Journal of Criminology and Forensic Studies
ISSN: 2640-6578
Academic Strive
Researcher's perception is our reality

Research Article *Volume 7 Issue 1*

Cheiloscopy Examination of the Correlation between Lip Print Patterns, Gender, and Age Differences in the Gujarat Population

Dahiya P[1]*, Oza D[2], Gadhvi J[2], Bhatt J[2] and Bhatia A[1]

[1]School of Forensic Science, National Forensic Sciences University, India

[2]Department of Biotechnology and Bioengineering, Institute of Advanced Research, India

***Corresponding author:** Parshant Dahiya, National Forensic Sciences University, Gandhinagar, India; Email: prashantdahiya444@gmail.com

Received Date: January 16, 2025; **Published Date:** February 03, 2025

Abstract

Background: Cheiloscopy, a forensic investigation approach, is focused on analysing ridges and grooves that create a distinguishing arrangement on the outer side of the lips. The present research aims to identify the most prevalent lip pattern in the Gujarat population, assess whether sex can be deduced from lip prints, and investigate potential relationships between lip patterns and advancing age using several classifications of lip prints employed in cheiloscopy analysis.

Material and Methods: A total of 210 subjects, including males and females, were randomly selected and distributed into two age groups (Group I: 18-34 years and Group II: 35-50 years). A considerable difference ($p < 0.0001$) in the lip patterns of males and females was found using statistical analysis.

Results: Type II was found to be the most common pattern (30.15%) among all the participants and Type V was the least common pattern (4.12%). It was also shown that age-related changes can substantially impact lip patterns, such as less mature lip characteristics in younger individuals and diminishing anatomical features and tonicity in older individuals. As a result, determining sex may be particularly challenging in specific age groups. Cheiloscopy is a valuable tool for personal identification, with lip prints being unique and stable throughout life. This study emphasizes the need for a comprehensive global database to enhance the method's potential for accurate forensic identification and sex determination.

Keywords: Forensic Investigation; Cheiloscopy; Lip Prints; Identification; Sex Determination

Introduction

The pattern formed by the lip grooves upon contact with mechanical surfaces such as glass, fabric, metal, etc., is known as a lip print (Figure 1). At the crime scene, visible lip prints are mostly present, often due to the application of any coloured substance such as lipstick on the individual's lips [1]. In other cases, latent lip prints are also found that are not initially visible but can be made apparent through the use of physical development methods like fingerprint powders [2]. Cheiloscopy is the analysis of lip print patterns that are created by the fissures or grooves at the skin-lip junction. The term "Cheiloscopy" is made up of two Greek words, "Cheilos," meaning lip, and "Scopy," indicating study, thus referring to the analysis of lip prints [3]. Due to their remarkable consistency, the patterns observed in the lip prints remain unchanged throughout an individual's lifespan, providing cheiloscopy with a temporal stability that is essential for forensic identification purposes [4]. In postmortem analysis, it is crucial to collect the lip furrow patterns within 24 hours of death to minimize the risk of any possible postmortem mechanical degradation of lip mucosa [5] [6]. Delays beyond this timeframe may cause degeneration of the mucosal tissues, jeopardizing the quality and integrity of the lip prints. Prompt collection helps to ensure correct documentation and preservation of these patterns for forensic use [7]. Latent or patent lip prints can serve as a valuable source for DNA extraction. DNA may be obtained from saliva, exfoliated epithelial cells, or other biological materials present on the lip prints [8]. Lip prints, like fingerprints, are considered unique identifiers for individuals. According to previous research, lip prints can regenerate after minor damage, inflammation, or herpes [9]. However, significant lip injuries can cause scarring and pathological diseases, and surgical treatments for these conditions can change the size and shape of the lip prints, changing the groove pattern and morphology [10,11]. Lip print evidence recovered from a crime scene can provide important details about the events of a crime, such as the gender and number of individuals involved, the type of cosmetic products used, regular habits, occupational traits, and any pathological alterations to the lips [12]. Previous studies have reported gender-specific variations in lip groove patterns. Despite this, the advancement and establishment of cheiloscopy as a distinct forensic discipline are constrained by the absence of a comprehensive database [13,14]. This study aims to recognize the most prevalent lip patterns in the Gujarat population, analyze gender variances in lip prints, and evaluate the relationship between lip prints and age. This was accomplished through the use of previously established lip print classifications such as Suzuki and Tsuchihashi, Renaud, and Kasprzak.

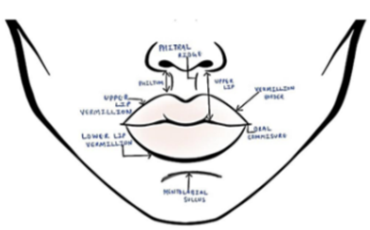

Figure 1: Key Anatomical Landmarks of the Lips.

Lip Print Classifications

- **Suzuki and Tsuchihashi Classification**: This is one of the extensively utilized classifications. It classifies lip prints into five basic categories (Table 1 and Figure 2).
- **Renaud Classification**: Renaud developed a system that categorizes lip prints into ten types based on the orientation and shape of the grooves (Table 2 and Figure 3).
- **Kasprzak Classification**: Kasprzak's method emphasizes the topographical distribution of grooves and their relationship to the lip zones (Table 3).

Classification	Lip Print Type
Type I	Clear-cut vertical grooves covering the entire lip
Type I'	Partial-length grooves of Type I
Type II	Branched grooves
Type III	Intersected grooves
Type IV	Reticular grooves
Type V	Grooves that do not correspond to any of the previously defined categories

Table 1: Suzuki and Tsuchihashi Classification

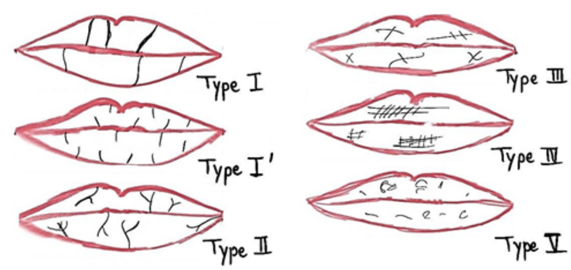

Figure 2: Lip Print Type based on Suzuki and Tsuchihashi Classification.

Classification	Lip Print Type
Type A	Complete Vertical
Type B	Incomplete Vertical
Type C	Complete Bifurcation
Type D	Incomplete Bifurcation
Type E	Complete Branched
Type F	Incomplete Branched
Type G	Reticular pattern
Type H	Cross Form
Type I	Horizontal/Complete horizontal
Type J	Horizontal in other forms

Table 2: Renaud Classification.

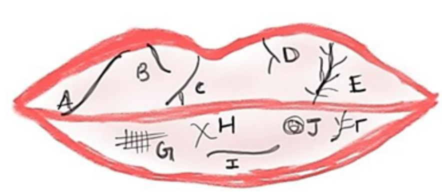

Figure 3: Lip Print Type based on Renaud Classification.

S. No.	Individual Features	Pictures	S. No	Individual Features	Pictures
1	Eye		13	Cross bottom bifurcation	
2	Hook		14	Delta-Like Opening	
3	Bridge		15	Simple opening	
4	Line		16	Close top bifurcation	
5	Dot		17	Pentagonal arrangement	
6	Rectangle		18	branch-like top bifurcation	
7	Triangle		19	Star-like bifurcation	
8	Group of Dots		20	Fence	
9	Simple top bifurcation		21	Branch-like bottom bifurcation	
10	Simple bottom bifurcation		22	Double Fence	
11	Double Eye		23	Hexagonal arrangement	
12	Crossing Lines				

Table 3: Kasprzak Classification.

Materials and methods

The primary objective of this research study is to determine the most common lip patterns, examine the differences in male and female lip prints, and evaluate the relationship between lip prints and advancing age.

Sample Size

Lip prints were collected from 210 subjects (105 males and 105 females) between the ages of 18 years to 50 years. The participants were informed about the objective of the study. Informed consent was also obtained.

Inclusion and Exclusion Criteria

Participants included in the study were individuals aged between 18 and 50 years with no known history of hypersensitivity to the lipstick used. Only individuals with normal lip structure and no visible deformities were considered, and informed consent was obtained from all participants. Subjects with congenital abnormalities affecting lip morphology, active lip inflammation, infections, trauma, or other medical or dermatological conditions impacting the lips were excluded. Additionally, the study did not include individuals unwilling or unable to provide informed consent.

Materials Used

A magnifying lens, scissors, transparent adhesive cellophane tape, white bond paper, and dark, vibrant, non-glossy lipstick were used to collect the lip print from the subjects.

Sample Collection

The participants were requested to wipe their lips with a wet tissue before sample collection. A red-coloured lipstick was applied to the index fingers of the subjects, who were then instructed to evenly spread it across their lips in a gentle, uniform motion. Lip impressions were collected by carefully applying pressure from the adhesive side of transparent cellophane tape onto the subjects' lips. The excess tape was trimmed using scissors, and the impressions were transferred to white bond paper via the adhesive side of the tape, applying minimal pressure during the process. A cleansing agent was provided to the subjects to remove the lipstick afterwards. A magnifying lens was used to examine the samples. Each sample was divided into six quadrants: upper right (quadrant 1), upper middle (quadrant 2), upper left (quadrant 3), lower left (quadrant 4), lower middle (quadrant 5), and lower right (quadrant 6), as illustrated in Figure 4.

Sample Analysis

The frequency of each lip print type was recorded based on the Suzuki and Tsuchihashi, Renaud, and Kasprzak classification systems. The percentage distribution for each lip print type was computed for further analysis. The collected data were then compiled and statistically evaluated using the Chi-square test, where a p-value of less than 0.001 was considered statistically significant, while a p-value of less than 0.0001 indicated extremely high significance.

Result and Discussion

Human identification represents one of the most complex challenges faced by forensic experts. Accurate identification is crucial for death certification and serves various personal, social, and legal purposes. Lip prints, as a unique biometric marker, can be vital in confirming an individual's identity. Cheiloscopy, is particularly valuable for identifying living individuals, as lip prints are often found at crime scenes and can establish a clear connection to a suspect involved in the crime [15]. Lip prints can be deposited on various surfaces, such as fabric, glass, utensils, and cigarette butts. Due to the sebaceous and sweat glands along the lip borders, latent lip prints can be developed using aluminium or magnetic powders [16].

These glands secrete oils and moisture, allowing for the formation of stable, persistent lip prints, analogous to latent fingerprints. The primary objective of this study was to analyze the correlation between lip patterns and demographic factors, including age and sex. In addition, the study also aimed to identify the predominant lip patterns within the Gujarat population. The inherent distinctiveness of lip prints ensures that no two individuals share the same pattern, underscoring their significance in forensic identification and personal identification studies.

1. Lip Pattern Distribution and Sex Differentiation in the Gujarat Population

The present study found that Type II lip patterns are the most prevalent, accounting for 30.15% of the sample population. This is followed by Type I patterns, which comprise 22.85% of the population. Type III and Type I' patterns also exhibit significant frequencies, representing 19.92% and 14.52% of the population, respectively. In contrast, Type IV and Type V patterns are the least common, observed in 8.41% and 4.12% of the individuals, respectively (refer to Table 1).

These results suggest a diverse distribution of lip patterns within the Gujarat population, with no single pattern showing clear dominance, thereby highlighting the heterogeneity of cheiloscopic profiles within this demographic region. According to the Suzuki and Tsuchihashi Classification, the findings indicate that Type II is the most prevalent lip pattern for males (31.11%) and females (29.20%).

Among males, Type I is the second most common pattern, observed in 23.49% of the population, whereas Type III is the second most prevalent in females, accounting for 24.12%. Type I' in particular, exhibits a significant gender difference, being more frequent in males (20.15%) than in females (8.88%).

On the other hand, Type III is more common in females than in males, and Type IV and Type V show higher frequencies in females (10.00% and 5.55%, respectively) compared to males (6.82% and 2.69%, respectively). These results highlight similarities and differences in lip pattern distribution between sexes, suggesting potential gender-related variations within the studied population.

The highly significant Chi-square result indicates distinct differences in the prevalence of lip patterns between males and females. Specifically, Type I' is notably more common in males (20.15%) than in females (8.88%), while Type III is more frequent in females (24.12%) compared to males (15.71%). These differences imply that certain lip patterns are associated with specific sexes, supporting the hypothesis that lip prints can be used to identify the sex of an individual. The significant variations in lip pattern frequencies emphasize the potential of cheiloscopy as a tool for sex determination in forensic and biometric applications (Tables 4 & 5).

Lip Pattern	Frequency (n=1260)	%
I	288	22.85
I	183	14.52
II	380	30.15
III	251	19.92
IV	106	8.41
V	52	4.12

Table 4: Distribution of Lip Patterns According to Suzuki and Tsuchihashi Classification.

Lip Pattern	Male (n=630)		Female (n=630)		Statistical Test (Chi-square test)
	Frequency	%	Frequency	%	
I	148	23.49	140	22.22	χ^2 = 49.34 and p-value = <0.0001
I’	127	20.15	56	8.88	
II	196	31.11	184	29.2	
III	99	15.71	152	24.12	
IV	43	6.82	63	10	
V	17	2.69	35	5.55	
Total	**630**	**100**	**630**	**100**	

Table 5: Gender-Based Distribution of Lip Patterns According to Suzuki and Tsuchihashi Classification.

2. Relationship between Advancing Age and Lip Patterns Using Various Cheiloscopy Classifications

In examining the relationship between age and lip patterns using Suzuki and Tsuchihashi Classification, distinct trends emerge across the two age groups studied. For individuals aged 18- 34, Type II (branched lines) is the most common lip pattern for males and females, with 138 males and 120 females exhibiting this type. Type I (straight lines) also shows significant prevalence among males.

In contrast, Type V (other or unclassifiable patterns) is the least frequent in this age group. Gender differences are apparent, with males more likely to have Type I’ (interrupted straight lines) and Type II, while females show a higher frequency of Type III (reticular patterns). The Chi-square test results for this age group (χ^2 = 33.73, $p < 0.0001$) indicate a significant difference in lip pattern distributions between genders. In the 35-50 years age group, Type II remains the dominant pattern, with equal occurrences among males and females (58 each). However, the frequency of Type I declines compared to the younger age group, with 51 males and 49 females showing this type. Type III becomes notably more common among females (62 occurrences) than males (40 occurrences), and Type I’ and Type IV frequencies decrease. The Chi-square test results for this age group (χ^2 = 15.36, $p < 0.0001$) also reveal significant gender differences.

Age does appear to affect lip patterns, with observable changes in the distribution of patterns from the younger to the older age group. The increase in Type III among older females and the decrease in Type I’ and Type IV suggest that age influences lip patterns, altering their distribution and prevalence over time. In analyzing the relationship between age and lip patterns using the Renaud Classification, several observations emerge for both age groups. For individuals aged 18-34 years, Type C (the most common pattern) appears frequently among both males (107 occurrences) and females (96 occurrences). Type A is also prevalent, with 87 males and 92 females exhibiting this pattern. However, Type I is the least common, with no males and only 6 females showing this pattern, and Type D is notably rare, appearing in only 15 males and no females. The Chi-square test results (χ^2 = 45.53, $p<0.0001$) indicate a significant gender difference in the distribution of these lip patterns.

In the 35-50 years age group, Type C continues to be the most common pattern for both genders, with 42 males and 37 females. Type A remains significant but slightly decreases compared to the younger group, with 52 males and 46 females. Type I still has low occurrences, with no males and 3 females.

Type J is also infrequent, with 4 males and 6 females. The Chi-square test (χ^2 = 49.46, $p < 0.0001$) confirms significant gender differences in lip pattern distributions in this age group as well. While the most common patterns, Type C and Type A, remain consistent across age groups, there are variations in less common patterns between the two age groups.

These observations suggest that while the primary lip patterns do not drastically change with age, some shifts in pattern frequency might reflect age-related influences. The significant gender differences noted in both age groups highlight that gender notably impacts lip pattern distributions.

The Kasprzak Classification proved ineffective in depicting significant variations in lip patterns related to ageing within the Gujarat population. The lip features observed across different age groups aligned more consistently with the classifications of Suzuki and Tsuchihashi and Renaud. As a result, these well-recognized systems appear more appropriate for analyzing the relationship between advancing age and lip pattern changes. At the same time, the Kasprzak Classification may lack the specificity needed to account for age-related variations in cheiloscopy analysis (Tables 6 & 7).

Lip Pattern	Male (n=630)		Female (n=630)		Statistical Test (Chi-square test)
	Frequency	%	Frequency	%	
I	148	23.49	140	22.22	χ2 = 49.34 and p-value = <0.0001
I’	127	20.15	56	8.88	
II	196	31.11	184	29.2	
III	99	15.71	152	24.12	
IV	43	6.82	63	10	
V	17	2.69	35	5.55	
Total	**630**	**100**	**630**	**100**	

Table 6: Age and Gender-Based Distribution of Lip Patterns According to Suzuki and Tsuchihashi Classification.

Type	Group I: Age 18-34 years		Statistical Test (Chi-square test)	Group II: Age 35-50 years		Statistical Test (Chi- square test)
	Male (Frequency)	Female (Frequency)		Male (Frequency)	Female (Frequency)	
I	95	91	χ2 = 33.73 and p-value = <0.0001	51	49	χ2 = 15.36 and p-value = <0.0001
I	84	35		43	20	
II	138	120		58	58	
III	60	84		40	62	
IV	32	46		11	18	
V	11	26		6	9	

Table 7: Age and Gender-Based Distribution of Lip Patterns According to Renaud Classification.

Limitations of the Study

While this study provides valuable insights into the correlation between lip print patterns, gender, and age within the Gujarat population, certain limitations must be acknowledged. One of the primary challenges in forensic cheiloscopy is the potential for deliberate alterations of lip prints through the application of cosmetic products such as lipsticks, lip balms, or surgical modifications, which may obscure or modify natural lip patterns, thereby affecting classification accuracy. Additionally, in forensic casework, lip prints recovered from crime scenes may be subject to smudging, environmental degradation, or incomplete impressions, which can compromise the reliability of pattern analysis. Another limitation of this study is the sample size. Although the current sample size offers valuable preliminary findings, a larger and more diverse population would be essential to improve the generalizability and statistical robustness of the results. Moreover, the study was conducted under controlled conditions, ensuring clear and well-defined lip impressions. However, this may not fully replicate real-world forensic scenarios where prints are often obtained from dynamic and uncontrolled environments. The influence of factors such as substrate variability, pressure applied during deposition, and post-depositional changes in different environmental conditions warrants further investigation. Addressing these limitations in future research could improve the forensic applicability of cheiloscopy. Expanding the sample size, employing advanced imaging techniques, and standardizing methodologies to mitigate the impact of cosmetic alterations and environmental factors will contribute to a more robust and reliable lip print analysis framework.

Future Scope of the Study

The future of cheiloscopy in forensic science can be greatly advanced by integrating cutting-edge digital technologies and AI-driven solutions. Though effective, manual methods of lip print analysis are time-consuming and subject to observer bias, limiting the reliability of this forensic tool in large-scale investigations. By implementing high-resolution digital imaging systems, lip print patterns can be captured in greater detail, allowing for more precise pattern differentiation. When processed with advanced pattern recognition software, these digital images could facilitate automated classification of lip print types, improving both the speed and accuracy of identification. The potential for artificial intelligence (AI) and machine learning (ML) in cheiloscopy is particularly promising. AI algorithms can be trained on vast datasets of lip prints to recognize patterns beyond human perception, allowing for the detection of minute variations that may be correlated with age, gender, and even genetic predispositions. Machine learning models can evolve to increase their accuracy with continued input, thus refining the classification of lip prints over time. In forensic investigations, AI could play a pivotal role in automating comparisons between lip prints found at crime scenes and those stored in digital databases, dramatically reducing the time taken for identification.

Moreover, developing a global digital database for lip prints, incorporating diverse population groups, is crucial. Such a database would allow for cross-referencing between regions and populations, enabling forensic experts to draw on a larger data pool when solving crimes. Cloud-based platforms could further enhance this capability, providing real-time access to lip print data across multiple jurisdictions, which could significantly expedite criminal investigations. Incorporating these digital advancements and AI-based methods improves the objectivity and reproducibility of cheiloscopy and paves the way for more complex analyses, such as studying the correlation of lip print patterns with genetic markers or environmental factors.

This would extend the utility of cheiloscopy beyond personal identification, potentially allowing it to serve as a broader forensic and anthropological tool. As technology continues to evolve, cheiloscopy, when integrated with digital and AI tools, has the potential to transform into a highly reliable, efficient, and globally accepted forensic identification technique.

Conclusion

Cheiloscopy presents a valuable forensic tool for personal identification, as lip prints, like fingerprints, are unique and remain stable throughout an individual's life. This study highlights the diversity of lip patterns within the Gujarat population, with Type II being the most prevalent, and significant gender differences, particularly with Type I' more common in males and Type III in females, demonstrating the potential of cheiloscopy for sex determination. The age-related variations in lip pattern distribution were also observed, thereby supporting its applicability in forensic anthropology. While the Suzuki and Tsuchihashi classification and Renaud classification effectively depicted these demographic trends, the Kasprzak Classification was less suitable for distinguishing age or gender differences. To identify the potential of cheiloscopy, developing a comprehensive global database for diverse populations is essential. As data collection expands and cheiloscopy techniques are refined, the method could become a robust and reliable tool for forensic investigations, significantly improving the accuracy of personal identification and aiding in solving crimes.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.
Concept and design: Parshant Dahiya, Ashna Bhatia Acquisition, analysis, or interpretation of data: Durwa Oza, Ashna Bhatia.
Drafting of the manuscript: Durwa Oza, Jayraj Gadhvi, Jiya Bhatt, Ashna Bhatia Critical review of the manuscript for important intellectual content: Parshant Dahiya, Ashna Bhatia

Declaration of Consent

The authors affirm that all necessary participant consent forms have been obtained. In these forms, participants have provided their consent for their images and other information to be published in the journal.

Disclosure Statement

No potential conflict of interest was reported by the authors.

Acknowledgements

The authors sincerely thank the volunteers for their valuable contributions to this study. Their participation and assistance were essential to the successful completion of the research, and we greatly appreciate their support and dedication.

References

1. Reshma KH, Don KR (2020) Identification of Latent Lip Prints in Forensics-Review. Indian Journal of Forensic Medicine & Toxicology 14(4).
2. Abedi M, Afoakwah C, Bonsu DN (2022) Lip print enhancement. Forensic sciences research 7(1): 24-28.
3. Augustine J, Barpande SR, Tupkari JV (2008) Cheiloscopy as an adjunct to forensic identification: A study of 600 individuals. J Forensic Odonto-Stomatology-JFOS 26(2): 44-52.
4. Sekharan PC (2013) Lip forensics for criminal identification. J Forensic Res S 11: 2.
5. Vijay P, Pardhe N, Singhal I, Punga R, Singh H (2016) Cheiloscopy: A Study of Manipuri Population. Int J Dent Rashid & Singla Med Res 3(3): 15-17.
6. Tsokos M (2005) Postmortem changes and artifacts occurring during the early postmortem interval. Forensic pathology reviews 3: 183-238.

7. Batts JJ, Sanger RM (2018) Collecting forensic evidence in the emergency department: A guide for lawyers, investigators, and experts. Am J Trial Advoc 42: 331.

8. Malik SD, Pillai JP, Malik U (2022) Forensic genetics: Scope and application from forensic odontology perspective. Journal of Oral and Maxillofacial Pathology 26(4): 558-563.

9. Saxena S, Kumar S (2015) Saliva in forensic odontology: A comprehensive update. Journal of oral and maxillofacial pathology. 19(2): 263-265.

10. Pausic M, Ekštajn H, Brkic S, Jasinski M, Utrobičić A, et al. (2021) Sex estimation by the patterns of lip impressions (cheiloscopy)–an analysis of a Croatian sample and a scoping review. ST-OPEN 2: 1-37.

11. Pathmashri VP, Sundari S, Ganapathy D (2019) Comparison and analysis of lip prints among North Indian and South Indian population. Drug Invention Today 11(9): 2053.

12. Reddy LV (2011) Lip prints: An overview in forensic dentistry. Journal of Advanced Oral Research 3(1): 17-20.

13. Begum S, Gupta S Methods of Age Estimation. Dentomed Publication House.

14. Jain AA, Patel MD, Pensi CA (2013) Study of lip prints among the Gujarati population for personal identification. Medical Science 2(11): 398-399.

15. Palakurthi N, Afroz S, Suri C, Chaitanya V, Narayen V (2015) Cheiloscopy: Scope in forensics, classification systems and limitations JDSR 5(1): 48-53.

16. Castelló A, Alvarez-Seguí M, Verdú F (2004) Use of fluorescent dyes for developing latent lip prints. Coloration technology 120(4): 184-187.