

## STUDY OF PALATAL RUGAE PATTERN OF RWANDAN PATIENTS ATTENDING THE DENTAL DEPARTMENT AT KING FAISAL HOSPITAL, KIGALI, RWANDA : A PRELIMINARY STUDY

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### ABSTRACT

**Introduction:** Palatal rugoscopy is the study of palatal rugae pattern. Rugae pattern remain unchanged during an individual's life time. Personal identification can be possible based on the rugae pattern since palate would remain intact till 7 days after death, due to their internal position in the head when most other anatomical structures are destroyed or burned. Rugae pattern is as unique to a human as his or her fingerprints.

**Objectives:** The purpose of the study was to identify the palatal rugae patterns in Rwandan patients attending the Dental Dept at King Faisal Hospital, Kigali, Rwanda and to find sexual differences if any.

**Methods:** 114 maxillary study models of 51 males and 63 females were randomly obtained from the Dental Clinic of King Faisal Hospital, Kigali, Rwanda, and from the Dental Clinic of Polyclinique La Medicale, Kigali, Rwanda. Different types of rugae patterns and their orientation in relation to the mid-palatal raphe were evaluated.

**Results:** The study revealed that although there were some significant differences in the pattern and orientation of rugae in both genders and on both sides of palate, there was no significant sexual dimorphism regarding the total number of rugae. The females showed more of the wavy type of rugae, while males had curved type. Their orientation was also found to be significantly different in both the genders.

**Conclusion:** It can be concluded that different rugae patterns and rugae orientation are present which show sexual dimorphism among the Rwanda population. But further studies are needed to corroborate these findings. Rugae pattern can be used as an additional method of identification in forensic science.

**Keywords:** Palatal Rugae - Rwanda - Orientation - Forensic - Rugoscopy

### RESUME

**Introduction:** La rugoscopie palatine est une étude de dessin du rugae palatal. Le dessin du Rugae reste inchangé pendant le temps de vie d'un individu. L'identification personnelle peut être possible basée sur le dessin du rugae puisque le palais resterait intact jusqu'à 7 jours après la mort, en raison de leur position intérieure dans la tête quand la plupart des autres structures anatomiques sont détruites ou brûlées. Le dessin du Rugae est aussi unique comme dans le cas des empreintes digitales.

**Objectifs:** le but de l'étude était d'identifier les dessins des rugae palataux chez les patients Rwandais consultant le Service Dentaire de l'Hôpital Roi Faisal du Rwanda, et de trouver des différences sexuelles.

**Méthodes:** 114 modèles d'étude de maxillaires de 51 sujets masculins et de 63 sujets féminins ont été au hasard obtenus de la Clinique Dentaire de l'Hôpital Roi Faisal du Rwanda et de la Clinique Dentaire de la Polyclinique La Medicale de Kigali au Rwanda. Les différents types de dessins du rugae et de leur orientation par rapport au milieu de raphe palatal ont été évalués.

**Résultats:** L'étude a révélé que bien qu'il y ait quelques différences significatives dans le dessin et l'orientation du rugae dans les deux genres et sur les deux côtés de palais, il n'y avait aucun dimorphisme sexuel significatif quant au nombre total du rugae. Les sujets féminins ont montré plus de type ondulé du rugae, pendant que les sujets masculins avaient un type courbé. Leur orientation a été aussi trouvée pour être de façon significative différente dans les deux genres.

**Conclusion:** Il peut être conclu que de différents types de dessins du rugae et une orientation du rugae sont présents et montrent le dimorphisme sexuel parmi la population Rwandaise. Mais d'autres études sont nécessaires pour corroborer ces conclusions. Le dessin du Rugae peut être utilisé comme une méthode supplémentaire pour l'identification en médecine légale.

**Mots clés:** Rugae Palatal - Rwanda - Orientation - Légale - Rugoscopy

### INTRODUCTION

According to the Glossary of Prosthodontics, rugae are anatomical folds, the irregular fibrous connective tissue located on the anterior third of palate behind the incisive papilla [1]. Palatal rugoscopy is the study of palatal rugae. Rugae patterns have been studied for various purposes mainly in the fields of anthropology, forensic science, prosthodontics and orthodontics [2, 3]. Rugae can be used as reference landmark in various dental treatment

modalities. In forensic medicine, the main methods of identifications used are the DNA test, retina, fingerprints and dental characteristics. DNA testing is the gold standard in forensic science but it is very costly and cannot be conducted for everybody. In many instances, one or all of these methods may not be totally effective or conclusive. Many criminal investigations and victims of aircraft accidents have been identified by their dentition. Thus the use of human palatal rugae has also been suggested as an alternative method of identification. Forensic odontology involves participation of a dental surgeon in assisting legal and criminal issues<sup>4</sup>.

Rugae are not damaged from trauma due to their internal

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position in the oral cavity and are insulated from heat by tongue and buccal fat pads [5]. In one study, it was reported that no two palates are alike in their configuration and that the palatal print did not change [6]. In twins also, the studies indicated that the patterns may be similar but not identical [4].

The pattern of orientation of rugae is formed by 12th to 14th week of prenatal life and remains stable throughout the life, until the oral mucosa degenerates, up to 7 days after death [7], & thus can be utilized for personal Identification [5].

At birth, the palatine rugae are well-formed, and the pattern of orientation typical for the person is present [8]. Palatine rugae can also be used as internal dental-cast reference points for quantification of tooth migration in cases of orthodontic treatment [9]. In a study conducted by Grove [10], the first anterior ruga was found to be distributed on both the anterior and posterior sides of the baseline (passing through the distal contacts of maxillary canines), by about 1 mm, thus the first ruga can be used as a landmark in prosthodontics and orthodontic treatment. They have been found stable in position even after the orthodontic treatment involving premolar extractions and then the retraction of anterior teeth [3,11].

### **Literature review**

Research has shown that anatomical position of rugae remains stable & it retains its shape throughout life [12]. No two palates are alike in their configuration and that the characteristic pattern of the palate does not change as a result of growth [5].

The number of rugae on each side of the palate varies between three and seven. The shape, length, number, orientation and inclination of rugae to the sagittal plane can differ markedly between the left and right sides of the same person and vary considerably among people. In general, no bilateral symmetry exists in the rugae pattern [13]. With the growth of anterior palate, the length of rugae and the distance between them increase, but the pattern of their orientation remains unchanged throughout life [12]. Research has found that characteristic pattern of palatal rugae did not change with growth, remaining stable from time of development until the oral mucosa gets degenerated after death [14,15, 16].

Rugae pattern has been found to be different in different populations, races and ethnic groups, which may be due to genetic differences. Thomas and Kotze found different rugae patterns in Southern African populations implying different genetic origins [17-21]. Different rugae patterns were found in two Indian populations, with no sexual dimorphism [22] while another study done on Western Indian population revealed significant differences between the genders regarding types and number of rugae [22]. A study done in Egypt has shown that rugal pattern was sex and age independent; was not affected by the presence or absence of teeth; and remained stable during the age [24]. Dohke and his coworkers found significant differences in rugae pattern in Japanese population [25]. Thus, the differences exist in the rugae patterns in different populations around the world.

Their uniqueness to individuals has been recognized in forensic science as providing a potentially reliable source of identification [4,5]. Computerized software has also

been developed and used to evaluate the palatal rugae patterns for forensic identification [26]. Thus it may help to keep the computerized records of rugae pattern of important personalities, criminals etc. Permanent records of rugae pattern are essential which can be done by scanning, digitizing and preserving as computer records. Thus, rugoscopy can be a method for use in the forensic odonto-stomatology and in medico-legal aspects.

On review of literature, no study describing the rugae pattern of the population of Rwanda origin, or even any East African country could be found. This prompted us to conduct a preliminary study with the aim of finding the rugae pattern in the people of Rwanda.

### **Objectives**

- To evaluate the palatal rugae pattern in patients who attended the King faysal Hospital during the study period.
- To find out any sexual dimorphism in rugae pattern.

### **METHODS**

#### **Study design**

It was an observational, quantitative, cross sectional, descriptive study.

#### **Null Hypothesis**

There is no difference between males and females in rugae pattern and the orientation of rugae.

#### **Materials**

Maxillary dental casts / models made for the purpose of making removable orthodontic appliances & for pre-treatment orthodontic records were used for the study. The casts were obtained from Dental Department of King Faisal Hospital, Kigali, Rwanda & supplemented by the casts obtained from the Dental Clinic of Polyclinique La Medicale, a private polyclinic in Kigali, Rwanda. The casts were made of Type II dental stone after taking impression in irreversible hydrocolloid material. Maxillary casts of 51 males and 63 females between the age range of 10 – 30 years, were randomly selected and cleaned of any air bubbles or nodules to demarcate the rugae & mid-palatal raphe properly.

#### **Selection Criteria**

- Following criteria were used for selection of study casts.
- Only casts with permanent dentition were chosen.
  - The casts were clean and with full palatal details esp up to first molar region.
  - Casts showing cleft, congenital anomalies/malformations, previous orthognathic surgery, bony and soft tissue protuberances, active lesions, deformity or scars and trauma of the palate were not selected.
  - They had no history of previous orthodontic treatment

#### **Ethical considerations**

The study was approved by the Ethics Research Committee, RBC/King Faisal Hospital, Kigali, Rwanda. All the casts were given serial numbers to maintain the anonymity of

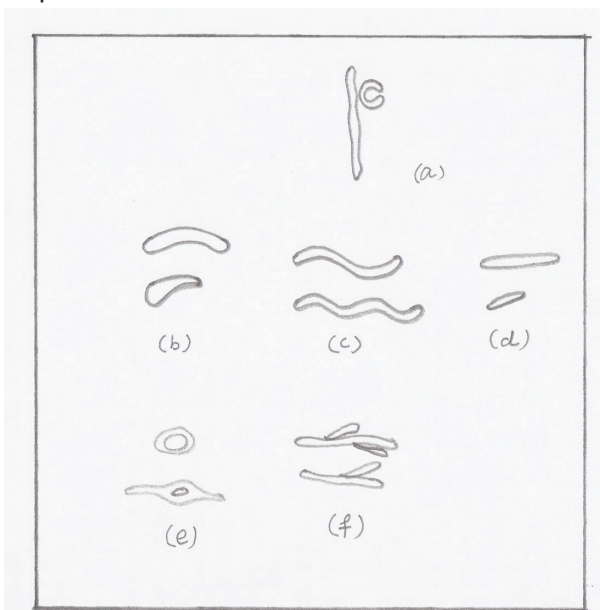
the subjects.

### Study Tool & Data Collection

Following parameters were recorded during the analysis of the casts.

- Types & number of the rugae on left and right side of the palate
- Direction or orientation of rugae on left and right side of palate in relation to mid-palatal raphe.

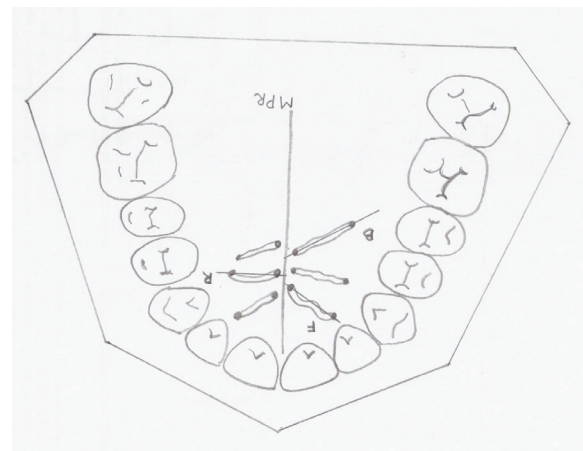
The method of rugae identification was based on the classification of Thomas et al (1983) [17, 18] & modified by including furcated rugae [5]. Thus, the shapes of individual rugae were classified into six major types viz. curved, wavy, straight, converging, circular, and furcated. In this study, the fragmented type of rugae of a size less than 5 mm was ignored [4]. Converging rugae are those where two rugae originate away from the centre and tend to unite towards its ends. Straight types ran directly from their origin to termination. The curved type had a simple crescent shape which curved gently. The basic shape of the wavy rugae was serpentine. Circular rugae were those which showed a definite continuous ring formation. Furcated rugae were having additional branches originating from the main body (Fig.1). The rugae were highlighted with a lead pencil for easy interpretation. (Fig 2). Type & number of rugae on both sides of palate in both genders was noted separately, and pooled also. The direction of each rugae was determined by observing the angle between the line joining its origin and termination and a line perpendicular to the mid-palatal raphe. Forward-directed rugae were associated with acute angles, backward-directed rugae with obtuse angles, and perpendicular rugae with angles of 90 degrees [27] (Fig 3). This data was also recorded for both genders for both sides of the palate separately and then pooled.



**Figure 1:** showing the different types of rugae patterns: (a) converging; (b) curved; (c) wavy; (d) straight; (e) circular; (f) furcated



**Figure 2:** showing the highlighting of rugae on the cast with lead pencil



**FIGURE 3:** showing the orientation of rugae in relation to (MPR) midpalatal raphe. (F) forward; (R) right angle; (B) backward

### Statistical Analysis

Total number of different types of rugae was counted for both the sides in both genders and then pooled also. Mean and standard deviation was calculated for total rugae numbers. The frequency was calculated as the percentages of each type of rugae in different categories. Two-sample t-test and chi square tests were performed. A significance level of 5% was considered as critical value. Microsoft excel was used to calculate mean, S.D, and t-test.

### RESULTS

The results obtained are compiled in the Tables 1 – 8; and graphical representation of data in Charts 1 – 11. Null hypothesis was accepted for number & pattern of the rugae pattern, while it was rejected regarding the orientation of rugae pattern in relation to midpalatal raphe.

Mean value of total number of rugae was 7.6 in males and 7.5 in females, with no significance difference. Mean

number of rugae were more on left side as compared to right side in both the genders. Also, in both genders, the wavy rugae were most common, followed by straight, curved, furcated, converging and circular in that order. Mean value of wavy rugae were more in females than males, while curved rugae were more in males than females. There was no significance difference between males and females in any type of the rugae pattern (chi square value 4.72, DF = 2; p <0.05; critical value = 5.99). Regarding the side distribution, in males, the wavy, circular, and furcated rugae were more common on left side, while straight were more common on right side of palate. In females, wavy rugae were more common on right side while furcated rugae were common on left side. But there was not statistical difference regarding types of rugae pattern in males and females for left and right sides compared (Table 7).

**Table 1:** Showing the gender and side distribution of total number of rugae, and their mean values

	Males (n = 51)			Females (n = 63)		
	Right	Left	Total	Right	Left	Total
Total rugae	187	200	387	218	252	470
Mean	3.67	3.92	7.6	3.46	4.0	7.5
S.D	0.91	0.82	1.512	0.82	1.05	1.664

**TABLE 2:** Showing Types Of Rugae On Right And Left Sides & Pooled Data In Both Genders And Their Percentages

Types of rugae	Male		Female		Total		Male		Female		Total	
	es	ge	es	ge	al	ge	es	fe	es	le	fe	al
Converging	8	4.28	8	4	16	4.13	9	4.1	11	4.4	20	4.3
Wavy	86	46	97	48.5	183	47.3	109	50	118	46.8	227	48.3
Curve	29	15.5	33	16.5	62	16	33	15.1	39	15.5	72	15.3
Straight	50	26.7	35	17.5	85	22	48	22	56	22.2	104	22.1
Circular	5	2.67	10	5	15	3.9	8	3.7	10	4	18	3.8
Furcated	9	4.81	17	8.5	26	6.7	11	5.1	18	7.1	29	6.2
Total=	187		200		387		218		252		470	
857												

**Table 3:** Showing Pooled Sample Of Rugae in both genders

Types of rugae	Total males	Total females	Pooled sample	%age	Relative Frequency
Converging	16	20	36	4.2	1.1
Wavy	183	227	410	47.84	12.4
Curve	62	72	134	15.63	4
Straight	85	104	189	22	5.7
Circular	15	18	33	3.85	1
Furcated	26	29	55	6.4	1.7
Total	387	470	857	100	

Chi square = 0.2048; DF = 5; non – significant (Males vs Females)

**Table 4:** Showing Direction / Orientation Of Rugae (Pooled Sample)

Direction	Total rugae, 857	%age	Relative Frequency
Forward	379	44.2	2.35
Right angle	317	37	1.97
Backward	161	18.8	1.0

**Table 5:** Showing Direction / Orientation Of Rugae (In Males And Females)

Gender	Males total rugae, 387	Males %	Females total rugae, 470	Females %
Direction				
Forward	187	48.3	192	40.8
Right angle	131	33.9	186	39.6
Backward	69	17.8	92	19.6

**Table 6:** Showing Direction / Orientation Of Rugae (Right And Left Sides Of Palate In Males And Females)

Gender	Male	Male	Male	Male	Female	Female	Female	Female
Direction	s	s	s left	s left	s right	s right	s left	s left
n	right,	right	ML	%	FR	%	FL	
	MR	%	(n =		(n =		(n =	
	(n =		200)		218)		252)	
	187)							
Forward	54	28.9	133	66.5	53	24.4	139	55.2
Right angle	83	44.4	48	24	102	46.8	84	33.3
Backward	50	26.7	19	9.5	63	28.4	29	11.5

MR vs ML (chi sq 56.5; DF 2; Highly significant; Critical value = 5.99); FR vs FL (chi sq 50.47; DF 2; Highly

significant; Critical value = 5.99); MR vs FR (chi sq 1.1; DF 2; Non significant; Critical value = 5.99); ML vs FL (chi sq 6.13; DF 2; H.S; Critical value = 5.99; significant).

**Table 7:** showing comparison between genders and sides regarding the rugae pattern

	t- value	P value	Significance
Males right vs Males left	0.1404	0.8886	NS
Females right vs Females left	0.00147	0.9988	NS
Males right vs Females right	0.1947	0.8459	NS
Males left vs Females left	0.6549	0.5139	NS

When the orientation / direction of rugae was analyzed, it was found that in both genders, forward – directed rugae were maximum in number, followed by right – angled and backward directed rugae. But there was no statistical difference among the genders regarding orientation of rugae (chi square value 4.87; DF = 2; P-value 0.0876;  $p < 0.05$ ; critical value = 5.99) (Table 8). Also, the mean value of forward directed rugae were more in males than females on both the sides, while right – angled and backward directed rugae were more in females on both sides as compared to males. When the sides were

**Table 8:** showing comparison between genders and sides regarding the orientation of rugae in relation to mid palatal raphe

	Chi square value	Degree of freedom	P value	Significance
Males vs Females	4.87	2	0.0876	NS
Males right vs Males left	56.5	2	0.0	Highly Significant
Females right vs Females left	50.47	2	0.0	Highly Significant
Males right vs Females right	1.1	2	0.577	NS
Males left vs Females left	6.13	2	0.047	Significant

(Critical value = 5.99); NS = non –significant

considered, then in both genders, forward directed rugae were more on left side than the right side, while right – angled and backward directed rugae were more on right side than left side.

There were highly significant differences between left and right sides in both genders regarding the rugae orientation (Chi square value 56.5 in males; 50.47 in females; DF = 2,  $p$  –values = 0.0). Also, significant difference was present when males left side was compared with females left side (Chi square value 6.13; DF = 2,  $p$  –values = 0.047;  $p < 0.05$ ; critical value = 5.99); but there was non-significant difference for the right side (Chi square value 1.1; DF = 2,  $p$  –values = 0.577;  $p < 0.05$ ; critical value = 5.99) in both the genders (Table 8).

## DISCUSSION

The study of maxillary dental cast is the most commonly used technique [3-5], because dental casts have the advantages of simple analysis, reduced cost; and direct intra-oral observation may lead to errors, & also the casts are easily available in each dental setting. The method to study rugae types used in this study (Thomas et al, 1983) [17-20] was found to be the most practical and easiest to apply. Post-orthodontic treatment casts were not taken since some changes in orientation of lateral margin of rugae has been found [3].

The mean number of total rugae was almost the same in males (7.6) and females (7.5) without any significant difference in this study. This finding is consistent with the finding of a study done on Saudis [4, 27] regarding the mean number of rugae & sexual similarity; but it conflicts with the finding on Japanese [25] where females had fewer rugae than males. This may be due to the fact that rugae of less than 5 mm size were not included in the present study, while Dohke [25] had considered such rugae in their study.

In the present study, the wavy rugae were most common followed by straight rugae in both the genders. It is different from other studies where curved form was found to be more common [5, 22]. Kapali and colleagues [27] studied the palatal rugae pattern in Australian Aborigines and Whites. They concluded that the mean number of primary rugae in Australian Aborigines was higher than that in Whites depicting racial differences. Also the most common shapes in both ethnic groups were wavy and curved forms, while straight and circular forms were least common.

In this study, the mean number of rugae was found to be more on left side of the palate as compared to right side in both the genders. This observation is same as found by Dohke [25] who reported fewer rugae on the right side of the palate than the left in Japanese. These authors claim that this was due to the phenomenon of regressive evolution dominating the right side of the palate and being more evident in females. But in the study conducted by Shetty & colleagues [28] on Indian and Tibetan populations, they found that males had more rugae on the right side than on the left side in both populations.

The present study found that wavy form was more in females than males, while curved form was more in males than females. Also, males showed wavy, circular and furcated rugae on left side, while straight rugae on right side. On the other hand, females showed more furcated

rugae on left side and wavy on the right side of palate. Such pattern is different from other studies where converging type was found to be significantly higher in females while the presence of the circular type was found to be significantly higher in males [4,29]. Other studies conducted on Indian subgroups [22,23,28-30], Australian Aborigines and Caucasians [27]; & Japanese [25] show differences in rugae patterns in genders and sides of palate. E.g. Indian subgroups showed wavy pattern was predominant, followed by curved and then straight [30]. Also, the right side showed a significantly more number of straight rugae in males from Madhya Pradesh, whereas wavy pattern was predominant in Keralite males [22]. Kapali et al. (1997) [27] in their study on Australian Aborigines and Caucasians, found the most common shapes in both the ethnic groups were wavy and curved, whereas straight and circular were least common. Thus, there exist racial differences in the rugae patterns even within the population subgroups of same country. Shetty and colleagues [28] found that Indian males had more primary rugae on the left side than females and vice versa for the Tibetan population, and Indian males had more curved rugae than Tibetan males [28]. It can therefore be concluded that rugae patterns vary among the populations and can play a role in population differentiation.

Regarding the orientation of rugae, the present study revealed that forward directed rugae were the maximum (44.5%), followed by right angled (36.4%), and backward directed (19.1%) rugae in the pooled sample, and the same pattern was present in both the sexes. Also, the forward directed rugae were more common on left side, while right angled and backward directed rugae were more common on right side of palate in both genders. Further to note, the forward directed rugae were more in males on both sides, while right angled and backward directed were more common in females on both sides. However, no data on direction of rugae could be found in literature except that Kapali et al [27] found that 53 % rugae moved backwards in their longitudinal sample of Australian Aborigines, while Lysell [31] had suggested the decrease in backward orientation of rugae with age. So, further studies in different races may be needed to establish the orientation of rugae.

## CONCLUSION

It can be concluded that the rugae patterns & orientation differ among the Rwandan patients and also show a sexual dimorphism. But further studies are needed to corroborate these findings. Also, the rugae patterns differ among the different population around the world & genders, & thus the mapping of rugae patterns can be of a great help in forensic sciences.

Although some differences have been noted in the rugae pattern of both genders in the present study, but these findings cannot be extrapolated to whole population of the country due to small sample size, so there is a need of further studies with larger sample & multi-centric involvement.

Since differences exist in the rugae pattern of different populations as found in other studies, therefore, a

standard and uniform procedure needs to be accepted at international level for future studies for the collection of data, recording and computerized analysis of the palatal rugae, esp of criminals, prisoners and VIPs. Computerized recording will be the best if it can be included from the beginning of the study.

Computer software program can be developed to record the rugae patterns & for their permanent storage to create a national data base. Development of an intraoral scanning device to capture the rugae pattern, with image transferred directly to computers, with appropriate software can be developed, as is presently available for fingerprints. This would eliminate the manual errors as well as time involved in the process of categorization of rugae pattern. With the use of centralized servers, it would be possible to capture & store a large amount of data from multiple centers nationwide, facilitating quick retrieval of information to assist with faster and more effective identification [32].

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