

Sexual Dimorphism in Lip Prints

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Abstract

Background: Cheiloscopy, as a corroborative means of identification in Forensic Science gains more importance now-a-days. Both patent and latent lip prints are used as an evidentiary source in court of law in recent era.

Aim: A cross-sectional study of various lip prints was conducted here to determine the sexual dimorphism with a sample size of 345 (Male - 160, Female - 185) after obtaining proper consent and ethical committee clearance.

Methods: The prints were taken using the standard cellophane tape method after the application of red coloured lip stick which were classified according to the Tsuchihashi classification and analysed.

Results: The study results revealed that Type V and Type I were predominantly seen in males and females respectively. Also, the study concludes that the pattern of the lip prints differs among the individuals. In spite of the difference noted in the prints, due to the over lapping features, cheiloscopy can be used as substantial evidence rather than a definitive one.

Conclusion: Like fingerprints, the uniqueness of lip impressions between individuals is utilized by Forensic experts to utilize them as corroborative evidence in solving the crimes along with other primary evidences. Factors like the moisture or the oil and the type of the lip sticks may alter the visibility as well as the quality of the prints which reduces their evidentiary value. But the significant pattern of difference noted among the individuals in our study prove that lip prints can be used as a valid tool in identification.

Keywords: Cheiloscopy, lip prints, identification, corroborative evidence.

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Introduction

Anthropologists first noted the biological phenomenon of system of furrows on the red part of the human lips which served valuable evidence in Forensic Science [1]. The study of lip prints is termed as 'Cheiloscopy' or 'Quiloscopy' (derived from the greek word 'cheilos' meaning "lips" and 'skopein' meaning "see" [2]. It not only includes studying about the visible prints but also the latent ones made with moisture provided by minor salivary and sebaceous glands of the lips [3]. External surface of the lips has many elevations, depression, wrinkles and grooves developed on the sulci labiorum, present in the zone of transition between the inner labial mucosa and the outer skin which differs from person to person. Lip prints can be found on various surfaces where the lips come into contact like drinking glasses and cups, cigarette butts, utensils, paper and documents, mirror and glass surfaces while lipstick or lip gloss can leave lip prints on surfaces like tissue paper, napkin or clothing. It is important to note that the visibility and quality of lip prints on these surfaces can vary based on factors such as the amount of pressure applied, the type of cosmetics (lipstick, lip gloss) applied and nature of the surface material (e.g., porous or non-porous). The lip prints obtained from such sites readily give clues about various factors in the crime scene which can provide a direct link to suspect [4]. The lip print produced by traditional lipsticks (visible) are generally easy to identify and analyze whereas latent (invisible) lip prints may be highly prevalent and be present as hidden evidence making it difficult for the identification [5].

In criminal investigations, lip print analysis can aid in identifying missing persons or unidentified bodies, especially when other forms of identification, like fingerprints or dental records, are not available. Though lip grooves are permanent and unchangeable, any irresistible environmental factors such as minor/major trauma, inflammation, herpetic lesions may alter the morphology and pattern of wrinkles and cause flaw in the cheiloscopy studies. Thereby, lip print identification is not widely used or standardized as fingerprint identification. The accuracy and reliability of lip print analysis can vary depending on the quality of lip print impression, environmental condition and the expertise of a Forensic expert. As

a result, lip print identification is typically used as a supplementary tool alongside other evidences and techniques in Forensic investigation. Hence, Forensic investigations involve combination of multiple methods, such as Deoxyribonucleic acid (DNA) analysis, skeletal examination, or other physical characteristics, to determine an individual's gender with a higher degree of accuracy [6]. However, the peculiar characteristics of lip print is considered as part of a comprehensive approach of using it as corroborative evidence in legal investigations.

Lip print identification

The process of lip print identification involves the comparing, matching and examining the characteristics of lip lines and grooves based on various classifications to determine if there is a match or exclusion. Lip prints consist of ridges and grooves created by the unique arrangement of skin on the lips as given in Figure 1.

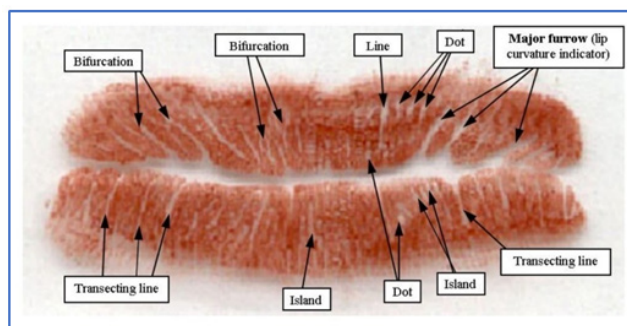


Figure 1. Lip print

The main types of lip print patterns include Vertical lip prints, followed branched lip prints, radial lip prints, rectangular prints, elliptical prints and diagonal prints according to the shape they present with. Also, the additional features such as wrinkles, scars, or other unique characteristics add up to their individuality. As fingerprints are unique to each individual, lip prints also have distinctive patterns and characteristics that can be used for identification [7].

In 1967, Clauco Martin Santos devised a simple system for classifying lip prints and lip grooves into simple types and composite types. Simple types include four groups viz straight line, curved line, angled line and sine shaped line. Likewise, Bifurcated, trifurcated and the irregular types are termed as

composite types.^[9] Two Japanese scientists namely, Yasuo Tsuchihashi and Kazuo Suzuki studied patterns of grooves on human lips and classified them into six types as shown in figure 3 which was also known as Tsuchihashi classification, one of the most widely used classification in literature. As given in figure 3, Type I - Clear cut vertical grooves run across the lips, Type I' - Partial vertical grooves, that does not run across the lips, Type II - Branched groove, Type III - Intersected grooves, Type IV - Reticular grooves and Type V- Undetermined. Renaud, a French scientist studied 4000 prints of the lips and found that all were different except in case of uniovular twins and accordingly gave the classification as given in figure 4.

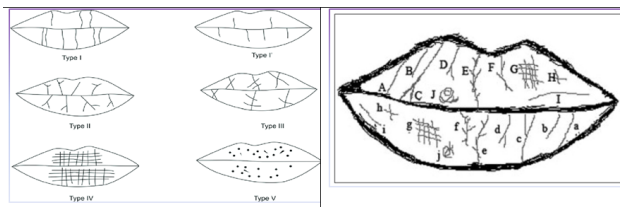


Figure 3: Tsuchihashi and Suzuki classification of lip prints

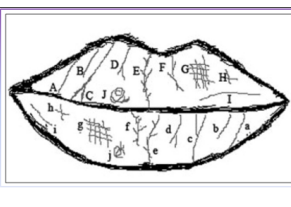


Figure 4: Renaud's classification of lip prints

In 1979, Afchar-Bayat classified lip prints based on groove patterns in the front and lateral position of the lips^[10]. Kasprzak Classified the lip prints using the pattern of lines in the lips. If the lines in the lips occur often, the pattern is described as linear, "L". If there is dominant bifurcation, it is called bifurcate, "R". If the lines cross then the pattern is dubbed reticular, "S". In the case where no superiority can be established, the pattern is named undetermined, "N".

Lip Prints from Crime Scene

Lip prints obtained from crime scene can be of 3 types viz patent, latent and plastic lip prints. A patent lip print, also known as a visible lip print, is the impression left by the markings created by the natural oils, saliva, or cosmetics on a person's lips onto a surface which are immediately apparent and can be seen through naked eye. Such lip prints can occur when a person's lips come in contact with objects such as drinking glasses, cups, or other smooth surfaces. Latent lip prints are not visible to the naked eye and has to be developed and analyzed for identification purposes. A plastic lip print, also

known as an indented lip print, is a type of lip impression created through pressure and indentation of the lips on pliable surfaces such as plastic, wax, or other malleable substances. Such prints are not immediately apparent to the naked eye like the patent prints but can still be detected easily.

Collection and Development of Lip Prints

Various collection techniques include tape method, photography, dusting powder method, chemical method and casting. Patent lip print collection involves simple processes since they are readily visible without any enhancement techniques. A cellophane tape is usually used to remove the visible prints from the object which is then pasted onto a clean white sheet for visualizing the individual characteristics of the print. As the latent prints are invisible to naked eye dusting powder method is used. Suitable powders (e.g., black or white fingerprint powder) is gently dusted over the possible suspected surface, using a natural hair brush which helps in development of hidden lip print, if any, by adhering to the oils and residues from the lips, making the lip print visible. The developed lip print is then photographed and analyzed for further clues. High-resolution photography is used to capture all types of lip prints for analysis and comparison. Special lighting techniques may be employed to enhance the visibility of the prints.

Chemical methods make use of reagents that react with the components of the latent lip print to bring out its visibility. For example, ninhydrin, a chemical reagent commonly used for fingerprint development, can also be used to develop latent lip prints by spraying over the surface. In some cases, a casting material like dental stone or silicone rubber can be used to create a three-dimensional replica of the lip impression. This technique can provide a permanent record for further analysis. Analyzing plastic lip prints requires specialized training and expertise and the process can be more challenging compared to patent or latent lip prints. Factors such as the texture and elasticity of the material, environmental conditions, and age of the print can affect the quality and usability of the impression.

Rachna kaul et. al., conducted a study in 755 individuals to assess the efficacy of lip prints in sex

determination using Vahanwala method and found that Type I pattern of lip print was the most prevalent cheilosopic pattern among the individuals. However, they concluded that lip prints do not serve a tool in sex determination [11]. Preeti Sharma et.al, studied particular pattern collected using tape lifting method on the basis of numerical superiority of types of lines and proved that lip prints are unique to one another and can be used in sex determination. Type I and Type I' patterns were found to be predominant in females while Type IV pattern was predominant in males [12]. According to a study by Sonal-Nayak et.al, Type I and Type I' patterns were found to be dominant in females, while Type III and Type IV patterns dominant in males. Another study conducted by Vahanwala-Parekh showed that all four quadrants having same type were predominantly seen in female subjects and male subjects showed presence of different patterns in a single individual [13].

Ghimire N et. al, conducted a study on analyzing and comparing the quadrant wise and sex wise predilection of lip print pattern by tape lifting method on applying lipstick. Based on Tsuchihashi classification, Type I pattern was found to be predominant in all the four quadrants among males with values of 62%, 56%, 54%, 57% in first, second, third and fourth quadrants respectively). Also in females, type I was predominant in 2nd, 3rd and 4th quadrant (40%, 45%, 51% respectively) whereas in 1st (right upper) quadrant type II pattern was predominant (37%) [14]. Neeti Kapoor et.al determined the predominant pattern among central Indian population using Suzuki and Tsuchihashi classification by digital photography. Type I (30.63%) was found to be most predominant overall in the Marathi population. Type I (29.75%) and Type III (35.75%) was found to be most prevalent in males and females [15].

Mohamed Jaber et. al used a systematic review and meta-analysis where the predominant lip print present among males was type III (30.2%), followed by type II (29.9%), and type I comprised of 21.1%. While among females, almost 36.5% reported with type I lip print pattern, followed by type II (28.9%) [16]. Most of the studies revealed the uniqueness of lip print but further studies are required to assess the efficacy of lip prints in sex determination.

Forensic Significance of Lip Prints

As with any Forensic technique, proper training, validation, and adherence to scientific standards are crucial for its successful application in legal and investigative settings. Lip prints serve as evidence in the Court of Law with respect to various aspects, of which personal identification is the foremost crucial one in identifying suspects or victims in criminal cases when lip impressions are left at crime scenes or on objects recovered from the scene. Especially in personal identification like access control, biometric authentication, and electronic device security, lip prints play a crucial role. Being a non-invasive forensic technique, collecting lip prints from objects like drinking glasses or cigarette butts is less intrusive compared to some other methods, making it easier to obtain evidence without requiring physical samples from the person. Unlike other forms of identification such as facial features or voice, lip prints are less prone to alterations through aging, plastic surgery, or changes in appearance. Lip prints can also be used to reconstruct certain events in the crime scene. In addition, they assist in identifying missing persons or unknown deceased individuals when traditional methods, such as fingerprints or dental records, are not available or inconclusive. Some studies suggest that association between lip print patterns and certain personality traits or behaviors could favour psychological profiling too. Likewise, in anthropological research also lip prints provide insights into genetic and racial characteristics of populations.

Materials

Out of 500 individuals, 345 were taken up for the study with respect to inclusion and exclusion criteria. A cross-sectional study involving 345 healthy individuals was conducted at Sri Ramachandra Institute of Higher Education and Research (SRIHER), Porur, Chennai for a period of 2 months after ethical clearance. From SRIHER ethical committee. Based on the statistical significance with 95% confidence interval, the sample size was calculated to be 211. To round of the value, 250 male and 250 female participants were taken up for the study, with a total sample size of 500. The aim is to determine the sexual dimorphism from lip prints using the Tsuchihashi's

classification. Participants between the age group of 18-30 years were taken up for the study. Those with lip congenital anomalies, cleft palate, cheilitis, mouth sores, persons with lip scars, lip lesions and person with hypersensitivity to lipstick were excluded. Individuals allergic to cosmetics and who were not willing to apply lipstick were also excluded. The samples were collected from the participants by making them understand the procedure thoroughly and by obtaining an informed consent.

The materials used were shown in figure 5. The subjects were seated in a comfortable position. The lips were cleaned thoroughly with apollo wet-wipes by gentle wiping before taking the prints (Figure 6). A single stroke of bright shade of lipstick (non-glossy, oil-free lipstick: MARS LIPSTICK PENCIL 17) was applied using lipstick brush to the vermillion region of both upper and lower lips (Figure 7). After application, a 50mm of transparent cellophane tape was pressed against the lips from center to the corners (Figure 8). The participants were asked to refrain from moving their lips during the procedure to avoid any distortions on the print recordings. The cellophane tape was slowly removed from one end of the lips and pasted onto a proforma in order to provide a permanent record, which can be studied at any time (Figure 9). The recording procedure was repeated in case of observing any defects so as to ensure having a clear record of each participant. Attention was paid to hygiene while recording the lip prints. After confirming proper registration of all areas of the lips on proforma, the remaining lipstick on the lips was cleaned with wet-wipes. Also, the lipstick brush used was sterilized to avoid any future contamination. The obtained lip prints as in Figure 10 were further examined for various lip characteristics using magnifying lens manually and categorized under different lip patterns based on Tsuchihashi's classification.



Figure 5. Materials used for collection of lip print



Figure 6. Cleaning of lips with wet-wipes



Figure 7. Application of lipstick using brush

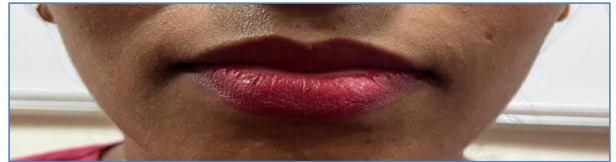


Figure 8. Lip print (after application of lipstick) ready for lifting

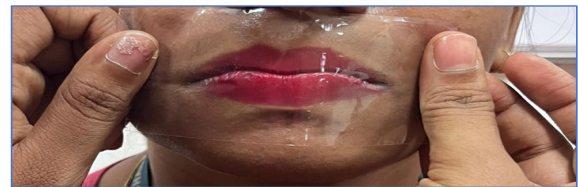


Figure 9. Taking impression of lip surface with cellophane tape.

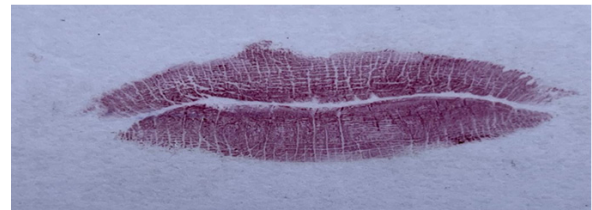


Figure 10. Resultant lip print obtained from the individual

Results

Table 1 shows the distribution among males and females of which total number of male participants was found to be 160 (46.4%) while the total number of female participants was found to be 185 (53.6%).

Table 1: Percentage calculation among males and females

Gender	Frequency	Percent
Male	160	46.4
Female	185	53.6
Total	345	100.0

Figure 11 shows the percentage calculation performed for both male and female populations separately. Among male population, Type V (24.4%) was the predominant type of lip pattern observed followed by Type I (22.5%), Type I' (21.2%), Type IV (12.5%), Type II (10.0%), Type III (9.4%) while

among female population, Type I' (28.1%) was the predominant type observed followed by Type I (24.3%), Type V (16.2%), Type III (12.4%), Type IV (11.4%), Type II (7.6%). Type I' and Type I patterns were seen more common in the overall population.

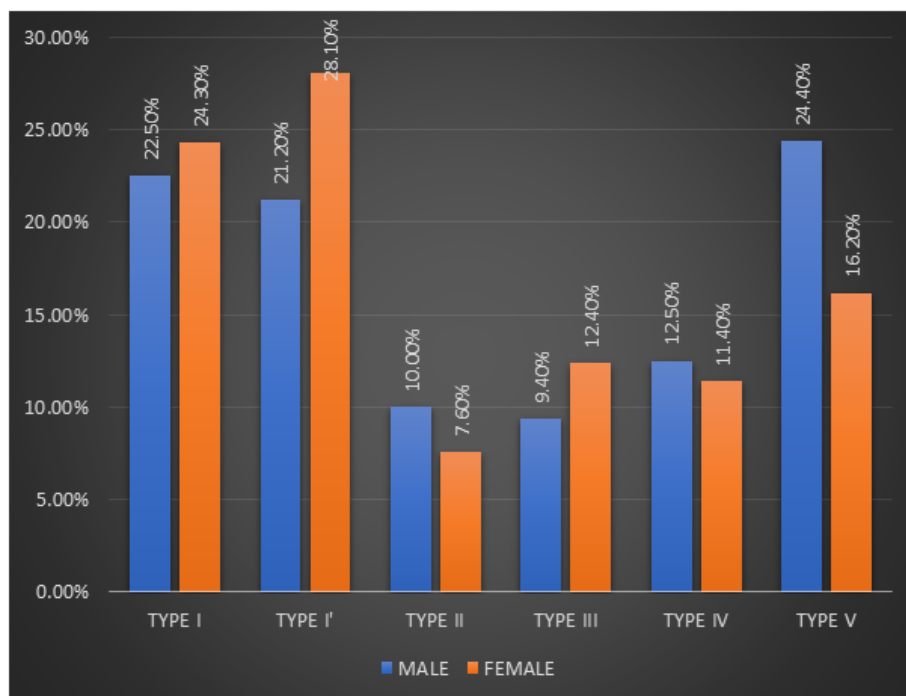


Figure 11. Percentage in male and female population based on lip print pattern.

Table 2 shows the Sample 'T' test performed for gender separately. Among the 160 (46.4%) male participants, mean and standard deviation were found to be 3.41 and 1.937 respectively. Among the 185 (53.6%) female participants, mean and standard deviation were found to be 3.07 and 1.818 respectively. In Independent sample T test, two-tail

method was performed to find out the significance between lip print pattern and gender. As a result, the 'p' value obtained in males and females were found to be 0.092 and 0.093 respectively. Since the obtained p value was found to be greater than 0.005, there was no significant difference observed between lip print pattern and gender.

Table 2: Sample 'T' test for different types of lip patterns.

Gender	N	Mean	Std. Deviation	T test	Pvalue
Male	160	3.41	1.937	1.691	0.092
Lip print					
Female	185	3.07	1.818	1.684	0.093

Discussion

Personal identification plays a crucial role in the field of Forensic Science. Many researches in cheiloscopy proved that even lip prints can serve as potential evidence in identification of its uniqueness. The present study assessed the association and

correlation between gender and lip print pattern on the basis of numerical superiority of types of lines present. The current study showed no significant difference ($P=0.093$) between gender and lip patterns. However, in males, Type V lip pattern was found as the highest recorded lip print pattern followed by Type I, Type I', Type II, Type III and Type IV.

Similarly, in females, Type I' was found as the highest recorded lip print pattern followed by Type I, Type V, Type III, Type IV, Type II. The predominant pattern observed in the overall population including both males and females was Type I' followed by Type I, Type V, Type IV, Type III, Type II. The Type V pattern considered as the second predominant pattern in the present study similar to the study conducted by Prabhu *et al.* in 2012 where they studied 100 students from Goa, India [34]. In accordance with another study conducted by Sharma *et al* and Satyanarayana *et al.* it is found that complete (Type I) and incomplete vertical grooves (Type I') found to be predominant in females, undetermined pattern (Type V) to be the most common in males as they had considered central part of lower lip for analysis unlike the current study where central part of both the lips were taken into account [17].

With reference to sex, non-significance could be due to low variance among the different lip print patterns in the overall population. In the current study, the participants included 160 males and 185 females. The highest prevalence of seen with type - I' of lip print pattern in overall study and the same pattern being highest in females can be attributed to higher number of female participants. The non significance between the gender could be attributed to lower sample size and unequal between male and female participants. However, the lip print pattern observed in each individual showed unique features making it an essential tool for identification in Forensic investigations. Based on the findings of the present study, it could be revealed that lip prints cannot behold the potential of determination of sex. Though the present study followed an infallible method, determining sex from lip prints showed no significance but certain differences were observed between males and females in terms of width, thickness, and shape of the lip grooves. Thereby, Type V and Type I' were the predominant lip print patterns observed in males and females respectively.

Conclusion

The current study concludes that there is difference between lip print patterns obtained among individuals and hence this method can serve as one of the identification methods in forensic scenarios where other forms of identification might be

challenging. However, determination of sex from lip prints should be approached with caution and should be considered as supplementary evidence rather than definitive proof. The variations in lip print patterns among individuals of the same sex can be substantial and there can be significant overlap between male and female characteristics. Additionally, the quality of lip prints and the method of collection can affect the accuracy of sex determination. Lip prints should be captured and analyzed under controlled conditions by trained professionals to minimize errors and inconsistencies. A comprehensive approach that considers multiple studies are necessary to draw reliable conclusions in gender determination from lip prints. Similar studies with more sample size and equal distribution of gender are suggested in order to get a significant difference in lip patterns. Although, cheiloscropy is still considered as very reliable evidence in personal identification in crime investigations, attempts should be made to use the same as a group identity trait which can be very useful in situations like mass disasters.

Limitations

Lesser sample size and the unequal gender distribution led to the insignificant trend in lip prints among the study population.

Conflict of interest: None

Source of funding: Self-funded

Ethical clearance: Taken from Ethical committee of Sri Ramachandra Institute of Higher education and Research dated 19/05/2023 with ref.no. CSP/23/APR/127/372.

Informed consent: Obtained from the legal heir.

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