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Role of Dental Pathologies and other Anomalies in Forensic Identification of Unknown Human Skeletal Remains: a Review

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Abstract. Teeth are the most resistant and hardest structures of human body which are usually better preserved than other parts of skeleton and maintain their forensic odontological significance for a comparatively longer period of time. They retain their unique features even in the worst environmental conditions from taphonomic degradations to biological or chemical destructions. They can survive all sorts of natural or man-made disasters and the taphonomic destructions. Besides the unique odontological, molecular and chemical characteristics of teeth; the dental pathologies and structural anomalies also play crucial role in forensic identification of unknown human skeletal remains. The idiosyncratic features like tooth staining/coloration patterns, developmental defects, tooth wear and attritions, dental restorations/implants, cultural tooth modifications, tobacco or nut-chewing signs, occupational stigmas etc., act as valuable adjuncts to forensic examination of teeth found in forensic or bio-archaeological contexts. Dental pathologies and anomalies may reflect the oral hygiene, dietary patterns (like consumption of sweets and sugar, fats, proteins) socio-economic or socio-cultural, and the occupational status of an individual. Present review article presents a brief overview of different dental defects and their putative role in forensic anthropological identification of unknown human remains.

Keywords: Dental anomalies; Forensic identification; Human remains; Enamel hypoplasia; Tooth staining; Tooth wear.

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1. Introduction

The term forensic odontology stands for application of dental evidences in legal investigations. Teeth are unique and the most resistant part of human body which retains their uniqueness even in the worst environmental conditions from degradations to the destructions. They can survive all sorts of natural or man-made disasters and the taphonomic destructions and are considered as artefacts of human behavior[1]. Like human beings, teeth are unique structures which retain their individualities. Identity establishment of the victim/s or the unknown human remains is the most significant aspect of forensic anthropological casework. Severely damaged, commingled, decomposed, burnt or putrefied nature of the corpse makes the task of a forensic expert more challenging and difficult, if not impossible (Figure 1). In such circumstances, an anthropologist is left with no other option than to rely upon skeletal and dental remains only to identify the victim. Teeth are the hardest and strongest structure of human body which can survive long term decomposition and can be helpful in tracking down unknown descendent. Identification from teeth is possible either from comparison of ante mortem or postmortem data or by dental profiling. In this article, we will focus how dental pathologies and anomalies can be helpful in forensic identification of unknown human remains. These features include tooth staining/coloration patterns, developmental defects, tooth wear and attritions, dental restorations and implants, cultural tooth modifications, tobacco or nut-chewing signs, occupational stigmas etc. The cultural, occupational, therapeutic/curative, cosmetic or idiosyncratic dental modifications can be conveniently differentiated from the habitual isolated or generalized dental defects[2].

Figure 1. Jaw fragments with teeth in sockets (1st author's Ajnala collection).

The articles related to the aims and objectives of this paper were searched from different scientific search engines like PubMed, Scopus, Web of Science(WoS), google scholar etc., and using different keywords. The papers which mentioned dental anomalies, pathologies and other characteristics for forensic identifications were included in this review and others were discarded. No time range was selected as there were only a very few article related to title of present article which could be scrutinized for their forensic anthropological instructions and information contained therein.

1.1 Tooth coloration and staining

Tooth staining and discoloration is significantly crucial for dental intervention and treatment strategies[3]. Appearance of unknown tooth is the first and foremost feature which attracts the eagled attention of a forensic odontologist. The deciduous human teeth are China-white or porcelain-white in colour compared to the ivory-white coloration of the permanent teeth. Changes in the enamel, dentin or pulp tissues can cause a tooth discoloration. The gradual darkening of tooth also occurs with the advancing age due to formation of secondary dentine. The environmental, dietary, occupational and diseased/health conditions etc., are the factors which can affect the staining or coloration pattern of human dentition[4]. Tooth discolorations may be categorized as intrinsic, extrinsic or internalized type, depending upon the location of the stain.

1.1.1 Intrinsic discolorations

Such type of discolorations occurs due to developmental or acquired defects in the enamel or dentin like defects in enamel or the exposed dentine. The defects may be in the form of dental caries and wear, dental traumas, infections and heritable, restorative effects etc. Internal stains occur due to any change in coloration of dental hard tissues of dentin or pulp chamber. Different types of diseases along with many external factors like traumatic injuries sometimes result in internal discoloration. Pathological conditions like alkaptonuria, enamel hypoplasia, amelogenesis imperfecta, dentinogenesis imerfecta, tetracycline staining, fluorosis, root resorption, ageing etc., are the factors which may cause intrinsic discoloration of teeth[5]. Teeth get permanently discolored with use of some drugs like tetracyclines[6]. Brown discoloration of tooth is encountered in alkaptonuria patients due to defective metabolism of amino acids[7]. In congenital erythroopoietic porphyria, teeth have red-brown discolorations[8].

The dosage and duration of tetracycline medication causes yellowish to brown-grey appearance of teeth[9-12]; there are different prototypes producing different discolorations like creamy and slate-grey discolorations for oxytetracycline and chlortetracycline, respectively. The excessive fluoride intakes from natural drinking water or from toothpastes, mouthwashes, medications etc., causes endemic fluorosis which infuses diffused mottling coloration patterns in tooth enamel (chalky white to dark brown/black appearance)[13]. The pulpal tissues get smeared with hemolytic RBCs to form black iron sulphides in traumatic tooth to give it a pinkish coloration. The cause of death has an influence on teeth discoloration, it being more noticeable in carbon monoxide poisoning and drowning.

1.1.2 Extrinsic discolorations

In this type of staining, the stain (metallic or non-metallic in nature) lies on the outer surface of the tooth. The chromogens present in the consumed dietary items taken for a longer time impart a particular color to dental staining. Smokers, person habitual to tea, coffee, coke, betel nut chewing etc., have discoloration stains on their teeth due to deposition of polyphenolic groups. The metallic extrinsic discoloration of the teeth occurs due to interaction of teeth elements with the metal or metallic salts consumed by a person e.g. people taking iron or iron supplements have black stains on their teeth. Non-metallic extrinsic discoloration is found on the tooth surface which is common in the people addicted to tea, coffee or any other beverage, smokers, mouth-rinsers (Figure 2). By examining the external discolorations, it can be easily discriminated between the smokers and non-smokers, along with their dietary habits to reflect their socio economic status[5].

Figure 2. Light betel staining in Ajnala mandibular tooth (1st author's Ajnala collection).

1.2 Developmental tooth anomalies

Some developmental or taphonomic defects of teeth like hypoplasiac growth, demarcating lines, shredding or capping of enamel etc., are crucially important for forensic odontological examinations of unknown skeletal remains:

1.2.1 Linear enamel hypoplasia (LEH)

It is a defect found on enamel of tooth. It comprises of formation of furrows or incremental microstructures around the crown of teeth during systemic stress (Figure 3). During this process, the ameloblasts cells responsible for enamel secretion get affected and thus the enamel formation id affected. The perikymata of the affected tooth can give a relative index of the formation and interval of LEH defect which, in turn, can be helpful in denoting the stress conditions during development period[14].

Figure 3. Linear enamel hypoplasia (LEH) signs on anterior teeth (1st author's Ajnala collection).

1.2.2 Regional odontodyplasia

It is a developmental dental anomaly in which the teeth have no demarcation between dentine and enamel. This type of defect occurs in more than one tooth in a particular jaw segment. The teeth which have this defect are called 'ghost teeth'[15].

1.2.3 Amelogenesis imperfecta

It is an inherited dental disorder in which enamel production is disturbed. It is further sub categorized into 14 categories; most of which are autosomal dominant or X-linked traits[15]. The enamel appears snow-capped or yellow to yellow-brownish in amelogenesis imperfecta[16].

1.2.4 Dentinogenesis imperfecta

It is autosomally dominant inherent defect which leads to amber coloration of tooth. The adherent property of enamel is reduced which lead to shredding of enamel rapidly leading to soft dentine part exposed due to environmental and dietary habits wears off[5]. Certain genetical and environmental influences introduce defects in dentine producing bluish or brown coloration of teeth, particularly in primary dentition[17].

1.3 Teeth wear tear and dental caries

General tooth wear and tear along with dental caries is commonly encountered in dentition of modern individuals of every age-group. These defects reflect a person's oral hygiene, dietary patterns (like consumption of sweets and sugar, fats, proteins) socio-economic and occupational status etc. The carious teeth being more porous in nature are further prone to severe cavities, mostly in molars due to their masticatory functions. Standardized universal method for registration of tooth wear in different populations is lacking[18].

The dental wear pattern analyses and their comparisons with the ante-mortem data can help in identification of the unknown victims, particularly for age estimations as the chances of tooth wear increase with the advancing age[19]. The enamel and dentine portions of tooth get destroyed due to attrition, abrasion or erosion[15]. Attrition is the loss of tooth substance frequently due to continuous mastication process and has been primarily used for assessing subsistence patterns, dietary habits, environmental and geographic affiliations[20]. Tooth abrasion is the result of pathological wearing off the dental hard tissue by any foreign means. Tooth erosion is the patterned loss of dental hard tissue superficially by some chemical means, except bacterial infections (Figure 4).

1.4 Dental restorative material and implants

Comparison of restorative materials is another usual but good mean to know the dental health status of an unknown individual. The tooth restoration is a very common method of curing dental anomalies (Figure 5). Thus, by collecting the antemortem data and its comparisons with postmortem effects/evidences, it becomes very easy to establish the biological identity of the victim. A person suffering from any dental problem generally prefers dental restorations to the teeth removal. Different types of dentures or restorative materials are used by the dentists of different clinics in different countries.

Two gold bridges in lower jawbones helped in positive identification of the cremated bodies of Hitler and his wife Eva[22].

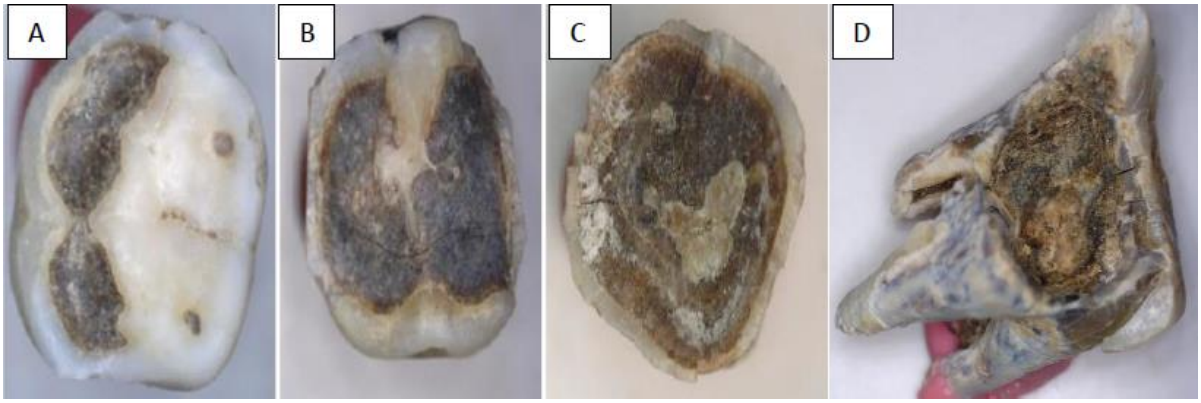

Figure 4. (A-C) shows different levels of occlusal wear on molars, (D) indicates intensive caries development in the molar obtained from Ajnala remains[21].

Figure 5. Dental restorations (accessed from google.com).

1.5.1 Cultural modifications of dentition

Artificial tooth modifications may be an individualistic or group characteristic feature and its occurrence may vary regionally, diachronically or historically. Non-masticatory or occupational use of teeth may leave certain unusual wear signs on them. Differences in nature of food consumed or the modes of food preparation can be estimated from the dental defects. Cultural modifications or decorations of teeth may be for certain cosmetic, therapeutic or curative purposes or due to cultural beliefs and practices[20]. Dental modifications may be accidental (passive or non-purposive) or intentional (active or purposive) which usually reflect the urbanization, socio-economic or socio-cultural, ritualistic status of an individual[2]. Shoemakers, dressmakers, musicians, tailors, carpenters, carpet/basket makers, jugglers, trapeze artists and some other modern professionals have hard tissue defects in few teeth, indicating the specific professional activity[2,23]. Artificial dentures, bridgework, metal or non-metal

fillings, gold ligatures, tooth extraction and trepanation etc., are the common effects of some dental therapeutic modifications. An anthropologist is expected to have sound knowledge about different cultural variations in human dentition and, thus can prove valuable adjunct in identification of unknown human skeletal remains found in forensic or bio-archaeological contexts.

1.6 Accidental teeth anomalies and modifications

The enamel chipping, tooth fracture, split teeth, fractured cusps, craze lines etc., are the common accidental and traumatic dental signatures. Non-masticatory, dietary and habitual or occupational use of teeth may introduce accidental traumatic signatures in dental hard tissues as attrition, abrasion or erosion, though such a differentiation is unnecessary for archaeological skeletal material (Figure 6). The defects from tooth-brush, occupational artefacts, chewing stick, toothpicks, smoking pipes, seed-cracking, nursing devices/bottles, pacifiers, pebble sucking etc., are imprinted unintentionally on the teeth[2], which, in turn, can be helped in identification of unknown dental or skeletal remains found in forensic or bio-archaeological contexts. The physiological and non-physiological dental attrition signs may be enhanced by abrasive as well as foreign elements like sand or grit.

Figure 6. Accidental dental root anomalies (1st author's Ajnala collection).

1.7 Occupational dental modifications

Carpenters, musicians, cobblers, mineworkers, quarry-workers etc., have occupation-specific dental modifications which can be easily interpreted and assigned to the occupational affiliations of a person[23,24]. The markers occur as deposition of mineral, metal or vegetation dust particles or as notched/abraded crowns. The individuals working in chemical plants may have erosive modifications on their tooth surfaces. The

occupational signatures can be comfortably differentiated from the subsistence, traumatic or pathological dental modifications.

1.8 Individualistic dental features

Personalized habits usually leave unique defects on the affected tooth surfaces; particularly in the anterior dentition. Lower lip piercing in Eskimos and some African tribes unintentionally leave smooth wear facets on the labial surface of opposite teeth[25]. Use of tooth-cleansing sticks and incorrect handling of tooth-brushes can also result in dental modifications.

1.9 Bite-marks and palatal rugae

The heinous crimes of sexual assault and child abuse are prevalent in every part of the world and such crimes can be investigated with the help of lip prints, bite marks or palatal rugae patterns. The palatal rugae are the folds or wrinkles found on the anterior side of palate just behind the front anterior portion of teeth. They are unique to each individual, being different even in identical twins (like fingerprints) and prove to be 94% accurate in forensic identification[26].The palatal rugae formation start around the third month of intrauterine stage and persist throughout lifetime. Cheiloscopy is the scientific study of different pattern types formed on the lips as lip prints. Lip prints are commonly found on the bottles, cups, glass tumblers, and cigarette butts etc., commonly encounters at the crime scene. As the suspect may be scared of being caught so he may drink water to calm down or he may be addicted to cigarette so chances are there to find the cigarette butts at the crime scene with lip prints of suspect. Bite marks are commonly found in rape cases and they usually show the aggressive nature of a person. The diameter of human bite can be variable up to 20-40 mm. Contusion is commonly seen in bite marks. They should be detected and preserved carefully as soon as possible because they get destroyed by the physical and environmental condition. If collected rapidly chances are there to get saliva with the bite marks which give the clue of the suspect as bite marks are composed of unique features of teeth like wear, attrition, tooth fracture etc. whereas dry saliva is hard to collect and preserve[26].

2. Forensic anthropological importance of dental defects, anomalies and pathologies

Healthy dentition is of no use for forensic anthropological identification of unknown human remains. Exceptional dental features may be encountered at any time during anthropological investigations. Dental evidences and their anomalies/defects retain their individuality even after death which can play pivotal role in forensic medico-legal investigations when properly examined by well experienced odontologists. The pathological status of teeth shows that an individual's oral health conditions have direct association with his/her socio-economic, socio-cultural and occupational status. Traumatic signatures in teeth show individual's interactions with the environment. Identification from DNA is the ultimate mean of identification, thus positive identification is possible even from the defective or carious teeth. Intentional therapeutic dental modifications are considered as characteristics features of high socio-economic groups which have significant ramifications in forensic anthropological identification of unknown human skeletal remains found in forensic or bio-archaeological contexts. Artificial dentures and restorative therapy are also taken as indicators of social status. Hus, dental pathologies, defects and anomalies may reflect the oral hygiene, dietary patterns, socio-economic or socio-cultural, and the occupational status of an individual.

3. Conclusions

Teeth have distinctive structures to preserve their individualities. The identity of the victim is the most important element of forensic investigations. There are sometimes deviations from normal morphology, such as the presence of extra teeth, variation in their shape and size and developmental anomalies like tooth staining/coloration patterns, developmental defects, tooth wear and attritions, dental restorations/implants, cultural tooth modifications, tobacco or nut-chewing signs, occupational stigmas etc. These dental anomalies can help forensic personnel identify bodies, especially where other methods of identification like facial features, fingerprints or DNA typing cannot yield satisfactory results as in cases of badly decomposed bodies, burnt remains, mass disasters, etc. Identification from dentition is based on the direct comparison of post-mortem dental profiles with ante-mortem dental records of the deceased. This article aims to review these developmental and morphological dental anomalies features and their role in post-mortem identification.

Conflict of Interest statement

There are no conflicts of interests with anyone regarding the publication of this review communication.

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