Original Research Article

Forensic application of cheiloscopy for gender identification: A cross-sectional study of lip patterns among natives of the Himalayan population

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Abstract

Aim and Objective: This study aims to evaluate lip print analysis as a tool for gender determination and to explore the correlation between distinct lip print patterns and gender in the Shimla population.
Introduction: Cheiloscopy, the study of lip prints, is a promising forensic tool for personal identification and gender determination, similar to fingerprints and dental records. Lip prints, being unique and permanent, are valuable in forensic science, especially for gender identification at crime scenes.
Materials and Methods: A total of 120 samples (60 males, 60 females) were randomly collected from District Shimla, aged 20-30 years, to minimize age-related variations. Lip prints were collected using a standardized lipstick application technique and classified according to Tsuchihashi's classification. The sample size was determined through power analysis to ensure statistical adequacy.
Results: Significant gender-based differences were found in lip print patterns. Type I and Type I' were more common in females (42%), while Type III and Type IV were more frequent in males (37%). Type II and Type V showed even distribution across genders. Statistical analysis confirmed a significant correlation between Type I' and females ($\chi^2 = 16.00$, p < 0.001).
Conclusion: Lip prints are a reliable tool for gender determination, with specific patterns like Type I' correlating strongly with gender. Further studies with larger, more diverse samples are needed to enhance the accuracy and forensic applicability of lip print analysis.

Keywords: Cheiloscopy, Gender identification, Forensic Science, Tsuchihashi's classification.

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1. Introduction

Human evolution from primitive beginnings to modern civilization has been marked by advancements in intelligence, yet these advancements have also correlated with an increase in crime, warfare, and natural disasters. Consequently, the importance of personal identification becomes paramount in such circumstances. Every individual carry unique, unchanging physical marker from birth to death, facilitating identification throughout their lifespan.[1] Forensic science, encompassing various methodologies accepted by courts and the scientific community, plays a vital role in distinguishing truth from falsehood. The mouth, with its myriad possibilities for forensic identification, underscores the universal and critical nature of personal identification in human society.[1] Every human possesses a unique set of characteristics, making them distinguishable from others. Scientific methods like fingerprint and DNA analysis capitalize on this uniqueness for personal identification and are widely utilized for rapid and reliable identifications owing to their distinctiveness. However, in certain crime scenarios, additional aids can be employed when these methods fail to establish a conclusive identity.[2]

Cheiloscopy, derived from Greek origins signifying "lips" and "to see," investigates the patterns of lip prints in humans. These prints are characterized by raised lines and grooves found between the outer skin and inner labial mucosa, creating distinct grooves and wrinkles. These grooves, referred to as "sulci labiorum," and the resulting figure, termed "figura linearum labiorum rubrorum".[3] Lip prints, akin to fingerprints, are distinct to each person except in identical twins, serving as crucial identifiers in personal identification and sex determination. They hold considerable value as supporting evidence in specific cases, and can be

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found at crime scenes on various objects.[4]Forensic experts emphasize the significance of evidence aiding in criminal detection, with lip prints proving instrumental in linking suspects to crimes and revealing insights into the individuals involved, including their genders, habits, and potential medical conditions. Its non-invasive nature and accessibility render it a subject of considerable interest for researchers in forensic investigations.[3]

Classification of lip prints is highly valuable for organizing and categorizing lip prints, facilitating investigation processes, and creating organized databases for information retrieval and comparison. Various scientists have proposed classifications, including Marty'n Santos, Suzuki and Tsuchihashi, Renaude, Afchar-Bayat, and Jose Maria Dominguez.[5,6] Among these, the Suzuki and Tsuchihashi classification is widely accepted for sex determination, which includes: Type I consist of complete vertical grooves that run across the entire lips, while Type I' comprises incomplete vertical grooves that do not extend across the entire lips. Type II is characterized by branched (y-shape) patterns, Type III features intersected grooves, and Type IV presents reticular grooves. Lastly, Type V encompasses undifferentiated patterns. These classifications aid in creating organized databases, facilitating information retrieval, and comparison, thus assisting in forensic investigations.[6]

Numerous studies have been conducted on lip prints, exploring various aspects of lip prints including the stability, uniqueness, and morphological characteristics of lip prints, including features that can be used to determine the sex of an individual.[7] Additionally, lip print's variations among different population groups have been studied.[8] These conclude that lip prints serve as valuable evidence in crime investigations, aiding in comparison and analysis of individuals based on their known lip prints found at crime scenes. Lip prints serve as crucial evidence in cases such as sexual assault, murder, and rape, often unknowingly left behind at crime scenes on items like cups, glasses, cigarette butts, clothing, and skin.[9]Significant work has been conducted on utilizing cheiloscopy for gender determination across various populations. However, to date, no studies have explored the same within District Shimla, Himachal Pradesh. Therefore, this study aims to investigate gender differences based upon cheiloscopy among population of District Shimla, Himachal Pradesh.

2. Materials and Methods

2.1 Materials

In this study Lipstick [Blue Heaven (silk crème, blush red-18)] **(Figure 1),** transparent adhesive tape, A4 size sheets.magnifying lens, writing material were used.

2.2 Methodology

2.2.1 Sample collection

A total of 120 samples were collected from individuals residing in District Shimla, Himachal Pradesh, comprising 60 males and 60 females. The sample size was determined through a priori power analysis to ensure sufficient statistical power for the study. The power analysis was conducted using [G*Power software], assuming a medium effect size (Cohen's d=0.5), a significance level (α=0.05), and a desired power (1−β=0.80) for the selected statistical tests. The minimum required sample size was calculated as 102 participants. To account for potential attrition or unusable samples, the total sample size was increased to 120, with equal representation of both genders.

Although the samples were described as being collected randomly, it is important to clarify that this study did not follow the methodology of a randomized controlled trial (RCT), but rather, the samples were randomly selected from a pool of participants within a specified geographic location and demographic criteria. This random selection approach was used to ensure a diverse and representative sample of the local population, but the study design does not include the experimental manipulation required for an RCT. The study was conducted at Alakh Prakash Goyal Shimla University, Shimla, Himachal Pradesh, India, where local individuals aged 20–30 years were selected as participants. Inclusion criteria required participants to have healthy lips free from visible injuries, scars, or deformities that could affect lip print clarity. Participants with a history of dermatological conditions, lip surgeries, or active lip infections were excluded. Precautions were taken to ensure uniformity in sample collection. Participants were instructed to refrain from using any lip products (e.g., balm or gloss) before sample collection, and lips were cleaned with a dry tissue to remove any residue before applying lipstick.

A thin, even layer of lipstick was applied along the vermilion border of the lips, and participants were instructed to press their lips onto a piece of cellophane tape, ensuring a complete and clear lip print. The cellophane tape bearing the lip print was affixed to a white sheet of paper **(Figure 2)**. Each participant provided six lip print samples under different conditions (closed mouth, half-opened mouth, fully opened mouth), both directly and using cellophane tape affixation **(Figure 3)**. Each sample was labeled with a unique identification code that concealed participant identity and collection conditions. To minimize potential bias, the investigator analyzing the lip print samples was blinded to the identity of the participants, as well as their gender and the specific conditions under which the samples were collected. Each sample was labeled with a unique code that ensured the investigator could objectively evaluate the lip print patterns.
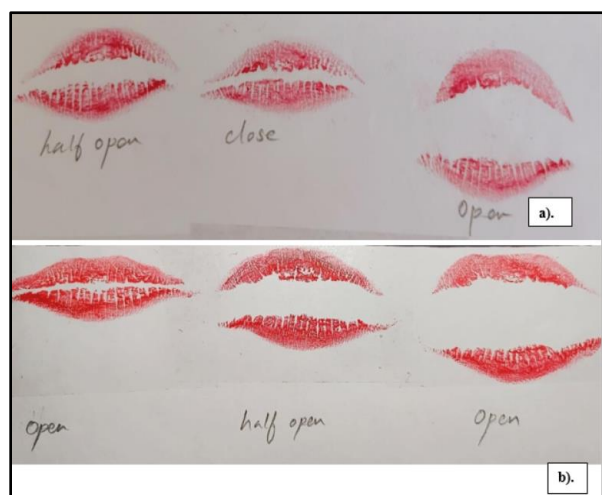
2.3 Sample analysis

The samples were analysed using a Magnifying lens and were further classified accordingto Suzuki and Tsuchihashi's Classification system as shown in **Table 1**.

Figure 1: Lipstick (Blue) Heaven silk crème, blush red-18)

Figure 2: Sample collection; **a).** Application of lipstick **b).** Lifting of lip prints using cellotape **c)** Affixation of lifted lip prints

Figure 3: Specimen sample; **a).** Lipstick directly applied **b).** Cello tape affixed impression

Table 1: Suzuki and Tsuchihashi's classification

Types	Name
Types I	Vertical grooves
Types I'	Incomplete vertical grooves
Types II	Branching grooves
Types III	Intersecting grooves
Types IV	Reticular grooves
Types V	Irregular grooves

3. Results

Lip print patterns were analyzed in 120 individuals (60 males and 60 females) from District Shimla, Himachal Pradesh, using the Suzuki and Tsuchihashi classification system **(Figure 3)**. Gender determination was performed based on the dominant characteristics of each pattern type, and the data were statistically analyzed using a chi-square test to evaluate the differences in distribution between genders **(Table 2)**. The distribution of lip print patterns by gender revealed several key findings. Type I pattern was observed in 40% of males (24/60) and 50% of females (30/60), with the chi-square test indicating no significant difference in its distribution between genders ($\chi^2 = 0.67$, $p = 0.414$). Type I', on the other hand, was found in 10% of males (6/60) and 50% of females (30/60), showing a statistically significant difference ($\chi^2 = 16.00$, $p < 0.001$) and confirming its predominance in females. Type II emerged as the most frequent pattern overall, present in 80% of males (48/60) and 90% of females (54/60), though the chi-square test revealed no significant gender-based difference ($\chi^2 = 0.35$, $p = 0.552$).

Type III and Type V patterns were equally distributed between genders, occurring in 40% of samples for both males and females (24/60), with the chi-square test confirming no significant differences ($\chi^2 = 0.00$, $p = 1.000$ for both). Type IV was observed in 70% of males (42/60) and 60% of females (36/60), but the chi-square test showed no statistically significant difference in its distribution ($\chi^2 = 0.46$, $p = 0.497$).The results suggest that Type I' is significantly more frequent in females compared to males, highlighting its potential as a gender-specific marker. Type II, being the most common pattern across both genders, emphasizes its general prevalence without gender-specific variation. Patterns such as Type III and Type V were equally distributed between genders, while Type IV, despite being slightly more prevalent in males, did not exhibit a statistically significant difference.

These findings underscore the potential utility of lip print patterns, particularly Type I', in gender determination. However, the lack of statistical significance in other patterns suggests the need for further studies with larger and more diverse samples to validate these results and enhance the reliability of lip print analysis for forensic applications.

Table 2: Distribution of *lip print patterns by gender*

Pattern Type	Male (%)	Female (%)	χ^2	p-value	Significance
Type I	40% (24/60)	50% (30/60)	0.67	0.414	Not significant ($p > 0.05$)
Type I'	10% (6/60)	50% (30/60)	16.00	< 0.001	Significant ($p < 0.05$)
Type II	80% (48/60)	90% (54/60)	0.35	0.552	Not significant ($p > 0.05$)
Type III	40% (24/60)	40% (24/60)	0.00	1.000	Not significant ($p > 0.05$)
Type IV	70% (42/60)	60% (36/60)	0.46	0.497	Not significant ($p > 0.05$)
Type V	40% (24/60)	40% (24/60)	0.00	1.000	Not significant ($p > 0.05$)

4. Discussion

Lip prints have emerged as a valuable tool in forensic science, offering a reliable method for personal identification and gender determination. Similar to fingerprints, lip prints are unique to individuals and retain their patterns throughout a lifetime. This study focused on the application of the Suzuki and Tsuchihashi classification system to analyze lip print patterns in 120 individuals (60 males and 60 females) and assess their utility in gender determination.

The results indicate that Type I' was significantly more frequent in females, with a statistically significant gender difference ($p < 0.001$), highlighting its potential as a gender-specific marker. Type II emerged as the most prevalent pattern across both genders, suggesting its general dominance and less discriminatory role in gender identification. Patterns such as Type III and Type V were equally distributed among males and females, reinforcing their lower overall frequency and limited application in gender determination. Type IV, while more common in males, did not exhibit a statistically significant difference, warranting further investigation into its potential utility. These findings are consistent with prior research[10,11,12,13,14] which suggests that lip prints exhibit unique patterns that can aid in forensic investigations. The predominance of Type I' in females aligns with earlier observations and reinforces the relevance of this pattern for gender determination. However, the lack of significant differences for other patterns underscores the need for larger and more diverse sample studies to establish more conclusive patterns.

The age range of the participants in this study was restricted to 20–30 years to minimize the potential influence of age-related changes in facial musculature on lip print patterns.[15] This age group represents a period of relative stability in facial musculature and skin elasticity, which reduces the likelihood of variability in lip print clarity and patterns due to age-related factors. While facial musculature and skin undergo consistent changes over time.[16,17] including reduced elasticity and increased wrinkling, these changes are more pronounced outside the selected age range. By limiting the study to this demographic, we aimed to ensure uniformity in sample quality and reliability. However, future studies could explore the impact of age-related anatomical changes on lip print patterns to assess their potential influence across broader age groups.

Despite its strengths, the study is not without limitations. The sample was limited to a specific geographical region (District Shimla, Himachal Pradesh), which may restrict the generalizability of the findings to other populations. Moreover, the study did not consider the impact of external factors such as age, cosmetic use, or lifestyle, which may influence lip print patterns. The environmental and temporal viability of lip prints as forensic evidence was also not evaluated, leaving gaps in understanding their practical utility in real-world crime scenes. The use of lip prints as forensic evidence depends on their preservation under various environmental conditions. Factors such as exposure to sunlight, humidity, and temperature can degrade lip prints, affecting their clarity and usability. Smooth, non-porous surfaces are more likely to retain clear lip prints compared to porous or textured ones. While lip prints may remain viable for a few days under optimal conditions, further research is required to establish their precise lifespan and reliability under different scenarios.

5. Conclusion

This study reaffirms the potential of lip print analysis as a forensic tool, particularly in gender determination. By identifying statistically significant differences in patterns such as Type I', the research highlights the importance of cheiloscopy in forensic investigations. While the findings underscore the value of lip prints, they also call attention to the need for further research to overcome existing limitations and refine the utility of this promising method in forensic science. Future research should aim to address the limitations of this study and enhance the forensic applicability of lip print analysis. Investigating the effect of environmental factors on the preservation and degradation of lip prints is crucial for improving the reliability of this technique in real-world scenarios. Expanding studies to include diverse populations will help validate and generalize the current findings. Additionally, examining variables such as age, lifestyle, and cosmetic use can provide insights into their influence on lip print clarity and patterns. Developing advanced techniques for enhancing and recovering degraded lip prints at crime scenes will further strengthen the utility of cheiloscopy in forensic science.

6. Source of Funding

None.

7. Conflict of Interest

None.

References

1. Abidullah, M., Hussain, S., Harish, M., Saraswathi, T. R.. Cheiloscopy and dermatoglyphics: An integrated approach for gender determination. *J Forensic Dentl Sci,*2015; *7*(1), 44–9.
2. Mohammed, A., Sharanesha, R. B., Virupakshappa, D. Gender determination using cheiloscopy in pediatric population. *J Dent Med.*2008;14(1), 60–3.
3. Raj, M., Krishna, S., Shankar, K., Manikandan, J. S., Priyadarshini, T. Lip Prints and Gender Identification. *IOSR J Dent Med Sci.*2016; 15(10),112–5.
4. Nagasupriya, A., Dhanpal, R., Reena, K., Saraswathi, T. R., Ramachandran, C. R.. Patterns - "A crime solver". *J Forensic Dent Sci.*2017; 3(1); 3–7.
5. Thermadam, T. P., Chatra, L., Ahsan, A. (2020). Evaluation for Correlation of Cheiloscopy and Dermatoglyphics in Gender Determination. Ind*ian J Forensic Med Toxicol,* 14(1):143–6.
6. Gupta, A., Sharma, N., Jain, S. K. Cheiloscopy A tool for sexual dimorphism in India. Shahin Salma Khatun, 2016; 4(3):2577–83.
7. Venkatesh, R., David, M. P., Jayanthi, K., Karthikeyan, P. Cheiloscopy: A novel aid for personal identification. *J Foren Dent Sci.*2011; 3(2):67–70.
8. Gazge, N. M., Poornima, B., Pachipulusu, Chandra, P., Basavaraju, S. M., Govindraju, P., Pawar, Y.. Assessment of reliability of cheiloscopy and dactyloscopy in human identification by digital method: a cross- sectional study. *Int J Forensic Odontol* 2018; 3(2):72–9.
9. Nagrale, N., Tirpude, B., Murkey, P., Patond. Establishing cheiloscopy as a tool for identification: An assessment on 500 subjects in central India. *Al Ameen J Med Sci*, 2014; 7(3):201–7.
10. Bharath, T. S., Kumar, G. R., Prasad, M. G., Kulkarni, P., & Vijay Kumar, K. Lip print patterns among adults of Dakshina Kannada region of Karnataka, India. *J Foren Dent Sci.*2014; 6(2), 122–5.
11. Chaitanya, B., Pramod, J. B., Rani, S., Manikya, R. A study of lip print patterns among students of Telangana region. *J Foren Dent Sci.*2013; 5(2), 104–8.
12. Garg, R., Sowmya, G. V. Study of lip prints as an aid to forensic methodology. *J Foren Dent Sci,* 2013;5(2), 109–14.
13. Gomes, M. L., Cavalcanti, P. H. A., de Oliveira, J. B. The role of lip prints in forensic practice. *J Foren Sci,*2014; 59(5), 1238–40.
14. Gondivkar, S. M., Indurkar, A., Degwekar, S., Bhowate, R. Cheiloscopy for sex determination. *J Foren Dent Sci,*2019; 1(2), 56–60.
15. Houstis, O., Kiliaridis, S. Gender and age differences in facial expressions. *Eur J Orthos*, 2009;31(5),459–66.
16. Tamura, E., Ishikawa, J., Sugata, K., Tsukahara, K., Yasumori, H., Yamamoto, T. Age-related differences in the functional properties of lips compared with skin, *Skin Res Technol*,2018; 24(3):472–8.
17. Randhawa, K., Narang, R. S., Arora, P. C. (2011). Study of the Effect of Age Changes n Lip Print Pattern and its Reliability in Sex Determination. *J Foren Odontost.*2011; 29(2); 45–51.