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Lip Print Patterns in Qassim: Demographic Variations Using Suzuki and Tsuchihashi Classification

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Abstract **Objectives:** Forensic scientists now recognize lip print research known as cheiloscopy as a valuable method for identifying people which supplements fingerprints and DNA examination. Although lip prints are unique and permanent features they receive limited use in forensic analysis of certain population groups. **Aim:** The study analyzes how gender and age influence lip prints among residents of Qassim Saudi Arabia according to Suzuki and Tsuchihashi's classification system. **Methods:** The study's design involved 100 participants selected by age from 18 to 45 among 50 males and equal female participants. Eye examination revealed lip print classifications that researchers collected using non-invasive method involving a lipstick and transparent film. Investigators used the Chi-square test to evaluate whether demographic variables showed an association with lip print distribution types. **Results:** The majority of participants showed Type I lip print patterns which accounted for 44% of all participants. The results showed that female participants displayed Type I patterns in 70% of cases but male participants mostly had Type IV patterns at 42%. A measurement analysis showed that lips print distribution across genders differed significantly in lip print frequencies ($\chi^2 = 15.72$, $p < 0.01$). Lip print type demonstrated no statistical connection with the participants' age divisions ($p > 0.05$). **Limitations:** The research contained a restricted participant number alongside a bias toward younger individuals which potentially reduced the study's ability to generalize its findings. The assessment process by manual methods along with missing power analysis measurements warrant attention because they could lead to classification bias. **Conclusion:** Interpretation of lip prints showed important distinctions based on gender thus strengthening cheiloscopy as an investigative aid during forensic investigations. Additional research of large size using artificial intelligence should be supported to study multiple population groups

Key Words Cross-sectional study, prevalence. Lip prints, cheiloscopy, forensic identification, suzuki and tsuchihashi system

INTRODUCTION

Cheiloscopy is a branch of forensic science focused on the analysis of lip prints for identification purposes. Lip prints, similar to fingerprints, have unique patterns of ridges and furrows that are established during fetal development and remain consistent over an individual's life unless altered by severe injury or disease [1]. These patterns are found on the labial mucosa, the lip's surface layer and are formed by grooves and wrinkles in early fetal stages. These characteristics make lip prints a reliable marker for individual identification in forensic investigations. Cheiloscopy gains forensic importance for its ability to associate individuals with crime scenes. Criminals, regardless of their carefulness, may inadvertently leave lip prints on items such as glasses, cigarette butts, or skin. These prints serve as vital evidence [2]. Through detailed analysis and comparison with existing samples or databases, investigators can identify or exclude suspects in criminal investigations.

The cheiloscopy procedure encompasses several precise steps. Initially, samples of lip prints are acquired, typically through the application of lipstick followed by transferring the print onto a clean surface. These prints are then analyzed and classified based on recognized classification systems. The Suzuki and Tsuchihashi classification system, which is broadly accepted, organizes lip prints into six primary types [3].

- **Type I:** Clear-cut vertical grooves that run across the entire lip
- **Type I' (Type I Prime):** Similar to Type I, but the vertical grooves do not cover the entire lip, appearing partially
- **Type II:** Branched grooves
- **Type III:** Intersected grooves
- **Type IV:** Reticular pattern of grooves
- **Type V:** Grooves do not fall into any of the above categories, considered as undetermined

By analyzing lip prints recovered from crime scenes against known samples from suspects or victims, or comparing them with databases of lip print records, forensic experts can reinforce their cases. Cheiloscopy, although an evolving discipline, necessitates ongoing research to affirm its evidentiary value in legal proceedings [4]. Challenges such as the potential for smudges or the difficulty in obtaining clear prints from various surfaces are present. However, cheiloscopy offers significant potential as an ancillary forensic tool, providing another method to elucidate truths from the subtle marks left by lips [5].

Current research investigates the distribution of Suzuki and Tsuchihashi lip print classifications across genders and age groups to identify potential demographic differences. This exploration seeks to ascertain variations in lip print patterns by age and gender, thereby improving the utility and accuracy of cheiloscopy in forensic settings.

Researchers conducted this study because Qassim has special ethnic characteristics alongside insufficient available lip print information. Studies conducted in India, Nigeria, Turkey demonstrated different patterns of lip prints between male and female participants while also factoring in their ethnic backgrounds. The Qassim population has not been studied to assess these patterns yet. The research initiative pursues to connect these two areas while delivering useful findings for area-specific forensic use.

Research Question:
What patterns of lip prints exist within the Qassim sub-population of Saudi Arabia according to their demographic characteristics and gender?

Hypothesis:
In the Qassim sub-population strong statistical evidence shows that lip print pattern types correlate closely to gender.

METHODS

The current cross-sectional study was conducted in the outpatient dental clinic at the College of Dentistry -Qassim University, Saudi Arabia. A cross-sectional observational design was selected for its efficiency in analyzing prevalence patterns in a specific population without the need for long-term follow-up. Participants were volunteers recruited from the outpatient dental clinic at this location. A total of 100 participants (55 females, 45 males), aged 18-45, were selected using convenience sampling from local universities. A power analysis was not conducted due to the pilot nature of the study; however, future research will consider it. The age distribution was skewed towards younger adults (84% <30 years). Ethical clearance for the study was obtained from the ethical committee at Qassim University (Reg Number: 24-88-02). Data collection utilized a safe and non-invasive method to gather lip prints from each participant. Participants' lips were cleaned and dark-colored lipstick was applied. Cellophane tape was used to capture the prints, which were then transferred to white paper. Care was taken to minimize smudging. Classification was done using Suzuki and Tsuchihashi's system under magnification. Two independent forensic examiners analyzed the lip prints. Inter-observer agreement was calculated using Cohen's Kappa ($\kappa = 0.81$), indicating substantial agreement. After collection, these lip prints underwent a detailed classification process based on the well-established Suzuki and Tsuchihashi system. Lip print images were anonymized and stored securely in an encrypted digital folder. This system intricately categorizes lip prints into distinct types, each reflecting unique characteristics and variations in the lip grooves. Specifically, the classification criteria include Type I (clear-cut vertical grooves that run across the entire lips), Type I' (similar vertical grooves but do not cover the entire lips), Type II (branching grooves), Type III (intersecting grooves), Type IV (reticular pattern) and Type V (grooves that do not fall into the other categories), providing a comprehensive framework for analyzing the diverse patterns observed in lip prints (Figure 1). Descriptive statistics and Chi-square test was used to assess the association between gender and lip print types. A p-value <0.05 was considered statistically significant. Missing data were handled using listwise deletion. Logistic regression was considered but not applied due to small sample size; it is recommended for future studies.

RESULTS

Demographic Distribution: Table 1 summarizes the key characteristics of the participants in the lip print study. Among the 100 total participants, there was a balanced gender distribution with 50 males (50%) and 50 females (50%) (Table 1). The most common lip print pattern observed was Type 1, found in 44 participants (44%). Types 2, 3 and 4 were less frequent, each present in 6 participants (6%) for Types 2 and 3 and 25 participants (25%) for Type 4. Type 5 was the least common, seen in 19 participants (19%). Interestingly, the majority of participants, 84 (84%), fell into the under-30 age group, with only 16 participants (16%) being 30 years old or older.

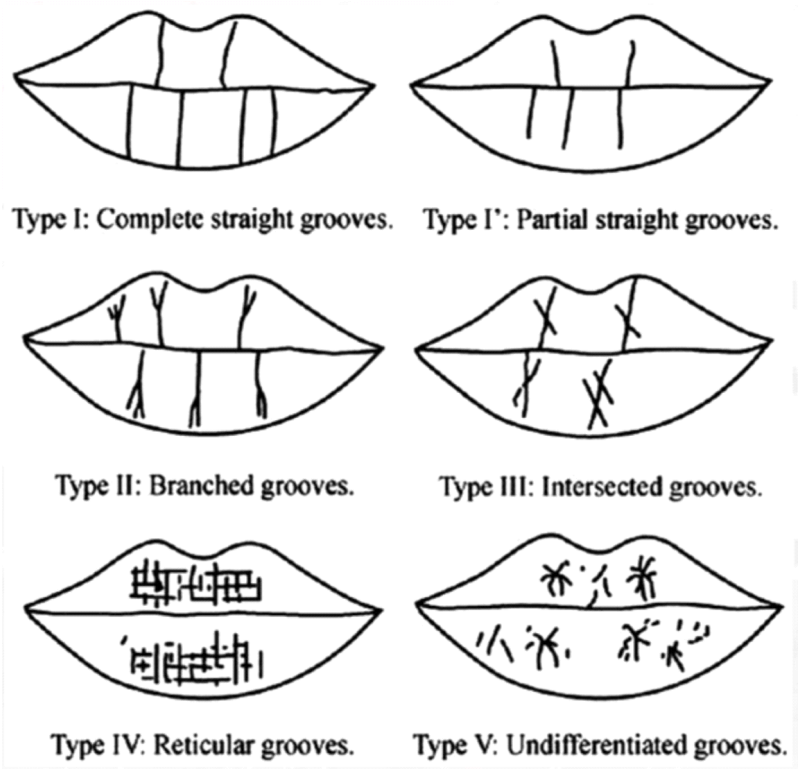

Figure 1: Lip Print Classification According to the Suzuki and Tsuchihashi System

Table 1: Distribution of study participants according to demographic details

Category	Count (n)	Percentage (%)
Total Subjects	100	100
Gender (Sex)		
Male	50	50.0
Female	50	50.0
K. Suzuki and Y. Tsuchihashi's Classification		
Type 1	44	44.0
Type 2	6	6.0
Type 3	6	6.0
Type 4	25	25.0
Type 5	19	19.0
Age Group		
<30	84	84.0
≥30	16	16.0

Lip Print Classification

Table 2 explains the potential link between age groups and the distribution of lip print classifications as categorized by the Suzuki and Tsuchihashi system. It separates the data for participants under 30 years old (Age Group <30) and those 30 years old or older (Age Group ≥30). Among the younger participants (Age Group <30), Type 1 remains the most dominant pattern, present in nearly half the group (39 participants, 46.43%). Types 2, 3 and 4 show a more balanced distribution within this age bracket, with representation ranging from 4.76% (Type 3) to 25% (Type 4). Type 5 appears to be the least frequent pattern in this younger population, observed in 17.86% (15 participants).

Interestingly, the data for the older age group (Age Group ≥30) reveals a more even spread across the lip print types. While Type 1 is still present in a third of the participants (5 out of 16, 31.25%), the proportions for other types range from a single participant (6.25%) for Type 2 to four participants (25%) for both Types 4 and 5. However, it's important to note that the sample size in this older group is considerably smaller (n = 16) compared to the younger participants (n = 84). There was no statistically significant difference in the distribution of lip print types between the two age groups ($p<0.66$).

Table 3 illustrates the association between gender and the distribution of lip print classifications using the Suzuki and Tsuchihashi system. Type 4 appears to be the most prevalent pattern, with 42.0% (21 participants) exhibiting it. Types 1, 3 and 5 seem to be relatively evenly distributed among males, ranging from 8.0% (for Types 3 and 5) to 18.0% (Type 1). Interestingly, Type 2 is the least common pattern observed in males, with only one participant (2.0%) classified under this type. In contrast, females display a dominance of Type 1 lip prints. A significant majority (70.0%, or 35 participants) fall under this category. The remaining types (Types 2-5) are considerably less frequent in females, with each type ranging from just 4.0% (for Types 2 and 4) to 8.0% (Type 3) representation (Figures 2 and 3). There was a statistically significant difference in how lip print types were distributed between genders ($p<0.05$*).

Table 2: Comparison of Age and K. Suzuki and Y. Tsuchihashi's Classification

Age Group	Type 1 n(%)	Type 2 n(%)	Type 3 n(%)	Type 4 n(%)	Type 5 n(%)	p-value (<0.05*)
30	39 (46.43%)	5 (5.95%)	4 (4.76%)	21 (25.00%)	15 (17.86%)	0.66
>30	5 (31.25%)	1 (6.25%)	2 (12.50%)	4 (25.00%)	4 (25.00%)	

Table 3: Gender and K. Suzuki and Y. Tsuchihashi's Classification

Gender	Type 1 n(%)	Type 2 n(%)	Type 3 n(%)	Type 4 n(%)	Type 5 n(%)	p-value (<0.05*)
Male	9 (18.0%)	1 (2.0%)	4 (8.0%)	21 (42.0%)	15 (30.0%)	<0.01*
Female	35 (70.0%)	5 (10.0%)	2 (4.0%)	4 (8.0%)	4 (8.0%)	

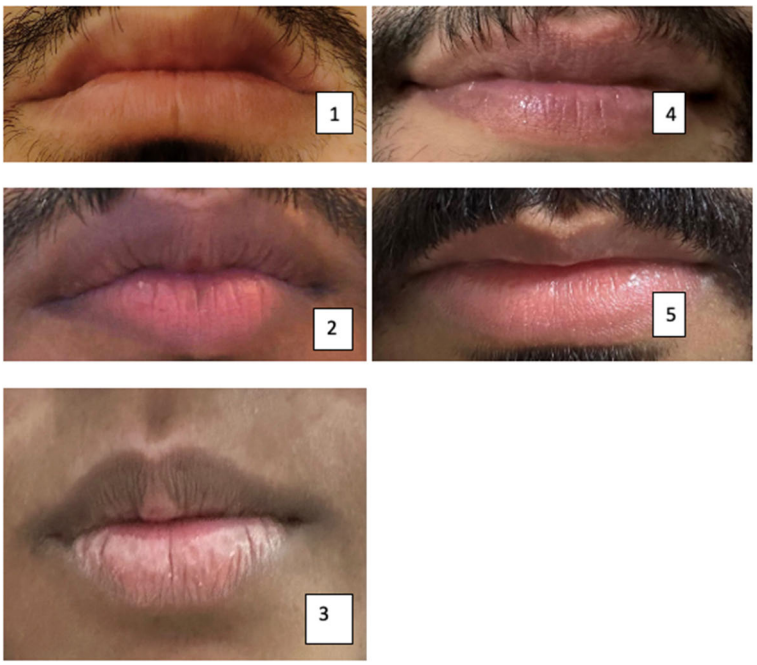

Figure 2: Images of Lips According to the Suzuki and Tsuchihashi System

Figure 3: Images of Lips Showing Type 1(A), Type II(B), Type III(C), Type IV(D)

DISCUSSION

The current study observed a dominance of Type 1 lip print patterns, which is consistent with the findings from prior studies conducted on Indian populations by Vahanwahal *et al.* [4] and George *et al.* However, divergences were noted in comparison to other research; for instance,

Sivapathasundharam *et al.*[6] reported a higher prevalence of intersected patterns in the Indo-Dravidian population, while Tsuchihashi [7] observed a similar trend in the Japanese population. This study did not find a statistically significant difference in lip print patterns based on age groups, aligning with findings from Suzuki and Tsuchihashi [8], who also did not observe significant changes with age. Conversely, Sharma *et al.* [9] suggested that lip print patterns might vary throughout an individual's life. The identification of a gender difference, with females predominantly exhibiting Type 1 patterns and males showing a higher prevalence of Type 4, is in agreement with some previous studies. Redfearn and Wood [10] reported a similar trend in a British population study. However, not all studies have found significant gender-based differences in lip print distribution; for instance, Santos *et al.* [11] found no such distinction in their Brazilian population sample.

The present study of lip print patterns revealed key insights, particularly the dominance of Type 1 prints across all age groups, suggesting a foundational trend yet underscoring the necessity for broader research. The lack of statistically significant age-related differences, likely influenced by the predominance of younger participants, highlights the need for future studies with a more diverse age range to accurately assess age's impact on lip print patterns. Notably, gender analysis presented a significant divergence, with Type 1 prints predominantly found in females and Type 4 in males, hinting at a potential gender-specific distinction in lip print characteristics. This variance echoes some previous findings while contradicting others, emphasizing the need for extensive research to explore these gender-based differences further and uncover their biological basis.

Traditional along with deep learning computer vision techniques for lip-based biometrics produce accurate results which makes them an effective method for personal recognition [12].

Although cheiloscopy, the analysis of lip prints, holds promise as a supplementary tool for forensic identification due to the unique patterns of lip grooves, its reliability and limitations in real-world settings require further investigation. This study's findings, if confirmed with larger samples, could pave the way for gender-specific lip print databases that could improve forensic analysis by enabling focused comparisons.

Despite the global interest, there remains a paucity of research in the Middle Eastern demographic. Moreover, existing literature lacks consensus regarding the dominance of specific lip print types by gender. This study attempts to compare Qassim's patterns with those observed globally while also updating methodological approaches for improved accuracy.

However, the potential influence of ethnicity, age and even medical conditions on lip prints necessitates further research. To solidify cheiloscopy's role in forensics, additional areas like collection methods, large-scale categorized databases and integration with existing techniques require exploration.

The research validates that Qassim sub-population displays gender-specific variations in lip print types which match India and Turkish scientific observations. Additional studies of biological nature must be conducted to understand the possible association between gender-specific lip print types and lip musculature structure and dermal ridges.

Further research should account for cultural along with genetic influences since these factors may shape such patterns. Manual classification methods introduce errors to identification processes therefore future studies need to use digital or AI assistance to boost classification accuracy. The research findings validate lip prints as effective personal identification evidence. Three factors need proper standardization to establish lip print evidence in forensic investigations as standardized databases should contain patterns of lip impressions, digital classification systems and legal framework for admissibility of cheiloscopic evidence

CONCLUSIONS

Type 1 emerged as the dominant lip print pattern across all participants, regardless of age group. Interestingly, gender appeared to play a significant role, with females exhibiting a strong dominance of Type 1 prints and males showing a higher prevalence of Type 4. While age didn't show a statistically significant influence in this study. These findings highlight the potential of cheiloscopy, the analysis of lip prints, as a supplementary tool in forensic identification.

Acknowledgment

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Conflicts of Interest

No conflicts of interest were declared.

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