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AMELOGLYPHICS-AN UPDATED REVIEW

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ABSTRACT In this modern era equipped with technologies, the crime rates are increasing exponentially. This requires newer methodologies to identify a person who is a victim as well as the perpetruator. Automated biometric systems helps in identifying the individuals by the stored information in the database which are unique for each individual. Some of the important methods are fingerprint biometrics and iris scanning.As these methods involves soft tissues they cant be relied upon during mass disasters like burn accidents and gas leakage accidents. Hence, a biometric system using the hard tissue is required for better identification of the individuals. Thus, Ameloglyphics is introduced to aid in identification of individuals died during mass disasters and it plays a vital role in forensic odontology. This review highlights this technology in detail.

KEYWORDS : Ameloglyphics, tooth prints, forensic dentistry

INTRODUCTION

Contemporary criminal investigation methods have increased the rate of solving crimes. [1] Forensic dentistry is a branch of forensic medicine or science which aids in solving crimes. The term "forensic" is derived from the Latin, meaning forum or a place where discussions of legal matters occurs. [2] The science of dentistry as related to the law is known as forensic dentistry or forensic odontology. [3] "No two mouths are alike" forms the basis of the forensic dentistry. [1,4] Keiser defined forensic odontology "as that branch of odontology which in the interest of justice deals with the proper handling and examination of dental evidence and with the proper evaluation and presentation of dental findings".[2] The establishment of forensic odontology as a unique discipline has been attributed to Dr. Oscar Amoeda. He is the Father of Forensic Odontology. [5,16,17] Forensic dentistry deals mainly with examination and evaluation of injuries to jaws, teeth and oral soft tissues, mass disasters, child/elder/spouse abuse cases, bite mark analysis, criminal and natural deaths and injuries, bioterrorism, etc., [5] Identification of decomposed and charred bodies like that of drowned persons, burns and victims of motor vehicle accidents can be done using forensic odontology. [1] There different methods used in forensic dentistry are bite mark analysis, tooth prints, rugoscopy, cheiloscopy, dental-DNA analysis, radiographs, photographic analysis, etc., [1] Despite serving as a gold standard in identification, DNA analysis may not be useful in severely mutilated cases. [6,7]

As enamel is the hardest tissue in the human body, it resistant to decomposition. Hence, hard tissues such as bone and teeth were the only reliable sources of DNA available in severely damaged body conditions. [1] Thus, the identification of badly burned, traumatized, decomposed, and skeletonized remains can be performed using dental evidence.[8]

Enamel is known to be the hardest tissue in the body of human beings. It is a product of ectoderm-derived cells. The formation of enamel is genetically modulated. The process of amelogenesis (enamel formation) is a complex and organized one accomplished by unique cells called ameloblasts. The structural unit of enamel, laid down by ameloblasts in an undulating and inter-twining path, is known as enamel rods. Enamel rods form distinct and unique patterns on tooth. [9-12] Enamel remodelling will not occur after it has been established. Ameloblasts lay down enamel and move away from the enamel surface, leaving behind the prism morphology once enamel is formed.[19] Enamel prisms morphology mirrors the morphology of ameloblasts in a species-specific manner. [20] Therefore, the study of enamel print patterns are unique for reach individual and can be employed as a reliable biometric procedure for human identification [21] Manjunath et al have coined a term 'Amyloglyphics' meaning the study of patterns of enamel rods (amelo means enamel; glyphics means carvings). [13] Tooth print is the word used to describe these enamel rod end patterns. [14,15]

Microscopic structure of Enamel rods:

Incremental pattern of enamel rods is manifested as perikymata on the tooth surface macroscopically. Microscopically, different patterns of enamel rod endings on tooth surface are observed as enamel rod groups run in unique direction. [22-26] Electron microscopic studies showed that the enamel rods typically exhibited a keyhole or paddle shaped patterns with rounded heads and narrow tail region. Though many patterns are observed regarding the arrangement of the rods, arrangement of their head portion near to the occlusal and the incised surface and their tail portion pointing cervically is commonly seen [10]. It has been evaluated that there are millions of enamel rods in each tooth

and they differ from the other teeth. Each tooth has unique patterns. Due to the wavy arrangement of the rods in oblique direction, the length of the rods in the enamel rod is greater than the thickness of the enamel. These enamel rods are long in the thicker portions such as the cuspal areas and short in the thinner portions such as the cervical area. As they reach the outer areas, the size and diameter of the enamel rods become extensive. The diameter of the enamel rods is approximately in the ratio of 1:2 while passing from the dentin enamel junction to the outer surface. [15,19] It has been estimated that each rod measures 5 to 6 microns in diameter and 2.5 microns in length. [9]

Orientation Of Enamel Rods

The enamel rods or prisms are the basic structural units of enamel. They form the tooth print patterns They move with an up and down wavy motion from the dentinoenamel junction to the external tooth surface. Many rods spread through the entire thickness of enamel in a straight course, whereas most have a wavy pattern. [9] The orientation of the enamel rods is vertical to the dentin surface in usual. The orientation of enamel rods in deciduous teeth are as follows: parallel plane to the long axis in the cervical and middle third; diagonal in the incisal and occlusal third and are perpendicular in the incisal edge and cusp tips. In permanent teeth, the arrangement is same as that of deciduous teeth in the occlusal and middle third but in the cervical third, the enamel rods show a propensity toward root or pass outward. [9,15, 29]

Type Of Enamel Rods:

The shape of the enamel prisms approximates to one of three patterns [23]:

Pattern I: Prisms are positioned in circular manner.
Pattern II: Prisms are oriented in parallel rows.
Pattern III: Prisms are aligned in staggered rows such that the tail of prism lies between two heads in the next row, giving a keyhole appearance.

Enamel Rod End Patterns

In the study done by Manjunath et al [8] using 30 tooth prints from canines and 1st premolars in males and females, eight distinct sub-patterns, namely linear-branched, linear-unbranched, wavy-branched, wavy-unbranched, whorl-open, whorl-closed, loop, and stem-like were identified. Each tooth print had the above sub-patterns in combination. Gupta et al [30] identified eight patterns of enamel rod ends in their study, namely wavy branched, straight, linear, turning loops, wavy unbranched, open whorls, branching, loop and radiating [15,31]

METHODS TO DETECT ENAMEL RODS PATTERN:

For reproducing complete and accurate enamel rod end patterns to identify a person, the following procedures are employed:

Acid Etching:

The inorganic content on the surface enamel is removed by acid etching. Etching unevenly dissolves the surface enamel and it also removes the smear layer. Acids used for etching surface enamel are 10% citric acid, 10% phosphoric acid, 10% maleic acid, 2.5% oxalic acid, and 2.5% nitric acid. Among them, 10% orthophosphoric acid in gel form is the most commonly used acid to etch the enamel for in vivo studies.[15] This demineralization results in selective changes in the angulation of the prism crystals. After etching, porous layer (5–50 μm deep) forms and 10 μm surface enamel is removed. [31] The mineral component in the rod and rod sheath is removed after acid etching. The mineral density of rods and rod sheaths is different from each other. This results in an uneven dissolution of the surface enamel along with the removal of the smear layer. The factors affecting the acid etching on enamel are the following: 1. Kind of acid used. 2. Acid concentration. 3. Etching time. 4. Form of etchant. 5. Rinse time. 6. Whether enamel is instrumented before etching. 7. Chemical composition and condition of enamel. [32]

Acetate Peel Technique:

A peel is an acid-etched mineral surface replication, prepared on an acetate film. The advantage of peeling is that it is simple, inexpensive, and rapid way of making replicas of dental hard tissues. The peeling technique was first introduced by palaeobotanists to study the cellular structures of the fossil plants. This technique was later employed carbonate petrologists, and paleontologists to study both the texture and structures of carbonate rocks and fossils. Additional modifications were done to study dental hard tissues as it has unique mineralogical structural configuration. [33] The peel can be studied under a microscope with the incident or transmitted light or with combinations of both and can be stored for future use. [19] Cellulose acetate film records the pattern and sub-pattern of the enamel rod ends accurately on the superficial tooth surface for personal identification.[26] No blank spaces or incomplete patterns are visible. This method has high level of reproducibility. It's difficulty to record the surface enamel rod endings of the complete teeth is the main disadvantage. Therefore, it is advised that a fibro-optic laser scanner that can scan the complete teeth should be developed with software dedicated to study enamel rod endings. [31]

Automated Biometric Technique:

The term "biometrics" refers to the statistical analysis of a biological data. It is a technology of identification or authentication of a person's biological, morphological, or behavioural characteristic in a digital value. When the patterns subjected for identification are recognized by the system, they are referred to as "positive identification". Various biometric-based identification and verification methodologies employed in forensics are fingerprint verification, iris scanning, and facial recognition. The data are stored in automated systems and software, which can identify the individuals reliably. [19]

An ideal biometric system used to identify an individual should possess the following characteristics : Highly distinctive and unique for every human being, data should be easily transmissible, should be distinguishable by humans with ease, data should be acquired without any interference. [14,15]

Various software applications are available to analyse fingerprints. Among them, Verifinger® standard SDK version 5.0 software was developed by Neurotechnologia in 1998. Verifinger SDK is studied for biometric system developers and integrators. It permits the development of biometric apps for Microsoft Windows, Linux, and Mac OS X platforms. Verifinger can be encompassed into a customer's security system with ease. As the input and output data of SDK is totally handled by the integrator, SDK functions in association with any scanner, any database, and any user interface. It employs specific set of fingerprint points (minutiae) to deposit an image in the form of outline similar to the minutiae. Ramenzoni and Line[34] were the pioneers in using the fingerprint identification and verification software (VeriFinger Demo 4.2, SDK/Fingersec) to evaluate the uniqueness of Hunter-Schreger bands for personal identification. The Verifinger software also aids in identifying all the surface patterns of a particular tooth with specific ID number, which was stored in the database in prior. Studies demonstrated that VeriFinger software v5.0 is a definitive tool in copying enamel rod-end patterns. It also proved to be reproducible without any differences. VerFinger 10.0 Standard SDK and VeriFinger 10.0 Extended SDK are the latest versions available but investigations for tooth prints copying have not been confirmed. [14,26,31]

The Recording Procedure [31,35]:

- All the extracted teeth are scaled.
- 37% orthophosphoric acid etching done for 2 minutes on middle third of the facial/buccal surface of the tooth. (The mid area is selected because the rods here run horizontally from the dentinoenamel junction to the enamel surface.)
- The etched surface is washed with water.
- Ethyl alcohol is sprayed for quick drying without any leftover residual moisture prior to taking an imprint.
- Extended cellophane tape applied over the etched tooth without any pressure.
- Apply a small piece of cotton roll over the area for a better adaptation of the cellophane tape.
- Immediately the cellophane tape is removed gently with a pull motion.
- The imprint portion of the cellophane tape is cut and transferred to a glass slide.
- The glass slide is focussed under conventional light microscope attached with a good camera for photomicrography and viewed at 10× and 40× magnification. Clearer digital image of the tooth imprints is seen at 40× magnification than 10×.
- The digital image is subjected to biometric conversion using Verifinger standard SDK version 6.0 software and they are analysed by Automated Fingerprint Identification System software. It has the capability to evaluate the similarity and differences between the two patterns in the form of lines (as used in fingerprint identification) and give the result as matching or not matching.

CONCLUSION:

Thus, ameloglyphics plays a significant role in identification of individuals involved in fire accidents and other incidents where the body is decomposed and mutilated. Further studies will help in understanding this identification method in detail. Ameloglyphics is a potential tool as a biometric system which can be used as an adjunct with conventional biometric systems for better identification.

REFERENCES:

1. Shah P, Velani PR, Lakade L, Dukle S. Teeth in forensics: A review. Indian J Dent Res 2019;30:291-9.
2. Puerini SJ. Forensic odontology and the postmortem identification process. Med Health R I. 2005 Sep;88(9):308-9. PMID: 16268209.
3. Henderson CE. President's editorial–AAFS and forensic science: The next 60 years. J Forensic Sci 2009; 54:5-6.
4. Singh K, AnandaniC, Bhullar RK, Agrawal A, Chaudhary H, Thakral A. Teeth and their secrets–Forensic dentistry. J Forensic Res 2012;3:141.
5. Saxena, S., Sharma, P., & Gupta, N. (2010). Experimental studies of forensic odontology to aid in the identification process. Journal of Forensic Dental Sciences, 2, 69 - 76.
6. Singroha K, Banerjee A, Kamath VV, Pramod J, Alangkar S, Elampovai E. Scanning electron microscope corroboration of ameloglyphics – A new tool in forensic odontology. Int J App Basic Med Res 2020;10:76-80.
7. Van Oorschot RA, Ballantyne KN, Mitchell RJ. Forensic trace DNA: A review. Investig Genet 2010;1:14.
8. Manjunath K, Sivapathasundharam B, Saraswathi TR. Analysis of enamel rod end patterns on tooth surface for personal identification--ameloglyphics. J Forensic Sci. 2012 May;57(3):789-93.
9. Girish H C, Murgod S, Manasa Ravath C J, Hegde RB. Ameloglyphics and predilection of dental caries. J Oral Maxillofac Pathol 2013;17:181-4
10. Boyde A. The development of enamel structure. J R Soc Med 1967;60:923-8.
11. Ramenzoni LL, Line SR. Automated biometrics-based personal identification of the Hunter-Schreger bands of dental enamel. Proc R Soc B Biol Sci [Internet]. 2006;273(1590):1155–8.
12. Rakesh, N., Sujatha, S., Pavan Kumar, T., Yashoda Devi, B.K., Gupta, D. and Harish, B.N.,. Reliability of Ameloglyphics for Person Identification Following Adverse Conditions. JDOR, 2018;14(1), pp.2-6.
13. Manjunath K, Sriram G, Saraswathi TR, Sivapathasundharam B. Enamel rod end patterns : A preliminary study using acetate peel technique and automated biometrics. J Forensic Odontology 2008;1:33-6
14. Manjunath K, Sriram G, Saraswathi TR, Sivapathasundharam B, Porchelvam S. Reliability of automated biometrics in the analysis of enamel rod end patterns. J Forensic Dent Sci 2009;1:32-6.
15. Bharanidharan R, Karthik R, Rameshkumar A, Rajashree P, Rajkumar K. Ameloglyphics: An adjunctive aid in individual identification. SRM J Res Dent Sci 2014;5:264-8.
16. Vij K. Textbook of Forensic Medicine and Toxicology. Churchill Livingstone, 2nd ed. 2002. p. 71-2.
17. Amedo O. The role of dentist in the identification of the victims of the catastrophe of the " Bazar de la Charite", Paris, 4th May, 1897. Dent Cosm. 1897;39:905–12.
18. Michael Bowers C, D. DS, D. J. Forensic Dental Evidence: An Investigator's Handbook. Elsevier Science, 2004.
19. Amrithaashri S., Archana Santhanam. Ameloglyphics - A Review. Annals of RSCB 2021, 6222-6229.
20. Dinkar D, Siddarth P, Shravya M, Kishore B, Nayak SV, Raghavendra K, et al. Ameloglyphics – A mirror within you. Austin J Forensic Sci Criminol. 2018; 5(1): 1075
21. Osborn JW. Evaluation of previous assessments of prism directions in human enamel. J Dent Res 1968;47:217-22.
22. Sheng Cheng Soo, Nani Murniati, Andriani Harsanti, Yuti Malinda, Fahmi Oscandar Padjadjaran Journal of Dentistry. 2020;32(2):118-124
23. Berkovitz BK, Holland GR, Moxiham BJ. Enamel. In: Berkovitz BK, Holland GR, Moxiham BJ, editors. Oral Anatomy, Histology and Embryology. 3rd Ed. London, Mosby publ; 2002. p.110-11.
24. Osborn JW. Directions and interrelationships of enamel prisms from the sides of human teeth. J Dent Res 1968;47:223-32.
25. Boyde A. Amelogenesis and the structure of enamel. In: Cohen B, Kramer IR, editors. Scientific foundations of dentistry. London, William Heinemann Medical books Ltd, 1976. p. 341-43.
26. K Manjunath; B Sivapathasundharam; T Saraswathi. Efficacy of Various Materials in Recording Enamel Rod Endings on Tooth Surface for Personal Identification. jfds 2011, 3, 71-76.
27. Osborn JW. Directions and interrelationships of enamel prisms from the sides of human teeth. J Dent Res 1968; 47: 223–232.
28. Berkovitz BKB, Holland GR, Moxham BJ. Oral Anatomy, Embryology and Histology. Mosby, 2002.
29. Rajkumar K. Enamel. In: Rajkumar R, Ramya R, editors. Text Book of Oral Anatomy, Histology, Physiology and Tooth Morphology. 1st ed. India: Wolters Kluwer Health 2012.
30. Gupta N, Jadhav K, Ahmed Mujib BR, Amberkar VS. Is re-creation of human identity possible using tooth prints? An experimental study to aid in identification. Forensic Sci Int 2009 Nov;192(1-3):67-71.
31. Beena VT, Mohammed R, Paul S, Stephen MM, Nair C, Mohan AP. Ameloglyphics: The Tooth Signature. Oral Maxillofac Pathol J 2018;9(2):70-75.
32. Perdigão J, Walter R, Miguez PA, et al. Fundamental Concepts of Enamel and Dentin Adhesion. Sturdevant's Art and Science of Operative Dentistry 2019; 136–169.
33. Garg N. Chapter-16 Bonding to Enamel and Dentin. Textbook of Operative Dentistry 2013; 275– 297.
34. Ramenzoni LL, Line SR. Automated biometrics-based personal identification of the Hunter–Schreger bands of dental enamel. Proc R Soc B 2006 May;273(1590):1155-1158.
35. Gupta N, Jadhav K, Ahmed Mujib BR, Amberkar VS. Is re-creation of human identity possible using tooth prints? An experimental study to aid in identification. Forensic Sci Int 2009 Nov;192(1-3):67-71.