DOI: 10.21088/ijfmp.0974.3383.18425.5

Indian Journal of Forensic Medicine and Pathology
Volume 18, Number 4, October - December 2025

ORIGINAL ARTICLE

The Morphometric Variation of Human Lips: A Cheiloscopic Study in Forensic Sex Determination

Adrita Mukherjee[1], Sreedatri Pal[2], Dibyashree Goswami[3], Arijit Dey[4], Diptendu Chatterjee[5], Biswarup Dey[6]

HOW TO CITE THIS ARTICLE:

Mukherjee A., Pal S., Goswami D., *et al.* The Morphometric Variation of Human Lips: A Cheiloscopic Study in Forensic Sex Determination. Indian J Forensic Med Pathol. 2025 Oct-Dec; 18(4): 239-246.

ABSTRACT

Background: Lip print is a common type of evidence found in a forensic context. The determination of the sex from an in-situ lip print is a critical job.

Aim and Objectives: The present study aimed to investigate the sexual dimorphism present in lip groove patterns and Cupid's bow morphology for sex determination.

Materials and Methods: The bilateral lip prints were obtained from 100 healthy youths, including 49 males (23.82±8.52) and 51 females (22.25±7.49) from North 24 Pargana District, West Bengal. All the prints were analyzed to quantify total grooves, vertical, cross, and fork-type grooves on both upper and lower lips.

Results: Males exhibited a significantly ($p<0.05$) higher count of vertical grooves on the lower lip, whereas females showed a significantly ($p<0.05$) higher count on the upper lip. However, the Cross-type grooves were significantly ($p<0.05$) dominant in both lips of the studied females. Total groove count across both lips was also significantly ($p<0.05$) higher in females. However, the fork-type grooves in the lower lip showed a significantly higher ($p<0.05$) count in males. Apart from those, Cupid's bow morphology showed distinct patterns among the males and

AUTHOR'S AFFILIATION:

[1] Postgraduate Student, Department of Forensic Science, SOBAS, Adamas University, Barasat, West Bengal, India.

[2] Postgraduate Student, Department of Forensic Science, SOBAS, Adamas University, Barasat, West Bengal, India.

[3] Former Postgraduate Student, Department of Forensic Science, SOBAS, Adamas University, Barasat, West Bengal, India.

[4] Associate Professor, Department of Forensic Medicine & Toxicology, All Indian Institute of Medical Science, Kalyani, West Bengal.

[5] Professor, Department of Anthropology, University of Calcutta, Kolkata, West Bengal, India.

[6] Assistant Professor, Department of Forensic Science, SOBAS, Adamas University, Barasat, West Bengal, India.

CORRESPONDING AUTHOR:

Biswarup Dey, Assistant Professor, Department of Forensic Science, SOBAS, Adamas University, Barasat, West Bengal, India.

E-mail: biswa.anth@gmail.com

➢ **Received:** 29-07-2025 ➢ **Accepted:** 07-10-2025

females, V-type structures significantly ($p<0.05$) predominated in the upper lips of males, while W-type structures were significantly ($p<0.05$) frequent in females. However, the lower lip showed significant ($p<0.05$) sexual dimorphism, with round structures significantly ($p<0.05$) prevalent in males and flat structures in females.

Conclusion: Therefore, lip print analysis can be used as a reliable indicator for individual and gender identification in a Forensic context.

KEYWORDS

• Lip print • Groove type • Cupid's bow structure, • Sex determination

INTRODUCTION

Human identification is an important aspect of forensic science, which relies on anatomical and biological characteristics such as fingerprints, skeletal morphology, and physiological traits (Christensen *et al*., 2013). This multidimensional process comprises both identification and exclusion, with substantial implications for legal proceedings (Christensen *et al*., 2013). Lavelle Davis was wrongfully convicted in 1997 based on unvalidated lip print evidence, with experts falsely claiming it as an accepted identification method (Exoneree, Centre on Wrongful Convictions, n.d.-a). His conviction was overturned in 2006 when independent experts and the FBI discredited lip print analysis (Exoneree, n.d.-a). Though unique and potentially stable like fingerprints (Srivastava *et al*., 2013), their forensic validity remains debated. Research by Santos, Suzuki, and Tsuchihashi confirmed individuality in lip prints, even among twins (Prabhu *et al*., 2012).

Forensic science is the application of scientific procedures to the judiciary (Saferstein, 2019), with biometric features such as lip prints (Cheiloscopy) gaining evidentiary significance, particularly from surfaces such as glasses, skin, or cigarette butts, particularly in cases involving physical proximity or violence. Their potential utility in gender determination, comparative analysis, and personal identification has generated growing interest in forensic circles (Vahanwala & Parekh, 2000). These lip prints exhibit distinct and permanent sulci labiorum patterns that remain throughout life unless altered by trauma (Sivapathasundharam *et al*., 2001). Suzuki and Tsuchihashi (1970) called these grooves "sulci labiorum rubrorum" and offered a six-type classification that is being used today (Sharma *et al*., 2017; Prabhu *et al*., 2012).

Lip grooves emerge as early as the sixth week of intrauterine life (Mohd *et al*., 2023), coinciding with the development of dermatoglyphics (Cummins & Midlo, 1961) and facial features (O'Rahilly, 1972; Noden, 1978; Couly *et al*., 1992; Hinrichsen, 1985; Yoon *et al*., 2000). Fingerprint minutiae, ridge ends, bifurcations, and islands are critical in identification (Wilder & Wentworth, 1918; Banerjee & Sarkar, 1983). Twins may have similar lip prints (Vahanwala *et al*., 2005), yet they are separate (Peterson, 2009). Lip prints may require powder procedures for visibility and have the possibility for DNA analysis, which has yet to be completely investigated (Sharma *et al*., 2009; Prabhu *et al*., 2012). Quantitative lip print investigations are limited but useful, with fork-like grooves reflecting fingerprint fork minutiae serving as valuable biometric identifiers (Prabhu, 2012).

Cupid bow is a facial feature where the double curve on the upper lip is seen as a bow, so that is called cupid bow (Houlton *et al*., 2019). The peaks of the bow coincide with the philtrum, giving a prominent bow appearance to the lip (Houlton *et al*., 2019). Lower Cupid area is a facial feature that's seen on the lower lip (Houlton *et al*., 2019). A significant portion of the anthropometric research on the mouth comes from the fields of dentistry and maxillofacial surgery, and most of the literature that looked into mouth dimensions reported sexual dimorphism, with males displaying larger mouth width, philtrum width, total lip height, and lip volumes (Houlton *et al*., 2019).

The present study aims to examine the morphometric analysis of grooves and the

cupid's bow to determine its potential in sex determination.

MATERIAL AND METHODS

Sample collection

The study was conducted among 100 Bengali-speaking adults, of whom 49 were males (23.82±8.52) and 51 were females (22.25±7.49) from North 24 Pargana District, West Bengal. A purposive random sampling was done based on the availability of the participants at the time of data collection. All the prints were taken by the lipstick and tape method (Suzuki & Tsuchihashi, 1970).

Selection of parameters

According to Suzuki and Tsuchihashi's (1970) lip print classification (*Figure* 1), the individual groove patterns, TYPE I A (clear-cut vertical grooves running across the lips), TYPE I B (similar to type I A but does not run across the lip), TYPE II (branched groove), TYPE III (intersected grooves), TYPE IV (reticular grooves), and TYPE V (undetermined) were studied. Cupid's bow structure (*Figure* 3) was examined based on the classification of Snyder (1950). The fork-type groove identification (*Figure* 2) and count were done by 3X magnification glass.

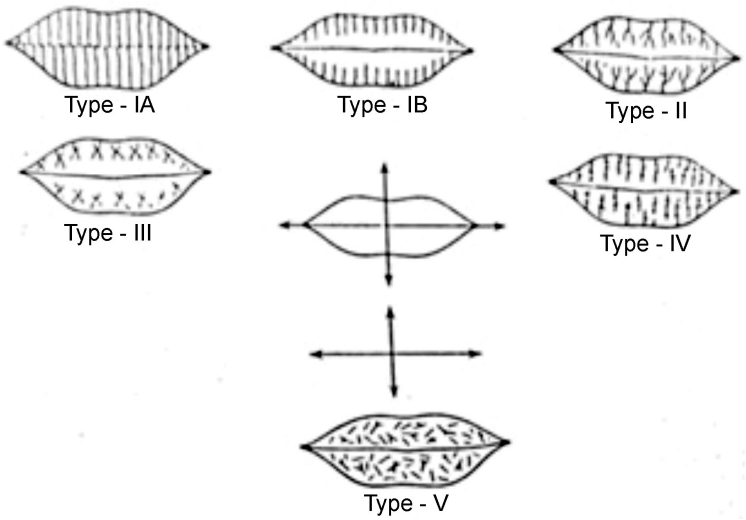

Figure 1: Different types of Groove Patterns (Suzuki & Tsuchihashi, 1970)

Data collection and interpretation

All the collected bilateral (both upper and lower lip) lip prints (*Figure* 2) were examined by using a 3X magnification glass. The groove patterns and cupid's bow structure were classified according to the standard classification (Suzuki & Tsuchihashi, 1970; Snyder, 1950). The tracing and counting of different types of grooves and the structural variation of cupid's line were computed by manual eye observation.

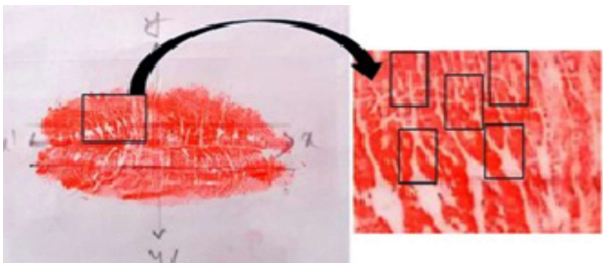

Figure 2: Locating Fork type Groves

Statistical Methods

All the data sorting and data validation are done by Microsoft Excel 2013. The collected data was interpreted by the Statistical Package for Social Sciences (SPSS) version 23. Pearson's t-test and Chi^2 test were performed to measure the sexual dimorphism of groove types and Cupid's bow structure. The cutoff was set at 95% probability limits.

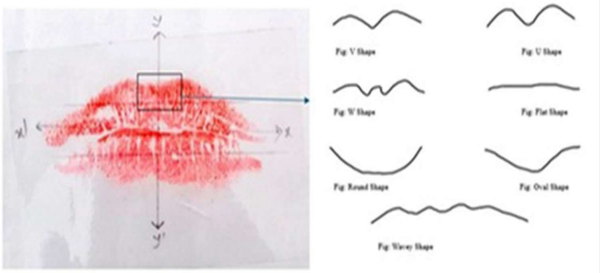

Figure 3: The structural variation of Cupid's Bow

RESULTS

Sexual Dimorphism of Grooves

Table 1 revealed the distribution of the vertical grooves found on the lower and upper lips for both males and females. The significantly ($p<0.05$) higher count of vertical grooves on the upper lips has been found among males in comparison to females. However, the females have a significantly ($p<0.05$) higher count of vertical grooves in upper lips than the males.

Table 1: Distribution of vertical grooves among the lips of the studied participants

Variables	Group	N	MEAN±SD	SE	t	df	p
Vertical grooves of the lower lip	Male	49	14.47±4.56*	0.65	4.914	98	0.000
	Female	51	10.06±4.42				
Vertical grooves of the upper lip	Male	49	5.02±3.7	0.53	-3.176	98	0.002
	Female	51	7.41±3.78*				

*p<0.05

Table 2 demonstrates the distribution of the cross-type grooves on the lower and upper lips of male and female subjects. The significantly ($p<0.05$) higher count of cross-type grooves on the upper and lower lips has been found among females in comparison to males. However, the distribution of cross-type grooves was comparatively higher in the upper lips than the lower lips in both sexes.

Table 2: Distribution of cross-type grooves among the lips of the studied participants

Variables	Group	N	MEAN±SD	SE	t	df	p
Cross-type of the lower lip	Male	49	7.22±4.68	0.67	-2.645	98	0.01
	Female	51	10.31±6.76*				
Cross-type of upper lip	Male	49	1.06±1.51	0.22	-4.881	98	0.00
	Female	51	3.71±3.45*				

*p<0.05

Table 3 revealed the distribution of total grooves in the upper and lower lips among the studied subjects. The females were documented to have a significantly higher ($p<0.05$) count of total grooves (including all types) than the males in both upper and lower lips.

Table 3: Distribution of the number of grooves among the Upper and Lower lips of the studied participants

Variables	Group	N	Mean±SD	t	df	p	SE
Upper Lip	Male	49	15.1±7.1	-2.94	98	0.00	1.13
	Female	51	18.4±3.7*				
Lower Lip	Male	49	24.3±4.3	2.20	98	0.03	0.76
	Female	51	22.6±3.2*				

*p<0.05

Table 4 demonstrates the distribution of the fork-type grooves. It was found that the upper lips never revealed any significant sexual dimorphism. However, the lower lips of the studied males have a significantly higher ($p<0.05$) presence of fork-type grooves in comparison to the females.

Table 4: Distribution of Fork type Groove among the Upper and Lower lips of the studied participants

Variable	Group	N	Mean±SD	t	df	p	SE
Upper Lip	Male	49	5.6±3.4	1.75	98	0.08	0.54
	Female	51	4.7±1.7	1.73			
Lower Lip	Male	49	10.5±2.7*	9.92	98	0.00	0.48
	Female	51	5.7±2.01	9.86			

*p<0.05

Sexual dimorphism of the Cupid's bow

Table 5 shows that the present study reveals the cupid bow structure on the upper lip among the subject population. However, among all the types, the frequency of vertical types is higher in males, and the frequency of U-shaped Cupid's line is higher among females.

Table 5: Distribution of cupid bow structure on upper lip [I (a)] among the studied participants

		Cupid Bow Structure I(a)							
Upper Lip	N	F	O	R	U	V	W	Wa	χ2 (df 6)
		(%)	(%)	(%)	(%)	(%)	(%)	(%)	
Male	49	2 (4.081)	4 (8.16)	2 (4.081)	13 (26.53)	17 (34.69)	8 (16.32)	3 (6.122)	8.818
Female	51	6 (11.76)	1 (1.96)	2 (3.92)	20 (39.1)	10 (19.60)	12 (23.52)	1 (1.96)	

Table 6 demonstrates the prevalence of different structural features of the lower lip cupid's line among both males and females. The round structure is significantly (p<0.05) prevalent among the studied males, where the flat structure is significantly (p<0.05) dominant among the studied females than the males.

Table 6: Distribution of cupid bow structure on lower lip (I b) among the studied participants

		Cupid Bow Structure I(b)							
Lower Lip	N	F	O	R	U	V	W	Wa	χ2 (df 6)
		(%)	(%)	(%)	(%)	(%)	(%)	(%)	
Male	49	9 (18.36)	7 (14.28)	20 (40.81)	3 (6.12)	6 (12.24)	2 (4.08)	2 (4.08)	14.544*
Female	51	22 (43.13)	9 (17.64)	8 (15.68)	1 (1.96)	4 (7.84)	1 (1.96)	6 (11.76)	

*p<0.05 Legend: F - Flat, O - Oval, R - Round, U - U Shaped, V - V Shaped, W - W Shaped, Wa - Waved

DISCUSSION

Lip prints, composed primarily of grooves known as sulci labiorum, are classified into various types, among which fork-type or bifurcation grooves have gained forensic significance (Vahanwala & Parekh, 2000). Studies have since recognized that bifurcation grooves are challenging to replicate and highly individualistic, making them reliable indicators for personal identification (Vahanwala & Parekh, 2000). According to Sivapathasundharam *et al.* (2001), lip print grooves, like fingerprints, remain unalterable over time and are not affected by aging, which further enhances their forensic efficacy. Quantifying these fork-type grooves involves counting bifurcation points and analyzing their morphological characteristics (Sivapathasundharam *et al.*, 2001). Studies have also suggested the potential of using lip prints for DNA extraction, although this remains largely theoretical and less involved in practice (Prabhu *et al.*, 2012). Wilson *et al.* (2012) utilized 3D facial data from 15-year-olds in the Avon Longitudinal Study to classify lip vermilion morphology. They found philtrum shape, width, and Cupid's bow to be the most reliable traits. Bindal *et al.* (2015)

studied 300 North Indians and observed sex-based lip morphology variations, with type II patterns most prevalent. Shang *et al*. (2024) highlighted the vermilion's layered structure and ageing-related changes, such as hydration increase and vascular decline. Campon *et al*. (2019) emphasized cosmetic and procedural aspects of lip cut repair, suggesting nerve blocks and proper irrigation. Taher *et al*. (2007) described vermilion reconstruction using Z-plasty post-Mohs surgery for basal cell carcinoma. Mommaerts *et al*. (2018) discussed cleft lip repair and secondary corrections using mucosal grafts. Ahmadi *et al*. (2012) examined the inferior labial artery's role in vermilion flap design for cleft repair using cadaveric studies. Houlton *et al*. (2019) assessed mouth width in sub-Saharan populations using CT scans and found no significant racial difference, suggesting environmental influence. In another study, Houlton *et al*. (2022) applied morphometric analysis on South African CBCT scans and reported that ageing reduced lip height, increased mouth width, and loosened oral features, with black individuals having thicker lips exceeding dental margins.

Moreover, recent studies on mouth morphology by Houlton *et al*. (2019, 2022) explored the effects of sex and population differences among South Africans, contributing to forensic facial approximation. Lip print analysis continues to rely seriously on the six-fold classification system introduced by Suzuki and Tsuchihashi (1970), which remains the global standard in Cheiloscopic evaluations. Apart from individual identification, fork-type grooves also show sexual dimorphism, aiding gender determination. Research demonstrated that females often display more presence bifurcations than males, offering an auxiliary method for sex estimation in forensic contexts (Vahanwala & Parekh, 2000; Busey *et al*., 2021). This is particularly valuable when traditional biometric evidence, such as DNA or fingerprints, is compromised. Lip prints recovered from items like cups, cigarettes, or tissue paper can link suspects to crime scenes and have proven helpful in cases involving mass disasters or advanced decomposition where other forms of identification fail (Pretty & Sweet, 2001). The present study also confirmed that the Vertical grooves count is significantly higher ($p<0.05$) in females' upper lips and males' lower lip (Table 1). The cross-type grooves are observed significantly ($p<0.05$) higher among the females in both upper and lower lips (Table 2). However, the distribution of the total groove count revealed a significant ($p<0.05$) sexual dimorphism as the females have a significantly ($p<0.05$) higher count of grooves in both upper and lower lips than the studied males (Table 3). The significantly higher ($p<0.05$) observation of fork-type grooves in the lower lips of the studied males in comparison to the females resulted in a marked sexual dimorphism (Table 4). However, the cupid's bow of the upper lip of males shows a predominance of V-type structure in males and W-type structure in females. However, in the lower lip, the males have a significantly ($p<0.05$) higher prevalence of round structure in males and flat structure in females, resulting in a marked sexual dimorphism.

CONCLUSION

Based on the findings of the present study, it can be suggested that the vertical, cross, fork-type and total groove count have a defined sexual dimorphism. Based on the prevalence of the types of groove count and the localization, a sex prediction can be made through the lip impressions. Further, the structure of the upper and lower lip cupid area can also be used as an inclusive parameter for sex determination.

Financial support and sponsorship: Nil

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Ahmadi A.J., Mowlavi A., Gupta S.C. The anatomy of the inferior labial artery: Implications for vermilion flap design in cleft lip repair. Ann Plast Surg. 2012; 68(3): 248–51. doi:10.1097/SAP.0b013e3182333d93.
2. Banerjee A.R., Sarkar S. A study of finger ridge minutiae in a group of Bengali population. J Indian Anthropol Soc. 1983; 18: 263–7.
3. Bindal P., Shukla S., Sharma P. A study of lip print types among North Indian population for sex identification. J Indian Acad Forensic Med. 2015; 37(2): 165–8.
4. Busey T.A., Mooney J.A., Kinoshita Y. Forensic identification using lip prints: Advances in technology and methodology. Forensic Sci Int. 2021; 317: 110590. doi:10.1016/j.forsciint.2020.110590.

5. Campon M.Z., Doucet J.C., Yoon R.S. Evaluation and management of traumatic lip lacerations: Emphasis on cosmetic outcome. J Oral Maxillofac Surg. 2019; 77(4): 722. e1–722. e6. doi:10.1016/j.joms.2018.11.004.

6. Christensen A.M., Passalacqua N.V., Bartelink E.J. Forensic anthropology: Current methods and practice. Waltham (MA): Academic Press; 2013.

7. Couly G., Coltey P., Eichmann A., Douarin M.N. The angiogenic potentials of the cephalic mesoderm and the origin of brain and head blood vessels. Mech Dev. 1992; 53(1): 97–112. doi:10.1016/0925-4773(92)90013-V.

8. Cummins H., Midlo C. Finger prints, palms and soles: An introduction to dermatoglyphics. New York: Dover Publications; 1961.

9. Center on Wrongful Convictions: Northwestern Pritzker School of Law. Lavelle Davis [Internet]. Chicago: Northwestern Pritzker School of Law; [cited 2025 Sep 9]. Available from: https://www.law.northwestern.edu/legalclinic/wrongfulconvictions/exonerations/il/lavelle-davis.html.

10. Hinrichsen K. The early development of morphology and patterns of the face in the human embryo. Adv Anat Embryol Cell Biol. 1985; 98: 1–79. doi:10.1007/978-3-642-69606-1.

11. Houlton T.M.R., Jooste N., Steyn M. Mouth width and Cupid's bow estimation in a Southern African population. J Forensic Sci. 2020; 65(2): 372–9. doi:10.1111/1556-4029.14207.

12. Houlton T.M.R., Jooste N., Steyn M., Hemingway J. Visualising trends in dentition to lip mouth morphology using geometric morphometrics. PLoS One. 2022; 17(9): e0274127. doi:10.1371/journal.pone.0274127.

13. Mommaerts M.Y., Nagy K., Gooris P.J.J. Cleft lip repair and secondary correction using mucosal grafts: A 20-year experience. J Craniomaxillofac Surg. 2018; 46(8): 1318–23. doi:10.1016/j.jcms.2018.05.014.

14. Noden D.M. The control of avian cephalic neural crest cytodifferentiation: Skeletal and connective tissues. Dev Biol. 1978; 67(2): 296–312. doi:10.1016/0012-1606(78)90179-0.

15. O'Rahilly R. Guide to the staging of human embryos. Anat Anz. 1972; 130(5): 556–9. doi:10.1016/S0003-2778(72)80029-9.

16. Peterson J.L. Forensic identification science and the criminal justice system: The need for better data. UCLA Law Rev. 2008; 55(4): 913–68.

17. Prabhu R.V., Dinkar A.D., Prabhu V.D., Rao PK. Cheiloscopy: Revisited. J Forensic Dent Sci. 2012; 4(1): 47. doi:10.4103/0975-1475.99167.

18. Pretty I.A., 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. doi:10.1038/sj.bdj.4800972.

19. Saferstein R. Criminalistics: An introduction to forensic science. 12th ed. Boston: Pearson; 2019.

20. Shang X., Zhao Y., Zhang Y., Xu T. Structural and morphological changes in human lip vermilion with aging: Implications for forensic and clinical applications. J Forensic Leg Med. 2024; 96: 102015. doi:10.1016/j.jflm.2024.102015.

21. Sharma E., Sharma B., Gupta V., Vij H., Tyagi N., Singh S. Cheiloscopy: A tool for antemortem identification. Indian J Dent Sci. 2017; 9(3): 176. doi:10.4103/ijds.ijds_60_17.

22. Sharma P., Saxena S., Rathod V. Cheiloscopy: The study of lip prints in sex identification. J Forensic Dent Sci. 2009; 1(1): 24–7. doi:10.4103/0974-2948.50885.

23. Sivapathasundharam B., Prakash P.A., Sivakumar G. Lipprints (cheiloscopy). Indian J Dent Res. 2001; 12(4): 129–32. doi:10.4103/0970-9290.33479.

24. Snyder L.M. Homicide investigation: Practical information for coroners, police officers, and other investigators. Springfield (IL): Charles C. Thomas Publisher; 1950.

25. Srivastava S., Iqbal H., Agarwal N., Sinha A, Prasad R., Agarwal S. Lip prints - an aid in individual identification: A study to assess the uniqueness of lip prints. Indian J Forensic Odontol [Internet]. 2013 [cited 2025 Sep 9]; 6(3–4). Available from: https://www.rfppl.co.in/subscription/upload_pdf/FO3_2965.pdf.

26. Suzuki K., Tsuchihashi Y. A new attempt of personal identification by means of lip print. J Indian Dent Assoc. 1970; 42: 8–9.

27. Suzuki K., Tsuchihashi Y. A study of lip prints. J Forensic Sci. 1970; 15(2): 197–204. doi:10.1520/JFS11571J.

28. Taher A.A., Smith D.M., Becker D.B. Management of facial lacerations. Clin Plast Surg. 2007; 34(1): 43–53. doi:10.1016/j.cps.2006.11.003.

29. Vahanwala S.P., Parekh D.K. Study of lip prints as an aid to sex determination. Med Leg Update. 2000; 5(1): 3–5.

30. Wilder H.H., Wentworth B. Personal identification: Methods for the identification of individuals, living or dead. Boston: The R.G. Badger Company; 1918.

31. Wilson J., Tobin M.J., Gill D.S., Tomkinson A., Mercuri L.G. Three-dimensional imaging of the lip vermilion in adolescents: A study of the Avon Longitudinal Study of Parents and Children (ALSPAC) cohort. Orthod Craniofac Res. 2012; 15(3): 169–78. doi:10.1111/j.1601-6343.2012.01544.x.

32. Yoon M., Park D., Park C. Development of the facial features in human embryos. Korean J Phys Anthropol. 2000; 13(3): 197–204.