ORIGINAL ARTICLE

Can dead man tooth do tell tales? Tooth prints in forensic identification

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Abstract

Background: We know that teeth trouble us a lot when we are alive, but they last longer for thousands of years even after we are dead. Teeth being the strongest and resistant structure are the most significant tool in forensic investigations. Patterns of enamel rod end on the tooth surface are known as tooth prints. **Aim:** This study is aimed to know whether these tooth prints can become a forensic tool in personal identification such as finger prints. A study has been targeted toward the same. **Settings and Design:** In the present *in-vivo* study, acetate peel technique has been used to obtain the replica of enamel rod end patterns. **Materials and Methods:** Tooth prints of upper first premolars were recorded from 80 individuals after acid etching using cellulose acetate strips. Then, digital images of the tooth prints obtained at two different intervals were subjected to biometric conversion using Verifinger standard software development kit version 6.5 software followed by the use of Automated Fingerprint Identification System (AFIS) software for comparison of the tooth prints. Similarly, each individual's finger prints were also recorded and were subjected to the same software. **Statistical Analysis:** Further, recordings of AFIS scores obtained from images were statistically analyzed using Cronbach's test. **Results:** We observed that comparing two tooth prints taken from an individual at two intervals exhibited similarity in many cases, with wavy pattern tooth print being the predominant type. However, the same prints showed dissimilarity when compared with other individuals. We also found that most of the individuals with whorl pattern finger print showed wavy pattern tooth print and few loop type fingerprints showed linear pattern of tooth prints. **Conclusions:** Further more experiments on both tooth prints and finger prints are required in establishing an individual's identity.

Key words: Acetate peel technique, Automated Fingerprint Identification System, biometrics, finger prints, minutiae, tooth prints

Introduction

Forensic identification is organized as a multidisciplinary collaboration which is based on positive identification as well as other presumptive or exclusionary methodologies. In mortal combat situations such as the violence associated with struggles of life and death between assailants and victims, the teeth are often used as a weapon for identification.[1]

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Forensic investigations are mainly concerned with finding differences/polymorphisms between different individuals. The theory that all individuals are unique forms the basis for identification. Materials used for identifying human remains are the personal belongings such as clothing, jewelry, fingerprints, lip prints, blood groups, and even dentition.[2,3]

Teeth are considered as hard tissue analog to the fingerprints and unique for an individual as fingerprints.[4] Personal identification is becoming increasingly important in modern life where positive identification is based on identifying unique features of an individual such as fingerprints, palm prints, footprints, DNA identification, and radiographic superimposition of structures such as mental foramen and mandibular foramen.[5]

Enamel being the hardest tissue in the human body is resistant to decomposition. Enamel rods being the structural unit of enamel, form distinct and unique patterns on tooth. Thus, study of these patterns of enamel rods (amelo: enamel, glyphics: carvings) is called ameloglyphics.[6] Ameloblasts laid down the matrix in a specific manner which is reflected on the outer surface of the enamel in a series to form enamel rods. The enamel rod end patterns can be replicated by various methods such as cellulose acetate paper, cellophane tape, and rubber base impression materials.[6] Hence, the present study was designed to investigate whether tooth prints were unique to particular tooth of individual as well as to compare the tooth prints of same tooth in other individuals and to identify the predominant pattern of tooth print of particular tooth. This study also aimed to analyze the reliability of these tooth prints by recording the prints at two different intervals. Efforts were also made to find out whether dermatoglyphics could be a guide in determining the pattern of tooth print.

Aims and objectives

This *in-vivo* study was designed to obtain tooth prints from individuals at two different intervals and to compare the same for similarity as well as to compare the same prints with other individuals using Verifinger standard software development kit (SDK) version 6.5 and Automated Fingerprint Identification System (AFIS) software. [Fingerprint reader, 300 pp, Neurotechnology].

This study also aimed to check the reproducibility of these tooth prints using the same software and to know the predominant pattern of tooth print. The study also involved in identifying the predominant tooth print pattern in relation to finger print pattern.

Materials and Methods

Materials

The materials used for this study were 10% orthophosphoric acid, cellulose acetate strips, distilled water, glass slides, acetone, glass-marking pencils, cotton rolls, and cellophane tape.

Methodology

Source of data

This *in-vivo* study was conducted on 80 individuals (52 females and 28 males) (age group - 20–30 years) who visited the department of orthodontics. Individuals whose extraction of the upper right first premolars was mandatory for orthodontic treatment were considered as study group.

Study group selection

Patients who visited for orthodontic treatment and in whom the upper first premolars extractions were mandatory were considered. An Ethical Committee clearance was obtained during the study. Patients were informed about the procedure being carried out and informed consent duly signed from all individuals was collected before the procedure. Further, under isolation, procedure was carried out.

Exclusion criteria

Teeth with decay, attrition, abrasion, erosion, hypoplasia, and fracture were not selected for the study.

Procedure

The scaling and polishing procedure was first performed for the patient. Then, the middle third of buccal surface of the upper first premolar (right) was etched with 10% orthophosphoric acid for 15–20 s. Etchant was washed with distilled water and air dried. Then, a drop of acetone was placed over cellulose acetate strip to soften the strip. Once tooth was dried, the softened strip was applied on etched tooth surface and finger pressure was applied. After 20 min, cellulose acetate strip with tooth prints recorded was removed. These prints were observed under 40× magnification and photomicrographs ([Leica Biomed Research Microscope] attached with a Nikon camera) of acetate peel (recorded tooth prints on acetate peel strip) obtained were subjected to biometric analysis using Verifinger standard SDK version 6.5 software [Figure 1]. Basically, this software identifies and forms images by recognizing certain points called minutiae; likewise, it reads tooth print consisting series of dots in the form of lines called minutiae to form image. The image obtained for the first time was stored in the computer as database record I [Figure 2].

Similarly, the second print was taken from the same individual and from the same tooth (site-specific) after a gap of 4–5 months during patient's further visit for orthodontic treatment. Tooth print obtained during the second time was also stored in the computer as database record II. Further, AIFS software using minutiae points compared both the images of data I and II and gave the scores remarking as match or no match [Figure 3]. Similarly, finger prints of

all the eighty individuals (thumb and index fingers) were obtained and were subjected to same biometric software for identifying and analyzing the finger print pattern.

Further, we followed the same technique and methodology to record the tooth prints using cellophane tape. Unfortunately, we could not get proper tooth prints, as they showed more voids in between the prints.

Results

In the present *in-vivo* study, a total of 80 teeth were studied. Out of the 80 cases, positive results were obtained in 42 cases. According to AFIS scoring system, score near to 1000 is considered as positive case. In our study, 42 cases showed AFIS score above 4000 and rest of the 38 cases did not match and did not give the scores. First, comparison of tooth prints obtained from the specific site of particular tooth (tooth specific) at two different intervals from the same individual showed that the prints were almost similar and identical. Second, comparison of the same tooth prints between different individuals showed totally distinct and dissimilar patterns.

Figure 1: Images 1–6 show the tooth prints obtained during *in-vivo* study

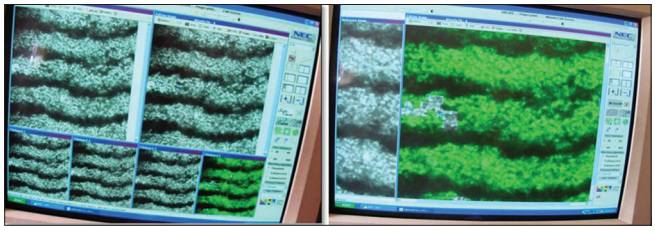

Figure 2: Image shows identification of minutiae in the tooth prints using Verifinger software development kit 6.5 software

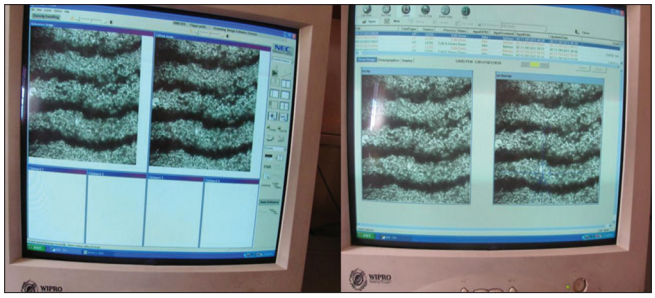

Figure 3: Image shows the application of Automated Fingerprint Identification System software for comparison of two prints using minutiae points, and scores are given

We also understood that the pattern of tooth print differed between individuals for the same tooth though maintaining the site specificity. The software did not give any score while comparing these prints between different individuals and result of not match was obtained. Thus, concluding, tooth prints were distinct between individuals and pattern of tooth print also varied. None of them matched with each other among the 80 cases.

As mentioned earlier, Verifinger standard SDK version 6.5 identifies minutiae and forms the image. Based on the arrangement of minutiae, different patterns such as straight, linear branched, linear unbranched and turning loops, and radiating whorls may be obtained. In our study, we found that among 42 cases, most of them showed wavy pattern tooth prints (30 cases) and very few showed linear pattern tooth prints (12 cases). Further, recordings of AFIS scores obtained from images were statistically analyzed using Cronbach's test. Finger print analysis reported whorl pattern finger print (dominant pattern finger pattern) (34 cases) to be mostly associated with wavy pattern tooth print and few of the loop pattern finger prints (8 cases) to be associated with linear pattern tooth print. Table 1 shows scoring chart of 10 cases with scores and its result.

Discussion

Tooth has millions of enamel rods and number varies from tooth to tooth. Rods are longer at thicker portions (cuspal area) and shorter in the thinner portions (cervical area). Similarly, fingerprints can be found on soft surfaces such as soap, wax, and on hard surfaces as either patent (visible) or latent (invisible) prints on paper, cloth, wood, metal,

Table 1: Scoring chart of 10 cases with its results

Cases	First print	Second print	Results
Case 1	999	999	Identical
Case 2	1999	1999	Identical
Case 3	1676	1676	Identical
Case 4	-	-	Negative
Case 5	926	926	Identical
Case 6	1171	1171	Identical
Case 7	999	999	Identical
Case 8	-	-	Negative
Case 9	1224	1224	Identical
Case 10	3242	3242	Identical

glass, or plastic. AFIS is the process of automatically matching unknown fingerprints which uses digital imaging technology to obtain, store, and analyze fingerprint data. The AFIS was originally used by the US Federal Bureau of Investigation in criminal cases.

Manjunath *et al*.[7,8] conducted a preliminary study on enamel rod end patterns using acetate peel technique that revealed tooth prints were unique to individual tooth and are valuable forensic weapon for personal identification. Further they conducted studies to know the reliability of automated biometrics in the analysis of enamel rod end patterns; they confirmed that acetate peel technique with Verifinger software was a reliable technique in the analysis of enamel rod end patterns. Added to this, in our present *in-vivo* study, we concluded that wavy branched subpattern was the predominant tooth pattern and ameloglyphics as stated is a reliable technique for personal identification.

A study conducted by Gupta *et al*.[9] on enamel rod patterns on tooth surface concluded that tooth prints were composed of varied patterns and subpatterns and on comparison of tooth prints of same individual and between different classes of teeth, it exhibited intra and inter differences. Girish *et al*.[10] conducted a study on the possibility of a correlation between enamel rod end patterns and occurrence of dental caries and concluded that no particular rod end pattern was found in teeth affected by dental caries and no particular pattern was found to be unique to teeth not affected by dental caries.

Our study results showed that tooth prints may be unique to individuals only if the tooth prints were taken from a particular tooth and specific site. However, slight change either in orientation/direction while recording can result in obtaining new pattern from the same individual and from the same tooth site. Our study also showed reliability on these prints even after 4–5 months which may help us in concluding the fact that tooth prints are a reliable and valuable tool for forensic investigations and this is practically true provided primary set of prints of that particular tooth are already stored in system as database record I. Similarly, tooth prints when compared between different individuals, almost all were distinct and varied in pattern. Thus, patterns for the same tooth between individuals are different and are unique to particular individual.

Our result also revealed that most of the individuals with whorl pattern finger print showed wavy pattern tooth print and few loop pattern finger prints being with linear pattern tooth prints, thus giving us a clue that dermatoglyphics may play a role in identifying particular pattern of tooth print in relation to particular tooth. However, further experiments are required to confirm it in applying for individual identification.

Pit fall of our study includes hidden and influence of other factors on tooth prints which includes genetic effect, environmental variation, and local etching (differences in the type of etching patterns). We also had difficulty in time management of selected orthodontic cases as well as localization of exact site during recording the 2nd print. Since the technique is sensitive and requires more precision during the recording procedure, other alternative methods to record tooth prints can be adopted.

Conclusions

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. Further investigations and experiments in both tooth prints and finger prints will support the use of the tooth prints as a newer technique for establishing an individual's identity.

Future prospective

Forensic dental identification is at technological crossroads. As truly 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. Thus concluding, combination of conventional methods with added advanced technologies such as tooth prints can make wonders in the science of forensic dentistry.

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Conflicts of interest

There are no conflicts of interest.

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