Original Article

Assessment of Reliability of Cheiloscopy and Dactyloscopy in Human Identification by Digital Method: A Cross-sectional Study

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ABSTRACT

Background and Objectives: Identification is of paramount importance in medicolegal investigations. Identification means the determination of the individuality of a person. This study involved the recording of lip and fingerprints of 50 males and 50 females in the age group of 18–24 years to assess their distribution in the gender groups and to evaluate the reliability of lip and fingerprint patterns in gender determination.

Materials and Methods: The individuals were selected based on the inclusion and exclusion criteria. The procured prints were scanned and analyzed for uniqueness and gender determination using Adobe Photoshop CS5 software (Adobe Systems Incorporated, San Jose, California, USA). Statistical analysis was done using statistical mean, standard deviation, Chi-square test, Student's unpaired *t*-test ($P < 0.05$), and Cohen's Kappa test.

Results: The most frequent lip print pattern was Type IV in males and Type I' in females. The most frequent fingerprint pattern was ulnar loop in the total population, as well as in the sex-wise distribution. Individuals with mean fingerprint ridge densities in the range of 10–12/25 mm^2 were predominantly males whereas those >14/25 mm^2 were predominantly females.

Conclusion: Fingerprint ridge density was found to be a more reliable tool in estimating the gender of an unknown individual than lip print.

Key Words: *Computer-assisted, digital, finger, forensic anthropology, gender determination, lip, personal identification*

Introduction

The identification of a living person is mostly the concern of investigating officers and is raised in criminal courts in connection with absconding soldiers and criminals, or persons accused of rape, assault, or murder. It is also frequently raised in civil courts owing to fraudulent personation practiced by people to secure unlawful possession of property, insurance claims or to obtain the prolongation of a lapsed pension. Being oral physicians, we have a role in assisting the investigating officers in the identification process.

Physical evidence such as sex, age, complexion, hair, fingerprints, lip print, bite marks, DNA profiling, tattoo marks, scars, occupational marks, clothes, and personal articles are used for the purpose of identification.[1,2] The use of conventional methods in personal identification such as finger and lip print patterns are of paramount importance, as other modalities such as DNA analysis are sophisticated, expensive, time-consuming, and not available in rural areas and developing countries.[3]

Cheiloscopy is a noninvasive forensic investigation technique that deals with the study of lip prints.[4] The importance of cheiloscopy is associated with the fact that lip prints are unique to a person except in monozygotic twins. The lip grooves are permanent and unchangeable. It has been verified that lip prints recover after undergoing alterations such as minor trauma, inflammation, and diseases like herpes.[5] Dactyloscopy is the study of fingerprints. Dactylography is the process of taking impression of papillary or friction ridges of the fingertips, for the purpose of identification of a person.[6] The fingerprint patterns are unique in each individual that even identical twins originating from one fertilized egg, sharing the same DNA profile have distinct fingerprint patterns. Also once formed, they do not change their course or alignment throughout the life of an individual.[2]

Lip and fingerprint patterns provide important information for identifying an individual, and they cannot be replicated. Hence, together, they may form an effective, authentic, and credible tool in the identification of an individual. Although many studies have been conducted on cheiloscopy and dactyloscopy, very few correlative studies have been

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conducted on a population of different ethnic backgrounds. In addition, most of these studies have utilized the manual method of analysis of the prints. Hence, this study aimed to go one step closer by utilizing Adobe Photoshop CS5 software (Adobe Systems Incorporated, San Jose, California, USA) for the comprehensible visualization of the imprints. With the above background, this study was designed to assess the reliability of cheiloscopy and dactyloscopy in human identification by the digital approach.

Aims of the Study

i. To assess the distribution of lip and fingerprint patterns among the gender groups
ii. To determine the predominant lip print and fingerprint patterns
iii. To evaluate and compare the reliability of lip print and fingerprint patterns in gender determination.

Materials and Methods

Source of data

This study enrolled 100 individuals, 50 male and 50 female dental students aged between 18 and 24 years from varying ethnic backgrounds studying in Rajarajeswari Dental College and Hospital, Bengaluru. A pair of identical twins was also included in the study. Ethical clearance was obtained from the Institution Ethical Committee.

Inclusion criteria

A. Lip prints
   a. Individuals with good general health
   b. Individuals having complete dentition
B. Fingerprints
   a. Individuals with good general health.

Exclusion criteria

A. Lip prints
   a. Pathologies such as inflammation, ulcer, trauma to lips, and surgical scars
   b. Known hypersensitivity to lipsticks
B. Fingerprints
   a. Individuals with physical deformities due to injury
   b. Individuals with permanent scars on their fingers.

Method of collection of data

Individuals were randomly selected based on the inclusion and exclusion criteria. A formal consent was obtained from the selected individuals. The relevant demographic data including name, age, and gender were recorded for each study subject in a specially designed pro forma. Each pro forma was assigned a serial number and contained slots for recording lip print and fingerprints.

Recording of lip prints

Armamentarium [Figure 1]:
i. Tissue paper
ii. Dark and nonglossy lipstick
iii. Lipstick application brush
iv. Transparent cellophane tape

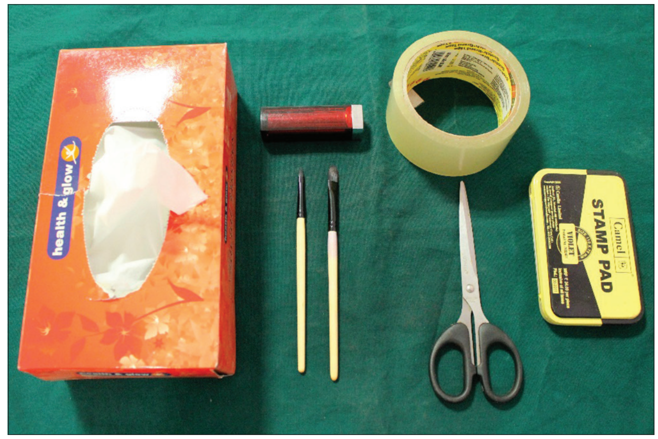


Figure 1: Armamentarium for recording of lip print and fingerprint

v. Scissors
vi. A4 size white Executive bond sheet.

Methodology

The upper and lower lips were wiped using a tissue paper, and care was taken to ensure that no trace of tissue paper was left on the surface of lips. Lipstick was applied gently using a lipstick application brush, and the individuals were asked to clutch the lips to ensure that the lipstick application was uniform [Figure 2]. The lipstick was allowed to dry for 2 min. The glue portion of a cellophane tape was placed on the lip surface, and the impression of the lip was obtained. The record was immediately transferred on to a white Executive bond sheet by sticking the cellophane tape.

The lip prints were scanned and imported to Adobe Photoshop CS5 software (Adobe Systems Incorporated, San Jose, California, USA) for the digital analysis [Figure 3]. The pencil tool in Adobe Photoshop CS5 software was used to trace the prints [Figure 4]. The type of pattern was determined based on numerical superiority of properties of the lines.[7] Each lip print was tested for uniqueness. The classification of patterns of lines on the lip proposed by Suzuki and Tsuchihashi was followed. Suzuki and Tsuchihashi classified lip print patterns into:[8,9]

- Type I - Clear cut grooves running vertically over the lips
- Type I' - Partial length grooves of Type I variety
- Type II - Branched grooves
- Type III - Intersected grooves
- Type IV - Reticular grooves
- Type V - Other patterns (Irregular nonclassified patterns).

For the purpose of gender determination, the lower middle quadrant was considered. Since this fragment is almost always visible in any trace.[10] The gender of the individual was determined as per the following description.

- Type I, I' and II dominant lip print patterns were assigned female gender[7]
- Type III, IV and V dominant lip print patterns were allotted male gender.[7]

The results obtained were verified from the data collected at the beginning of the study corresponding to the serial number of the lip print.

Recording of fingerprints

Armamentarium [Figure 1]:

i. Stamp pad
ii. A4 size white Executive bond sheet.

Methodology

The hands were cleansed using soap and wiped dry using tissue paper. The fingertips of both the hands were rolled over a stamp pad, ensuring that the ink covered the entire pattern area. Then, the fingers were rolled from nail to nail over a white bond sheet taking care that complete ridge pattern of the distal phalanx of all ten fingers was acquired. Excessive pressure on finger was avoided during inking and printing [Figure 5].

The fingerprints were scanned for the digital analysis using Adobe Photoshop CS5 software (Adobe Systems Incorporated, San Jose, California, USA). Each print was tested for uniqueness. The analysis was carried out using the classification given by Sir Henry Galton (1892).[11]

Loop

Loops usually begin on one side of the finger and end on the same side. When this happens from ulnar side, it is called ulnar loop end and if on radial side, it is called radial loop.

Whorl

Multiple circular/oval ridges one around the other, or a single round, round in multiple rounds.

Arch

When it is wave-like, from one side of the finger to other side (Plain arch) or when the arch is sharp and spike-like (Tented arch).

Composite

It is a combination of more than one pattern, either a combination of arch, whorl, loop, or two different patterns-two whorls, arch, or loop (twin/double).

For the purpose of gender determination, the fingerprint ridge density had to be calculated. The upper portion of the radial border of the print was chosen as the area of analysis as all fingerprint pattern show a similar ridge flow in this region. This method serves to isolate the ridges to a well-defined area facilitating the process of ridge count. A 5 mm × 5 mm square was marked on the fingerprint image in the chosen area using the rectangle tool [Figure 6]. The epidermal ridges from one corner of the square were counted to the diagonally opposite corner.

Dots were not counted. Forks were counted as two ridges excluding the handle and lake was counted as two ridges. The value obtained represents the number of ridges in a 25 mm^2 area and reflected the ridge density value. The ridge density value was obtained for all 10 fingers, and the mean was calculated. This mean represented a single data point for that particular individual. It is found that the mean ridge

Figure 2: Recording of lip print

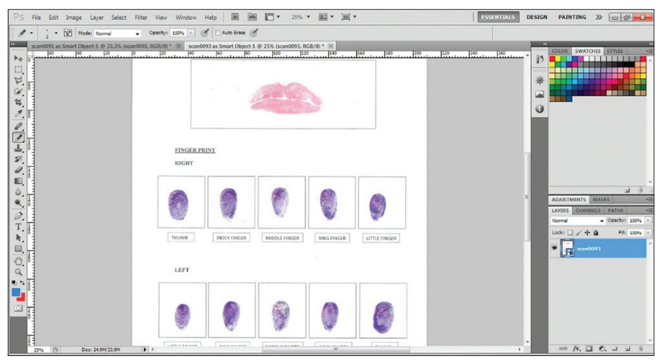


Figure 3: Prints scanned and imported to Adobe Photoshop CS5 for analysis

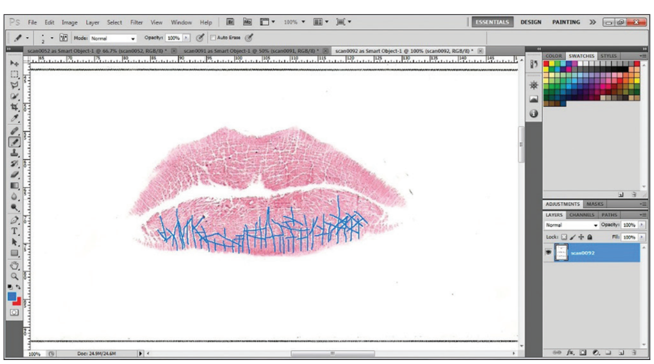


Figure 4: Lip print marked using the pencil tool

Figure 5: Recording of fingerprint

density of 12 ridges/25 mm^2 or less is more likely to be a male and a mean ridge count of more than 13 ridges/25 mm^2 is more likely to be a female.[12] The results obtained were verified from the data collected at the beginning of the study corresponding to the serial number of the lip and fingerprints.

Results

The lip and fingerprints were recorded as described in the methodology. The bond sheets containing the lip and fingerprints of study individuals were scanned and then imported to Adobe Photoshop CS5 (Adobe Systems Incorporated, San Jose, California, USA). The recorded prints were analyzed digitally; the values were tabulated using Microsoft Excel (Version 3. 2013. Jones, Chicago: USA) and subjected to statistical analysis using IBM SPSS Statistics for Windows (version 22.0. Armonk, NY: USA). The data were subjected to statistical mean, standard deviation, Chi-square test, Student's unpaired *t*-test ($P < 0.05$), and Cohen's Kappa test. The mean age of the study population was 22.4 ± 1.7 years, and it was 22.2 ± 2.0 years for males and 22.5 ± 1.4 years for females [Graph 1].

In males, the most predominant pattern of lip print was found to be Type IV (40%) followed by Type III (36%), Type II (12%), Type I' (10%), and Type I (2%). In females, the most predominant pattern of lip print was found to be Type I' (50%) followed by Type I (26%), Type IV (14%), Type II (6%), and Type III (4%). Type V pattern of lip print was not seen in any of the gender groups [Figure 7]. Comparison between the gender groups was made using Chi-square test, and it was found to be statistically significant with $P < 0.001$ [Table 1].

In males, the most predominant pattern of fingerprint in little fingers (Digits 10 and 5) was ulnar loop (67%) followed by plain whorl (31%). The most predominant pattern of fingerprint in ring fingers (Digits 9 and 4) was ulnar loop (63%) followed by plain whorl (20%). The most predominant pattern of fingerprint in middle fingers (Digits 8 and 3) was ulnar loop (76%) followed by plain whorl (18%). The most predominant pattern of fingerprint in index fingers (Digits 7 and 2) was ulnar loop (66%) followed by plain whorl (31%). The most predominant pattern of fingerprint in thumbs (Digits 6 and 1) was ulnar loop (79%) followed by plain whorl (19%). Hence, the ulnar loop fingerprint pattern was the most predominant pattern among all ten digits in males [Figure 8 and Table 2].

Table 1: Distribution of the lip print patterns in males and females

Lip print pattern	Males, *n* (%)	Females, *n* (%)	χ^2	*P*
Type I	1 (2)	13 (26)	43.678	<0.001*
Type I'	5 (10)	25 (50)		
Type II	6 (12)	3 (6)		
Type III	18 (36)	2 (4)		
Type IV	20 (40)	7 (14)		
Type V	0	0		

*Statistically significant

In females, the most predominant pattern of fingerprint in little fingers (Digits 10 and 5) was ulnar loop (64%) followed by plain whorl (35%). The most predominant pattern of fingerprint in ring fingers (Digits 9 and 4) was ulnar loop (51%) followed by plain whorl (38%). The most predominant pattern of fingerprint in middle fingers (Digits 8 and 3) was ulnar loop (76%) followed by plain whorl (20%). The most predominant pattern of fingerprint in index fingers (Digits 7 and 2) was ulnar loop (54%) followed by plain whorl (44%). The most predominant pattern of fingerprint in thumbs (Digits 6 and 1) was ulnar loop (68%) followed by plain whorl (30%). Hence, the ulnar loop fingerprint pattern was the most predominant pattern among all ten digits in females [Figure 8 and Table 3].

The mean fingerprint ridge density was found to be 11.85/25 mm^2 in males and 15.86/25 mm^2 in females ($P < 0.001$). Hence, females were found to have a higher mean fingerprint ridge density compared to males [Table 4]. The mean ridge density in the range of

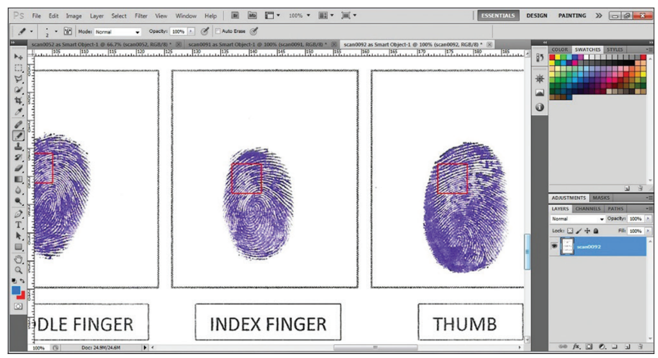


Figure 6: Fingerprint ridge density measured by marking a 5 mm × 5 mm square using the rectangle tool

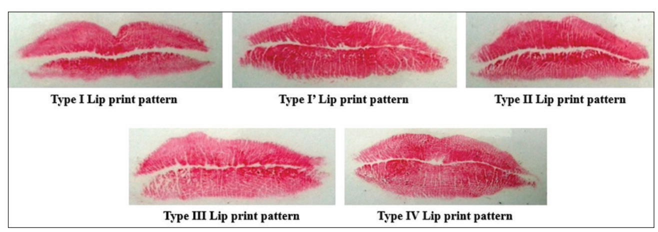
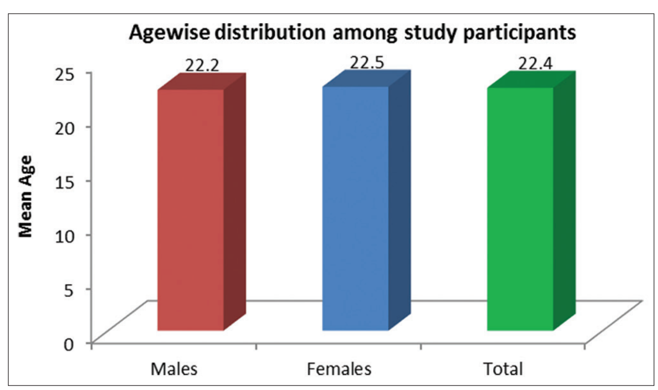


Figure 7: Lip print patterns found



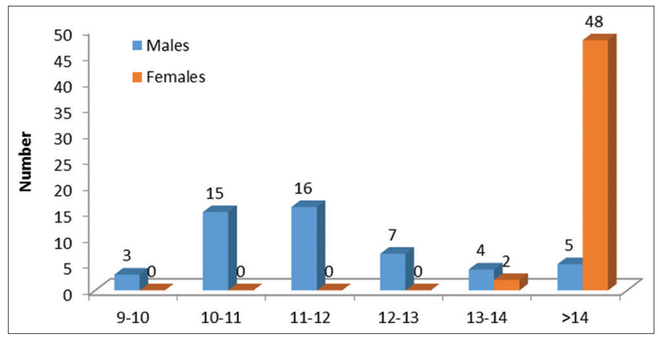
Graph 1: Mean age of the study population

9–10/25 mm^2 was seen in three males. Mean ridge density in the range of 10–11/25 mm^2 was seen in 15 males. Mean ridge density in the range of 11–12/25 mm^2 was seen in 16 males. Mean ridge density in the range of 12–13/25 mm^2 was seen in seven males. Mean ridge density in the range of 13–14/25 mm^2 was seen in four males and two females. Mean ridge density >14/25 mm^2 was seen in 5 males and 48 females. Hence, individuals with mean fingerprint ridge densities in the range of 10–12/25 mm^2 were predominantly found to be males and those above 14/25 mm^2 were predominantly found to be females [Graph 2].

About 78% of the males were accurately identified as males whereas the remaining 22% of males were estimated to be females using lip prints. Nearly 82% of the females were accurately identified as females whereas the remaining 18% of females were estimated to be males using lip prints ($P < 0.001$). The accuracy between estimated and actual gender among the study population was found to be 60% using lip prints (Cohen's Kappa value = 0.60) [Table 5].

About 80% of the males were accurately identified as males whereas the remaining 20% of males were estimated to be females using fingerprint ridge density. 100% of the females were accurately identified as females using fingerprint ridge density ($P < 0.001$). The accuracy between estimated and actual gender among the study population was found to be 80% using fingerprint ridge density (Cohen's Kappa value = 0.80) [Table 6]. Hence, fingerprint ridge density was found to be a more reliable tool in estimating the gender of an unknown individual than lip print.

Figure 8: Fingerprint patterns found



Graph 2: Gender wise frequency distribution of fingerprint ridge density

Table 2: Distribution of the fingerprint patterns in males

Fingerprint patterns	Little fingers (digits 10 and 5), *n* (%)	Ring fingers (digits 9 and 4), *n* (%)	Middle fingers (digits 8 and 3), *n* (%)	Index fingers (digits 7 and 2), *n* (%)	Thumbs (digits 6 and 1), *n* (%)
Loop (ulnar)	67 (67)	63 (63)	76 (76)	66 (66)	79 (79)
Loop (radial)	0	7 (7)	0	0	0
Plain (whorl)	31 (31)	20 (20)	18 (18)	31 (31)	19 (19)
Plain (arch)	2 (2)	10 (10)	6 (6)	3 (3)	2 (2)
Tented arch	0	0	0	0	0
Composite	0	0	0	0	0
All patterns	100 (100)	100 (100)	100 (100)	100 (100)	100 (100)

Table 3: Distribution of fingerprint patterns in females

Fingerprint patterns	Little fingers (digits 10 and 5), *n* (%)	Ring fingers (digits 9 and 4), *n* (%)	Middle fingers (digits 8 and 3), *n* (%)	Index fingers (digits 7 and 2), *n* (%)	Thumbs (digits 6 and 1), *n* (%)
Loop (ulnar)	64 (64)	51 (51)	76 (76)	54 (54)	68 (68)
Loop (radial)	1 (1)	4 (4)	2 (2)	1 (1)	0
Plain (whorl)	35 (35)	38 (38)	20 (20)	44 (44)	30 (30)
Plain (arch)	0	1 (1)	0	0	0
Tented arch	0	6 (6)	2 (2)	1 (1)	2 (2)
Composite	0	0	0	0	0
All patterns	100 (100)	100 (100)	100 (100)	100 (100)	100 (100)

Table 4: Gender-wise comparison of the mean fingerprint ridge density using Student's unpaired *t*-test

Gender	*n*	Mean±SD	SEM	Minimum	Maximum	Mean difference	95% CI of the difference		*t*	df	*P*
							Lower	Upper			
Males	50	11.85±1.58	0.22	9.30	16.1	−4.01	−4.54	−3.48	−14.973	98	<0.001*
Females	50	15.86±1.04	0.15	13.70	17.9						

*Statistically significant. SD: Standard deviation, SEM: Standard error of mean, CI: Confidence interval

Table 5: Reliability of gender estimation by lip print using Cohen's kappa test

Estimated gender	Gender		Total (%)	Cohen's kappa value	*P*
	Males (%)	Females (%)			
Males	39 (78)	9 (18)	48 (48)	0.60	<0.001*
Females	11 (22)	41 (82)	52 (52)		
Total	50 (100)	50 (100)	100 (100)		

*Statistically significant

Table 6: Reliability of gender estimation by fingerprint ridge density using Cohen's kappa test

Estimated gender	Gender		Total (%)	Cohen's kappa value	*P*
	Males (%)	Females (%)			
Males	40 (80)	0	40 (40)	0.80	<0.001*
Females	10 (20)	50 (100)	60 (60)		
Total	50 (100)	50 (100)	100 (100)		

*Statistically significant

Discussion

The identification of a living person is based exclusively on the known fingerprints or birthmarks or several personal impressions with regard to characteristic gestures, movements or features of the teeth, lips, eyes, hair, or voice. With the rise in the number of criminal cases, fingerprints and lip prints are increasingly becoming an indispensable tool for the investigating officers to apprehend the culprits. If the gender of the individual is established with certainty using these prints, the burden of the investigating officer would be reduced considerably.

This study was designed to assess the reliability of cheiloscopy and dactyloscopy in human identification by digital approach. Lip prints and fingerprints of 100 students of Rajarajeswari Dental College and Hospital were recorded. Hence, the study population included individuals of mixed ethnic background, i.e., individuals from Karnataka, Kerala, Bihar, Northeast states, Tamil Nadu, and Andhra Pradesh. A pair of identical twins was also included in the study population to emphasize and verify the uniqueness of lip prints and fingerprints.

Lip prints were recorded using lipstick and cellophane tape as used by Sivapathasundharam *et al*.,[10] Augustine *et al*.,[13] Nagasupriya *et al*.,[14] Mutalik *et al*.,[15] Prabhu *et al*.,[16] Nandan *et al*.,[17] Bijjargi *et al*.,[18] Bajpai *et al*.,[19] Kaul *et al*.,[20] Verghese and Mestri[21] and Patil *et al*.[4] This method helped to avoid smudging of the prints. It was also found that a red or dark pink shade of lipstick on white bond sheet gave the best print visibility. A nonglossy lipstick served better than a glossy lipstick as the latter would lead to smudging of the lip prints. The usage of brush for lipstick application and asking the subject to rub the upper and lower lips together before taking the print ensured that the lipstick spread evenly. The lipstick-cellophane tape method was also quite feasible for the purpose of recording the grooves on the lips for a large number of individuals.

Fingerprints were recorded using the stamp pad technique as mentioned by Adamu *et al*.,[3] Nagasupriya *et al*.,[14] Mutalik *et al*.[15] and Nandan *et al*.[17] The stamp pad was easy to carry and use. It was also quite feasible for the purpose of recording the friction ridges on the fingers for a large number of individuals.

The obtained prints were scanned and imported to Adobe Photoshop CS5 (Adobe Systems Incorporated, San Jose, California, USA) for digital analysis as reported by Prabhu *et al*.,[16] Augustine *et al*.,[13] Nagrale N,[22] Bijjargi *et al*.[18] and Jatti D *et al*.[23] The pencil tool was used to mark the lip prints. The rectangular tool was used to draw a 5 mm × 5 mm square at the upper portion of the radial border of the fingerprints for recording the ridge density count.

The software made it possible to enlarge the working area and zoom in. The brightness/contrast and sharpness could be adjusted. Measurements could be performed with ease using the ruler provided on the top and left-hand corner.[13] It is also possible to analyze photographs and overlap images using this software to help in forensic identification. The digital method not only provided ease in the identification of the imprint patterns but also served as an ideal method of permanently storing antemortem data of the study individuals.[16]

A perceived drawback of using Adobe Photoshop software in this study was that when an image is edited, it gets modified, effectively destroying the original. In today's world of cybercrime, unfortunately, it is very easy to manipulate forensic evidence stored digitally. Even the best visual experts, who know every trick to pry out fakery eventually, hit their limits. Another limitation of using this software is the requirement of expertise to use the sophisticated tools provided in the software.

In our study, the most predominant pattern of lip print was found to be Type IV (40%) in males whereas in females, the most predominant pattern of lip print was found to be Type I' (50%). Hence, both the genders showed dissimilar lip print patterns. Type V pattern of lip print was not seen in any of the gender groups [Table 1]. These findings were in accordance to studies conducted by Sharma *et al*.,[7] Verghese and Mestri,[21] Malik and Goel.[24] However, these findings were in contrast to the studies conducted by Tsuchihashi,[8] Sivapathasundharam *et al*.,[10] Patil *et al*.,[4] Mutalik *et al*.,[15] Nagasupriya *et al*.,[14] and Nandan *et al*.[17] This may be explained by the difference in the study population as in our study, the individuals belonged to varying ethnic backgrounds.

In our study, it was observed that all the lip prints were unique, even in case of the twins. This is in concurrence with Suzuki and Tsuchihashi,[9] Tsuchihashi,[8] Sivapathasundharam *et al*.,[10] Bajpai *et al*.,[19] Prabhu *et al*.,[16] and Nagrale *et al*.[22] All of them have found that no two individuals have the same lip print, not even twins. The reason being, lip prints vary in different parts of the lip in an individual making them unique. Hence, ante-mortem record of lip prints can be compared with postmortem record for personal identification. This can be done by either comparing lip print in total or compartment wise.

With reference to fingerprints, the ulnar loop was the most frequently observed pattern followed by plain whorl, in the total subject population in all the ten digits. The least frequently observed pattern in the total population was plain arches, tented arches [Tables 2 and 3]. These findings were concurrent with studies done by Desai *et al*.,[1] Nagasupriya *et al*.,[14] Mutalik *et al*.[15] and Nandan *et al*.[17] However, studies conducted by Nithin *et al*.,[2] Reddy and Reddy,[25] Rastogi and Pillai,[26] and Ekanem *et al*.[27] recorded whorl pattern predominantly in males and loop pattern in females which explains that different racial and ethnic groups show difference in the predominant fingerprint pattern.

The present study observed that all the fingerprints were unique. This is in concurrence with Nadar,[28] Senn and Stimson.[29] It is proven that no two individuals have the same fingerprint, not even twins.

In our study, the mean fingerprint ridge density in males was found to be 11.85/25 mm^2 and 15.86/25 mm^2 in females ($P < 0.001$) [Table 4]. Mean fingerprint ridge densities in the range of 10–12/25 mm^2 were predominantly found to be males. Mean fingerprint ridge densities above 14/25 mm^2 were predominantly found to be females. Hence, females were found to have a higher mean fingerprint ridge density compared to males [Graph 2]. This is in agreement to the studies conducted by Acree,[30] Gungadin,[31] Nithin *et al*.,[2] Gutiérrez-Redomero *et al*.[32] and Nayak *et al*.[33] The reason being, males have coarser finger ridges than females which suggests that males usually have fewer ridges in a given area than females and thus, lesser ridge density.[34] Another interesting finding in our study was that the fingerprint ridge density in both genders was found to be greater in the digits of the left hand, thus showing finer ridges compared to the right hand. This is in accordance with the study conducted by Gutiérrez-Redomero *et al*.[32]

In our study, 78% of the males were accurately identified as males whereas the remaining 22% of males were estimated to be females using lip prints. 82% of the females were accurately identified as females whereas the remaining 18% of females were estimated to be males using lip prints ($P < 0.001$) [Table 5]. This is in accordance to studies by Bajpai *et al*.[19] and Malik and Goel[24] whereas Kaul *et al*.[20] found that lip prints were not an effective tool in gender determination. According to her study, the accuracy of lip print patterns in gender determination was 17.4% in males and 35.4% in females. This can be explained by the difference in the age range of the study population of both studies. Our study comprised of individuals of younger age group in the range of 18–24 years whereas their study included individuals in the age range of 1 to above 40 years. Hence, the influence of age changes on the size and shape of the lips and the perioral skin could be cited as the reason for the low accuracy.

In our study, 80% of the males were accurately identified as males whereas the remaining 20% of males were estimated to be females using fingerprint ridge density. 100% of the females were accurately identified as females using fingerprint ridge density ($P < 0.001$) [Table 6]. Hence, fingerprint ridge density (Cohen's Kappa value = 0.80) was found to be a more reliable tool in estimating the gender of an unknown individual than lip print (Cohen's Kappa value = 0.60) [Tables 5 and 6]. This is in accordance with Nagasupriya *et al*.[14] However, this is in contrast to the findings in the study by Nandan *et al*.[17] who concluded a weaker correlation and approachable significance of lip and fingerprint pattern in gender identification. This can be explained by the difference in analysis of the lip print and fingerprint patterns. Nandan *et al*.[17] examined the lip print and fingerprint patterns using magnifying glass whereas in our study, Adobe Photoshop software was used. In our literature search, very few comparative studies were found on lip prints and fingerprints with respect to gender estimation.

Conclusion

It was found that the digital method not only provided ease in identification of the imprint patterns but also served as an ideal method of database storage of the imprints. Each lip print and fingerprint was unique and can be used for positive identification of an unknown individual. Fingerprint ridge density was found to be a more reliable tool in estimating the gender of an unknown individual than lip print. Hence, the degree of ridge densities and lip print patterns can be used as a presumptive indicator of sex of an unknown print left at a crime scene. However, more studies need to be conducted to determine the predominant lip print and fingerprint patterns among the large number of racial and ethnic groups in our country. Prospect studies should also be encouraged in terms of software-based identification for lip and fingerprint analysis in gender identification for more accurate results.

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Conflicts of interest

There are no conflicts of interest.

References

1. Desai B, Jaiswal R, Tiwari P, Kalyan JL. Study of fingerprint patterns in relationship with blood group and gender – A statistical review. Res J Forensic Sci 2013;1:15-7.
2. Nithin MD, Balaraj BM, Manjunatha B, Mestri SC. Study of fingerprint classification and their gender distribution among South Indian population. J Forensic Leg Med 2009;16:460-3.
3. Adamu LH, Taura MG, Hamman WO, Ojo SA, Dahiru AU,

Sadeeq AA, *et al*. Relationship of thumb prints and lip prints among Nigerians. J Dent Med Sci 2013;9:12-7.

4. Patil D, Hiremath R, Mugadlimath A. A study on lip print types among North Karnataka people. Int J Biom Adv Res 2013;4:619-22.
5. Caldas IM, Magalhães T, Afonso A. Establishing identity using cheiloscopy and palatoscopy. Forensic Sci Int 2007;165:1-9.
6. Vij K. Textbook of Forensic Medicine and Toxicology: Principles and Practice. India: Elsevier Pvt Ltd.; 2012.
7. Sharma P, Saxena S, Rathod V. Cheiloscopy: The study of lip prints in sex identification. J Forensic Dent Sci 2009;1:24-7.
8. Tsuchihashi Y. Studies on personal identification by means of lip prints. Forensic Sci 1974;3:233-48.
9. Suzuki K, Tsuchihashi Y. New attempt of personal identification by means of lip print. J Indian Dent Assoc 1970;42:8-9.
10. Sivapathasundharam B, Prakash PA, Sivakumar G. Lip prints (cheiloscopy). Indian J Dent Res 2001;12:234-7.
11. Rao NG. Textbook of Forensic Medicine and Toxicology. 1st ed. Delhi: Jaypee; 2000. p. 108.
12. Floris G. Sex and side difference and correlations between quantitative palmar characteristics in a sample Sardinian population. J Anat 2001;1995:577-84.
13. Augustine J, Barpande SR, Tupkari JV. Cheiloscopy as an adjunct to forensic identification: A study of 600 individuals. J Forensic Odontostomatol 2008;26:44-52.
14. Nagasupriya A, Dhanapal R, Reena K, Saraswathi T, Ramachandran C. Patterns – "A crime solver". J Forensic Dent Sci 2011;3:3-7.
15. Mutalik VS, Menon A, Jayalakshmi N, Kamath A, Raghu AR. Utility of cheiloscopy, rugoscopy, and dactyloscopy for human identification in a defined cohort. J Forensic Dent Sci 2013;5:2-6.
16. Prabhu RV, Dinkar A, Prabhu V. A study of lip print pattern in Goan dental students – A digital approach. J Forensic Leg Med 2012;19:390-5.
17. Nandan SR, Bandaru BK, Santosh AB, Thankappan P, Chundru NS, Amudala R. A study on association and correlation of lip and finger print pattern analysis for gender identification. J NTR Univ Health Sci 2015;4:176-81.
18. Bijjargi SC, Malligere SB, Sangle VA, Saraswathi FK, Majid IA, Ashwini SR. A new attempt in comparision between 3 racial groups in India – Based on lip prints (Cheiloscopy). IJADS 2015;1:20-3.
19. Bajpai M, Mishra N, Yadav P, Kumar S. Efficacy of lip prints for determination of sex and inter observer variability. Eur J Exp Biol 2011;1:81-6.
20. Kaul R, Padmashree SM, Shilpa PS, Sultana N, Bhat S. Cheiloscopic patterns in Indian population and their efficacy in sex determination: A randomized cross-sectional study. J Forensic Dent Sci 2015;7:101-6.
21. Verghese AJ, Mestri SC. A study of efficacy of lip prints as an identification tool among the people of Karnataka in India. Indian Acad Forensic Med 2011;33:200-2.
22. Nagrale N, Tirpude B, Murkey P, Patond S. Establishing cheiloscopy as a tool for identification: An assessment on 500 subjects in central India. Al Ameen J Med Sci 2014;7:201-6.
23. Jatti D, Rastogi P. Digital analysis of lip prints for personal identification: A cross sectional study in South Indian population. Indian Acad Forensic Med 2015;37:289-3.
24. Malik R, Goel S. Cheiloscopy: A deterministic aid for forensic sex determination. J Indian Acad Oral Med Radiol 2011;23:17-9.
25. Reddy BM, Reddy CP. Population structure and pattern of dermatoglyphics variation in Andhra Pradesh, India. IJHG 2001;1:203-9.
26. Rastogi P, Pillai KR. A study of finger prints in relation to gender and blood groups. J Indian Acad Forensic Med 2010;32:11-4.
27. Ekanem EP, Eluwa MA, Udoaffah GU, Ekanem TB, Akpantah AO. Digital dermatoglyphic pattern of Annang ethnic group in Akwa Ibom state of Nigeria. Internet J Biol Anthropol 2009;3:1-4.
28. Nadar DS. Forensic Science in Crime Investigation. 3rd ed. Hyderabad: Asia Law House; 2002. p. 48-9.
29. Senn DR, Stimson PG. Forensic Dentistry. 2nd ed. USA: CRC Press; 2010.
30. Acree MA. Is there a gender difference in fingerprint ridge density? Forensic Sci Int 1999;102:35-44.
31. Gungadin S. Sex determination from fingerprint ridge density. Internet J Med Update 2007;2:4-7.
32. Gutiérrez-Redomero E, Alonso C, Romero E, Galera V. Variability of fingerprint ridge density in a sample of Spanish Caucasians and its application to sex determination. Forensic Sci Int 2008;180:17-22.
33. Nayak VC, Rastogi P, Kanchan T, Lobo SW, Yoganarasimha K, Nayak S, *et al.* Sex differences from fingerprint ridge density in the Indian population. J Forensic Leg Med 2010;17:84-6.
34. Kralik M, Novotny V. Epidermal ridge breadth: An indicator of age and sex in paleodermatoglyphics. Variability Evol 2003;11:5-30.