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Study of Palatal Rugae Patterns and their Use in Sex and Ethnicity Identification in a Sample of Adult Egyptians and Malaysians

دراسة أنماط الغضون الحنكية واستعمالها في التعرف على الجنس والعرق في عينة من المصريين والماليزيين البالغين

Heba A. S. M. Hussein[1]*, Nermeen A. S. Rady[2]

[1] Forensic Medicine & Clinical Toxicology Department, Faculty of Medicine, Alexandria University, Egypt.
[2] Department of Removable Prosthodontics, Faculty of Dentistry, Alexandria University, Egypt.

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Abstract

Palatal rugoscopy is the use of palatal rugae for identification of unknown persons. The majority of the population in Egypt consists of native Egyptian people. However, some Malaysian people live in Alexandria city of Egypt for the purpose of education. So, in case of mass disaster, there is a critical need for a reliable and easy method to differentiate between Malaysians and Egyptians. This study aimed to determine the palatal rugae patterns in two diverse populations; Egyptians and Malaysians and its relation to sex and population difference.

Eighty students of Alexandria Faculty of Dentistry; forty Egyptians (20 females and 20 males) and forty Malaysians (20 males and 20 females). The age ranged 18-30 years. Impressions were taken with alginate (irreversible hydrocolloid impression material). Thomas and Kotze classification was used to assess palatal rugae regarding their length, shape, direction and unification. Data were introduced to the computer and processed using IBM SPSS software version 20.0.

Qualitative data were defined using number and percent. The Kolmogorov-Smirnov test was applied to attest the normality of distribution. Significance of the obtained results was judged at the 5% level. Significant difference was noted be-

Keywords: *Forensic Science, Forensic Odontology, Palatal Rugae, Sex Difference, Ethnicity Difference, Egyptians, Malaysians.*

المستخلص

تنظير الغضون الحنكي هو استخدام غضون الحنك للتعرف على الأشخاص المجهولين. غالبية السكان في مصر هم من الشعب المصري. ومع ذلك، فإن بعض الماليزيين يعيشون في مدينة الإسكندرية في مصر لغرض التعليم. لذلك في حالة وقوع كارثة جماعية، هناك حاجة ماسة لطريقة موثوقة وسهلة للتمييز بين الماليزيين والمصريين. وهدفت الدراسة إلى تحديد أنماط الغضون الحنكية في مجموعتين متنوعتين من السكان؛ المصريين والماليزيين وعلاقتها باختلاف الجنس والسكان. وشملت الدراسة ثمانين طالبًا وطالبةً من كلية طب الأسنان بالإسكندرية، أربعين مصريًا (20 أنثى و20 ذكرًا) وأربعين ماليزيًا (20 ذكرًا و20 أنثى)، تراوحت أعمارهم بين 18 و 30 سنة. وقد تم أخذ الانطباعات باستخدام الألجينات (مادة انطباع غرواني مائي غير قابل للانعكاس)، واستخدم تصنيف توماس وكوتز لتقييم غضون الحنك من حيث الطول والشكل والاتجاه والتوحيد. تم إدخال البيانات إلى الكمبيوتر ومعالجتها باستخدام حزمة برامج IBM SPSS الإصدار 20.0 وتم تحديد البيانات النوعية باستخدام العدد والنسبة المئوية. تم تطبيق اختبار Kolmogorov-Smirnov لإثبات الحالة الطبيعية للتوزيع، وتم الحكم على دلالة النتائج المتحصل عليها عند مستوى 5٪.

الكلمات المفتاحية: علوم الأدلة الجنائية، طب الأسنان الشرعي، غضون الحنك، اختلاف الجنس، اختلاف العرق، المصريون، الماليزيون.

* Corresponding Author: Heba A. S. M. Hussein
Email: hebaforensic@gmail.com
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tween Malaysian males and females according to total number of rugae on both sides (t= 2.210 and *p*= 0.033). Malaysians had significantly higher total rugae number on both sides than Egyptians. Curved shape was the predominant shape in the total sample in the four studied groups (42.9%, 36.3%, 46.8% and 44.1%). Significant difference was detected between Egyptians and Malaysians according to the predominant palatal rugae direction on both left and right sides (x2 = 6.293 and *p*=0.043) (x2 =6.620 and *p*=0.037) respectively.

Egyptian females had significantly higher percentage of absent unification than Egyptian males. Binary logistic regression models for sex and ethnicity identification were built up.

وفي النتيجة لوحظ اختلاف كبير بين الذكور والإناث الماليزيين حسب العدد الإجمالي للغضون على كلا الجانبين (t= 2.210 and *p*= 0.033)، وكان لدى الماليزيين عدد أعلى بكثير من إجمالي عدد الغضون عند كلا الجنسين وذو دلالة إحصائية مقارنة مع المصريين. وكان الشكل المنحني هو الشكل السائد في العينات الأربع المدروسة (42.9%, 36.3%, 46.8% and 44.1%) . وتم الكشف عن فرق ذي دلالة إحصائية بين المصريين والماليزيين فيما يتعلق باتجاه الغضون الحنكية السائد على كلا الجانبين الأيسر والأيمن (x2 =6.620) (x2 = 6.293 and *p*=0.043 and *p*=0.037) بالتتالي. وكان لدى الإناث المصريات نسبة أعلى بكثير من تغيب الشكل الموحد مقارنة بالذكور المصريين. وتم بناء نماذج الانحدار اللوجستي الثنائي لتحديد الجنس والعرق.

1. Introduction

Identification of unidentified individuals is of utmost importance in forensic field. It is a requirement for death documentation and for legal, personal and social causes. Fingerprints, DNA comparisons and dental records are the most common methods applied that allow rapid and protected identification [1].

However, using fingerprints in identification may have some limitations that may occur when the hands are burnt or damaged. Sometimes, the use of a less known and uncommon methods of identification, like palatoscopy, is required [2].

Palatal rugoscopy or palatoscopy can be defined as the study of palatal rugae in identification of unknown persons. They are asymmetric, irregular folds of mucosa covering the anterior third of the palate, on the side from the incisive papilla and the anterior portion of the median palatal raphe, that is immediately behind the central maxillary incisor teeth [2,3].

Palatal rugae are distinctive to every person and stay unchanged throughout life. Moreover, being protected in the oral cavity by the cheeks, tongue, and teeth, palatal rugae are much less affected by burns, physical trauma, and other external factors. Thus the individuality, its resistance to postmortem changes, general stability, as well as low utilization charge makes palatal rugae a perfect forensic tool to be used in identification [4,5].

The majority of the population in Egypt consists of Egyptian people. On the year 2006, the Supreme Council of Universities and the Ministry of Higher Education approved the Bachelor of Dental Sciences/Credit Hour System Program, which accepted international students from Malaysia mainly and many other countries. In 2020, about one thousands of Malaysian student's study at Faculty of Dentistry and Faculty of Medicine, Alexandria University. This mandates to propose a reliable and easy method to differentiate between Malaysians and Egyptians.

Although the pattern of palatal rugae has been studied in various populations around the world, this study has not been performed in Alexandria. As a result, considering the high number of Malaysians living in Alexandria, there was a need to recognize differences in rugae patterns among the two different population groups, Egyptians and Malaysians.

The current study aimed to study the pattern and number of palatal rugae in two distinct populations namely, Egyptians and Malaysians and its relation to sex and ethnicity difference.

2. Materials and Methods

2.1 Subjects

The present study was performed on eighty vol-

unteered students of Faculty of Dentistry, Alexandria University. They were divided into two groups depending on race; forty Egyptians (20 males and 20 females) and forty Malaysians (20 males and 20 females). The age of study participants ranged from 18-30 years.

Informed consents were obtained from all study participants and ethical approval was obtained from The Ethics Committee of Alexandria Faculty of Medicine (IRB No: 00012098, FWA No: 00018699) before starting the research.

Subjects wearing partial dentures or braces, those with anomalies of lips and palate, and persons having history of orthodontic treatment were excluded from the present work. Moreover, damaged casts and casts with air bubbles or holes were also excluded.

2.2 Materials

The materials used in this research were; irreversible hydrocolloid impression material (Cavex Imperssional, Cavex Holland BV, The Netherlands), dental stone, sharp 2b pencil, magnifying lens and a digital Vernier caliper.

2.3 Methods

Each study participant was examined clinically, to screen for exclusion criteria, and appropriate maxillary impression tray was selected. Impressions were taken with alginate (irreversible hydrocolloid impression material) and cast was attained by pouring with dental stone. All casts obtained from study participants were numbered accordingly belonging to individual states, age, and sex.

The rugae were outlined using a 2b sharp pencil and observed using a magnifying lens. They were recorded on both right and left sides of the mid-palatine raphe. Both authors of the study examined all the casts and then the obtained results were adjusted.

For all the study models, the total number of rugae on both sides was counted. Then the whole number of rugae and the number on the right and left sides was recorded separately.

Thomas and Kotze classification was used to assess palatal rugae regarding their length, shape, direction and unification [6]. All the parameters were assessed by the two researchers who contributed in this work independently.

Regarding the shape of the rugae, it was circular, linear, wavy or curved (Figure-1). Moreover, the direction of the palatal rugae was assessed. An imaginary line was drawn perpendicular to the mid- palatine raphe. Then the angle between this imaginary line and a line connecting the beginning and termination of the ruga was measured. The rugae were; forward (positive angle), straight (zero

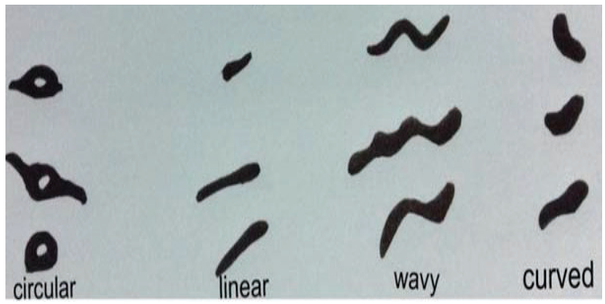


Figure 1- *Classification of palatal rugae according to their shape [7].*

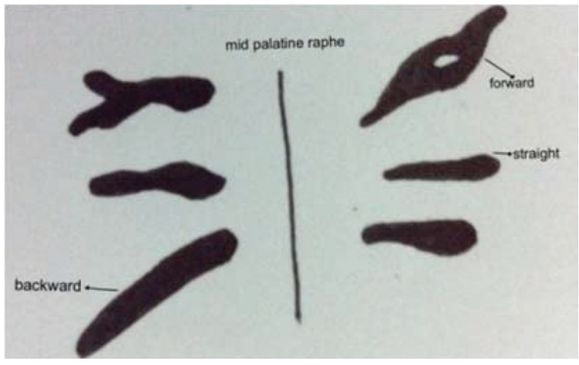


Figure 2- *Classification of palatal rugae according to their direction [7].*

angle) or backward (negative angle) (Figure-2).

The length of every ruga was estimated by measuring its largest length irrespective of its shape by using a digital caliper. Palatal rugae were classified, depending on their length, into primary (more than 5 mm) and secondary (from 3 to 5 mm). Those shorter than 3 mm were neglected.

Lastly, palatal rugae were classified according to their unification into diverging (having the same origin by the mid- palatine raphe and then they branched) or converging (having different origins by the mid- palatine raphe and then they united) (Figure-3).

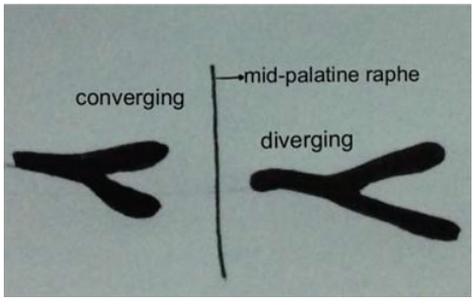


Figure 3- *Classification of palatal rugae according to unification [7].*

2.4 Statistical Analysis of the Data [8]

Data were introduced to the computer and processed using IBM SPSS software version 20.0. (Armonk, NY: IBM Corp). Qualitative data were defined using number and percent. The Kolmogorov-Smirnov test was applied to test the normality of distribution. Quantitative data were designated using, mean, standard deviation. Significance of the obtained results was judged at the 5% level.

Chi-square test was used for categorical variables, to relate between various groups, Student t-test was applied for quantitative variables that were normally distributed, to relate between two studied groups. Moreover, Receiver operating characteristic curve (ROC) was made by plotting sensitivity (TP) on Y axis versus 1-specificity (FP) on X axis at various cut-off values. The area under the ROC curve indicates the diagnostic performance of the test. Area more than 50% offers adequate performance and area about 100% is the greatest performance for the test. The ROC curve permits also a judgment of performance between two tests. Binary logistic regression was used to detect sex in the studied Egyptian and Malaysian sample.

3. Results

3.1 Number of rugae (Table-1)

In the current study, non-significant difference was noted between the mean of the total number of palatal rugae, number of rugae on the right side and number on the left side among Egyptian males and females (t=0.368 and p=0.715), (t=1.00 and p=0.324) and (t=0.658 and p=0.515) respectively.

On the other hand, significant difference was noted between Malasyian males and females according to total number of rugae on both sides where t= 2.210 and p= 0.033. However, non-significant difference was observed between Malasyian males and females according to number of rugae on the right and left side (t=1.675 and p=0.102) and (t=1.674 and p=0.104).

At the same time, Malasyian males had significantly higher total number, number on the right side and number on the left side of palatal rugae than Egyptian males, where (t=2.717 and p=0.010), (t=2.719 and p=0.010) and (t=2.082 and p=0.044) respectively. On the contrary, non-significant difference was noticed between Egyptian and Malasyian females according to the total number of rugae, number on the right side and number on the left side (t=0.248 and p=0.806), (t=0.000 and p=1.000) and (t=0.325 and p=0.747) respectively.

Regarding the relation between the two racial groups, Malaysians had significantly higher total

Table 1- *Comparison between Egyptian and Malasyian males and females according to number of rugae (n=80).*

Number of rugae	Egyptian			Malaysian		
	Male	Female	Total	Male	Female	Total
Total number	1.4 ± 7.3	1.2 ± 7.5	1.3 ± 7.4	1.6 ± 8.6	1.4 ± 7.6	1.6 ± 8.1
t (p_1)	(0.715) 0.368			(*0.033) *2.210		
t (p_2)				(*0.010) *2.717	(0.806) 0.248	*2.185 (*0.032)
Right side	0.8 ± 3.7	1.1 ± 4.0	0.9 ± 3.9	1.1 ± 4.6	0.9 ± 4.0	1.1 ± 4.3
t (p_1)	(0.324) 1.000			(0.102) 1.675		
t (p_2)				(*0.010)*2.719	(1.000) 0.000	1.888 (0.063)
Left side	0.7 ± 3.6	0.8 ± 3.5	0.7 ± 3.5	0.7 ± 4.1	1.1 ± 3.6	1.0 ± 3.8
t (p_1)	(0.515) 0.658			(0.104) 1.674		
t (p_2)				(*0.044)*2.082	(0.747) 0.325	1.447 (0.152)

t: Student t-test; p_1: p value for comparing between Male and Female in each country; p_2: p value for comparing between Egyptian and Malaysia in each sex; *: Statistically significant at $p \leq 0.05$

Figure 4- *Example of the casts used in the study; a: Egyptian, b: Malaysian.*

number of palatal rugae on both sides than Egyptians, where t=2.185 and *p*=0.032.

3.2 Predominant shape (Table-2)

Curved shape was the predominant shape in the total sample (among the four studied groups on both right and left sides) (42.9%, 36.3%, 46.8%

Figure 4- *Example of the casts used in the study; a: Egyptian, b: Malaysian.*

and 44.1%). The linear shape and the wavy shape were the second predominant shapes in the total Egyptian sample, on the right and the left sides, respectively.

Regarding the Malaysian sample, the second predominant shape was the wavy shape on both right and left sides (33.9% and 33.6%) respectively. Non-significant difference was observed between all the studied groups regarding the predominant shapes of palatal rugae.

3.3 Predominant direction (Table-3)

The present study demonstrated that the predominant direction in the total sample was the forward direction, followed by straight then backward direction. Egyptians had more forwardly directed rugae than Malaysians. Significant difference was detected between Egyptians and Malaysians according to the predominant direction of palatal rugae on both right and left sides, where (χ^2= 6.293 and *p*=0.043) (χ^2=6.620 and p=0.037) respectively. On the other hand, non- significant difference was noted between males and females in both populations according to direction of palatal rugae.

3.4 Length of palatal rugae (Table-4)

The present study revealed that the majority of palatal rugae were primary (more than 5mm in length) in the total sample (in both Egyptian and Malaysian males and females and on both sides) with percentages of 95.5% and 94.2% in Egyptian and Malaysian samples on the right side respectively. At the same time, primary rugae were predominant on the left side with percentages of 96.5% and 96.7% in Egyptian and Malaysian samples respectively.

Significant differences were noted between Egyptian males and females and between Malaysian males and females according to length where

Table 2- *Comparison between Egyptian and Malaysian males and females according to predominant shape (n=80).*

Predominant Shape	Right												Left											
	Egyptian						Malaysian						Egyptian						Malaysian					
	Male		Female		Total		Male		Female		Total		Male		Female		Total		Male		Female		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Curved	34	45.9	32	40.0	66	42.9	35	38.5	27	33.8	62	36.3	32	44.4	34	49.3	66	46.8	29	35.8	38	53.5	67	44.1
Linear	20	27.0	28	35.0	48	31.2	22	24.2	20	25.0	42	24.6	18	25.0	14	20.3	32	22.7	16	19.8	15	21.1	31	20.4
Wavy	16	21.6	19	23.8	35	22.7	28	30.8	30	37.5	58	33.9	22	30.6	18	26.1	40	28.4	34	42.0	17	23.9	51	33.6
Circular	4	5.4	1	1.3	5	3.2	6	6.6	3	3.8	9	5.3	0	0.0	3	4.3	3	2.1	2	2.5	1	1.4	3	2.0
χ^2 (p_1)	3.075 (0.368)						1.480 (0.703)						3.515 (0.320)						6.687 (0.065)					
χ^2 (p_2)							2.076 (0.563)		7.589 (0.078)		6.485 (0.090)								3.899 (0.273)		6.612 (0.085)		1.032 (0.823)	

χ^2: Chi square test; p_1: p value for comparing between Male and Female in each country; p_2: p value for comparing between Egyptian and Malaysia in each sex; *: Statistically significant at $p \leq 0.05$

Table 3- *Comparison between Egyptian and Malaysians males and females according to predominant direction of rugae (n=80).*

Predominant direction	Right												Left											
	Egyptian						Malaysian						Egyptian						Malaysian					
	Male		Female		Total		Male		Female		Total		Male		Female		Total		Male		Female		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Backward	16	22.2	12	15.0	28	18.4	28	30.8	21	26.3	49	28.7	6	8.3	7	10.1	13	9.2	9	11.1	6	9.0	15	10.1
Forward	36	50.0	46	57.5	82	53.9	37	40.7	34	42.5	71	41.5	46	63.9	50	72.5	96	68.1	43	53.1	37	55.2	80	54.1
Straight	20	27.8	22	27.5	42	27.6	26	28.6	25	31.3	51	29.8	20	27.8	12	17.4	32	22.7	29	35.8	24	35.8	53	35.8
χ^2 (p_1)	1.469 (0.480)						0.441 (0.802)						2.181 (0.336)						0.199 (0.905)					
χ^2 (p_2)							1.880 (0.391)		4.446 (0.107)		6.293* (0.043*)								1.831 (0.400)		5.991 (0.051)		6.620* (0.037*)	

χ^2: Chi square test; p_1: p value for comparing between Male and Female in each country; p_2: p value for comparing between Egyptian and Malaysia in each sex; *: Statistically significant at $p \leq 0.05$

Table 4- *Comparison between Egyptian and Malaysian males and females according to Length (mm) (n=80).*

Length (mm)	Egyptian						Malaysian					
	Male		Female		Total		Male		Female		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Right												
Primary (>5)	68	91.9	79	98.8	147	95.5	89	97.8	72	90.0	161	94.2
Secondary (3–5)	6	8.1	0	0.0	6	3.9	2	2.2	8	10.0	10	5.8
Fragmentary (<3)	0	0.0	1	1.3	1	0.6	0	0.0	0	0.0	0	0.0
χ^2 (p_1)	7.598* (0.011*)						4.707* (0.031*)					
χ^2 (p_2)							3.090 (0.141)		9.817(0.005*)		1.668 (0.374)	
Left												
Primary (>5)	68	94.4	68	98.6	136	96.5	79	97.5	68	95.8	147	96.7
Secondary (3–5)	4	5.6	1	1.4	5	3.5	2	2.5	3	4.2	5	3.3
Fragmentary (<3)	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
χ^2 (p_1)	1.737 (0.367)						0.367 (0.665)					
χ^2 (p_2)							0.964 (0.421)		0.972 (0.620)		0.015 (1.000)	

χ^2: Chi square test; p_1: p value for comparing between Male and Female in each country; p_2: p value for comparing between Egyptian and Malaysia in each sex; *: Statistically significant at $p \leq 0.05$

(χ^2=7.598 p=0.011) and (χ^2=4.707 and p=0.031) respectively. At the same time, significant difference was observed between Egyptian and Malaysian females according to the length of rugae (χ^2= 9.817 and p=0.005).

3.5 Unification of rugae (Table-5)

The present study demonstrated that 87.7% and 88.3% of palatal rugae, in the Egyptian and Malaysian samples, lacked unification on the right side, whether divergent or convergent. Moreover, 85.1% and 89.5% of palatal rugae on the left side of the Egyptian and Malaysian samples had no unifications.

Furthermore, 11.0% and 12.1%, on the right and left sides respectively, of the Egyptian sample was divergent and only 1.3% and 2.8% of them were convergent, on right and left sides, respectively. While in the Malaysian sample, 9.4% and 9.2% of the rugae were divergent on the right and left sides and 2.3% and 1.3% of them were convergent on the right and left sides, respectively.

Regarding sexual difference, Egyptian females had significantly higher percentage of absent unification than Egyptian males with (χ^2= 5.878 and p=0.040).

3.6 Regression equations for the prediction of sex and ethnicity

Table-6 shows sex determination using binary logistic regression equations, from palatal rugae pattern, using the total number of rugae and the unification of the right rugae in both Egyptian and Malaysian samples. For the Egyptian group, the equation accuracy was 67.5%. While in the sample of Malaysian population, the equation accuracy was of 65%.

On the other hand, binary logistic regression equations were applied for identification of ethnicity to each sex separately, using the total number of rugae in males and the length of the right rugae in females. The accuracy of the equation was found to be 65.0% for the sample of males. Regarding the female group, the equation accuracy for identification of ethnicity was 54.4% (Table-7).

4. Discussion

Identification of unknown individuals could be a challenging task in forensic field. Dental identification, fingerprints and DNA are the most common techniques used for rapid and confident identification. However, when these methods cannot be used either due to financial or methodological limitations; casesof mass disasters with complete body damage, no dental records for comparison, fire with charred bodies or severe decomposition, application of simple technique as palatal rugoscopy is effective and can be applied [3].

Palatal rugae are the folds found on the anterior one third of the palatal mucosa behind the incisive papilla on both sides of the median palatal raphae. They are unique, and not the same even in cases of twins. They are also consistent in shape all through life following ending of growth in childhood period [9,10].

The site of palatal rugae in the mouth, makes them protected by lips, cheeks, tongue, teeth, and bone from trauma and burn when the fingerprints are lost. They can also resist putrefaction for a period of up to 7 days [11,12].

Moreover, palatal rugae remain unchanged in morphology and number except in cases of damage of a tooth, continuous sucking of finger, persistent pressure, orthodontic movement of a tooth that may alter teeth orientation. At the same time, palatal rugae can resist postmortem changes, they are unique for every individual, generally stable. In addition,

Table 5- *Comparison between Males and Females gender according to Unification (n=80).*

Unification	Right												Left											
	Egyptian						Malaysian						Egyptian						Malaysian					
	Male		Female		Total		Male		Female		Total		Male		Female		Total		Male		Female		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Negative	60	81.1	75	93.8	135	87.7	81	89.0	70	87.5	151	88.3	60	83.3	60	87.0	120	85.1	73	90.1	63	88.7	136	89.5
Diverge	12	16.2	5	6.3	17	11.0	7	7.7	9	11.3	16	9.4	10	13.9	7	10.1	17	12.1	6	7.4	8	11.3	14	9.2
Con-verge	2	2.7	0	0.0	2	1.3	3	3.3	1	1.3	4	2.3	2	2.8	2	2.9	4	2.8	2	2.5	0	0.0	2	1.3
χ^2 (p_1)	5.878* (0.040*)						1.303 (0.632)						0.593 (0.854)						2.016 (0.518)					
χ^2 (p_2)							2.949 (0.235)		2.220 (0.273)		0.714 (0.755)								1.848 (0.408)		1.769 (0.524)		1.544 (0.455)	

χ^2: Chi square test; p_1: p value for comparing between Male and Female in each country; p_2: p value for comparing between Egyptian and Malaysia in each sex; *: Statistically significant at $p \leq 0.05$

Table 6- *Binary logistic regression equations predicting sex in the Egyptian and Malaysian sample.*

Sample	Equation	AUC	p	Cut - off value	OR	CI of OR 95%	Accuracy
Egyptian	+ (X= -0.378 + (Total no. of rugae x 0.143 (Unification of right rugae x -1.490)	*0.713	*0.021	0.58<	1.153	0.68-1.94	67.5%
					0.225	0.063-0.80	
Malaysian	+ (X= 4.128 + (Total no. of rugae x -0.521 (Unification of right rugae x 0.111)	0.675	0.058	0.491<	0.594	0.35-1.003	65.0%
					1.117	0.39-3.132	

AUC: Area Under the Curve; OR: Odds ratio; SEE: Standard Error Estimates; *: Statistically significant at $p \leq 0.05$ > cut-off = female

their forensic application has low charges making it an ideal means for forensic identification [13,14].

The objective of the current work was to study the pattern of palatal rugae among a sample of Egyptians and Malaysians and its ability to identify sex and ethnicity.

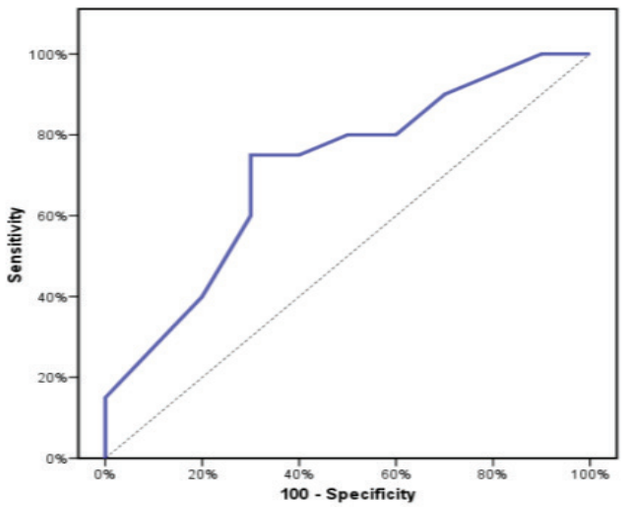
Simple materials were used in the present research in order to analyze the rugae, this is to be easily applicable in any laboratory with low cost and less time frame. This was in accordance to Shetty et al., (2013) [15].

At the same time, subjects wearing partial dentures or braces, those with palate and lips anomalies, and those having history of orthodontic treatment were excluded from the present work. This was done to avoid possible changes that may happen in the pattern of palatal rugae. In their study, Shetty et al., (2013) [15] concluded that the palatal rugae may be altered because of many reasons, like using complete dentures, trauma resulting from dental procedures, cleft palate, fibrous tissue and calluses.

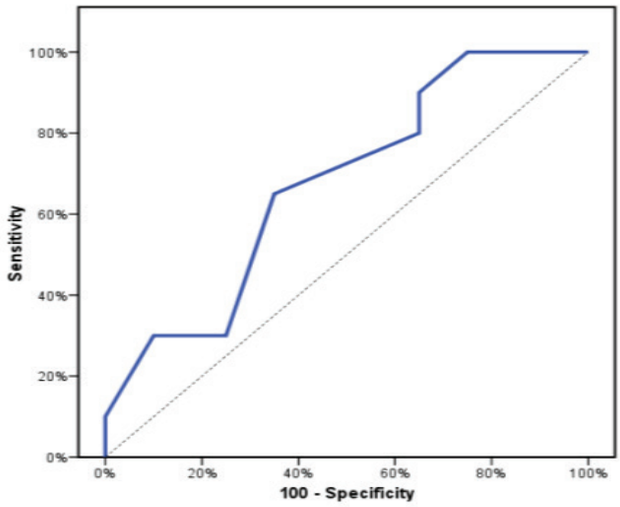
Furthermore, the present study used Thomas and Kotze classification [6], to analyze palatal rugae regarding their length, number, shape, unification and direction. This classification was chosen as it is less time consuming and easily applied. It was in accordance with Saxena et al., (2015) [16], Mushannavar et al., (2015) [17]. In their study, Pramanik et al., (2019) [18] stated that it is the most easy, practical and consistent technique.

In the current research, all the parameters were assessed by the two researchers contributed in this work independently to avoid intrapersonal and interpersonal bias.

Regarding the age of study participants, in the current study, it was not less than 18 years. This was to avoid the changes that occur in the length



Egyptian



Malaysian

and number of palatal rugae during childhood period. This coincided with Selvamani et al., (2015), Hemanth et al., (2010) [19,20].

In the current study, non-significant difference was noted between Egyptian males and females according to the total number, number on the right side and number on the left side of palatal rugae. On the other hand, Malaysian males showed significant increase in the total number of rugae on both sides than Malaysian females. However, non-significant difference was observed between Malaysian males and females according to number of rugae on the right and left side. This was in contrary to Shetty et al., (2013) [15] who found that females had slightly higher number of rugae compared with that in males. This may be attributed to different populations studied. In their study, Pramanik et al., (2019) [18] found that the number of rugae on the right side was significantly greater in females than in males, while the difference in the number of rugae on the left side was not significant. Regarding the total number of rugae, there was no statistically significant difference between male and female samples.

Concerning the relation between the two racial groups in the present work regarding number of palatal rugae, Malaysians had significantly higher total number, number on the right side and number on the left side of palatal rugae on both sides than Egyptians. This was contrary to Paliwal et al., (2010) [21] and Shetty et al., (2005) [22], who showed no significant difference between the studied populations, according to number of palatal rugae, in their studies. However, in a study conducted in India, Hosmanii et al., (2018) [23] noted greater total number of rugae in Indian population compared to Tibetan population.

Moreover, in the present work, curved rugae shape was the predominant shape in the total sample. The linear and the wavy shapes were the second predominant shape in the total Egyptian sample, on the right side and the left side respectively. Regarding the Malaysian sample, the second predominant shape was the wavy shape on both sides. Non-significant difference was noted between all the studied groups regarding the predominant shapes of palatal rugae. This result may be attributed to small sample size.

Table 7- *Binary logistic regression equations predicting ethnicity in male and female.*

Sample	Equation	AUC	p	Cut-off value	OR	CI of OR 95%	Accuracy
Male	X= -4.860 + Total number of rugae x 0.614	0.728	*0.014	0.51<	1.848	1.10-3.11	65.0%
Female	X = -1.341+ Length of right rugae 1.273	0.543	0.346	0.483<	3.572	0.77-16.48	54.4%

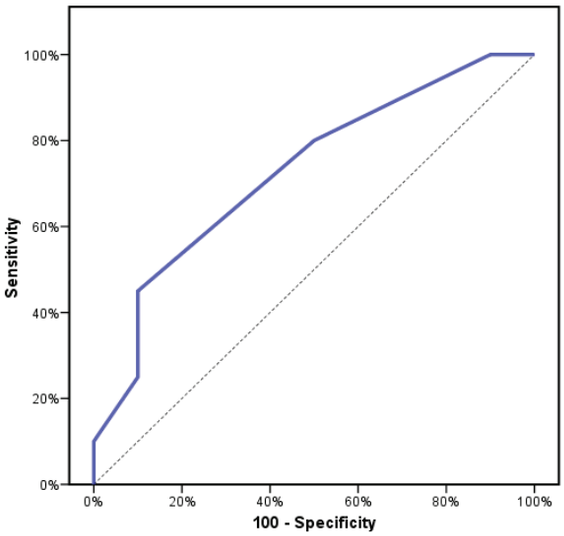
*AUC: Area Under the Curve; OR: Odds ratio; SEE: Standard Error Estimates; *: Statistically significant at p ≤ 0.05 > cut-off = Malaysian*

This result coincided with Sivakumar et al., (2015) [7] and Pramanik et al., (2019) [18]. However, it was in contrast to Paliwal et al. (2010) [21], Swetha et al., (2015) [24] where the wavy shape was the predominant one, and while the straight pattern was the most commonly observed among Madhya Pradesh population. At the same time, Hosmanii et al., (2018) [23] found that the predominant rugae were straight and wavy in Indians and curved in Tibetans. On the other hand, Srikala et al., [25] found that wavy rugae shape was the predominant one in both male group and female group followed by straight, curved and circular rugae.

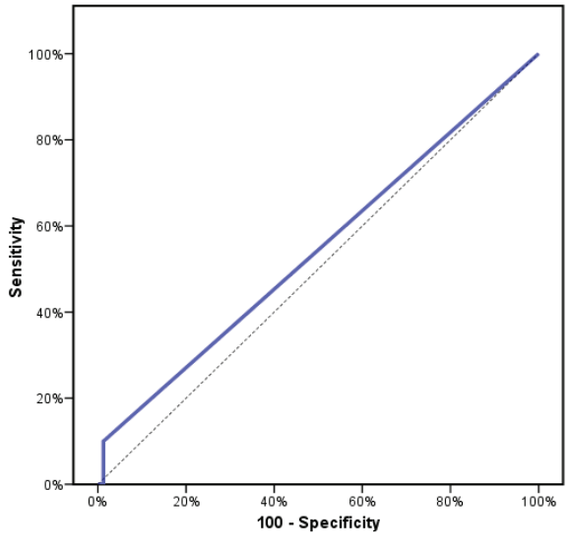
Furthermore, the present work presented non-significant difference between all the participated groups regarding the predominant shapes of palatal rugae. This result was in contrary to Shetty et al., (2013) [15] who found that diverging pattern was more common in females than males. Moreover, Dineshshankar et al., (2017) [26] showed that females had more of the wavy type of rugae, while the predominant shape in males was the curved.

Regarding direction of palatal rugae, the present study demonstrated that the predominant direction in the total sample was the forward direction. This was in accordance with Sivakumar et al., (2015) [7]. Significant difference was detected between Egyptians and Malaysians according to the predominant direction of palatal rugae on both right and left sides. On the other hand, non- significant difference was noted between males and females in both populations according to direction of palatal rugae. This result disagreed Pramanik et al., (2019) [18] who found that the backward direction of rugae was significantly predominant in females but the straight rugae was significantly predominant in males.

The present study revealed that the majority of



Male



Female

palatal rugae were primary, in the total sample, (in both Egyptian and Malaysian males and females and on both sides). Regarding the sex difference, primary rugae were more common in Egyptian females than in males with significant difference between them. While in the Malaysian sample, primary rugae were significantly more common in males than females. This was in contrast to Saxena et al., (2015) [16]. On the other hand, Swetha et al. (2015) [24] highlighted, in their study, that primary rugae were found more in males while secondary and tertiary rugae were more common in females.

In the present study, the majority of study sample lacked unification. At the same time, divergent pattern was the predominant in the remaining sample. Regarding sexual difference, Egyptian females had higher percentage of absent unification than Egyptian males. This observation was contrary to Shetty et al., (2013) [15] who found that diverging rugae were more common in females compared with males. Moreover, this was different from a study carried out by Kamala et al., (2011) [1], who indicated that females had significantly greater number of converging rugae compared to males. Also, Fahmi et al., (2001) [27] showed that females had a greater significance of converging type.

Using regression analysis of different analytic parameters of palatal rugae patterns, the current work built up two equation models for sex identification using the total number of rugae and the unification of the right rugae in both Egyptian and Malaysian samples with different accuracies. For Egyptian group, the equation accuracy was 67.5%. On the contrary, the accuracy of the equation, for the Malaysian population, was 65%. These models confirmed the ability of palatal rugae patterns to identify sex. This result was in agreement with Elbanna et al., (2019) [28].

Furthermore, ethnicity determination was confirmed in the present work by building up two regression models that were applied to each sex separately, using the whole number of rugae in males and the length of the right rugae in females. The accuracy of the equation was found to be 65.0% for the sample of males. Regarding the female group, the equation accuracy for ethnicity determination was 54.4 %. This result reflected the

importance of palatal rugae in ethnicity prediction.

Depending on the obtained results of the present research, we can recommend building up of a database, in every region, of ante mortem casts in order to be a reference in cases of civil lawsuits, mass disasters and crimes. Moreover, future research should entail the individuality of palatal rugae patterns on both sexes and on different population groups on larger samples to confirm the obtained results of the present study.

5. Conclusion

The data attained from the current study indicated the individuality of palatal rugae patterns. It showed that palatal rugae patterns are unique from one individual to another, between males and females and between Egyptians and Malaysians. Furthermore, regression equations can define sex and population with different levels of accuracies. So, beside the traditional methods and with provision of ante mortem casts, palatal rugoscopy can also help in personal identification.

Limitations

The small sample size of the study, which may affect generalization of the obtained findings and needed to be confirmed in further researches using larger number of samples.

Conflict of Interest

None

Funding

Nil

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