Journal of Dentistry Indonesia

Volume 26
Number 1 *April*

Article 4

4-30-2019

Association between Direction Patterns of Palatal Rugae and Thumbprints: Implications for Forensic Identification

Desyani Setiadi
Biomedical Sciences Master Program, Faculty of Medicine, Universitas Padjadjaran, Bandung-Indonesia, desyani13001@mail.unpad.ac.id

Yoni Fuadah Syukriani
Department of Forensic Medicine, Faculty of Medicine, Universitas Padjadjaran, Bandung-Indonesia

Sudradjat Supian
Department of Mathematics, Faculty of Mathematics and Natural Sciences, Universitas Padjadjaran, Bandung-Indonesia

Fahmi Oscandar
Department of Forensic Odontology, Faculty of Dentistry, Universitas Padjadjaran, Bandung-Indonesia

Yuti Malinda
Department of Microbiology, Faculty of Dentistry, Universitas Padjadjaran, Bandung-Indonesia

See next page for additional authors

Recommended Citation

Setiadi, D., Syukriani, Y. F., Supian, S., Oscandar, F., Malinda, Y., & Nugraha, A. Association between Direction Patterns of Palatal Rugae and Thumbprints: Implications for Forensic Identification. J Dent Indones. 2019;26(1): 19-25

Association between Direction Patterns of Palatal Rugae and Thumbprints: Implications for Forensic Identification

Authors

Desyani Setiadi, Yoni Fuadah Syukriani, Sudradjat Supian, Fahmi Oscandar, Yuti Malinda, and Alhana Nugraha

Journal of Dentistry Indonesia 2019, Vol. 26, No. 1, 19-25
doi: 10.14693/jdi.v26i1.1297

ORIGINAL ARTICLE

Association between Direction Patterns of Palatal Rugae and Thumbprints: Implications for Forensic Identification

Desyani Setiadi[1], Yoni Fuadah Syukriani[2], Sudradjat Supian[3], Fahmi Oscandar[4], Yuti Malinda[5], Alhana Nugraha[6]

[1]Biomedical Sciences Master Program, Faculty of Medicine, Universitas Padjadjaran, Bandung-Indonesia
[2]Department of Forensic Medicine, Faculty of Medicine, Universitas Padjadjaran, Bandung-Indonesia
[3]Department of Mathematics, Faculty of Mathematics and Natural Sciences, Universitas Padjadjaran, Bandung-Indonesia
[4]Department of Forensic Odontology, Faculty of Dentistry, Universitas Padjadjaran, Bandung-Indonesia
[5]Department of Microbiology, Faculty of Dentistry, Universitas Padjadjaran, Bandung-Indonesia
[6]Faculty of Dentistry, Universitas Padjadjaran, Bandung-Indonesia
Correspondence e-mail to: desyani13001@mail.unpad.ac.id

ABSTRACT

Palatal rugae have been proven to be useful as a means of individual identification. As there are no antemortem data about palatal rugae, they have to be connected with other indicators, such as fingerprints with available antemortem data. **Objectives**: To assess the association of the direction patterns of palatal rugae prints and thumbprints in the Deutero-Malay sub-race to improve forensic identification. **Methods**: Palatal rugae intraoral photos and thumbprints scans were from 193 Deutero-Malay individuals aged between 18–25 years (170 female, 23 male). ImageJ and Adobe software was used to identify direction patterns of the palatal rugae and thumbprints. **Results**: An antero-posterior direction was the most common direction pattern among right (64.17%) and left (49.26%) palatal rugae and right (58.12%) and left (56.02%) thumbprints. An association with small effect size was found between first right palatal rugae and right thumbprint (p-value = 0.024; Cramer's V = 0.181) and with medium effect size between second left palatal rugae and left thumbprint (p-value = 0.000; Cramer's V = 0.332). **Conclusion**: There is a significant association between the direction patterns of palatal rugae and thumbprints. This finding may lead to the development of a new effective technique in forensic odontology identification.

Key words: Fingerprint, forensic odontology, image processing, palatal rugae

How to cite this article: Desyani Setiadi, Yoni F. Syukriani Sudradjat Supian, Fahmi Oscandar, Yuti Malinda, Alhana Nugraha. Association between direction patterns of palatal rugae and thumbprints: implications for forensic identification. J Dent Indones. 2019;26(1):19-25

INTRODUCTION

Palatal rugae are a series of irregular and asymmetrical ridges located on the anterior third of the palatal mucosa. They extend laterally from the incisive papilla and the anterior part of the palatal raphe.[1,2] Palatal rugae have been proven to be useful in forensic dentistry as an individual identification tool.[3,4] Differences in shape, size, and direction of palatal rugae can be used as special characteristics that can distinguish one individual from another.[1,2,5–7] These characteristics also have a significant differentiation between identical twins.[8.] Palatal rugae can be used as a parameter in forensic identification as they are difficult to falsify, resistant to trauma by protection of surrounding anatomical structures, resistant to decomposition for up to seven days after death, resistant to high-temperature combustion, and distinguishable in different races.[5,7,9–13] One of the disadvantages of using palatal rugae as an individual identification tool is the lack of availability of antemortem data [3,14]. Therefore, for identification purposes, palatal rugae needs to be connected with other individual identification tools such as fingerprints that have easily accessible antemortem data with a high level of authentication.[15]

Palatal rugae develop from a pattern on the epidermal layer that forms after the fusion of the prosessus palatinus in the twelfth to fourteenth weeks of

intrauterine development. Fingerprint patterns develops from the epidermal layer that forms at the volar tip in the tenth to sixteenth weeks of intrauterine development.[9,16] The direction of the pattern growth in the palatal rugae starts from the median palate to the lateral palate; whereas, fingerprint pattern growth starts from the tip and the middle part of the volar pads to the edge of the volar pads.[9,16,19] The formation of those patterns is regulated by a series of gene interactions.[17,18] Previous research showed similarities in the genes involved in the formation of palatal rugae and fingerprint patterns, including the Shh, Wnt, and BMP4 genes.[17,36,37] The interaction of these three genes with several other genes formed a distinctive pattern in fingerprints and palatal rugae through a series of cell proliferation and apoptosis processes.[17,18]Although palatal rugae and fingerprints have similarities in the process of pattern formation, no studies have been able to find a relationship between the two patterns.

As one of the main tools for forensic identification, fingerprints also have several disadvantages. Fingerprint data can be easily damaged if exposed to high temperatures and severe trauma, and they also can easily be lost during the decomposition process.[20] Therefore, it would be valuable for fingerprints to be associated with palatal rugae patterns. Wichnieski et al. [21] studied the association between palatal rugae and thumbprints and classified palatal rugae direction patterns according to Carrea's classification[22]. Meanwhile, thumbprints were classified according to shape pattern, based on Vucetich's classification[16]. Wichnieski et al.[21] did not show a statistically significant association. Unfortunately, there were no other studies with the same method found in the current medical literature to support or compare to these findings. Improvement and adjustment of classification methods are needed to be able to find a relationship between palatal rugae and thumbprints.

The aim of this study was to find an association between palatal rugae and thumbprints using the same method, by classifying patterns according to the direction. Palatal rugae were classified according to Carrea's classification, and thumbprints were classified by adapting the Carrea's classification.

METHODS

The initial sample consisted of 200 students of the Faculty of Dentistry, Universitas Padjadjaran, Bandung-Indonesia. Participants were of the Deutero-Malay sub-race, and all were aged between 18 and 25 years. Individuals with a history of injury or surgery in the anterior third of the palate and individuals with injury on the thumb that could cause difficulty in reading fingerprints were excluded from the study. The final sample consisted of 193 individuals, 170 females and 23 males. The final number of participants was sufficient according to the minimum sample size calculation (α = 0.05% and 1-β = 90%). All examined participants received previous information about the study and signed an informed consent. The study was approved by the Health Research Ethics Committee, Faculty of Medicine, Universitas Padjadjaran, Bandung-Indonesia.

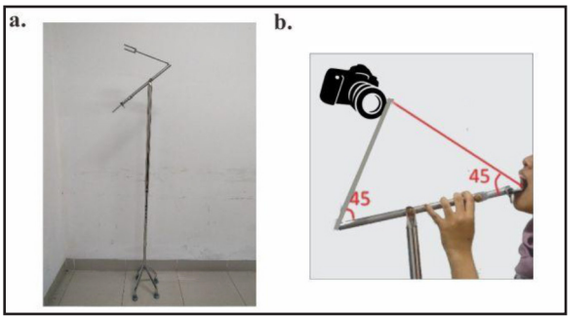

Figure 1. a. Custom-made equipment with an installed intraoral mirror **b.** Optimal angles for upper occlusal photos (45º).

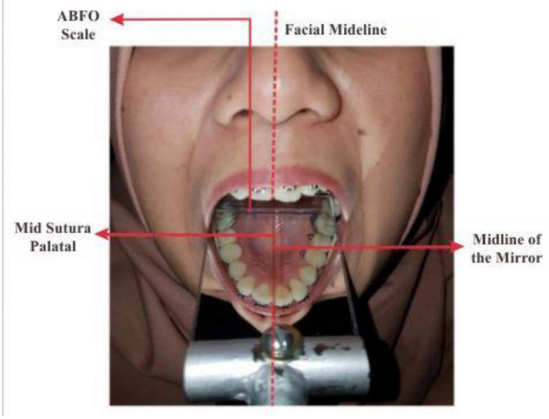

Figure 2. Facial midline and mid sutura palatal of the participant must be parallel to the midline of the intraoral mirror while photographing intraoral palatal rugae.

Intraoral photos of palatal rugae of all participants were taken using a digital single lens reflex camera, and thumbprints scans were taken using a fingerprint scanner. Custom-made equipment with an installed intraoral mirror was used to standardize the shooting angle of all intraoral photos (Figure 1.a). This equipment allowed intraoral palatal rugae images with optimal angles for upper occlusal photos (45º) in all participants (Figure 1.b). The American Board of Forensic Odontology scale was affixed to intraoral mirror for calibration to determine actual palatal rugae size from the photo. In the process of photographing palatal rugae prints, facial midline and mid sutura palatal of the participant must be parallel to the midline of the intraoral mirror (Figure 2). The results of all intraoral photos were rotated 180 degrees so that the right side of the photo could simulate the right side of the observer and vice versa.

Figure 3. Results of palatal rugae selection with Adobe® Photoshop® CS8 software

Figure 5. Result of palatal rugae intraoral images with clear boundaries

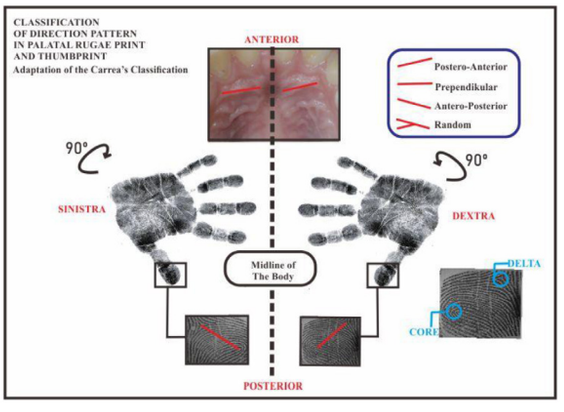

Figure 4. Adaptation of Carrea's classification used for thumbprints (red lines show the direction pattern of palatal rugae and thumbprints, blue circles show the position of core and delta in thumbprint)

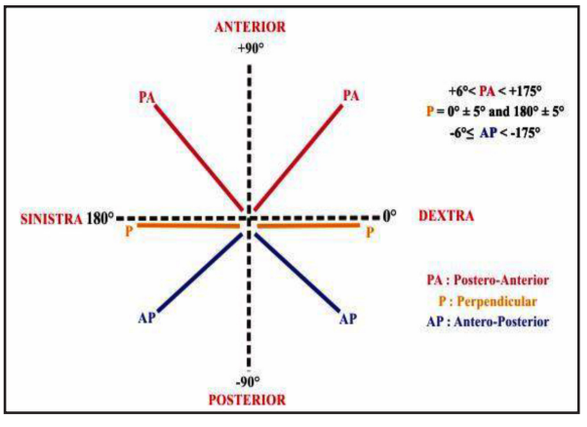

Figure 6. Angle boundary to determine the direction pattern classification

The fingerprint scanner used in this research was Fingerplus® type FM 200, which could scan fingerprint patterns and produce an image in JPEG format using Zsoft™ Attendance software. Intraoral photos were processed with Adobe® Photoshop® CS8 image processing software to identify rugae boundaries and open source ImageJ version 1.52a software to analyze the direction of rugae. The Adobe® Photoshop® CS8 software used a magnetic lasso feature to manually identify palatine rugae borders (Figure 3). Intraoral photo size calibration was done by using the set scale feature in the ImageJ software to avoid photo distortion caused by using two different image processing software programs.

The classification method used in this study was Carrea's classification according to direction patterns. In 1955, Carrea developed a classification system to divide palatal rugae into four groups: antero-posterior (AP), postero-anterior (PA), perpendicular (P), and random directions (R).[22] Currently, there are no classification methods that classify fingerprints according to their direction. Therefore, this study classified thumbprints using an adaptation of Carrea's classification. First, the thumbprints were rotated 90 degrees to the midline of the body. Then, the direction group was determined by drawing a line from the center of the finger (core) to the edge of the finger (delta). (Figure 4).

ImageJ version 1.52a open source image processing software was used to identify the direction of palatal rugae and thumbprint patterns.[23] This software was used to process intraoral palatal rugae images to obtain the final result, which was an image of palatal rugae with a distinct border. First, the image of palatal rugae was converted into an 8-bit image and applied in approximately 85% – 90% threshold to remove artifacts in the image except for the palatal rugae. After that process, the filling color was removed so the border of the palatal rugae could be clearly seen (Figure 5). The thumbprint image direction pattern could be directly determined after being rotated 90 degrees to the midline of the body.

Table 1. Frequency distributions of the direction pattern of the palatal rugae print and thumbprint

Direction	Palatal Rugae Direction Patterns				Thumbprint Direction Patterns			
	Right (n=1214)		Left (n=1212)		Right (n=191)		Left (n=191)	
	N	%	N	%	N	%	N	%
AP	779	64.17	597	49.26	111	58.12	107	56.02
P	185	15.24	325	26.82	6	3.15	2	1.05
PA	10	0.82	4	0.32	32	16.75	37	19.37
R	240	19,77	286	23.6	42	21.98	45	23.56

Table 2. Analysis of the relationship between palatal rugae pattern and thumbprint direction pattern

	Palatal Rugae-Thumbprint	df	X^2	p-value
Right Side	first palatal rugae - thumbprint	9	19.18	0.024*
	second palatal rugae - thumbprint	9	8.7	0.466
	third palatal rugae - thumbprint	9	4.86	0.846
	fourth palatal rugae - thumbprint	9	9.9	0.359
	fifth palatal rugae - thumbprint	9	4.78	0.853
	sixth palatal rugae - thumbprint	6	8.13	0.229
	seventh palatal rugae - thumbprint	6	7.84	0.250
Left Side	first palatal rugae - thumbprint	9	4.68	0.861
	second palatal rugae - thumbprint	6	36.72	0.000*
	third palatal rugae - thumbprint	9	7.18	0.618
	fourth palatal rugae - thumbprint	9	3.05	0.963
	fifth palatal rugae - thumbprint	6	3.9	0.690
	sixth palatal rugae - thumbprint	6	8.83	0.183
	seventh palatal rugae - thumbprint	4	9.38	0.052

*significant ($p < 0.05$); df: degree of freedom; $X^{2:}$ chi-square association

Using the ImageJ program, the direction patterns were analyzed based on the angular size formed by the intersection of the line of the direction of the palatal rugae print pattern and thumbprints with a line perpendicular to the median line. In this study, each palatal rugae (from the first until the last that appeared on the right and left side of the palate) and each thumb (right thumb and left thumb) were analyzed. The direction pattern was expressed as PA if the angle was + 6 ° to + 175 °, the direction pattern was expressed as perpendicular if the angle was 0 ° ± 5 ° or 180 ° ± 5 °, and the direction pattern was expressed as AP if angle was −6 ° to −175 °, while the direction pattern was considered random if more than one angle was formed (Figure 6).

The statistical tests used in this study were Cohen's Kappa test to determine the level of intra- and inter-examiner agreements and Chi-square contingency table test for association analysis[24,25] of the direction patterns of the palatal rugae print and thumbprint. The level of significance was defined as p-value < 0.05. The effect size calculation used in this study was Cramer's V test. All statistical analyses were done using SPSS 25.0 software (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp.).

RESULTS

A total of 2426 palatal rugae patterns were observed from 193 participants (1214 on the right side and 1212 on the left side), and 382 thumbprint patterns were identified from 193 individuals. The intra-examiner and inter-examiner reliability for the two researchers was calculated by Cohen's Kappa test. Kappa statistics revealed very good intra-examiner ($\kappa = 0.95$) and inter-examiner agreement ($\kappa = 0.94$) in measuring the number of rugae and direction pattern of the palatal rugae and thumbprints.

AP direction was the most common direction pattern among right palatal rugae (64.17%) and left palatal rugae (49.26%); and in thumbprints on the right hand (58.12%) and the left hand (56.02%). (Table 1)

Chi-square contingency table test (p-value of < 0.05 with a 95% confidence interval) was used for association analysis of the palatal rugae print direction

Table 3. Effect size analysis of the significant association between palatal rugae and thumbprint direction patterns

Palatal Rugae-Thumbprint	df	X^2	p-value	Cramer's V	Value of Effect Size
First right palatal rugae - right thumbprint	9	19.18	0.024*	0.181	Small
second left palatal rugae - left thumbprint	6	36.72	0.000*	0.332	Medium

*significant ($p < 0.05$); df: degree of freedom; $X^{2.}$ chi-square association

patterns from first until seventh on the right side and left side with thumbprint direction patterns for the right and left hands. Results are shown in Table 2.

As shown in Table 2, there was a significant association between the first right palatal rugae and the right thumbprint (p-value = 0.024) and between the second left palatal rugae and the left thumbprint (p-value = 0.000). To show the magnitude of the effect from the significant association found in this study, Cramer's V test was used to calculate effect size (Table 3). According to Cohen (1988), the effect size of Cramer's V test was classified as large effect (Cramer's V result ≥ 0.5), medium effect (Cramer's V result ≥ 0.3), and small effect (Cramer's V result ≥ 0.1).[26,27] Therefore, as shown in Table 3, the effect size of the association between the first right palatal rugae and the right thumbprint showed a medium effect size (Cramer's V = 0.332) and between the second left palatal rugae and the left thumbprint showed a small effect size (Cramer's V = 0.181).

DISCUSSION

This study used digital image processing techniques with the aim of reducing human error and the subjectivity factor of researchers.[28] The method for the direction pattern used as a reference was Carrea's classification. The use of Carrea's classification was for the purpose of producing more homogeneous results. This study was also conducted on one sub-racial species, the Deutero-Malay sub-race as the majority sub-race in Indonesia, to obtain more homogeneous results due to the unique characteristic of palatal rugae in different sub-races.[2,9,29–31] Analysis according to gender and certain age groups was not done in this study, because several recent studies showed that palatal rugae did not have significant differences for gender[32–34] and age group.[4,35]

Palatal rugae have been proven to be more than capable as an ideal identification method compared with other methods (e.g., fingerprints and DNA), due to their resistance to trauma, exposure to high temperature, and the decomposition process. Also, no special and expensive equipment is needed to identify palatal rugae.[4,5,10,12] A limitation of palatal rugae as an identification method is the lack of antemortem data and absence of a standardized identification method;[1,4] therefore, data acquired from palatal rugae need to be connected with data from fingerprints that is available from antemortem data, is easily accessible, and already has a standardized identification method.[15,16]

This study focused on finding the association between palatal rugae and thumbprints using direction pattern classification with individuals from Deutero-Malay sub-races. Most of the direction patterns in the Deutero-Malay sub-race found in this study were AP (right palatal rugae 64.17%, left palatal rugae 49.26%, right thumbprints 58.12%, and left thumbprints 56.02%). The results of this study indicate a significant association between the palatal rugae prints and thumbprints in terms of the direction pattern. An association with small effect size was found between first right palatal rugae and the right thumbprint (p-value = 0.024; Cramer's V = 0.181) and with medium effect size between second left palatal rugae and the left thumbprint (p-value = 0.000; Cramer's V = 0.332). There were no other studies with the same method found in the current medical literature to support or compare these findings. Several studies have been conducted focusing on finding the relationship between fingerprints and lip prints or fingerprints and the type of malocclusion.[38–40]

In 2012, Wichnieski, et al. conducted a study to find the association between thumbprints and palatal rugae based on Carrea's classification for palatal rugae and Vucetich's classification[16] for thumbprints.[2]
[1] Wichnieski and colleagues did not perform analysis according to gender and age groups as in this study, but they used a maxillary cast model to identify palatal rugae and thumbprints by making an impression on paper using black pigment ink.[21] They found no significant association between thumbprints and palatal rugae prints.[21] The different results in the Wichnieski, et al. study compared with our study may be due to differences in data processing techniques and classification methods. Until now, no other study has examined the association between palatal rugae and fingerprints.

The significant association found in this study is limited to the Deutero-Malay sub-race and has not been analyzed in other sub-races. Association testing in this

study was linear between the right palatal rugae and right thumb and between the left palatal rugae and left thumb, so further research is needed to determine the relationship between these two variables using cross-linking analysis (right side with left side and vice versa).

Now that an association between palatal rugae pattern and fingerprint direction pattern has been found, it is expected that additional studies will examine other aspects of the association between palatal rugae and fingerprints. Aspects such as shape and size, the association between palatal rugae and fingerprints other than thumb, and data from other sub-races with further genetic and mathematical studies can contribute to new breakthroughs in forensic identification.

CONCLUSION

There is an association with small effect size between first right palatal rugae and right thumbprint (p-value = 0.024; Cramer's V = 0.181) and with medium effect size between second left palatal rugae and left thumbprint (p-value = 0.000; Cramer's V =0.332) in individuals of the Deutero-Malay sub-race. This association can be used to develop a new alternative method to identify individuals in forensic science.

CONFLICT OF INTEREST

The authors declare no conflict of interest on the publication of the research.

REFERENCES

1. Kesri R, Das G, Tote J, Thakur P. Rugoscopy-science of palatal rugae: A review. Int J Dent Med Res. 2014; 1(4): 103-7.
2. Kommalapati RK, Katuri D, Kumar K, Prakash L, Kantheti C, Babu R, et al. Systematic analysis of palatal rugae pattern for use in human identification between two different populations. Iran J Public Heal. 2017; 46(5): 602-7.
3. Sabarigirinathan C, Vinayagavel K, Meenakshi A. Palatal rugae in forensic odontology-A review. J Dent Med Sci. 2015; 14(10): 83-7.
4. R K, Gupta N, Bansal A, Sinha A. Palatal rugae pattern as an aid for personal identification: A forensic study. J Indian Acad Oral Med Radiol. 2011; 23(September): 173-8.
5. Bing L, Wu X-P, Feng Y, Wang Y-J, Liu H-C. Palatal rugae for the construction of forensic identification. Int J Morphol. 2014; 32(January 2012): 546-50.
6. Panda S, Sahoo A, Mohanty N, Sahoo SR, Subramaniam R. Tooth morphometry and the pattern of palatal rugae among monozygotic and dizygotic twins in India. J Orofac Sci. 2018; 99-105.
7. Siddique S, Panchmal GS. Palatal rugae - A tool in forensic odontology. J Medico-Legal Updat. 2011; 11(2): 55-6.
8. Taneva E, Evans C, Viana G. Case report 3D evaluation of palatal rugae in identical twins. 2017; 2017(Figure 3): 1-7.
9. Kesri R, Das G, Tote J. Rugoscopy- science of palatal rugae: A review. Int J Dent Med Res. 2014; 1(4): 103-7.
10. Muthusubramanian M, Limson KS, Julian R. Analysis of rugae in burn victims and cadavers to simulate rugae identification in cases of incineration and decomposition. J Forensic Odontostomatol. 2005; 23(1): 26-9.
11. Suresh Babu G, Sreenivasa Bharath T, Govindraj Kumar N. Characteristics of palatal rugae patterns in west Godavari population of India. J Clin Diagnostic Res. 2013; 7(10): 2356-9.
12. Batinjan G, Vodanovic M. Is the palatal rugae pattern as unique as a fingerprint? Asian Acad Res J Multidisclipinary. 2016; 3(February): 2.
13. Tammam RA. Palatal rugae biometric characteristics for use in human identification in an upper Egyptian population sample. Ann Forensic Res Ana. 2017; 4: 1-6.
14. Chugh A, Narwal A. Oral mark in the application of an individual identification: From ashes to truth. J Forensic Dent Sci. 2017; 9(2): 51-5.
15. Bose PK, Kabir MJ. Fingerprint : A unique and reliable method for identification. J Enam Med Coll. 2017; 7(1): 29-34.
16. Holder EH, Robinson LO, Laub JH. The fingerprint sourcebook. 1st ed. McRoberts A, editor. National Institute of Justice. National Institute of Justice; 2012. 422 p.
17. Lee JM, Miyazawa S, Shin JO, Kwon HJ, Kang DW, Choi BJ, et al. Shh signaling is essential for rugae morphogenesis in mice. Histochem Cell Biol. 2011; 136(6): 663-75.
18. Jiang TX, Widelitz RB, Shen WM, Will P, Wu DY, Lin CM, et al. Integument pattern formation involves genetic and epigenetic controls: Feather arrays simulated by digital hormone models. Int J Dev Biol. 2004; 48(2-3): 117-35.
19. Hermosilla Venegas V, San Pedro Valenzuela J, Cantín López M, Claudio Suazo Galdames I. Palatal rugae: Systematic analysis of its shape and dimensions for use in human identification. Int J Morphol. 2009; 27(3): 819-25.
20. Waghmare PB, Bg C, Sd N. Forensic biomechanics establishing identity and cause of death in mutilated and un identifiable corpses: A challenging task for medico legal expert. 2015; 6(1): 1-5.
21. Wichnieski C, Franco A, Ignácio S, Batista P. Comparative analysis between dactyloscopy and rugoscopy. J Morphol Sci. 2012; 29(3): 174-7.
22. Carrea J. Gaumenfalten-Fotostenogramme ein

neues identfizierungsverfahren (Fotostenograms of palate folds, a new identification technic). Dtsch Zahnarztl Z. 1955; 10: 11-7.
23. Schneider CA, Rasband WS, Eliceiri KW, Instrumentation C. NIH Image to ImageJ: 25 years of Image Analysis. 2012; 9(7): 671-5.
24. Mchugh ML. Lessons in biostatistics The Chi-square test of independence. Biochem Medica. 2013; 23(2): 143-9.
25. Rana R, Singhal R. Chi-square test and its application in hypothesis testing. J Pract Cardiovasc Sci. 2015; 1(1): 2015-7.
26. Cohen J. Statistical power and analysis for the behavioral sciences. 2nd ed. New York: Lawrence Erlbaum Associates; 1988. 79-80 p.
27. Lwoga ET, Questier F. Open access behaviours and perceptions of health sciences faculty and roles of information professionals. Heal Infomation Libr J. 2015; 32: 37-49.
28. Christine K, Fernandes CMS, Serra C. Evaluation of a digital methodology for human identification using palatal rugoscopy. Braz J Oral Sci. 2011; 10(3): 199-203.
29. Eboh DE. Palatal rugae patterns of Urhobos in Abraka, South-Southern Nigeria. Int J Morphol. 2012; 30(2): 709-13.
30. Bhullar A, Preet Kaur R, Sharad Kamat M. Palatal rugea - An aid in clinical dentistry. J Forensic Res. 2011; 02(03): 2-5.
31. Ahmed AA, Hamid A. Morphological study of palatal rugae in a Sudanese population. 2015; 2015.
32. Sheikhi M, Zandi M, Ghazizadeh M. Assessment of palatal rugae pattern for sex and ethnicity identification in an iranian population. 2018.
33. Abdellatif AM, Awad SM, Hammad SM. Comparative study of palatal rugae shape in two samples of Egyptian and Saudi children. Pediatr Dent J [Internet]. 2011; 21(2): 123-8. Available from: http: //dx.doi.org/10.1016/S0917-2394(11)70238-5
34. Kotrashetti VS, Hollikatti K, Mallapur MD, Hallikeremath SR, Kale AD. Determination of palatal rugae patterns among two ethnic populations of India by logistic regression analysis. J Forensic Leg Med [Internet]. 2011; 18(8): 360-5. Available from: http: //dx.doi.org/10.1016/j.jflm.2011.07.007
35. Suhartono AW, Syafitri K, Puspita AD, Soedarsono N, Gultom FP, Widodo PT, et al. Palatal rugae patterning in a modern Indonesian population. Int J Legal Med. 2016; 130(3): 881-887.
36. Welsh IC, O'Brien TP. Signaling integration in the rugae growth zone directs sequential SHH signaling center formation during the rostral outgrowth of the palate. Dev Biol [Internet]. 2009; 336(1): 53-67. Available from: http: //dx.doi.org/10.1016/j.ydbio.2009.09.028
37. Sagai T, Amano T, Maeno A, Kiyonari H, Seo H. SHH signaling directed by two oral epithelium-specific enhancers controls tooth and oral development. Sci Rep [Internet]. 2017; (September): 1-11. Available from: http: //dx.doi.org/10.1038/s41598-017-12532-y
38. Negi A, Negi A. The connecting link ! Lip prints and fingerprints. J Forensic Dent Sci. 2016; 8: 177-8.
39. Murugan M, Karikalan T. A study of relative correlation between the pattern of finger prints and lip prints. J Evol Med Dent Sci. 2014; 3(56): 12768-72.
40. Achalli S, Patla M, Nayak K, Ashoka B, Bhat M. Assessment of dermatoglyphic patterns in malocclusion. J Dent Indones. 2018; 25(2): 104-7.

(Received February 14, 2019; Accepted April 22, 2019)