GUHES 2024; 6(2); 63-72
DOI: 10.59124/guhes.1441851

Research Article

Journal of Gazi University Health Sciences Institute

journal homepage: https://dergipark.org.tr/tr/pub/guhes

Evaluation of The Palatal Ruga Morphologies of Young Adult Individuals Attending A Dental School in Turkey

Arzu Zeynep Yıldırım[1], Senem Unver[2], Filiz Kardiyen[3], İlkay Peker[4]

[1] Gazi University, Department of Prosthodontics, Ankara, Türkiye
[2] Private Dental Klinik, Ankara, Türkiye
[3] Statistics Consulting, Training, Practice and Research Center, Ankara, Turkey
[4] Gazi University, Department of Oral and Maxillofacial Radiology, Ankara, Turkey

Article info:

Received: 23.02.2024
Accepted: 11.07.2024

Keywords:

ethnicity
forensic
gender determination
palatal rugae
rugae pattern

Abstract

The aim of this study is to evaluate the change of palatal rugae morphology. The dental plaster models of 232 (133 females and 99 males) individuals aged between 18-40 years (mean age ± standard deviation: 32.3 ± 5.4) were examined to evaluate palatal rugae morphology. The length, shape, and direction of rugae were recorded. Types for length, shape, and direction were compared with Friedman and Wilcoxon's signed rank tests regarding the number of occurrences. The differences between genders were assessed using the Mann–Whitney non-parametric tests. Primary ruga type is 5 to 10 mm / 10 mm or more. The most common rugae was the primary type and no significant difference was found in terms of rugae length by gender. The most common rugae was curved rugae. No significant difference was found between genders. The results of this study showed that no statistically significant differences were found between genders for the length and direction of rugae.

Arzu Zeynep Yıldırım **(Corresponding author):** ORCID: 0000-0002-9332-8982, e-mail: dtzeynep@yahoo.com
Senem Ünver, ORCID: 0000-0001-5565-1167, e-mail: dtsenemuysal@hotmail.com
Filiz Kardiyen, ORCID: 0000-0002-8730-2751, e-mail: fyuva@gazi.edu.tr
İlkay Peker, ORCID: 0000-0002-2888-2979, e-mail: drilkaypeker@gmail.com

Citation: Yıldırım, A. Z., Unver S., Kardiyen F., & Peker, I. (2024). Evaluation of the palatal ruga morphologies of young adult individuals attending a dental school in turkey. *Journal of Gazi University Health Sciences Institute*, 6(2), 69-78. https://doi.org/10.59124/guhes.1441851

1. Introduction

Forensic medicine plays a very important role in criminal and civil law. In this context, the science of dentistry is also used in human identification. This branch of science is known as forensic dentistry and forensic odontology (Gadicherla et al., 2017). Determining the age, gender, and ethnicity of people is difficult, especially in mass disasters (Sheikhi et al., 2018).

Ethnicity is defined as a category of people who identify with one another based on similarities such as common ancestry, language, social, cultural, or national experiences (Peoples & Baley, 2011). The most common identification methods used include visual identification, fingerprinting, dental record comparisons, and D.N.A. (deoksiribonükleik acid) profiling (Muthusubramanian et al., 2005; Saraf et al., 2011). These techniques are reported to have some limitations (Buchner, 1985; Muthusubramanian et al., 2005). D.N.A. profiling is an ideal method often used in forensic medicine. However, using it in large populations can be expensive and time-consuming (Muthusubramanian et al., 2005). Visual identification and fingerprints are methods that have limitations for post-mortem identification due to variations in time, temperature, and humidity (Morlang, 1982). In addition, these methods are useless when the body is burned or rotten (Subramanian & Jagannathan, 2015). However, it has been shown that the durability of dental tissues in these conditions has a significant advantage in terms of identification (Anderson et al., 1995; Nambiar et al., 1977).

Among the oral tissues, palatal rugae are permanent, unique to each individual, and can establish identity through discrimination (Muthusubramanian et al., 2005). Palatal rugae or transverse palatine folds are asymmetrical irregular elevations of the mucosa, which are located in the anterior third of the hard palate (Verma et al., 2014). Palatal rugae, due to their internal position, are protected from trauma and high temperatures by lips, cheek, tongue, and buccal pad of fat teeth and bone and do not demonstrate age-related changes (Muthusubramanian et al., 2005).

The aim of thissrudy is to evaluate the change of palatal rugae morphology according to gender in patients attending a dental school in Turkey.

2. Material and Methods

The human subject protocol was approved by the Ethics Committee of Gazi University, Faculty of Dentistry, Ankara, Turkey (confirmation number: 17/09/2018-E.34993-21071282-050.99-) by the Helsinki Declaration of 1975, as revised in 2013.

In this study, the palatal rugae morphology of 232 individuals aged between 18-40 years who applied to Gazi University Faculty of Dentistry for several dental treatments was evaluated. The sample size was determined as 232 with the G-power 3.1 program with a power value of 0.95, an error level of 0.05, and an effect size of 0.2.

The participants who applied to the Oral Diagnosis Clinic of Gazi University Faculty of Dentistry, Department of Dento-maxillofacial Radiology for various reasons, needed to obtain a dental plaster model due to their treatment (prosthetic rehabilitation due to tooth deficiency, parafunctional habit-preventing night plaque such as nocturnal bruxism, etc. Patients meeting the following criteria were included in the study; no systemic disease, no orthodontic treatment before, absence of missing teeth in the upper jaw, or removal of missing teeth with fixed prosthetic restorations. Participants who agreed to participate in the study were informed and written consent was obtained from volunteers. Then, master models of individuals whose upper jaws were measured as a requirement for treatment in Gazi University Faculty of Dentistry, Department of Prosthodontics, were obtained with hard plaster material. Incisive papilla and median raphe regions were marked with a pencil in the prepared plaster models and were used as anatomical landmarks. The borders of the palatal rugae on the model were drawn with a pencil to make a more precise evaluation. Palatal rugoscopy was performed according to the closed classification; in this context, the rugae on both sides were evaluated separately as the right and left, with the median raphe being the midline.

The length, shape of the rugas, and the direction of rugas recorded on the prepared special forms for the study. Rugae longer than 5 mm were defined as primary rugae, rugae between 3-5 mm long were defined as secondary rugae, and rugae shorter than 3 mm were defined as fragmentary rugae (Thomas & Kotze, 1983). The shape of the rugas was called curved, wavy, straight, and circular (Kapali et al., 1997.) (Fig. 1).

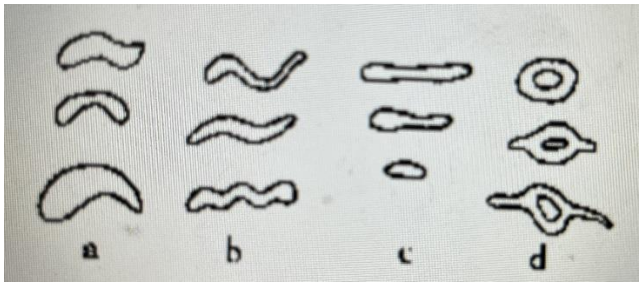

Fig.1. a) curved b) wavy c) straight d) circular

To evaluate the directions of the rugae, a line perpendicular to the median raphe was drawn according to the angle formed, those that formed a positive angle were defined as forward-looking rugae, those that created a negative angle were defined as backward-oriented rugae, and those that form 0° were defined as vertical rugae. Rugas that branch towards the midline were recorded as convergent and rugae that unite towards the midline were recorded as divergent. In line with the data obtained, it was examined whether gender and age factors affect rugae morphology (Kapali et al., 1997).

3. Results

A total of 232 people (133 females; 99 males) with a mean age of 32.3 (standard deviation 5.4) were included in the study. Test results regarding the comparison of rugae length types according to the number of occurrences are given in Table 1. Accordingly, there is a significant difference between the frequency of occurrence of ruga length types on the right ($p<0.05$) and left ($p<0.05$) sides. The most common rugae was the primary type. There is no significant difference was found in terms of rugae length by gender (Table 2) ($p > 0.05$).

Table 1. Rugae length types

Types of rugae length	Right-side Mean Rank	Left-side Mean Rank
Primary	2,76	2,85
Secondary	1,92	1,80
Fragmentary	1,32	1,34
Friedman Test		
Chi-Square	290,94	321,85
Asymp. Sig.	0,000	0,000

According to shape, the most observed rugae was curved (Table 3). Only, the distribution of a number of left side-wavy rugae differs significantly between males and females (Table 4) ($p < 0.05$). It can be said that the number of left wavy rugae was higher in males than in females.

Table 2. The relationship between rugae length and gender

Variables	Gender	Mean	SD	Median	Minimum	Maximum	Z	p-value
Right Side-Primary Rugae	**Male**	2,66	,82	3,00	1,00	4,00	-0.773	0.439
	Female	2,75	,98	3,00	1,00	5,00		
Right Side-Secondary Rugae	**Male**	1,87	1,23	1,50	1,00	8,00	-0.360	0.719
	Female	1,77	1,01	1,00	1,00	5,00		
Right Side-Fragmentary Rugae	**Male**	1,33	,65	1,00	1,00	3,00	-0.428	0.669
	Female	1,55	1,06	1,00	1,00	5,00		
Left Side-Primary Rugae	**Male**	3,13	,99	3,00	1,00	5,00	-0.348	0.728
	Female	3,22	,99	3,00	1,00	6,00		
Left Side-Secondary Rugae	**Male**	1,80	1,23	1,00	1,00	6,00	-0.287	0.774
	Female	1,68	,80	1,00	1,00	4,00		
Left Side-Fragmentary Rugae	**Male**	1,33	,49	1,00	1,00	2,00	-0.476	0.634
	Female	1,48	,68	1,00	1,00	3,00		

Z: Mann-Whitney U test *SD: Standard deviation*

Table 3. Shapes of palatal rugae

Palatal rugae shapes	Right-side Mean Rank	Left-side Mean Rank
Curved	3,59	3,59
Wavy	2,64	2,69
Straight	2,03	1,97
Circular	1,74	1,76
Friedman Test		
Chi-Square	372,737	381,619
Asymp. Sig.	0,000	0,000

There is a statistically significant difference in terms of the number of occurrences of rugae direction types on the right side (Table 5) ($p < 0.05$). Accordingly, convergent type is more common than the divergent type. No significant difference was found between the number of rugae in terms of gender for each type of direction and side (Table 6) ($p > 0.05$).

Table 4. The relationship between rugae shape and gender

Variables	Gender	Mean	SD	Median	Minimum	Maximum	Z	p-value
Right Side-Curved Rugae	**Male**	2,91	1,25	3,00	1,00	7,00	-0.137	0.891
	Female	3,02	1,55	3,00	1,00	8,00		
Right Side-Wavy Rugae	**Male**	1,78	,90	2,00	1,00	4,00	-1.049	0.294
	Female	1,59	,73	1,00	1,00	4,00		
Right Side Straight Rugae	**Male**	1,52	,79	1,00	1,00	4,00	-0.084	0.933
	Female	1,44	,58	1,00	1,00	3,00		
Right Side-Circular Rugae	**Male**	2,00	1,73	1,00	1,00	4,00	-0.711	0.477
	Female	1,44	1,33	1,00	1,00	5,00		
Left Side-Curved Rugae	**Male**	3,16	1,44	3,00	1,00	7,00	-1.220	0.222
	Female	3,46	1,63	3,50	1,00	8,00		
Left Side-Wavy Rugae	**Male**	2,11	1,09	2,00	1,00	5,00	-2.136	0.033*
	Female	1,74	,97	1,00	1,00	5,00		
Left Side Straight Rugae	**Male**	1,47	,64	1,00	1,00	3,00	-0.335	0.738
	Female	1,43	,73	1,00	1,00	4,00		
Left Side-Circular Rugae	**Male**	1,00	,00	1,00	1,00	1,00	0.000	1.000
	Female	1,00	,00	1,00	1,00	1,00		

*Z: Mann-Whitney U test; SD: Standard deviation * p<0.05*

Table 5. Directions of rugae

Rugae directions	**Right-side**	**Left-side**
	Mean Rank	**Mean Rank**
Convergent	27,56	33,52
Divergent	26,74	30,31
Wilcoxon Signed		
Z	-2,470[b]	-1,582[b]
Asymp. Sig.	0,013	0,114

4. Discussion

Palatal rugoscopy, which has been used successfully to identify an individual based on pattern analysis, has proven to be significantly unique among individuals in terms of shape, length, width, salience, number, and orientation. Therefore, postmortem rugae details can be compared with antemortem records (Purohit et al., 2015).

Table 6. The relationship between the number of rugae direction and gender

Vaiables	Gender	Mean	SD	Median	Minimum	Maximum	Z	P value
Right Side-Covergent (Konvex) Rugae	**Male**	1,14	,38	1,00	1,00	2,00	-1.195	0.232
	Female	1,00	,00	1,00	1,00	1,00		
Right Side-Divergent Rugae	**Male**	1,00	,00	1,00	1,00	1,00	-0.894	0.371
	Female	1,05	,22	1,00	1,00	2,00		
Left Side-Covergent (Konvex) Rugae	**Male**	1,70	1,34	1,00	1,00	5,00	-1.679	0.093
	Female	1,06	,25	1,00	1,00	2,00		
Left Side-Divergent Rugae	**Male**	1,11	,32	1,00	1,00	2,00	-0.765	0.445
	Female	1,04	,21	1,00	1,00	2,00		

Z: Mann-Whitney U test *SD: Standard deviation*

Palatal rugae are transverse, irregular, and asymmetrical projections of the mucous membrane behind the papillae in the anterior part of the palate (Gondivkar et al., 2011). They appear as localized epithelial thickening near the incisive papillae during the 3rd month of intrauterine life and are fully formed by 12 to 14 of prenatal life (Nayak et al., 2007). They may then experience changes in size due to growth, but their shape remains constant (Gandikota et al., 2012; Gondivkar et al., 2011).

Muthusubramanian et al. (2005) performed a rugae analysis in burn victims and cadavers in 2005 to simulate rugae identification in cases of burning and decomposition. When examining subjects with third-degree pan facial burns after storing them for 72 hours in a mortuary at 5 degrees and 30 to 40 percent relative humidity, they reported that 93 percent of the palatine rugae were normal and 77 percent of the palatine rugae showed no color change (Muthusubramanian et al., 2005).

Our study analyzed the rugae patterns on dental casts made from the subjects' impressions. Stone castings offer the advantage of simulating the oral cavity in the forensic laboratory: they are easy to use, straightforward to analyze, low cost, and easy to fabricate. Sognnaes argued that using casts made from jaws rather than dentures gives a more reliable result (Sognnaes, 1977, as cited in Rajan et al., 2013). Observing rugae shapes using stone molds, which is a subjective study, is relatively easy and less time-consuming (Gadicherla et al., 2017), and does not require complex instruments (Bharath et al., 2011). Being unique to each person makes the palatal rugae ideal for forensic personal identification.

There is a consensus in the literature that the palatal rugae pattern is personal, similar to fingerprints (Palliwal et al., 2010; Santos & Serra, 2011). Another advantage of the palatal rugae is that it is protected by the cheeks, lips, and tongue in the mouth.

Therefore, the probability of their morphology changing is very low in the event of trauma, chemical attack, and fire (Nayak et al., 2007). It has been shown that the palatal rugae remain unchanged after various treatments such as tooth movement, palate enlargement, and tooth extraction (Barbieri et al., 2013; Muthusubramanian et al., 2005).

In the present study, the most common rugae were the primary type, which was matched with the findings of other studies. (Bharath et al., 2011; Gondivkar et al., 2011; Kapali et al., 1997; Palliwal et al., 2010; Surekha et al., 2012). Surekha et al. (2012) have shown that no difference was found in the total number of rugae for sexes and between the two sides of the palate, in females in general, had slightly more rugae than males, and the left side of the palate showed comparatively more number of rugae than on the right side. Regarding the length of rugae, primary rugae were predominant compared to secondary rugae in both females and males, but this difference is not statistically significant. The predominant rugae shape in males and females was a wavy pattern followed by curved, straight, and circular in that study. Palliwal et al. (2010) have reported that Keralite females showed slightly more secondary rugae than *Madhya Pradesh (M.P.)* females (*two groups of geographically different regions of India, namely, M.P. and Kerala).* Also, Gondivkar et al. (2011) have reported that a statistically significant difference in primary type was noticed which was higher in females than in males. Kapali et al. (1997) showed that analysis of the number of aboriginal primary rugae failed to reveal any significant differences between sides or sexes.

Bharath et al. (2011) also reported significant differences in the total number and junctional pattern of rugae between men and women. A study of the Japanese population showed that women have fewer rugae than men (Dohke & Osato, 1994). It has been reported that Indian men have more primary rugae on their left side than women, and vice versa in the Tibetan population (Shetty et al., 2005). In our study, the dominant rugae type was curved and primary rugae. Our results differed from who showed that the dominant rugae type was wavy in their studies (Kallianpur et al., 2011; Saraf et al., 2011). Also, Kallianpur et al. (2011) have found secondary and fragmentary palatal rugae forms more common in Nepalese than in Indians.

A study by Saraf et al. (2011) showed that convergent rugae types are more common in males and circular types in females. Also, the number of left wavy rugae was significantly higher in males than females and other rugae shapes were not significantly different between males and females in the present study. Similarly, Sheikhi et al. (2018) have reported that the rugae shape was not significantly different between males and females. Gautam et al. (2017) showed that the average straight pattern was higher in men and the average circular pattern was the least in women.

When the rugae shapes were compared between the sexes, it was revealed that the left-sided wavy rugae were more common in males, which was statistically significant. Chatterjee and Khanna (2011) and Saraf et al. (2011) drew attention to the excess of convergent type rugae in women and circular type rugae in men.

Our study found the convergent type more than the divergent type on the right side.The results did not show a considerable difference in the rugae lengths between sexes. This correlates with the results of studies conducted by Malekzadeh et al., (2018) and Nayak et al. (2007) confirmed the studies conducted by Kapali et al. (1997) and Saraf et al. (2011). In contrast, Dohke and Osato (1994) showed increased rugae lengths in females. The number of primary rugae increased in both sexes, followed by the secondary rugae (Malekzadeh et al, 2018). Fragmented rugae were the least rugae pattern. Malekzadeh et al. (2018) has reported that the primary rugae were more common in males. In contrast, the fragmentary rugae were more common in females on both sides (Chatterjee & Khanna, 2011; Malekzadeh et al., 2018). This result does not agree with the findings of Abdulmajid et al. (2015), observed no difference in rugae length of more than 10 mm among males and females. In addition, Fahmi et al. (2001) showed no significant difference in fragmented rugae within 5 to 10 mm length among males and females. Bajracharya et al. (2014) conducted a study on the Nepalese population to determine an association between sex and the pattern and number of palatal rugae. They found no statistically significant difference in the palatal rugae number and pattern among sex groups. The distribution of different palatal rugae shapes in males and females showed that, in terms of the overall sample, the most prevalent palatal rugae patterns in descending order were primary, secondary, fragmentary, curved, wavy, straight, and circular. There is a general agreement among studies on various populations that wavy and curved configurations are the most prevalent patterns of palatal rugae (Abdellatif et al., 2011; Nayak et al., 2007; Rath & Reginald, 2014).

5. Conclusions

This study examined the length, shape, and direction of the rugae to evaluate the palatal rugae morphology used to determine gender.

The following results were obtained:

- No statistically significant differences were found between genders for the length and direction of rugae.
- There was a statistically significant difference between genders for the wavy shape of the rugae only on the left side.
- The most common rugae was the primary type with a length of more than 5 mm, the most common rugae was curved rugae and the most common rugae direction was convergent type on the right side.

Data Analysis

Data analysis was done using S.P.S.S. software version 28 (IBM SPSS Statistics, Armonk, NY). The normality of the data was examined by the Shapiro-Wilk test. Overall differences between gender groups were assessed using the Mann–Whitney Types for length, shape, and direction and were compared with Friedman and Wilcoxon signed rank tests in terms of the number of occurrences. Data analysis was performed using the IBM SPSS V.22 program, and the results were interpreted at 0.05 significance levels.

Funding

This research received no external funding.

Institutional Review Board Statement

The human subject protocol was approved by the Ethics Committee of Gazi University, Faculty of Dentistry, Ankara, Turkey (confirmation number: 17/09/2018-E.34993-21071282-050.99-) by the Helsinki Declaration of 1975, as revised in 2013.

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

Conflicts of Interest

The authors declare no conflict of interest.

Author Contributions

Conceptualization, A.Z.Y., I.P., and S.U.; methodology, A.Z.Y., I.P. and S.U.; software, A.Z.Y., S.U., I.P., and F.K.; validation, A.Z.Y., S.U., I.P., and F.K; formal analysis, A.Z.Y. and S.U. investigation, A.Z.Y., and S.U.; data curation, A.Z.Y., S.U., I.P., and F.K; writing-original draft preparation, A.Z.Y., I.P., and F.K.; writing-review and editing, A.Z.Y., S.U., I.P., and F.K.; visualization, A.Z.Y., and I.P.; supervision, A.Z.Y., and I.P.; project administration, A.Z.Y., and I.P. All authors have read and agreed to the published version of the manuscript.

Acknowledgment

We would like to thank the late Prof. Dr. Bulent Altunkaynak, who passed away (very unexpectedly, very young), for his considerable contribution that made this work possible.

References

Abdellatif, A.M., Awad, S.M., & Hammad, S.M. (2011). Comparative study of palatal rugae shape in two samples of Egyptian and Saudi children. *Pediatric Dental Journal*, 21,123-128. https://doi.org/10.1016/S0917-2394(11)70238-5

Abdulmajid, Z., & Bugaighis, I. (2015). Evaluation of the morphology of palatal rugae in Libyan school children. *Journal of Dental Research*, 2, 024.

Anderson, L., Juhl, M., Solheim, T., & Burrman, H. (1995). Odontological identification of fire victims: potentialities and limitations. *International Journal of Legal Medicine*, 107,229-234. https:// doi: 10.1007/BF01245479. PMID: 7632598.

Bajracharya, D., Vaidya, A., Thapa, S., & Shrestha, S. (2014). Palatal rugae pattern in Nepalese-subjects. *Orthodontic Journal of Nepal*, 3, 36-39.

Barbieri, A.A., Scoralick, R.A., Naressi, S.C., Moraes, M.E., Daruge, E.Jr., & Daruge, E. (2013). The evidence of the rugoscopy effectiveness as a human identification method in patients submitted to rapid palatal expansion. *Journal of Forensic Sciences*, 58 Suppl 1,235-238.

Bharath, S.T., Kumar, G.R., Dhanapal, R., & Saraswathi, T. (2011). Sex determination by discriminant function analysis of palatal rugae from a population of coastal Andhra. *Journal of Forensic Sciences*, 3, 58-62. https:// doi: 10.4103/0975-1475.92144.

Buchner, A. (1985). The identification of human remains. *International Dental Journal*, 35,307-311.

Chatterjee, S., & Khanna, M. (2011). Dimensional analysis of various rugae patterns in north Indian population subset. *Journal of Forensic Dental Sciences*, l; 3 (2), 86-88.https:// 10.4103/0975-1475.92153

Dohke, M., & Osato, S. (1994). Morphological study of the palatal rugae in Japanese 1. Bilateral differences in the regressive evaluation of the palatal rugae. *Japanese Journal of Oral Biology*, 36,125-140.

Fahmi, F.M., Al-Shamrani, S.M., & Talic, Y.F. (2001). Rugae pattern in a Saudi population sample of males and females. *The Saudi Dental Journal*, 13, 92-95.

Gadicherla, P., Saini, D., & Bhaskar, M. (2017). Palatal rugae pattern: An aid for sex identification. *Journal of Forensic Dental Sciences*, 9,48-49.https:// doi: 10.4103/jfo.jfds_108_15.

Gandikota, C., Venkata, Y.P., Challa, P., Juvvadi, S.R., & Mathur, A. (2012). Comparative study of palatal rugae pattern in class II div 1 and classI individuals. *Journal of Pharmacy Bioallied Sciences*, 4 Suppl 2,358-363. https:// doi: 10.4103/0975-7406.100271

Gautam, N., Patil, S.G., Krishna, R.G., Agastya, H., Mushtaq, L., & Kumar, K.V. (2017). Association of Palatal Rugae Pattern in Gender Identification: An Exploratory Study. *The Journal of Contemporary Dental Practice*, 18(6), 470-473.

Gondivkar, S.M., Patel, S., Gadbail, A.R., Gaikwad, R.N., Chole, R., & Parikh, R.V. (2011). Morphological study of the palatal rugae in western Indian population. *Journal of Forensic Legal Medicine*, 18,310-312. https:// doi: 10.1016/j.jflm.2011.06.007

Kallianpur, S., Desai, A., Kasetty, S., Sudheendra, U., & Joshi, P. (2011). Anthropometric analysis of facial height, arch length, and palatal rugae in the Indian and Nepalese population populations. *Journal of Forensic Dental Sciences,* Jan; 3(1), 33-37. https:// doi: 10.4103/0975-1475.85294.

Kapali, S., Townsend, G., Richards, L., & Parish, T. (1997). Palatal rugae patterns in Australian aborigines and Caucasians. *Australian Dental Journal*, 42(2), 129-133.

Malekzadeh, A.R., Pakshir, H.R., Ajami, S., & Pakshir, F. (2018). The Application of Palatal Rugae for Sex Discrimination in Forensic Medicine in a Selected Iranian Population. *Iranian Journal of Medical Sciences,* 43(6), 612-622.

Morlang, W.M. (1982). Forensic dentistry. *Aviation, Space, and Environmental Medicine*, 53, 27-34.

Muthusubramanian, M., Limson, K.S., & Julian, R. (2005). Analysis of rugae in burn victims and cadavers to simulate rugae identification in cases of incineration and decomposition. *The Journal of Forensic Odonto-Stomatology,* 23, 26-29.

Nambiar, P., Jalil, N., & Singh, B. (1997). The dental identification of victims of an aircraft accident in Malaysia. *International Dental Journal*, 47, 9-15. https:// doi: 10.1111/j.1875-595x.1997.tb00671.x.

Nayak, P., Acharya, A.B., Padmini, A.T., & Kaveri, H. (2007). Differences in the palatal rugae shape in two populations of India. *Archives Oral Biology*, 52,977-982. https:// doi: 10.1016/j.archoralbio.2007.04.006

Palliwal, A., Wanjari, S., & Parwani, R. (2010). Palatal rugoscopy: Establishing identity. *Journal of Forensic Dental Sciences,* 2,27-31.https:// doi: 10.4103/0974-2948.71054.

Peoples, J., & Bailey, G. (2011). Humanity. An Introduction to Cultural Anthropology. 9th ed. Canada: Cengage Learning; p. 389.

Purohit, S.C., Shah, V., Manjunatha, B.S., Handge, K., Reddy, & N.M., G.S.S. (2015). Palatal Rugae: A Tool for Sex Identification in Forensic Odontology. *Research Journal of Pharmaceutical Biological and Chemical Sciences,* (3), 1351-1357.

Rajan, V.P., John, J.B., Stalin, A., Priya, G., & Abuthagir, A.k. (2013). Morphology of palatal rugae patterns among 5-15-year-old children. *Journal of Pharmacy and Bioallied Sciences.* Jun; 5 (Suppl 1), S 43-47. https:// doi: 10.4103/0975-7406.113295. PMID: 23946575

Rath, R., & Reginald, B.A. (2014). Palatal rugae: An effective marker in population differentiation. *Journal of Forensic Dental Sciences*, 6, 46-50. https:// doi: 10.4103/0975-1475.127771Santos, K.C., & Serra, M.D. (2011). Evaluation of a digital methodology for human identification using palatal rugoscopy. *Brazilian Journal of Oral Sciences*, 10, 199-203.

Saraf, A., Bedia, S., & Indurkar, A., Degwekar, S., Bhowate, R. (2011). Rugae patterns as an adjunct to sex differentiation in forensic identification. *Journal of Forensic Odonto-Stomatology*, 29, 14-19.

Sheikhi, M., Zandi, M., & Ghazizadeh, M. (2018). Assessment of palatal rugae pattern for sex and ethnicity identification in an Iranian population. *Dental Research Journal,* 15, 50-56. https:// doi: 10.4103/1735-3327.223611

Shetty, S.K., Kalia, S., Patil, K., & Mahima, V.G. (2005). Palatal rugae pattern in Mysorean and Tibetan populations. *Indian Journal of Dental Research,* 16, 51-55.

Subramanian, P., & Jagannathan, N. (2015). Palatal rugoscopy as a method of sex determination in forensic science. *Asian Journal of Pharmaceutical and Clinical Research,* Jan; 8(2), 136-138.

Surekha, R., Anila, K., Reddy, V.S., Hunasgi, S., Ravikumar, S., & Ramesh, N. (2012). Assessment of palatal rugae patterns in Manipuri and Kerala population. *Journal of Forensic Dental Sciences*, 4, 93-96. https:// doi: 10.4103/0975-1475.109896.

Thomas, C.J., & Kotze, T. (1983). The palatal rugae pattern: a new classification. *Journal of The Dental Association of South Africa,* 38(3), 153-157.

Verma, K., Verma, P., Bansal, N., Basavaraju, S., Sachdeva, S., & Khosa, R. (2014). Correlation of Palatal Rugoscopy with Gender, Palatal Vault Height and ABO Blood Groups in Three Different Indian Populations. *Annals of Medical and Health Science Research*, Sep; 4(5), 769-774. https:// doi: 10.4103/2141-9248.141556.