Analysis of Enamel Rod End Pattern at Different Levels of Enamel and its Significance in Ameloglyphics

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Abstract

The aim of this study is to determine the thickness of enamel showing similar enamel rod end patterns, and extrapolating our study results to estimate the duration of time takes to change into the subsequent pattern due to in vivo brushing and its significance in ameloglyphics. Eighteen maxillary left first premolars were used in this study. Of these, three teeth were used to select appropriate abrasive paper among 80-, 400-, 600-grit silicon carbide abrasive papers and five teeth were used to check reliability of the selected abrasive paper. Ten teeth were used to analyze enamel rod end patterns. The patterns were analyzed at an interval of 1 μm thickness of enamel from the tooth surface till the change of third set of pattern to its subsequent pattern. Our study showed 600-grit silicon carbide abrasive paper abrades 1 μm thickness of enamel upon one rotation in microtome. Biometric analysis of enamel rod end patterns obtained from 10 extracted teeth revealed that 10%, 60% and 30% of enamel rod end patterns were similar up to 3 μm, 4 μm and 5 μm depth of enamel, respectively. In this study, 3-5 μm thickness of enamel showed similar enamel rod end pattern. On extrapolation our study results with earlier literature revealed that each enamel rod end pattern takes approximately 4-6 years to change into the subsequent pattern due to in vivo brushing. So, the enamel rod end pattern should record for at least every 4 years during its practical application.

Keywords: Enamel rod end patterns; Ameloglyphics; Biometrics analysis; Personal identification

Introduction

Odontogenesis is genetically modulated. The formation of enamel is a highly organized dynamic process, in which the ameloblasts lay down the enamel rods in an undulating and inter-twining path [1,2]. This is reflected on the outer surface of the enamel as a series of enamel rod end patterns. The study of these enamel rod end patterns is known as Ameloglyphics (amelo-enamel; glyphics-carvings) [3].

The term 'Biometrics' refer to identification techniques based on physical characteristics. They are sometimes referred to as positive identification because they are claimed to provide greater confidence that the identification is accurate [4]. To identify an individual based on biometric information, the biometric data should have characteristics like highly unique to each individual, easily transmittable, able to be acquired as un-intrusively as possible and distinguishable by humans without much special training [5]. In 1998 Neurotechnologija developed biometric software known as Verifinger finger identification software for biometric system integrators [6]. Liza et al. [4] used this software for automated biometric study of Hunter Schreger bands in enamel for personal identification [4]. Manjunath et al. [3] studied enamel rod endings on tooth surface using Verifinger SDK v5.0 software and revealed the uniqueness of enamel rod patterns for personal identification [3]. They also revealed that Verifinger SDK v5.0 software was reliable software for the analysis of enamel rod end patterns [7].

Even though enamel is the hardest substance in our human body, it is always subject to both micro and macro wearing during our daily activities [8]. So, the practical implementation of ameloglyphics in forensic odontology is not clear as the depth at which each enamel rod end pattern changes to subsequent pattern is unknown. If the enamel rod end pattern of a particular person is recorded, then the period at which the enamel rod end pattern changes and duration for recording the enamel rod end pattern is unknown. So, in this present study the enamel rod end patterns were analyzed at an interval of 1 μm thickness of enamel from the tooth surface till the change of third set of pattern to its subsequent pattern. This helps to determine the appropriate duration of time taken to change each type of enamel rod pattern to its subsequent pattern, which in turn signifies for practical application of ameloglyphics.

Materials and Methods

Eighteen male patients of age 17-24 years who were undergoing maxillary left first premolar extraction for orthodontic purposes were selected for this study. Eighteen maxillary left first premolars were collected immediately after extraction, cleaned and dispensed in 10% formalin. Of these, three teeth were used to select appropriate abrasive paper, which abrades tooth surface of approximately 1 μm thickness in microtome and five teeth were used to check reliability of the selected abrasive paper. Ten teeth were used to study enamel rod end patterns at different levels of enamel.

Dentagauge 2 digital vernier caliper was used to measure the thickness of enamel abrasion. Weswox optic MT1090A rotary microtome was used to abrade the tooth surface, 0.1 mm thick commercially available cellulose acetate film, commercial grade acetone solvent, 10% Orthophosphoric acid, Olympus CH 20i light microscope, Nikon 5200 digital camera, Verifinger standard SDK version 5.0 software (Neurotechnologija Company, Lithuania) were

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The µm thickness of enamel was calculated. Decayed tooth, hypoplastic tooth, fractured tooth, abraded/eroded tooth and restored tooth were excluded from our study.

**Abrasive paper selection**

In this *in vitro* study the tooth surface was abraded in the microtome (fixed to 4 µm thickness) using 80-, 400-, 600-grit silicon carbide abrasive papers. The abrasive paper which abrades the tooth surface of approximately 1µm was selected by abrading the three different teeth.

**Procedure**

A vertical line was drawn at the centre of lingual and buccal surface of the teeth (parallel to the long axis of the tooth). Then, a horizontal line was drawn at the mid-third area passing across the vertical line on the lingual and buccal surfaces. The Point of intersection was noted and considered as the distance of measurement. Thickness of the tooth was measured using a digital vernier caliper and measurement was noted a (Figure 1). The tooth was mounted in a block of dental plaster and fixed to the paraffin block holder of the microtome so that the tooth surface is parallel to the abrasive paper, which was mounted in the knife table of the microtome (Figure 2). The tooth surface was abraded for 10 rotations in the microtome. The amount of surface abraded was measured using the digital vernier caliper and measurement was noted b. Difference between the width of the tooth as measured initially (a) and after abrasion (b) gives the amount of tooth abraded by respective abrasive paper. Then, the number of rotations necessary for abrading 1 µm thickness of enamel was calculated.

**Results**

80-grit silicon carbide abrasive paper abrades 50 µm thickness of enamel in 10 rotations, then one rotation abrades 5 µm thickness of enamel. 400-grit silicon carbide abrasive paper abrades 30 µm thickness of enamel in 10 rotations, and then one rotation abrades 3 µm thickness of enamel. 600-grit silicon carbide abrasive paper abrades 10 µm thickness of enamel in 10 rotations, and then one rotation abrades 1 µm thickness of enamel.

Since 600-grit silicon carbide abrasive paper abrades 1 µm of enamel in one rotation in microtome, it was selected for our study.

In order to check the reliability of 600-grit silicon carbide abrasive paper in abrading 1 µm thickness of enamel in one rotation in microtome, the procedure was repeated in five different teeth. The results confirmed that 600-grit silicon carbide abrasive paper abrades 1 µm thickness of enamel upon one rotation in microtome.

**Analysis of enamel rod end patterns at different levels of enamel**

All 10 extracted teeth collected from 10 different individuals were cleaned and polished. In order to avoid error in positioning the acetate film over recording area during serial recordings, the buccal surface of the tooth was ground using an aerotor hand piece except a circular area in the mid-third measuring approximately 0.5 cm² in diameter. Palatal surface of the tooth was flattened parallel to the long axis of the tooth in order to avoid error during measurement using digital vernier caliper. Unground circular area on buccal surface of the tooth was conditioned using 10% orthophosphoric acid for 20 seconds, then 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 conditioned surface of the tooth without any finger pressure for 15 minutes. The film was gently peeled after 15 minutes. The peeled strip was placed on the clear glass slide and observed under the Olympus CH 20i light microscope. Photomicrograph of the imprint was obtained at 40X magnification using Nikon 5200 digital camera in 1.4X digital zoom. The photomicrograph was then cropped at the centre to 2000×1500 pixels dimension using Microsoft picture manager software.

The photomicrograph was subjected to Verifinger standard SDK v 5.0 software for obtaining enamel rod end patterns and biometric analysis.

Enamel rod end patterns are obtained at a different levels of enamel by abrading it using 600-grit silicon carbide abrasive paper i.e., at an interval of 1 µm each, till the third set of enamel rod end pattern changes to subsequent pattern (Figure 3).

This procedure was repeated as described above in all 10 different teeth and results were tabulated and analyzed.

**Results**

**Biometric analysis**

Thickness of enamel showing similar enamel rod end patterns in all 10 extracted teeth is tabulated in Table 1.
patterns change as standard areas to evaluate thickness of the enamel showing similar enamel rod end patterns. 10%, 60% and 30% of enamel rod end patterns were similar up to 3 µm, 4 µm and 5 µm depth of enamel respectively.

Lambrechts et al. and Joiner et al concluded that 0.4-0.8 µm thickness of enamel abrades annually due to in vivo brushing [11,12]. In the present study, 3-5 µm thickness of enamel showed similar enamel rod end pattern. On extrapolation our study results confirm with Lambrechts et al and Joiner et al in situ model study, which reveals that each enamel rod end pattern takes approximately 4-6 years to change into the subsequent pattern due to in vivo brushing. So, the enamel rod end pattern should record for at least every 4 years during its practical application.

This study enlighten the practical application of ameloglyphics in various fields and situations, especially for individuals working in dangerous occupations such as soldiers, divers, jet pilots and people who live and travel to potentially unstable areas, where short duration analysis of enamel rod end patterns may play an important role for personal identification. However, further in vivo study is suggested to analyze enamel rod end pattern and its changes over a period of time as a result of abrasion in individuals for better application of this technique for personal identification and verification.

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