JOURNAL OF FORENSIC SCIENCES

J Forensic Sci, September 2012, Vol. 57, No. 5
doi: 10.1111/j.1556-4029.2012.02118.x
Available online at: onlinelibrary.wiley.com

TECHNICAL NOTE

GENERAL; ODONTOLOGY

Vírginia A. Costa,[1] *D.M.D. and Inês M. Caldas,*[1,2] *Ph.D.*

Morphologic Patterns of Lip Prints in a Portuguese Population: A Preliminary Analysis

ABSTRACT: Lip prints are thought to have the ability to distinguish individuals and, hence, have a potential use in human identification purposes. However, questions remain regarding their utility for sex determination. This study aimed to classify lip prints for different individuals in a Portuguese population and to determine whether sex differences exist. Lip prints of 25 females and 25 males were obtained using dark-colored lipstick and cellophane tape. Lip prints were analyzed using a magnifying lens and classified according to the Suzuki and Tsuchihashi classification. A Type II pattern was found to be most common. A comparison of lip-print patterns between males and females showed results with a statistically significant difference: Type III pattern was most common in males, and a Type II pattern in females. This study corroborates the hypothesis that lip prints are able to distinguish individuals and may be useful in sex determination.

KEYWORDS: forensic science, forensic odontology, cheiloscopy, lip prints, human identification, sexual dimorphism

Cheiloscopy, from the Greek words *cheilos*-lips and *skopein*-see, is the name given to the study of lip prints (1–5). Lip prints are normal lines and fissures in the form of wrinkles and grooves present in the transition zone of a human lip, between the inner labial mucosa and the outer skin (5–7). The importance of cheiloscopy is linked to the fact that lip prints have the ability to distinguish individuals (4–6,8–11). In addition, lip prints are remarkably stable, and do not change during a person's life (1,12–15). It has also been verified that lip-print patterns can be recovered even after undergoing severe alterations such as trauma, inflammation, and diseases, such as herpes (1,13,14). In addition, the disposition and the form of furrows does not vary with environmental factors (1,13). Lip prints are also classifiable (16,17). There are various classifications of lip prints, including Martin Santos's classification, Renaud's classification, Afchar Bayat's classification, and Jose Maria Dominguez's classification, but among them, the Suzuki and Tsuchihashi classification (1970) is the most widely used (1,4,5,17,18).

Another important aspect of lip-print analysis is that all lip prints are important, even the ones that are not visible. In fact, the complex process is not restricted to studying visible prints but also includes the latent ones. The vermillion border has minor salivary glands, and the edges of the lips have sebaceous glands with sweat glands. Thus, one may assume that secretions of oil and moisture from these glands enable the development of latent lip prints (4,6,12,19). The identification of latent print evidence is often considered critical for solving crimes (4). In fact, even when located on "difficult" surfaces (such as porous or multicolored surfaces), latent prints can be easily be seen using fluorescent dyes (4,20–22).

[1]Faculdade de Medicina Dentária da Universidad do Porto, Rua, Dr. Manuel Pereira da Silva, 4200-393 Porto, Portugal.
[2]CENCIFOR – Center of Forensic Sciences, Portugal Associação Centro de Ciências Forenses, Largo da Sé Nova, INML IP, 3000-213 Coimbra, Portugal.

Received 23 Jan. 2011; and in revised form 10 May 2011; accepted 3 July 2011.

However, although lip prints are capable of distinguishing individuals, it has been noted that the cheiloscopic formulae of parents, children, and siblings have some similarities (1,13). It has also been suggested that a variation in the pattern among males and females may exist and could help in the context of personal identification and sex determination (1,5,8,10,12,13).

The present investigation aimed to classify lip prints in different parts of the lip for different individuals to investigate the potential role for lip prints in human identification and to contribute to the cheiloscopic literature with the specific characterization of a Portuguese sample. This study was also intended to determine if other population data can be applied to this sample. A final goal was to verify the potential for sex determination from a lip-print configuration in a Portuguese population.

Materials and Methods

The materials used were gloves, napkins, a camera, dark colored lipsticks (Nivea®; Beiersdorf AG, Hamburg, Germany), cellophane tape, scissors, white paper, makeup remover wipes, and a magnifying lens. The study sample included 50 patients from the Faculty of Dental Medicine of University of Porto, Portugal. The inclusion criteria were (i) absence of lip lesions or abnormalities on lips and (ii) a Portuguese geographical origin.

Individuals with known hypersensitivity to lipsticks were not included in the study. Also, subjects with inflammation, trauma, congenital, or other abnormalities of the lips were excluded (4,23).

Written informed consent was obtained from each of the participants, and the investigation was submitted to and approved by the Ethics Commission of the Faculty of Dental Medicine of Porto University.

Four different methods of lip-print recording were tested prior to the final method selected: (i) after lipstick application, the subject was asked to rub both lips to spread the lipstick and the lip print was collected on a white paper; (ii) the same procedure was repeated, but the lip impression was collected on a strip of cellophane tape that

was then stuck to white bond paper; (iii, iv) for the third and fourth methods, the subjects were not asked to rub their lips. The lip print was then taken directly on a white paper (iii) or with cellophane tape (iv). Ultimately, the fourth method was selected for the study because it provided a better lip-print reading.

Each individual was coded in a file and demographic data (date, name, date of birth, sex, nationality, and place of birth) were collected.

For lip-print collection, the lips were first cleaned with a napkin and a picture was taken. Next, a dark-colored lipstick was applied uniformly on the dry, immobile, and closed lips in the vermillion zone, and a second photo was taken. After approximately 2 minutes, a lip impression was taken on a strip of cellophane tape on a glued portion, which was then stuck to a second codified file. Recordings were made until all of the lipstick was used. The lips were then cleaned with makeup removing wipes.

Each lip print was scanned and divided into four areas, that is, two areas on each lip, and were assigned the digits 1–4 in a clockwise sequence starting from the right upper lip. At the time of analysis, lip prints were studied carefully with a magnifying lens, and the subject's sex was not disclosed.

The classification type used was the one proposed by Suzuki and Tsuchihashi (24) (Fig. 1): Type I — complete vertical groove, Type I' — incomplete vertical groove, Type II — branched groove, Type III — intersected groove, Type IV — reticular pattern, Type V — irregular, undetermined. The determination of the pattern depended on the numerical superiority of properties of the lines in each area. To ensure reliability, each lip print was observed and classified four times on different days.

In a second study stage, sex was determined following the recommendations from other studies results (8,12), to verify whether other population data can be applied to this Portuguese sample. For classification, both lips were analyzed and the sex of the individual was determined as:

- Type I, I' pattern dominant: female.
- Type I and II patterns are dominant: female.
- Type III pattern present: male.
- Type IV showing varied patterns: male.
- The classification "undecided" was used when the lip print couldn't fit any of the above criteria.

Statistical analysis was performed using SPSS 17.0 software (SPSS Inc., Chicago, IL). A Pearson's Chi-square (χ^2) test was used to compare qualitative data and determine statistical significance. The level of statistical significance was set at $p < 0.05$.

Results

A total of 25 males and 25 females were studied. Subjects' ages ranged from 22 to 33 years (mean age 23.64; standard deviation 1.93), and the age distribution can be observed in Table 1.

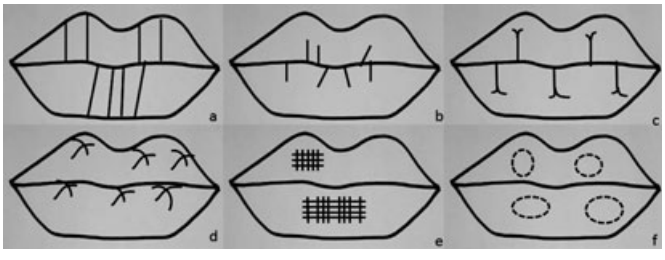

FIG. 1 —*Suzuki and Tsushihashi's classification: (a) Type I, (b) Type I', (c) Type II, (d) Type III, (e) Type IV, (f) Type V.*

It was found that a Type II pattern was most the common, and was present in 35.5% of subjects, followed by Types III, I, and IV (34.0%, 22.5% and 3%, respectively). The least common patterns were Types I' and V, each represented by 2.5% of the sample (Table 2).

The upper lip showed a predominance of a Type III pattern (48%), followed by Type II (31%), Type I (13%), Type IV (4%), Type I' (3%), and Type V (1%).

These data differed from those seen on the lower lip, where a Type II pattern was more predominant (39%), followed by Type I (32%), Type III (21%), Type V (4%), Type I' (2%), and Type IV (2%).

A Type III pattern was the most predominant in males and accounted for 52% of occurrences; a Type II pattern (44%) was the most common among females (Table 3).

The distribution of lip-print patterns in different areas of the lips and their correlation with sex can be seen in Table 4. The upper and lower lips of males revealed Type III to be the predominant pattern, accounting for 64% and 40% of all occurrences, respectively. In females, a Type II pattern was the most frequent in both the upper and lower lips (42% and 46%, respectively). These differences were statically significant ($p < 0.001$).

A correlation analysis, with Spearman's rank order correlation (rho), was used to assess the strength the linear relationship between the lip patterns for the upper and lower lips (right and left sides) and sex. We found a medium correlation value (from 0.385 to 0.484) with statistical significance ($p < 0.005$) for every relationship with the exception of the upper right lip (correlation value = 0.183, $p = 0.203$).

TABLE 1—*Age and sex distribution of the study population (n = 50).*

	Age				
	< 20 Years	20–22 Years	23–25 Years	≥ 26 Years	Total (%)
Sex					
Male	0	3	19	3	25 (50)
Female	0	3	21	1	25 (50)
Total (%)	0 (0)	6 (12)	40 (80)	4 (8)	50 (100)

TABLE 2—*Lip pattern distribution (n).*

Type	*n*
I	45
I'	5
II	71
III	68
IV	6
V	5

TABLE 3—*Lip pattern distribution according with sex (%).*

Type	Males	Females
I	12	33
I'	2	3
II	26	44
III	52	17
IV	6	0
V	2	3

TABLE 4—*Distribution of lip-print patterns in different areas of the lips of males and females (n).*

Type	Sex	URL	ULL	LLL	LRL	Total	Total UL	Total LL
Type I	Males	1	1	4	6	12	2	10
	Females	4	7	12	10	33	11	22
Type I'	Males	1	1	0	0	2	2	0
	Females	0	1	1	1	3	1	2
Type II	Males	6	4	10	6	26	10	16
	Females	12	9	11	12	44	21	23
Type III	Males	17	15	9	11	52	32	20
	Females	8	8	0	1	17	16	1
Type IV	Males	0	4	1	1	6	4	2
	Females	0	0	0	0	0	0	0
Type V	Males	0	0	1	1	2	0	2
	Females	1	0	1	1	3	1	2
Total		50	50	50	50	200	100	100

URL, upper right lip; ULL, upper left lip; UL, upper lip; LLL, lower left lip; LRL, lower right lip; LL, lower lip.

With regard to sex determination, after following established recommendations (8,12), 18 (72%) females were correctly identified based on their lip prints; however, one female was identified as male, and six could not be classified. In total, 16 (64%) males were correctly identified, eight were classified as females and one could not be classified as male or female (Table 5).

Discussion

Searching for lip prints in a crime scene investigation can be very important, as they can link a subject to a specific location if found on clothes or other objects, such as glasses, cups, or even cigarette butts (25,26). Sometimes, lip prints will be seen as lipstick smears. Lipsticks are complex substances, which have in their constitution, several compounds, oils, or waxes (25,27). The color of the lipsticks is due to organic inks and inorganic pigments (27). However, all lip prints are important, even the ones that are not visible (25,28). In fact, this complex process is not restricted to studying visible prints, but also the latent ones (25). The vermillion border of the lips has minor salivary and sebaceous glands which, together with the moisturizing done by the tongue, lead to the possibility of the existence of latent lip prints (19). Another kind of lip prints are those done with persistent lipsticks; these are also non-colored lip prints (29).

Another important aspect of lip-print analysis is DNA analysis. In fact, some studies (30,31) point out the possibility of DNA detection, even in latent lip prints. For instances, Castelló et al. (21) stated that "despite the difficulties that may arise, the possibility of obtaining DNA from latent prints makes these traces doubly useful for identification: besides the traditional analysis of labial lines, it is possible to get a print maker's genetic profile" (p. 616).

In this investigation, the classification proposed by Suzuki and Tsuchihashi was selected because this is the most widely used classification system in literature (5,6,8,10,12–14,32,33). This classification has a clear description of nearly all of the commonly encountered lip patterns and is easy to interpret. Its resemblance to the dental formula is also familiar to a forensic dentist (13). The fact that a minimum number of Type V patterns were observed in the present study demonstrates the complete inclusion of patterns in this classification.

TABLE 5—*Sex determination according with lip patterns.*

Sex/Result	Match	Mismatch	Undecided
Female	18	1	6
Male	16	8	1

With regard to methodology, after a trial of different methods for lip-print collection, the fourth described method was selected because it provided detailed readings. This procedure has also been used by other authors, such as Augustine et al. (13), Saraswathi et al. (6), Sharma et al. (8), and Utsuno et al. (33). However, when individuals spread the lipstick, we observed a higher concentration in the lip-print center, which could compromise the lip-print analysis.

As recommended by several authors (20,23), before collecting lip prints, lips were cleaned with a napkin, and the lipstick was applied uniformly because any debris or fluid on the lip surface or application of a thick layer of lipstick can alter lip-print recording. As the lip-print pattern depends on whether the mouth is opened or closed (23), lipstick was applied to closed lips. In the closed-mouth position, the lips exhibit well-defined grooves, whereas in the open position, the grooves are relatively ill-defined and difficult to interpret (23).

The lip print is produced by a substantially mobile portion of the lip. This fact alone explains the reason why the same person can produce different lip prints according to the pressure, direction, and method used when taking the print. If lipstick is used, the amount applied can also affect the print. This problem, however, was solved by recording prints until all of the substance was gone.

Pictures of lip prints were useful for confirming the pattern in cases where details of the lip print were diminished. The obtained lip prints were scanned, and the scanned images could be preserved safely with minimal loss of details. These images could be filed systematically and stored in a database for further use when necessary.

In terms of results, the present investigation confirms the ability to discriminate individuals of each lip print. These results agree with those from other investigations, such as the one performed by El Domiaty et al. (34) that stated that, in their sample, the lip patterns were unique even between twins and family members. Sharma et al. (8) also stated that no two lip prints matched each other, vouching for lip prints' ability to discriminate individuals.

Recently, some researchers have studied lip prints with the goal of proving that a gender difference does exist in a lip print. The present investigation supports this theory: a Type III pattern was more common in males, whereas a Type II pattern was more common in females. This sexual dimorphism has also been verified by other authors (2,8,12,35,36). However, the most prevalent lip print for each gender was not the same in every study, suggesting the

possibility of specific population standards for sex determination through lip prints. For instance, Sharma et al. (8) found that Type I and Type I' patterns were dominant in females, while a Type IV pattern was dominant in males; Vahanwala et al. (12) stated that Type I and Type I' patterns were dominant in females, while Type III and Type IV patterns were dominant in males; Mohamed et al. (5) concluded that a type I pattern was most common in females, whereas a Type II pattern was most prevalent in the lips of male subjects. Patel et al. (36) stated that, in males Type I was more frequent, whereas in females, Type II was dominant.

The need for population-specific data was also confirmed when sex determination was made following recommendations of the Sharma et al. (8) and Vahanwala et al. (12) studies.

Conclusions

Lip prints can be left at crime scenes and can provide a direct link to a suspect. In fact, a lip print can be the basis for identification, providing information about a person's identification.

A major limitation of cheiloscopy is that very few circumstances include antemortem data, which obviously impairs a comparative study. However, for living individuals, lip prints can be of the utmost importance, primarily due to their ability to distinguish individuals and stability.

Nevertheless, it has been recognized that cheiloscopy requires more long-term studies to be substantially documented. The problems involved in cheiloscopy are relatively unknown, and thus, lip prints have only occasionally been used. The only possible solution to this problem is to place cheiloscopy side-by-side with dactyloscopy and other means of person identification within the scope of criminalists, and to introduce it into the syllabus of training for forensic dentistry.

Research progress in this area will contribute not only to its direct use in personal identification in forensic medicine and dental medicine but will also open up a new field that can contribute extensively to criminal investigation and identification.

This study contributed to the cheiloscopic characterization of a Portuguese sample and, despite the results of the present study, does not prove that sex determination through cheiloscopy is perfect. However, it does seem to move us one step closer to confirming the validity of this technique.

Further studies with a larger sample size need to be performed to confirm specific lip patterns among males and females. A standard and uniform procedure also needs to be developed for the collection, the development and recording of lip prints, and the ensuing comparison that will occur. Lip patterns are an important form of transfer evidence. They should not be overlooked and can be a supplement to other forensic aid tools for the detection of sex and the identification of individuals, when needed, for investigative procedures.

Acknowledgments

The authors thank to Shamaz Mohamed, Jenny Ball, Michal Choras, Rick Coward, and Mukesh Asrani who kindly provided access to their papers. The authors also thank the reviewers, whose important comments were very useful to the final form of this manuscript.

References

1. More C, Patil R, Asrani M, Gondivkar S, Patel H. Cheiloscopy—a review. Indian J Forensic Med Toxicol 2009;3:17–20.
2. Molano MA, Gil JH, Jaramillo JA, Ruiz SM. Estudio queiloscópico en estudiantes de la facultad de odontología de la Universidad de Antıoquia. Rev Fac Odontol Univ Antioquia 2002;14:26–33.
3. Perper JA, Menges DJ. The skin as a repository and masker of evidence. Am J Forensic Med Pathol 1990;11:56–62.
4. Caldas IM, Magalhaes T, Afonso A. Establishing identity using cheiloscopy and palatoscopy. Forensic Sci Int 2007;165(1):1–9.
5. Mohamed S, Shenoy PG, Vijaya H. Cheiloscopy—can it be a tool for sex determination? Med Leg Update 2009;9:56–60, http://www.indianjournals.com/ijor.aspx?target=ijor:mlu&volume=9&issue=2&article=012 (accesed October 18, 2010).
6. Saraswathi TR, Mihra G, Ranganathan K. Study of lip prints. J Forensic Dent Sci 2009;1:28–31.
7. Maheswari U. Lip prints [Thesis]. Chennai (India): Tamil Nadu University, 2005.
8. Sharma P, Saxena S, Rathod V. Cheiloscopy: the study of lip prints in sex identification. J Forensic Dent Sci 2009;1:24–7.
9. Kaur R, Garg RK. Personal identification from lip prints. Forensic Sci Int 2007;169:S48.
10. Vahanwala SP, Parek BK. Study of lip prints as an aid to forensic methodology. J Forensic Med Toxicol 2002;17:12–18.
11. Sivapathasundharam B, Prakash PA, Sivakumar G. Lip prints (cheiloscopy). Indian J Dent Res 2001;12(4):234–7.
12. Vahanwala S, Nayak CD, Pagare SS. Study of lip-prints as aid for sex determination. Med Leg Update 2005;5:93–8.
13. Augustine J, Barpande SR, Tupkari JV. Cheiloscopy as an adjunct to forensic identification: a study of 600 individuals. J Forensic Odontostomatol 2008;27:44–52.
14. Murkey PN, Sutay S, Khandekar IL, Tirpude BH, Pawar VG. Cheiloscopy—everything in nature is unique. J Indian Acad Forensic Med 2008;30:194–7.
15. Coward RC. The stability of lip pattern characteristics over time. J Forensic Odontostomatol 2007;25:40–56.
16. Stamm ADB. Odontologia Forense: identificación atraves de la Queiloscopía. Fundación Médica Jurídica 2008;5–12.
17. Barros GB. Cheiloscopy: use of the technique in the forensic identification [Thesis]. São Paulo (Brazil): Faculdade de Odontologia da USP, 2006.
18. Muñoz MC. Nuevas aportaciones al procesado de Huellas Labiales: los lisocromos en Queiloscopia [Thesis]. Valencia (Spain): Facultat de Medicina i Odontologia, 2004.
19. Ball J. The current status of lip prints and their use for identification. J Forensic Odontostomatol 2002;20(2):43–6.
20. Alvarez Segui M, Miquel Feucht M, Castello Ponce A, Verdu Pascual F. Persistent lipsticks and their lip prints: new hidden evidence at the crime scene. Forensic Sci Int 2000;112(1):41–7.
21. Castelló A, Alvarez M, Verdú F. Just lip prints? No: there could be something else. FASEB J 2004;18(6):615–6.
22. Castelló A, Alvarez-Seguí M, Verdú F. Luminous lip-prints as criminal evidence. Forensic Sci Int 2005;3:185–7.
23. Kavitha BEA, Sivapathasundharam B, Saraswathi TR. Limitations in forensic odontology. J Forensic Dent Sci 2009;1:8–10.
24. Suzuki K, Tsuchihashi Y. New attempt of personal identification by means of lip print. J Indian Dent Assoc 1970;42:8–9.
25. Ponce AC, Seguí M, Muñoz MCN, Verdú Pascal FA. Revelado de huellas labiales invisibles con reactivos fluorescentes. Cuadernos Med Leg For 2003;34:43–7.
26. Ehara Y, Marumo Y. Identification of lipstick smears by fluorescence observation and purge-and-trap gas chromatography. Forensic Sci Int 1998;96(1):1–10.
27. Webb LG, Egan SE, Turbett GR. Recovery of DNA for forensic analysis from lip cosmetics. J Forensic Sci 2001;46(6):1474–9.
28. Castelló A, Alvaréz-Seguí M, Verdú F. Use of fluorescent dyes for developing latent lip prints. Color Technol 2004;120(4):184–7.
29. Seguí MA, Feucht MM, Ponce AC, Pascual F. Persistent lipsticks and their lip prints: new hidden evidence at the crime scene. Forensic Sci Int 2000;112:41–7.
30. Pretty I, Sweet D. A look at forensic dentistry—part 1: the role of teeth in the determination of human identity. Br Dent J 2001;190(7):359–66.
31. Valenzuela A, De las Heras SM, Marques T, Exposito N, Bohoyo JM. The application of dental methods of identification to human burn victims in a mass disaster. Int J Legal Med 2000;113:236–9.
32. Barros G, Silva M, Galvão LCC. Study cheiloscopy in students of the course of Odontology of the Universidade Estadual de Feira de Santana - BA. Rev Saúde Com 2006;2:3–11.

33. Utsuno H, Kanoh T, Tadokoro O, Inoue K. Preliminary study of post mortem identification using lip prints. Forensic Sci Int 2005;149(2-3):129–32.
34. El Domiaty MA, Al-gaidi SA, Elayat AA, Safwat MD, Galal SA. Morphological patterns of lip prints in Saudi Arabia at Almadinah Almonawarah province. Forensic Sci Int 2010;200(1-3):179. e1–9.
35. Gondivkar SM, Indurkar A, Degwekar S, Bhowate R. Cheiloscopy for sex determination. J Forensic Dent Sci 2009;1:56–60.
36. Patel S, IshPaul S, Madhusudan AS, Gayathri R, Sowmya GV. A study of lip prints in relation to gender, family and blood group. Int J Oral Maxillofac Pathol 2010;1(1):4–7.

Additional information and reprint requests:
Inês M. Caldas, Ph.D.
Faculdade de Medicina Dentária da Universidade do Porto
Rua Dr. Manuel Pereira da Silva
4200-393 Porto
Portugal
E-mail: icaldas@fmd.up.pt