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by Nila Kasuma

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: The aim of this study is to examine the similarity of palatal rugae in the *Minangkabau*ethnicfamily 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 which 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 show that there is a similarity of palatal rugae based on family relationship. Circular rugae of the son has similarities with that of the father (p<0.05) while that of the daughter is derived from the mother, wavy rugae is derived from both parents (p <0.05). The

right index fingers of both the son and the daughter are similar with that of their mother, whereas their left middle fingers are derived from the theirfather (p <0.05).

Conclusion: The similarities of palatal rugae and fingerprints is 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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Introduction

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 more 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 - 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 7 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, the commonly used methods are fingerprints, dental, and DNA identification. No two individuals have the same fingerprints. Fingerprint patterns are very useful in forensicidentification 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 can not 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 this study is to examine the similarity of rugaepalatina in *Minangkabau* family members.

Materials and Methods

This cross sectional study was conducted from October 2017 to February 2018 on *Minangkabau* families at *Luhak Nan tigo*. *Guguak, Sitta, and Tanjung* sub-districts represent *Luhak 50 Kota*, *TanjungBaru*Subdistrict representing *Luhak Tanah Datar*, and *Baso* Sub-district, *Banuhampu* and *Tanjung Raya* representing *LuhakAgam*. A total of 27 families consisting of 4 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 mould. The maxillary mould wasanalyzed by 2 observers i.e. different dentists in single blind for more accurate measurements. The result of the measurement was tested by *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, the size of the palatal rugae was grouped by SunitaKapali method.

Criteria

Measurement	Primary rugae A – 5 to 10 mm B – 10 mm or more Secondary rugae (3-5 mm) Fragmentary Rugae (< 3 mm)
Shapes	Curved Wavy Straight Unification Circular

Figure 1. Shape of Palatal rugae accordingto Thomas Kotze[5]

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 ; (8) Accidental .
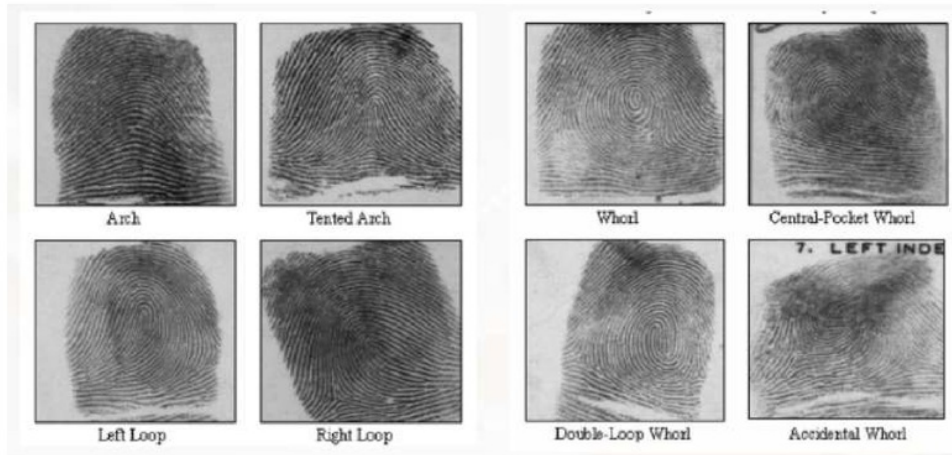

Figure 2. Pola sidik jari menurut klasifikasi Henry[8]

Data were collected, decoded and analyzed statistically by using IBM SPSS Statistic 20 Software. Data were 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 ($B: Boy$) orthe 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 3 parts:

1. Rugae shape consisting of five characteristic variables: curved, straight, wavy, unification, and circular;
2. Right fingers consisting 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, there were 21 with complete data for each characteristic variable, and of the 21 families, there were 13 with 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. The most dominant fingerprints are described in table 2 below:

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±.929
	Circular	108	.24±.578
Size	Primary	108	6.13±3.568
	Secondary	108	1.12±1.477
	Fragmentary	108	0.30±.687

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	9.2	6.9	18.4	3.4
	Middle finger	14.6	64.0	0	5.6	3.4	11.2	1.1
	Ring finger	40.4	36.0	0	2.2	10.1	11.2	0

	Little finger	29.1	57.0	0	2.3	5.8	5.8	0
	Thumb	17.4		55.8	3.5	1.2	16.3	5.8
Left hand's fingerprints	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	

The shape and size of the rugae do not show a significant resemblance between the children- father and mother. But the present study shows that there are specific patterns that can be inherited. Circular rugae of the son tends to be inherited from the father (p = 0.011) while in the daughter, it is inherited from both the father and mother. Wavy rugae on the other hand, is handed down by the mother (p <0.05). Right index fingerprints share a resemblance with the mother while left ring finger prints are more similar to those of the father (p <0.05). This is described in the following tables 3 and 4.

Table 3:*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. (If the selected level of significance is ≥ 5%, then the p-value printed in bold is the small value implying that the null hypothesis (H0) is rejected. P-value printed in red indicates the goodness of fit of the regression model at the characteristic variable indicated).

		P-VALUE							
		SHAPES RUGAE				SIZEOF RUGAE			
		CURVED	STRAIGHT	WAVY	UNIFICATION	CIRCULAR	PRIMARY	SECONDARY	FRAGMENTED
SON n=13	β□	,148	,038	,083	,177	,635	,007	,144	,168
	β□	,749	,699	,119	,684	,005	,434	,385	,647
	β□	,370	,356	,466	,903	,326	,197	,194	,538
	model y	,612	,577	,270	,916	,011	,216	,176	,761
DAUGHTER n=10	β□	,257	,108	,027	,142	,316	,004	,095	,465
	β□	,516	,303	,093	,456	,018	,289	,480	,797
	β□	,855	,167	,032	,720	,015	,827	,299	,094
	model y	,791	,151	,085	,601	,043	,547	,342	,202

Table 4:*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. (If the selected level of significance is ≥ 5%, then the p-value printed in bold is small values implying that the null hypothesis (H0) is rejected. P-value printed in red indicates the goodness of fit of the regression model at the characteristic variable indicated).

		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)	β	,324	,033	,118	,014	,423	,117	,437	,082	,435	,094
	β	,627	,348	,169	,894	,938	,877	,628	,927	,953	,945
	β	,279	,671	,620	,604	,128	,667	,452	,815	,107	,692
	model y	,502	,525	,339	,777	,245	,827	,691	,970	,236	,921
DAUGHTER (n=10)	β	,568	,060	,026	,319	,007	,059	,422	,018	,007	,001
	β	,359	,110	,181	,889	,078	,355	,809	,186	,018	,167
	β	,306	,030	,942	,573	,157	,888	,732	,511	,510	,291
	model y	,482	,021	,382	,672	,141	,620	,873	,357	,049	,148

Discussion

Palatal rugae and fingerprints have morphological patterns that can be used in forensic identification. The 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 and it was first discovered by Spanish researcher, named Trobo Hermosa.(6)Data collection on palatal rugae as a medical records document was performed in the South America due to the fact that its ability to accurately identify exceeds that of fingerprints especially in particular cases where fingerprints can not 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 does not change with age(10). Palatal rugae lies in a position protected by the cheek, tongue, tooth, and alveolar process, thus protected from trauma, orthodontic treatment, and extreme finger sucking. Palatal rugae can last up to seven days after death and can withstand heat, for example burn degree 3. The uniqueness, stability, and resistance to destruction is what causes 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). This research was conducted in three areas namely *LuhakAgam*, *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 our previous research which

revealed that circular rugae patterns of children show a relationship of resemblance with their parents (Kasuma et al, 2018). This result is also in line that of Pasiga and Hardianti who studied the Bugis ethnic group. (12)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 studyof(6)which states 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 3rd month of intrauterine and its growth is regulated by epithelial - mesenchymal interactions in which extracellular matrix molecules are expressed during this development (13).

Conclusion

The most dominant palatal rugae patterns in the *Minangkabau* people are wavy patterns. However, the shape and size of palatal ruegaeis 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 this 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. We hope this research can contribute to the forensic odontolysiy, especially on the Minangkabau and DeutroMelayu ethnic groups.

What is already known on this topic?

Common forensic identification methods in Indonesia DNA,fingerprintand dental record

What this study adds?

After the introduction of palatal rugae identification, dentist in Padang , West Sumatera, have been educated to take patient palatal rugae pattern for personal dental record data.

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