Original Research

Enamel rod end patterns: a preliminary study using acetate peel technique and automated biometrics

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ABSTRACT

Dental enamel is the highly mineralized tissue in the human body and resists post mortem degradation. Tooth prints are the enamel rod end patterns on tooth surface. In this study, acetate peal technique is used to record enamel rod end patterns on tooth surface. Microphotograph of the acetate peel imprint is subjected to biometric analysis using Verifinger standard SDK 5.0 to obtain the pattern of enamel rod ends (tooth prints). 30 extracted tooth were selected, and tooth prints were obtained. We observed that unlike finger prints, tooth prints were composed of various sub-patterns like wavy-branched, wavy-unbranched, linear-branched, linear-unbranched, whorl-open, whorl-closed, loop and stem-like. Each tooth print was made up of combination of the eight different sub-patterns. The tooth prints obtained were compared both between and within the same individual. None of the patterns showed intra- and inter-individual similarity. Further studies are needed to explore the usefulness of tooth prints for personal identification.

Keywords: acetate peel technique, enamel rod end patterns, tooth prints

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INTRODUCTION

Personal identification is becoming very important in the present world. It may be required in simple procedures such as logging into a computer network, in more complex situations like post-mortem identification and crime analysis. It is usually achieved by the use of passwords, physical tokens, photographs, iris and dental patterns, fingerprints and, more recently, DNA analysis.[1] These identification methods commonly fail or have certain limitations and may not be efficient when bodies are decomposed, burned or in cases when only small fragments of calcified tissues are left.[2] But enamel and dentin of the teeth are highly calcified structures in the body that resist decomposition.

Formation of enamel is a highly organized process in which the ameloblasts lay down the enamel rods in an undulating and inter-twining path. This is reflected on the outer surface of the enamel as patterns of the ends of a series of adjacent enamel rods. We have coined the term '*Ameloglyphics*', which means the study of patterns of enamel rods (a*melo* meaning enamel; *glyphics* meaning carvings).

These enamel rod end patterns or tooth prints could be duplicated by various methods like using cellulose acetate paper, rubber base impression materials etc. Acetate peel technique is a well known technique for replicating surface details. This peel technique was first developed by paleobotanist Walton in the year 1928, to study the cellular structures of fossil plants. Later, petrologists and paleontologists developed similar techniques to study both the texture and structure of the rocks and fossils.[3-5] Depending on the nature of substrate and purpose of study, peels can be prepared in various ways. In the present study the cellulose acetate peel technique was used to obtain the replica of enamel surface.

Biometrics refers to identification of individuals using biological traits, such as those based on retinal or iris scanning, fingerprints, or face recognition. Verifinger® standard SDK version 5.0 is a biometric software designed to compare and analyze finger prints. Liza et al[6] used the same software for automated biometric study of Hunter Schreger bands in enamel for personal identification.

With the aim of studying the pattern of enamel rod endings on the enamel surface, we used the Verifinger® standard SDK version 5.0 software to compare and analyze the various patterns obtained.

MATERIALS AND METHODS

In the present study, 30 different extracted teeth were collected. Some of the teeth were collected from different individuals and some from the same individual for inter-

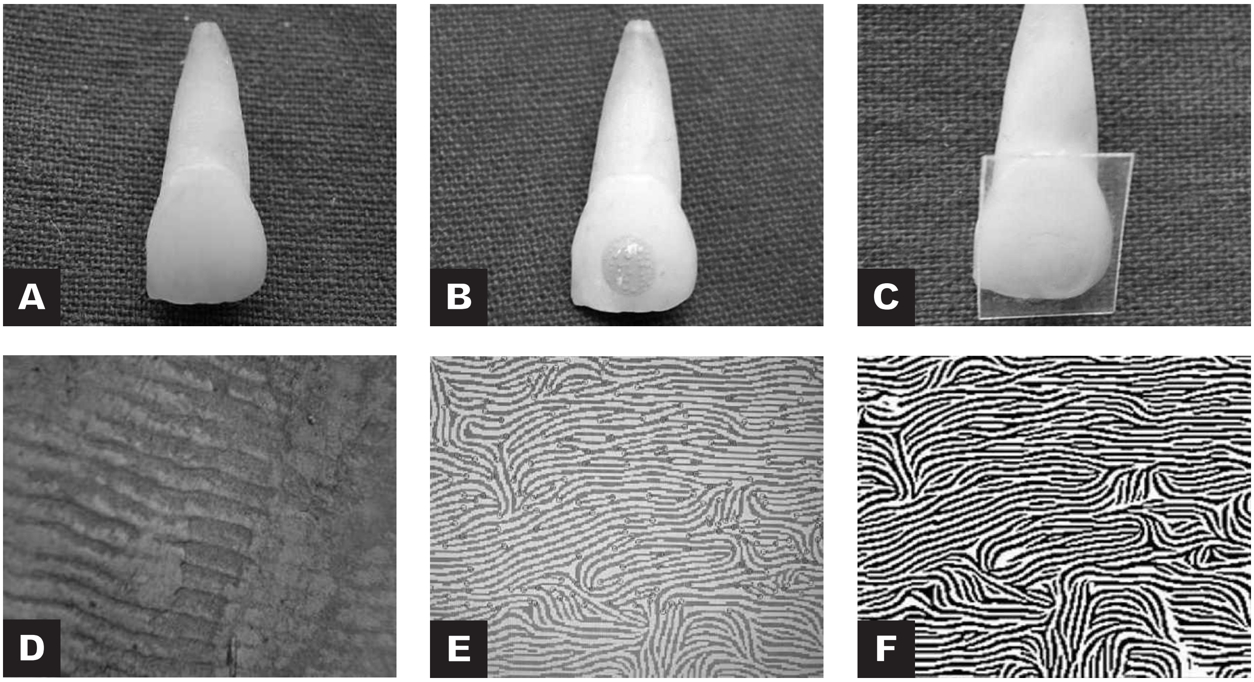

Figure 1: A: Tooth scaled and polished. B: Middle thirds of facial surface etched with 37% orthophosphoric acid. C: Cellulose acetate film with a thin layer of acetone placed over etched surface for 20 minutes. D: Photomicrograph of acetate peel at 10x magnification. E: Biometric generation of tooth print with minutae using verifinger®. F: Tooth print obtained representing the series of endings of adjacent enamel rods.

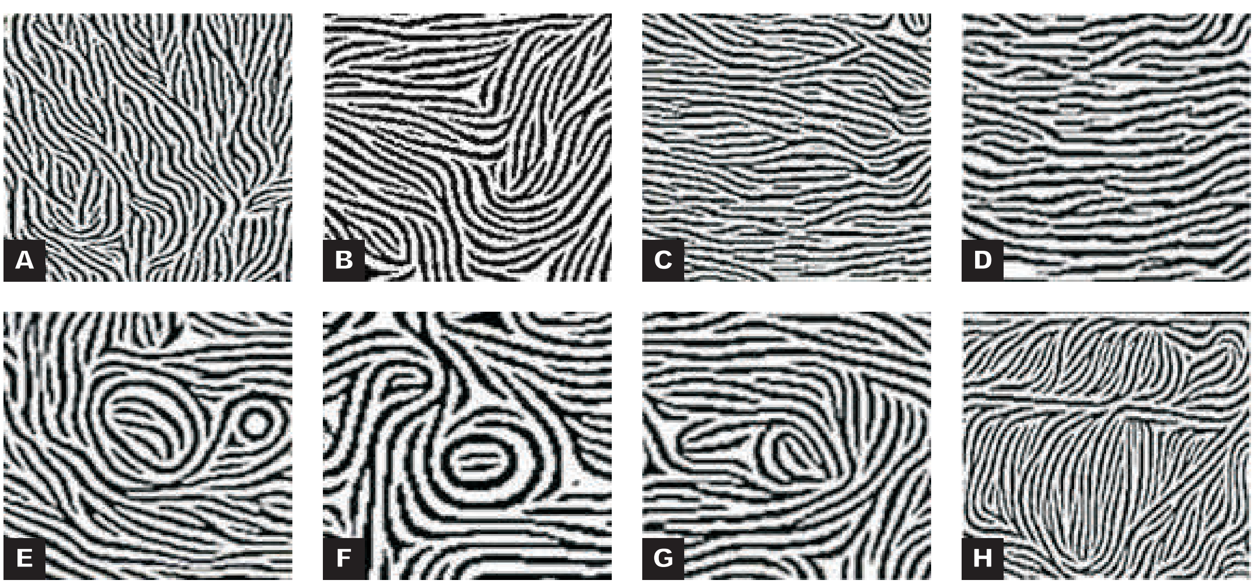

Figure 2: Distinct sub-patterns observed in tooth prints. A: wavy-branched, B: wavy-unbranched, C: linear-branched, D: linear-unbranched, E: whorl-open, F: whorl-closed, G: loop, H: stem-like.

individual and intra-individual comparison. Teeth with decay, attrition, abrasion, erosion, hypoplasia, fracture and/ or restorations were not selected for the study.

All the extracted teeth were scaled and polished. The middle thirds of the facial surface of the tooth was etched with 37% orthophosphoric acid for 20 seconds, washed with water and dried. A thin layer of acetone was applied over a small piece of cellulose acetate film and placed immediately over the etched surface of the tooth without any finger pressure for 20 minutes. The actone dissolves a layer of cellulose acetate, and the dissolute settles down along the irregularities on the enamel surface. The film is gently peeled after 20 minutes and observed under light

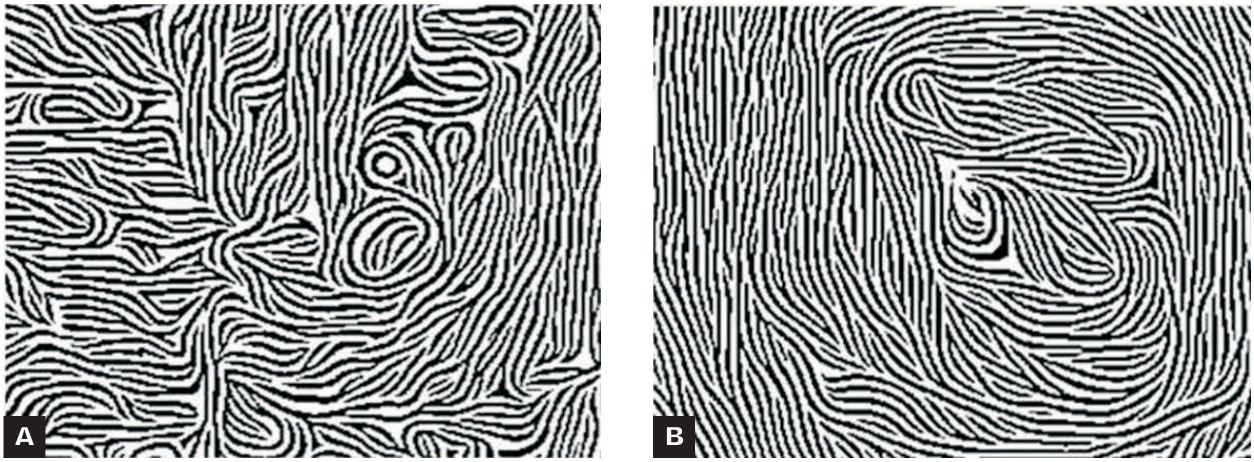

Figure 3: Inter individual variation in the pattern of tooth prints. A:Mrs. Y, tooth no. 33. B: Mr. X, tooth no. 23.

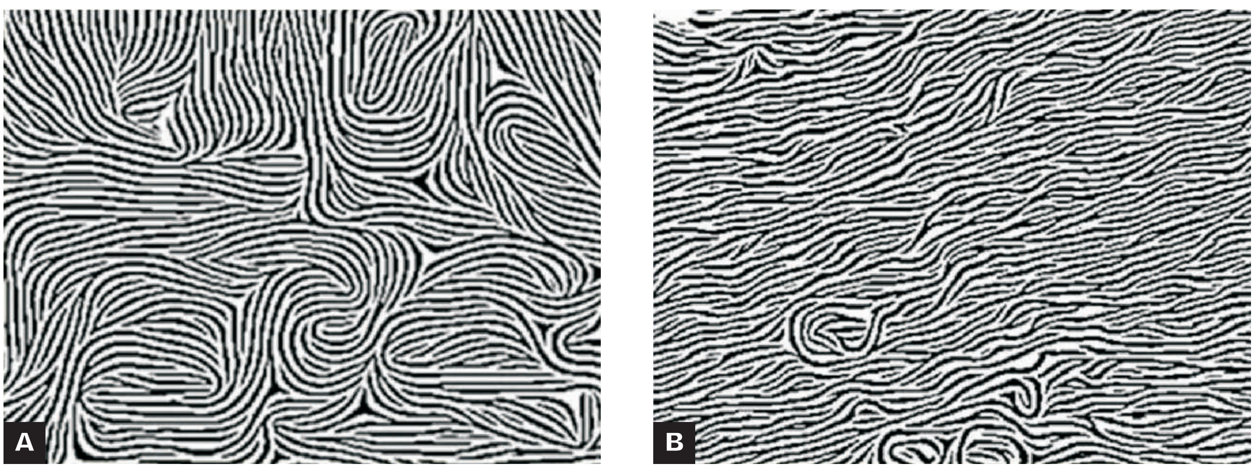

Figure 4: Intra individual variation in the pattern of tooth prints. A:Mrs. A, tooth 14. B: Mrs. A, tooth 15.

microscope. A photomicrograph of the acetate peel is obtained at 10x magnification. (Figure 1)

The microphotograph is subjected to biometric analysis using Verifinger® standard SDK version 5.0 software. The software recognises the patterns of enamel rod endings as series of lines running in varying directions. The software uses certain points called minutae for identification of each pattern. These minutae will be used by the software to compare the similarity/ variability of two patterns. Minutae are discontinuities of the lines, it may be line endings the point at which ridge stops, dot very small lines, ponds empty spaces between two lines etc.

Tooth prints obtained from different teeth were analysed for similarity among tooth prints of teeth of different individuals (incisor with incisor; premolar with premolar) and among same individuals (incisor with incisor; premolar with premolar)

RESULTS

In the present study a total of 30 teeth were analysed. Each tooth print obtained composed of series of lines representing series of adjacent enamel rod ends. These lines were seen running in varying directions creating distinct sub-patterns. Analysis of the 30 tooth prints yielded 8 distinct sub-patterns namely wavy-branched, wavy-unbranched, linear-branched, linear-unbranched, whorl-open, whorl-closed, loop and stem-like. Each tooth print was a combination of these sub-patterns. (Figure 2)

None of the 30 tooth prints obtained showed distinct similarity to each other. Comparison of tooth prints obtained from different individuals (incisor with incisor; premolar with premolar) and from same individuals (incisor with incisor; premolar with premolar) showed to be dissimilar.

DISCUSSION

The undulating course of ameloblast during amelogenesis results in the formation of a pattern by series of adjacent enamel rod ends. These patterns on the enamel surface are called as tooth prints.

In this maiden study, we found that the tooth prints from any single tooth exhibited a pattern of lines that represented the endings of series of adjacent enamel rods. These series of lines running in various directions composing a single tooth print, created various sub-patterns. Analysis of the 30 tooth prints yielded 8 distinct sub-patterns namely wavy (branched), wavy (unbranched), linear (branched), linear (unbranched), whorl (open), whorl (closed), loop and stem-like.

A finger print is composed of a single distinct pattern like whorl, loop or arch. On the other hand, a tooth print is composed of combination of basic sub-patterns.

These tooth prints, were unique to single, exhibiting dissimilarity both between teeth of different individuals and of the same individual. This uniqueness of the tooth print could be used as a valuable tool in forensic science for personal identification. This technique is simple, inexpensive, rapid and can also be performed by non-professionals.

Even though enamel is the most hardest substance in the body, the enamel surface is always subject to both micro- and macro-wearing. Processes like abrasion, attrition and erosion wears the outermost layer of enamel rod ends, and exposes the underneath layer.[7] The effect of these processes on the pattern of enamel rod ends needs to be determined.

Secondly, the enamel rods do not traverse the whole length of enamel in a straight path. Instead, they traverse in undulating and inter-twining path which has been attributed to high tensile strength of enamel and appearance of gnarled enamel and Hunter-Schreger bands. So, the course of enamel rods is not the same throughout the thickness of enamel.[8] Hence, theoretically the enamel rod end pattern should vary at varying depths of enamel. This needs to be verified by further studies.

Even though tooth prints, are unique to an individual tooth, the value of it as a tool in forensic science for personal identification lies in its reproduction and permanency. These two attributes of tooth prints needs to evaluated by further studies.

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