Original Article

Palatal Rugae As an Alternative Method in Forensic Identification

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Background: Common forensic identification methods are dental evidence, fingerprint, and DNA. Although DNA is the most accurate method of them all, it remains unpopular due to its high cost and inaccessibility in natural disasters causing many casualties. Consequently, an alternative method is needed. Palatal rugae is a unique, stable, and resistant morphological landmark that has the potential to be an alternative method of forensic identification.

Objective: To examine the similarity of palatal rugae in the Minangkabau ethnic family relationship.

Materials and Methods: Cross-sectional study of 27 families consisting of father, mother, son, and daughter. The sample was taken randomly. Palatal rugae was extracted from alginate printing and yielded a study model for analysis. Fingerprints were printed onto white papers after they were all dyed blue. IBM SPSS 17 was used for statistical analysis with multiple regression tests.

Results: The results showed similarity of palatal rugae based on family relationship. Circular rugae of the son had similarities with that of the father ($p<0.05$), while that of the daughter was derived from the mother. Wavy rugae was derived from both parents ($p<0.05$). The right index fingers of both the son and the daughter were similar with that of their mother, whereas their left middle fingers were derived from their father ($p<0.05$).

Conclusion: The similarities of palatal rugae and fingerprints are influenced by genetic factors. Palatal rugae and fingerprints are useful identification methods in forensic science.

Keywords: Palatal rugae, Minangkabau family lineage, Fingerprints, Forensic identification

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The Republic of Indonesia, an archipelagic located at the confluence of three giant tectonic plates (Eurasia, India Australia, and the Pacific), is a Southeast Asia country with some territories in Oceania. Situated between the Indian and Pacific oceans, it is the world's largest island country, with more than thirteen thousand islands[(1)]. This geographical position causes Indonesia to be one of the countries prone to natural disasters, such as tsunamis, earthquakes, volcanoes, floods, and landslides, which cause many casualties. The deadly earthquake that struck Aceh, a town situated in Northern Sumatra in 2004, has caused many more earthquakes to the south of Sunda Strait[(2)]. West Sumatra, a province located in the western part of the island of Sumatra, has become the focus of the international community due to frequent natural disasters and the seismic gaps that potentially causes earthquakes of magnitude 8.8 to 8.9[(2)]. The most dominant ethnic group in West Sumatra is Minangkabau, the only ethnic group with matrilineal lineage in Indonesia[(3)]. In West Sumatra, at least seven districts and cities are declared disaster-prone areas with 921,349 people living in the red zone[(1)]. The identification of disaster victims is a very challenging process in forensic science. Currently,

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the commonly used methods are fingerprints, dental, and DNA identification. No two individuals have the same fingerprints. Fingerprint patterns are very useful in forensic identification for they are individual. The identification of teeth is very useful in natural disasters that cause many casualties. It a method that has 75% of accuracy[4]. Palatal rugae is the unique and potential anatomy of the oral cavity of each individual, a dental method that can be used if the dentition cannot establish an identification[5]. DNA is the most accurate yet very expensive method especially during major natural disasters. However, the unique pattern and structure of palatal rugae and fingerprints can be questioned as to whether they can determine the resemblance between relatives in one family. The aim of the present study was to examine the similarity of rugae palatina in Minangkabau family members.

Materials and Methods

The present study was a cross-sectional study conducted between October 2017 and February 2018 on Minangkabau families at Luhak Nan tigo. Guguak, Sitta, and Tanjung Sub-districts represent Luhak 50 Kota, Tanjung Baru Sub-district representing Luhak Tanah Datar, and Baso Sub-district, Banuhampu and Tanjung Raya representing Luhak Agam. Twenty-seven families consisting of four family members namely father, mother, son, and daughter whose patterns of palatal rugae and fingerprints were observed. Ethical clearance has been conducted before the research with the 2015 080/KEP/FK ethical test number in September 2017. Upper jaws were first printed with irreversible hydrocolloid (alginate) (GC Aroma) then cast in dental stone type 3 mold. The maxillary mold was analyzed by two observers i.e. different dentists in single blind for more accurate measurements. The result of the measurement was tested by the Technical Error of Test Measurement (TEM) as much as 20 times the sample examination between the observers. The shape of palatal rugae was classified according to the Thomas Kotze classification method (Figure 1), the size of the palatal rugae was grouped by Sunita Kapali method.

Criteria

Fingerprints of all the fingers on both hands were taken. The subject pressed one finger that had been stained with blue ink on a white paper. Fingerprints were grouped into eight patterns according to Henry's classification (1800), namely 1) whorl, 2) right loop, 3) left loop, 4) tented arch, 5) central pocket, 6) twin loop, 7) plain arch, and 8) accidental (Figure 2).

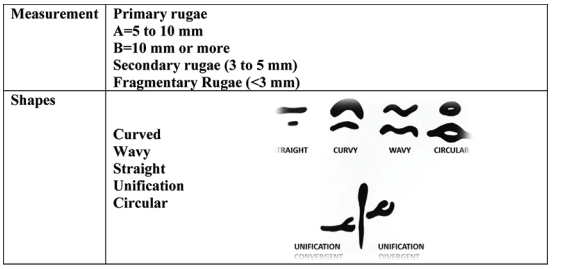

Figure 1. Shape of palatal rugae according to Thomas Kotze[5].

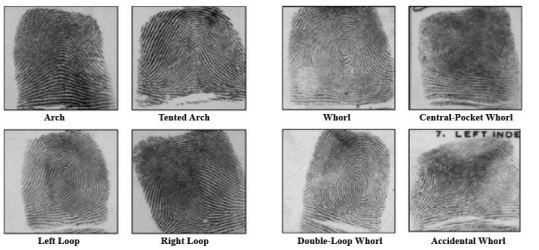

Figure 2. Fingerprint patterns according to Henry's classification[8].

Data was collected, decoded and analyzed statistically by using IBM SPSS Statistic 20 Software. Data was tested with multiple regression. The pair observation of fam-I (I-family) as (x_{1i}, x_{2i}, $y_{B,i}$, $y_{G,i}$) yielded two variable predictors namely x_{1i} indicating the father's characteristic variable and x_{2i} showing the mother's characteristic variable. While response $y_{B,i}$ indicates the characteristic variable of either the son (B: boy) or the daughter (G: girl). Thus, for each observed characteristic variable, it was obtained two multiple regression models defined as:

$$y_{B,i} = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \varepsilon_{B,i}$$

$$y_{G,i} = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \varepsilon_{G,i}$$

with normal identical independent distribution, (i.i.d) such as: $\varepsilon_{B,i} \sim N(0,\sigma_B^2)$ dan $\varepsilon_{G,i} \sim N(0,\sigma_G^2)$, β_0, β_1, and β_2, which are the regression coefficients.

There are 15 characteristic variables that are modeled and classified into three parts:

1. Rugae shape consisted of five characteristic variables, which are curved, straight, wavy, unification, and circular;

2. Right fingers consisted of five characteristic variables of the thumb, index finger, middle finger, ring finger, and the little finger; and

3. Left fingers made of five characteristic variables of the thumb, index finger, middle finger, ring finger, and the little finger.

Results

Of the 27 families observed, 21 had with complete data for each characteristic variable, and of the 21 families, 13 had complete data of their fathers, mothers, and sons, and 11 families with complete data of fathers, mother, and daughter. The most dominant shape and size of palatal rugae in Minangkabau ethnic group is the circular pattern and the primary rugae (Table 1). The most dominant fingerprints are described in Table 2.

The shape and size of the rugae did not show a significant resemblance between the children- father and mother. However, the present study showed specific patterns that could be inherited. Circular rugae of the son tended to be inherited from the father ($p=0.011$), while in the daughter, it was inherited from both the father and mother. Wavy rugae on the other hand, was handed down by the mother ($p<0.05$). Right index fingerprint shared a resemblance with the mother, while left ring fingerprint was more similar to that of the father ($p<0.05$). These are described in Table 3 and 4.

Table 1. The average distribution of the shape and size of the palatal rugae

Palatal rugae	n	Mean±SD
Shape		
Curved	108	1.83±1.979
Straight	108	2.06±2.344
Wavy	108	2.82±2.351
Unification	108	0.81±0.929
Circular	108	0.24±0.578
Size		
Primary	108	6.13±3.568
Secondary	108	1.12±1.477
Fragmentary	108	0.30±0.687

SD=standard deviation

Discussion

Understanding of palatal rugae

Palatal rugae and fingerprints have morphological patterns that can be used in forensic identification. Palatal rugae is an asymmetrically extended anatomical bulge of the papillary insivum and the anterior part of the palatal media raphe[6]. They are supported laterally by a submucosal cushion of adipose tissue, thus forming a fatty antero-lateral region. The lining epithelium is of stratified squamous type with an underlying dense collagenous connective tissue[7]. Palatal rugae was first used in identification by Harrison Allen in 1889. Rugoscopy is the study of palatal rugae first discovered by Spanish researcher, named Trobo Hermosa[6]. Data collection on palatal rugae as a medical records document were performed in the South America due to its ability to accurately identify individuals and exceeds that of fingerprints especially in particular cases where fingerprints cannot be collected[8,9]. Palatal rugae is as stable and unique as any other oral topographies such as fingerprints. The quality and quantity of palatal rugae do not change with age[10]. Palatal rugae lies in a position

Table 2. Fingerprints proportion

Fingerprints	Whorl (%)	Right loop (%)	Left loop (%)	Tented arch (%)	Central pocket (%)	Twin loop (%)	Plain arch (%)
Right hand's fingerprints							
Thumb	20.5	48.9	2.3	1.1	1.1	22.7	3.4
Index finger	21.8	40.2	0.0	9.2	6.9	18.4	3.4
Middle finger	14.6	64.0	0.0	5.6	3.4	11.2	1.1
Ring finger	40.4	36.0	0.0	2.2	10.1	11.2	0.0
Little finger	29.1	57.0	0.0	2.3	5.8	5.8	0.0
Left hand's fingerprints							
Thumb	17.4		55.8	3.5	1.2	16.3	5.8
Index finger	24.4	1.2	37.2	11.6	4.7	18.6	2.3
Middle finger	19.8	2.3	57.0	3.5	1.2	12.8	3.5
Ring finger	36.9		34.5	3.6	9.5	15.5	
Little finger	19.8		67.9	2.5	8.6	1.2	

Table 3. A p-value for four types of hypotheses, related to the suitability of the regression model and the significance of the shape and size parameters of the palatal rugae

	p-value							
	Shapes rugae					Size of rugae		
	Curved	Straight	Wavy	Unification	Circular	Primary	Secondary	Fragmented
Son (n=13)								
B_0	0.148	0.038*	0.083	0.177	0.635	0.007*	0.144	0.168
B_1	0.749	0.699	0.119	0.684	0.005*	0.434	0.385	0.647
B_2	0.370	0.356	0.466	0.903	0.326	0.197	0.194	0.538
Model y	0.612	0.577	0.270	0.916	0.011*	0.216	0.176	0.761
Daughter (n=10)								
B_0	0.257	0.108	0.027*	0.142	0.316	0.004*	0.095	0.465
B_1	0.516	0.303	0.093	0.456	0.018*	0.289	0.480	0.797
B_2	0.855	0.167	0.032*	0.720	0.015*	0.827	0.299	0.094
Model y	0.791	0.151	0.085	0.601	0.043*	0.547	0.342	0.202

If the selected level of significance is ≥5%, then p-value is the small value implying that the null hypothesis (H0) is rejected, *p-value indicates the goodness of fit of the regression model at the characteristic variable indicated

Table 4. A p-value for four types of hypotheses, related to the suitability of the regression model and the significance of the parameters of the right hand and left hand fingerprint patterns

	p-value									
	Right fingers					Left fingers				
	Thumb	Index finger	Middle finger	Ring finger	Little finger	Thumb	Index finger	Middle finger	Ring finger	Little finger
Son (n=13)										
B_0	0.324	0.033*	0.118	0.014*	0.423	0.117	0.437	0.082	0.435	0.094
B_1	0.627	0.348	0.169	0.894	0.938	0.877	0.628	0.927	0.953	0.945
B_2	0.279	0.671	0.620	0.604	0.128	0.667	0.452	0.815	0.107	0.692
Model y	0.502	0.525	0.339	0.777	0.245	0.827	0.691	0.970	0.236	0.921
Daughter (n=10)										
B_0	0.568	0.060	0.026*	0.319	0.007*	0.059	0.422	0.018*	0.007*	0.001*
B_1	0.359	0.110	0.181	0.889	0.078	0.355	0.809	0.186	0.018*	0.167
B_2	0.306	0.030*	0.942	0.573	0.157	0.888	0.732	0.511	0.510	0.291
Model y	0.482	0.021*	0.382	0.672	0.141	0.620	0.873	0.357	0.049*	0.148

If the selected level of significance is ≥5%, then the p-value is small values implying that the null hypothesis (H0) is rejected, *p-value indicates the goodness of fit of the regression model at the characteristic variable indicated

protected by the cheek, tongue, teeth, and alveolar process, thus protected from trauma, orthodontic treatment, and extreme finger sucking. It is these unique characteristics of palatal rugae that make it so useful and valuable to forensic identification.

The role of palatal rugae in forensic identification

Palatal rugae can last up to seven days after death and can withstand heat, such as burn of third degree. The uniqueness, stability, and resistance to destruction are the reason for the palatal rugae to be a very potential anatomical landmark[10]. Race, ethnicity, and geographical variations are also considered in identification, especially during natural disasters and anthropology[11]. The present research was conducted in three areas namely Luhak Agam, Luhak Tanah

Datar, and Luhak 50 Kota, mainly home to the Minangkabau native people. It can be concluded that the patterns of palatal rugae and fingerprints can be used to determine kinship and resemblance between relatives. The circular rugae patterns of the male child are inherited from his father. This is in line with the finding of the authors' previous research revealing that the circular rugae patterns of children show a relationship of resemblance with their parents (Kasuma et al, 2018[12]). The present result is also in the line of Pasiga and Hardianti who studied the Bugis ethnic group[13]. The shape of palatal rugae is more similar between father and son than mother and son. In girls, the circular pattern is derived from the father and mother, while wavy pattern is derived from the mother. These results bear a resemblance with the study[6] stating the relationship pattern of palatal rugae shows a positive correlation between the child and both parents. Wavy rugae pattern is more derived from the mother than from the father. The patterns of palatal rugae are handed down by parents. Genetic affects the formation of morphological signs in a way that prevents the patterns of palatal rugae from being common. According to Mendek's theory, every parent's gene will be passed on to their child. The inherited properties will be noticed depending on the dominant gene. Environmental factors influence the formation of palatal ruga patterns, which are determined by genes. Genes govern the orientation of collagen fibers during embryogenesis and the diversity of palatal rugae patterns in different populations. Palatal rugae is formed in the third month of intrauterine and its growth is regulated by epithelial, mesenchymal interactions in which extracellular matrix molecules are expressed during this development[12].

Conclusion

The most dominant palatal rugae patterns in the Minangkabau people are wavy patterns. However, the shape and size of palatal ruegae is not significant regarding kinship relationship. Even so, circular patterns in the son are derived from the father. In daughter, circular rugae patterns are derived from the father and mother while the wavy rugae patterns are inherited from the mother. The characteristics of the mother are more similar to those of the daughter than those of the son. Identification with palatal rugae is as accurate as the use of fingerprint. Since the present study was conducted on 27 families, further study is needed on more samples for better conclusions. There are hereditary factors in both palatal rugae patterns and fingerprints. Palatal rugae can be a genetic marker in future identification. The authors hope that the present research can contribute to the forensic odontolysiy, especially on the Minangkabau and Deutro Melayu ethnic groups.

What is already known on this topic?

Common forensic identification methods in Indonesia include DNA, fingerprint, and dental record.

What this study adds?

After the introduction of palatal rugae identification, dentists in Padang, West Sumatera, are now able to take patients' palatal rugae patterns for personal dental record data. Therefore, this study adds that in addition to common identification methods such DNA, fingerprints, and dental records, palatal rugae can offer a cheaper and more reliable way to identify individual.

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Conflicts of interest

The authors declare no conflict of interest.

References

1. Ristrini R, Rukmini R, Oktarina O. Analisis Implementasi kebijakan kesiapsiagaan penanggulangan bencana bidang kesehatan di provinsi sumatera barat. Buletin Penelitian Sistem Kesehatan 2012;15:91-102.
2. Imamura F, Muhari A, Mas E, Pradono MH, Post J, Sugimoto M. Tsunami disaster mitigation by integrating comprehensive countermeasures in Padang City, Indonesia. J Disaster Res 2012;7:48-64.
3. Fanany R, Fanany I, Tasady R, society. The experience of old age in West Sumatra, Indonesia: Culture shift and cultural consonance in the modern era. Int J Aging 2014;3:51-9.
4. Rath R, Reginald BA. Palatal rugae: An effective marker in population differentiation. J Forensic Dent Sci 2014;6:46-50.
5. Sharma P, Saxena S, Rathod V. Comparative reliability of cheiloscopy and palatoscopy in human identification. Indian J Dent Res 2009;20:453-7.
6. Patel RN, Umesh K, Sangeeta, Patel R, patel H, Patel

N, et al. Assessing the inheritance of palatal rugae patterns. Int J Adv Res 2015;3:297-301.
7. Hatfield NT. Broadribb's introductory pedriatic nursing. Philadelphia: Lippincott Williams & Wilkins; 2001.
8. Wichnieski C, Franco A, Ignácio SA, Batista PS. Comparative analysis between dactyloscopy and rugoscopys. J Morphol Sci. 2012;29:174-7.
9. Paliwal A, Wanjari S, Parwani R. Palatal rugoscopy: Establishing identity. J Forensic Dent Sci 2010;2:27-31.
10. Pillai J, Banker A, Bhattacharya A, Gandhi R, Patel N, Parikh S. Quantitative and qualitative analysis of palatal rugae patterns in Gujarati population: a retrospective, cross-sectional study. J Forensic Dent Sci 2016;8:126-34.
11. Hermosilla Venegas V, San Pedro Valenzuela J, Cantín López M, Suazo Galdames IC. Rugas palatinas: Sistematización del análisis de su forma y dimensiones para su uso en identificación humana. Int J Morphol 2009;27:819-25.
12. Kasuma N, Dewi E, FItriana A, Fajrin FN, Fitri H, Tegnan H. Palatal rugae pattern identification to determine family lineage in Minangkabau, West Sumatera, Indonesia. Indian J Forensic Med Toxicol 2018;12:222-35.
13. Pasiga BD, Hardianti LS. Palatal Rugae pattern based on lineage (Pilot study for ethnic bugise – South of Sulawesi Indonesia). Int J Res 2017;4:1310-5.