Original article

Ameloglyphics: A Novel Appraisal of the Enamel Structure in Identification of an individual

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Abstract

Introduction: Ameloglyphics is a newly emerging field that studies the patterns of enamel rods. Amelo means enamel and glyphics means carving. It is said by some investigators that the patterns of enamel rods are unique to each individual.

Methods: The aim of the study was to estimate and categorise tooth print patterns among 30 teeth of known age and gender and to analyze the variation among carious and non carious teeth. The tooth surface was etched and imprint was transferred to a slide using an adhesive tape. Further evaluation was done under light microscopy by using verifinger SDK software.

Results: The various patterns observed were straight, wavy, branched, looped, intersecting and radiating. The carious teeth and deciduous dentition showed predominance of wavy and straight pattern which is in accordance with their softer nature and increased susceptibility to bacterial invasion.

Keywords: Enamel, Tooth prints, Biometrics, Ameloglyphics

Introduction

Human dentition is considered as a hard tissue analogy to fingerprints which is a reliable tool in a body obtained in a decomposed situation. In fact enamel is the least reactive of the three hard tissues of the teeth and resists decomposition. Superior organization and mineralization give dental enamel its outstanding physical properties, making it the hardest tissue in the vertebrate body[1]. It consists of undulating and intertwining enamel rods emerging from dentinoenamel junction till external tooth surface[2]. Macroscopically, incremental pattern of enamel rods is exhibited on tooth surface as perikymata[3], but microscopically, groups of enamel rods run in unique direction, which differ from adjacent group of enamel rods and results in forming different patterns of enamel rod endings on tooth surface[4,5,6]. Study of these enamel rod patterns is called as Ameloglyphics. These patterns have been found to be unique to individual teeth of the same individual and also to different individuals.

Ameloglyphics can play a significant role in personal identification of individuals particularly working in dangerous occupations such as soldiers, divers, jet pilots and people who live and travel to potentially unstable areas. In these cases short duration analysis of enamel rod patterns can play an important role for personal identification[7].

An attempt has been made to study the reproducibility and reliability of using enamel pattern in identifying an individual.

Methods

The study group comprised of 30 teeth. Teeth which were fractured, restored, attrited, eroded, abraded and hypoplastic were excluded from the study, as these are likely to alter the tooth print or render it unmatchable with an intact tooth.

The selected teeth were cleaned and polished with cotton dipped in distilled water to obtain a clean working surface. The teeth are then washed in distilled water and dried. The middle third of the labial surface of a tooth was selected for tooth imprint as the enamel rods are least likely to show

directional curves and entangling in the rod pattern; also the working surface is relatively flattened to obtain an imprint free of creases. The selected area of the tooth was etched with 37% orthophosphoric acid for 70 seconds. The tooth was then washed with distilled water, followed by washing in ethyl alcohol before being dried with a chip blower. A strip of cellophane tape was closely adapted to the etched and cleaned surface and using slight digital pressure with cotton pellet; the tape was held onto the surface for a few seconds and then lifted off and transferred to a clean grease-free glass slide with the sticky side adherent to the slide. The imprints were taken thrice by 3 investigators.

Biometric analysis was performed using photomicrographic images obtained under 40x magnification (NA=0.65) of a light microscope (Olympus CH 20i) Verifinger standard SDK version 6.0 (biometric recognition software used for fingerprint analysis) was used to obtain pattern of enamel rods and the pattern was then tabulated.

Results

Different patterns obtained were straight, wavy, branched, intersecting, radiating and looped (Figure 1). Interobserver variability of technique and pattern variation was assessed using Kendal Tau B test and the variation was found to be less with a value range of 0.922 to 0.966 with p value of <0.0001(Table 1) indicating good agreement between investigators. This result indicates patterns are similar from multiple print taken from tooth surface.

Among the patterns obtained from carious teeth that were taken for the study only straight, wavy or linear pattern were observed (Figure 2). It did not show complex branching, radiating and/or intersecting pattern. This indicated that the host tooth structure differs in carious and noncarious teeth. When compared between deciduous and permanent dentition there was no significant difference in the pattern obtained but deciduous dentition showed only wavy and linear pattern (Figure 3).

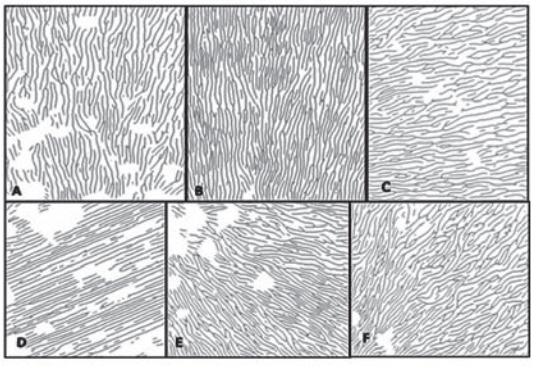

Figure 1 Types of pattern present in the tooth print obtained, Branched (A), Wavy (B), Intersecting (C), Straight (D), Looped (E), Radiating (F)

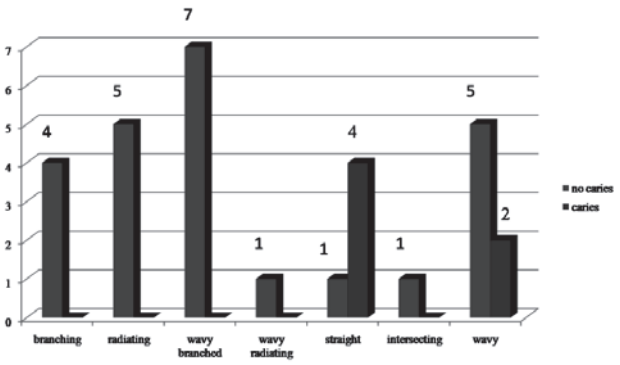

Figure 2 Comparison of the different patterns in carious and non-carious teeth

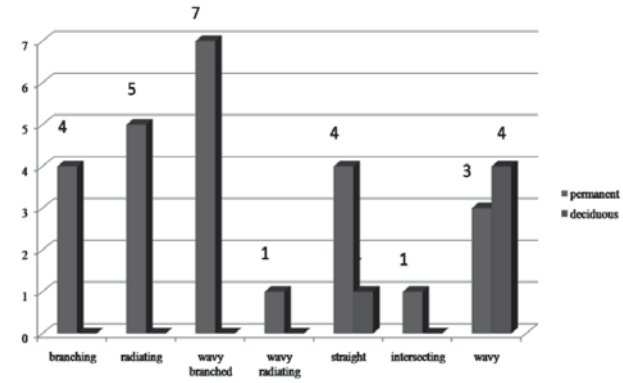

Figure 3 Comparison of the different patterns in deciduous and permanent dentition

Table 1 Comparison of print variation among different observers

Comparison of print	Number of teeth	Kendall Tau B test value	Significance
1 and 2	30	0.966	<0.0001
2 and 3	30	0.928	<0.0001
1 and 3	30	0.922	<0.0001

Discussion

Enamel is a product of ectoderm derived cells called ameloblasts. The basic structural unit of enamel is the enamel rods (enamel prisms) arranged in a highly organized but complex structure formed by ameloblast (cells forming enamel) moving in an undulating and inter-twining path. This is reflected on the surface of enamel which can be lifted as a tooth print. Ameloglyphics is the word used for the study of such patterns of enamel rods (amelo: enamel,

glyphics: carvings). Enamel does not remodel nor does it remain in close contact with the cells which synthesize it, rather the ameloblasts retract away from the enamel surface once it has matured and the tooth has erupted thus giving as stable imprint. Enamel prisms morphology reflects the morphology of ameloblasts in a species-specific manner. Alterations to the matrix are reflected as defects in the structural organization of enamel[8].

In our study of tooth prints, it was seen that tooth print pattern from individuals were entirely different from one another as proven earlier by Gupta N et al[8].

The individualization of tooth print may be attributed to the unique variations in environmental factors surrounding each developing tooth which includes placement of the developing tooth bud, temperature, pressure, nutrition to the ameloblasts cells, etc. Genetics might also have a role in predetermining the type of pattern[8].

The comparative data of the imprints in our study showed that tooth prints obtained from different individuals (comparison of incisor with incisor; premolar with premolar) and from different teeth of same individuals were dissimilar. Manjunath K, et al[9] and Scott DB et al[10] arrived at the same conclusion. According to the authors the general form of their print is the same on all surfaces, but they demonstrate marked differences in width, depth, distance apart, and course on individual surfaces and on different teeth[10].

The perikymata/ imbrication lines of pickerel are surface manifastations of striae of retzius. These crests and troughs get accentuated by etching the actual enamel rod pattern available for imprint.

In our study there was slight difference in the pattern obtained from deciduous dentition from permanent dentition. Deciduous dentition showed only straight and wavy pattern without any branching, intersecting and radiating pattern. This may be explained by variation in the formation of primary and secondary dentition[11]. Calculations of prism size and spacing in human dentitions show that the number and density of ameloblasts is different between deciduous and permanent teeth. It appears that deciduous teeth grow faster than permanent teeth but have smaller, less densely arranged enamel prisms[12].

It may also be explained by the fact that buccal and lingual surfaces of molars and premolars retain more structure with advancing age than do similar surfaces on canines and incisors. This is also the case with the proximal surfaces, but, in all types of teeth, structure on these surfaces persists much longer than on labial, buccal, and lingual surfaces. The last regions to lose their structural detail are the cervical thirds of surfaces[10]. Most of the deciduous tooth taken in our study were anterior and may not have retained the print.

In the study the comparison between non carious and the carious teeth showed that carious tooth has only straight and wavy pattern without any intersection/radiation/ branching pattern as observed by Scott DB et al[10]. These less complicated enamel rod patterns (straight and wavy) could represent the host factors promoting easy spread of caries offering less resistance. The enlargement of the intercrystalline spaces due to partial dissolution of the individual crystal peripheries may give this pattern. As the caries proceeds ultrastructurally, there is complete dissolution of the thin perikymata overlappings; marked dissolution corresponding to developmental irregularities such as Tomes' processes, pits, and focal holes; and continued enlargement of the intercrystalline spaces[13]. Thus a tooth with an imprint of straight/ wavy pattern may be susceptible to caries.

Conclusion

Ameloglyphics as yet a nascent field is gaining popularity as a tool in personal identification. Though a reliable technique has some limitations to it as there is need for ante-mortem records for the matching and also the reliability and credibility of fingerprint analyzing software (Verifinger®) in analysis is unknown.

Conflict of interest: None declared.

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