finger prints

The record of fingerprint impressions was obtained using blue ink stamp pad, white bond paper, and a magnifying glass. The subjects included were all healthy, and individuals with physical disability, systemic illness, or syndromes were excluded. Subjects were asked to wash and dry their hands to remove dirt and grease. The imprint obtained from the left thumb was transferred on to white bond paper. These prints were examined, classified, and analyzed using the magnifying glass. Analysis of fingerprint patterns was carried out using the most widely accepted Michael Kucken's classification. (1) Loop pattern, (2) arch pattern, (3) whorl pattern [Figures 9-11].[14]

All the above values of lip print and fingerprints were subjected to Chi-square test.

Figure 5: Type-II lip print

Figure 6: Type-III lip print

Figure 7: Type-IV lip print

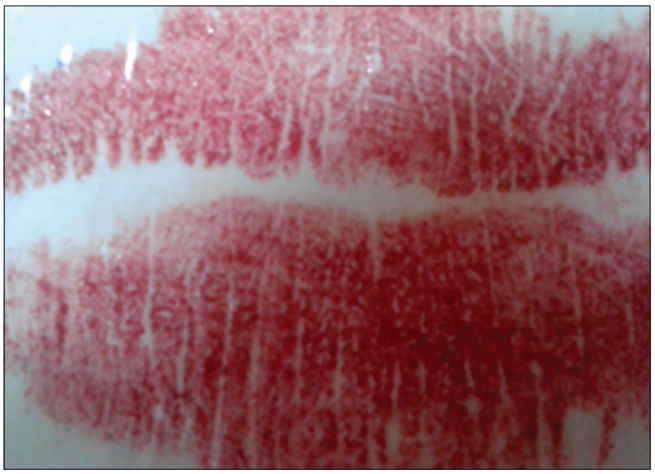
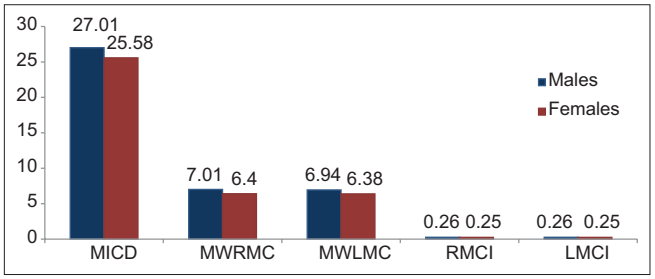


Figure 8: Type-V lip print

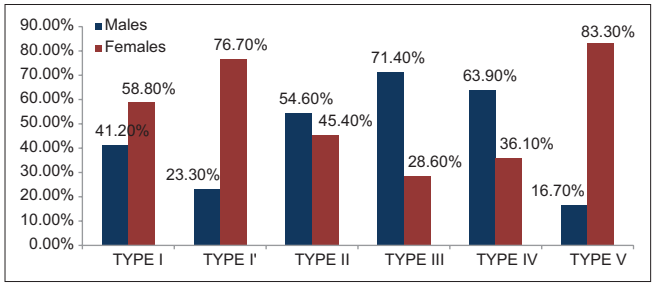
Figure 9: Fingerprint pattern-loop

Figure 10: Fingerprint pattern-whorl type

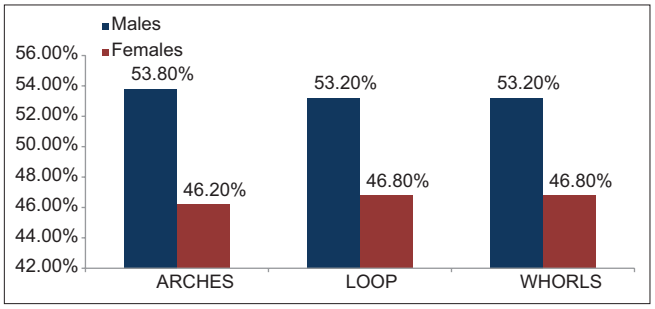
Figure 11: Fingerprint pattern-arch type



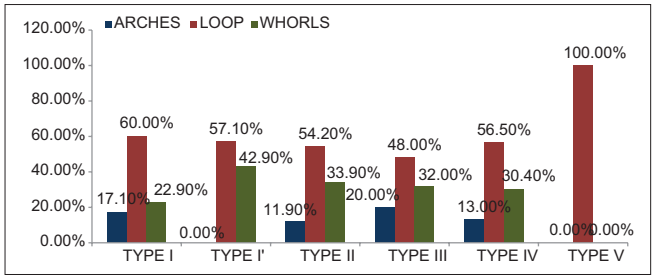
Graph 1: Comparison between males and females for mandibular intercanine distance, mesiodistal width of right mandibular canine, mesiodistal width of left mandibular canine, right mandibular canine index and left mandibular canine index (independent sample *t*-test)



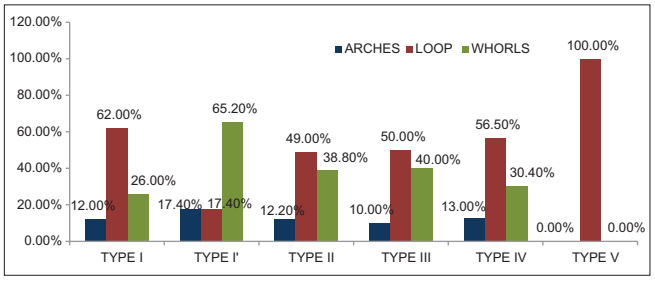
Graph 2: Comparison between males and females for lip prints (Chi-square test)



Graph 3: Comparison between males and females for fingerprints (Chi-square test)



Graph 4: Comparison between lip prints and fingerprints for males

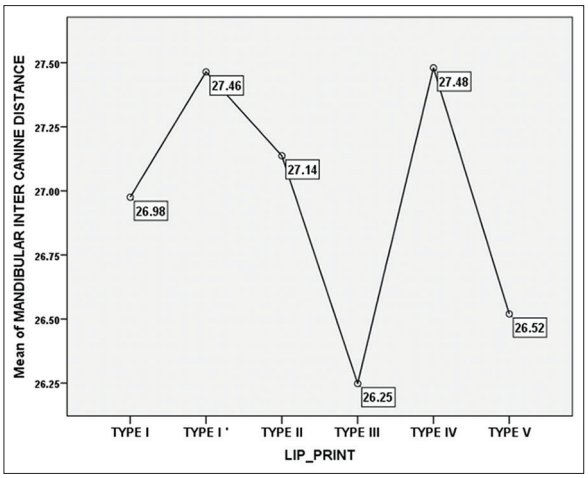


Graph 5: Comparison between lip prints and fingerprints for females

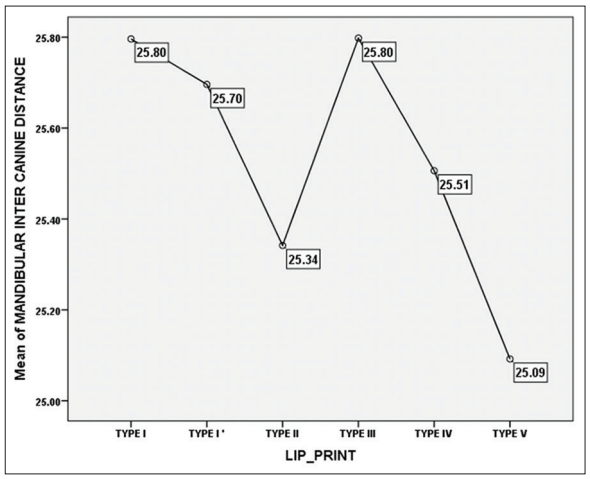
For mandibular canine index

The materials used were the lower impression trays, alginate impression material (Tropicalgin), dental stone (Denstone), graphite lead black pencil, and magnifying glass. Besides fulfilling the criteria of having the full complement of teeth, abnormalities such as severe malocclusion, increased overjet and overbite, supernumerary teeth, and transposed canine were excluded.

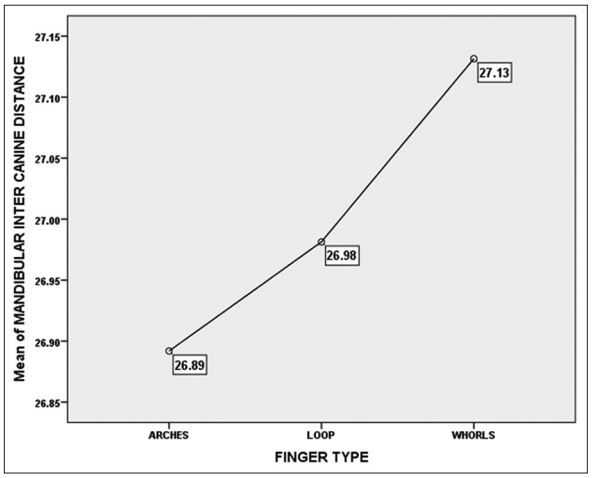
Mandibular impressions of all the samples were made with alginate and study models were prepared in dental stone.



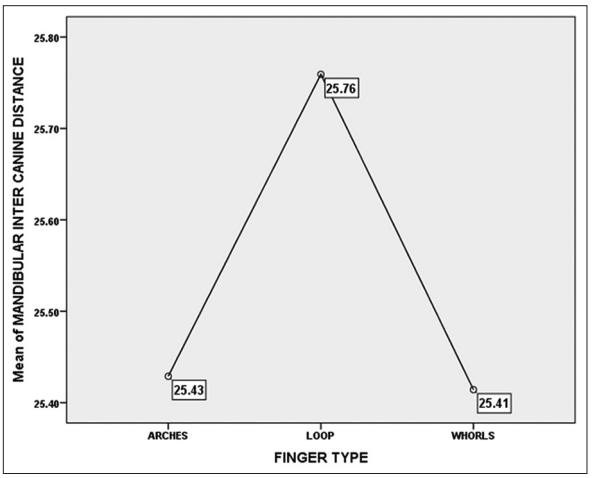
Grah 6: Comparison between lip prints and mandibular intercanine distance for males



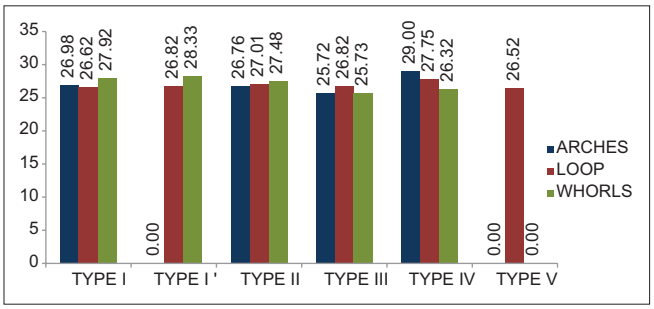
Graph 7: Comparison between lip prints and mandibular intercanine distance for females



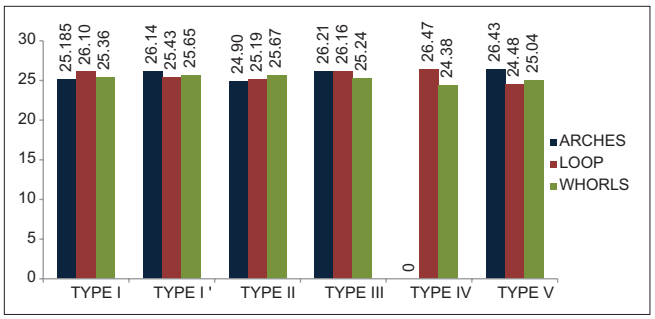
Graph 8: Comparison between fingerprints and mandibular intercanine distance for males



Graph 9: Comparison between fingerprints and mandibular inter-canine distance for females



Graph 10: Correlation between lip prints, fingerprints, and mandibular intercanine distance for males



Graph 11: Correlation between lip prints, fingerprints, and mandibular intercanine distance for females

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 caliper.

Mandibular canine width was measured as the greatest mesiodistal dimension of mandibular canine on either side of the jaw using a vernier caliper, and the average of this was taken. The intercanine distance was measured as the linear distance between the cusp tips of right and left mandibular canine. The observed mandibular canine width and intercanine width were subjected to statistical analysis to assess gender difference using independent *t*-test.[15,16]

$$\text{Mandibular Canine Index} = \frac{\text{Mesiodistal crown width of mandibular canine}}{\text{Mandibular canine arch width}}$$

Table 1: Comparison between males & females for MICD, MWRMC, MWLMC, RMCI and LMCI (Independent sample t-test)

Variables	Males			Females			Total			*t*	*p*
	N	Mean	Std. Dev.	*N*	Mean	Std. Dev.	*N*	Mean	Std. Dev.		
MICD	150	27.01	1.86	150	25.58	1.69	300	26.30	1.89	7.095	<0.0001 (very High Sig)
MWRMC	150	7.01	0.49	150	6.40	0.41	300	6.70	0.54	11.466	<0.0001 (very High Sig)
MWLMC	150	6.94	0.47	150	6.38	0.40	300	6.66	0.52	10.89	<0.0001 (very High Sig)
RMCI	150	0.26	0.02	150	0.25	0.02	300	0.26	0.02	4.38	<0.0001 (very High Sig)
LMCI	150	0.26	0.02	150	0.25	0.02	300	0.25	0.02	3.95	<0.0001 (very High Sig)

Table 2: Comparison between males & females for lip prints: (Chi-Square test)

Lip prints	Males *N* (%)	Females *N* (%)	Total *N* (%)	Chi-Square	*P*
TYPE I	35 (41.2)	50 (58.8)	85 (28.3)	23.98	<0.0001 Very High Sig
TYPE I′	7 (23.3)	23 (76.7)	30 (10.0)		
TYPE II	59 (54.6)	49 (45.4)	108 (36.0)		
TYPE III	25 (71.4)	10 (28.6)	35 (11.7)		
TYPE IV	23 (63.9)	13 (36.1)	36 (12.0)		
TYPE V	1 (16.7)	5 (83.3)	6 (2.0)		
TOTAL	150 (50.0)	150 (50.0)	300 (100.00)		

Table 3: Comparison between males & females for finger prints: (Chi-Square test)

Finger Prints	Males *N* (%)	Females *N* (%)	Total *N* (%)	Chi-Square	*P*
ARCHES	21 (53.8)	18 (46.2)	39 (13.0)	2.481	0.289 (NOT SIG)
LOOP	83 (53.2)	73 (46.8)	156 (52.0)		
WHORLS	46 (43.8)	59 (56.2)	105 (35.0)		
TOTAL	150 (50.0)	150 (50.0)	300 (100.00)		

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 univariate ANOVA test.

Results

Within individual groups

The examination of lip print and fingerprint patterns revealed the following observations:

No two lip prints and fingerprints matched with each other. Our observation revealed that in fingerprint pattern, the loop pattern (52%) is predominant in both males and females followed by whorls (35%) and arches (13%). All the results were subjected to statistical analysis by Chi-square test and the results obtained were not of significance within the gender ($P = 0.289$) [Graphs 1-3].

With regard to lip print pattern, Type II lip print was found to be predominant in males, females and in both. In both males and females, 28.3% had Type I, 10% with Type I′, 35% with Type II, 11.7% with Type III, 10% with Type IV, and 5% with Type V lip prints. In males, Type II lip prints were predominant followed by Type I, Type III, Type IV, Type I′, and Type V. In females, Type I lip prints were predominant followed by Type II, Type I′, Type III, Type IV, and Type V. Results were analyzed by Chi-square test and showed very high statistical significance ($P < 0.0001$) for different lip patterns in between males and females.

Mandibular intercanine distance (MICD), mesiodistal width of right mandibular canine, mesiodistal width of left mandibular canine, right MCI, and left MCI gave statistical significance results, and sexual dimorphism of right mandibular canine is proved to be higher than that of left mandibular canine. All measurements indicate that in the sample investigated, males have larger tooth and arch dimensions and found to be statistically significant and with 89% accuracy. Results were analyzed by independent sample *t*-test. Statistical analysis showed very high significant difference.

Intergroup comparison and correlation

If we consider single parameters in our study, we got statistical significance for MICD with 89% accuracy and lip prints with 80% accuracy. Fingerprints did not give any statistical significance results in gender determination [Tables 1-3].

On correlating all the three parameters, the observations were subjected to statistical analysis by univariate ANNOVA test within the genders [Graphs 4-11] and in between the genders and the results were not of statistical significant in gender determination [Table 4].

On comparison, Type II lip print is associated with loop pattern predominantly in both males and females followed by whorl pattern and MICD >26.5 mm considered to be as males.

Discussion

Human identification is one of the most challenging subjects that human has been confronted with.[11] Usually, personal

Table 4: Comparison between lip prints, finger prints & micd for both male & females (Univariate ANOVA test - GLM)

Descriptive Statistics				
Dependent Variable: Mandibular inter canine distance				
Finger type	**Lip_print**	**Mean**	**Std. Deviation**	***N***
ARCHES	TYPE I	26.0800	1.54626	12
	TYPE I '	26.1400	2.16927	4
	TYPE II	25.9015	1.88860	13
	TYPE III	25.7983	2.17540	6
	TYPE IV	28.9967	0.27209	3
	TYPE V	26.4300		1
	Total	26.2167	1.86976	39
LOOP	TYPE I	26.3077	1.50843	52
	TYPE I '	26.1200	1.36475	8
	TYPE II	26.2275	1.89044	56
	TYPE III	26.6241	1.53301	17
	TYPE IV	27.3045	1.71918	20
	TYPE V	25.1600	2.25247	3
	Total	26.4095	1.71162	156
WHORLS	TYPE I	26.3329	2.48685	21
	TYPE I '	26.0967	1.86311	18
	TYPE II	26.5992	2.08762	39
	TYPE III	25.5650	1.47789	12
	TYPE IV	25.4262	2.53765	13
	TYPE V	25.0350	0.45962	2
	Total	26.1666	2.12996	105
Total	TYPE I	26.2818	1.78156	85
	TYPE I '	26.1087	1.72379	30
	TYPE II	26.3225	1.95932	108
	TYPE III	26.1194	1.66209	35
	TYPE IV	26.7672	2.25290	36
	TYPE V	25.3300	1.53813	6
	Total	26.2994	1.88532	300

identification is made by comparing antemortem data with that of postmortem records.[8] Cheiloscopy is an upcoming tool in the forensic dentistry which helps in forensic investigation. They are most important forms of transfer evidence analogous to finger prints. Lip prints might be left at crime scenes and can provide a direct link to the suspect. The edges of the lips have sebaceous glands and sweat glands in between. The secretions of oil and continuous moisturizing by the tongue leads to latent lip prints similar to fingerprints.[17]

The current study was conducted using the Tsuchihashi classification, which is considered as a standard classification. Even though lines and furrows are present in both upper and lower lip from one corner to the other, the middle portion of lower lip (10 mm wide) was taken for the study as this area is almost always visible in any trace and determination of the pattern depends on the numerical superiority of the lines.[12]

In our study, no two lip prints match with each other, thus suggesting the distinctiveness of lip prints. In the past, few researchers have worked on lip prints with the idea of proving that lip prints aid in gender identification.

The analysis of fingerprints as a form of identification has been used since 1891. No two fingerprints even in a given individual have the same ridge pattern and this remains unchanged throughout life from birth till death. This uniqueness in its presentation of the fingerprint analysis offers an excellent means of forensic investigations.[3] Gender classification from fingerprints is an important step in forensic anthropology to identify the gender of a criminal and minimize the list of suspects search. Most of the studies on dermatoglyphics were carried to study the fingerprint pattern in relation to different blood groups and the number of ridges, ridge density.

Studies on fingerprint patterns for gender determination are scarce in the literature.[18,19] Studies done by Wijerathne *et al*.[20] and Mutalik *et al*.[3] showed loop pattern to be predominant in both males and females followed by whorls and arches, which were similar with the results obtained in our study.

Studies on tooth morphology have been conducted in the past using either intraoral measurements or measurements on casts.[21] Among all teeth, the mandibular canines are found to exhibit greatest sexual dimorphism.[5] The present study endeavors to establish the effectiveness of MCI in predicting sex by taking correct dental alignment into consideration. This is of definite significance as tooth morphology is known to be influenced by cultural, environmental, and racial factors.

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,[22] who conducted a study on Saudi males and females and found that only the canines in both jaws exhibited a significant sexual difference. Studies performed on the lower canines using the ratio between the maximum crown width and canine arc width, resulting in an MCI. The study has shown an ability to determine gender when performed on 384 females and 382 males of the South Indian population with an accuracy of 84.3% in males and 87.5% in females by comparing the observed MCI with a standard MCI value.[2,6] In the present study, both these parameters were measured in males and females and compared. The difference was found to be statistically significant. Sexual dimorphism of right mandibular canine is proved to be higher than that of left mandibular canine. Males have larger tooth and arch dimensions and found to be statistically significant with 89% accuracy.

The comparison and correlation of the lip prints, MCI, and fingerprints did not yield any significant statistical

significance. However, a study by Nagasupriya *et al*.[8] has drawn a significant correlation between vertical type of lip prints, arch-type fingerprints in females, and branched type of lip print with arch type in males. However, this pilot study tried to correlate all the three parameters, but the interpretations derived from this study are precluded by limited sample size. A more extensive and detailed research in a more logical manner is required to authenticate our findings. As the sampling in our case was purposive with the sole objective of identification and gender determination of individuals in a setup which comprises heterogeneous mix of population, we could not draw any correlation. However, continuation of this work to include more subjects, and further validation of results may provide some clues of any correlation of these three parameters in identification in future.

Conclusions

As forensic science identification revolves around the four pillars of age, sex, race, and stature, we have made an attempt to pilot study the pattern of three commonly used parameters in a small, yet diverse group, with a purpose of preparing a blueprint of individuals. The pilot study confirmed the distinctiveness in cheiloscopy and MCI in gender determination but there was no statistical correlation between lip prints, fingerprints, and MCI. Studying in depth and establishing further facts in the patterns will aid in population subtyping. Thus, there is scope for use of these methods in criminal investigations and personal identification.

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Nil.

Conflicts of interest
There are no conflicts of interest.

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