Reliability of Ameloglyphics for Person Identification Following Adverse Conditions

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Abstract

Ameloglyphics is the study of tooth prints or enamel rod end patterns. These patterns are unique to an individual tooth of same individual and different individuals. The dental hard tissue has the highest resistance to most environmental effects like fire, desiccation, and decomposition and may be used as a forensic evidence. Human teeth are considered as a hard tissue analogy to fingerprints which is a reliable tool in a decomposed body. This study was executed to evaluate if the tooth prints could be used as an adjuctive forensic tool for an individual's identification and to assess the reproducibility and permanency of these tooth prints after exposing the teeth to various degrees of temperature. 90 tooth prints from 20 freshly extracted maxillary premolar teeth were obtained. To record enamel rod end pattern cellophane tape technique was used on the tooth surface. The impression was made of the teeth surface after incineration at various intervals (80° C, 400° C, 600° C, and 750° C). The resultant tooth prints were analyzed using Verifinger® standard SDK version 5.0 software. All tooth prints were distinct from each other and no inter-individual or intra-individual similarity was found. The toothprint obtained after such environmental insult are reproducible and showed high to very high similarity with the original tooth print of that particular tooth stored in the database. Tooth prints can be used as an effective adjuvant aid in person identification even in adverse conditions such as thermal injuries.

Keywords: *Enamel rod end patterns, Forensic Odontology, Tooth Print, Biometrics*

1. INTRODUCTION

Forensic odontology is a branch that is evolving over time and has opened newer vistas that may help in the identification of individuals. Accurate and efficient identification have become a essential requirement for forensic application due to diversities of criminal activities, man-made or natural mass disasters. Forensic investigations are based on finding differences such as polymorphisms, between different individuals. Some variations are unique and most of them are different. Indeed identification of an individual is the tenet of biology. The traditional positive identification involves a comparison of data unique to an individual like fingerprints, palm prints, footprints, DNA identification and radiographic superimposition. These identification methods have limitations and may not be efficient when bodies are burned, charred or in cases when only small fragments of calcified tissues are left.[1] Identification of burned bodies starts with the identification of objects that have remained in the body, which may not be always readily available unlike teeth, which are considered to be the most indestructible components of the human body. Teeth have the highest resistance to most environmental effects like fire, desiccation, and decomposition. Human dentition survive most natural disasters and are a possible tool for personal identification of an otherwise unrecognizable body.[2] Enamel rods which are the structural unit of enamel, form distinct and unique patterns on tooth.[3] Ameloblasts lay down enamel matrix in a species-specific pattern which is reflected on the outer surface of the enamel in a series to form enamel rods. Thus, human teeth are considered hard tissue analog to fingerprints. Tooth prints is the term used to describe the enamel rod end patterns. Ameloglyphics is the term used for the study of patterns of enamel rods.[4] There are methods for duplication or recording of this enamel rod end patterns, such as using celophane tape technique ,cellulose acetate paper and rubber base impression materials.[5]

The term “biometrics” is a technique referred for identification purpose, based on physical and morphological characteristics of a person. Following advancements in biometric technology which is equipped with computational intelligence techniques is replacing manual identification approaches in forensic science.[6] Biometric-based identification and verification methodologies such as fingerprint verification, iris scanning and facial recognition have been used successfully with improved and refined automated systems and softwares.[7] These identification methods commonly fail or have certain limitations and may not be efficient when bodies are burned, charred or in cases when only small fragments of calcified tissues are left. Previous *in vitro* studies[4,8,9,1,10] have been done to study the pattern of enamel rod endings on the enamel surface and to examine if tooth prints patterns could be used for an individual’s identification. To our knowledge, none of the studies have evaluated the reproducibility, permanency and uniqueness of these tooth prints after exposing the teeth to adverse environmental condition like high temperature (e.g. in case of burning), when the teeth come into play to be used as a diagnostic aid in forensic science comes. Therefore, the present study was designed with an aim of evaluating whether the tooth prints could be used for an individual’s identification after exposing the teeth to various degrees of temperature and to access their reproducibility and permanency.

2. MATERIALS & METHODS

Twenty maxillary premolar indicated for extraction for orthodontic purpose from 10 subjects were collected for the study from the Department of Oral & Maxillofacial Surgery. Teeth with decay, attrition, abrasion, erosion, hypoplasia, fracture and/or restorations were excluded from the study because of the alteration of surface enamel characteristics in such teeth. Two teeth from each subject were collected for the purpose of intra-individual comparison. Inter-individual comparison was also done between teeth from different individuals. Informed consent was obtained from each patient prior to collection of extracted teeth.

All the extracted teeth were scaled and on the comparatively flat area (middle-thirds) of the labial surface of each tooth a circle of 5 mm diameter was drawn. The labial surface of the tooth was ground using high speed air rotor handpiece except for the marked circular area. Ungrounded circular area over the tooth was then subjected to acid etchant with 37% orthophosphoric acid for 2 min. The etched surface was then washed with water and air-dried properly. Once the surface had dried a portion of extended cellophane tape was applied over the etched area without applying finger pressure. Instead a small piece of cotton roll was applied without pressure for a better adaptation of the cellophane tape over the etched surface. The cellophane tape was then peeled away gently and was then transferred on a glass slide observed under research microscope (Olympus CX 21) and a digital image was obtained at 40 X magnification. In order to prevent bias during recording of enamel rod end patterns or tooth prints, the following measures were taken: All the photomicrographs were taken at a magnification of 40X, the photomicrographs were taken without zooming the camera lens and the photomicrographs hence obtained images were cropped to 2000 × 1500 pixels in Microsoft Office picture manager software [Figure 1].

After taking photomicrographs of all the collected teeth, the teeth were exposed to high temperatures in dental casting machine. After achieving the desired temperature, teeth were maintained for 5 min at same temperature and then allowed to cool and impressions were made at various temperature intervals (80° C, 400° C, 600° C, and 750° C). Photomicrographs for all the samples were taken as described. The photomicrographs (total of 90) were analysed using Verifinger® standard SDK version 5.0 software to identify enamel rod end patterns called as minutae [Figures 2 and 3;Figure 2 is the photomicrograph with minutae points as detected by software and Figure 3 is the processed image]. Minutae represent the enamel rod end patterns which may be in the form of discontinuities, end points or empty spaces between two lines.[4] These minutae points were analysed by the software to compare the similarity or variability of two patterns.

Tooth prints obtained from different teeth (total of 90 tooth prints) were analysed for similarity among tooth prints of teeth of different individuals, among same individuals and among same tooth after exposing it to either temperature (80° C, 400° C, 600° C, and 750° C). The software provides a numeral score of similarity in bits. (Figure 4) Higher scores are given for more similar minutae points, and lower scores for poorly similar minutae. For dissimilar characters software prompts “non identified”. The similarity scores were divided into four groups as recommended by Ramenzoni *et al*.[3]
group I, 2000-1001 bits (very high similarity); group II, 1000-101 bits (high similarity); group III, 100-10 bits (low similarity); and group IV, 9-0 bits (very low similarity).

3. RESULTS

A total of 90 tooth prints were obtained from 20 teeth and were analyzed by the software. Each of the 20 original tooth prints, which were made first, were distinct from each other and no inter-individual or intra-individual similarity was found. The best match (i.e. the highest minutae score) was always achieved when a tooth was compared with itself on the database [Figure 4]. This indicates that toothprint analysis as fingerprint, exhibits a high discrimination power and that a toothprint pattern is highly specific, stating the uniqueness in every individual. The tooth prints from the same tooth after exposing it to thermal insult were reproducible and showed very high to high similarity with the original tooth print of that particular tooth stored in the database.

4. DISCUSSION

From the point of forensic dental identification especially in identifying victims of man-made disasters such as in military conflicts and wars involving multiple fatalities, there is urgent need for new and reliable methods of identification and corroboration. The tooth prints are unique, exhibiting dissimilarity both between teeth of different individuals and of the same individual. This uniqueness of the tooth print could be used as a valuable tool in forensic science for personal identification.[11] Forensic odontology has been playing a major role in human identification, especially when soft tissue cannot provide reliable information. Enamel covering the crown of the tooth, is the hardest biological tissue and while highly mineralized, withstands both shearing and impact forces well.[8]

During amelogenesis, the undulating course of ameloblasts results in the formation of a pattern by series of adjacent enamel rod ends.The enamel surface presents variable appearance, exhibiting features such as aprismatic enamel, perikymata, prism end markings, pits and elevations. Enamel prism which is the basic structural unit of enamel consists of several million hydroxyapatite crystals packed into a long thin rod 5-6 mm in diameter and up to 2.5 mm in length. These prisms run from the dentino-enamel junction to the surface[12].The adjacent enamel rods form a unique pattern due to undulating course of ameloblasts during formative stages. Such patterns on the surface of enamel are called tooth prints.

In the present study, it was observed that the tooth prints obtained from each tooth were unique, exhibiting dissimilarity both between teeth of different individuals and of the same individual. Previous *in-vitro* studies [4,8,9,1,10] on tooth prints have also shown tooth print patterns to be unique with dissimilarities in both inter-and intra-individual comparisons. This uniqueness of the tooth print could be used as a valuable adjunctive tool in forensic science for personal identification. The reproducibility and permanency of these tooth prints, even after exposing the tooth to adverse conditions like high temperature, may be used in cases of accidents, air crash, bomb blasts and terror acts. Experimental evidence indicates that teeth can withstand much higher temperatures in burned corpses. The preservation of enamel structure is achieved due to the protective effect of the tongue, muscles of mastication, and other soft tissues.[12] Our literature search revealed that there are very few studies that have focused on the positive identification after destruction of the human body.

In our study, we attempted to record the tooth prints after exposing the tooth to high temperatures, to check their reproducibility and similarity to the original tooth print. Our results showed that tooth prints were obtained at temperatures as high as 750° C hence, supporting the application of this technique in the case of burn injury leading to charred corpse.

5. Conclusion

As said by Louis Pasteur, “In the field of observation, chance favors the mind that is prepared scientifically”. Likewise, a scientifically prepared mind with the proper knowledge may become a significant biological tool in forensic investigations. Importance of forensic dentistry is on increase year after year. This is due to the fact of increasing incidence of mass disasters such as cyclones, earthquakes, floods, and volcanic explosions as well as non-natural occurrences such as airplane accidents, industrial accidents, and terror acts. Major arena of forensic odontology is the identification of human beings, either dead or alive. Tooth prints are one of the new fields in the forensic research work. The uniqueness of these tooth prints may be utilized as a successful adjunctive identification tool in forensic science. According to our study, tooth prints appear to be unique, with dissimilarities between those of different individuals and also the same individual and more importantly these prints are reproducible, even after exposing the tooth to adverse conditions like high temperature. 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 injuries leading to charred corpse where soft tissue biometric does not play its role.

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