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Emily Regan
Old Dominion University, e4smith@odu.edu

Brenda Bradshaw
Old Dominion University, bbradsha@odu.edu

Ann Bruhn
Old Dominion University, abruhn@odu.edu

Walter Melvin
Old Dominion University, wmelvin@odu.edu

Sinjini Sikdar
Old Dominion University, ssikdar@odu.edu

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ORIGINAL ARTICLE

Cheiloscopy patterns in individuals with and without parafunctional oral habits: A cross-sectional observation pilot study

Emily Regan[1] | Brenda Bradshaw[1] | Ann Bruhn[1] | Walter Melvin[1] | Sinjini Sikdar[2]

[1]Gene W. Hirschfeld School of Dental Hygiene, Old Dominion University, Norfolk, Virginia, USA

[2]Department of Mathematics and Statistics, Old Dominion University, Norfolk, Virginia, USA

Correspondence
Brenda Bradshaw, Gene W. Hirschfeld School of Dental Hygiene, Old Dominion University, 4608 Hampton Blvd., Health Sciences Bldg., Room 3102, Norfolk, VA 23529, USA.
Email: bbradsha@odu.edu

Abstract

Purpose: Lip prints are unique and have potential for use as a human identifier. The purpose of this study was to observe possible cheiloscopy differences of individuals with and without parafunctional oral habits such as smoking, vaping, playing a wind instrument or using an asthma inhaler.

Methods: This IRB approved blinded cross-sectional observation pilot study collected lip prints from 66 individuals, three of which were excluded. Participants cleansed their lips, then lipstick was applied to the vermillion zones of the upper and lower lips. Adhesive tape was applied to the lips and prints were transferred to white bond paper for viewing purposes. Each set of included lip prints was divided into quadrants and dichotomized into a group of those with an oral parafunctional habit or with no such habits. Each quadrant sample was then manually analysed and classed according to the gold standard Suzuki and Tsuchihashi system.

Results: A total of 252 dichotomized lip print quadrants (with habits $n=76$, 30.2%, and without habits $n=176$, 69.8%) were analysed. Type II patterns were the most common for examined quadrant samples; however, no statistically significant differences (Pearson's chi-squared test, $p=0.366$) were observed between pattern classifications of samples with and without parafunctional oral habits.

Conclusions: There is no statistically significant difference of lip print patterns between individuals with and without parafunctional oral habits. Further research on populational variations is needed for cheiloscopy to aid in human identifications.

KEYWORDS
Cheiloscopy, forensic odontology, lip prints, parafunctional oral habits, population

1 | INTRODUCTION

Cheiloscopy is an anatomical biometric characteristic which assesses the patterns of grooves and ridges on the vermillion zone of the lips.[1,2] Patterned areas of the lips are considered as unique as fingerprints and it is theorized that they can serve as evidence when attempting to determine human identifications.[1,2] Existing data on cheiloscopy variations is insufficient for it to be used as a

validated biometric tool and cannot be solely relied upon as evidence. However, there is a need for further research and data on a variety of human populations to strengthen the scientific validation of cheiloscopy.

The current 'gold standard' for cheiloscopy is manual analysis utilizing the Suzuki and Tsuchihashi Classification System[2,3] which assigns classification based on the predominant visible pattern.[4] Pattern formations are categorized as Type I (complete vertical lines), Type I′ incomplete vertical lines, Type II (branching), Type III (intersecting), Type IV (reticular), or Type V (irregular). Type V irregular classification is used when the lip print pattern does not match any of the other five categories, or is unable to be determined by the examiner.[2] Appendix 1 includes a diagrammatic drawing of each pattern type within the classification system.

Research suggests that the individuality of lip prints may be influenced by biologically inherited traits such as gender and race.[1,5-9] The literature also suggests that lip prints may be altered as the result of adaptive muscle functions including activities that involve frequent pursing of the lips.[5,10-19] Pursing the lips causes a contraction of the multilayered and complex *orbicularis oris* muscle,[17] which is primarily responsible for the shape, form, and movement of the lips.[18] Over time and with exaggerated use for parafunctional oral habits, this muscle may exacerbate the formation of deep wrinkles of the vermillion zone.[18-20] There maybe also be predictable physiological and anatomical transformations of oral soft tissues because of parafunctional oral habits such as smoking,[10-12] using an asthma inhaler,[13,21] playing a wind instrument,[14,15] and vaping.[16] Parafunctional oral habits are defined as any nonpurposeful action not associated with mastication, swallowing, or speech.[22,23] Commonly known parafunctional oral habits include but are not limited to bruxism, soft tissue biting, nail-biting and thumb sucking.

Chemicals and heat involved with smoked or vaped products change the physicality of the lips by causing inflammation or altered firmness as tissues are damaged.[12] However, studies have not found a significant difference in pattern variations between populations with and without parafunctional oral habits.[5,20] This blinded cross-sectional observation pilot study aimed to analyse observed differences of cheiloscopy patterns among lip print quadrant samples dichotomized as originating from a person with or without self-reported parafunctional oral habits.

2 | MATERIALS AND METHODS

This blinded cross-sectional observation pilot study received IRB full committee review approval and was deemed to pose minimal risk (IRB #1973106–3). Flyers were used to recruit participants located in Virginia from December 2022 to April 2023. A total of 70 individuals were pre-screened via email to determine appropriateness for inclusion. Participants met inclusion criteria if they were 18 years or older, did not have scars, piercings, cuts, burns, active herpetic lesions, or any type of raised lesion that distorts groove patterns on their lips, had not had an adverse or allergic reaction to facial cosmetics, cleansers, or adhesive tape and were available to come to research centre in person. Participants who met inclusion criteria were scheduled for individual appointments to participate.

Participants completed a six-question researcher designed survey through an online survey tool (Qualtrics) to answer demographic questions about age, gender, ethnicity, self-reported parafunctional oral habits and lip dryness or chapping to control for confounders. Additionally, participants were asked to report all current parafunctional oral habits such as smoking tobacco, marijuana, or hookah products, vaping, playing a wind instrument, and/or using an asthma inhaler. Participants were considered as having a parafunctional oral habit if they self-reported one or more from the list. Participants with oral habits, were prompted with a text box to report how often they performed the parafunctional activity. As an incentive, the final survey question prompted participants to record their email address for a chance to win one of four 50-dollar gift cards. Following survey collection, participants' lip prints were collected during a one-time encounter with participants and did not include a follow up.

2.1 | Procedure

Current research does not describe a prescribed manner for lip print collection procedures. Therefore, the researchers devised data collection procedures based on the materials and methods described by other researchers.[2,6,8,10] Participants were given a hypoallergenic cleansing wipe (The Honest Company® baby wipes) to cleanse their lips of excess oil, moisturizer, or lipstick. After 1 min of drying time, red lipstick (Almay Colour Vibes, 'Treat Yourself') was applied with single use lipstick applicators to the vermillion zone of the upper and lower lips. Participants were asked to not rub their lips together during or after the application process. One strip of 1″ width adhesive tape (Scotch Magic™; 3 M) was gently applied to the lower lip and slowly removed, transferred, and pressed to white bond paper for viewing; the process was repeated for the upper lip. A second coat of lipstick was applied, and a second set of prints was collected in the same manner so that the best of the two prints could be selected for inclusion and analysis. When the tape was transferred to the white bond paper, researchers were careful to only press around the edges of the tape, and not on the collected print sample. The researchers calibrated with each other through several practice sessions for the lip print collection process. This allowed for honing of the step-by-step procedures, verbal instructions given to participants, as well as techniques for lipstick applications, lip print transfer to tape and tape transfer to paper.

Following print collection, the same researchers who collected the prints also manually examined the lip prints to classify them according to the 'gold standard' Suzuki and Tsuchihashi cheiloscopy system. The examiners pilot tested the manual classification process by calibrating with one another on lip print samples from other studies, and on lip print samples that were collected for practice purposes, not for study purposes and not included in statistical analyses.

Included lip print samples were divided into four quadrants (upper right, lower right, upper left, and lower left) and categorized by quadrant as type I, type I′, type II, type III, type IV, or type V. The samples were then dichotomized into those with a parafunctional oral habit, and those from people with no such habits.

The manual analysis was blinded, so neither researcher was aware if the print being analysed came from a person with or without habits. The researchers reached a consensus on classification type for all examined lip print quadrants. As the researchers examined each quadrant, the predominant pattern was selected as the assigned type which follows the methodology of other cheiloscopy studies.[5,6] Statistical analyses were conducted using R statistical software with statistical significance set at $\alpha = 0.05$. A Pearson's chi-squared test was used to detect possible associations between the Suzuki & Tsuchihashi[4] classified lip print quadrants and participants' self-report as having or not having a parafunctional oral habit.

3 | RESULTS

A total of 70 individuals contacted the researchers and were screened via email. Sixty-six met inclusion criteria and participated by responding to the demographic survey and consenting to have their lip prints taken. However, survey responses and lip prints collected from three of those participants were removed from the study due to incomplete participant survey information. Therefore, a total of 63 full lip prints were included for study purposes. Participants were predominantly female ($n = 43$, 67%) and white ($n = 49$, 71%), followed by Black ($n = 8$, 12%), Asian ($n = 6$, 9%), Hispanic ($n = 3$, 4%) and mixed or other races ($n = 3$, 4%).

The sixty-three collected lip prints were divided into quadrants to yield $n = 252$ samples that were then dichotomized into those with self-reported parafunctional oral habits ($n = 76$), and those who self-reported no habits ($n = 176$). Table 1 shows the types of self-reported parafunctional oral habits and frequency of use among included participants. The researchers manually examined each quadrant sample to visually observe the grooves and ridges, then categorized a Suzuki and Tsuchihashi type for each quadrant. Table 2 shows the frequencies of assigned Suzuki and Tsuchihashi types for each lip quadrant print and how they were distributed after being dichotomized. Type II was observed most frequently for both habit ($n = 32$, 42.1%) and non-habit ($n = 86$, 48.9%) quadrant samples. Type IV was observed least frequently in the non-habit group ($n = 7$, 4.0%). Additionally, Type IV and Type V were tied as the least frequently observed for the habit quadrant samples ($n = 4$, 5.3%). A Pearson's chi-squared test was performed to evaluate association between the Suzuki & Tsuchihashi classified types and the dichotomized lip print quadrant samples (with and without habits). The p-value for the test was 0.366 indicating that there was no statistically significant difference in the frequency of classification types according to subjects with parafunctional oral habits and those without.

4 | DISCUSSION

Cheiloscopy pattern variation has been studied for human groups to observe differences according to sex, ethnicity, and blood type.[24] However, research on variations resulting from parafunctional oral habits is lacking. Results of the current research support findings of Bernardi et al, which assessed pattern differences of an Italian population with and without parafunctional oral habits,[5] and Harquad et al, which assessed an Indonesian population of smokers and non-smokers.[20] Their research found no significant difference in pattern distributions between the two groups of individuals with and without habits. However, Harquad et al reported that smokers had increased numbers and depth of wrinkles on the vermillion zone on the lip.[20] The presence of greater numbers and depth of wrinkles on the lips has been noted in other studies due to muscular and skin changes from parafunctional oral habits.[12,20]

In a study analysing cheiloscopy patterns between groups of smokers and non-smokers in an Indian population, researchers found type III grooves most common for both groups but, it was noted that in the smokers' prints, vertical cracking of the grooves was present.[25] This was attributed to the rise in temperature of the oral mucosa caused by the cigarettes. The presence of heat while smoking has been associated with exacerbated wrinkling on and around the lips.[20] Smoke blown through pursed lips upon exhalation has also been associated with further skin damage[10] and wrinkling. The presence of nicotine and other additives in smoke, causes the breakdown of natural collagen and fibrin, two important materials which help prevent the formation of fine-lines and wrinkles.[12]

TABLE 1 Self-reported parafunctional oral habits among included participants ($n = 19$).

Types of parafunctional oral habits	Participants self-reported habits ($n = 19$)[a]	Frequency of self-reported habits
Smoke tobacco	2	<1x per week & daily
Smoke marijuana	11	1x per week - daily
Smoke hookah	0	N/a
Vape	8	2x per week - daily
Use an asthma inhaler	4	1x per week - daily
Play a wind instrument	4	1x per week – 4x per week

[a]Nine participants who self-reported parafunctional oral habits indicated having more than one habit.

TABLE 2 Frequencies of observed lip print types per quadrant of dichotomized samples ($N = 252$).

		Assigned Suzuki and Tsuchihashi types					
		I	I′	II	III	IV	V
Examined Lip Quadrants	Lip print quadrant samples	$n = 38$ (15.1%)	$n = 27$ (10.7%)	$n = 118$ (46.8%)	$n = 33$ (13.1%)	$n = 11$ (4.4%)	$n = 25$ (9.9%)
Upper left quadrant	Habit $n = 19$	2	2	6	5	3	1
	Non-habit $n = 44$	5	5	15	9	3	7
Upper right quadrant	Habit $n = 19$	2	4	8	4	1	0
	Non-habit $n = 44$	6	5	17	8	0	8
Lower left quadrant	Habit $n = 19$	5	1	11	1	0	1
	Non-habit $n = 44$	6	4	25	3	2	4
Lower right quadrant	Habit $n = 19$	6	3	7	1	0	2
	Non-habit $n = 44$	6	3	29	2	2	2

Research has also found that the heated elements in e-cigarettes or vape pens can have negative effects on the oral tissues due to released byproducts that can lead to increased levels of oral irritation and inflammatory responses.[13,16] Inflammatory responses by use of these products may create swelling of the lips, and thereby expand the grooves, changing the appearance of a collected lip print. Additionally, burns or explosions, due to spontaneous combustion of the heating element in these devices, can scar the vermillion zone and cause permanent changes to the lip print appearance.[13] Similar to the changes noted in the lips of smokers, research studies conducted on wind instrument musicians found impacts on hard and soft tissues related to forces of the connection between the mouth and the mouthpiece.[14,15,26] The repetitive pursing of lips, blowing of air, and pushing of the mouthpiece has been shown to contribute to physical changes including increased thickening of the lips.[14,15] Additionally, repetitive use of these forces could cause irritation or scarring of the lips[15] and wind instrument mouthpieces are harbourers of bacteria that, if not adequately and regularly cleaned, can lead to infection or distortion of the lips.[15] However, even with these considerations, no statistically significant findings have been reported on wind instruments' affect on lip print patterns.[5] Despite suggestions in the literature of how smoking, vaping, and playing a wind instrument may affect lip print patterns,[13-16,26] this phenomenon has not been observed enough to be proven by research and findings from the current study align with this lack of evidence. Additionally, Bernardi et al studied lip print patterns on individuals which included smokers and wind instrument musicians and reported that such habits did not seem to have an effect on lip print morphology, which is aligned with the findings in the current study.[5]

There is less research on the soft tissue effects of using an asthma inhaler compared to the effects of smoking or playing a wind instrument. Blakey et al reported that oral cortical steroids cause skin changes in individuals with acute or chronic asthma, but did not specify the types of changes that occur.[21] Some patients with asthma, are taught specialized breathing techniques using a pursed lip movement to alleviate symptoms without the use of an inhaler.[27] The repetitive pursing of lips, whether on an inhaler or with breathing techniques, mimics the same muscular movements of the *orbicularis oris* seen in habits such as smoking, playing a wind instrument, or vaping. Considering the findings and suggestions of the aforementioned literature, researchers of the current study chose to include users of wind instruments and asthma inhalers as part of the sample population to add to the body of knowledge related to cheiloscopy observations.

Suggestions from the literature regarding physical changes resulting from parafunctional oral habits, seem to result as an increase in the number and depth of wrinkles on the vermillion zone of the lips due to the frequent pursing of lip muscles[18,20] and chemicals which break down fibrin of the skin.[12] Descriptors of these physical changes most closely resemble the descriptions of Types I (complete vertical lines) and I′ (partial vertical lines). However, upon analysis, type I and I′ vertical lines occurred in less than half (32.9%) of samples from participants with habits.

Despite the lack of differences between dichotomized samples, combined samples revealed that, type II was observed most frequently ($n = 118$, 46.8%) followed by type I ($n = 38$, 15.1%) and type III ($n = 33$, 13.1%) for the quadrant samples regardless of having a habit or not. Additionally, types I, II and III combined were observed in 76.3% of the habit quadrants, and in 74.4% of the non-habit quadrants. These findings were similar to previous cheiloscopy research which reported that types I, II, and III were most observed in examined samples.[4,5,25]

There were several limitations for the current study. The sample population conveniently consisted of campus members from one university in Norfolk, Virginia and the small sample size consisted of a variety of participants from various demographic backgrounds. Though not proven by research, it is possible that lip patterns are more influenced by gender and race compared to parafunctional oral habits. Since participants of the current study were not matched for gender or race this may have influenced the findings. Recruitment of participants with and without parafunctional oral habits was matched in effort; however, the researchers had difficulty finding willing participants with habits that met the inclusion criteria for the study. Additionally, lip prints were collected during the winter

months when lip chapping is more common. The researchers noticed chapping among some of the collected prints which could have affected the variability of the samples; however, no prints were unable to be analysed due to severity of chapping. Finally, even though the investigators responsible for collection and analysis of the prints did not have cheiloscopy experience, currently there is no formal training for this forensic practice. However, the protocols used for this study were designed and based on what exists in the current literature. Future research is needed regarding print collection practices and examiner training to provide additional observational studies on potential populational variations.

Research on cheiloscopy needs to be strengthened by including larger and more diverse populations with and without parafunctional oral habits. Due to the small sample size and convenience sample, results of the current pilot study should not be generalized to other populations.

5 | CONCLUSION

Results showed no statistically significant differences of cheiloscopy classification patterns between individuals with and without parafunctional oral habits. Results of this study do not support the theory that the existence or absence of parafunctional oral habits can assist human identifications by cheiloscopy methods; therefore, the benefits of cheiloscopy to aid in human identification requires further study.

6 | CLINICAL RELEVANCE

6.1 | Scientific rationale for the study

Cheiloscopy may be considered secondary evidence for human identification; however, pattern frequencies among populations are not well understood. Lip print pattern differences exist according to sex and race, but research is lacking for differences among people with parafunctional oral habits. Understanding lip print patterns among populations may assist investigators and could be part of dental records.

6.2 | Principal findings

Results do not show significant differences in lip print patterns resulting from parafunctional oral habits.

6.3 | Practical implications

If included in dental records, lip print patterns may assist investigators when narrowing down a list based on gender and race, but not based on parafunctional oral habits.

AUTHOR CONTRIBUTIONS

Emily Regan and Brenda Bradshaw devised the study design, methodology, and contributed to data collection. Sinjini Sikdar contributed to study design, methodology, results, and statistical analyses. Ann Bruhn, and Walter Melvin were consulted regarding the study design, methodology, discussion, and conclusions. All authors equally contributed edits for the manuscript.

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CONFLICT OF INTEREST STATEMENT

The authors report no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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APPENDIX 1

Suzuki & Tsuchihashi classification system: Adapted from Suzuki and Tsuchihashi.