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Individuality of Human Palatal Rugae

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ABSTRACT: Investigators have implied that palatal rugae are unique to each individual. However, these researchers have disagreed as to whether or not legal identification could be based solely on palatal rugae. Previous studies used poor duplicating materials and may not have considered the effects of growth, extractions, palatal expansion, or some combination of these. The inadvertent use of other features of the cast, such as teeth, edentulous ridge morphology, muscle attachments, vestibular depth, or some combination of these, to aid in the identification, may have influenced their results. The purpose of this investigation was to determine if palatal rugae can be relied upon for identification.

Twenty-five orthodontic cases were selected with pre- and post-treatment casts; orthodontic treatment had taken eighteen to sixty months. One hundred casts were randomly selected as variables. All casts were trimmed so that all areas except for the rugae area of the hard palate were removed. The twenty-five post-orthodontic casts were dispersed within 100 randomly selected casts. Nine investigators were given the twenty-five pre-orthodontic casts and asked to compare them to the other one hundred and twenty-five casts for possible matches. Data were collected as to percentage of correct matches and time required for comparison.

Each set of pre- and post-orthodontic casts was properly identified (100%) by 8 investigators, and the remaining investigator correctly matched 22 out of 25 casts (88%).

These conclusions were drawn. The team approach significantly reduced the time required to make correct matches; it appears that the palatal rugae pattern is sufficiently characteristic to discriminate between individuals; and this study supports the hypothesis that palatal rugae are unique and identification could be based upon their comparison.

KEYWORDS: odontology, palatal rugae, castings, human identification

In modern society, death is a complicated medicolegal matter. The identification of human remains is necessary so that a death certificate can be issued, which is itself needed to resolve legal matters such as insurance claims and wills. In the majority of jurisdictions within the United States, the courts basically recognize three methods of identification: vi-

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sual, fingerprints, and dental characteristics [1]. In many instances, one or all of these methods may not be totally effective or conclusive.

Visual identification is the most common method because most deaths do not occur under unusual circumstances, thus remains are visually identifiable. However, in complex identifications, visual means have always been the least desirable method because of emotional stress and lack of objective assessment at the time of the identification.

Morlang [1] stated that fingerprints have long been the standard identification process, but this form of identification is not possible if there are no antemortem records. Also, postmortem fingerprints are often unavailable, especially in cases involving fire, decomposition, or massive trauma.

Rawson et al. [2] have written about the statistical evidence for the individuality of the human dentition. Victims of aircraft accidents [3-6] have been identified by their dentition. Gillespie et al. [4] reported that dental evidence was of vital importance in identifying 83.7% of the victims from the bombing of the U.S. Marine Headquarters, Beirut, Lebanon. Victims of natural disasters [6-8], such as fires and floods, have also been identified by dental means. Many criminal investigations [9,10] have included the use of dental evidence. Unfortunately, the dentition is not always available for identification. Teeth may be lost due to trauma, heat fracture, or may not be present if the victim was edentulous at the time of the accident.

An ideal postmortem identifier is one that is present in all victims, is resistant to change (aging, trauma, and so forth), and has individual characteristics which are unique in every person.

The use of human palatal rugae was suggested as an alternate method of identification in 1889 by Harrison Allen [11]. The earliest reference to rugae was in an anatomy text by Winslow [12] in 1732 and was first illustrated by Santorini [13] in 1775. Many researchers have studied the morphology [11,14-23] and the racial differences [24-27] of palatal rugae.

Rugae are protected from trauma by their internal position in the head, and they are insulated from heat by the tongue and the buccal fat pads. Sassouni [28] stated that no two palates are alike in their configuration and that the palatoprint did not change during growth. Ritter [29] studied the rugae of twins and found that the pattern was similar but not identical. Carrea [30] published a system of classification and stated that rugae are unique to each individual, of constant shape, and permanent. Hausser [31] studied children from birth to nine years old and found that the characteristic picture of the palate does not change as a result of growth. Leontsinis [32] ascertained that rugae do not change from the time they develop until the oral mucosa degenerates at death. Peavy et al. [33] have shown that slight morphologic alterations occur in the relationship of rugae to teeth during orthodontic tooth movement, but no major alteration in the rugae shape occurs.

Kogon and Ling [34] described a photographic superimposition technique that can easily be adapted to conventional photographic equipment for rugae comparisons.

Aufiero and Cesati [35] used Carrea's classification and found that systems of classification have no legal value but may be useful in limiting the searches of the archives in identifications. Lysell [36] found that rugae are, in general, unchanged throughout life and can thus be used to help in the identification of an individual. He doubted, though, that legal identification could be made solely on palatal rugae. Thus, the use of palatal rugae for forensic identifications is in question.

In the previous studies of palatal rugae there have been several techniques and materials used. Comoy [37] took elastomeric impressions of the entire maxillary arch of 200 subjects, poured them in dental stone, and then drew on the stone casts the outlines of the incisive papillae. Comoy also developed a classification system based upon the length of the rugae. Sassouni [28] devised a study using 100 casts in which he developed a print of the palate. He advocated the use of bubble gum and a wooden spoon for obtaining the impression of the rugae. He would ink the impression and transfer it to paper to make a palatoprint similar to

fingerprinting procedures. This technique leaves doubt as to the accuracy of this procedure because of the inaccuracy of the impression material (bubble gum) and the formation of a negative impression to produce the palatoprint. Lysell [36] and others have used photographs of the entire maxilla with the teeth and alveolar ridges partially blocked out.

The analysis of data in these previous investigations may not have taken into account other influencing factors, including (1) the inadvertent use of other features of the cast to aid in the identification, such as teeth, edentulous ridge morphology, muscle attachments, vestibular depth, or some combination of these; (2) the effects of growth, extractions, or palatal expansion upon the shape of the rugae; and (3) the possible distortion of the palatal rugae replicates as a result of poor duplicating materials and techniques.

The purpose of this investigation was to determine if palatal rugae are unique identifiers. The study used modern dental impression techniques, a large number of palatal casts for comparison, and a design which excluded influencing factors other than rugae.

Methods and Materials

One hundred and fifty duplicate maxillary casts of patients treated at Lackland Air Force Base (AFB) were used in this investigation. All initial impressions were made with ADA-approved impression materials of either irreversible hydrocolloid, polysulfide, silicone, or polyether materials. The first group consisted of one-hundred dental plaster duplications of all maxillary casts. These plaster casts were made at the same dental laboratory⁶ from 15 Jan. 1986 through 15 March 1986, using reversible hydrocolloid.⁷

The second group consisted of 50 dental plaster duplications of pre-treatment and post-treatment casts from 25 orthodontic cases obtained from the Orthodontic Department, Wilford Hall Medical Center, Lackland AFB, San Antonio, Texas. The time span between pre- and post-orthodontic casts ranged from a minimum of 18 months to a maximum of 5 years. Only orthodontic patients 14 years old and older were used, so that the palatal width was of adult size.

All casts were trimmed on an orthodontic cast trimmer in a standardized manner. The base was trimmed parallel to the occlusal plane. The posterior of the cast was trimmed perpendicular to the base until the cast measured 2.5 cm from the incisive papilla (Fig. 1).

Finally, the remaining borders were trimmed perpendicular to the base following the arch form until all teeth and edentulous ridges were removed (Fig. 1). This step eliminated bias from the use of teeth, edentulous areas, and the vestibule as identifiers and insured that only the palate could be used in the identification process.

The 25 pre-orthodontic casts were designated by letters (A-Y). The remaining casts were assigned numbers (1-125), with the 25 post-orthodontic casts randomly dispersed among the other 100 casts. Each patient's sex, age, name, social security number, and if possible, race were recorded but were not revealed to evaluators.

Seven dentists and two dental assistants were selected as evaluators. An array of experience levels in forensic science identification was represented by this group. Five dentists were selected as individual evaluators, with their experience ranging from zero to over one thousand forensic science identifications. Two teams were formed, one composed of two dentists and the other with two dental assistants. None of the team members had any forensic experience. Each team or individual was given the twenty-five pre-orthodontic casts (A-Y) and asked to compare them to the other one hundred and twenty-five casts (1-125) for possible matches.

Data were recorded for each individual investigator or team as to the number of correct matches obtained (Fig. 2) and time required for completion of the evaluation (Fig. 3).

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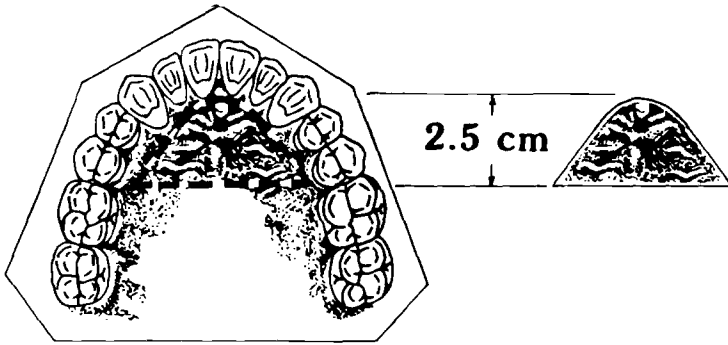


FIG. 1—Casts trimmed to a length of 2.5 cm from the incisive papilla and on periphery to eliminate all teeth and edentulous ridges.

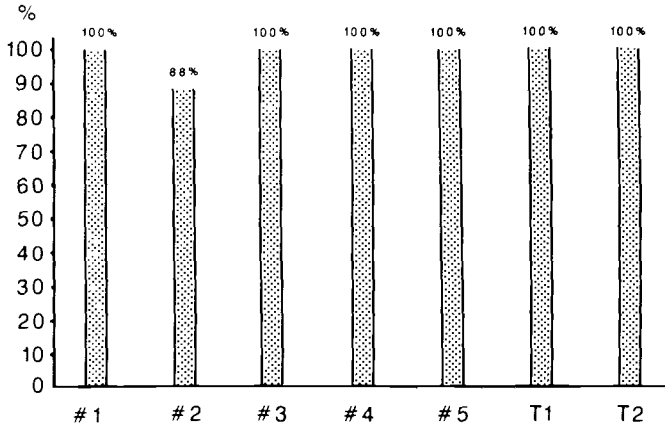


FIG. 2—Percent of correct matches obtained.

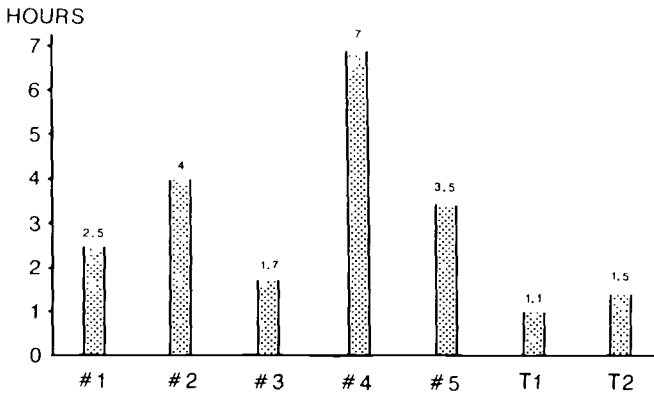


FIG. 3—Time required for comparison of casts.

Results

Figure 2 shows the percentage correct for each investigator or team. Each set of pre- and post-orthodontic casts was matched (100% correct) by four investigators and both teams. The remaining investigator correctly matched 22 out of 25 casts (88% correct).

Dentist 1 (dentist with 2 years advanced education in general dentistry), 17 years out of dental school with moderate level of experience (12 cases) in forensic science identification, was able to make 25 of 25 correct matches. Dentist 2 (dentist with 2 years advanced education in general dentistry), 9 years out of dental school with novice level of experience (0 cases) in forensic science identification, was able to make 22 out of a possible 25 matches. Dentist 3 (general dentist), 6 years out of dental school, with novice level of experience (0 cases) in forensic science identification, was able to make all correct matches. Dentist 4 (general dentist), 8 years out of dental school, with novice level of experience (0 cases) in forensic science identification, was able to make all correct matches. Dentist 5 (Board certified oral pathologist), 15 years out of dental school, with expert level of experience (more than 1000 cases) in forensic science identification, was able to make all correct matches. Team 1 (both dentists with 2 years advanced education in general dentistry), 13 and 15 years out of dental school, with novice level of experience (0 cases each) in forensic science identification, were able to make all correct matches. Team 2 (both USAF dental assistants), with no prior exposure to any type of forensic science identification, were able to make all correct matches.

Each evaluator and team was asked if they developed or used a classification system in the comparison of palatal rugae. There were no classification systems developed or used during this investigation.

Discussion

This study found that palatal rugae are sufficiently characteristic to indicate identity through discrimination and gave evidence that palatal rugae may be used for identification purposes. The investigation used only that portion of the palate that contains the rugae; all other possible structures that might have been used for identification were removed.

By duplicating casts submitted to a dental lab and not taking specific impressions for this study, case selection would be similar to actual forensic science identification. The forensic science team would be required to use an existing cast as an antemortem record. The quality of the casts varied widely, from those having no bubbles in the original impression to others having numerous voids. Even with these discrepancies, the evaluators were able to identify the pattern of each individual and make the correct matches. The post-orthodontic casts in this study would represent postmortem casts in an actual forensic science identification, and the pre-orthodontic casts represent the antemortem records. The purpose of this study was not to duplicate an identification scenario but to establish that the palatal rugae pattern is characteristic for an individual.

In one of the orthodontic cases used in this study, the pre-orthodontic cast (Fig. 4), palatal hyperplasia was present because of the use of a maxillary temporary removable partial denture to replace Tooth 7. When orthodontic treatment was initiated, the denture tooth was attached to the archwire and use of the denture was discontinued. At the completion of treatment, the palatal hyperplasia had resolved (Fig. 4). Even with this significant morphological change to the palatal tissue, the rugae pattern was identifiable.

Several participants in this study initially attempted to group the casts by size or shape before attempting to match them. They soon found this to be too time-consuming, so identification was made by careful individual comparisons of the casts. Classification of rugae have been described by Peavy and Kendrick [33], Comoy [37], Thomas and Kotze [38], and others. These or similar systems may in the future provide a method for identification, just as fingerprints and footprints are used today. It was not the purpose of this study to develop a



FIG. 4—Pre- and post-orthodontic casts showing palatal hyperplasia resolved.

classification system or to determine frequency distributions of morphologic features of the rugae.

The team of two dental assistants correctly matched all cases. They have had instruction in basic dental anatomy but no training in forensic science identification techniques. Their ability to match all the casts successfully (100% correct) indicates that specific training or knowledge may not be required in this type of comparison.

There was no correlation found between previous forensic science identification experience and time required for matching or percentage of correct matches. Meticulous attention to detail was demanded in each case, and this discriminating process was affected by fatigue and time required for the comparison. The average time required for individual evaluation was 3.7 versus only 1.3 h average time for the teams. The team of two dental assistants correctly matched all cases in only 1.5 h, as compared to one dentist who took 7 h to obtain the same results. The team approach significantly reduced the time required to make the correct matches and is recommended for forensic science identification using rugae.

The use of pre- and post-orthodontic cases also demonstrates that the changes occurring with palatal expansion, short term aging, extractions, and tooth movement do not significantly alter the pattern of the palatal rugae. Even though the width was greatly increased, as shown in Fig. 5, the palatal rugae pattern remained constant.

Most dental identifications are based on comparison of teeth and associated restorations. In the last decade, there has been a substantial decrease (up to 50%) in the prevalence of dental caries and an increase in the numbers of caries-free children 5 to 17 years of age [39,40]. With fewer projected dental restorations being placed, the identifications based on these characteristics will probably decrease. Instances could occur in which the palate would remain intact when most other anatomical structures are destroyed, burned, or dehydrated. This could occur when the body is exposed to fire and impact, as in an aircraft crash. Therefore, anatomical structures, such as palatal rugae, may have more importance in the future.

Approximately 11% of the U.S. population is edentulous [41]. Dentures may be marked during processing with the name or social security number of the individual, but this is not always accomplished. In addition, oral prostheses are often expelled in severe trauma and are lost, damaged, or melted. In these individuals, the palatal rugae could be the only means of making a positive identification.

The ability to use this method of identification is dependent on having an antemortem record of the palatal rugae. This could simply consist of existing dental casts. However,



FIG. 5—Pre- and post-orthodontic casts showing palatal expansion.

other methods of recording the rugae pattern are possible for identification purposes. These might include photographs, palatal prints, or computerized topography of the rugae pattern.

Further studies to resolve the following questions are recommended: (1) is the palatal rugae pattern stable throughout the life of an individual?, (2) can a simple, effective classification system for recording and comparing these patterns be established?, and (3) after trauma or surgical removal, does the rugae pattern regenerate?

Conclusions

1. The team approach significantly reduced the time required to make correct matches.
2. It appears that the palatal rugae pattern is sufficiently characteristic to discriminate between individuals.
3. This study supports the hypothesis that palatal rugae are unique and identification could be based upon their comparison.

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