Original Research

Analysis of total lip score system and total groove score for gender identification: A cross-sectional study

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Abstract

Background: Endless ink and pixel space have been spent to validate the use of cheiloscopy classification systems in the field of identification. It is becoming evident that lip-print patterns may provide indications about an individual's gender, race, occupation, habits, blood type, and paternity. Over the course of time, much data have been collected on a substantial population in this field. In the present study, we strive to see how well a noble total lip scoring (TLS) system works in identifying a person's gender among the College of Dentistry students. We also quantified the total groove score (TGS) and compared it with each quadrant for better authentication of the set study design.

Materials and Method: A cross-sectional descriptive study was conducted among 60 dental students (30 males and 30 females), with an age range of 18–30 years. Lip prints were recorded using the writing pad method and subsequently digitalized by capturing the images using Adobe Photoshop CS 6 Extended Version, counted and summed up, quadrant-wise, in both upper and lower lips. The TLS and TGS between males and females were statistically calculated using the Jamovi project.

Results: The mean value for TLS for males (n = 402; SD ± 92.1) is higher than that for females (n = 348; SD ± 86.1). The correlation matrix applying a non-parametric test for non-continuous data using Spearman's ratio inferred a statistically significant correlation (-0.354) with a P-value of 0.005 for TLS, whereas a correlation (-0.162) of TGS with gender was not so significant with a P-value of 0.217.

Conclusion: Our study proved the uniqueness of applying TLS as a novel approach to gender identification. The study revealed that males had a statistically higher lip score than females.

Clinical Significance/Future Implications: Being unique, our study inferred the importance of TLS, which needs to be explored in detail for applying, evaluating, and validating its accuracy in forensic research that can help for errorless investigations as full-proof evidence in court.

Keywords: Adobe photoshop, cheiloscopy, digital forensics, digital method, gender determination, total lip score system

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INTRODUCTION

Personal identification plays an eminent role in forensic crime investigations, and we are all aware of the various scientific methods of identification, one of which is the study of lip prints through cheiloscopy or quiloscopy. Being a scientific method of human identification, this biological

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phenomenon was first noted in 1902 by anthropologist R.Fischer.[1-3] It is considered one of the strongest biological tools for untapping innumerable crimes and offenses that are committed by the perpetrator, thereby serving as valuable, substantial evidence of proof in a court of law. Traced back to historiography, many evidence-based research studies have already been conducted for recording, studying, and classifying this unique entity. Eminent scientists like Suzuki and Tsuchihashi (1971), Martin Santos (1967), Renaud (1973), Caldas (2007), and Jose Maria Dominguez have classified lip prints solely based on the shape of patterns of wrinkles and grooves and individual characteristics present on the entire lip. The most accepted, amongst these, was the Suzuki and Tsuchihashi classification system, which subcategorizes lip prints as Types I, I', II, III, IV, and V.[4-6] These studies have focused on the qualitative aspects of lips, where shape was the main determining factor.

The majority of the studies conducted on lip-print analysis exhibited significant heterogeneity, with none of them adhering to the recommended EQUATOR requirements for methodological structure and data reporting. The overall quality of the research exhibited a tendency toward poor standards, with a notable absence of standardized methodologies used in the examination of lip prints. Furthermore, it is crucial to acknowledge the dearth of studies specifically dedicated to statistically assessing the overall quantity of lip prints and using a formula based on predetermined scores to establish an association with gender identification.

Given the prevailing conditions, the present study used an innovative methodology to quantify lip prints and derive the total lip score (TLS) and total groove score (TGS). The primary objective was to investigate the potential utility of TLS in facilitating gender identification. The secondary objective was to determine whether TGS can aid in gender identification. To date, no studies have been conducted or published on the application of TLS and TGS to gender identification. The present study followed the STROBE guidelines, which are recommended by the EQUATOR for the systematic organization and reporting of methods and data. The total score was determined by tallying the number of lip prints in each quadrant for both males and females. This allowed us to assess any disparities in the total score system between the two genders. The predetermined hypothesis posits that there is a higher prevalence of TLS and TGS in males as compared to females.

MATERIALS AND METHOD

A double-blinded, cross-sectional descriptive study design was conducted among a total of 60 dental students (30 males and 30 females) at the College of Dentistry. We followed the EQUATOR network and STROBE guideline checklist, "The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: Guidelines for Reporting Observational, Cross-Sectional Studies."[7,8]

The investigation was conducted within a specific time frame, spanning from November 10 to November 15, 2023. This period encompassed various activities such as participant selection, obtaining their consent, recording lip prints, and digitizing the prints for quantification.

The sample size was derived as follows:

$$\frac{Z_{1-\frac{\alpha}{2}}^{2}\, SD^{2}}{d^{2}}$$

Here, Z_1 is the standard normal variant for 05% CI = 1.96, SD is the standard deviation from the pilot study (SD = 50), and d is the precision set at 15%. Due to the preliminary nature of the study and resource limitations (including time, budget, and personnel), a higher degree of precision (15%) was implemented.[9] The sample size derived was 43. A total of 60 participants (30 males and 30 females) with stratified random sampling method were considered for the study. Five males and 5 females from each level of BDS were included in the study. The weighted kappa values for intra-examiner calibration showed agreement of 97.14% and 96.67% for TLS and TGS, respectively.

The age range of the participants was 18–30 years. The inclusion criteria were subjects who were voluntarily willing to participate in this study design. The exclusion criteria were subjects with allergic contact cheilitis, that is, persons who are allergic to lipsticks, individuals with any deformities on the lips, and male participants who were reluctant to apply the lipsticks. The study was conducted after due approval from the Research Ethics Committee, College of Dentistry, King Khalid University (Institutional Review Board) with Reference No. IRB/KKUCOD/ETH/2023-24/019. Ethical considerations were fulfilled by obtaining written informed consent from all participants who fit the study inclusion criteria. The confidentiality and anonymity of all the participants were maintained.

Recording lip prints

Basic lipstick and A4 sheet paper (B2B Copier super-unruled A4 printer paper) were used for all the study participants. The allergic reaction to the selected material was examined with verbal consent and history for any reactions to specific cosmetic materials. The study participants were given

the printed version of the standard operating procedure for maintaining aseptic precautionary measures and the method for lipstick application. This step was initiated so as to allow free-hand self-application techniques for applying the lipstick to the labial mucosa of the upper and lower lips and safe reuse of the lipstick.

All the participants were informed to clean the labial mucosa with wet wipes and follow stringent antiseptic precautionary measures so as to avoid any cross-contamination and infections during the procedure. This initial step was followed by using ultrafine applicator tips (Instru-Dent Company, cylindrical 904, microfibre tips) for lipstick application on a separate palette. The mixed material was then applied to the upper lip, followed by the lower lip, and vice versa. Once applied, the brush was discarded.

For the purpose of convenience and to avoid smudging of lip prints, we applied the writing pad method, wherein we took the lip prints on a Stenopad (Drake writing pad with plastic clipboard storage paper). The participants were instructed to make a lip-print impression over the paper placed on the Stenopad. This unique technique was applied so as to avoid smudging or overlapping of lip-print grooves, which could lead to increased error rates in counting total lip prints.

Each sample obtained was designated with a sample number. Thereafter, the lip imprints were photographed using a 16-megapixel Philips Zoom camera, and the images were subjected to Adobe Photoshop CS6 Extended Version. A double-blinding method was adopted by the author to avoid selection and performance bias. The digital analysis of the lip prints in Adobe Photoshop software was carried out, and the lip scores were tabulated.

Digital analysis

Each image was subjected to Adobe Photoshop CS6 Extended Version. Rulers were activated, and guides were placed by clicking the cursor from the midline of the lip. For better visualization, the image was edited to grayscale, and the resolution was set to 300 dots per dpi. The upper and lower lips were divided into four quadrants, as shown in Figure 1. For convenience, the Klein Zone (the anatomical zone that forms the oral sphincter in the lip area covered with wrinkles and grooves) was considered for interpretation.

In our study, the Suzuki and Tsushihashi[6] classification was taken into consideration. Each type was designated with a score number (TS).

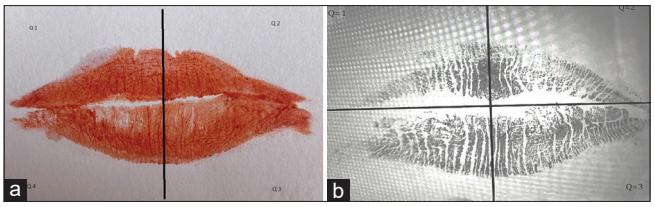

Figure 1: Depicts the lip prints recorded on the writing pad method (a) and digitised image of the lip print in Adobe Photoshop software (b)

Total Lip Score

Type I was designated with the score number of 1, Type I' was designated with the score number of 2, Type II was designated with the score number of 3, Type III was designated with the score number of 4, Type IV was designated with the score number of 5, and Type V was designated with the score number of 6. The TLS was derived by calculating the product of the type of lip grooves (Suzuki and Tsushihashi[6] classification) and a predefined score number (TS) according to the observed lip type.

Total Groove Score

The lip grooves for each quadrant (Q1, Q2, Q3, and Q4) were computed individually, and the aggregate of these values across all quadrants determined the final TGS score for each participant.

The quantification and aggregation of lip grooves is conducted in a quadrant-specific manner in both the maxillary and mandibular arches. Subsequently, a comprehensive evaluation of the whole lip score system is performed, allowing for a comparative analysis between men and women. The collected raw data were further subjected to statistical analysis.

Statistical analysis

The data were entered in MS Excel in CSV format and subjected to statistical analysis using the Jamovi project (https://www.jamovi.org). Descriptive statistics, Spearman's non-parametric data correlation matrix, independent sample *t*-test, and binomial regression analysis were performed.[10,11]

RESULTS

Descriptive statistics were carried out for TLS and TGS, and the mean value and standard deviation between males and females were analysed as shown in Tables 1 and 2. The mean value for TLS for males ($n = 402$; SD ± 92.1) is higher than that for females ($n = 348$; SD ± 86.1). The correlation matrix applying a non-parametric test for non-continuous data using Spearman's ratio was done for TLS and TGS. The x-axis at 1.00 indicated males, and the x-axis at 2.00

indicated females. The results inferred a statistically significant correlation with a *P*-value of 0.005 for TLS, whereas a correlation of -0.34 was inferred for TGS with a *P*-value of 0.217, as shown in Figure 2 and Table 3. The independent sample test, considering the male variable as a reference point and applying the Mann–Whitney U test, inferred that TLS (0.007) is highly significant compared to TGS (0.217), as shown in Table 4. The model fits the data well, as indicated by the overall model test, which has a Chi-square value of 10.7 with 2 degrees of freedom and a *P*-value of 0.005. This means that the model is significantly better than a null model that only includes the intercept. The R-squared McFadden value of 0.128 indicates that the model explains about 12.8% of the variation in the outcome variable. The model coefficients and the intercept value for each unit showed a gradual increase in predictor values in males when compared to females. [Tables 5 and 6; Figure 3] The standard errors, Z-values, and *P*-values showed the statistical significance of the coefficients. Both TLS and TGS have negative and significant effects on the outcome variable, as their *P*-values are less than 0.05. The 95% confidence intervals show the range of values that are likely to contain the true population coefficients. For instance, the 95% confidence interval for the coefficient of TLS is from -0.0180 to -0.00284, which means that we are 95% confident that the true population coefficient of TLS is between these two values.

DISCUSSION

Cheiloscopy has recently demonstrated promising results in the identification of individuals in various crime scenarios by narrowing down the potential suspect by gender, as these unique biological entities do not repeat between different individuals.[11-18] Over the course of an extended period, it has been shown that lip-print patterns provide valuable insights on the characteristics of an individual, including their gender, ethnicity, profession, behaviours, blood type, and familial relationships.[2-4] Some authors[13–19] say that scientific studies have shown that lip prints are just as good as fingerprints at identifying a person as a fingerprint. The

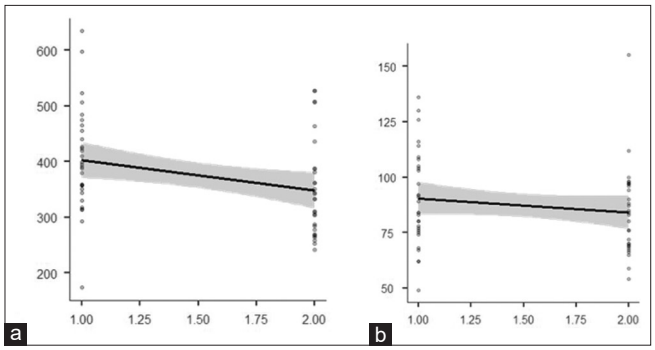

Figure 2: Scatter plot shows correlation matrix (non-parametric test for non-continuous data) using Spearman's correlation difference in score in males and females for total lip score (TLS) (a) and total groove score (TGS) (b) (x-axis = 1.00 – males; x-axis 2.00 – females; y-axis = score)

Table 1: Descriptive analysis done for TLS & TGS using Jamovi project software for depicting mean, standard deviation, and the maximum and minimum score in between males and females

	Gender	TLS	TGS				Total TGS	Age
			UR	UL	LL	LR		
N	Male	30	30	30	30	30	30	30
	Female	30	30	30	30	30	30	30
Mean	Male	402	28.5	20.3	22.1	19.4	90.4	21.7
	Female	348	22.3	19.5	20.5	21.7	84.1	22.2
Standard	Male	92.1	13.7	7.33	9.78	6.56	21.3	2.17
deviation	Female	86.1	8.29	6.61	10.6	8.17	19.6	3.06
Minimum	Male	174	11	10	9	6	49	18
	Female	241	12	11	6	12	54	18
Maximum	Male	634	56	33	43	32	136	26
	Female	527	42	32	46	43	155	30

TLS: Total lip score; TGS: Total groove score; UR: Upper right; UL: Upper left; LL: Lower left; LR: Lower right

Table 2: Descriptive analysis depicting the mean, median, standard deviation (SD), and standard error (SE)

	Group	*n*	Mean	Median	SD	SE
Total lip	Male	30	402.4	392.5	92.1	16.82
score (TLS)	Female	30	348.2	333.0	86.1	15.72
Total groove	Male	30	90.4	86.5	21.3	3.89
score (TGS)	Female	30	84.1	83.5	19.6	3.58

Table 3: Correlation matrix (non-parametric test for non-continuous data) using Spearman's correlation difference in score in males and females for TLS and TGS

Correlation matrix			
Variables	**Correlation statistic**	**Gender**	**TLS**
Gender	Spearman's rho	–	
Total lip	df	–	
score	*P*	–	
	Spearman's rho	-0.354	–
	Df	58	–
	P	0.005	–
Variable	**Correlation statisitic**		**TGS**
Total	Spearman's rho	–	
groove	df	–	
score	*P*	–	
	Spearman's rho	-0.162	–
	df	58	–
	P	0.217	–

TLS: Total lip score; TGS: Total groove score

Table 4: Independent sample *t*-test applying Mann–Whitney U Test between genders for TLS and TGS

Independent samples *t*-test					
Variable	**Test**	**Statistic**	***P***	**Mean difference**	**SE difference**
TLS	Mann–Whitney U	266	0.007	60.48	
TGS	Mann–Whitney U	366	0.217	7.00	

Note. H_a $\mu_{Male} \neq \mu_{Female}$. TLS: Total lip score; TGS: Total groove score; SE: Standard error

only case where lip prints are thought to be less accurate than fingerprints is in monozygotic twins. Therefore, the recovery of lip prints at the site of a crime has significant evidential significance. This enigmatic entity is an equivalent tool to fingerprints in identification, as criminals are well aware of fingerprints and know how to avoid fingerprint traces in a crime scenario, but the same does not hold true about lip prints. A court appellate in Illinois in 1999 and the FBI have unconditionally accepted lip-print identification as a positive means of personal identification.[12]

Lip scoring systems, however, can act as an accurate tool for a faster identification process. Based on the hypothesis that the number of lip grooves and fissures is unique to males and females, it is thus a sex-determinant factor for identification in sexual dimorphism. Few studies have proven the occurrence of particular classes or types of lip prints in males and females; however, no study has focused on quantifying the total number of lip prints by applying the TLS and TGS and comparing the accuracy between the two parameters. However, when considering the diagnostic accuracy of cheiloscopy, a systematic literature review was conducted on 72 observational studies, which revealed that one in every four studies showed low accuracy results, leading to high heterogeneity and error rates in the identification and counting of lip prints.[20] This could be due to multiple factors, such as improper recording techniques or difficulty in counting the number of lip prints due to an inaccurate method or technique of recording, which in turn leads to wrong analysis and counting, thereby resulting in high failure rates.[21] To comprehend this, we decided to apply the TLS system as a novel approach using Adobe Photoshop digital analysis for accurate counting of lip prints. One study conducted by Shivapathasundaram in 2001[22] documented that the middle part of the lower lip (10 mm wide) can be the best area to trace the lip prints, and hence we concluded to include only the Klein zone for interpretation using Adobe Photoshop. Being unique, our study can help to rule out the existing error rates in cheiloscopy studies with a new ray of hope in gender identification in forensics. A blind trial was done before commencement, and noteworthy observations were derived. The samples were individually analysed using Adobe Photoshop CS 6 Extended Version according to the proposed new classification scoring method, where the lip prints were counted exclusively in the Kleins zone area.

We applied the STROBE guidelines, and the results of our study showed a statistically significant higher TLS among males, which was in agreement with our set null hypothesis. When the TGS was quantified, we could see that the most predominant type of lip-print pattern was Type I, which was in agreement with a few studies done for qualitatively analysing the types of lip prints among genders.[20,23] Consistently, most studies[23,24] like ours have found a statistically significant association between gender

Table 5: Binomial logistic regression shows prediction model showing model fit measures

Model	Deviance	AIC	R^2_{McF}	Overall model test		
				χ^2	df	*P*
1	72.5	78.5	0.128	10.7	2	0.005

Table 6: Binomial logistic regression shows prediction model showing model fit measures for gender

Predictor	Estimate	95% confidence interval		SE	*Z*	*P*	Odds ratio
		Lower	Upper				
Intercept	6.8916	2.0577	11.72542	2.46630	2.79	0.005	983.932
TLS	-0.0104	-0.0180	-0.00284	0.00387	-2.69	0.007	0.990
TGS	-0.0343	-0.0663	-0.00220	0.01636	-2.09	0.036	0.966

Note. Estimates represent the log odds of "Gender=2" vs "Gender=1". TLS: Total lip score; TGS: Total groove score; SE: Standard error

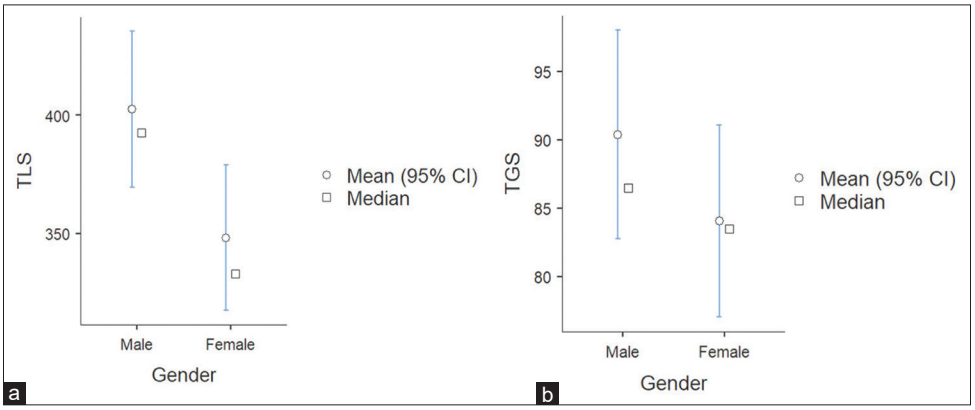

Figure 3: Binomial regression plot for total lip score (TLS) (a) and total groove score (TGS) (b)

and different types of lip patterns[21,22,25] but not in studies from the Indian states of Goa and North Karnataka.[26] The sample in this study comprehends the importance of lip prints in the determination of gender for forensic investigations as its results resonate with those done in different institutions in India, especially with the female gender, but the lip-print patterns differ among the male gender. This study, unlike other research studies, has additionally demonstrated a novel approach of applying the TLS system and analysing the correlation between TGS among males and females and has inferred a statistically significant correlation with a *P*-value of 0.005 for TLS, whereas a negative correlation with an R value of -0.34 was inferred for TGS with a *P*-value of 0.217. Since the data were non-parametric discontinuous variables, we applied a correlation matrix with a Pearson's coefficient and an independent Mann–Whitney T-test to test the independent variables for their accuracy in gender identification. We found that TLS would be a better parameter for identification than TGS. Many studies have already documented the qualitative aspect of lip-print patterns, regarding the most predominant type of lip print among gender identification. Research, such as the one conducted by Prabhu *et al.*,[27] has used weighted scores to evaluate lip lines. Nevertheless, they have not allocated these values to any particular classification system. The kind of lip prints was not allocated a numerical score. The author used a weighted value scoring approach, in which numbers were allocated to quantify the number of lip lines from the midline to the periphery, quadrant by quadrant. The given values ranged from 1 to 15. The overall cumulative lip score was calculated by summing the scores from each quadrant (Q1 + Q2 + Q3 + Q4).

However, there is a lack of research that has examined the use of a formula-based method to quantify lip prints and establish a correlation between the variation in the total number of lip prints in all four quadrants, known as the TLS, across males and females.

There was a scarcity of novel research conducted in this arena, and we could also find variations in the total number of lip prints in all four quadrants, thereby leading to a hypothesis on which quadrant shows large counts of lip prints and asymmetrical dimensions of the total count, creating a curiosity to study the lip prints more in detail. Is this difference or variation due to an inconsistent or inaccurate way of recording the lip imprints, or is there any genetic role involved in paving this path? This needs to be explored in future research studies.

The most challenging task in lip-print studies is the method of recording the lip prints, as smudging of lip prints is a very common occurrence, making it difficult to count. Therefore, we focused on applying both the writing pad method of recording the lip prints and the digital method, that is, Adobe Photoshop CS 6 version of counting the lip grooves, to solve this issue. Our study inferred that the writing pad method for recording lip prints could avoid smudging of prints, and the digital method could be easier and more accurate for counting the lip prints, thereby reducing the error rates to only 5%–10%. However, more comparative studies on a larger sample size need to be conducted to confirm this hypothesis.

Future perspectives

More studies can be conducted for analysing the effectiveness and accuracy of the digital method by applying digital tools like Adobe, GIMP Software, etc., for recording the lip prints and on geographic variation and diversity among different populations, as well as on the role of genetics in the formation of the total number of lip prints in different quadrants.

CONCLUSION

The study delves into the fascinating realm of cheiloscopy, exploring the potential of quantifying lip-print patterns as a means of gender identification. Through the innovative application of the TLS system and TGS, coupled with advanced digital analysis using Adobe Photoshop, the research sheds light on the accuracy and effectiveness of these methods. By meticulously recording and analysing lip prints, the study uncovers a statistically significant correlation between TLS and gender, offering a promising avenue for forensic investigations. Furthermore, the exploration of digital methods presents a compelling opportunity to minimize error rates and enhance the precision of gender determination through lip prints. This study not only underscores the significance of meticulous recording techniques but also paves the way for future research into geographic and genetic variations in lip-print patterns, as well as the comparative efficacy of diverse digital tools. In essence, the study shows a significant progress in quantifying lip prints as a useful technique for determining gender in forensic contexts.

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Conflicts of interest

There are no conflicts of interest.

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