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Research Paper

Lip Print Analysis: Gender Differences And Identification Potential In Forensic Science

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Abstract

Lip prints, often referred to as cheiloscopic patterns, are a possible tool in forensic identification because they are exclusive to each person and do not alter over time. In order to appraise gender-specific characteristics and determine their relevance for personal identification, this study compares the lip print patterns of males and females. Lip prints were categorized using Tsuchihashi's classification after a sample of 50 people—25 men and 25 women—was gathered using a systematic procedure. A statistical analysis was conducted on the distribution and frequency of various lip print kinds by gender. According to preliminary results, there is a notable difference in the prevalence of specific lip print patterns between males and females, which may imply sexual dimorphism. These outcomes demonstrate the value of lip print analysis as a non-invasive, cost-effective aid in forensic investigations. Further research with larger sample sizes and diverse populations is recommended to strengthen the findings and standardize its application in forensic science. According to the data, males were more likely to exhibit Type III and IV patterns, whereas females were more likely to exhibit Type I and I' patterns. The distribution of Type II was fairly equal for both sexes.

Keywords: Lip Print Patterns, Sexual Dimorphism, Gender Comparison, Forensic Identification

1. Introduction

The concept of biometrics has come in existence over a century, first used for criminal identification. Human identification is one of the most unique and recent technique for the identification of people and has originated in forensic and criminal investigation. The human lips are two highly sensitive mucocutaneous folds comprised of skin, muscles, mucous membranes, and sebaceous glands. Lip prints are the wrinkles or grooves between the outer skin of the lips and the inner labial mucosa. Cheiloscopy, which comes from the Greek word cheilos which means lips, is the study of lip prints in the field of forensic odontology. (Farrukh and Haar, 2022). A primary focus of cheiloscopy is its ability to distinguish between

genders through distinctive lip print patterns. This gender-based analysis can assist in identifying suspects or victims in criminal investigations. With advancements in forensic science, lip print analysis shows potential as an auxiliary method for personal identity and gender determination, providing significant evidence in the quest for justice. The importance of cheiloscopy is linked to the fact that the lip prints are unique to one person, except in monozygotic twins like fingerprints and palatal rugae, the lip grooves are permanent throughout life. In 1902, R. Fischer was the first to introduce the furrows on the red part of the human lips. Edmond Locard was the first to recommend the use of lip prints in personal identification and criminalization in France in early 1932. Moyne Synder was the first to present a case, in which he mentioned the potential of lip prints in personal identification. Suzuki and Tsuchihashi were among the first categorize the different lip prints. (Kapoor and Badiye, 2015).

Lips can also be classified. Emending scientists such as Suzuki and Tsuchihashi (1971), Martin Santos (1967), Renaud (1973), Caldas et al (2007) and Jose Maria Dominguez have proposed a number of systems to classify lip prints according to various types of wrinkles and grooves, whereas Kasprzak (200) classified lip prints on the basis of personal traits. Among all the discussed classification, the Suzuki and Tsuchihashi classification system has been most widely used. (Kaur and Thakar, 2021).

The forensic significance of lip prints arises from their uniqueness, durability, and relative resilience to environmental or pathological alterations. The configurations of grooves and wrinkles on the lips begin by the sixth week of intrauterine growth and remain constant throughout life, akin to fingerprints (Thermadam et al., 2020). Cheiloscopy has demonstrated efficacy in intricate forensic scenarios, including mass disaster victim identification, missing persons cases, or civil identification, where alternative evidence (such as DNA or fingerprints) may be compromised or inaccessible due to decomposition, incineration, or mutilation (Varghese, 2020).

Cheiloscopy, while promising for forensic identification, presents several limitations that may compromise the reliability and reproducibility of lip print analysis (Palakurthi et al., 2015; Vaishnavi and Nirmal, 2022). A significant limitation is that lip prints originate from a highly mobile region of the body—the lips—rendering the prints vulnerable to distortion due to factors such as pressure, movement, direction, and the method employed for collection (Prabhu et al., 2012) The same individual may yield slightly different lip prints under varying conditions, thereby compromising consistency.

2. Material & Methodology:

2.1 Sample:

The study comprised of 50 individuals (25 males and 25 females) with age group of 19-22 years) of different regions of Uttarakhand including Nainital, Haldwani, Ramnagar, Bageshwar, Almora, Pantnagar and Bhimtal/Bhowali. Individuals with no deformities such as cut marks or any injury were included for the lip print study.

2.2 Collection of Lip prints:

Lipstick was applied on the lips of the subject with a single stoke and the subject was then asked to rub his lips to spread the lipstick uniformly. Then with the help of a paper, the centre portion of lips were dabbed first and then left and right

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corners of lips were pressed, applying uniform pressure, taking care to avoid sliding of lips to prevent smudging of the print **(Figure. 2.1)**. After the lip prints were acquired, details such as sex, age, state of origin were documented. The lip prints were then studied by the help of a magnifying lens to analyse quadrant-wise distribution, denoting the type according to Suzuki's classification, which is as follows.

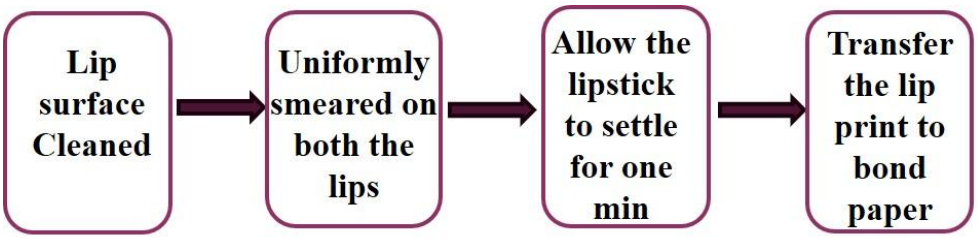

Figure 2.1: Steps involved in acquisition of lip prints from the study subjects

The number of lines and furrows present, their length, branching, and combinations were noted. The lip prints obtained were coded, keeping in account the name and sex of the respective individuals.

Figure 2.2: Images depicting the procedures used to obtain the study participants' lip prints

2.3 Classification schemes

In this study, we followed (Fig. 1) the classification of patterns of the lines on the lips proposed by Suzuki and Tsuchihashi (Suzuki and Tsuchihashi, 1971; Tsuchihashi, 1974).

1. Type I- Complete Vertical
2. Type II- Incomplete Vertical
3. Type III- Branched groove
4. Type IV- Intersected Groove
5. Type V- Reticular Pattern
6. Type VI- Undetermined patterns

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2.4 Analysis of Lip Print:

The patterns (Basic), which were commonly present and repeated throughout the sample size (50 samples and 200 quadrants), were grouped into Table. Sample-wise frequency and quadrant-wise frequency were calculated for every Basic pattern using manual method. Gender-based frequency of various Basic Patterns were also calculated to determine the predominance of various Basic Patterns. The sample-wise frequency and quadrant-wise frequency of basic patterns lip prints among all the individuals have been given in Table 4.2.

Lip groove patterns were categorized into four regions predominantly by dropping a perpendicular from the philtrum of lips: upper right (UR) region, upper left (UL) region, lower right (LR) region, and lower left (LL) region. The obtained lip groove patterns were carefully examined under the magnifying lens (Suzuki and Tsuchihashi, 1971; Tsuchihashi, 1974). The analysis was done as per the Suzuki and Tsuchihashi classification to classify the lip prints, the classification proposed by Suzuki and Tsuchihashi was used Type I - Complete vertical, Type I' - Incomplete vertical pattern, Type II - Branching or "Y" pattern, Type III - Criss-cross pattern, Type IV - Reticular pattern, and Type V - All other patterns

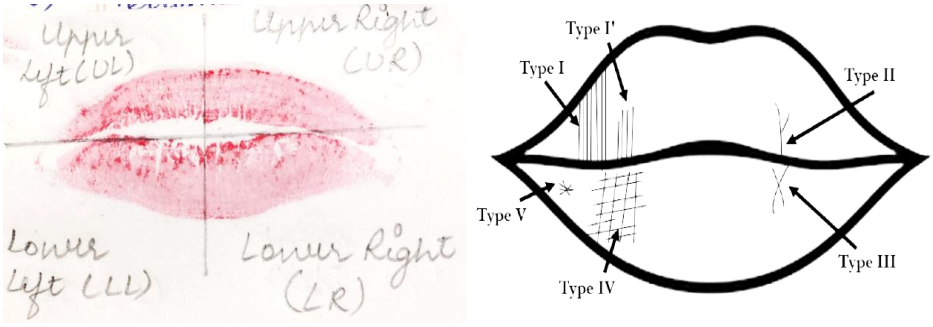

Figure 2.3: Diagrammatic representation of the lip print patterns

3. Result and Discussion:

A total of 50 individuals (25 males and 25 females) aged between 18 to 22 years participated in the study. Each individual provided lip prints from four lip compartments, making a total of 25 samples per gender. The Tsuchihashi classification system was used to analyse the lip print patterns.

3.1 Geographical distribution of Lip Prints

The geographical study of lip prints was done for the evaluation of various lip prints among the Uttarakhand region from various places including Nainital, Almora, Bageshwar, Haldwani, Pantnagar, Pithoragarh, Bhimtal/ Bhowali, and Ramnagar consisting males and females (Figure 3.1).

The highest number of individuals were from Nainital with 11 males and 16 females. Three males and two females were from the Almora while Bageshwar, Pithoragarh, Bhimtal and Ramnagar had only one individual of both male and female with very less representation of individuals. Average percentage of individuals were seen from Haldwani with five males and four females, Pantnagar with three males and two females (Table 3.1).

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Table 3.1: Geographical distribution of Lip Prints

Places	Male	Female
Nainital	11	16
Almora	03	02
Bageshwar	01	-
Haldwani	05	04
Pantnagar	03	02
Pithoragarh	01	-
Bhimtal/ Bhowali	01	-
Ramnagar	-	01

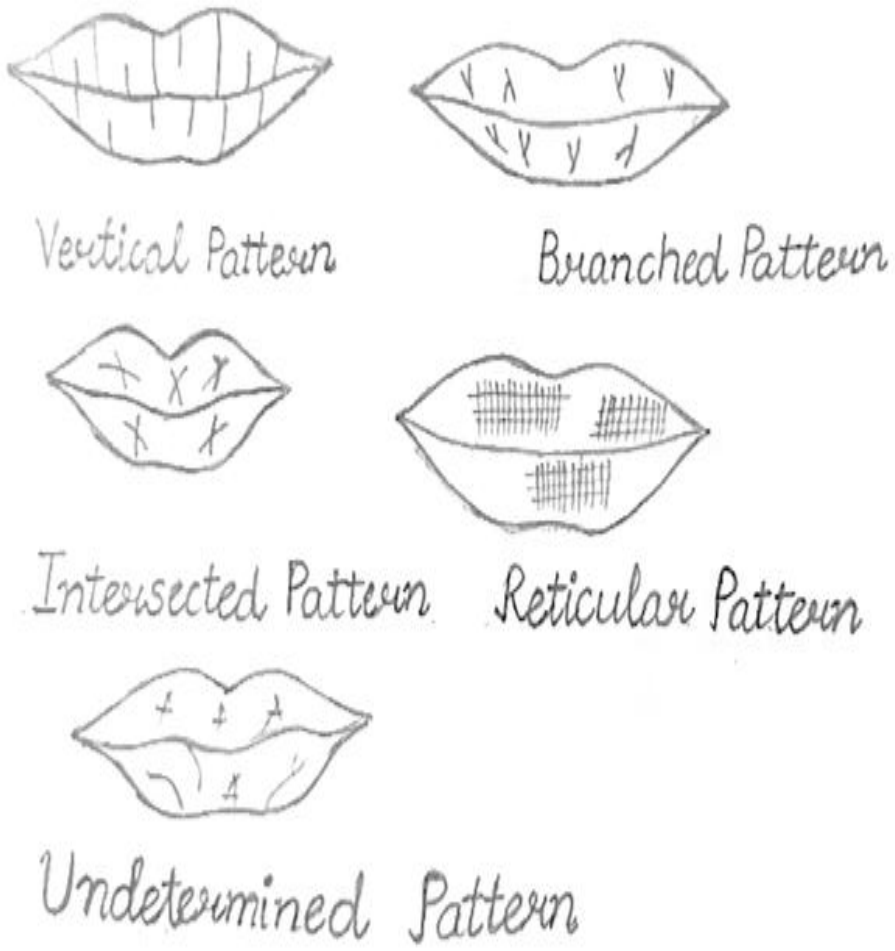

Figure 3.1: Collected Lip print patterns demonstrating inter-individual variation

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3.2 Overall Distribution of Lip Print Patterns

The Incomplete Vertical pattern was the most frequent among males (13%), while among females, the Vertical pattern was slightly more common (11%). The Branched and Vertical patterns each accounted for 12% of the total samples in both genders. Other observed patterns included Intersected (11%), Reticular (7%), and Undetermined, which was the least frequent (3% in males and 5% in females) (Table 3.2).

Table 3.2: Overall Distribution of Lip Print Patterns among Males and Females

Lip print pattern (%)	Males (N=25×4)	Females (N=25×4)
Vertical	12(6)	11(5.5)
Incomplete vertical	13(6.5)	7(3.5)
Branched	12(6)	9(4.5)
Intersected	11(5.5)	8(4)
Reticular	7(3.5)	8(4)
Undetermined	3(1.5)	5(2.5)

3.3 Distribution of Lip Print Patterns by Compartment

The distribution of lip print patterns across the four lip compartments revealed noticeable variations between males and females. In compartment 1, the Branched pattern was most prevalent among males, observed in 20% of the cases, whereas the Intersected pattern was dominant in females, occurring in 14% of samples. In compartment 2, males exhibited the Branched pattern most frequently (24%), followed closely by the Vertical pattern (22%). Conversely, in females, the Intersected pattern remained the most common at 14%. Moving to compartment 3, the Vertical and Branched patterns were equally prominent among males, appearing in 18% and 14% of cases, respectively, while females showed a higher occurrence of the Intersected pattern at 16%. In compartment 4, males showed the highest concentration of any single pattern across all compartments, with the Vertical pattern reaching 28%. Among females, the Reticular pattern was most frequent in this compartment, occurring in 16% of the samples. Throughout all compartments, the Undetermined pattern was consistently the least common in both sexes, with frequencies ranging between 2% and 6%. This compartment-wise distribution underscores the influence of both gender and anatomical lip region on the manifestation of specific lip print patterns (Table 3.3).

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Table 3.3: Lip print patterns in each lip compartment of males and females.

Lip compartment	Lip print pattern (%)	Males (N= 25×4)	Females (N=25×4)
1	Vertical	9(18)	6(12)
	Incomplete vertical	7(14)	4(8)
	Branched	10(20)	5(10)
	Intersected	6(12)	7(14)
	Reticular	5(10)	3(6)
	Undetermined	2(4)	4(8)
2	Vertical	11(22)	4(8)
	Incomplete vertical	5(10)	3(6)
	Branched	12(24)	6(12)
	Intersected	5(10)	7(14)
	Reticular	8(16)	2(4)
	Undetermined	3(6)	1(2)
3	Vertical	9(18)	3(6)
	Incomplete vertical	5(10)	2(4)
	Branched	7(14)	7(14)
	Intersected	6(12)	8(16)
	Reticular	4(8)	5(10)
	Undetermined	2(4)	3(6)
4	Vertical	14(28)	11(22)
	Incomplete vertical	4(8)	7(14)
	Branched	11(22)	5(10)
	Intersected	10(20)	6(12)
	Reticular	5(10)	8(16)
	Undetermined	2(4)	1(2)

3.4. Distribution of Basic Patterns of Lip Print

Shows different types of lip prints with their sub lip print patterns present among the individuals. By analysing the data, it was found that the most dominant lip print that was present in all the individuals was the Lines, with 70% samples and 14% quadrants. In contrast, Intersected bifurcations and Square were almost equal in both samples and quadrant with 5% of occurrence. Curved intersected bifurcations were seen with the percent of 4 % sample and 35% quadrant, whereas curved bifurcations were found with 14% sample and 65% quadrant. Curves were found in 36% samples and 9% in quadrants (Table 3.4).

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Therefore, the study shows that the lines were the most common among people, the square and the intersecting bifurcations were the least found patterns which shows the variation in the distribution of lip prints in samples and quadrants.

Table 3.4: Frequency of Basic Patterns of Lip Print.

Types of Patterns	Total sample size	Number of samples with patterns	Total number of quadrants	Number of quadrants with patterns	Sample wise percentage	Quadrant wise percentage
Lines	50	35	200	28	0.7%	0.14%
Curves	50	18	200	18	0.36%	0.09%
Bifurcations	50	10	200	30	0.2%	0.15%
Curved Bifurcations	50	07	200	13	0.14%	0.065%
Intersected Bifurcations	50	10	200	10	0.2%	0.05%
Curved Intersected Bifurcations	50	20	200	07	0.4%	0.035%
Square	50	05	200	10	0.1%	0.05%

(Sharma et al., 2009) found similar results, with Type I and I' being more prevalent in females and Type IV (Undetermined) being more common in males, supporting the sexual dimorphism reported in lip prints. Their findings showed that lip prints are distinctive and can help identify an individual's sex with reasonable accuracy. Similarly, (Thermadam et al., 2020) did a large-scale investigation of 2112 individuals and discovered that Type I and I' patterns were prominent in males, while Type IV and V were more prevalent in females. These patterns were constant throughout both the upper and lower lips, demonstrating the accuracy of cheiloscopy in gender determination.

In contrast, (Saraswathi et al., 2009) discovered that the Intersected (Type III) pattern was most common in both males and females, whereas the Reticular (Type IV) pattern was least common. This dominant pattern is somewhat replicated in the current study's compartmental analysis, where intersecting patterns were more common in females, particularly in compartments 2 and 3. These small changes may be due to regional and genetic variety, as pattern occurrence varies across cultures and ethnic backgrounds.

(Chadha et al., 2022) added another dimension by doing a comparative analysis of Indian and Malaysian-Chinese people

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and reporting Type V and III as the most common across both groups. Interestingly, their data revealed no statistically significant gender differences in pattern distribution, implying that ethnic background may occasionally overwhelm gender-based variations. Their research also underscored the importance of combining manual and digital cheiloscopic approaches, despite the fact that their custom-developed software failed to accurately reproduce manual assessments.

The current study is more consistent with the findings of (Sharma et al. 2009 and Thermadam et al., 2020) supporting the claim that Type I and I' patterns are more common in males, whereas Intersected and Branched patterns are relatively more common in females. The distinct compartmental tendencies observed—such as the dominance of vertical patterns in the fourth compartment in males and intersecting patterns in the middle compartments in females—provide additional support for the concept that specific lip regions may reflect gender-linked morphological features.

Overall, these findings add to the expanding body of research indicating that lip prints are not only unique to people, but also exhibit gender-specific patterns, making them a promising forensic marker. However, due to the study's small sample size and limited geographic breadth, additional research on larger, ethnically varied populations is required to validate these findings and build uniform databases. Establishing such demographic references would increase the utility of cheiloscopy in criminal investigations, victim identification, and catastrophe victim recovery scenarios, particularly when traditional identification methods are unavailable.

Lines were the most common pattern in this study, which is consistent with the findings of Kaur and Thakar (2021), who claimed that they were more common. In contrast, curves were less common in both studies and had a narrow distribution. Compared to the current study, bifurcations, curved bifurcations, intersected bifurcations, and curved intersected bifurcations were shown to be more prevalent. The square patterns, which are uncommon in the varied Nainital region, were the least common designs in both investigations.

In addition, lines were the most common in this study which are similar to the study of Qassim Saudi Arabia. In contrast reticular patterns were in higher prevalence, especially in males. Bifurcations, Curved Bifurcations, and Intersected Bifurcations, Curved Intersected Bifurcations were uncommon in our study in contrast to Type IV and V, which were more common in Qassim Saudi Arabia. Square patterns were found least; these differences show the gender differences and population variations. (Alayouni et al., 2025).

4. Conclusion

The findings of the study indicate that cheiloscopy possesses considerable promise as an auxiliary instrument in the realms of forensic identification and the determination of gender. The analysis of lip prints revealed that they possess unique characteristics, demonstrate a degree of stability over time, and display distinct patterns that correlate with gender, thereby reinforcing their potential utility in forensic science. Despite the presence of limitations, including a small sample size and the lack of standardized databases, the findings underscore the significance of cheiloscopy as a straightforward, non-invasive, and economically viable technique. This method proves particularly advantageous in scenarios where traditional biometric evidence is not accessible. Future investigations involving larger and more diverse populations, along with the

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establishment of digital lip print databases, are crucial for enhancing the reliability, precision, and acceptance of cheiloscopic analysis within the field of forensic science.

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