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Rugoscopy in human identification: a study in a sample of twins

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ABSTRACT

Palatal rugae patterns can be useful for forensic identification purposes. However, some doubts persist in concerning the pattern singularity in twins. The purpose of this study was to assess palatal rugae pattern singularity in a sample of twins. To do this, the palatal rugae patterns of 19 pairs of monozygotic twins and 47 pairs of dizygotic twins were studied. Our results showed that in monozygotic twins, no statistical significant differences were found, either in the form or number of palatal rugae. However, in dizygotic twins, differences were found in the number or shape of all palatal rugae (except for the shape of the first two right ones), suggesting that the palatal rugae pattern can be useful for identification purposes of dizygotic, but not of monozygotic, twins.

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Rugoscopy; palatoscopy; palatal ruga; human identification; twins

Introduction

Rugoscopy, or palatoscopy, is the name given to the study of palatal rugae. Some authors have claimed that rugoscopy can be useful in human identification, due to several palatal rugae features. For example, palatal rugae remain fairly stable during the decomposition process, keeping their anatomy unchanged until seven days after death [1,2]. In addition, palatal rugae patterns display extraordinary resistance to hazardous factors, due to their anatomical location in the oral cavity, surrounded by cheeks, lips, tongue and the buccal fat pad [1], giving additional protection in trauma or incineration events [3]. Furthermore, they are described as stable markers and, once formed, they do not undergo any change during a person's life. This claim has been disputed, as some factors seem to, in fact, alter palatal rugae size, shape and position. Saraf and collaborators [4] stated that trauma, extreme finger sucking in infancy and persistent pressure with orthodontic treatment and dentures use can modify the palatal rugae pattern. As for trauma, it is clear that some injuries can destroy the palatal rugae; however, these injuries and their scars should be noticeable, and therefore useful for identification purposes. In extreme finger sucking in

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infancy, palatal shape can be severely modified, and therefore the shape, position and size of palatal rugae can be altered as well. Yet, these changes happen early in life, and after that they persist throughout an individual's life, so once again can be used as an identifier.

Studies have shown that palatal rugae size can change after orthodontic treatments [5,6]; however, rugae shapes remain unaltered, suggesting that only the length of the rugae changes after orthodontic treatment and therefore may not be a valid parameter for human identification. On the other hand, morphologic stability was recognized, suggesting that a quantitative evaluation can be more adequate for forensic human identification [5].

As for denture use, the nature of the changes in palatal rugae patterns in such a situation is not clear; in fact, literature references to this effect are scarce, and relate to adding one or more palatal rugae to the prosthetic devices to improve function [7]. Yet, it remains to be proven if such changes also produce an alteration in the rugae pattern of the denture wearer.

Besides their stability, palatal rugae patterns have also been described as unique to an individual [8], and some authors have suggested that when the identification of an individual by other methods is difficult, palatal rugae may be considered as an alternative source of information, if comparative data are available.

The singularity of palatal rugae patterns has been discussed and some authors claim that this uniqueness remains to be proven, while others state that palatal rugae patterns are unique [9–11] – except in twins [12]. Still others argue that even in twins the singularity does exist [4].

The purpose of this study was to assess palatal rugae pattern singularity in a sample of twins. Specifically, we intended to study the palatal shape of the first three palatal rugae, and the total number of right and left rugae, in a sample of monozygotic and dizygotic twins, to assess differences between them.

Material and methods

The studied sample had 19 pairs of monozygotic twins and 47 pairs of dizygotic twins. The sample's distribution by sex is depicted in Table 1.

The 66 pairs of twins were part of the *Geração XXI* ('Generation XXI') cohort, from the Public Health Institute of the University of Porto. *Geração XXI* consists in the first cohort in Portugal, whose objective is prenatal characterization and postnatal development, identifying determinants in health with an interest in childhood, adolescence and adulthood, and is described elsewhere [13]. The selected twins were of European ancestry and aged between 11 and 13 years old. This study included monozygotic and dizygotic twins, whose zygotia was proven before inclusion in the study. All participants who have congenital or acquired disorders, or medically relevant conditions were excluded, as were children with a history of orofacial traumatology.

Table 1. Sex distribution of the participants, *n* (%).

Sex	Monozygotic	Dizygotic
Male	24 (63.2)	50 (53.2)
Female	14 (36.8)	44 (46.8)

Table 2. Basauri's classification of palatal rugae.

Rugae morphology	Rugae classification
Point	A
Line	B
Angle	C
Sinuous	D
Curve	E
Circle	F
Polymorphic	X

Informed consent was obtained, and the investigation was submitted and approved by the Ethics Commission of the Faculty of Dental Medicine of Porto University (reference number 000030–10/01/2017) and by the Portuguese Data Protection Authority (reference number 64.567.634–13/10/2017).

The first three rugae of each side of the palate were classified using Basauri's morphological classification, as depicted in Table 2. The total number of right and left palatal rugae was also recorded.

Reproducibility was evaluated by assessing agreement between 20 randomly selected photographs examined twice by the same examiner, one month apart. Cohen's kappa (κ) was used to evaluate the quality of the agreement, as suggested by Landis and Koch [14]. The agreement was almost perfect with κ = 0.890. Repeatability was evaluated by measuring the agreement between 20 randomly selected photographs examined by two different examiners. Again, the agreement was almost perfect with κ = 0.880.

Statistical analysis was performed using SPSS 26.0 software (SPSS Inc., Chicago, IL). Pearsons' Chi-square test was used to compare qualitative data and determine statistical significance. The level of statistical significance was set at $p \leq 0.05$.

Results

Considering the rugae shape, the most frequent first palatal rugae shape in monozygotic twins was the line shape, and no sinuous nor circular shapes were found (Table 3). As for the second rugae form, the most prevalent shape was the sinuous type, and no point nor circular rugae were found (Table 4). No circular shapes were found in the third palatal rugae

Table 3. First right/left palatal rugae shape per monozygotic pair (nc: not classifiable) (*n*).

	Right			Left		
	Twin A	Twin B	Total	Twin A	Twin B	Total
A	0	0	0	1	0	1
B	4	4	8	6	7	13
C	0	1	1	0	1	1
D	7	4	11	3	3	6
E	2	2	4	3	2	5
F	0	0	0	0	0	0
X	5	7	12	6	0	6
nc	1	1	2	0	0	0
Total	19	19	38	19	19	38
p	0.731			0.186		

Table 4. Second right/left palatal rugae shape per monozygotic pair (nc: not classifiable) (*n*).

	Right			Left		
	Twin A	Twin B	Total	Twin A	Twin B	Total
A	0	0	0	0	0	0
B	4	4	8	5	7	12
C	0	1	1	4	0	4
D	14	4	18	4	8	12
E	1	2	3	4	3	7
F	0	0	0	0	0	0
X	0	7	7	2	0	2
nc	0	1	1	0	0	0
Total	19	19	38	19	19	38
p	0.693			0.220		

Table 5. Third right/left palatal rugae shape per monozygotic pair (nc: not classifiable) (*n*).

	Right			Left		
	Twin A	Twin B	Total	Twin A	Twin B	Total
A	1	0	1	3	1	4
B	7	4	11	4	6	10
C	1	0	1	0	0	0
D	7	12	19	9	11	20
E	1	2	3	3	1	4
F	0	0	0	0	0	0
X	1	0	1	0	0	0
nc	1	1	2	0	0	0
Total	19	19	38	19	19	38
p	0.541			0.101		

of monozygotic twins, and the most frequent form was once again the sinuous type (Table 5).

As for differences between each monozygotic twin pair, no statistically significant differences were found, either in form (Tables 3–5) or number of palatal rugae (Table 6); as a result, palatal rugae could not be used for distinguishing between these twins, as they may display the same shape or number pattern in the same pair.

Monozygotic twins more frequently displayed palatal rugae patterns with four rugae (20 on the right side and 22 on the left), and patterns with seven or more rugae did not exist (Table 6). Differences between the total number of rugae between pairs were non-existent ($p > 0.05$, in both sides).

Table 6. Total number of right/left palatal rugae per monozygotic pair (nc: not classifiable) (*n*).

	Right			Left		
	Twin A	Twin B	Total	Twin A	Twin B	Total
3	3	1	4	1	1	2
4	8	12	20	10	12	22
5	5	5	10	5	5	10
6	3	1	4	3	0	3
7	0	0	0	0	0	0
nc	0	0	0	0	1	1
Total	19	19	38	19	19	38
p	0.580			0.661		

Table 7. Number of first right/left palatal rugae shape per dizygotic pair (nc: not classifiable) (*n*).

	Right			Left		
	Twin A	Twin B	Total	Twin A	Twin B	Total
A	0	0	0	1	0	1
B	13	12	25	9	10	19
C	2	1	3	0	2	2
D	7	5	12	5	10	15
E	4	4	8	8	4	12
F	0	0	0	0	0	0
X	19	22	39	21	20	41
nc	2	1	3	3	1	4
Total	47	47	94	47	47	94
p	0.013			0.826		

Table 8. Number of the second right/left palatal rugae shape per dizygotic pair (nc: not classifiable) (*n*).

	Right			Left		
	Twin A	Twin B	Total	Twin A	Twin B	Total
A	2	3	5	2	7	9
B	11	12	23	10	13	23
C	2	4	6	2	2	4
D	21	19	40	16	16	32
E	7	4	11	10	5	15
F	0	0	0	0	0	0
X	3	2	5	6	22	28
nc	1	3	4	1	2	3
Total	47	47	94	47	47	94
p	0.040			0.095		

In dizygotic pairs, statistically significant differences were found in the shape of the first right ruga on the right-hand side ($p = 0.013$) (Table 7), suggesting that this ruga shape could be used for distinguishing these individuals

Similarly, statistically significant differences were found on the right-hand side of the second and in both sides of the third ruga ($p = 0.040$, and $p = 0.005/p < 0.001$, respectively) (Tables 8 and 9). These rugae, by displaying different patterns, may be useful in distinguish among these individuals, as well.

In dizygotic twins, the first and second rugae were most commonly polymorphic, and circular shapes were not present. The sinuous shape was the most frequent shape of the third palatal rugae in this group, and once again, no circular forms were found.

Table 9. Number of third right/left palatal rugae shape per dizygotic pair (nc: not classifiable) (*n*).

	Right			Left		
	Twin A	Twin B	Total	Twin A	Twin B	Total
A	2	1	3	4	4	8
B	10	7	17	8	8	16
C	1	1	2	2	3	5
D	26	29	55	26	21	47
E	3	6	9	5	7	12
F	0	0	0	0	0	0
X	3	0	3	0	0	0
nc	2	3	5	2	4	6
Total	47	47	94	47	47	94
p	0.005			<0.001		

Table 10. Total number of right/left palatal rugae per dizygotic pair (nc: not classifiable).

	Right			Left		
	Twin A	Twin B	Total	Twin A	Twin B	Total
2	0	0	0	0	1	1
3	7	4	11	10	3	13
4	16	18	34	13	15	28
5	13	10	23	14	14	28
6	8	9	17	7	10	17
7	1	2	3	1	2	3
nc	2	4	6	2	2	2
Total	47	47	94	47	47	94
p	0.013			<0.001		

Statistically significant differences were also found in dizygotic twins concerning the number of the right and left rugae ($p = 0.013$ and $p > 0.001$, respectively) (Table 10).

Dizygotic twins displayed more frequently palatal rugae patterns with four rugae, and patterns with seven or more rugae did not exist.

Discussion

In forensic sciences, a feature is valuable for identification purposes if three principles can be verified: (1) stability over time; (2) classification is possible; (3) variation among individuals.

Palatal rugae patterns are thought to obey those principals, and therefore have been considered as a useful tool in human identification cases. However, doubts have been raised when the subjects are twins.

To best of the authors' knowledge, this is the first study addressing palatal rugae shape and number pattern in a twin population. The interest in studying palatal rugae patterns relates to the fact that it is believed that palatal rugae develop through strict genetic control in most mammals, and are an excellent model for studying genetic commonality of developmental processes [15].

Thus, it is believed that these features, by developing under strict genetic control may be useful in forensic human identification of dizygotic twins, as they should display different palatal rugae patterns. Conversely, in monozygotic twins no such differences are expected.

Our results support this thesis, and differences in palatal rugae pattern were found in dizygotic, but not in monozygotic twins.

For forensic purposes, our results suggest that palatal rugae number and shape can be useful for distinguishing dizygotic but not monozygotic twins. Specifically, we've found differences in palatal rugae in dizygotic twins, both in number and shape, with two exceptions. Surprisingly, no differences were found in the shape of the first and second right palatal rugae. The authors cannot offer any explanation for this fact, and don't understand why the first two right palatal rugae display a different behaviour. This has happened before, and in a previous study, concerning the behaviour of palatal rugae shape and size after orthodontic treatment; Braga and Caldas [5] found that the first right ruga was the only one displaying differences in size.

At that time, the authors proposed that as the majority of dentists are right-handed, they can apply greater strength in teeth positioned in the first quadrant. As for why differences happen only in females, the authors hypothesized that women may respond differently to stressor agents, such as orthodontic treatment, and that can be translated in a biological response [5].

However, the current results suggest that this hypothesis may be incorrect, as no such stressor agents were present in this study. The first two right rugae may behave differently for unknown reasons, and perhaps should be discarded for identification purposes.

In fact, with the exception of this feature, all remaining rugae can be used for identification purposes of dizygotic twins, as they display different shapes and number patterns. Several authors have discussed the stability of different palatal rugae. Some referred to the third ruga as the most stable [16,17]. Conversely, Almeida et al. [18] referred to the first ruga as the more stable. All things considered, the authors believe that for forensic purposes it would be better to consider the whole pattern (in terms of shape and number), and individually, discard the first two right rugae.

In monozygotic twins, there were no statistical differences in palatal rugae shape pattern or number. These results suggest that these features cannot be used to distinguishing between these individuals and they support the strict genetic control thesis of palatal rugae development.

As for the number pattern, differences aside, both mono and dizygotic twins displayed a similar global pattern of palatal rugae, with the four rugae pattern the most frequent; no patterns with seven or more rugae were found in both groups, suggesting that this is perhaps a human-species feature, as is the asymmetry [11,19]. In fact, according to Trakanant et al. [15], the number and pattern of palatal rugae are species-specific and are consistent in all mammals except humans, which corroborates our results.

Conclusions

Our results point to the singularity of palatal rugae patterns in dizygotic twins; yet, in monozygotic twins, no such differences were found, suggesting that in these cases the palatal rugae pattern is not useful for identification purposes.

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Disclosure statement

No potential conflict of interest was reported by the author(s).

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Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee (Faculty of Dental Medicine of Porto University – reference number 000030–10/01/2017; Portuguese Data Protection Authority – reference number 64.567.634–13/10/2017) and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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