https://doi.org/10.48047/AFJBS.6.14.2024.4496-4507

African Journal of Biological Sciences

Journal homepage: http://www.afjbs.com

Research Paper Open Access

Determination of Fingerprint and Lip-print patterns in Assamese community and assessment of their reliability in human identification.

Dr. Mrinal Haloi,[1] Dr. Mamata Devi,[2] Dr. Raktim Pratim Tamuli,[3] Dr. Mintu Dewri Bharali,[4] Dr. Rwishumwi Daimari,[5] Dr Kum Kum Bora,[6] Dr Ronit Kaushik,[7] Dr. Syeda Tanvi Islam[8]

[1]Assitant professor, Department of Forensic Medicine, GMCH, [2]Assitant professor, Department of Forensic Medicine, GMCH, [3]Associate professor, Department of Forensic Medicine, GMCH [4]Assitant professor, Department of Community Medicine, GMCH [5]Assitant professor, Department of Pathology, GMCH, [6]Associate professor, Department of Otorhinolargology, GMCH, [7]Fellowship student, Forensic odontology, Department of Forensic Medicine, GMCH, [8]Assitant professor, Department of Forensic Medicine, GMCH.

Address for Correspondence: Dr. Mrinal Haloi,

Volume 6, Issue 14, Aug 2024

Received: 09 June 2024

Accepted: 19 July 2024

Published: 08 Aug 2024

doi: 10.48047/AFJBS.6.14.2024.4496-4507

Abstract:

Identification is the determination of individuality of person which plays a significant role in medico-legal cases. In this study lip prints and fingerprints of 100 individuals, 50 male and 50 female, aged between 21 and 78 years are recorded to find out the distribution of different patterns of lip and fingerprint and their reliability in determination of sex.

Based on inclusion and exclusion criteria the individuals were selected. The collected lip prints and fingerprints were examined for uniqueness using magnifying lens and sex was determination. Statistical analysis was done using statistical mean, standard deviation, Chi-square test, Student's unpaired t-test, and Cohen's Kappa test.

The most predominant pattern of lip print was found to be Type IV in male and Type I' in female. The most predominant fingerprint pattern was ulnar loop in both male and female. 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.

We suggest that fingerprint ridge density is more accurate in sex determination of an unknown individual than lip print.

Key Words: Identification, lip print; fingerprint; sex determination; medico legal.

Introduction:

Identification is the determination of individuality of person based on certain physical characteristics [1,2]. In dealing with both civil and criminal cases, the Investigating officer mostly concerned with identification. Identification is needed in civil courts because of fraudulent personation to secure unlawful possession of property, insurance claims or prolongation of a lapsed pension. Whereas in Criminal courts, it is essential in case of absconding criminals or persons accused of heinous crime like rape, assault, murder etc. Various identification data such as age, sex, race, religion, anthropometric measurements ect. are useful, but fingerprint is the surest data of identification [3].

Lip print patterns and fingerprint plays a pivotal role in personal identification as other methods like analysis of DNA are sophisticated, expensive, time-consuming, and not available in rural areas and developing countries [1-3].

Cheiloscopy, study of lip prints, is noninvasive forensic investigation method and are unique to a person except in identical twins which makes cheiloscopy as useful method in personal identification [5]. The grooves of the lips are permanent and unchanged throughout the life of an individual. Lip prints recover after they are altered due to trauma, inflammation, and diseases like herpes [6]. Cheiloscopy is a rapidly evolving scientific knack aiding in personal identification. Lip prints are an extremely reliable method to individualize a person if they are found in good condition, specifically at crime scene, where lip prints are often present [1,2].

Dactylography is the study of impressions of patterns formed by the papillary or epidermal ridges of the fingertips [1,2]. It is the process of taking impression of papillary or friction ridges of the fingertips [7]. The fingerprints are different in everyone, even in identical twins that have identical DNA. The chance of two individual having similar fingerprint is one in 64 billion. The ridge pattern of fingertips appears between 12-16 weeks of intra uterine life and completed by 24 weeks and do not change throughout the life [1,2]. Both lip-print and fingerprint patterns provide valuable information for identifying an individual, and they cannot be duplicated. Dactylography and cheiloscopy form a reliable, effective, authentic, and credible method in the identification of an individual. Through the world, many studies have been done on cheiloscopy and dactylography but a very few correlative studies have been carried out in the region of Northeastern states of India. This study was designed to figure out the distribution of the fingerprints and lip-print pattern in the Assamese community and to assess the reliability of dactylography and cheiloscopy in human identification.

Aims and Objectives

This study is carried out to find out the distribution of different patterns of lip and fingerprint, to determine the predominant lip-print and fingerprint patterns in the community and to evaluate and compare the reliability of lip-print and fingerprint patterns in determination of sex in Assamese community.

Materials and Methods

This study enrolled 100 individuals, 50 male and 50 female brought for medico legal autopsy to a government medical institute in the state of Assam in India, in the age group of 21 to 78 years. Necessary clearance from the Institution Ethical Committee was taken before starting the study.

Inclusion criteria

For lip-prints, individuals with good general health and one who has completed the permanent dentition

Fingerprints, individuals with good general health without any disease which might alter the fingerprint pattern like eczema, dermatitis, colitis etc.

Exclusion criteria

For lip prints, congenital deformity like cleft lip and pathologies such as inflammation, ulcer, trauma to lips, and surgical scars. Decomposed bodies are also excluded from the study.

Fingerprints, individuals with finger deformities due to injury, individuals with scars on their fingers and decomposed bodies.

Method of collection of data

Based on inclusion and exclusion criteria the individuals were selected. A formal informed written consent was obtained from the guardians of the deceased. Various demographic data like name, age, sex, gender etc. were noted in specially designed pro-forma having slots for recording lip-print and fingerprints with a serial number.

Equipment for recording of lip-prints [Figure 1]: Tissue paper, dark and non-glossy lipstick, lipstick application brush, transparent cellophane tape, scissors, and white bond paper.

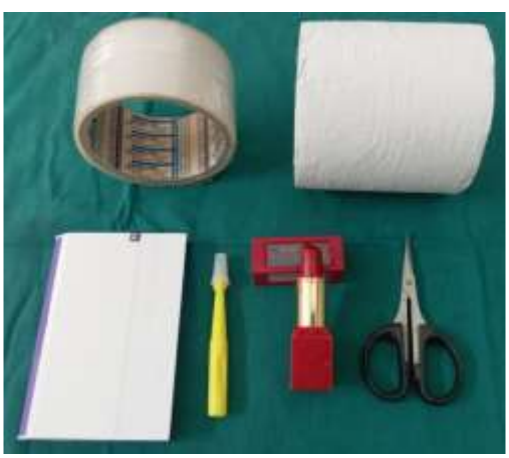

Figure1: *Equipments for recording lip print and fingerprint*

Methodology

Both the lips (upper and lower) were cleaned using a tissue paper in such a way that no piece of tissue paper was left behind. A lipstick application brush was used to apply lipstick evenly on both the lips and allowed to dry for 2 minutes. Lip impression was taken by placing the adhesive side of a cellophane tape on the surface of lips and was at once transferred on to a white bond paper by sticking the cellophane tape [Figure 2]. The characteristic fissures and grooves of lip prints were considered to find out the type of lip-print pattern [7]. A black pen was used to categorize the lip-prints. Each lip print was analysed for their uniqueness [Figure 3]. Classification of cheiloscopy as suggested by Suzuki and Tsuchihashi was followed in this study. Suzuki and Tsuchihashi classified lip print patterns as [9,10]

- 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 non-classified patterns).

Sex was determined based on characteristic pattern of the lower middle quadrant because of its higher visibility [11]. Sex of the individual was determined by type of lip prints as mentioned below.

- Type I, I' and II dominant lip print patterns were allotted female [8]
- Type III, IV and V dominant lip print patterns were allotted male [8].

The results obtained were verified with the data on the pro-forma collected at the beginning of the study corresponding to the serial number of the lip print.

Figure 2: *Recording of Lip print*

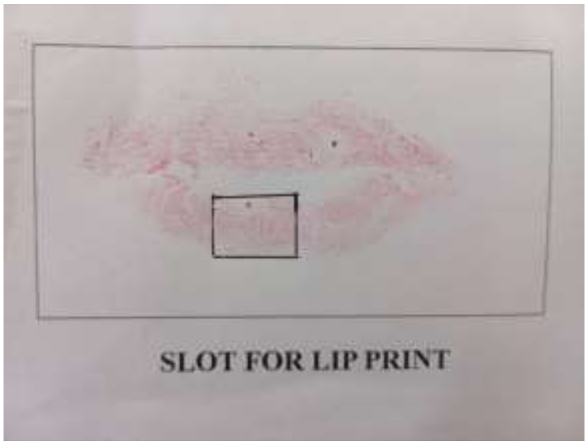

Figure 3: *Analysis of lip print*

Equipment for recording of fingerprints [Figure 1]**:** Stamp pad and white bond paper.

Methodology

Hands of the deceased were cleaned with the help of soap and water and dried using tissue paper. The fingerprints of both the hands were collected by rolling the fingertips over a stamp pad, taking care of the fact that the ink covered the whole fingertip; fingers were rolled from outer to inner side over a white bond paper taking care of the fact that complete ridge pattern of the distal phalanx of all ten fingers was obtained [Figure 4]. A black ball pen was used to draw a 5 × 5 mm^2 at the upper portion of the radial border of the fingerprints for recording the ridge density count with the help of a magnifying glass. Each fingerprint was analysed for their pattern. The analysis was carried out following the classification of Fingerprint as suggested by Sir Henry Galton in 1892 [1,2,12].

Loops: begin on one side of the finger and end on the same side and that begins from ulnar side is called ulnar loop and on radial side is called radial loop.

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

Arch: 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: Combination of more than one pattern, either a combination of arch, whorl, loop, or two different patterns like two whorls, arch, or loop (twin/double).

Fingerprint ridge density is calculated to determine the sex of the individual. The upper portion of the radial border of the fingerprint was taken into consideration as in that area all fingerprint patterns show a similar ridge flow. This method serves to isolate the ridges to a well-defined area facilitating the process of ridge count. A 5 × 5 mm^2 was marked on the fingerprint in the selected area [Figure 5]. The papillary ridges from one corner of the square were counted to the diagonally opposite corner excluding the dots. Forks were counted as two ridges excluding the handle and lake was counted as two ridges. Thus, the value obtained gives the number of ridges in a 25 mm^2 area and reflected the ridge density value. The ridge density value was calculated for all 10 fingers, and the mean was calculated. This mean stood for a single data point for that individual. It is found that the mean ridge density of 12 ridges/25 mm^2or 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 [13]. The data obtained were verified for sex of the individual with the data on the pro-forma collected at the beginning of the study corresponding to the serial number of the fingerprint.

Figure 4: *Recording of fingerprint*

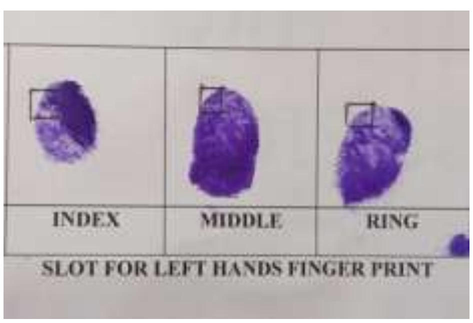

Figure 5: *Analysis of Fingerprint*

Results

The bond paper with the lip and fingerprints of study individuals were examined using a magnifying lens. These data were tabulated using Microsoft Excel and subjected to statistical analysis using Graph pad prism version 10. 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 46.2+/-13.89 years for males and 45.08+/-14.34 years for females, SEM 1.964, Normality test KS 0.08139 and passed normality test [Table 1].

Table 1 Age wise distribution of study population (Mean age)

Sex	Sample size (n)	Mean	SD	SEM	Min	Max	Median	95% CL Lower	95% CL Upper	Normality test KS	Passed Normality test
Male	50	46.42	13.89	1.96	21	78	45	42.46	50.37	0.081	Yes
Female	50	45.08	14.34		23	73	46	40.99	49.16	0.096	Yes

In males, the most predominant pattern of lip print was as the Type IV (36%) followed by Type III (30%), Type II (16%), Type I’ (12%), and Type I (6%). In females, the most predominant pattern of lip print was the Type I’ (46%) followed by Type I (24%), Type II (12%), Type IV (10%), and Type III (8%) patterns. Type V pattern of lip print was not found in our study. Comparison between the gender groups was made using Chi-square test, and it was found statistically significant with $P < 0.0001$ [Table 2].

Table 2 Distribution of Lip Print pattern in Male and Female

Lip print pattern	Male	Female	Chi-Square	P
Type I	3	12	25.967	<0.0001
Type I’	6	23		
Type II	8	6		
Type III	15	4		
Type IV	18	5		

In males, the most predominant pattern of fingerprint in little fingers (Digits 10 and 5) was ulnar loop (71%) followed by plain whorl (27%). The most predominant pattern of fingerprint in ring fingers (Digits 9 and 4) was ulnar loop (60%) followed by plain whorl (31%). The most predominant pattern of fingerprint in middle fingers (Digits 8 and 3) was ulnar loop (78%) followed by plain whorl (19%). The most predominant pattern of fingerprint in index fingers (Digits 7 and 2) was ulnar loop (64%) followed by plain whorl (32%). The most predominant pattern of fingerprint in thumbs (Digits 6 and 1) was ulnar loop (81%) followed by plain whorl (17%). Hence, the ulnar loop fingerprint pattern was the most predominant pattern among all ten digits in males [Table 3]

Table 3 Distribution of fingerprints pattern in male

Fingerprint pattern	Little (10,5)	Ring (9,4)	Middle(8,3)	Index(7,2)	Thumb(6,1)
Loop ulnar	71	60	78	64	81
Loop Radial	0	2	0	0	0

Whorl	27	31	19	32	17
Arch plain	2	7	3	4	2
Arch Tented	0	0	0	0	0
Composite	0	0	0	0	0

In females, the most predominant pattern of fingerprint in little fingers (Digits 10 and 5) was ulnar loop (68%) followed by plain whorl (31%). The most predominant pattern of fingerprint in ring fingers (Digits 9 and 4) was ulnar loop (52%) followed by plain whorl (36%). The most predominant pattern of fingerprint in middle fingers (Digits 8 and 3) was ulnar loop (75%) followed by plain whorl (21%). The most predominant pattern of fingerprint in index fingers (Digits 7 and 2) was ulnar loop (56%) followed by plain whorl (41%). The most predominant pattern of fingerprint in thumbs (Digits 6 and 1) was ulnar loop (71%) followed by plain whorl (26%). Hence, the ulnar loop fingerprint pattern was the most predominant pattern among all ten digits in females [Table 4].

Table 4 Distribution of Fingerprint Pattern in Female

Fingerprint Pattern	Little (10,5)	Ring (9,4)	Middle (8,3)	Index (7,2)	Thumb (6,1)
Loop ulnar	68	52	75	56	71
Loop Radial	1	3	3	2	1
Whorl	31	36	21	41	26
Arch plain	0	2	0	0	1
Arch Tented	0	7	1	1	1
Composite	0	0	0	0	0

The mean fingerprint ridge density was found to be 11.47/25 mm^2 in males and 15.09/25 mm^2 in females ($P < 0.001$). Hence, females were found to have a higher mean fingerprint ridge density compared to males [Table 5]. The mean ridge density in the range of 9–10/25 mm^2 was seen in 4 males. Mean ridge density in the range of 10–11/25 mm^2 was seen in 16 males. Mean ridge density in the range of 11–12/25 mm^2 was seen in 18 males. Mean ridge density in the range of 12–13/25 mm^2 was seen in 7 males. Mean ridge density in the range of 13–14/25 mm^2 was seen in 2 males and 3 females. Mean ridge density >14/25 mm^2 was seen in 3 males and 47 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.

Table 5 Gender wise comparison of the mean fingerprint ridge density using student's unpaired t-test

Gender	Sample	Mean	SD	SEM	Min	Max	Mean	95% CI	t	df	P

	size (n)						diff	Lower	Upper			
Male	50	11.47	1.23	0.17	9.00	14.60	3.62	11.12	11.82	16.88	98	<0.001
Female	50	15.09	0.87	0.12	13.40	16.80		14.84	15.34			

About 66% of the males were accurately identified as males while the remaining 34% of males were estimated to be females using lip prints. In case of females, 82% were accurately identified as females while the remaining 18% of females were estimated to be males using lip prints ($P < 0.001$). The accuracy between estimated and actual sex among the study population was found to be 48% using lip prints (Cohen's Kappa value = 0.48) [Table 6]. About 76% of the males were accurately identified as males while the remaining 24% 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 sex among the study population was found to be 76% using fingerprint ridge density (Cohen's Kappa value = 0.76) [Table 7]. Hence, fingerprint ridge density was found to be a more reliable criterion in sex determination of an unknown individual than lip print.

Table 6 Reliability of sex determination by Lip-print using Cohen's Kappa Test

Estimated Sex	Sex		Total (%)	Cohen's Kappa Value	P
	Male (%)	Female (%)			
Male	33 (66)	9 (18)	42 (42)	0.48	<0.001
Female	17 (34)	41 (82)	58 (58)		
Total	50 (100)	50 (100)	100 (100)		

Table 7 Reliability of sex determination by Fingerprint Ridge density using Cohen's Kappa Test

Estimated Sex	Sex		Total (%)	Cohen's Kappa Value	P
	Male (%)	Female (%)			
Male	38 (76)	0 (0)	38 (38)	0.76	<0.001
Female	12 (24)	50 (100)	62 (62)		
Total	50 (100)	50 (100)	100 (100)		

Discussion

Identification of a person is based on certain physical characteristics like age, sex, race, stature, fingerprints, moles, scar, gait, teeth, lips, eyes, hair, intelligence, memory or voice. With increase in the number of criminal cases, fingerprints and lip-prints has become an important tool for the investigating officers to link the crime with the culprit. The increased burden of the investigating officer is reduced remarkably by correctly establishing the gender of the culprits with the help of fingerprints and lip prints. This study was designed to assess the reliability of fingerprint and lip-print in identification of an individual. Lip prints were recorded using non glossy lipstick to avoid smudging of the prints and cellophane tape is used for lifting the lip-print which was also used by Gazge NM et al., [3] Patil et al., [5] Sivapathasundharam et al.,[11] Augustine et al.,[14] Nagasupriya et al.,[15] Mutalik et al.,[16] Prabhu et al.,[17] Nandan et al.,[18] Bijjargi et al.,[19] Bajpai et al.,[20] Kaul et al.,[21] Verghese and Mestri[22], Tandon A et.al [37] and Negi A et al. [38] in their studies. Red shade of lipstick on white bond paper gave the best print visibility. To spread lipstick evenly, lip stick application brush was used. In this study, lipstick-cellophane tape method was used to record fissures and grooves on the lips keeping in mind the feasibility of the method in considerable number of cases. Fingerprints were recorded using the stamp pad technique as the method is easy, convenient, cheap and feasible and was also used by Gazge et al.,[3] Nagasupriya et al.,[15] Mutalik et al. [16] and Nandan et al. [18] Adamu et al.,[23] Tandon A et.al [37] and Negi A et al. [38] in their studies. In our study, the most predominant pattern of lip print was found to be Type IV (36%) in males while in females, it was Type I' (46%). Hence, both the genders showed dissimilar lip print patterns. Type V pattern of lip print was not seen in any of the gender groups. These findings were in accordance to studies conducted by Gazge et al., [3] Sharma et al.,[8] Verghese and Mestri,[22] Malik and Goel.[24] However, these findings were in contrast to the studies conducted by Patil et al.,[5] Tsuchihashi,[9] Sivapathasundharam et al.,[11] Nagasupriya et al.,[15] Mutalik et al.,[16] , Nandan et al. [18] Tandon A et al. [37] and Negi A et al. [38] which may be explained by the difference in the study population. In our study, it was observed that all the lip prints were unique, which is in concurrence with Tsuchihashi,[9] Suzuki and Tsuchihashi,[10] Sivapathasundharam et al.,[11] Prabhu et al.,[17] Bajpai et al.,[20] and Nagrale et al. [25], all of them have found that no two persons have the similar lip-prints. 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 as a whole or partially. With reference to fingerprints, the ulnar loop was the most often observed pattern followed by plain whorl, in the total subject population in all the ten digits. The least commonly observed pattern in the total population was plain arches, tented arches [Tables 3 and 4]. These findings were similar with studies done by Gazge et al., [3] Desai et al.,[4] Nagasupriya et al.,[15] Mutalik et al. [16] and Nandan et al. [18] and Negi A et al [38]. However, studies done by Nithin et al.,[26] Reddy and Reddy,[27] Rastogi and Pillai,[28] and Ekanem et al. [29] Tandon A et al. [37] found 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 accordance with Nadar,[30] Senn and Stimson [31]. It is proven fact that no two individuals have the same fingerprint. In our study, the mean fingerprint ridge density in males was found to be 11.47/25 mm^2 and 15.09/25 mm^2 in females ($P < 0.001$) [Table 5]. 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 [Table 5]. This is in agreement to the studies conducted by Acree,[32] Gungadin,[33] Nithin et al.,[26] Gutiérrez-Redomero et al. [34] and Nayak et al [35]. 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]. Our study finds that the fingerprint ridge density in both genders was 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 [34]. In our study, 66% of the males were accurately identified as males while the remaining 34% of males were estimated to be females using lip-prints; and 82% of the females were accurately identified as females while the remaining 18% of females were estimated to be males using lip prints ($P < 0.001$) [Table 6]. This is in accordance with studies by Bajpai et al. [20] and Malik and Goel [24], whereas Kaul et al. [21] found that lip-prints were not an effective tool in gender determination. According to Kaul et al., 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 wide age group in the range of 21–78 years while their study included individuals of narrow age group. 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, 76% of the males were accurately identified as males while the remaining 24% of males were estimated to be females using fingerprint ridge density; and 100% of the females were accurately identified as females using fingerprint ridge density ($P < 0.001$) [Table 7]. Hence, fingerprint ridge density (Cohen's Kappa value = 0.76) was found to be a more reliable tool in estimating the gender of an unknown individual than lip-print (Cohen's Kappa value = 0.48) [Tables 6 and 7]. This is in accordance with Gazge et al.,[3] and Nagasupriya et al. [15]. However, this is contrary to the findings in the study by Nandan et al. [18] 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. In our literature search, very few comparative studies were found on lip-prints and fingerprints with respect to gender estimation. So, more studies involving larger sample size will give more exact result.

Conclusion

Lip-print and fingerprint were found to be particularly important positive data of identification of an unknown person as they are unique in everyone. Sex determination of an unknown person can be done more accurately using fingerprint ridge density than lip-print. In a crime scene, if lip print and fingerprints are found then they can provide an idea about sex of the person. Studies involving substantial number of participants of different racial and ethnic groups should be conducted to decide predominant lip-print and fingerprint pattern that help in determination of sex of an unknown person.

Financial support and sponsorship

Nil

Conflict of Interest

There are no conflicts of interest.

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