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Analysis of palatal rugae in males and females of an average age of 35 in a population from Bosnia and Herzegovina (Sarajevo Canton)

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ABSTRACT

The goal of this study is to identify and compare palatal rugae patterns in males and females of an average age of 35 in a sample population from Bosnia and Herzegovina (Sarajevo Canton), as an additional method for sex differentiation in various situations. The research did not determine any statistically significant difference in the total number of palatal rugae between the sexes, which is in line with previous research. However, in the case of the number of secondary palatal rugae where the probability of an equal average is slightly higher than the tolerance of 5%, the difference being 7.6% which may indicate that secondary palatal rugae are more common in women. However, logistic regression analysis LRA is still more successful in classifying males, 69% of them, while for women the success rate is significantly lower with only 41%. In total, 55% of subjects were correctly classified. It may be concluded that using LRA in palatal rugae could be used as an additional sex differentiation method for the population of Bosnia and Herzegovina.

1. Introduction

In situations of mass deaths any help in forensic methods is welcome. Forensic odontology attempts to help in identifying victims by introducing new and improved old methods. The idea is to overcome shortcomings of comparative identification which is basically identification of a deceased person using dental records which are often not up to date.[1–4]

characteristics of palatal rugae such as uniqueness and stability make them convenient for forensic identification of victims.[2,5]

At birth, palatal rugae have typical orientation and location which remain the same over the entire lifetime. The growth process only changes the length of the rugae.[6]

The special feature of the palatal rugae, being the soft tissue, is their specific anatomic position within the oral cavity where they remain protected from high temperatures or severe physical trauma.[7] They are, therefore, known as the most protected morphologically individual soft tissue that remains preserved longer after death, and is easily accessible over the entire lifetime.[7] These are the reasons why attempts are being made to use this particular characteristic of palatal rugae in forensics.[8]

Palatal rugae are particularly useful in identification of a toothless person. There are some indications on sex-related and regional variation in palatal rugae patterns.[9] These were the facts that led us engage in this research, in order to examine the role of palatal rugae in differentiation between sexes in a B&H population from the Sarajevo Canton noting that this type of research had not been performed in Bosnia and Herzegovina before.

2. Materials and methods

This prospective research included 250 patients of which 127 were men and 123 women aged between 20 and 40. All the patients were citizens of Bosnia and Herzegovina residing in the Sarajevo Canton who met the following inclusion criteria:

- Patients with various forms of dentition
- Patients with a permanent dentition
- Patients with mobile prosthesis

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The study did not process any patients with severe congenital anomalies or systemic diseases.

Before joining the study, each patient had to sign a consent form expressing their voluntary participation in the research. After basic anamnesis information on the patients were recorded, an imprint of the upper jaw was taken from each patient (using the impression material - alginate "Hydrogum" manufactured by Zhermack Clinical) and then casted in gypsum ("Elite model" manufactured by Zhermack Technical). The prominent palatal rugae, median palatal suture and papillae incisiva cast were marked with a pencil on the gypsum model and then photographed using an Olympus FE-130 camera (Fig. 1).

The length of the palatal rugae, width of palatal rugae, the distance between the palatal rugae and the median palatal suture and distance between the palatal rugae and the papilla incisiva were measured using VistaMetrix® 1.38 computer programme (Fig. 2.). Categorisation of rugae according to Lysel and Lima was performed.[10] All the measures were taken by the same person, however, 20 randomly chosen models were evaluated by a different person (*intra-observer variation*) without showing any significant differences in interpretation.

2.1. Statistical analysis

The data read were organised in a form suitable for statistical analysis. The association between the number of palatal rugae according to their location (left or right), and the number of those categorised using Lysell and Lima criteria was tested using Mann–Whitney test. Logistic regression analysis (LRA) was used to test the possibility of prediction of sex according to the number of palatal rugae and their location, and the number of those according to Lysell and Lima categories as predictors. Analyses were made using software pack for data analysis PASW Statistics 18 software pack for data analysis.

3. Results

3.1. Total number of palatal rugae in males and females

Total number of tested subjects with average values of their age and total number of palatal rugae, divided according to the sex showed that men and women were on average 35 years old with almost the same number of palatal rugae (Table 1).

3.2. Distribution of the number of right and left palatal rugae in subjects categorised according to their sex

Mann–Whitney test analysis showed no statistically significant difference in the distribution of the number of right and left rugae in male and female patients (Table 2).

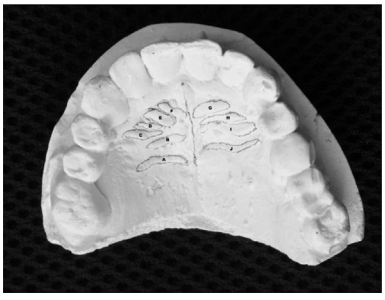

Fig. 1. Palatal rugae tracing and marking.

Fig. 2. Palatal rugae measuring.

Table 1
Total number of subjects and total number of rugae in males and females.

Sex	Number of subjects	Age		Number of rugae
		Mean	St. dev.	
Males	127	35.06	15.01	737
Females	123	34.95	14.96	724
Total	250	35.01	14.95	1461

Table 2
Descriptive statistics numbers of rugae per subject categorized by sex.

Rugae	Sex	Number of subjects	Mean	St. dev.	Median	p-value[a]
Right	Males	127	2.85	0.93	3	0.831
	Females	123	2.89	0.88	3	
	Total	250	2.87	0.90	3	
Left	Males	127	2.95	1.02	3	0.797
	Females	123	3.00	1.02	3	
	Total	250	2.98	1.02	3	
Right and left	Males	127	5.80	1.72	6	0.929
	Females	123	5.89	1.77	6	
	Total	250	5.84	1.74	6	

[a] Mann–Whitney Test.

3.3. Analysis of the palatal rugae number according to Lysell

Mann–Whitney test analysed the number of palatal rugae according to Lysell and showed no statistically significant differences between males and females (Table 3).

3.4. Analysis of the number of palatal rugae according to Lima

Mann–Whitney test analysis of the number of palatal rugae according to Lima has shown no statistically significant difference between sexes (Table 4).

Table 3
Descriptive statistics numbers of rugae per subjects categorized by Lysell by sex.

Type of rugae by Lysell	Sex	Number of subject	Mean	St.dev.	Median	p-value[a]
Primary (5 mm and more)	Males	127	5.31	1.60	5	0.333
	Females	123	5.13	1.58	5	
	Total	250	5.22	1.59	5	
Secondary (3–5 mm)	Males	127	0.47	0.91	0	0.076
	Females	123	0.73	1.21	0	
	Total	250	0.60	1.07	0	
Fragmented (2–3 mm)	Males	127	0.02	0.12	0	0.626
	Females	123	0.02	0.15	0	
	Total	250	0.02	0.14	0	

[a] Mann–Whitney Test.

Table 4
Descriptive statistics of the numbers of rugae per subject categorized by Lima by sex.

Type of rugae by Lima	Sex	Number of subject	Mean	St.dev.	Median	p-value[a]
Straight	Males	127	0.78	1.06	0	0.261
	Females	123	0.98	1.25	1	
	Total	250	0.88	1.16	0	
Wavy	Males	127	3.20	1.93	3	0.413
	Females	123	2.98	1.75	3	
	Total	250	3.10	1.84	3	
Curvy	Males	127	1.46	1.04	1	0.671
	Females	123	1.46	1.24	1	
	Total	250	1.46	1.14	1	
Circular	Males	127	0.36	0.76	0	0.131
	Females	123	0.46	0.75	0	
	Total	250	0.41	0.76	0	

[a] Mann–Whitney Test.

3.5. Prediction of sex based on the number of right and left rugae, and the number of rugae categorised according to Lysell and Lima

According to the results concerning the difference between the numbers of palatal rugae between the sexes LRA did not produce any statistically significant predictors (Table 5).

Logistic regression analysis (LRA) was performed in order to predict sex, and it was based on the number of right and left rugae, the number of primary and secondary rugae (categorisation by Lysell) and the number of straight, wavy, and curved rugae (categorisation by Lima). The analysis did not show any statistically significant difference, however, it should be noted that the number of fragmented and circular rugae was excluded due to redundancy. Therefore, LRA did not produce any statistically significant predictors (Table 5). In fact, -2 Log Likelihood slightly decreased compared to the initial model and shows 341.02, Goodness of Fit 249.69, Cox & Snell R2 only 2.2%, similar to Nagelkerke R2 which is 2.9%. However, the resulting logistic regression models were still more successful in detecting males (69%), with significantly poorer results in the case of females with only 41%. In total 55% of subjects were categorised successfully (Table 6).

4. Discussion

In the field of forensic dentistry, palatal rugoscopy is still very young discipline.[11] Compared to more sophisticated and advanced methods such as isolating DNA from the pulp, dentine and cement for the purpose of identification, this method is simple and economically viable.[12]

Various criteria used in research to categorise palatal rugae have been described.[10,12,13]

The link between the number of palatal rugae and sex of the subject has been the focus of interest of many authors. For instance, Kapali et al. did not find any statistically significant difference between the numbers of primary palatal rugae in Aborigine males and females, or in males and females of Indian origin.[14] Dohke and Osato, in their research of Japanese population, indicated that female patients have somewhat more rugae that male patients. The reason behind this result is in the fact that secondary and fragmented rugae were excluded from the research.[15]

Shilpa et al., in their research on the use of palatal rugae in forensics, found significant differences in the numbers of rugae between males and females, in favour of females.[8] A significant difference was detected by the same authors concerning the shape of rugae (wavy and curved), while there was no statistically significant difference in the case of the straight type of rugae. No statistically significant differences between sexes were found in case of circular, convergent or divergent rugae either.[8]

Shilpa et al. have also found a statistically significant difference between males and females in the length of palatal rugae of <3 mm and rugae 5 to 10 mm long, but the finding remains unsupported by other studies.

The results of the study conducted by Selvamani et al. showed a statistically significant difference in the number of palatal rugae in Kerala population of both sexes, in favour of the females. Analysis of the length of palatal rugae in this population did not show any statistically significant difference between males and females. Analysis of the location of palatal rugae of the Kerala population also showed no differences between males and females, while the analysis of different shapes of palatal rugae showed a statistically significant difference between males and females.[16]

The results of our study are in line with the results of Kapali et al., where no statistically significant difference was found in the number of palatal rugae between males and females. The presented literature shows that majority of other authors found statistically significant difference between males and females concerning various characteristics of palatal rugae (number, shape, length). Bearing in mind that the research was mainly performed on subjects from an Indian population, it is likely that the results are closely related to race and probably genetic predisposition. The possible genetic coding behind a certain type of rugae is described in the study by Saxena et al. which found a significant difference in certain characteristics of palatal rugae (number, length, shape, direction) between transgender persons, both males and females.[11]

Thomas and Kotze have noticed that, in general, primary rugae are more often the subject of research although they lack prominent discriminatory characteristics in different human populations.[17] It appears that further research should focus on secondary and fragmented rugae and their role in differentiating sexes and ethnic groups.[18] In addition, Nayak et al., in their study of population differentiation, used the shape of palatal rugae as a variable, and therefore mentioned that the purpose is better served by using discrete variables such as the shape of palatal rugae rather than continuous variables such as the length of palatal rugae. The results of their study showed no statistically significant difference in the length of the rugae between sexes, while the difference was statistically significant in case of the shape of the rugae, implying that the shape of the rugae is more useful for sex differentiation.[19]

Our research did not show any sex-related differences in the tested parameters except perhaps in the number of secondary skin

Table 5
Regression coefficients of all number of rugae.

Categorization	Number of rugae	Regression coefficient (b)	p-value
Total	Right	0.0943	0.929
	Left	0.0851	0.933
by Lysell	Primary	−0.0611	0.954
	Secondary	−0.3166	0.769
by Lima	Straight	−0.0936	0.698
	Wavy	0.0385	0.867
	Curved	−0.0175	0.942
	Constant (a)	0.0024	0.996

Table 6
Predictive value using all numbers of rugae.

Actual group	Predicted value		Total number	Correct percentage
	Male (127)	Female (123)		
Male	88	39	127	69%
Female	72	51	123	41%
Overall				55%

rugae where, with an error of 7.6%, it may be concluded that females more frequently show secondary palatal rugae.

In an attempt to predict sex based on the characteristics of palatal rugae, a large number of researchers used Logistic regression analysis (LRA). Acharya et al. in their research of odontometry in sex prediction indicated benefits of the LRA analysis compared to the DFA analysis (Discriminant Function Analysis).[20] LRA analysis was used by Saraf et al. with the intention of testing the possibilities of sex differentiation based on the palatal rugae scheme. LRA showed a high level of accuracy (99.2%) in differentiating sexes using palatal rugae shape. In practice, this would mean that palatal rugae schemes may be used for correct differentiation of the subject's sex with reliability of 99%. Therefore, according to the research by Saraf et al. the shape of palatal rugae can be extremely useful in predicting sex.[18]

Our LRA analysis did not resulted in statistically significant predictors, and therefore it is insignificant in differentiating sexes within the BH population.

5. Conclusion

According to the results of the analysis of sex-related differences using Mann–Whitney test, males and females of average age of 35 do not show any statistically significant differences in those variables. No differences in the number of palatal rugae in both sexes in the categories proposed by Lysell were not found either, except perhaps in case of the number of secondary palatal rugae where probability of an equal average is slightly above the tolerable error of 5%. It may be claimed that secondary palatal rugae are more frequent in females. The description of palatal rugae by Lima here too shows no statistically significant differences between males and females.

Logistic regression model is still more successful in determining males, then females.

Conflict of interest
None declared.

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Ethical approval
None declared.

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