COMPUTERIZED RECORDING OF THE PALATAL RUGAE PATTERN AND AN EVALUATION OF ITS APPLICATION IN FORENSIC IDENTIFICATION

K.S. Limson, R. Julian

Department of Prosthetic Dentistry, Tamilnadu Government Dental College and Hospital, Chennai, India

ABSTRACT

In circumstances where identification of an individual by fingerprint or dental record comparison is difficult, palatal rugae may be considered as an alternative source of comparative material. This article evaluates the use of palatal rugae patterns for forensic identification with an indigenously developed computer software program. Comprehensive computerized antemortem records were constructed for 250 subjects and a comparison matching process performed using both recorded and unrecorded samples. The efficiency of this computer-based identification method was then assessed. The program proved to have an average sensitivity of 0.93 and specificity of 1 and had a success rate of 92-97% in matches with digitized rugae pattern samples.
(J Forensic Odontostomatol 2004;22:1-4)

Key words: Palatal rugae, Forensic identification, Computer software, Antemortem records

INTRODUCTION

Keiser-Nielson described Forensic odontology as "the proper handling and examination of dental evidence in the interest of justice, so that the dental findings may be properly presented and evaluated."[1] Identification of humans is a prime requisite for certification of death and for personal, social and legal reasons. Fingerprint and dental record comparisons are the most commonly used scientific methods of forensic identification.[2, 3]

Limitations to the use of fingerprints occur in situations where the hands are charred or mutilated[4] and, while teeth are more durable, identification using dental records may also prove to be inconclusive, since many records may be inaccurate or incomplete, or contain fraudulent data. Additional dental treatment might have been done in the time interval between the creation of a dental record and death of the individual.[5]

Palatal rugae have been shown to be highly individual and consistency in shape throughout life.[6-10] The anatomical position of the rugae inside the oral cavity, surrounded by cheek, lips, tongue and buccal pad of fat, also afford some protection in cases of trauma or incineration. The purpose of this study was to assess the use of palatal rugae, based on Lysell's classification of palatal rugae[6] and the modifications of Thomas and Kotze,[7] as an aid to forensic identification.

Technological advances now available to the forensic dentist such as computers, image capturing devices and ability to transfer information quickly have simplified the task of human identification in deceased individuals as well as in mass fatality situations.[11,12]

Use of such technology has been employed in this study where the principle behind commonly available personal identification systems for fingerprints was modified to create an indigenous computer software program RUG FP-ID Match. The same methodology of fingerprint comparison was used in this computer-based identification using palatal rugae.

MATERIALS AND METHODS

Creation of antemortem records

Two hundred and fifty undergraduates of the Tamilnadu Government Dental College constituted the initial study group, with distribution of the sample shown in Table 1. Comprehensive computerized antemortem records consisting of personal and physical details, digitized fingerprint, digitized rugae pattern and dental record were created and stored for each subject in the study group.

A fingerprint of each subject was recorded by placing the left thumb on the scanning surface of the Fingerprint Scanning Device* (Fig.1). The image was directly transferred to the computer and characteristic 'Minutiae' points processed and stored (Fig.2).

* *Hanno Technologies, Korea*

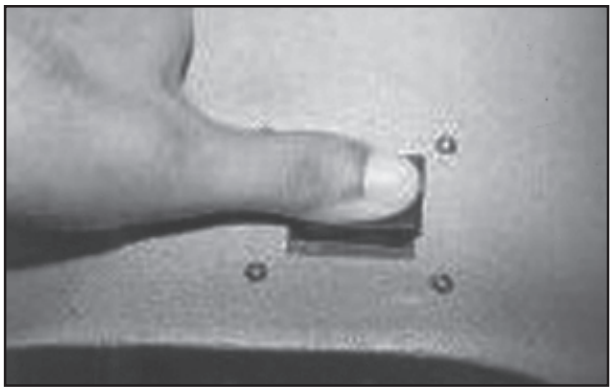

Fig.1: *Left thumb of a subject placed on the scanning surface of the Fingerprint Scanning Device*

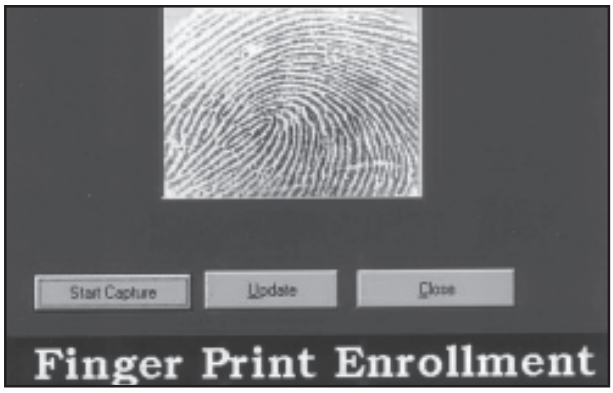

Fig.2: *Fingerprint recording screen*

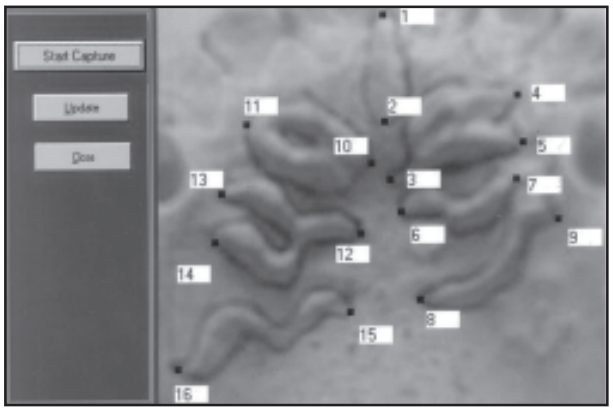

Fig.3: *Sequential manual plotting of characteristic points on the rugae pattern image*

An irreversible hydrocolloid impression of the upper arch of each of the subject was made and casts were prepared with Type III dental stone. Rugae on the casts were delineated with a sharp graphite HB pencil under a spotlight. Fragmentary rugae less than 3mm in length were omitted. The rugae pattern image was captured with a Digital camera* under standardized conditions. The camera was mounted on a stand, inclined forward to 45 degrees and focused at a distance of ten cm from the surveyor table of a Ney's† surveyor. After delineation casts were placed on the surveyor table and adjusted until the occlusal plane of the cast was parallel to the floor. The rugae pattern was photographed and transferred to the computer as a Jpeg image file.

Anatomical characteristics on the rugae pattern image were marked manually with a 'Target' shaped cursor on the computer image. (Fig.3). A strict protocol was undertaken for the order in which points were plotted - tip and base of incisive papilla, then each ruga was plotted at the medial and lateral ends, working from anterior to posterior. Left sided rugae were plotted before right. These plotted points were processed by the software and the information sequentially stored corresponding to pixel position.

Comparison matching process

A sub-sample of 120 individuals were randomly selected, 60 from the original sample group for whom comprehensive data had been collected and recorded in a database (recorded subjects) and 60 new individuals from the general population (unrecorded subjects) for whom maxillary casts were constructed.

The left thumb of each individual was placed on the scanning surface of the Fingerprint Scanning Device* and checked for a database match using the search mode in the software. Four operators, a dentist with forensic odontology training, a general dental surgeon, a computer professional and a general physician, each produced computer images of the

Table 1: *Distribution of sample*

Age group	Males	Females
17-18	21	29
18-19	24	26
19-20	18	32
20-21	22	28
21-22	26	24

* *Canon Inc. Tokyo, Japan*

† *JM Ney Co, Bloomfield CT, USA*

rugae patterns of those in the sub-sample using the study protocol. Each operator then matched the images that he produced against the stored antemortem records.

RESULTS

RUG FP-ID Match was tested using both fingerprint and rugae samples. All the fingerprint samples of recorded subjects correctly matched the stored antemortem records and none of fingerprint samples of unrecorded subjects matched with the stored antemortem data. The efficiency of the computer-based matching process using rugae pattern was then assessed, using the 100% correct fingerprint matching as a standard. The statistical data of the matching process with digitised rugae pattern of sample subjects and the success rate of each of the operators were tabulated in Table 2. The sensitivity of this software in the matching process was 0.97, 0.91, 0.93 and 0.91 respectively for each operator, with an average of 0.93. The specificity and positive predictive values were one. The negative predictive values were 0.97, 0.92, 0.94 and 0.92 respectively for each operator, with an average of 0.94 (Table 3)

DISCUSSION

It is widely acknowledged that there are limitations in identification by fingerprints and dental records in some forensic situations, and the palatal rugae pattern of an individual may be considered as a viable alternative for identification purposes. This study aimed to assess the feasibility of using palatal rugae patterns for identification with the aid of a computer and software program. The program proved to be completely reliable for fingerprint matching, but somewhat less so for matches of palatal rugae. The error rate of 3-8% observed during the matching process for several operators may be due to errors in the delineation of rugae or incorrect sequential plotting of characteristic points on the rugae pattern image manually on the computer screen. The error rate may be reduced by development of an intraoral scanning device to capture palatal rugae pattern, with image transfer directly to a computer, with appropriate software, as is presently available for fingerprints. This would eliminate the manual errors and time involved in the process of digitization of rugae pattern samples. With the use of interconnected computers networks it would be possible to store a large amount of data, facilitating quick retrieval of information and fast and effective identification.

Table2: *Analysis of results of the matching process with rugae pattern samples*

S.No	OPERATORS	% success	True positive	False positive	False negative	True negative
1	Forensic Odontologist	97	58	0	2	60
2	Dental Surgeon	92	55	0	5	60
3	Computer professional	93	56	0	4	60
4	General Physician	92	55	0	5	60

Table 3: *Analysis of the efficiency of identification using the software program*

S.No	OPERATORS	Sensitivity	Specificity	Positive predictive value	Negative predictive value
1	Forensic Odontologist	0.97	1	1	0.97
2	Dental Surgeon	0.91	1	1	0.92
3	Computer professional	0.93	1	1	0.94
4	General Physician	0.91	1	1	0.92

REFERENCES

1. Fearnhead RW, Furness J, Midda M, Waller DF. Report of working party. Forensic odontology. Br Dent J 1969 Dec 2;127:521-6.

2. Whittaker DK. Introduction to forensic dentistry. Quintessence Int 1994;25:723-30.

3. Morlang WM. Forensic dentistry. Aviat Space Environ Med 1982;53:27-34.

4. Buchner A. The identification of human remains. Int Dent J 1985;35:307-11.

5. Chester D, ed. Forensic dentistry. Colgate oral care report 2002;12:1-3.

6. Lysell L. Plica palatinae transversae and papilla incisiva in man: a morphological and genetic study. Acta Odontol Scand 1955;13:5-137.

7. Thomas CJ, Kotze T. The palatal ruga pattern: a new classification. J Dent Assoc S Afr 1983;38:153-7.

8. Harrison A. The palatal rugae in man. Proc Acad Nat Soc 1889;6:245.

9. English WR, Robinson SF, Summitt JB, Oesterle LJ, Brannon RB, Morlang WM. Individuality of human palatal rugae. J Forensic Sci 1988;33:718-26.

10. Abou EF, Mona M, Gamal ZHES. A study of palatal rugae pattern (rugoscopy) in Egyptian population. Egypt Dent J 1998;44:3177-84.

11. McGivney J, Fixott RH. Computer assisted dental identification. Dent Clin North Am 2001;45:309-25.

12. Lorton L, Rethman M, Friedman R. The computer assisted postmortem identification (CAPMI): a computer based identification program. J Forensic Sci 1988;33:977-84.

***Address for correspondence**:*
Dr.K.S.Limson
157 Gangawar Lane
Oppanakara Street
Coimbatore 641001
Tamilnadu – India.
Phone: +91 0422-2399541
Email: lovelimson@yahoo.co.in