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Assessment Of Enamel Rod End Patterns In The Cervical Region Of Teeth That Were Subjected To Microwearing – An Invitro Study

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Abstract

Background: Resistance of dental hard tissue to postmortem decomposition is a unique person identification tool in Forensic Odontology. Microwearing of enamel surface by mechanical or frictional forces occurs due to chewing and vigorous horizontal tooth brushing technique. The purpose of this study is to find out if, there is any tooth print pattern other than the main eight patterns given by Manjunath et al in the cervical region of teeth, as enamel formation varies from incisal edges/cusp tips towards the cervical area and also their atypical enamel formation in the cervical area.

Materials and Method: A total of 100 extracted permanent teeth were selected and were divided into two equal groups. All the samples were conditioned with acid and cellophane tape impressions were taken in the cervical region of teeth which was transferred to a glass slide and subjected to microscopic imaging. Images captured under a microscope were uploaded to SOURCE AFIS 1.7.0 for biometric analysis. All the glass slides with tooth prints captured using cellophane tape were subjected to photography and were analyzed using colorimetry software.

Results: Every tooth has a discrete type of pattern in the cervical region. Eight distinct types of tooth print patterns were recorded.

Conclusion: Toothprints serve as supplementary person identification tool in natural catastrophes. Recording enamel patterns every 3-4 years is essential as there is a difference in enamel rod patterns at varying depths.

Keywords: Toothprints, ameloglyphics, enamel rod ends, Forensic Odontology

Introduction

Forensic odontology plays a major role in human identification in mass disasters, crime investigations, and the identification of deformed bodies of victims in fire and motor vehicle accidents. Person identification is a challenging task in the modern world. Person identification in worst scenarios using conventional biometrics such as palm print, fingerprint, iris scan, or using passports, keys, secret codes, badges etc. may not be possible[1]. Teeth and other materials dentists use for restoring and replacing missing teeth are usually resistant to postmortem putrefaction. Therefore, dental evidences serve as the only means of person identification in worst scenarios of severely traumatized, putrefied, badly burned and skeletonized remnants[2] . The enamel rods or prisms are structural units of enamel laid down by ameloblasts during the process of amelogenesis which is a controlled secretory process.[3] Ameloglyphics is the science of recording and analyzing enamel rod patterns on tooth surfaces[4]. It is of particular interest to Forensic odontologists because enamel is highly resistant to decomposition and enamel rod end patterns are unique

for each tooth in an individual and serve as unique identification tool for individuals working in a dangerous occupation.[2]

Biometrics refers to automated identification of individual based on unique physical or biological measurement pertaining to that individual. Some commonly used measurements for person identification are weight, height, eye color, skin color, hair color and iris of an individual. These measurements were used for describing the individual and are not unique in person identification, as more than one person can fit into such description[1]

Formation of enamel is under genetic and environmental influences and is controlled and regulated with over 10000 genes expressed by ameloblasts [5]. The uniqueness of each tooth print can be ascribed to differences in the surrounding environmental conditions for each growing tooth which includes the position of the developing tooth bud, temperature, pressure or the nutrition to the ameloblasts.[2] Ameloblasts lay down enamel in a rippling and intertwining fashion which is unique on every tooth surface[6]. Enamel is the hardest substance in our body, it is always subjected to macro and micro wearing during our daily activities so, periodic recording must be done since enamel rod patterns vary at different depths [2].

Materials And Methods

The protocol for the study was approved by the Institutional Review Board and was granted ethical clearance. A total of 100 extracted permanent premolars and molars were selected. Permanent premolars extracted in young individuals undergoing orthodontic treatment were grouped as Group- A [n= 50]. Permanent premolars and molars extracted in old individuals due to poor periodontal prognosis were grouped as Group- B [n=50].

Inclusion criteria

1. Premolars which are clinically normal extracted during orthodontic treatment.
2. Permanent premolars and molars with cervical abrasion extracted due to poor periodontal prognosis.

Exclusion criteria

1. Teeth with cervical caries
2. Teeth with developmental anomalies
3. Teeth with restoration in the cervical region
4. Teeth with attrition, erosion, and abfraction
5. Fractured teeth

All the extracted tooth samples were scaled and polished before taking toothprints. An area of 5 mm diameter was marked on the cervical third of the facial surface of teeth and 10% orthophosphoric acid was used for conditioning the tooth surface for 1 minute. All the samples were rinsed with water and air-dried. A drop of acetone was applied on the cervical third of the tooth surface and cellophane tape was applied over it and left undisturbed for 5 minutes. Imprints obtained using cellophane tape were transferred to a glass slide and observed under a DMRB microscope at 40X magnification and images were captured. Images were then uploaded to SOURCE AFIS 1.7.0 software for biometric analysis.**[Figure 1]**

Automated Biometric Analysis

The SOURCE AFIS 1.7.0 software was used for analyzing the enamel rod end patterns and the resulting patterns of all the samples were compared using minutiae points.**[Figure 2 and 3]** The minutiae points are the discontinuities of the lines seen as dots, loops, bifurcations or line endings which can be marked and used for comparison of the patterns.

Image Analysis Colorimetry

All the imprints obtained using cellophane tape were subjected to photography and every image was cropped using Microsoft Picture Manager to a size of 175 X 215 pixels dimensions. The images were then uploaded to colorimetry software to extract the RGB intensity level**. [Figure 4]**

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Figure 1: Procedural steps involved in obtaining tooth prints

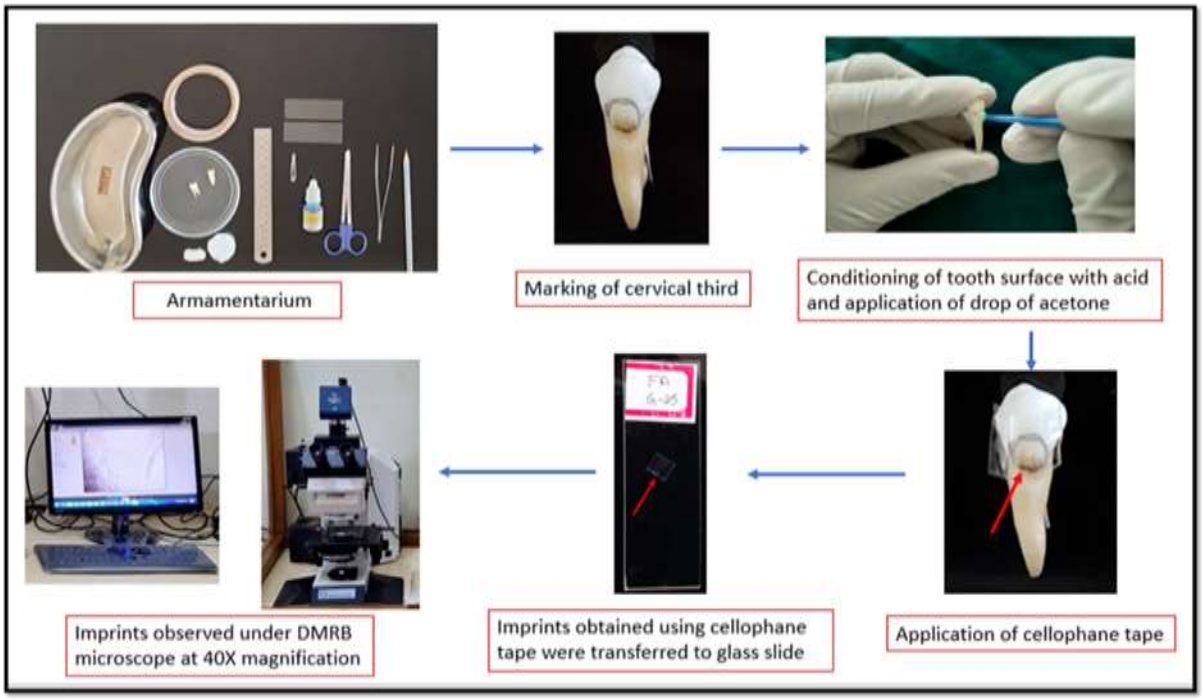

Figure 2: Showing biometric conversion of tooth prints using SOURCE AFIS 1.7.0 software

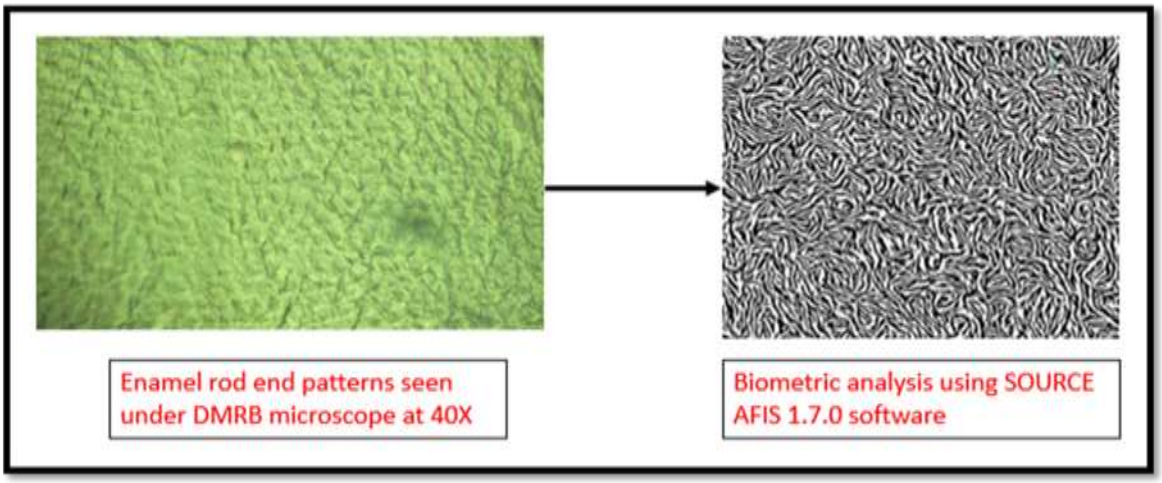

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Figure 3: Showing various types of tooth print sub-patterns.

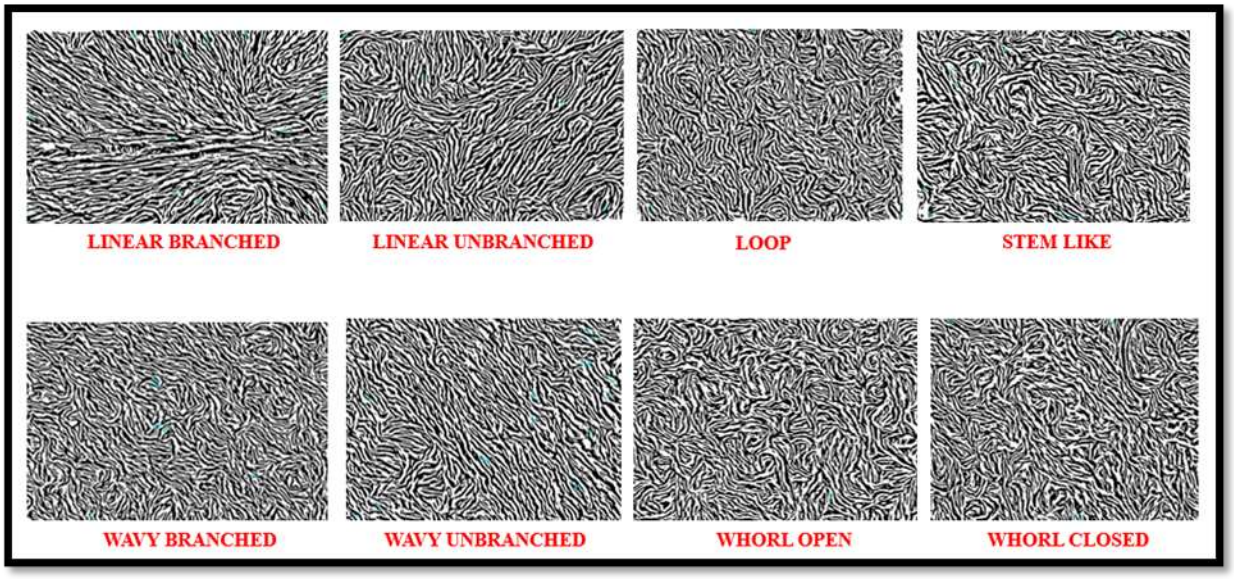
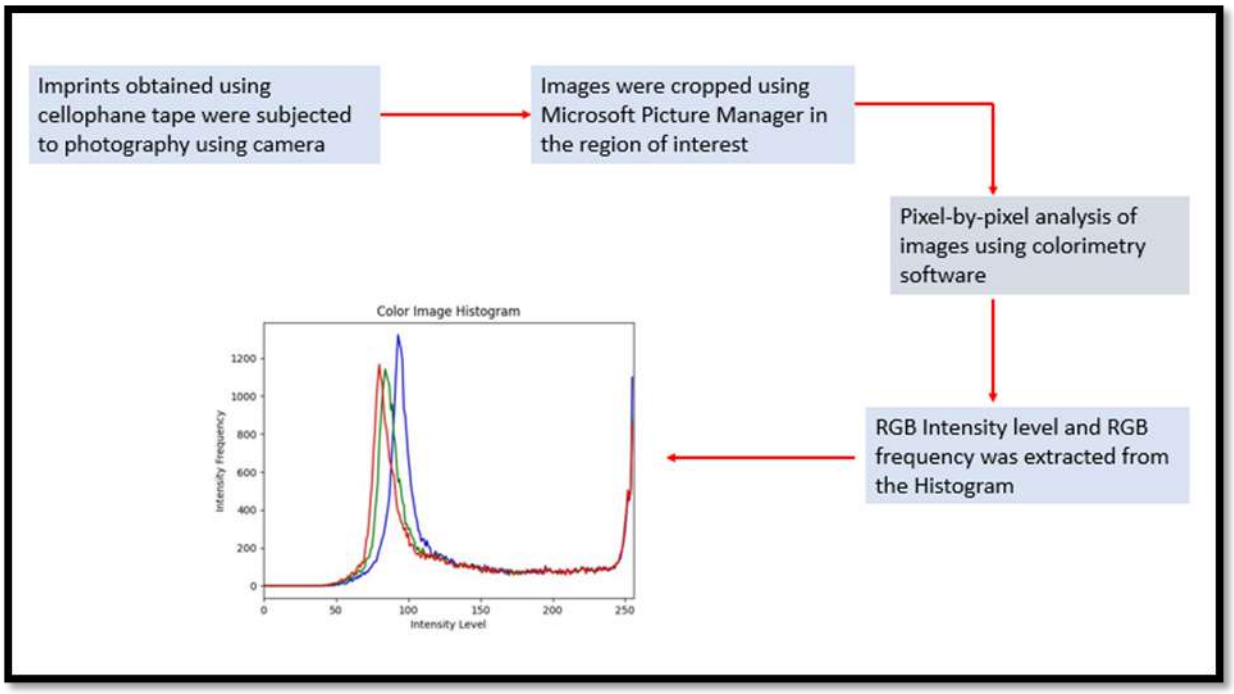


Figure 4: Procedural steps involved in image analysis using colorimetry software



Statistical Analysis

The data obtained was compiled systematically in a Microsoft Excel Sheet and subjected to statistical analysis using SPSS Software version 20. The significant level will be fixed at $p<0.05$.

The graph obtained using colorimetry software was compared using the X and Y axis coordinates, which represent RGB intensity level and intensity frequency respectively.

Results

The present study showed that tooth print patterns obtained from the cervical third of the teeth were unique. Every tooth is composed of combination of subpatterns, but was predominated by a single

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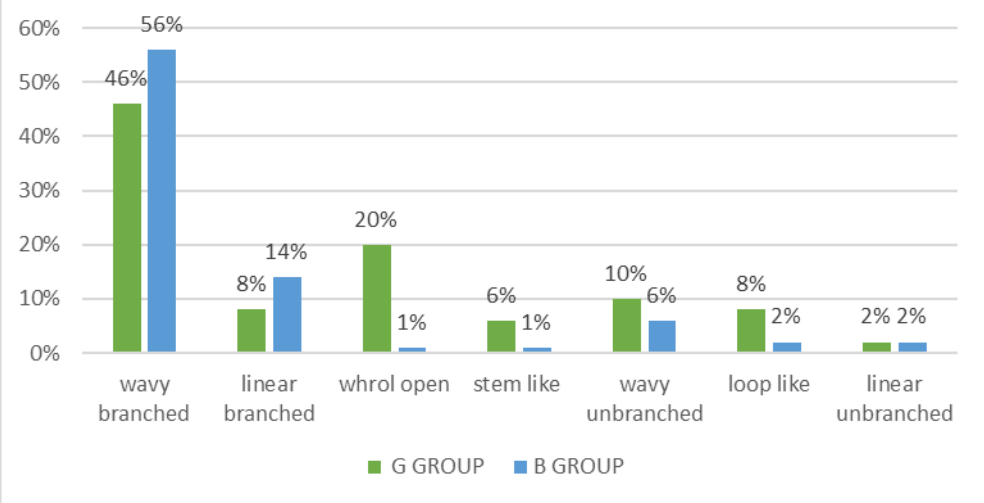
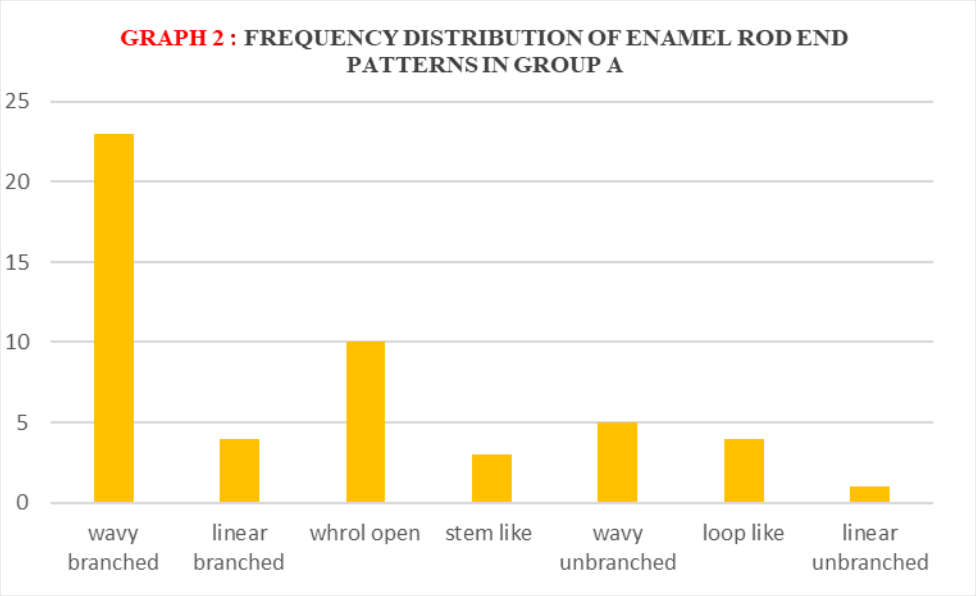
subpattern. Eight distinct types of tooth print patterns recorded include wavy branched, wavy unbranched, linear branched, linear unbranched, stem-like, loop-like, whorl open, and whorl closed patterns. Wavy branched pattern was found to be the most predominant pattern found in our study. [Graph 1,2 and 3].

Graph 1 : Distribution of enamel rod end patterns in the two different groups





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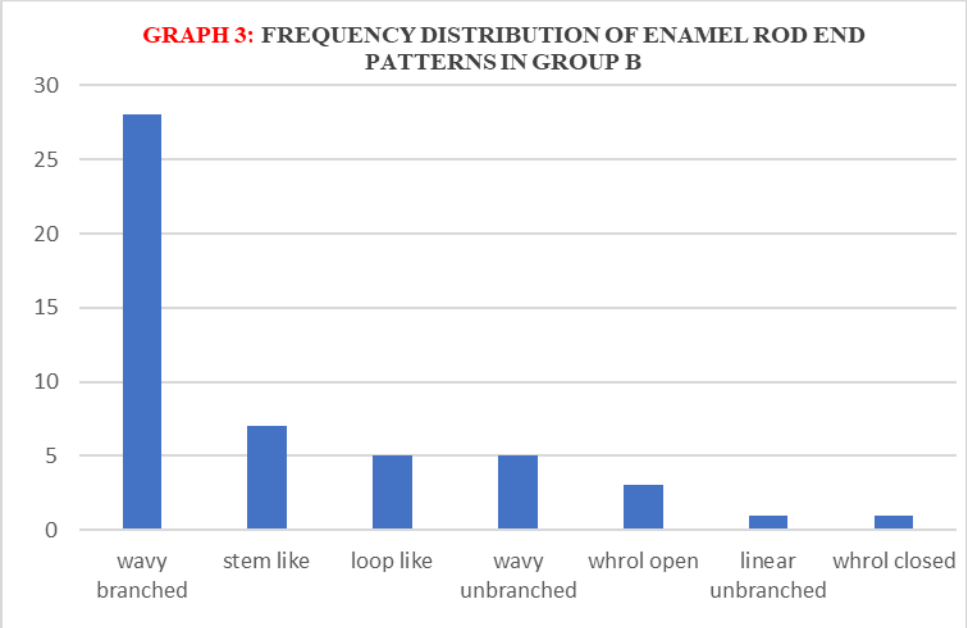

Discussion

Identification of the individuals using dental hard tissues provides reliable information compared to soft tissue analysis, as teeth are highly resistant to environmental effects such as decomposition, desiccation and fire accidents.[2,7] Ameloglyphics is considered as a highly reliable person identification tool for people working in dangerous occupations such as soldiers, divers, jet pilots, fire fighters and people who live in unstable areas.[2] Enamel formation is a highly organized and complex process in which ameloblasts lay down enamel in an undulating and intertwining pattern on the tooth surface in different directions and at different depths.[8] This difference in the direction of enamel rod end patterns for different individuals and of the same individual serves as a unique person identification tool. Microwearing of enamel surface by mechanical or frictional forces occurs due to chewing and vigorous horizontal tooth brushing technique. Other factors contributing to the cervical wearing of enamel include forces acting on removable appliances, inappropriate use of toothpicks and floss, age related tooth abrasion, attrition and parafunctional habits. Enamel rod end patterns may vary at different depths due to the microwearing of the enamel surface, so the appropriate recording of patterns every 4 years in detail serves as a supplementary person identification tool for individuals working in a dangerous occupation.[8,9]

A study conducted by Raju et al showed that enamel rod end patterns were unique for an individual and also for a particular tooth [10]. An in-vitro study conducted by Manjunath et al on enamel rod end patterns using the acetate peel technique revealed that tooth prints were unique to individual teeth and it serves as a valuable person identification tool in forensic odontology [11]. Further studies were done to determine the thickness of enamel showing similar rod end patterns and they concluded that each enamel rod end pattern takes approximately 4-6 years to change into subsequent pattern[6].

A Study was conducted by Rakesh et al to analyze the reliability of ameloglyphics for person identification by exposing the teeth to be studied at various temperatures – 80^0C ,400^0C, 600^0C, 750^0C. The tooth prints obtained showed a high degree of similarity with the original tooth print[12].

According to the results obtained from the present study tooth print patterns are composed of eight distinct subpatterns, but was predominated by a single pattern. The SOURCE AFIS 1.7.0 biometric software was used for analyzing the toothprints and the resulting patterns were compared using minutiae points.[8] The subpatterns were wavy branched, wavy unbranched, linear branched, linear unbranched, whorl open, whorl closed, loop and stem-like patterns as described by Manjunath et al.[2] The wavy branched pattern was the predominant pattern found in the cervical third of the tooth. This predominance of wavy

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branched pattern may be caused by fact that the enamel rods follow a wavy course throughout the thickness of enamel. In contrast, many rods follow an undulating pattern from the dentinoenamel junction to the external surface of the teeth.[8] The tooth prints obtained from the cervical third of the tooth are entirely different from one another and there is no interindividual and intraindividual similarities between the patterns obtained.

Various materials that can be used in recording and duplication of the enamel rod end patterns include cellophane tape, cellulose acetate film and light body rubber base impression compound. According to the study conducted by Manjunath, et al cellulose acetate film technique is reliable for recording enamel rod end patterns compared to cellophane tape and rubber base impression techniques.[6] The main disadvantage of the cellulose acetate film technique is unable to adapt properly on irregular surfaces of the tooth which makes the process of recording enamel rod patterns more complicated.[7] The cellophane tape technique is a simple, cost-effective method of recording tooth prints for forensic investigations with limited resources but obtaining clear and complete imprints might be challenging.[8]

Acid etching of the enamel surface can be done using 10% orthophosphoric acid, 10% citric acid, 10% phosphoric acid, 2.5% oxalic acid, 10% maleic acid and 2.5% nitric acid but 10% orthophosphoric acid in the gel form is most commonly used.[7] Various factors which determine the effect of acid etching on the enamel are kind of acid used, concentration of the acid used, etching time, form of etchant, rinse time and the chemical composition and condition of enamel.[13]

In the present study, photographs of the imprints were analyzed using image analysis colorimetry which was used for the extraction of RGB intensity values and frequency. The coordinates of the X-axis represent the pixel intensities and the Y-axis represents the frequency of each intensity.[14] For each value of pixel intensity, the histogram analysis yields information about the distribution of pixels in an image.

Conclusion

Ameloglyphics is a simple, reliable, non-invasive and cost-effective method used as a supplementary tool for person identification particularly for individuals working in dangerous occupations. Both microwearing and macrowearing of the enamel surface result in the loss of the outermost layer of enamel rod ends and exposing the underneath layer. As the enamel rod end patterns vary at different depths, appropriate method of recording, identification and storage of data is necessary at least for a minimum period of 4 years.

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