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## Research Article

### Evaluation of the Morphology of Palatal Rugae in Libyan School Children

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#### Abstract

**Aim:** The aim of this prospective cross-sectional study was to investigate the morphological variation and sexual dimorphism of Palatal Rugae (PR) in Libyan Subjects.

**Materials and Methods:** The sample comprised dental casts of 103 Libyan school children, aged 6-12 years; 51 males [mean age (SD): 7.3 (1.1) years], and 52 females [mean age (SD): 8 (1.7) years]. Each maxillary dental cast was explored for PR morphology (straight, wavy, curved, circular, unification and cross-link) and their prevalence was recorded. Paired Student *t*-test was used to assess the symmetry between the paired palatal rugae. Correlation between PR morphology and males and females was explored employing chi-square analysis.

**Results:** There was no significant correlation between sex and prevalence of PR as revealed by chi square analysis ( $P > 0.079$ ). Paired student *t*-test revealed that there are no significant discrepancies between the shapes of the paired PR. Wavy (38.01) and curved (24.39) PR were the most prevalent shape, followed by cross-linked (14.96%) and then by diverging unification (14.96%) and straight (14.28) PR, while, circular and converging PR were not found in Libyan schoolchildren.

**Conclusion:** Wavy and curved were the most observed PR shape in Libyan subjects. Furthermore, the present findings were in agreement with the reported similar studies on different populations that there is lack of sexual dimorphism in PR morphology.

#### Introduction

Palatal Rugae (PR) are asymmetric bilateral elevations of variable prominence on the roof of the hard palate. They are present from birth in the anterior region of the palatal mucosa behind the incisive papilla and bilateral to the medial palatal raphe [1]. PR takes various configurations and their design and structure, like fingerprints, are unique to each individual [2]. There are between three and five PR bilaterally, and none of these crosses the midline raphe. The physiological functions of PR include a role in swallowing and enhancement of the association between food and taste receptors on the dorsal surface of the tongue [3,4]. PR also assists speech and suction in children [4].

The anterior rugae are usually more elevated than their posterior counterparts. While PR do not increase in length after 10 years of age, there is no agreement in the literature about the influence of age on the number of PR [5]. It has been reported that the number of PR changes in adolescence and noticeably increases between 35 and 40 years of age [6]. In contrast, Lysell [7] proposed that the overall number of PR reduces from the age of 23 onward, while English et al [8]. and Peavy and Kendrick [9] suggested that the specific configuration of the PR remains stable during growth and maintains its morphology from the time of maturity until the oral mucosa degenerate at death. Clearly, therefore, more longitudinal studies with greater sample size are required to reach a clear picture on the correlation between age and PR

numbers.

PR occurs in different shapes: wavy, curved, straight, divergent, convergent or circular. Fragmentary PR is found in the posterior half of the PR area. The length, shape, width and direction of PR vary significantly amongst individuals and populations. Although to a lesser extent than between individuals, there are also differences in shape and orientation between the right and left side of the same palate, resulting in an asymmetric PR configuration in most individuals [5,10].

If PR are damaged, they regenerate in their original location [2]. Their structure is stable and is not changed by heat, chemicals, disease or trauma [2]. During normal growth of the palate, PR increase in length, but remain in the same position throughout life [11]. However, occasionally tooth extraction might produce local alteration in the position and direction of the PR adjacent to the alveolar arch [9,12]. Other circumstances may contribute to deviations in the configuration of PR, such as finger sucking in childhood and consistent pressure during orthodontic treatment [12].

After fingerprints, odontogenic features, such as tooth restoration, bony protuberances and PR, represent the second most accurate means of recognition in medico legal identification [13-15]. Recently, dental identification was shown to be the most favorable scientific approach in mass catastrophes, with a success rate of nearly 75% [16]. Among the many intraoral records used in such situations, PR are recognized as being stable and characteristic of each individual and are well preserved throughout life [8,17]. A number of PR classification schemes are reported in the literature by Lysell [7], Carrea [18], Basauri [19], Kapali et al. [20], Thomas and Kotze [21] and Hermosilla et al.[22], Kapali et al. [20] characterized the shape of PR as wavy, curved, straight and circular. Thomas and Kotz [21] considered two-armed PR as branches or unifications that can be distinguished as either diverging or converging according to the branch's origin [21].

There is agreement among researchers that certain PR patterns and shapes may be representative of specific populations [1,5,7,9,10]. To date, there are no published data on PR morphology in Libyan subjects. Therefore, the aim of the present study was to examine and characterize PR morphology in a cohort of Libyan children with the objective of providing preliminary data on possible differences in PR morphology between the sexes and to compare the results with those obtained from other populations.

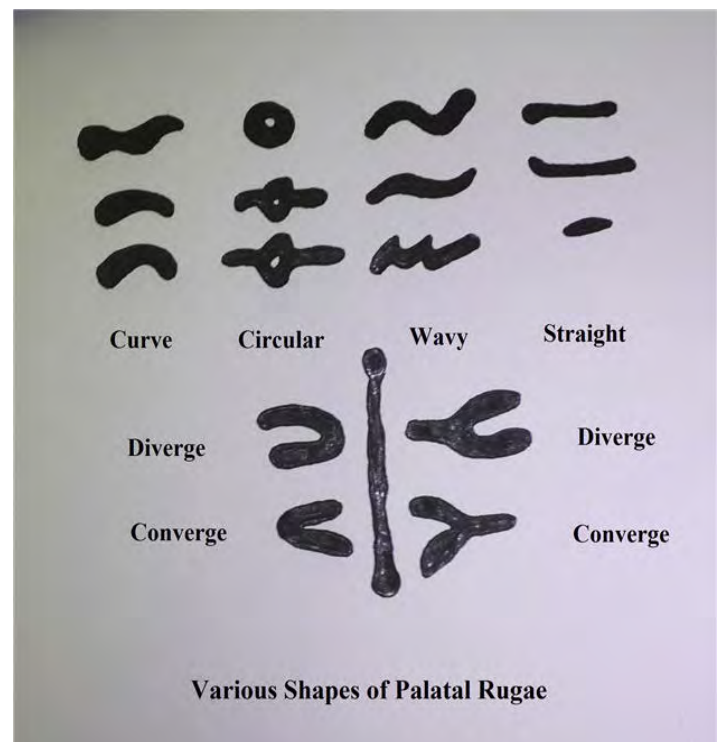
## Materials and Methods

Ethical approval was granted from the Ministry of Health in Benghazi-Libya and parents of students were informed. The participants were of Libyan descent for at least two generations on both maternal and paternal sides (i.e. both parents

and grandparents of the participants on the maternal and paternal sides were born and lived in Libya). None of the subjects had craniofacial abnormality, inflammation, trauma or extraction and none had undergone previous orthodontic treatment. Children were examined at the school premises with mouth mirrors under natural daylight. Students who fulfilled the inclusion criteria were asked to participate in the study after obtaining verbal approval from their parents.

Alginate impressions (ALGINKID, Italy) were recorded for the maxillary arch of each subject on perforated disposable plastic trays and then cast the same morning with dental stone, taking care to generate providing casts free of air bubbles or voids, especially in the anterior third of the palate. All casts were checked and numbered.

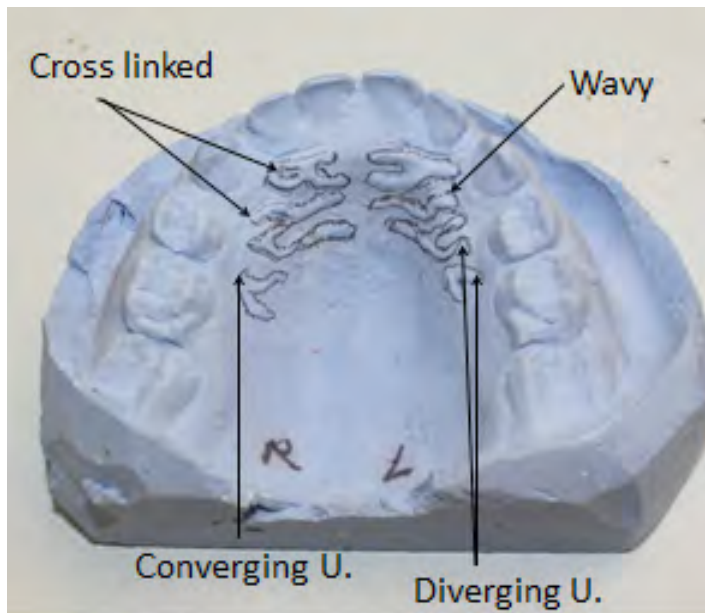
The sample comprised 103 dental casts of 6-12 year-old children attending primary school; 51 males [mean age (SD): 7.3 (1.1) years], and 52 females [mean age (SD): 8 (1.7) years]. The age range of the subjects sampled was designed to be narrow to minimize concerns about lack of PR stability in older children [7, 20].



**Figure 1.** Classification of Palatal rugae morphology according to [21].

PR morphology was assessed in each maxillary dental cast under adequate light and magnification. Each PR was marked using a sharp pencil (0.5 mm, HB). PR shape was registered principally according to the classification of Thomas and Kot-

ze, [21] which categorizes the rugae as wavy, curved, straight, circular or cross-linked. The same researchers designated two-armed rugae as ‘unification’ rugae, which were further classified as converging or diverging according to the origin of the branch point. Thomas and Kotze [21] defined PR  $\leq 3$  mm in length as fragmentary PR and suggested excluding them from studies on morphology and configuration (Figure 1 and Figure 2). PR morphology and prevalence were recorded by a single operator (Z A). A number of sessions were arranged by the examiner for training purposes and to standardize PR identification according to the adopted classification. Subsequently, all recorded data were entered in a spreadsheet (Microsoft Excel).



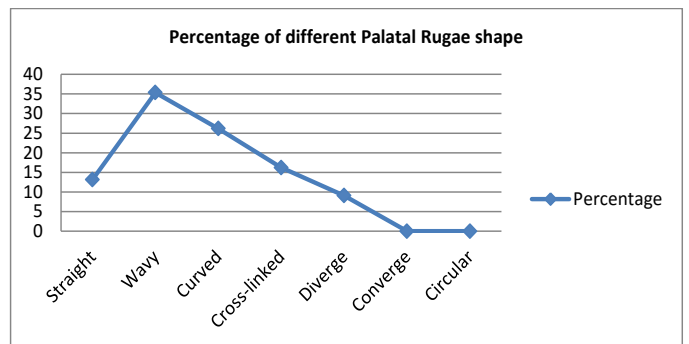
**Figure 2.** Maxillary upper stone cast for Libyan child showing different individual palatal rugae shape.

Individual rugae shape	No	percentage
Straight	106	14.28
wavy	282	38.01
curved	181	24.39
Cross linked	111	14.96
Diverging unification	62	8.36
Converging Unification	0	0
Circular	0	0
Total	742	100

**Table 1.** Frequency and mean of different palatal rugae shape in Libyan children.

**Assessment of Method Error**

Fifteen randomly selected maxillary dental casts were re-examined after a two-week interval to assess intra-observer reproducibility. The intra-class correlation coefficient (ICC) revealed excellent reproducibility ( $\geq 0.97$ ). A paired Student *t*-test was used to assess the symmetry of the PR. The correlation between PR morphology in males and females was explored by chi-square analysis.



**Figure 3.** The percentage of different palatal rugae morphology in Libyan subjects.

**Results**

We assessed a total of 742 PR. A paired Student *t*-test revealed that there were no significant differences between the shapes and number of the paired PR on the right and left side of the palate ( $P > 0.05$ ). Chi-square analysis found that there was no significant correlation between sex and PR configuration ( $P > 0.079$ ). Thus, all data were pooled and subsequently analyzed together. Wavy and curved were the most prevalent PR shapes (38.01% and 24.39% respectively), followed by cross-linked (14.96%), while straight PR comprised 14.28% of the total (Table 1 and Figure 3). PR with diverging unification were the least frequently observed (8.36%), while, circular PR and PR with converging unification were not present in this sample of Libyan schoolchildren.

**Discussion**

We performed a cross-sectional observational study aimed at exploring the morphology, prevalence and sexual dimorphism of PR in a cohort of Libyan schoolchildren from Benghazi city in Libya. For the moment, we regard these results as preliminary and more studies are required on larger groups across the whole country to reach a conclusion.

In the present study, care was taken to allow sufficient time to practice the identification of the various categories of PR morphology prior to conducting the study. Moreover, stone casts were employed to improve the accuracy of PR categorisation,

[25] leading to excellent intra-operator agreement between the two assessment sessions. We excluded fragmentary rugae ( $\leq 3$  mm) from the assessment procedure to ensure a straightforward classification scheme, thereby avoiding detection errors that might arise with more complex approaches [26].

Comparative stability and individuality of PR have been reported by a number of researchers, which justifies their possible use for recognition purposes in forensic dentistry [3,8,24]. Thomas and Kotze [21] emphasized the challenges in detecting, defining and classifying the many small differences in PR morphology and highlighted the importance of standardizing the procedure. Currently, as these authors reported [21], there is no generally accepted classification system and therefore researchers often employ their own methods. In the present research, Thomas and Kotz [21] classification was used as it is less complicated and clearer than other reported systems [7,18-20,22]. Moreover, it has been widely used in similar published studies, and thus allowed us to make more meaningful comparisons of our results with those conducted on other populations [20, 26-30].

In our sample of Libyan children, there was no significant difference in the frequency and configuration of PR between the sexes. Similar findings were reported in Indians [26], Egyptians and Saudis [27], Aboriginal Australians [20] and Japanese subjects [28]. In contrast, other Saudi [29] and Japanese [30] studies observed significant differences in PR morphology and percentage between males and females. These latter contradictory outcomes might be influenced by the sample age groups, as suggested by some researchers [7, 20]. Thus, while the former research studies were undertaken on Japanese and Saudi children under 10 years of age [27,28], the latter Japanese [29] and Saudi [30] studies were performed on adult subjects >20 years old. Further studies with larger sample sizes and different age groups are required to reach a definitive conclusion on this issue.

In the Libyan cohort, the number and shape of the paired PR were similar. Shetty et al. [31] reported no statistically significant difference in the total number of PR between Mysore and Tibetan subjects or the two sides of the palate in these subjects. In contrast, Dhoke and Usato [30] observed that the right side of the palate had fewer PR than the left side. It was suggested that this might be the result of regressive evolution dominating the right side of the palate [30].

Comparative research has revealed variability in PR morphology among populations. In the present study, the various PR configurations were observed to different extents in the Libyan population. The most prevalent PR patterns, in decreasing order, were wavy and curved followed by cross-linked, then straight PR and PR with diverging unification. PR with converging unification and curved PR were not found. There is agreement among studies on different populations that wavy

and curved configurations are the most prevalent PR morphology [26, 27, 32]. Wavy and curved PR were found to comprise 45.85% and 24.41% of total rugae, respectively, in Indian Odisha subjects [32], 55.8% and 23.2% respectively in Australian Aborigines [20], 40.6% and 25.8% respectively in Caucasian individuals [20], 34.47% and 44.71% respectively in western Indians and 38.33% and 26.83% respectively in southern Indians [26], 29.38% and 35.40% respectively in Egyptians and 29.38% and 35.40% respectively in Saudi children [27]. These findings are in agreement with the present study where the wavy and curved PR configurations were 38.01% and 24.39% of the total, respectively. Taken together, these studies suggest that wavy and curved shapes represent the most frequent PR morphology across a range of different ethnicities [20,33].

In the present study, cross-linked rugae comprised 14.96% of the total number of PR. This percentage was greater than that in Egyptian subjects (5.31%), while cross-linked rugae were not found in Saudi subjects [27], in Andhra Pradesh and Odisha Indian individuals [32], or in Australian Aborigines and Caucasian cohorts [20].

The frequency of straight PR (14.28%) in the present study was similar to that in Caucasians [20] (15.2%) and slightly less than in Egyptians (20.71%) and Saudis (19.71%).<sup>27</sup> In all of these populations (Caucasians, Libyans, Egyptians and Saudis), the frequency of straight PR was markedly lower than in Andhra Pradesh Indians [32] (37.3%), but higher than in Odisha Indians [32] (6.69%) and Australian Aborigines (3.6%) [20].

The frequency of diverging unification was found to be 9.06% in Libyan subjects, while converging unification and circular PR were not observed. PR with diverging and converging unification represented 2.64% and 4.07% of total rugae, respectively, in Egyptian subjects and 4.84% and 0% respectively in Saudis [27], 13.9% in Australian Aborigines, 15.6% in Caucasians [20], 4.16% in Andhra Pradesh and 16.23% Odisha Indian individuals [32]. Circular PR were not observed in the present study, but were reported at 2.48% of total rugae in Egyptians and 1.25% in Saudis [27], 3.6% in Australian Aborigines and 2.9% in Caucasians [20].

The above analysis suggests that certain PR patterns and shapes may be particular to specific populations [1,5,7,27-33]. Consistent with this is the observation that some types of PR morphology are rare or absent in other ethnicities.

Because these results are preliminary, nationwide research projects on larger groups are required to obtain a clearer picture of the morphological variation in PR in the Libyan population. It would also be interesting to examine cohorts from neighboring countries alongside Libyan subjects to allow a comparison between different populations within the same study.

## Conclusions

We provide insight into the morphological variation and sexual dimorphism of PR in Libyan schoolchildren. Wavy and curved PR were the most frequently observed category in Libyan subjects, as reported in the literature for other ethnicities, while circular and converging unification PR were not found. We did not find evidence for sexual dimorphism in PR morphology and therefore the use of PR to determine sex in Libyan subjects is not recommended.

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