Palatal rugae as a tool for human identification

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Abstract

Objective: This study was conducted to assess the accuracy of palatal rugae as a tool for human identification and to determine factors that may limit accuracy. This will serve as a potential basis for advising national health policy formulation on human identification as forensic rugoscopy is unexplored in sub-Saharan Africa.
Materials and Methods: One hundred consenting participants were recruited; impressions of the upper jaws were taken and cast with dental stone. All the teeth on the models were trimmed off to prevent identification by tooth morphology and the models were coded. Five uncalibrated dentists independently pair-matched the models based on the pattern of the palatal rugae.
Results: The overall accuracy for all 50 paired models ranged from 72 to 96%, while the percentage correct match for each of the 50 paired models range from 40-100%. All the examiners properly matched 60% of the models.
Conclusion: Rugoscopy is a useful technique for human identification due to the unique rugae pattern in every individual. However, without the aid of ancillary aids, visual inspection alone can be challenging.
Clinical relevance: This study provides useful information on an additional clinical technique relevant for human identification.

Key words: Forensic, human, identification, palatal rugae, rugoscopy, Ibadan, Nigeria

Introduction

The common methods used in forensic science for confirming the identity of persons are deoxyribonucleic acid (DNA) analysis, fingerprinting, and dental comparison.[1,2] The duties of a forensic dentist include estimating the age of an individual and studying bite marks on victims, but the most frequently performed examination is comparative identification when a deceased person is identified based on their dental records.[3,4] Dental records consist mostly of teeth number, morphology, and alterations. Some of these records may change over time without appropriate clinical update and sometimes the records are basically incomplete or nonexistent.[5,6]

Under these circumstances, the palatal rugae, being unique to individuals and relatively stable in adult life has been proposed as a means for establishing identity similar to the fingerprinting method.[6,7] Despite the simplicity, reliability, and economic advantage; forensic rugoscopy is unexplored in Nigeria mostly because of poor planning and inadequate documentation; therefore, this study was conducted to assess the accuracy of rugoscopy as a tool for human identification and to determine factors which may limit accuracy. This will serve as a basis for advising policy formulation on human identification in Nigeria.

Materials and Methods

One hundred consenting participants, who were predominantly of southwestern Yoruba race, were recruited into the study; this consisted of dental students, interns, and dental technicians in training. Informed verbal consent was obtained from all participants. The study models

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were obtained from individuals within the age range 20-25 years.[8,9] Participants with prominent palatal tori and those using dentures were excluded from the study.

Sample size was calculated using a convenient sampling technique in which all the students that were willing to participate were recruited into the study.

Fifty subjects had two separate impressions of the upper jaw taken with alginate impression material (Tub-Henry Schein-Regular Set) loaded into upper full arch metal stock trays. The other 50 subjects had only one upper jaw impression taken. The impressions were taken by the same operator to correct for internal errors of technique. All impressions were cast immediately with dental stone (Dentsply-Trubyte) and those in pairs were each boxed separately. All the teeth on the models were trimmed off to prevent identification by tooth morphology. The posterior palatal vault was also trimmed off to approximately 2 mm short of the rugae with a model-trimming machine (JNSX-5 Plaster Trimming Machine).

An independent operator inscribed random prepaired and unpaired alphanumeric codes on both the paired and unpaired models. All paired and unpaired model were then boxed together and mixed thoroughly.

Five uncalibrated dentists were then requested to independently pair matching models based on the pattern of the palatal rugae and to indicate the codes as paired or unpaired. They were advised that only 50 pairs were achievable. These examiners consisted of two lecturers and three interns.

All entries were submitted to the operator that inscribed the codes to compare with the master list. The operator that inscribed the codes did not participate in the pairing exercise. The accuracy of the match for each examiner was calculated as the percentage of correct matches.

Ethical clearance was obtained from the Oyo State Research Ethical Review Committee (AD13/479/352). Statistical analysis was conducted using the software of Statistical Package for Social Sciences version 16. Individual examiner's performance was expressed as percentages, while group performance was expressed as means and standard deviation, intergroup performance of examiners was compared using Student's *t*-test and Pearson's correlation index. Reliability index (RI) was assessed using Fleiss' kappa statistics. Level of statistical significance was set at $P \leq 0.05$ at 95% confidence interval.

Results

The overall accuracy of pair-matching for all the 50 paired models by the five examiners ranged from 72- 96% [Figure 1]

with a mean score of 84.8 ± 11.2 and a median of 88%, while the percentage correct match for each of the 50 paired models range from 40 to 100% with a mean of 84.0 ± 20.9% and median of 100% [Figure 2]. All examiners properly matched 60% of the paired models.

Concerning performance according to the examiners groups, accuracy of pair-matching by the lecturers revealed a mean and median score of 95%; while the mean and median score for the dental interns was 81%. Fleiss' kappa statistics showed that the overall accuracy of all examiners was 60%, while those of the lecturers and interns were 90 and 64%, respectively. There was a low level of positive correlation ($r = 0.25$) between the two groups of examiners as lecturers were significantly more accurate in their assessment than dental interns ($P = 0.001$; confidence interval = 0.11-0.41).

Discussion

There are several ways to study the palatal rugae with the simplest, easiest, and most widely used method being direct visual inspection; but this method is subject to recall error and difficulty when future comparison is required.
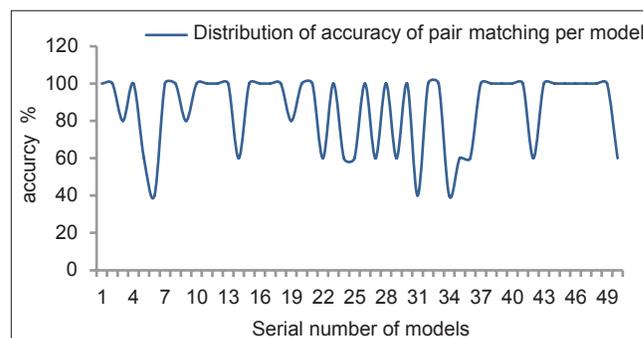

Figure 1: Percentage accuracy of pair matching for each model
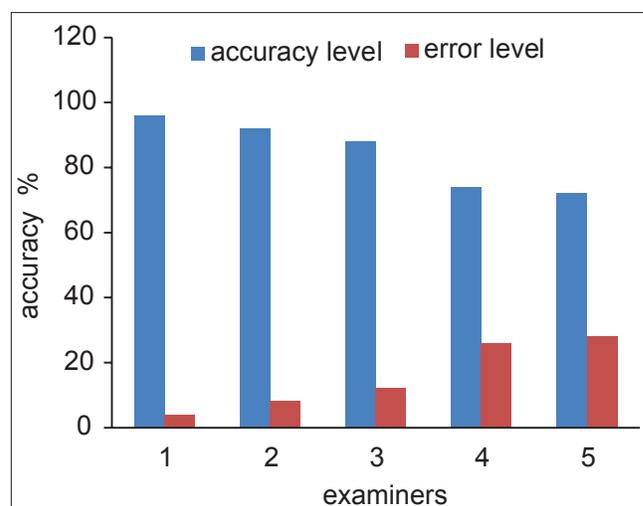

Figure 2: Examiners accuracy for pair matching

Therefore, intraoral photography and dental model fabrication is justified when there is a need to preserve evidence.[10,11] For the present study, dental stone model was used to assess the accuracy of human identification in a blinded situation.

The accuracy of correct matching for the paired models by the five examiners ranged from 72-96%, this level of accuracy is similar to findings of previous studies by Bansode and Kulkarni (76.66-96.66%)[12] and English *et al.*, (100%).[13] In a similar study by Limson and Julian,[14] the utilized scanned models and digital photographs with highlighted rugae patterns yielded 92-97% success rate. The authors suggested that using an intraoral camera with direct transfer to a computer could reduce the error rate of 3-8%.

Significantly higher success rate among lecturers was observed when compared with dental interns in this study, suggesting the need for further professional training to attain high accuracy in rugoscopy. Bansode and Kulkami[12] also observed differences in accuracy levels of dental professionals and non-dental professionals, but attributed difficulty in matching to complex patterns or to overlapping and poorly demarcated palatal rugae.

We observed that none of the hundred individuals were alike in terms of the shape of the palatal rugae and this supports the uniqueness of palatal rugae pattern as a tool for human identification. This observation is an indication for further studies of ethnic differences in primary rugae pattern among Nigerians.

In this study, there was no significant difference between the rugae pattern of the model with 100% accurate pair matching and the other models with various levels of matching error that suggest that the errors of matching were purely observer errors. It has been suggested that these errors may be minimized with the utilization of advanced ancillary aids for accurate matching such as stereoscopy and stereophotogrammetry.[15]

Conclusion

Rugoscopy is a useful technique for human identification due to the unique rugae pattern in every individual. However without the aid of ancillary aids, visual inspection alone can be challenging.

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