

## ***In vitro* Examination of Credibility of General and Specific Morphological Characteristics of Human Palatal Rugae in the Process of Recognition/Identification or Disassociation**

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**Abstract:** In this *in vitro* survey an examination of credibility of general and specific morphological characteristics of human palatal rugae was undertaken in order to be used at the process of identification or disassociation in Forensic Odontology. About 50 orthodontics' cases were examined. The casts were collected before and after the orthodontic treatment which lasted from 18 months to 4 years. Then, the 50 after treatment casts were mixed among 100 other randomly selected casts. All the surfaces of the casts except for the one representing the palatal rugae were trimmed by an orthodontic trimmer. The 50 before treatment casts were given to 5 researchers and the last ones were asked to compare them with the 150 casts for possible similarities. The collection of data occurred by the form of percentage proportions of correct recognition and requisite time for compare and recognition. The 4 researchers identified the casts correctly at a percentage of 100% and the one combined correctly the 47 casts (94%), (non-statistic significant difference, t-test). It appears that the form of the palatal rugae is a rather distinctive attribute in order to be recognized between individual persons. It is concluded from this study that the general shape, size and other significant data are identified as unique and personalized forensic evidence of identification.

**Key words:** Orthodontic casts, palatal rugae, recognition, identification/disassociation, credibility, forensic odontology

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### **INTRODUCTION**

Now a days, in the complex and rapid changing world, it is sometimes difficult to recognize the deceased. People lose their lives in car accidents, plane crashes or natural disasters. Decomposed, amputated or cremated bodies may be found in such conditions. Body identification is very important for return to the family or for legal reasons. Legal statements arise from the death of a person that must be dealt with in a positive identification such as settlement of property issues, estimate of life insurance, initiation of accountability, etc. Apart from specific legal issues, social and ethical reasons impose the rapid and definite identification of a human body (Morlang and Siegel, 1982; Cottone and Standish, 1982; Stavrianos *et al.*, 2010).

The use of dental records is a basic approach for resolving issues in problems during the procedure of identification of mass destruction victims, especially when the fundamental methods of forensic medicine cannot be implemented. In these cases, human identification is

based upon the comparative evaluation of the antemortem dental data that exist in dental history files with the postmortem records of the victims. The use of dental data implies that the last state of the dental arches of the victim is precisely known. In this light the necessity of extensive dental records has become acceptable by many countries which require by law for the dentists to hold them. Many times people who die under such circumstances often are in state of decomposition. The absence of fingerprints or facial characteristics requires the techniques of Forensic Odontology for a positive identification (Morlang and Siegel, 1982; Stavrianos, 2009).

Forensic Odontology relies on the fact that there are not two persons not even twin brothers or sisters that have the identical dental arches and the same dental characteristics as far as size, shape, position number and structure are concerned. Also, during dental investigation, certain characteristics reveal abnormalities or malformations and include: Individual teeth in relation to dental occlusion; dental arches with the alveolar processes and soft tissues of the mouth; teeth and

jaw bones relation (Stavrianos and Vasiliadis, 2002; Herschaft *et al.*, 2006). These characteristics are the result of developmental disorders of the oral and maxillofacial area and concern changes and variations of structural and morphological parameters (Fig. 1). As known, structure and form of the oral and maxillofacial development is the result of numerous interactions between genes and environment. Several morphological characteristics contribute also in tribal identification. Many individual dental characteristics concern patients with dental malformations of size, shape, position and number of teeth (Cottone and Standish, 1982; Sweet and DiZinno, 1996). During human identification via Forensic Odontology, the more rare and unique characteristics of the oral and maxillofacial area accrue the more rapid and reliable human identification is. In case that all teeth are present (including third molars), each posterior one has five surfaces and each anterior four resulting to 148 surfaces to compare between antemortem and postmortem data. The number of possible combinations between filled, missing or supernumerary teeth, root canal treatments, fixed or removable prosthetic appliances, tori, general abnormalities, etc. is astronomic. If radiographs exist then the number of possible combinations of various characteristics tends to infinity. The systematic recording of such information coupled with the use of computers is a powerful tool for the successful recognition of corpses on the basis of dental evidence (Cottone and Standish, 1982; Herschaft *et al.*, 2006; Stavrianos, 2009; Stavrianos *et al.*, 2009).

Most identification is based on fillings, root canal therapies, prosthetic restorations, missing teeth that can easily be documented in dental records. It should be noted that the reduction of frequency of decayed teeth the last years will dictate greater reliance on other



Fig. 1: The stage of the mixed dental arches can be a rather distinctive characteristic for the individual. The orthodontic device attaches uniqueness on this person's OPG

dental findings in the future. However, if there is enough evidence, almost infinite number of factors has high value of worth in a recognition process. Thus, the objective findings, especially those that are unique in an individual, provide the basis for identification or disassociation. The forensic odontologist will study and analyze the dental state of the under examination body will record all dental findings thoroughly and will make radiographic and photographic records of the dental arches and other elements of the skull. Then, he will assess them in a comparative way with the antemortem dental records and radiographs of possible victims or missing persons and will result in positive identification or not (Fig. 2). The search and collection of antemortem files is the responsibility of the research department that has access to reports of missing persons in local or national level (Sweet and DiZinno, 1996; Stavrianos, 2009; Stavrianos *et al.*, 2009).

Orthodontic treatment is used to correct occlusal discrepancies of the dental arches which can cause some sort of deformity or functional impairment. The treatment is carried out by removable orthodontic appliances or fixed orthodontic devices. Also, the extraction of certain teeth is required, usually the first or second premolars in order to create the necessary space for the proper settlement of the dental arches. After the treatment, the patient's history, radiographs, photographs and casts of the case must be archived as they can be used as antemortem dental data in the process of identification (Whittaker and MacDonald, 1989; Herschaft *et al.*, 2006; Stavrianos, 2009). It is recommended that in any case of identification, especially in disasters with many victims, teeth moved for orthodontic reasons must be recorded. Any antemortem radiograph as old as may be should



Fig. 2: The dental arch as it is imprinted in a cephalometric radiography can be unfaltering antemortem evidence

be presented for comparative assessment, e.g., a lateral cephalometric or an orthopantomograph, taken by an orthodontist may allow clear recognition even if the case has been completed years ago.

In some cases the anatomy of root and bone structured may be a little bit altered but it will help in an attempt of identification. Also, dental fillings done before the start of the orthodontic treatment are visible in such radiographs and may be compared with antemortem radiographs of the corpse (Sweet and DiZinno, 1996; Stavrianos, 2009).

A lot of literature has been published on identification of unknown corpses with removable orthodontic appliances or fixed orthodontic devices. As well known, rigor mortis in cases of charring bodies causes adamant conjoining of the mouth (ankylosis), thereby protecting the contents of the oral cavity. Consequently, in this case the acrylic parts of orthodontic appliances are retained intact, together with welded orthodontic brackets, hooks, rings etc. thus helping the process of identifying an individual (Whittaker and MacDonald, 1989).

Unfortunately, teeth are not always available for identification. The teeth may be lost due to trauma, thermal fracture in addition, the victim may have been edentulous at the time of the accident. An ideal tool of postmortem identification would be the one that is present in all victims is resistant to change (old age and trauma etc.) and has individual characteristics that are unique for each person. Most dental identifications are based on a comparison of the teeth and restorations (Whittaker and MacDonald, 1989; Cottone and Standish, 1982; Stavrianos *et al.*, 2009).



Fig. 3: Palatal rugae is an accessible finding in all patients but in orthodontic patients it is always data that is recorded via casts

One method that is proposed for human identification with the use of an individual characteristic in the oral cavity is the one of the comparison of the palatal rugae (Hauser *et al.*, 1989). The individuality of the palatal rugae has been proposed by numerous studies (Paliwal *et al.*, 2010) and may be the only available characteristic in a mouth of an edentulous deceased that can lead in positive identification (Fig. 3).

The purpose of this research *in vitro* study was to determine whether the small changes that occur to the bones in relation with the teeth during orthodontic movement affect the recognition process when the single asset for recognition is the palatal rugae.

## MATERIALS AND METHODS

Fifty orthodontic cases were used in this study. From each case 2 maxillary casts were taken; the one referring to the patients' condition prior the orthodontic treatment and the one after the treatment. The pre-orthodontic and post-orthodontic casts were from patients treated in private dental practices in Thessaloniki, Greece. All dental impressions were taken with irreversible hydrocolloid, silicon or polyether materials. The time span between pre and post-orthodontic casts ranged from a minimum of 18 months to 4 years. The palatal width was considered stable and as of an adult's size thus the patients' age was 14 years old or older. Then, the casts were trimmed in an orthodontic trimmer and only the palatal rugae's area was left intact. This was done in order to exclude all other areas of the casts such as the teeth, edentulous areas and the vestibule from use at the identification process.

The 50 post-orthodontic casts were mixed among another 100 randomly selected casts. All data referring to the patients were recorded but none of them were revealed to the evaluators. The evaluators were 5 dentists with variant experience in forensic science identification. The experience ranged from novice to great. Each evaluator assessed the casts alone. Researcher 1 had the greatest experience continuing to researcher 5 with the less. The evaluators were asked to match each one of the 50 pre-orthodontic casts with one of the 150 promiscuous casts. The researchers were evaluated for the number of correct matches and time required for completion of evaluation.

## RESULTS AND DISCUSSION

Figure 4 and 5 show the percentage of correct matches of each researcher. Each set of pre and post-orthodontic casts were matched (100% correct) by four evaluators. Evaluator 5 (with the less experience on

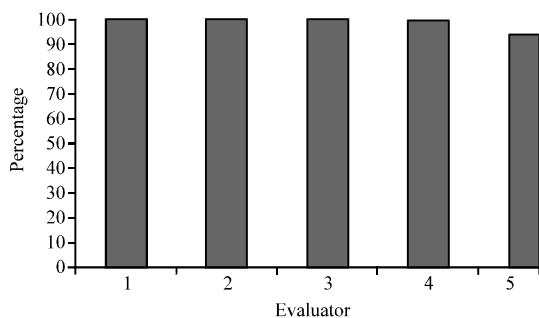


Fig. 4: Percent of correct matches obtained

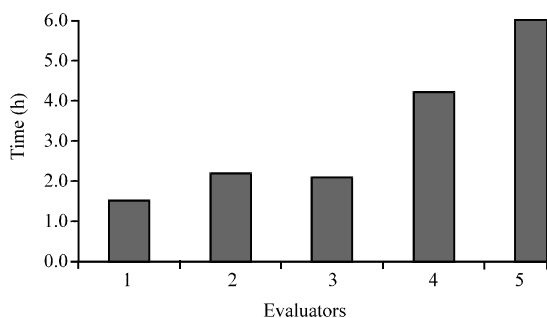


Fig. 5: Time required for comparison of casts (h)

the field) managed to match the pre and post-orthodontic casts in a percentage of 94% (Student t-test,  $p = 0.05$ ,  $a = 3$ , 45.12-53.18, non statistical significant values). Researchers did not use any classification system of the palatal rugae to compare them.

Palatal rugae are irregular, asymmetric ridges of mucous membrane in the anterior third of the palate, posterior to the incisive papilla. Anatomically it is used to participate in the chewing process. It also participates in the sense of taste. Nor the number of palatal rugae is not bilateral symmetric neither the distribution from the midline. Male usually have more rugae than female and the left half has slightly more rugae than the right in both genders (Simmons *et al.*, 1987; Kapali *et al.*, 1997; Abdel-Aziz and Sabet, 2001; Buchtova *et al.*, 2003).

Historical aspects of this process show that the first person to study the palatal anatomy and identify certain anatomical features was Kuppler in 1897. Santorini was the first to publish an illustration of the palatal rugae in 1775. Palatal rugae can be classified according to various systems that use different characteristics to do so.

The most used system now a days is the one proposed by Cormoy (Thomas and van Wyk, 1988) which classifies the rugae according to size, line, curve and angle. Other system such Carrea, Martins dos Santos, da Silva are used also. All classifications are based on the

first classification by Lysell (1955). Older studies have suggested the use of palatal rugae as an individual print such as fingerprints for identification (Kapali *et al.*, 1997; Robinson *et al.*, 1998; El-Fotoh and El-Sharkawy, 1998; Patil *et al.*, 2008; Sharma *et al.*, 2009; Viridi *et al.*, 2010). Only the portion of the rugae in dental casts is sufficiently characteristic to discriminate different specimens and match positively antemortem and postmortem data (English *et al.*, 1988). In an actual forensic identification, the pre-orthodontic cast would represent the antemortem data obtained by the person's dentist and the post-orthodontic cast the one's obtained from the body during the identification process.

This study comes to cohere with the earlier ones, stating that it is legitimate to use the palatal rugae pattern for positive human identification in Forensic Odontology, under any circumstances (Ermenc and Rener, 1999). The usefulness of this is that each maxillary cast reproduces the palatal rugae, having a constant impression that can be used for forensic reasons as antemortem data. In addition, oral photographs and earlier prosthetic devices imprint this anatomical feature. Thus, it is available at a high extend and can be used in most of cases. In fact, pilots of the Brazilian Aeronautics are obliged to palatal rugoscopy in order to ensure identification in cases of accident. Indeed, modern identification techniques such as DNA profiling may be more accurate but they are expensive and time consuming in large populations. So, the uniqueness of the palatal rugae is an inexpensive and a rapid technique in contrast to DNA profiling (Sweet and DiZinno, 1996).

Limitations exist in cases of edentulous patients according to Ohtani *et al.* (2007) but palatal rugae can be used in identification in a reliable way as in cases of dentate cases.

The number of rugae remains stable throughout the person's life. Changes may be seen only to their length as a result of orthodontic treatments such as rapid maxillary expansion. The palatal rugae pattern, though and remains constant (Kapali *et al.*, 1997; Damstra *et al.*, 2009). Despite that there are studies which suggest that conditions like trauma, extreme finger sucking during infancy, persistent pressure and loss of tooth may modify the alignment of the pattern (Jacob and Shalla, 1987; Hauser *et al.*, 1989; Paliwal *et al.*, 2010). This seems to need further research in order to prove this.

Finally, this study suggests that specific knowledge or certain training is not required to complete successfully this type of correlation. The identification process with the use of palatal rugae patterns does require a larger amount of time for novice researchers though.

## CONCLUSION

The study of palatal rugae is an accurate method for positive human identification by comparing antemortem and postmortem data. Palatal rugae are sufficiently characteristic to discriminate between individuals.

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