ORIGINAL PAPER

PALATAL RUGAE SHAPES IN SEX DETERMINATION IN FORENSIC ODONTOLOGY

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ABSTRACT

Introduction: In cases of mass mortality, forensic identification is certainly needed. One of forensic identification methods that can be used in such cases is forensic odontology, which is helpful in human identification based on dental records and evaluation of dental findings. The INTERPOL has categorized disaster victim identification (DVI) into primary and secondary methods. The primary identification methods include fingerprint, DNA, and dental analyses. The secondary identification methods involve palatal rugae analysis, lip prints, and objects found with victims at a scene. Palatal rugae is known for its resistance to environmental change, stability, and individuality. Palatal rugae can be investigated for up to 7 days after death, and it can also be identified even when a victim's body is in a bad condition, such as burned out. Moreover, palatal rugae analysis can be applied as one of the secondary identification methods to identify the gender of individuals.

Objectives: This study was conducted to determine the differences in palatal rugae shape between males and females in an Indonesian subpopulation.

Material and methods: This cross-sectional study was conducted by observing 100 maxillary jaws of 50 men and 50 women from Indonesia, aged 19-60 years based on Basauri classification.

Results: There was no significant difference in the palatal rugae shape between males and females on either the left or right side, but the shape of palatal rugae was different between males and females in terms of distribution.

Conclusions: It can be concluded that although palatal rugae in every individual is different, they still cannot disclose the differences between males and females in the Indonesian subpopulation.

Key words: forensic odontology, sex determination, palatal rugae.

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INTRODUCTION

According to the Indonesia Disaster Information Data (DIBI)-BPNB, Indonesia is a disaster-prone country, with > 1,800 disasters reported between 2005 and 2015. Indonesia shows an increasing rate of catastrophes, resulting in more victims who are difficult to identify [1]. In cases of mass mortality, forensic identification is certainly needed. One of the forensic identification methods that can be used in such cases is forensic odontology [2], which is helpful in human identification based on dental records and evaluation of dental findings [3]. The INTERPOL has categorized disaster victim identification (DVI) into primary and secondary methods. Primary identification methods include fingerprint, DNA, and dental analyses. Secondary identification methods include palatal rugae analysis, lip prints, and objects found with the victims at the scene [4].

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The secondary identification methods can be helpful in identification of victims when the primary identification methods cannot be conducted due to various aspects, such as when the victim is edentulous, burned out, and severely decomposed, which is difficult to identify the victim via fingerprint and DNA analyses [5, 6]. One of the analyses that can be used to identify the tribe and gender is palatal rugae analysis. Analysis of palatal rugae can be achieved based on the shape, length, unification, and direction of rugae [7, 8]. Some of the advantages of this identification method are that palatal rugae are not deformed, they cannot be lost unless degeneration due to death has occurred, they remain stable, and they present unique features (even in identical twins they are not similar) [9].

Gondivkar *et al.* reported a significant association between palatal rugae shape and ethnicity [10]. Moreover, a study conducted by Kolude *et al.* in Nigerian population reported that palatal rugae were helpful in identifying the tribe but not gender [11]. Meanwhile, Dohke *et al.* examined the differences that appeared in palatal rugae in males and females in Japan [12]. However, Muhasilovic *et al.* reported that there were no significant differences in gender among Bosnia and Herzegovina population [2]. There are some classifications for palatal rugae, and in this study, we used Basauri classification that divides palatal rugae based on shapes. This classification has also been used in a previous research of Santos *et al.* in Portuguese population [13].

Based on the above mentioned data, we conducted this study to determine whether there are differences in the palatal rugae shape between males and females in Indonesian subpopulation according to Basauri classification, so that this analysis can be used as a supporting information for specific identification of individuals in cases of gender determination.

OBJECTIVES

This study was conducted to determine whether there are differences in palatal rugae shape between males and females in Indonesian subpopulation.

MATERIAL AND METHODS

Overall, 100 maxillary jaws (obtained by the total sampling method) were used in this study including 50 males and 50 females, obtained from the Oral Biology Department, Faculty of Dentistry, Universitas Indonesia. Approval from the ethics research commission of the Faculty of Dentistry of the University of Indonesia number 98/ethical approval/FKGUI/X was obtained. Subjects with specific criteria that could be used as research samples, such as male or female aged 18-60 years proven by identity cards, complete dental conditions, not using dentures, and not under current orthodontic treatment were considered for enrollment. Bold lines were drawn along the palatal rugae on the 100 maxillary jaw using a sharp pencil under bright lighting according to Basauri classification and recorded in the data form.

Principal rugae that were located most anteriorly were documented using capital letters (A, B, C, D, E, F, X), whereas accessory rugae that included the remaining ones were recorded using numbers (1, 2, 3, 4, 5, 6, 7) [14]: A/1 for point rugae shape, B/2 for line rugae shape, C/3 for angle rugae shape, D/4 for sinuous rugae shape, E/5 for curve rugae shape, F/6 for circle rugae shape, and X/7 for polymorphic rugae shape.

The palatal rugae were observed twice. Statistical analysis was performed using Statistical Package for the Social Sciences (SPSS), version 16.0. Subsequently, inter-observer (measurement by different observers) and intraobserver (measurement by the same observer but at different times) reliability was assessed using Cohen's κ test in SPSS 16.0. Mann-Whitney *U* test was applied to analyze the palatal rugae shape.

RESULTS

The line, circle, and polymorphic rugae shapes on the left palatal side were more predominant in females than in males. The sinuous rugae shape on the left side of the palate showed similar predominance in both males and females. Based on the total number of palatal rugae on the left palatal side, the curve was the most dominant shape in both genders. The mode values of all rugae shapes demonstrated statistically non-significant differences ($p = 0.12$) between males and females. The total number of all palatal rugae shapes was higher in males (596) than in females (577). Palatal rugae with the point, line, angle, sinuous, circle, and polymorphic shapes were more in number in males than in females. However, those with the curve shape were more in number in females than in males. Based on the total number, the curve was the most dominant shape in both genders. The mode

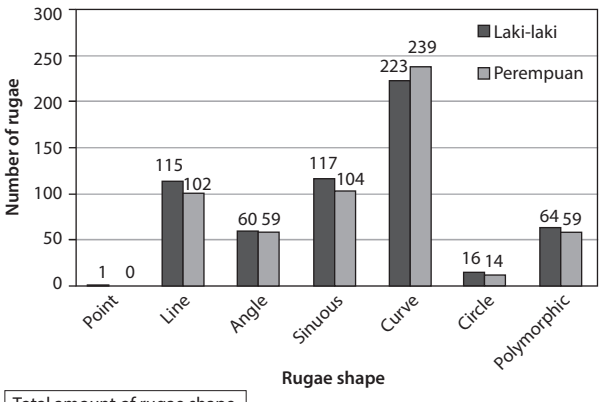
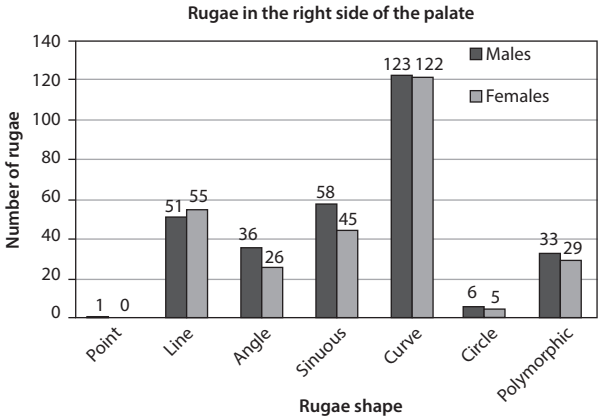
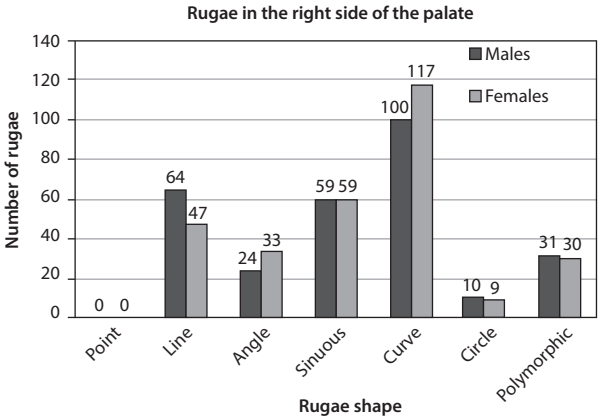


FIGURE 1. Frequency graphs of palatal rugae shapes in males and females



Total amount of rugae shapesin the right palatal side: 590
Males: 308
Females: 282

FIGURE 2. Frequency graphs of rugae shapes in the right palatal side in males and females



Total number of rugae shapes: 583
Males: 288
Females: 295

FIGURE 3. Frequency graphs of rugae shapes in the left palatal side in males and females

Name : 73
Age: 29
Sex: female
Ethnicity: Javanese

FIGURE 4. Study model of palatal rugae

values of all rugae shapes on the right side indicated a statistically non-significant difference (p = 0.67) between males and females. Furthermore, the total number of all palatal rugae shapes on the right side of palate was higher in males (308) than in females (282). Palatal rugae with the point, angle, sinuous, curve, circle, and polymorphic shapes on the right palatal side were higher in number in males than in females. However, females showed a greater number of rugae with the line shape on the right side of palate than males. Based on the total number of rugae on the right palatal side, the curve was the most dominant shape in both genders. The mode values of all rugae shapes on the left side showed a statistically non-significant difference (p = 0.78) between males and females. Figure 3 shows that the total number of all rugae shapes on the left palatal side was higher in females (295) than in males (288). The point rugae shape was not found in both males and females.

TABLE 1. Analytical results of palatal rugae shapes in males and females

Rugae shape	Gender	Mode	Max	Min	*p* value
Point	Male	0	1	0	0.317
	Female	0	0	0	
Line	Male	0	5	0	0.595
	Female	1	4	0	
Angle	Male	0	3	0	0.968
	Female	0	3	0	
Sinuous	Male	1	3	0	0.254
	Female	1	5	0	
Curve	Male	2	6	1	0.197
	Female	2	6	1	
Circle	Male	0	1	0	0.556
	Female	0	1	0	
Polymorphic	Male	0	3	0	0.493
	Female	0	2	0	

DISCUSSION

The aim of this this study was to investigate whether there are differences in palatal rugae shape between males and females in Indonesian subpopulation based on Basauri classification, which divides rugae into 7 different shapes including point, line, angle, sinuous, curve, circle, and polymorphic. Based on the results of Cohen's kappa statistical test, we found that the coefficient value of interobserver and intraobserver reliability met

TABLE 2. Analytical results of palatal rugae shapes on the right palatal side in males and females

Rugae shape	Gender	Right side of the palate			*p* value
		Mode	Max	Min	
Point	Male	0	1	0	0.317
	Female	0	0	0	
Line	Male	0	4	0	0.498
	Female	1	4	0	
Angle	Male	0	3	0	0.219
	Female	0	3	0	
Sinuous	Male	1	3	0	0.18
	Female	1	3	0	
Curve	Male	2	6	0	0.701
	Female	2	5	0	
Circle	Male	0	1	0	0.75
	Female	0	1	0	
Polymorphic	Male	0	2	0	0.507

TABLE 3. Analytical results of palatal rugae shapes on the left palatal side in males and females

Rugae shape	Gender	Left side of the palate			*p* value
		Mode	Max	Min	
Point	Male	0	0	0	1.000
	Female	0	0	0	
Line	Male	1	5	0	0.121
	Female	0	4	0	
Angle	Male	0	3	0	0.122
	Female	0	2	0	
Sinuous	Male	1	3	0	0.674
	Female	1	5	0	
Curve	Male	2	6	0	0.210
	Female	2	6	0	
Circle	Male	0	1	0	0.800
	Female	0	1	0	
Polymorphic	Male	0	2	0	0.933
	Female	0	3	0	

the accuracy requirement of > 0.61. Mann-Whitney test revealed no significant differences between male and female palatal rugae. The results of this study were consistent with those reported by Muhasilovic *et al.* from Bosnia and Herzegovina, and also according to the study conducted by Kapali *et al.* in Caucasoid races and Australians, who reported that there were no significant differences in rugae shapes between males and females. However, our results were in contrast to those reported by Saxena *et al.* from an urban population of Bhopal and those reported by Nayak *et al.* among Indian populations, who found differences in rugae shapes between males and females [2, 14-16].

In this study, the curve and wavy/sinuous rugae shapes showed statistically non-significant differences between males and females. This finding was different from that observed by Saraf *et al.*, who found differences between males and females in terms of the curve and wavy/sinuous rugae shapes. The results of our study were in line with those reported by Bajracharya *et al.* from Nepalese population, who found no difference in the curve and wavy/sinuous rugae shapes between males and females [17, 18].

This study indicated that the maximum number of rugae with the curve shape was found in both males and females. This finding was in contrast with an investigation of Portuguese population conducted by Santos and Caldas and a research performed by Ibeachu *et al.* in a Nigerian population, who reported that the most dominant form of rugae shape was wavy/sinuous. However, our results were similar to those reported by Surekha *et al.*, who investigated Manipuri population, and in accordance with a study by Abdellatif *et al.* conducted among a Saudi population, who found that the curve rugae shape was more common in males and females [5, 9, 13, 19].

In addition, the second most dominant form of rugae shape found in males and females was sinuous, which was different from the results reported by Kallianpur *et al.* investigating Nepalese population and those found by Azab *et al.* from Egypt, who stated that the second most dominant shape was straight. However, our results were in line to those reported by Eboh who reported wavy/sinuous as the second most dominant rugae shape among a Nigerian population [20-22].

In the present study, it was found that the total number of all rugae shapes on the right palatal side was higher than that on the left side. This finding was in opposition to results reported by Dohke and Osato from Japan and to by Surekha *et al.* conducted among populations of Manipur and Kerala, India, who reported that the total number of all rugae shapes on the right palatal side was less than that on the left side. However, our findings were similar to those of Suhartono *et al.* among an Indonesian population and those reported by Bing *et al.* from China, who observed that the total number of all rugae shapes was higher on the right than on the left side of the palate [9, 12, 23, 24].

In this study, the number of rugae with the curve shape was higher in females than in males. This was consistent with that of Shetty *et al.* performed among Mysorean and Tibetan populations, who stated that the curve rugae shape was more common in females than males. However, our results were different to the study by Madhankumar *et al.* from Chennai (India), who found that the curve rugae shape was more common among males than females [25, 26].

In an earlier study by Kalia *et al*., the straight/line rugae shape was found to be more common among females than males. This contrasts with the results of the present study, where the straight/line shape was observed in fewer females than males. Kalia *et al*. also suggested that the wavy/sinuous rugae shape was more common among males than females. This conclusion was consistent with the present study results and those of another research by Indira *et al*. conducted among Indian population, who reported that the wavy/sinuous rugae shape was more common among males than females. However, it was in contrast to the research by Madhankumar *et al*. from Chennai (India), who reported that the wavy/sinuous rugae shape was more common among females than males [25-27].

The results of this study also showed that the total number of all rugae shapes was higher in males (596) than in females (577). This finding is in opposition to the research by Gondivkar *et al*. conducted among West Indian population as well as the study by Eboh from Nigeria, who found that the total number of all rugae shapes was higher among females than males. However, our result was in line with a study by Shrestha *et al.* who investigated Nepalese population and those reported by Suganna *et al.* from Libya, who stated that females had fewer rugae than males [10, 22, 28, 29].

Various studies on palatal rugae have been conducted in several populations, but no studies have reported similar results. This could be due to the differences in genetic factors in each population since the pattern of rugae is determined by genetic factors. The difference in the distribution of rugae shapes in various populations indicated that the rugae pattern is specific to certain populations due to various factors such as race and ethnicity. The results of this study conducted on 100 study models of maxillary jaw revealed that the palatal rugae are unique and different between individuals, and even the shape of rugae is not similar between the right and left palatal sides. A general interpretation of these results is that the most common shape found in males and females is the curve shape, whereas the least encountered is the circle shape.

CONCLUSIONS

This study demonstrated no statistically significant differences in the shapes of palatal rugae between male and female subjects among Indonesian subpopulation, considering both the left and right sides of the palate. However, after analyzing the distribution of rugae shapes, there was a difference in the number of rugae between males and females on the left and right sides of the palate. The most dominant shape of palatal rugae was the curve shape in both males and females on the left and right sides of the palate. The limitation of this study is that the testing can be subjective. However, interobserver and intraobserver analyzes were completed, so that the results of the research are objective. In our study, we used Basauri classification, but to determine the pattern of palatal rugae and to validate our results, different types of classifications should be employed. To improve the quality of research, further study with anthropometric measurements other than palatal rugae should be used. A relation to medial palatine raphe/suture, incisive papilla/foramen as well as cranial/palatine linear diameters would strongly improve further study.

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CONFLICT OF INTEREST

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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