Developmental anomalies of teeth and their applications in forensic odontology

Mithun Rajshekar¹, Thejaswini Mithun², Jose Joy Idiculla³, Marc Tennant⁴

ABSTRACT

Forensic odontologists are often part of disaster victim identification teams that help in establishing the identity of victims. There may be situations when forensic odontologists get summoned to establish or confirm identities of victims after mass disasters whose identities cannot be established by any other means, identify individuals in crime scenes, or even be used as corroborative evidence. The primary objective of a forensic odontologist at a disaster site/crime scene is to establish the identity of a deceased victim by comparing ante-mortem and post-mortem records. The objective of this article is to briefly explain the clinical and radiological features of developmental dental anomalies and associated syndromes and highlight their role in victim identification. The authors emphasize the roles of dental practitioners and forensic odontologists in victim identification by examining and recording dental features that may assist in establishing the identity of deceased individuals during disasters or otherwise.

KEY WORDS: Forensic sciences, forensic odontology, dental anomalies, dental evidence, disaster victim identification

INTRODUCTION

Forensic odontology is an integral part of the forensic fraternity, and one of its primary applications is to establish the identity of individuals: perpetrators of a crime and victims of disasters [1,2]. Disasters can be both natural or man-made [3] and may result in damages of unimaginable magnitudes [3-5]. The primary objective of forensic odontologists after disasters or in crime scenes is to collect dental information from the deceased, compare ante-mortem and post-mortem dental information [6,7] and find similarities among them to establish identities of deceased victims. Dental identification is primarily used to confirm the identities of unknown persons when identification by other means such as DNA or fingerprints is not possible in disaster situations that result in skeletonization, decomposition, severe burning [8] or charring [9] of the individuals beyond recognition, especially in disasters that involve multitude of casualties [10].

The advantages of using teeth in establishing identities of people are because they are durable [11] and are capable of resisting damage unlike the other structures of the body [1,12]. Previous studies on the subject have described methods involved in collecting and examining dental evidence [13], but little
research has been conducted on quantifying the information required to establish a positive identification. Disaster victim identification charts suggested by the Interpol [14] require forensic odontologists to identify and record all available dental findings [7], but these charts have limited number of dental features printed on them for forensic odontologists to collect and record. Additionally, working in stressful conditions such as in disaster zones can result in failing to record vital information that may be used to establish a person identity. As experts, it is essential for us to be able to identify all types of information on dental features that can be observed in a deceased person, those including dental anomalies.

Dental anomalies can be vital pieces of information that can be used to identify a person if and when that information has been recorded in the ante-mortem dental records. Historically, dental characteristics have been of utmost value in distinguishing several hominid fossils, and one of the most outstanding finds was that of the Neanderthals. Apart from various other differences and similarities between the modern man and the Neanderthal, one feature that stood apart was the taurodont, a developmental anomaly found in the human dentition features of which are explained further in the article [15]. The aim of this paper is to briefly describe some important dental anomalies and their manifestations in the oral cavity. The authors of this article accentuate the importance of recording such information that has the potential to play an important role in establishing the identities of unknown persons who cannot be identified by any other means due to the nature of a certain disaster.

**METHODOLOGY**

This article focuses on dental anomalies and their role in establishing identities of unknown victims of disasters or other crimes. The authors advocate the importance of dental features such as developmental anomalies of teeth and associated syndromes and utilizing this information to simplify and ameliorate the person identification process. Some common and uncommon dental anomalies that can be identified in human dentitions have been presented further. An intense literature search from online resources such as PubMed, Medline along with online resources at the University of Tasmania was performed to collect appropriate literature for this review article.

**Dental Anomalies and Their Presentations**

The anomalies presented in this article are classified according to their extent of changes to teeth. These changes are: (a) Surface abnormalities, (b) shape abnormalities, (c) changes in position, and (d) increase or decrease in a number of teeth. These anomalies have been briefly explained based on their modes of diagnosis. Dental anomalies that can be assessed or diagnosed clinically are:

**Surface Abnormalities**

**Mottled enamel**

Chalky white or dull white patches seen on the surface of teeth are characteristics of mottled enamel. Most often, severely affected teeth present themselves with a characteristic unglazed white. The teeth glow when exposed to light due to loss of normal translucency. Weakening of teeth is seen due to loss of enamel material and restorations is often unsuccessful in such cases [16,17].

**Enamel hypoplasia**

Enamel hypoplasia is one of the most common abnormalities of human dentition [18] and can be observed as round or band like irregularities on the dental enamel and may change color to yellow or brown due to external pigmentation. It is considered to occur as the result of a disturbance caused during the stage of active enamel formation [19-21] and can be classified into hereditary and environmentally induced enamel hypoplasia [22]. These anomalies are seen to occur both in primary and permanent dentition. A variation of enamel hypoplasia is Turner’s hypoplasia, which unlike other developmental anomalies affects just one tooth which is often referred to as Turner’s tooth [23].

**Amelogenesis imperfecta**

Amelogenesis imperfecta [Figure 1] is a developmental anomaly of the enamel [24,25] as a result of either hypoplasia or hypomineralization or both affecting almost all the teeth present. The enamel of affected teeth is often discolored, and is sensitive and is inclined to disintegrate easily. This condition is genetically derived [26,27] and is easily diagnosed with a thorough family history [25].

**Dentinogenesis Imperfecta**

Dentinogenesis imperfecta is a hereditary dysplastic condition affecting the dentin of teeth affecting both deciduous and permanent dentitions [28]. It has a genetic predisposition and is directly inherited from the affected parent(s) [29]. It has been previously known as hereditary opalescent dentin [28-30], hereditary hypoplasia of the dentin or odontogenesis imperfecta [29]. The crowns of affected teeth range from blue to brown in color and radiographically, the affected teeth appear to have bulbous crowns and short constricted roots [30].

**Shape Abnormalities**

**Talon cusp**

It is also called dens evaginatus or evaginated odontoma. It is an additional cusp like structure and shaped like an eagle’s talon [Figure 2a and b]. It usually projects from the cingulum of teeth mostly, the maxillary and mandibular incisors and are visible on clinical inspection. When viewed as a radiograph, it contains all normal characteristics of a normal tooth-the enamel, dentin including a pulp horn. It has been reported in both males and females and only in permanent teeth [31-33]. Apart from being called as the above, they have also been described under various other names in the past, some of them being supernumerary cusp, occlusal enamel pearl, interstitial cusp, odontome of the axial core, and tuberculated premolar [33].
Supernumerary teeth found in the molar region are classified as distomolars and paramolars [34]. Paramolars [Figure 3a] are presented as vestigial teeth buccal to the molars [35] and distomolars [Figure 3b] are usually presented as the fourth molar [34].

Cusp of carabelli

As the name suggests, cusp of carabelli [Figure 4] is a tubercle [36] or cusp like structure present on the mesiolingual surface of the upper first molars [37] and can either be found unilaterally or bilaterally [38] but with no sexual dimorphism [39]. The structure can appear as a furrow or pit, a slight protuberance or as a fully formed cusp like structure [Figure 7] [38].

Fusion

Fusion of teeth [Figure 5a-c] or synodontia is a phenomenon where two separate teeth fuse to become one. This may either be partial fusion or complete fusion. Identifying fused teeth is part clinical and part radiographic [40].

Germination

Germination [Figure 6a-c] is the phenomenon where one tooth fails to divide completely often leading to bifid crowns on a single set of root or roots. Identification is the appearance of two crowns at the place of one. The results can be confirmed using radiographs [40].

Peg shaped lateral incisors

An anomaly affecting the maxillary lateral incisors [Figure 7a-c], where the crown size is evidently reduced and is associated with the tapering of the incisal edge giving it a peg shaped appearance [41]. It is 1.35 times more prevalent in females as compared to males and can be seen in either of the upper quadrants [42].
molars. Affected permanent first molars are usually smaller and dome shaped with cusps placed closer than normal. They have also been called bud molars [43] and mulberry molars [44].

Retained deciduous teeth

Clinically, deciduous teeth can be retained in their positions longer than normal [Figure 8]. This may be seen in cases both with and without a successor tooth [45]. Retained deciduous teeth can result in transposition of teeth [46] which has been explained further in the article.

Mesiodens

Mesiodens [Figure 9] are the most common found supernumerary teeth in both the primary and permanent dentitions [47]. They are found in the incisor regions between the maxillary central incisors [48,49] and can be unilateral or bilateral. Mesiodens are diagnosed by panoramic radiographs, but can be suspected in cases involving retained primary incisors or ectopic eruptions of the incisors [47].

Change in Position

Tooth transposition

Tooth transposition [Figure 10] can be best described as the phenomenon where adjacent teeth interchange their positions. It technically means that space normally occupied by a specific tooth is no longer occupied by that tooth but the adjacent tooth. One must be sure that the tooth is not an ectopic tooth before diagnosing the transposed tooth as such [46,50].

Submerged tooth

Submerged teeth [Figure 11] occur as a result of partial eruption or retention of teeth at the absence of a physical barrier [51-53]. Other terms used to describe the phenomenon are secondary retention, half retention or even re-impaction. The etiology of this anomaly remains unknown; however, studies have suggested a strong genetic predisposition. A tooth may be classified as
submerged when the marginal ridges of the particular tooth are at least 0.5 mm below the marginal ridge of the adjacent teeth. The most commonly affected teeth are the deciduous mandibular second molars [54] and are clinically visible. Another reason for teeth to be submerged or partially erupted is because of teeth ankylosis. Ankylosis is a dental phenomenon where the cementum or dentin of teeth are fused with the alveolar bone preventing it from erupting completely [52,55,56].

**Increase or Decrease in Number of Teeth**

*Supernumerary teeth*

Supernumerary teeth [Figure 12a-c] are the presence of more than the usual number of teeth in the oral cavity [57]. Supernumerary teeth most often occur in the pre-maxilla region. They can be seen both in permanent and deciduous teeth. In normal, they resemble normal teeth but they may also be conical in shape [58].

*Dental agenesis*

Dental agenesis [Figure 13] is the congenital absence of teeth [59] often associated with terms such as hypodontia, oligodontia, and anodontia [60]. It is one of the commonest dental anomalies affecting humans [61] and the second mandibular premolar is the most common affected tooth. It is also observed with lateral maxillary incisor and the second maxillary premolar [62]. Dental agenesis is often associated with other oral anomalies [62], some of which have been discussed below in the anomalies section.

**Some Dental Anomalies are Best Observed or Diagnosed Radiographically**

*Tooth impactions*

Teeth are considered to be impacted when their eruption is delayed due to radiographic or clinical obstructions [65] [Figure 14]. All teeth can potentially be impacted; however, it has been found that third molars, maxillary canines, premolars and maxillary central incisors are most commonly affected. It is a common phenomenon among people today, but impacted teeth are found in skulls that are from the prehistoric age. In a recent excavation in Croatia, an adult female skull dated between 2700 and 24BC was found [64] and it was observed that the maxillary canine was impacted in bone and was established as an important finding. Impacted teeth have been considered to be evolutionary variations of teeth and have been reported widely in previous excavations, which mean it has been a feature for thousands of years [64].

*Dens invaginatus*

Furthermore, referred as dens in dente or dens telescopes, dens invaginatus [65] is a rare developmental abnormality of teeth...
where the teeth affected display an infolding of enamel before mineralization of the soft tissue and may extend all the way to the root. The appearance may range anywhere from a loop to pear shape or a tooth within a tooth. The teeth most often affected are the maxillary lateral incisors [66]. It can be diagnosed radiographically by looking for radio-opaque invagination that may extend from the cingulum to the root [65].

**Odontoma**

Odontomas are the most commonest [67] of odontogenic tumors that are clinically asymptomatic. They can occur as a compound or complex odontomas [68] depending on their structural presentation. Compound odontomas [Figure 15a] are anatomically, and structurally similar to normal teeth, however, complex odontomas [Figure 15b] display an irregularity in their structure [69]. Compound odontomas often occur in the anterior region of the oral cavity closer to the incisors and the canines, whereas complex odontomas normally occur closer to the pre-molar and molar regions of the oral cavity and associated more with the permanent teeth and are generally rare in association with deciduous teeth [70]. Radiographically, they appear as single or multiple radio-opaque lesions. At times, odontomas may cause secondary disturbances such as impaction or retention of teeth [69,70].

**Enamel pearls**

Enamel pearls [Figure 16] are pearl like projections of the enamel of teeth and they may either be found on the crown or the root [71]. The size of enamel pearls vary, but there have been reports of more than one enamel pearl found on a tooth and in rare instances up to four pearls on a tooth [72]. These pearls can be visually identified when they are present on the enamel surface and appear on a radiograph when they occur on the root surface. Ectopic enamel pearls are normally associated with periodontal destruction in molars and hence can be used as markers to identify people with periodontal diseases [73]. Enamel pearls have been occasionally found in primary dentition in the past [74].

**Taurodontism**

Taurodontism or “bull like teeth” [Figure 17] is a dental anomaly characterized by large pulp chambers and short roots that furcate at the lower thirds of the root the etiology of which involves both genetic and environmental factors [15,75,76]. It is usually seen in molars with an increased distance of more than 2.5 mm and can be diagnosed radiographically. It is one of the common features found both in the modern man and the Neanderthal [15,77].

**Tooth dilaceration**

Tooth dilaceration [Figure 18a and b] is an acute deviation of the long axis of the tooth on either the root or the crown [78]. Third molars are the most common teeth that are dilacerated, with the maxillary lateral incisors coming in second [79]. Tooth
dilacerations have been seen in the primary dentition [80] and can be observed radiographically.

**Concrecence**

Concrecence [Figure 19a and b] is a condition of teeth where the neighboring teeth are attached to one another only by their cementum. Concrecence has been reported as occurring in both the crown as well as the roots of teeth and can be diagnosed radiographically [81-83].

**Hypercementosis**

Furthermore called as cementum hyperplasia, hypercementosis [Figure 20] is expressed by excessive deposition of cementum on root surfaces of teeth and can be diagnosed radiographically [84,85].

**Dentin Dysplasia**

Dentin dysplasia describes a rare developmental defect of teeth usually characterized by a defective root form with a pulp chamber that may be partially or fully obliterated by whorl like dentine [86]. Dentinal dysplasia can be diagnosed through radiographs [86,87].

Listed above are some of the dental anomalies that occur in the oral cavity. These anomalies often present themselves as solitary occurrences, but sometimes these anomalies can occur in groups to form syndromes. Syndromes associated with dental anomalies can be used in identifying unknown persons. Table 1 shows characteristic features of a few syndromes associated with dental manifestations. These syndromes have been categorized based on their rarity of occurrence.

**DISCUSSION**

Dental agenesis is the most common developmental anomaly affecting humans [61]. Crouzon syndrome and Treacher Collins syndrome are the most common syndromes that manifest with dental abnormalities. These findings are based on syndromes that have been listed in this article; however, there are many more syndromes with dental manifestations that can be added to the list.

Establishing identities of individuals as part of forensic investigations are a result of collaborative efforts between various teams. These teams often consist of specialists from various fields of criminal investigations, such as the law enforcement departments, pathologists, odontologists, and anthropologists amongst others [158]. Dental variations among people are noted to be unique, and this knowledge will guide us in achieving positive identifications of people involved in disasters [159]. The process of using dental evidence in establishing identities of people primarily involves examining and collecting vast numbers of dental features present in the dentitions of the deceased persons [160] and comparing them with their previous dental records. Complete and well maintained dental records with reports on dental anomalies can be accessed by the investigating team while establishing the identities of people.

It is crucial to understanding the importance of additional features such as dental anomalies and their potential in achieving positive identification of victims during or
Table 1: Characteristic dental features of syndromes associated with oral and dental manifestations and the rarities of their occurrences

<table>
<thead>
<tr>
<th>Syndrome</th>
<th>Oral manifestations</th>
<th>Rarity of occurrence</th>
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<tbody>
<tr>
<td>Hutchinson-gilford progeria syndrome</td>
<td>Hutchinson-Gilford progeria syndrome is associated with an increased mandibular angle (upto about 150°) Gorlin and Sedano in 1968 suggested that the lack of developmental space in both the maxilla and mandible lead to severe dental crowding. Delayed eruption of teeth, localized enamel hypoplasia of the permanent central incisors, and periodontitis have been previously reported along with reduction in the size of pulp chambers [88]</td>
<td>Extremely rare [89-92]</td>
</tr>
<tr>
<td>Rubinstein-Taybi syndrome</td>
<td>Common dental findings with Rubinstein-Taybi Syndrome include micrognathia [93], retrognathia [94], presence of Talons cusp [94], crowding, and narrow palate leading to anterior and posterior cross bites [95]</td>
<td>1/125000 live births [93]</td>
</tr>
<tr>
<td>Kabuki syndrome</td>
<td>Kabuki syndrome is represented by cleft lip/cleft palate [96-98] along with a bifid uvula. Malocclusion is seen which may range from micrognathia or retrognathia. Other features seen are high arched palate, with wide spacing of teeth, delayed tooth eruption and abnormalities such as neonatal teeth, screwdriver shaped incisors [96,97] teeth with enlarged pulp chambers and cone shaped teeth [97-99]</td>
<td>Rare with 350 cases around the world [98,100]</td>
</tr>
<tr>
<td>Axenfeld-rieger syndrome</td>
<td>Is characterized by anodontia [101], microdontia [101,102], maxillary hypoplasia along with abnormally shaped and abnormally implanted teeth [103,104]</td>
<td>Rare (1:200,000,000) [104-106]</td>
</tr>
<tr>
<td>Hallerman-streiff syndrome</td>
<td>Hallerman-Streiff Syndrome is characterized by microstomia [107] severe malocclusion [108], enamel hypoplasia [108], premature fracture of permanent teeth, hypodontia and presence of neonatal teeth [109]</td>
<td>Rare &lt;1/1,000,000 [108-111]</td>
</tr>
<tr>
<td>Blepharo-chelio-dontic syndrome</td>
<td>The common manifestations are the presence of bilateral cleft lip or bilateral cleft palate [112,113]. Oligodontia and microdontia [113] have been seen in at-least half of all the cases reported [112,114]</td>
<td>Rare (&lt;1/1,000,000) [112,115-117]</td>
</tr>
<tr>
<td>Russell silver syndrome</td>
<td>This syndrome is characterized by the presence of microdontia [118] a high arched narrow palate [119] and associations of cleft palate along have been reported along with a triangular shaped face [120-123]</td>
<td>Rare (1:100,000) [124-126]</td>
</tr>
<tr>
<td>EVC</td>
<td>The syndrome has wide dental manifestations including neonatal teeth, partial anodontia [127,128], gingival hypertrophy, malocclusion, labiogingival frenulum hypertrophy, serrations on the incisal margins, conical teeth, premature eruptions of teeth, enamel hypoplasia and hypodontia [129]</td>
<td>Rare around 5.2/100,000 of live births in UAE alone [127,129-131] and 1/60,000 in a general population [132]</td>
</tr>
<tr>
<td>Incontinentia pigmenti syndrome</td>
<td>Cases of Incontinentia pigmenti (Bloch-Sulzberger syndrome) are reported to have delayed tooth eruption, retained deciduous (which may be inter related) hypodontia associated with malformed crowns of lower incisors (mostly cone shaped) [133-135]. Cleft lip and cleft palate have been reported in the past [136]</td>
<td>Rare [134-138]</td>
</tr>
<tr>
<td>Apert syndrome</td>
<td>Presence of a Byzantine-arched palate [139], ectopic eruptions, severe crowding and shovel shaped incisors [139] are class characteristics of Apert Syndrome [140,141]</td>
<td>Rare (139,142,143) (15.5/1,000,000)</td>
</tr>
<tr>
<td>Downs syndrome</td>
<td>Is characterized by anomalies such as high arched palate, peg shaped laterals, hypoplasia [144] taurodontia, hypodontia, partial anodontia along with a pseudo class III malocclusion [145,146]</td>
<td>Relatively rare 1.15-1.62/1000 (based on a report by Zeuten et al. 1973) [147,148]</td>
</tr>
<tr>
<td>Variant Carvajal syndrome</td>
<td>Has been reported with the presence of premature resorption of deciduous roots along with extensive caries along with localized absence of permanent teeth [149]</td>
<td>Rare [150,151]</td>
</tr>
<tr>
<td>Crouzon syndrome</td>
<td>Crouzon syndrome is commonly associated with dental agenesis. The syndrome exhibits dental malocclusion, maxillary hypoplasia and retrudated upper lip. Association of dental malformations like Angles class III, open bite cross bite has also been noted [62]</td>
<td>Common (1/250000)[156] to Rare (16.5/1,000,000) [157]</td>
</tr>
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EVC: Ellis-van creveld syndrome

after disasters [98]. Both general dental practitioners and forensic odontologists must ensure that all developmental anomalies and associated syndromes (if and when present) are recorded in the ante-mortem clinical dental records as well as the post-mortem records [161]. This information will be significant when forensic odontologists compare ante-mortem and post-mortem dental records to establish the identity of an individual for forensic investigations. The authors of this article suggest that, in addition to examining and recording information on existing dental anomalies and associated syndromes, it is also vital to conduct further research on estimating incident rates for the occurrence of such dental anomalies and associated syndromes for different communities or populations and integrate those incident rates into a matrix where the probability of their occurrence in a population can be calculated. This will increase the ability of forensic odontologists to establish positive person identifications.

CONCLUSION

Forensic odontology is the culmination of wide knowledge of all the intraoral structures and deriving information on how these structures function as a unit and applying it in forensic investigations. Dental characteristics and features have set individuals apart from one another, and these features and their variations or similarities could help us in identifying unknown individuals during disasters or any situation that
requires identification of individuals based on teeth. Dental practitioners and forensic odontologists share the responsibility of ensuring that a complete and thorough examination of the oral cavity must be performed for all possible findings to be recorded. Dental practitioners must record and save all findings in secure folders to facilitate easy retrieval when required. Forensic odontologists that assist with identifying victims after disasters or otherwise have a responsibility to extract and record all possible information from the victims and compare it with detailed dental records when available, to ensure a scientific, faster yet efficient positive identification. Finally, identifying all potential dental features and inclusion them in comparing ante-mortem and post-mortem records is the key to establishing positive identities of unknown individuals.

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