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Amelogyphics: A multidimensional tool in human identification- A short study

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Abstract--Background: Dental proof may provide significant assistance in identifying a victim's body and determine specific facts thus influencing the investigative procedure. Amelogyphics or tooth prints symbolizes exceptional differences enlightening distinctive patterns between teeth of unlike individuals and of the same individual, and also between males and females. Aim: This novel study was performed to determine and establish the fact that enamel in teeth could be used to identify an individual as such by the help of the tooth prints or amelogyphics. Materials & Method: 30 individuals (15 males and 15 females) were selected for the study. The anterior tooth of every individual was dried with cotton and impression of the enamel imprints were obtained on a cellophane tape which was then transferred to a glass slide and was subjected to photography. These

photographs were then analyzed using Image Analysis Colorimetry. Results: The colorimetry analysis showed two different variations i.e. Red waves depicted male prints and Black waves showed females tooth prints. The results showed that ameloglyphics helped to determine the gender of an individual and also revealed that each individual had a separate discrete type of imprint. It was thus documented that ameloglyphics can be used to identify an individual both in ante mortem and post mortem cases. Conclusion: Tooth prints have shown to be unique and distinctive to an individual, with variations between those of different persons.

Keywords---Ameloglyphics, Enamel rods, Tooth prints, Forensic odontology.

Introduction

Dental identification is considered to be one of the most dependable and commonly functional methods of identification in forensic science amongst which forensic odontology is a separate forte in itself. It is quite difficult to identify human remains in mass disasters. Teeth are thought to be the most indestructible and imperishable constituents in the human body. They have the utmost resistance to numerous environmental consequences like fire, desiccation and decomposition. Teeth have a unique composition of both inorganic and organic constituents and thus can survive maximum natural calamities and helps to afford a confident, personal identification of an unrecognizable body.^{1,2}

Dental evidence may produce convincing relations to help in identifying a victim's body and ascertain specific facts that could disturb the course and final consequence of the investigative casework. These details not only provide post mortem details but also can be helpful in ante mortem identification cases on individuals. Due to the high resistance capacity of the human teeth to various environmental factors and post mortem proteolysis, they are thought to be of prime importance in forensic investigation. Human teeth is envisaged as a hard tissue equivalent to fingerprint wherein enamel is the least responsive of all the three hard tissues of the teeth (enamel, dentin and cementum) and repels disintegration. This high resistance property of enamel is attributed to its excellent composition and mineralization matrix.^{3,4} It was Skinner and Anderson in 1991, who had tried to distinguish different individuals by using Striae of Retzius in enamel by associating it with the known stressors of life in order to identify a missing child. Although there was a restraint of age dependency in the mentioned case scenario.³

Ameloglyphics also referred to as tooth prints has been gaining more popularity lately. Ameloglyphics is used to study the enamel rod-end patterns (amelo meaning enamel; glyphics meaning carvings). The term "ameloglyphics" was created by Manjunath *et al.* almost like the term dermatoglyphics.⁵ The process of enamel matrix formation called Amelogenesis is an exceptionally controlled secretory procedure. The ameloblasts secrete enamel matrix proteins in an undulating, rippling and interweaving manner which is portrayed as a series of

pattern on the enamel surface, termed as tooth prints. These tooth prints represent unique variations revealing different patterns between teeth of unlike individuals and of the same individual, and also between males and females.⁶ This explicit characteristic of the tooth print can be utilized as an important tool in forensic science for identifying an individual particularly (not only gender determination).⁷ Thus, this novel pilot study was performed with the aim to determine and establish the fact that enamel in teeth could be used in identify an individual as such by the help of the tooth prints or amelogyphics.

Materials & Method

A total sample size of 30 individuals (15 males and 15 females) was selected for the study. All the candidates were subjected to oral prophylaxis treatment in the Department of Oral pathology & Microbiology, Kusum Devi Jain Dental College & Hospital, Kolkata. The anterior tooth of every individual was dried using cotton and impression of the enamel imprints were obtained on a cellophane tape. The cellophane tape was then transferred to a glass slide and this was then subjected to photography. These photographs were then analyzed using Image Analysis Colorimetry. The current technique utilizes image processing of acquired images by studying pixel by pixel analysis. Colorimetry was performed by extracting RGB value from the images. This helped to understand and interpret batch to batch variation and color depth information also. The software was developed in lab-view platform and was an intuitive user interface which analyzed the data to develop graph corresponding to each pixel value.

Results

The colorimetry analysis showed two different variations to represent the males and females enamel prints in different colors. Figure shows two distinctive type of waves: Red waves depicted male prints and Black waves showed females tooth prints. The present study results depicted that amelogyphics could be a significant tool to determine the gender of an individual and also showed that each individual (whether male or female) had a separate discrete and definite type of imprint thus, explaining the fact that amelogyphics can not only be used to identify an individual after death but also can be used for person identification when alive.

Discussion

Forensic medicine incorporates a multidisciplinary team work trusting on positive identification approaches thus helping in forensic investigation. Forensic odontology serves to be an important adjunct in forensic investigative procedures to identify the victim and also in identification of human remains.¹ Enamel is derived from the ectodermal cells called ameloblasts and is thought to be the hardest mineral structure in human body. Amelogenesis (formation of enamel) is a highly controlled and orderly process wherein, ameloblasts lay down the enamel rods or prisms (basic structural unit of enamel) in an undulating and inter-twining manner. This is replicated on the outer surface of enamel as patterns of rod-ends in a series of adjacent enamel rods. These rod-end patterns are referred to as tooth prints. Amelogyphics is the study of patterns of enamel rods or tooth

prints that has established itself to be a remarkable tool in human identification.⁸ Enamel neither undergoes remodeling nor does it remain in close proximity with the enamel forming cells, rather these ameloblasts withdraw away from the surface of deposition after the maturation process and the tooth eruption. Enamel prisms morphology reveals the morphology of ameloblasts in a species-specific manner. Any alteration in the enamel matrix are reproduced as faults in the enamel structure and organization.⁹ These enamel rod end patterns or tooth prints could be replicated and reproduced by different modes like using cellulose acetate paper, rubber base impression materials etc.¹⁰ There are three main patterns of enamel rods shape which can be enumerated as below:-

Pattern 1: Circular

Pattern 2: Aligned in parallel rows

Pattern 3: Arranged in zigzag rows so that the tail end lies between two heads in the new row (keyhole appearance).

There are numerous methods to study the tooth prints namely acid etching, recording patterns, peel technique and automated biometrics are facilities for the study of enamel rod-end patterns in amelogliophics. These are used as consecutive steps for individual identification.¹¹ However, the simple use of cellophane tape has been used in the present study to record and document the replica of enamel tooth prints of an individual. The same cellophane tape is quite commonly used by the fingerprints experts to acquire finger imprints. Such procedures are categorized into biometrics which refers to identification of individuals with the help of biological traits, typically those that are based on retinal or iris scanning, fingerprints, or faces recognition.¹⁰

Girish HC *et al.* (2013) concluded in their study that each tooth of the study groups showed a different pattern. They observed that the pattern varied in distinctive areas of the print from the same tooth also. This was perhaps due to the differential movement of the ameloblasts during amelogenesis in relation to the same tooth. It is probably believed that the environmental factors might have had an effect on the course of the ameloblasts during the different periods of the tooth development thus causing diverse arrangements. These disturbances are expressed as distinctive print patterns.¹²

Juneja M *et al.* (2016) performed a study to evaluate if the tooth prints could be used for an individual's identification and observed that tooth print analysis just like fingerprint demonstrates a high discrimination potential. It has also been emphasized that a tooth print pattern is extremely specific and unambiguous, being exceptional for each tooth of an individual. Thus, they established the fact that tooth prints may be used as an efficient aid in person identification even in adverse conditions such as burn and acid attack injuries.¹³

Rakesh N *et al.* (2018) also conducted a study to evaluate whether tooth prints could be used for an individual's identification. They perceived that the tooth prints achieved from each tooth were unique and inimitable thus, unveiling dissimilarity both between teeth of different individuals and of the same individual.¹⁴ Few other in vitro studies on tooth prints conducted by Manjunath K *et al.* (2012)⁶, Sivapathasundaram B *et al.* (2014)¹⁵, Dahal S *et al.* (2014)¹⁶, have also shown that these specific tooth print patterns are rare with discrepancies in

both inter and intra individual comparisons. The extraordinariness of these tooth prints could serve as a precious additional means to identify an individual and also in gender determination which would be helpful in forensic investigation. The reproducibility and perpetuity of these tooth prints, even at hostile conditions like high temperature, may be used in cases of accidents, air crash, bomb blasts and terror acts.¹⁴ However, it could also be used as ante-mortem records for individual identification as was seen in the present study.

In the present study of tooth prints, it was observed that they are entirely different from one and another, when compared between teeth of the same and even for different individuals. Even with a slight change of field of tooth print of same individual and even the same tooth, the pattern had changed. This could probably be due to disparity in the movement of adjoining ameloblasts in relation to the same tooth during amelogenesis. The variations in environmental factors surrounding a developing tooth like with time might be also causing an obvious effect. These factors could include placement of the developing tooth bud, temperature, pressure, nutrition to the ameloblasts cells, etc. Genetics might also have a function in predestining the type of pattern of tooth print. These results were also seen in a study performed by Gupta N *et al.* (2009).¹⁰ The present novel study entails certain specific advantages. These include:-

- Reliable method
- Simple procedure
- Non-invasive
- Cost effective
- No trauma (extraction or acid etching procedure in the subjects)

However, there are specific drawbacks of the procedure also i.e. the various surface structures of enamel are lost following attrition and abrasion of the tooth structure. This could further alter the enamel rod end patterns with time in an individual thus, changing the print patterns with time.

Conclusion

The study of tooth prints is considered to be a novel and innovative area of research in the field of forensic odontology. The inimitability of these tooth prints may be employed as a efficacious tool in forensic science and investigative procedures. According to our study, tooth prints have shown to be unique and distinctive to an individual, with variations between those of different persons. However, more elaborate studies are essential to be carried out to ascertain the efficacy of tooth prints as a significant and dependable forensic identification tool for individual identification and gender determination. There are certain obvious advantages of this procedure, however the results might have been prejudiced by few pitfalls that are mentioned above. It could be anticipated that the tooth prints might have actually acquired in them some unseen evidences yet to be disclosed. Thus, a lot of studies and research needs to be conducted in order to explore the enamel rod end patterns especially in cases of deciduous teeth, teeth with developmental disorders and differences as per the type of acid etching patterns. Hence, further extravagant studies with greater sample size and more elaborate work should be undertaken in future so as to help in forensic investigative procedures and also to keep proper dental records of an individual as the tooth

prints have proven to be person specific.

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