

INTERFERENCE OF ORTHODONTIC TREATMENT IN THE HUMAN IDENTIFICATION PROCESS BY THE PALATINE RUGAE

INTERFERÊNCIA DO TRATAMENTO ORTODÔNTICO NO PROCESSO DE IDENTIFICAÇÃO PELAS RUGAS PALATINAS

INTERFERENCIA DEL TRATAMIENTO ORTODÓNCICO EN EL PROCESO DE IDENTIFICACIÓN DE LAS RUGAS PALATINAS

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DOI: 10.54899/dcs.v22i81.3005

Recibido: 05/06/2025 | Aceptado: 27/07/2025 | Publicación en línea: 18/08/2025.

ABSTRACT

This observational study investigate the interference of fixed orthodontic treatment on the morphology of palatine rugae, and the compromise the process of forensic human identification. Of the 51 cases studied (26 males), aged between 7 and 39 years, which had been prepared in gypsum before and after fixed orthodontic treatment. The principal morphological changes included a second right rugae in males (50%) and a third left rugae in females (56%); the anterior rugae were more altered in males. The most significant change in architecture was between the ages of 22 and 39, with a 57.1% rate for the third right rugae. No statistically significant difference was observed between morphological rugae patterns and gender, skin color, or age. The prevalence of the bifurcated type for the first right rugae; the straight type for the second right and left rugae and the sinuous type for the third right and left rugae. For the initial rugae, there was a correspondence of 43.1% to 47.1% for the oval shape before and after treatment, respectively. It is concluded that the fixed orthodontic treatment may result in morphological modifications to the palatine rugae.

Keywords: Orthodontic. Human Identification. Palatine Rugae. Forensic Anthropology. Forensic Dentistry. Forensic Medicine.

RESUMO

Este estudo observacional investiga a interferência do tratamento ortodôntico fixo na morfologia das rugas palatinas e o comprometimento do processo de identificação humana forense. Foram estudados 51 casos (26 do sexo masculino), com idades entre 7 e 39 anos, que foram preparados

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em gesso antes e depois do tratamento ortodôntico fixo. As principais alterações morfológicas incluíram a segunda ruga direita no sexo masculino (50%) e a terceira ruga esquerda no sexo feminino (56%), sendo as rugas anteriores mais alteradas no sexo masculino. A alteração mais significativa na arquitetura ocorreu entre os 22 e os 39 anos, com uma taxa de 57,1% para a terceira ruga direita. Não foram observadas diferenças estatisticamente significativas entre os padrões morfológicos das rugas e o sexo, cor da pele ou idade. A prevalência do tipo bifurcado para a primeira ruga direita; o tipo reto para a segunda ruga direita e esquerda e o tipo sinuoso para a terceira ruga direita e esquerda. Para as rugas iniciais, houve uma correspondência de 43,1% a 47,1% para a forma oval antes e depois do tratamento, respectivamente. Conclui-se que o tratamento ortodôntico fixo pode levar a modificações morfológicas das rugas palatinas.

Palavras-chave: Ortodontia. Identificação Humana. Ruga Palatina. Antropologia Forense. Odontologia Forense. Medicina Legal.

RESUMEN

Este estudio observacional investiga la interferencia del tratamiento ortodôntico fijo en la morfología de las rugas palatinas, y el compromiso del proceso de identificación humana forense. De los 51 casos estudiados (26 varones), con edades comprendidas entre los 7 y los 39 años, los cuales han sido preparados en yeso tanto antes como después del tratamiento de endodoncia fijo. Los principales cambios morfológicos incluyeron una segunda ruga derecha en los varones (50%) y una tercera ruga izquierda en las mujeres (56%); las rugas anteriores estaban más alteradas en los varones. El cambio más significativo en la arquitectura se produjo entre los 22 y los 39 años, con una tasa del 57,1% para la tercera ruga derecha. No se observaron diferencias estadísticamente significativas entre los patrones morfológicos de las rugas y el sexo, el color de la piel o la edad. La prevalencia del tipo bifurcado para la primera ruga derecha; el tipo recto para la segunda ruga derecha e izquierda y el tipo sinuoso para la tercera ruga derecha e izquierda. Para las rugas iniciales, hubo una correspondencia del 43,1% al 47,1% para la forma ovalada antes y después del tratamiento, respectivamente. Concluyendo que el tratamiento ortodôntico fijo puede dar lugar a modificaciones morfológicas de las rugas palatinas.

Palabras-clave: Ortodoncia. Identificación Humana. Ruga Palatina. Antropología Forense. Odontología Forense. Medicina Forense.



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INTRODUCTION

A person's identity is made up of a series of particular properties, including physical and psychical characteristics¹, which may be manipulated or camouflaged, and which are of great importance². The identification process is legitimately supported by several well-established techniques, such as typoscopy, DNA testing, and the study of palate rugoscopy³.

Datiloscopy is based on the study of the digital ridges and the positioning of the sudoripid pores located in the pulp epithelium⁴. The DNA analysis provides details for the establishment of kinship⁵ and the identification of people by genetic markers⁶. On the other hand, palatine rugoscopy, a method proposed by Trobo Hermosa⁷ and Ubaldo Carrea⁸, is the analysis of palatine rugae^{1,9}, which may be conducted by using an inspection, photographs, and impressions, as well as methods like stereoscopy, stereophotogrammetry, palatophotography and calcorrugoscopy^{1,10,11}.

This is why we are studying, by analyzing palatal rugae, the possibility that fixed orthodontic treatments alter morphology, which may be prejudicial to the process used in human forensic identification.

THEORETICAL FRAMEWORK

Human palatine rugae is asymmetric, composed of fibrous mucous tissue and a mucous membrane. They are considered to be permanent and diversiform, inclusive in a monozygotic twin, and may change in size through a natural process of growth and development^{4,12}.

Their topography is located on the anterior region of the hard palate and their functions may include the prevention of trauma from mastication, lingual positioning guidance, assisting in the swallow and sound production, and conferring the tone and resonance of voice¹³.

The palatoscopy, a study of palatal roughness, is regarded as an easy process to catalog and is a legally solid identification method, but it becomes vulnerable post-mortem because of the cadaverisation process^{10,13,14} or when external factors like trauma, dental lost⁴ and/or orthodontics treatment may cause changes to the architectural design^{15,16}, which makes palatoscopy a questionable method in forensic identification.

For example, treatment of patients with midpalatal expansion may lead to a modification in the medial and distal aspects of the second and third rugae¹⁷, and even in the first lateral rugae in the transverse bilateral direction; or not¹⁸ so that more attention is required to minimize mistakes during description¹⁹ and bias in interpretation²⁰.

Table 1

Numerical and perceptual evaluation of the morphological aspect of rugae and papilla incisive by the side, before and after orthodontics for the 51 cases

Variable	Before		After	
	N	%	N	%
First, right rugae				
Straight	12	23,5	15	29,4
Curve	7	13,7	6	11,8
Angle	8	15,7	8	15,7
Sinuuous	2	3,9	2	3,9
Bifurcated	22	43,1	17	33,3
Anomalous	-	-	2	3,9
Absent	-	-	1	2,0
First, left rugae				
Straight	13	25,5	13	25,5
Curve	8	15,7	11	21,6
Angle	13	25,5	9	17,6
Tight curve	2	3,9	-	-
Sinuuous	1	2,0	1	2,0
Bifurcated	13	25,5	15	29,4
Anomalous	1	2,0	1	2,0
Absent	-	-	1	2,0
Second, right rugae				
Straight	21	41,2	19	37,3
Curve	3	5,9	3	5,9
Angle	9	17,6	8	15,7
Sinuuous	10	19,6	16	31,4
Bifurcated	8	15,7	3	5,9
Compound	-	-	1	2,0
Absent	-	-	1	2,0
Second, left rugae				
Straight	21	41,2	14	27,5
Curve	2	3,9	2	3,9
Angle	7	13,7	10	19,6
Sinuuous	17	33,3	20	39,2
Bifurcated	2	3,9	2	3,9
Longilineal	1	2,0	-	-
Straight	-	-	1	2,0
Absent	1	2,0	2	3,9
Third, right rugae				
Straight	11	21,6	7	13,7
Curve	2	3,9	2	3,9
Angle	9	17,6	10	19,6
Sinuuous	25	49,0	28	54,9
Bifurcated	1	2,0	1	2,0
Interrupted	1	2,0	1	2,0
Absent	2	3,9	2	3,9
Third, left rugae				
Straight	10	19,6	7	13,7

Curve	4	7,8	3	5,9
Angle	9	17,6	9	17,6
Sinuous	22	43,1	27	52,9
Bifurcated	2	3,9	1	2,0
Absent	4	7,8	4	7,8
Papilla Incisive				
Straight	18	35,3	18	35,3
Oval	24	47,1	22	43,1
Point	6	11,8	7	13,7

Table 2

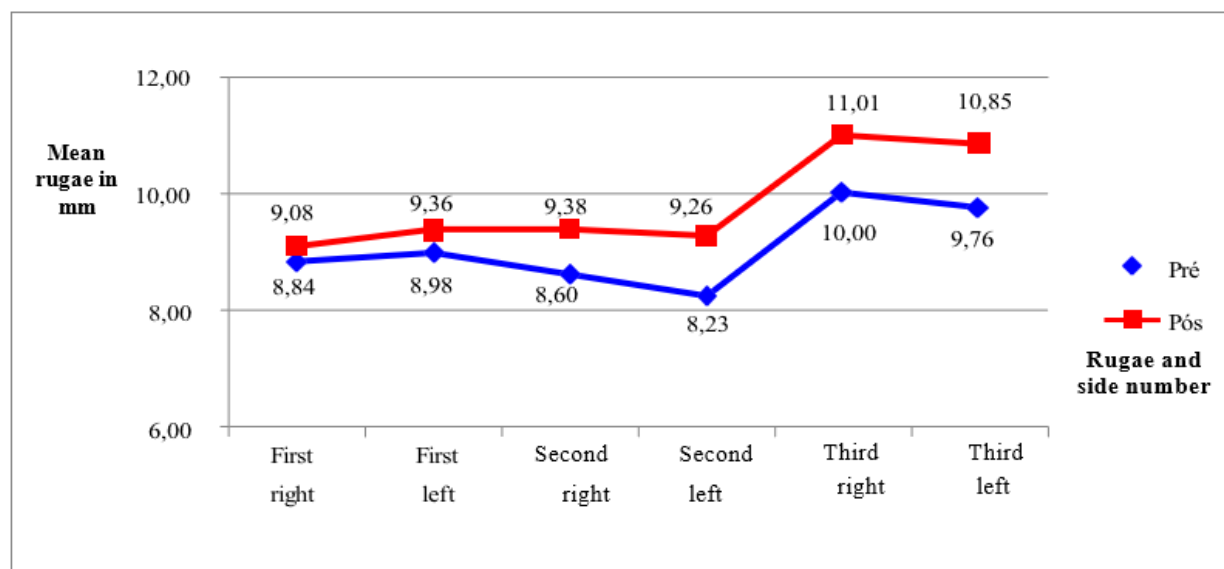
*Mean, Standard Deviation, and Median (mm) of palatal rugae by side before and after
Orthodontic Treatment.*

Palatine rugae/evaluated side	Pré - treatment		Pós-tratamento		Diferença Pós - pré	
	Média ± DP Mediana (P25; P75)	DP (P25; P75)	Média ± DP Mediana (P25; P75)	DP (P25; P75)	M p	Valor
First palatal rugae/right	8,84 ± 1,49 8,74 (7,99; 9,96)		9,08 ± 1,40 8,89 (8,10; 9,86)	4	0,2 (1)	0,172
First palatal rugae/left	8,98 ± 1,46 9,08 (7,92; 9,78)		9,36 ± 1,53 9,34 (8,49; 10,05)	8	0,3 (1)	0,053
p-value	0,576 ⁽²⁾		0,255 ⁽²⁾			
Second palatal rugae/right	8,60 ± 3,12 8,27 (6,69; 10,72)		9,38 ± 4,25 8,97 (6,96; 11,78)	8	0,7 (1)	0,131
Second palatal rugae/left	8,23 ± 2,32 8,15 (6,47; 9,99)		9,26 ± 3,07 8,57 (7,06; 11,41)	3	1,0 (1)	0,001*
p-value	0,368 ⁽²⁾		0,792 ⁽²⁾			
Third palatal rugae/right	10,00 ± 3,15 10,33 (7,43; 12,67)		11,01 ± 3,08 11,40 (9,05; 12,86)	1	1,0 (1)	0,002*
Third palatal rugae/left	9,76 ± 2,67 9,74 (8,01; 11,60)		10,85 ± 2,75 11,04 (9,26; 12,79)	9	1,0 (1)	0,006*
p-value	0,482 ⁽²⁾		0,635 ⁽²⁾			

Note:(*) Significant difference at 5%; (1) Using the Paired Student's t-test to compare before and after the treatment for each rugae. (2) Using the Paired Student's t-test to compare the right and left sides for each one of the rugae and the assessments.

Figure 1

Analyzing the mean rugae dimensions by side and evaluation.



METHODOLOGY

Study Design

An analytical and descriptive study of prevalence was submitted and approved by the Ethics in Research Committee of the University of Pernambuco (CAAE 54631916.2.0000.5207/Protocol 1.529.383). A total of 51 jaw models had been selected (26 males), which had been prepared in gypsum before and after fixed orthodontic treatment at a particular dentistry service.

Eligibility Criteria

The study included orthodontic cases that had been carried out and completed using a fixed treatment appliance with no need for a tooth to be removed. The maxillary study models, before and after treatment, had to present a satisfactory quality for reproducing palatal roughness through the photographic method and for direct viewing to enable comparison between before and after treatment.

The cases in which tooth agenesis, malformation of dental elements, periodontium alterations, the presence of cleft palate and or maxillary torus, or any previous orthopedic treatment were excluded.

Process of Evaluation

Demographic data including age, gender, and self-reported skin color were considered, the palatine rugae were demarcated with a 0.5 mm graphite tip and then measured by a digital caliper (Kingstools®); by the Martins dos Santos classification³, and the architecture of the first and third palatine rugae ("right" and "left") was determined in the before and after orthodontic models relative to their long axis and the papilla initially.

The systems for classifying palatine roughness have predominantly considered morphological and topographical characteristics. With or without the use of numbers, characters, icons, characteristics of the tooth, or the personality²¹. These systems are guided by their precision, their easy classifiability, and, most importantly, by their purpose, which is influenced both by the quality of the samples and the researchers' choice, hindering the comparison of scientific results.

Martins dos Santos' classification system, used here, is based on the position and format of each palatine rugae, such as a) Initial rugae: most anterior rugae to the right of the median palatine raphe ("uppercase"); b) Complementary rugae: other rugae to the right of the mid palatal Rafe ("numbers"); c) Subinitial rugae: most anterior rugae to the left of the mid palatal Rafe ("lower case"); d) Subcomplementary rugae: other rugae to the left of the mid palatal Rafe ("numbers"); as well as the relationship of the type of rugae and their position³.

The photographs were taken with a digital camera (Sony Cyber Short), which was mounted using a tripod, with 10X optical zoom and a wide 25mm lens, and supported by adequate lighting and a straight line perpendicular to the model, oriented in a two-dimensional direction.

Treating the Data

All the data were individually cataloged with the SPSS23 program and analyzed with the Chi-square test with a 5% margin of error.

Descriptive analyses were done with absolute frequencies and percentage frequencies for the categorical parameters and average, standard deviation, median, and percentiles for the numeric parameters. For inferential analysis, paired Student's t-tests were used to compare assessments or side-by-side comparisons, Student's t-tests were for independent samples or

Mann-Whitney for comparisons of two categories, and F-tests (ANOVA) or Kruskal-Wallis were used for comparisons of more than two categories.

Pearson's chi-square test was used to assess a significant relationship between the two categorical variables, or Fisher's exact test when the conditions for use of the chi-square test were not met.

Paired Student's t-tests, Student's t-tests for an independent sample, and F-tests (ANOVA) were used when normal data was tested, and the Mann-Whitney and Kruskal-Wallis were used when normal data was rejected.

The tests for the hypothesis of data normality were done using the Shapiro-Wilk test and for the equality of variances were done using Levene's F test.

RESULTS AND DISCUSSIONS

In the 51 models analyzed of patients treated by fixed orthodontic treatment (26 males), the age group was between 7 and 39 years old, with 76.5% of self-declared white patients in comparison with 23.5% for pardons.

Despite the relationship between morphological rugae patterns, genders, color of the skin, or age groups being statistically non-significant, a more significant alteration was observed in the second right rugae for males (50%) and in the third left rugae for females (56%); the anterior rugae exhibited a greater alteration in males.

Regarding the age aspect, the change in morphology was 50% between the ages of 7 and 14 for the third left rugae, 52.6% between the ages of 15 and 21 for the second left rugae, and 57.1% between the ages of 22 and 39 for the third right rugae. As for skin color, for self-reported "white" and "brown" patients, the lowest percentage was the first right rugae (23.1%) and third right rugae (16.7%) respectively.

For males, the initial rugae presented a 50% change, and for females 44.0%, with a greater incidence in the 15 to 21 age group (57.9%), with 50.0% for self-declared brown people.

A significant difference between the sexes was observed in the first right palatine rugae, with a reduction (-0.20 mm) in the mean for males and an average increase of 0.68 for females. There were no significant differences ($p > 0.05$) between age groups in terms of the variations in the measurements of the rugae, the palatine raft, and the anterior papilla.

The papillae form showed a prevalence of the bifurcated type for the first right rugae (43.1% before and 33.3% after), followed by the straight type (23.5% before and 29.4% after). In the first left rugae, three types stood out before treatment: straight, angle, and bifurcated with 25.5% each, and after treatment, the three most frequent types were: bifurcated (29.4%), straight (25.5%), and curved (21.6%).

For the second right rugae, the percentage that was highest before and after orthodontics was straight, with 41.2% and 37.3% respectively. In the second left rugae, the two highest percentages corresponded to the straight (41.2%) and sinuous (33.3%) rugae in the pre-orthodontic treatment; in the post-treatment stage, the sinuous type had the highest frequency with 39.2%.

The sinuous type had the highest prevalence in pre-and post-orthodontic treatments, with 49.0% and 54.9% respectively. For the left third rugae, the sinuous type continued to be the most common, corresponding to 43.1% in the pre-and 52.9% in the post-orthodontic phase. The oval type accounted for the highest percentage of the initial rugae, with percentages between 47.1% before and 43.1% after treatment (Table 1).

The mean difference and a standard variation associated with the dimensions of the rugae per evaluation side showed no statistical difference between the first, second, and third rugae, on both sides, when compared before and after treatment, but was higher after treatment (Table 2; Figure 1)

Considering the objective statement of questioning the influence of orthodontic therapy on the palatal rugae morphology and the human identification process, the authors found that the fixed orthodontic treatment modified the rugae morphologically, independent of gender, age, or the color of the skin. In this study, one point observed was a decrease in the initial rugae shape when there was a diastema closure and palatalization of the anterior incisors.

The morphological alteration of palatal rugae may or may not be related to orthodontic treatment, but there is an association with more invasive procedures like palatal expansions²² which increase the perimeter of the arch¹⁹; especially by rapid maxillary expansion²³.

In addition, there is a morphometrical study that correlates palatal rugae with the influences of orthodontic treatment with²⁴ or without tooth extraction, however less frequently¹⁶. On the other hand, a cohort study shows that with or without previous orthodontic treatment, there are no influences of orthodontics, age, or gender on palatal rugae²².

This study showed that the buccalisation of teeth produces changes in both their size and shape, but statistically less in the first rugae. This occurrence could be due to the palatal mucosa's strong adherence to the bone, which it follows when it suffers mechanical pressure.

As such, the more posterior the rugae become less susceptible to the influence of the movement. Furthermore, the region of the molars is more resistant to orthodontic interventions because of its density of bone in the palatal/buccal and buccal/lingual direction and moves with more difficulty²⁵.

The shape of the rugae develops in the pre-natal period²⁶ and may be associated with a characteristic of the population²⁷, gender²⁸, or purely hereditary²⁹, being a conflicting subject both for sexual dimorphism and population characterization²⁶, even though it is considered to be one of the elements in the process of human Identification³⁰. In this study, the most common forms were the bifurcated, the straight, and the sinuous, despite a relationship with gender that was statistically non-significant.

A non-standard modification was visualized, which was an inversion of the vertex in a pre-teenage individual where the right first rugae palatine was of the bifurcate model with the angle of the vertex facing sagittal and at the end of the treatment, this rugae had the angle of the vertex turned to lingual, which calls into check the dogma that rugae palatine are immutable.

As for sex and age, while the literature indicates that women suffer more alterations in the shape of the first right rugae, this study found significant changes in the first left rugae of the group composed of individuals - men, and women - aged between 15 and 21. These findings emphasize the instability of the morphology of these structures in specific circumstances, suggesting that there may be changes in the first wrinkle no matter which side of the palate you are on.

No significant modifications in shape or size were observed when regard was had to skin color. It is worth noting, nonetheless, that of 51 models, there were 12 brown people and no black people. We recommend that the ethnic differences and a higher study population be analyzed, in a society as mixed-race as Brazil's furthermore, genetic phenotypes such as BMPs have been shown to influence the phenotype of palatal rugae³¹.

The architectonic instability of palatal rugae, however, has not made them a predictive element of failure in the process of human identification³², and they may be helpful in cases involving mutilation, compared to other body parts¹⁵. Comparison of extraction and non-extraction limit cases using fractal analysis and 3D overlay demonstrated that palatal rugae

change shape during orthodontic treatment, but their complexity, as measured by fractal dimensions, remains unchanged³³.

We believe that continuous follow-up, with up-to-date records during and after the orthodontic intervention period, as well as an efficient process for archives of patient data, would facilitate the identification of studies.

CONCLUSION

The fixed orthodontic treatment may result in morphological modifications to the palatine rugae. Therefore, a standardized method for this legal method of human identification would provide an additional means for forensic investigation and population studies. The use of palatine rugae in human identification continues to be a valid method but should be used with caution in individuals undergoing interventions that may modify the rugae pattern.

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