Human identification by the analysis of palatal rugae printed in complete dentures

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ABSTRACT

The study of palatal rugae is shown to be scientifically valid to human identification due to the unique number and style of the palatal ridges. Dentures provide an array of data and specifics that allow for the individualization of their wearers. This article describes the identification of edentulous, skeletonized remains through the analysis of the palatal rugae printed on the complete upper denture and subsequent comparison with the palatal rugae of an old complete denture of an unknown missing person. The analyses focus on the form, classification, location, and size of the palatal rugae which, in conjunction with the information obtained from the anthropological examination, resulted in a positive identification of the cadaver. This method has a significant impact on the identification process, particularly when other identification methodologies and techniques cannot be implemented. This case report highlights the importance of palatal rugae in human identification in cases of edentulous cadavers.

INTRODUCTION

The identification of skeletonized or burned human remains requires a multidisciplinary approach in order to identify unique traits that can ascertain an individual's identity and allow differentiation from all other individuals.[1]

In these situations, teeth represent the main approach in forensic dental identification. Teeth comprise unique structures with particular chemical compositions,[2] which can reveal related characteristics about the sex, age, and ancestry of an individual.[3-5] In addition, teeth reveal their uniqueness through their morphological and structural features, allowing for the identification of human remains through the teeth's shape and size,[6] analysis of dental anomalies,[7] observation of dental work,[8] or even through the presence of intra-oral micro-identification discs, which contain information in their surface that facilitate the identification of its owner.[9] However, in case of edentulism, the palatal rugae might be useful to assess characteristics for the identification.[10]

The palatal rugae, also referred to as palatal ridges, are irregular folds or corrugations or asymmetric ridges of the anterior mucous membrane of the palate extending laterally from the incisive papilla and the median palatal raphe.[11,12] The study of the patterns of the palatal rugae, palatal rugoscopy, can be used in the identification of an individual, as palatal rugae are stable and unique to each person.[12,13] The palatal rugae appear towards

the third month of foetal development and, in case of trauma, they reform themselves in their exact original position.[13,14] Although the size of the palatal rugae varies through time, the location and form remain constant throughout an individual's lifetime.[13,15] As a result, dentures have an important role in forensic odontology analysis, as each set of dentures can provide data and specific features that are unique to their wearer. For example, the internal surface mould of complete dentures can provide plaster models that reproduce the details of the alveolar ridge in which the denture was placed. This data can then be used for forensic identification.[10] Literature reports showing the identification of a cadaver through palatal rugae comparison with ante-mortem data are rare, although the device is widely worn by edentulous populations.[16,17]

This study presents a case report on human identification through the analysis of the palatal rugae printed in a complete upper denture found with edentulous, skeletonized remains. The comparison of the palatal rugae was completed with the features found in an old denture of a missing man that was provided by his family. This paper aims to emphasize the crucial importance of palatal rugae in cases of edentulous remains in an advanced stage of decomposition, in particular when the analysis of teeth traits and development and fingerprints are not possible.

CASE REPORT

The Medicolegal Institute of Ji-Paraná, in the inland of the Brazilian Amazon, received a skeletonized body found in an empty lot. The remains had complete upper and lower dentures made with acrylic resin. The anthropological examination established that the individual was an elderly male of admixture ancestry with primarily Asian and European features, and stature estimated to be between 1,60cm and 1,70cm (5'4" – 5'6"). Ante-mortem trauma was found on the left clavicle. The cause of death could not be determined due to the lack of traumatic peri-mortem lesions or any other evident features at the skeletonized stage. The forensic odontology examination showed the total absence of teeth in the maxillary and mandibular arches, with advanced resorption and bone remodeling, suggesting that the tooth loss occurred ante-mortem (Figure 1).

Figure 1. Cranium and edentulous mandible examined by anthropologist and legal odontologist.

The complete dentures found alongside the remains (Figures 2 and 3) had a precise fit with the maxilla and mandible of the remains, demonstrating compatibility in size and shape between the bony ridges and the prostheses.

Figure 2. Complete upper prothesis found with remains – internal surface moulded for analysis.

Figure 3. Complete upper prosthesis found with remains – occlusal view

Family members of a missing man contacted the Medicolegal Institute during the police investigation to provide information about the individual's characteristics: a 50 year old brown male with approximated living stature of 1,70cm (5'6"). The family members also provided information on a healed fracture located on the left clavicle of the missing man, which was consistent with the trauma found on the skeleton. During the search for the ante-mortem dental data of the missing man, the family delivered the old complete dentures (upper and lower) of the missing man to the forensic experts working on the case (Figures 4 and 5).

Figure 4. Complete upper prosthesis of missing man – internal surface moulded for analysis

Figure 5. Complete upper prosthesis from missing man – occlusal view

The complete dentures belonging to the disappeared, and the ones found with the skeleton were examined and named as *ante-mortem* and *post-mortem*, respectively. A plaster mould of the dentures internal surface was created in order to reproduce the palatal rugae and the edentulous maxillary and mandibular ridges. These models were analyzed using a magnifying glass under 5x magnification. The corrugations and undulations in the palatal area representative of the ridges belonging to the wearer of the prostheses were analyzed. All macroscopically visible criteria present in the models were listed and used to distinguish the *ante-mortem* and *post-mortem* dentures. Both showed an increase of the vestibular-palatal thickness on the contour of the superior alveolar ridge, located to the left of the incisive papilla. The palatal rugae were identified, marked with graphite, and their anatomy was classified according to the Martins-dos-Santos method,[14,18] as described on Table 1. The size of the rugae was measured using a caliper for posterior comparison of the maximum extension of each ruga.

Additionally, the upper plaster models obtained from the dentures were photographed using the ABFO No.2 metric scale, to avoid magnification and to provide a geometrical reference in the photographic documentation of the ridges.

The software Power Point® (Microsoft®, Redmont, EUA) was used to create a digital contour using the pictures of the models, with the tab "Insert → Form". The tool "curve" was used to delineate the contour and form of each palatal ruga present in the models, resulting in the Palatograms show as figures 6 and 7.

Table 1. Classification of palatal rugae printed in the maxillary protheses

Rugae of *Ante-mortem* Prothesis		Rugae of *Post-mortem* Prothesis	
Right Side	Curve	Right Side	Curve
	Sinuous		Sinuous
	Line + Bifurcated*		Bifurcated*
	Interrupt		Interrupt
Left Side	Curve	Left Side	Curve
	Sinuous		Sinuous
	Point		Point
	Line + Line*		Bifurcated*

* Two ridges displayed minor discontinuance in form due to the occurrence of artifacts during the moulding technique that created air bubbles in the plaster. These disruptions, however, did not exclude the compatibility between ridges.

Figure 6. Plaster model of interior surface of prosthesis found with remains. In yellow: correspondent palatogram In blue: the alveolar ridge contour.
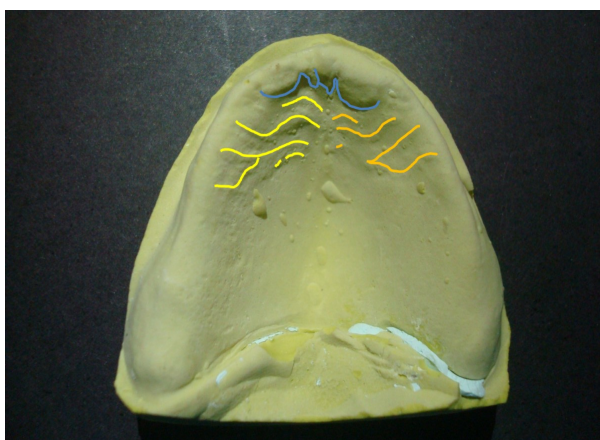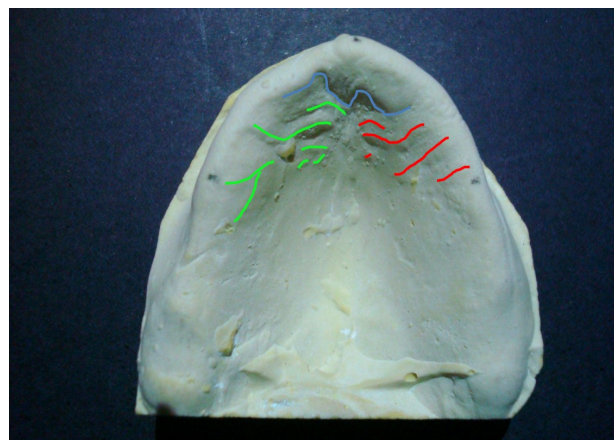

Figure 7. Plaster model of interior surface of prosthesis from missing man. In green and red: correspondent palatogram. In blue: the alveolar ridge contour.

The Palatograms obtained from the prostheses were thenceforth used to make a direct comparison between the palatal surfaces and the representative images of the ridges. They were compatible in form, location and size of the palatal ridges. Only two ridges displayed minor discontinuance in form due to the occurrence of artifacts during the moulding technique that created air bubbles in the plaster. The presence of disruptions or discontinuances, however, did not prevent the compatibility between ridges, which coincided in their general contour and location.

In addition, the models obtained from the complete lower dentures and the mandible analyzed during the forensic examination revealed the presence of slightly triangular edentulous ridges, with a high bone loss, especially in the posterior region. The region also displayed minimized dimensions in both thickness and length, expressing similarities in the contour, format, size, thickness and bone resorption at the mandibular ridges represented.

DISCUSSION

Human identification can be performed though a variety of forensic methods including fingerprint analysis, dental arch comparison and DNA analysis, in addition to rugoscopy and cheiloscopy.[19–22] However, in some cases, the advanced stage of decomposition of the bodies, the lack of ante-mortem data from possible victims, or even the complete absence of teeth, can hinder the application of traditional techniques in the search for the identity of a body. Furthermore, some traditional techniques, such as DNA analysis for human identification, are cost prohibitive in many settings, highlighting the importance of alternative methodologies that are reliable according to scientific standards.

A study[10] performed on moulds of the internal surface of complete maxillary prostheses of twenty eight edentulous individuals evaluated the rugae present and the topographic aspects of the ridges, comparing the plaster models originated from the wearers of the dentures with their original dentures. The research showed an unequivocal individualization of 100% accuracy when the plaster models were analyzed entirely, including the palatal rugae and the topography of bone contour, demonstrating the reliability of the method.

The dentures provide important information for human identification as they are unique and specific to each patient, and they artificially reproduce the dental arch and adjacent mucosa. These characteristics do not undergo significant alterations with time and are resistant to environmental changes and diverse conditions. Moreover, the devices are easy to collect, study, and compare to information present in dental records, allowing for frequent comparison in forensic odontology examinations.[23,24]

The printed rugoscopy in the palatal region of dentures and prostheses represent a unique mark of each patient, and are extremely valuable for the forensic odontologist responsible for a case.[15,25] Although the length of rugoscopic eminences can be shorter in edentulous individuals when compared to dentulous ones, points such as angles, curves and bifurcations can be observed in a clear and easy form from models originated from old and new prostheses, leading to reliable results.[26]

The palatal rugoscopy has marked advantages when compared to traditional methods, namely low cost and feasibility, in edentulous skeletonized individuals. However, the authors understand that unless palatal ridge patterns had been recorded in life through dentures or moulds, a rugoscopic comparison cannot occur.

Other disadvantages can be pointed out as the possibility of rugae pattern forgery and the possible distortion of the palatal rugae replicate as a result of poor duplicating materials and techniques. Poorly demarcated eminences of the rugae, especially in edentulous cases, are the most common cause of difficulty in identification.[27] Controversy still exists about the stability of quantitative and qualitative characteristics of rugae during human growth development and the extent of differences between ethnic groups and sexes.[28,29]

Based on the findings of forensic investigation of the presented case, the following traits were common to the skeletal remains and the supposed victim: the time frame of disappearance, the taphonomic and body decomposition changes, sex, age, ancestry, and stature. In addition, analysis revealed the presence of a bone callous resulting from an ante-mortem fracture in the left clavicle of the skeletonized remains, which is consistent with a fracture reported to be present in the missing person.

Despite these commonalities, a comparative scientific method was still necessary to reliably establish a positive identification. Thus, a comparative analysis of the dentures provided by the family, the dentures found with the remains, and the plaster models of each was completed to reach a positive identification. In the presented case, the comparison was made based on visual analysis of dentures and the two plaster models. When available, a superimposition using the scans of the two models could improve the degree and the accuracy of identification.

The contour, topographic aspects, size of the bony ridges and the presence of specific points in both prostheses represented individualizing features important for the forensic examination. However, it was the palatal rugoscopy that allowed the effective positive identification of the remains by establishing the equivalence in the form, location and size of the palatal ridges obtained among the maxillary prostheses.

Finally, it is important to stress that the methodology has been recognized as an effective, safe and reliable technique, based on valid

parameters that are advantageous and efficient for the forensic analysis.

CONCLUSION

In the presented case, the old upper denture of a missing man provided ante-mortem data on the individual's pattern of palatal rugae and the anatomy, size, and form of the alveolar ridges. This allowed the experts to confirm that the analysis of the internal surface of the complete maxillary prostheses shows a considerable value to the individualization of its owner. Therefore, this case study shows the importance of the palatal rugoscopy as an important technique in the processes of human identification in forensic examination and legal dentistry, especially in cases of complete edentulous skeletonized remains.

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