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Human Teeth a Tool to your Identification-Dead or Alive: A Review on Ameloglyphics

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Abstract

Forensic Odontology is a branch of Forensic sciences that uses the skill of the dentist in personal identification during mass calamities, sexual assault, and child abuse to name a few. This branch is no stranger to many as it has been growing tenfold in its potential and its ability to bring the forlorn to justice where dental remains are the only available evidence. Its role and importance in the judiciary are fast-growing and hence in-depth knowledge in this field seems more than justified. Various methods currently employed in forensic odontology for personal identification include comparing with antemortem dental charts, rugoscopy, denture labeling, DNA analysis from dental pulp, bite mark analysis, etc. Recently there is growing interest in the study of enamel rod end patterns. These enamel rod end patterns are termed as tooth prints and the study of these prints is known as ameloglyphics. In this manuscript, we intend to systematically appraise and emphasis on the role of ameloglyphics in forensic odontology.

Keywords: Forensic odontology • Ameloglyphics • Saliva • Enamel rod

Introduction

Just like fingerprints, bite marks, iris scanning, or snowflakes, there are no two teeth that are alike. Teeth are distinctive and only of one kind. Even identical twins do not have the same teeth. Since teeth are specific to every individual they are often used as an identifier. They are an outstanding source of DNA since they can stand up against conditions like humidity, temperature, and microbial action.

Forensic Odontology is derived from a Latin word in which forensic means 'to the forum' and Odontology means 'the study of teeth and it involves the processing, review, evaluation, and presentation of dental evidence to contribute scientific and objective data in legal processes. Forensic dentists require knowledge encompassing some disciplines since the dental records obtained can identify an individual or afford the information needed by the authorities to establish neglect, fraud, or abuse [1].

Keiser-Neilson defined forensic dentistry as "that branch of forensic dentistry that in the interest of justice deals with the proper handling and examination of dental evidence and the proper evaluation and presentation of dental findings [2]."

Over time, the role of forensic dentistry has amplified, because teeth and dental restorations are often the only means of identification. Forensic odontology has played a key role in the identification of persons in mass disasters (aviation, earthquakes, Tsunamis), in criminal investigations, in ethnic studies, and in the identification of decomposed and disfigured bodies like that of drowned persons, fire victims, and victims of motor vehicle accidents. The various methods used in forensic dentistry embrace dental imprints, radiography, photographic studies, subcutaneous microscopy, liposcopy, and molecular methods. The investigative methods used in forensic dentistry are quite reliable, but they must be made up to make them more meaningful procedures [3].

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Recently there is growing interest in the study of enamel rod end patterns. These enamel rod end patterns are termed tooth prints and the study of these prints is known as ameloglyphics.

Purpose of Forensic Odontology

Forensic odontology plays a major role in both death investigations as well as in the evaluation of victims of child abuse and sexual assault. It assistances in the identification of species, race, gender, age, DNA analysis, rugoscopy, cheiloscopy, bitemarks, and countless more.

Teeth play a grave role when the recognizable proof of remains of a perished individual is skeletonized, deteriorated, burned, or disarticulated and cannot be distinguished by visual or unique strategies. They are extremely durable even at high temperatures and may be identified even when the rest of the body has undergone decomposition. The labiolingual thickness of crown and root and the anchorage in the alveolar process along with the self-cleansing quality tend to preserve these teeth throughout life.

Dentists can help by maintaining accurate dental records and providing all necessary information for recognizing individuals. The core of the identification procedure is comparing the post mortem remains with antemortem records which include notes, radiographs, study cast, etc. In Disaster Victim Identification the dental evidence poised together is compared to the antemortem records available to the dentist for identification of a deceased person [4].

Ameloglyphics

Ameloglyphics is derived from a Latin word meaning: amelo-enamel, and glyphics-carvings. The study of the enamel rod end patterns is termed ameloglyphics [5]. It aid as an identification tool in decomposed or burned bodies as enamel is the hardest mineralized substance in the human body, can resist decomposition, it 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 [5]. The teethprints may be used as a diagnostic aid in forensic science after exposing the teeth to an adverse environmental condition like high temperature (e.g. in case of burning) and acid exposure (e.g. in case of crime) [6].

Enamel rods/prism

Enamel is a product of ectoderm-derived cells called ameloblasts. 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. Macroscopically, the

enamel surface presents a variable appearance, exhibiting features such as aprismatic enamel, perikymata, prism end markings, pits, and elevations but microscopically groups of enamel rods run in a unique direction, which differs from an adjacent group of enamel rods and results in forming diverse patterns of enamel rod endings on the tooth surface.

The basic structural unit of enamel is the enamel prism or enamel rod comprising of several million hydroxyapatite crystals packed into a long thin rod 5-6 mm in diameter and up to 2.5 mm in length and the general orientation of the enamel rods is perpendicular to the dentin surface. These prisms run from the dentino-enamel junction to the surface. Enamel prisms morphology reflects the morphology of ameloblasts in a species-specific manner (Figure 1).

The adjacent enamel rods form a unique pattern on the surface of enamel due to the undulating course of ameloblasts during formative stages and are called tooth prints.

The shape of the enamel prisms shows mainly three patterns:

- Pattern I: Prisms are circular.
- Pattern II: Prisms are aligned in parallel rows.

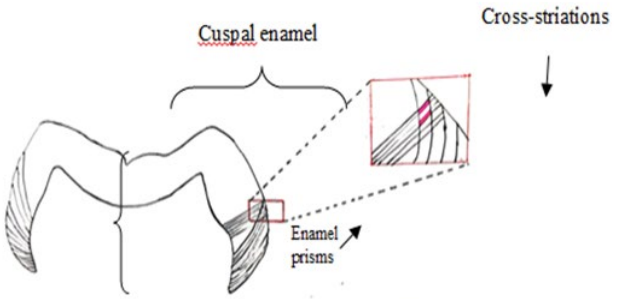


Figure 1. Tooth showing enamel and enamel prisms.

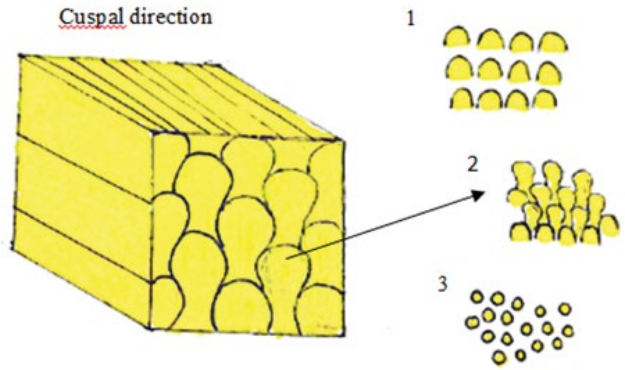


Figure 2. Shape of the enamel prisms.

- Pattern III: Prisms are arranged in staggered rows such that the narrow tail of the prism lies between two rounded heads in the next row, giving a keyhole appearance or paddle-shaped pattern (Figures 2 and 3).

In deciduous teeth, the enamel rods lie in a horizontal plane in the cervical and middle third. They gradually become more oblique in the incisal and occlusal third and are almost vertical in the incisal edge of the cusp tip and permanent teeth, the arrangement is similar to deciduous teeth in the occlusal and middle third; in the cervical third, the enamel rods show a rootward inclination or pass outward [7].

The various types of enamel rod end patterns are [8]:

- Wavy branched
- Wavy un-branched
- Linear branched
- Linear un-branched
- Whorl open
- Whorl closed
- Loop (L)
- Stem-like

These enamel rod end patterns can be obtained by various methods like using cellulose acetate film, metal shadowed colloid ion film, rubber base impression materials, etc. Acetate peel technique is a well-known technique for replicating surface details [9].

Practical applications of ameloglyphics in various fields

- Individuals working in dangerous occupations such as:
    1. soldiers
    2. divers
    3. jet pilots
- People who live and travel to potentially unstable areas [9].

Procedure for Recording of Enamel Rod Endings in Ameloglyphics

It is initiated by using acid etchant, followed by acetate peel technique, and automated biometrics as sequential steps for reproducing complete and accurate enamel rod end patterns for personal identification.

Acid etching

The most commonly used acid for *in vivo* studies to

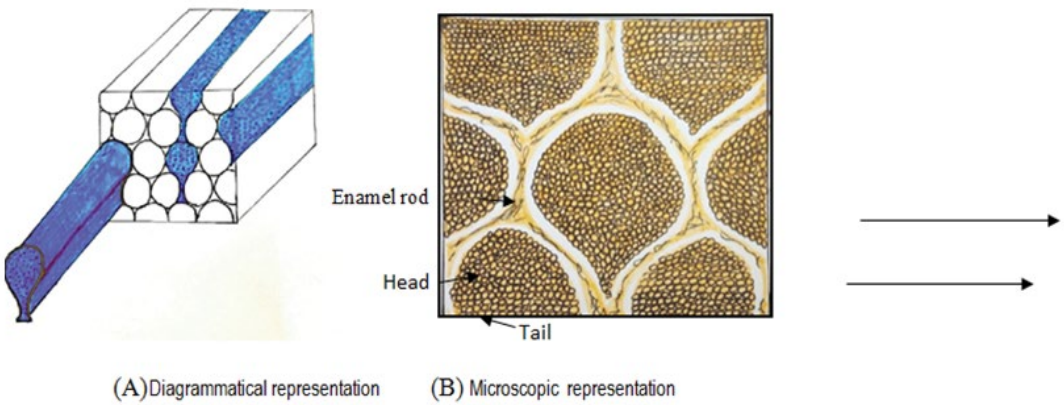


Figure 3. Keyhole shaped enamel rods.

Table 1. Historical overview of tooth prints.

Year	Author	Aim	Results
2005	Fusun A, et al. [10]	To study dental structures in 3D especially from fully mineralized enamel without routine decalcifying, dehydrating, sawing, and mounting processes using acetate peel technique.	This technique enabled making numerous sequential surface replicas (peels) from a tooth, especially from fully mineralized enamel.
2006	Ramenzoni LL, et al. [11]	To study Hunter-Schreger Bands (HSB) in enamel for personal identification.	Toothprint is a suitable physiological biometric trait for human personal identification and verification
2008	Manjunath K, et al. [5]	To study enamel rod endings on the tooth surface	Each enamel rod end pattern takes years to change into the subsequent pattern
2009	Gupta N, et al. [12]	To study enamel rod end patterns on the tooth surface	Tooth prints were composed of varied patterns and sub-patterns.
2013	Girish HC, et al. [13]	To study the correlation between enamel rod end patterns and occurrence of dental caries	No particular rod end pattern was found in teeth affected by dental caries.
2014	Manjunath K, et al. [9]	To study enamel rod end patterns from the tooth surface.	Each enamel rod end pattern takes approximately 4-6 years to change into the subsequent pattern
2020	Singroha K, et al. [14]	To assess the scope of viability, reproducibility, and identification of enamel prints and their patterns as a tool for identification.	There appeared to be a high rate of reproducibility (98%-100%) and specificity (100%).

condition the enamel is 10% orthophosphoric acid in gel form.

Three types of etching patterns can be obtained:

1. Predominant dissolution of prism cores.
2. Predominant dissolution of prism peripheries.
3. No prism structure is evident

Peel technique

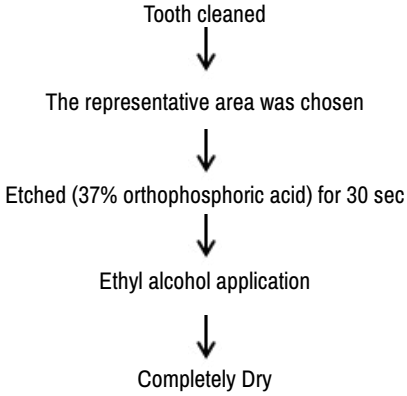
A peel is a replica of an acid-etched mineral surface, made on acetate film. A thin layer of acetone is then applied over a small piece of cellulose acetate film and placed immediately over the etched surface of the tooth without any finger pressure for 20 minutes. The acetone dissolves a layer of cellulose 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 microscope. A photomicrograph of the acetate peel is obtained at 10X magnification.

Biometric analysis

It is a technology of identification or authentication of a person which transforms a biological, morphological, or behavioural characteristic into a digital value. Biometric-based identification and verification methods (such as fingerprint verification, iris scanning, and facial recognition) have been steadily improved and perfected in automatic systems and software, which can reliably distinguish individuals. When the patterns studied are consistently recognized and provide greater confidence, they are referred to as "positive identification" [10-15].

Methods

Juneja M, et al. [6] and Manjunath K, et al. [9,16] in 2012, 2014 described almost a similar method for how to go further onto the extracted tooth for the study of enamel rods and prisms.



Flowchart representing the methodology of ameloglyphics from the extraction of a tooth to its analysis for the study of enamel rods and prisms.

Scanning Electron Microscopy for Tooth Prints

Different authors studied enamel prints under SEM (Table 1).

Boyde (1964) investigated the enamel surface at various stages of development under SEM for the first time. He integrated observation of developing enamel with enamel prism packing patterns and the formation of each pattern was attributed to a characteristic number of ameloblasts.

He described three patterns:

- Pattern 1 (formed by one cell),
- Pattern 2 (by two cells) and
- Pattern 3 (by three cells and a small contribution by the fourth ameloblast).

Also, Singroha K, et al. [14] studied the geometry of enamel prisms in SEM and manually grouped them into three categories:

- Long prism patterns
- Short prism patterns
- Combination of the above (long prism short prism [LPSP]

Advantages

- The technique is simple
- Inexpensive
- A rapid method
- Can be performed by even a dental auxiliary staff [17].

Conclusion

Forensic dentistry plays a major role in the identification of those individuals who cannot be identified visually or by other means. Greater knowledge and awareness of forensic odontology among dental practitioners would be required in the growing field of medicine. The exclusive nature of our dental anatomy and the placement of custom restorations ensure accuracy when the techniques are appropriately employed. Dental records that are used to provide patients with optimal dental service could also be very beneficial to legal authorities during an identification process. Hence, all forms of dental treatment should be recorded and kept properly. Forensic disciplines span a large range including general toxicology, firearms/tool marks, questioned documents, trace evidence, controlled substances, biological/serological screening, fire debris/arson analysis, impression evidence (e.g., fingerprints, shoe/tire prints), blood pattern analysis, crime scene investigation, medicolegal death investigation, and digital evidence.

The uniqueness of the tooth prints may be utilized as a successful identification tool in forensic science as tooth prints are unique for each tooth of an individual. Ameloglyphics is still in its infancy and whether the tooth prints are the same at different depths of enamel has to be evaluated with further studies. However, further studies need to be carried out to establish the usefulness of tooth prints as a substantial and unfailing forensic identification tool in cases of acid and burn injuries.

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