



Original communication

## Morphological changes in palatal rugae patterns following orthodontic treatment

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## ABSTRACT

This study investigated the morphometric changes that occur in palatal rugae during orthodontic treatment. The potential impact of these changes on the individuality of the palatal rugae patterns and on the use of palatal rugae patterns in human identification was also explored. Fifty pairs of pre- and post-orthodontic treatment dental casts were used. The palatal rugae patterns were compared between each pre-treatment cast and its post-treatment counterpart to reveal any morphometric changes. In addition, the individuality of the pre- and post-treatment sets of the casts was evaluated. Finally, a matching test of the palatal rugae patterns was performed in which the ability to match each post-treatment cast with its duplicate was compared with the ability to match that post-treatment cast with its pre-treatment counterpart. Statistical analysis of the results revealed the incidence of several morphometric changes, including segmentation (22%); unification (20%); changes in orientation (6%), shape (6%), and length (28%); anteroposterior displacement of the medial (54%) and lateral (60%) end of the ruga; and mediolateral displacement of the medial end of ruga (20%). The individuality of the palatal rugae patterns was confirmed in both pre- and post-treatment sets of casts. Finally, the mean percentage of correct matches was found to be significantly higher when the post-treatment casts were matched with their duplicates compared to when they were matched with their pre-treatment counterparts. The study revealed that Orthodontic treatment induces various morphometric changes in the palatal rugae patterns. These changes may potentially complicate palatal rugae-based human identification.

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### 1. Introduction

Palatal rugae are ridges or wrinkles situated in the anterior part of the hard palate behind the incisive papilla. These ridges are distributed on both sides of the median palatal raphe. Palatal rugae are also referred to as “plicae palatinae”, “transverse palatal folds”, or “rugae palatina”.<sup>1,2</sup> Palatal rugae are formed by the 12th–14th week of prenatal life as a connective tissue core embedded deeply between the submucosal fatty tissue and the stratum reticulum of the palate.<sup>3,4</sup> Several groups have characterized the morphometric patterns of palatal rugae in various populations to reveal that palatal rugae patterns are highly variable among different genders and ethnicities.<sup>5–7</sup> Palatal rugae patterns have gained more attention from researchers due to their clinical significance. The size and morphology of palatal rugae are relevant to dental practice in terms of influencing prosthodontic treatment plans for edentulous

patients.<sup>2,8,9</sup> Palatal rugae are utilized as reference points to measure teeth migration during orthodontic therapy.<sup>2,8,9</sup> They can also be used to diagnose and detect submucosal clefts in the palate because certain morphometric patterns of palatal rugae can be indicative of the presence of submucosal clefts.<sup>10,11</sup>

Several reports have suggested that palatal rugae patterns are unique.<sup>5,12–14</sup> The proposed individuality of palatal rugae patterns may facilitate their use in postmortem identification.<sup>9,13,14</sup> This is reinforced by the fact that palatal rugae can resist postmortem decomposition changes for up to 7 days after death and can withstand massive thermal insults like third degree burns.<sup>15,16</sup> Palatal rugae can also resist other forms of massive trauma because their location is protected by the tongue, dentition, and cheeks. However, several studies have questioned whether palatal rugae patterns can remain stable and constant during orthodontic treatment,<sup>9,17–20</sup> leading to conflicting reports on the stability of palatal rugae. This study was designed to further investigate the stability of palatal rugae patterns during orthodontic treatment. The study aims to document the incidence of any morphological change in the palatal

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rugae patterns following orthodontic treatment. It also aims to investigate the impact of these changes (if any) on the individuality of palatal rugae and their potential use in human identification.

## 2. Materials and methods

### 2.1. Morphometric changes in the palatal rugae

The assessment of palatal rugae was carried out on dental casts replicating the upper jaw and the palate. The study was approved by the Institutional Review Board (IRB) at Jordan University of Science and Technology. Fifty pairs of pre- and post-treatment dental casts were collected from private orthodontic clinics in Jordan. Each cast was given a serial number and marked with the gender and age of the patient (for whom the cast was made). The palatal rugae and the median palatal raphe in each cast were outlined with a pencil and a vernier caliper was used to measure the length of each ruga. The palatal rugae were then categorized according to the classification provided by Thomas et al. (1987) and described in detail by Mustafa et al. (2013).<sup>5</sup> Subsequently, each pair of the casts was examined for evidence of the following morphometric changes:

- Changes in number: These could result from segmentation, where one or more rugae in the pre-treatment cast split into two or more in the post-treatment cast; and/or unification, where two or more rugae in the pre-treatment cast combine to become one in the post-treatment cast.
- Changes in orientation: These occur when the rugae orientation changes, e.g., posterior rugae become horizontal rugae.
- Changes in shape: These occur when the rugae shape changes, e.g., circular rugae become crescent.
- Changes in length: These occur when the rugae undergo elongation or shortening.
- Displacement of lateral end in the mediolateral direction: Movement of the lateral end of one or more rugae closer to or farther from the median palatal raphe.
- Displacement of medial end in the mediolateral direction: Movement of the medial end of one or more rugae closer to or farther from the median palatal raphe.
- Displacement of medial end in the anteroposterior direction: Movement of the medial end of one or more rugae closer to or farther from the incisive papillae.
- Displacement of lateral end in the anteroposterior direction: Movement of the lateral end of one or more rugae closer to or farther from the incisive papillae.

### 2.2. Testing the individuality of the palatal rugae patterns

The individuality of the palatal rugae was examined by performing pair-wise qualitative comparisons within each set of the 50 casts (pre-treatment casts and post-treatment casts). Each cast was compared with the other 49 casts resulting in 1225 qualitative pair-wise comparisons. Each comparison was based on examining the palatal rugae patterns in the compared casts to reveal identical patterns (if any).

### 2.3. Matching test of the palatal rugae patterns

The post-treatment set of casts was duplicated, and the teeth in each cast were covered with tape, basing the matching test only on the palatal rugae patterns. Random samples of 10 casts were selected from the post-treatment casts. In the first part of the matching test, each examiner was asked to match the selected 10 casts with their duplicates of post-treatment casts. While in the

second part of the matching test, each examiner was asked to match the selected casts with their pre-treatment counterparts. Each examiner repeated the matching test three times using three different samples of selected casts. The results for each examiner were averaged, and the mean percentage of correct matches for all examiners was compared between the two parts of the matching test.

### 2.4. Statistical analysis

All the data were manually transferred into a computer. The frequencies and percentages of the morphometric changes were calculated and reported without further analysis. The results of the matching test were analyzed using paired student's *t*-test.

## 3. Results

### 3.1. Changes in the number of palatal rugae

Changes in the number were represented either by an increase or decrease in the palatal rugae number, resulting from segmentation or unification, respectively. Segmentation was detected in 11 (22%) palatal rugae patterns, whereas unification was detected in 10 (20%) palatal rugae patterns (Table 1).

### 3.2. Changes in the orientation of palatal rugae

Changes in orientation occurred on a limited scale and were detected only in three palatal rugae patterns (6%; Table 1).

### 3.3. Changes in the shape of palatal rugae

Only three casts showed changes in shape (6%; Table 1).

### 3.4. Changes in the length of palatal rugae

Changes in the length of rugae were evident in 14 casts (28%), as shown in Table 1. The changes involved either elongation or shortening of the palatal rugae.

### 3.5. Changes related to the displacement of lateral ends of palatal rugae

Displacement of the lateral ends of the palatal rugae occurred on a larger scale compared to the previous changes. Thus, 60% of the casts showed anteroposterior displacement while 28% of the post-treatment casts showed mediolateral displacement (Table 1).

**Table 1**

Frequencies and percentages of morphometric changes of palatal rugae after orthodontic treatment.

Morphological change	Frequency	Percentage (%)
Segmentation	11	22
Unification	10	20
Orientation	03	06
Shape	03	06
Length	14	28
DLat: A-P	30	60
DLat: M-L	28	56
DMed: A-P	27	54
DMed: M-L	10	20

DLat: A-P, displacement of the lateral end in anteroposterior direction. DLat: M-L, displacement of the lateral end in mediolateral direction. DMed: A-P, displacement of the medial end in anteroposterior direction. DMed: M-L, displacement of the medial end in mediolateral direction.

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