Pathology of the teeth

Keith D Hunter

Geoff Craig

Abstract

Teeth are rarely submitted to general pathology departments, but on the rare occasions they are, the response is often confusion. This practically focused review aims to demystify the assessment of teeth, outlining the abnormalities which may be assessed without specialist equipment and others which may require specialist input. We will also provide a brief summary of some of the more common dental abnormalities and outline some forensic aspects of tooth pathology.

Keywords cementum; dentine; developmental disorders; enamel; forensic odontology; ground section; histopathology; tooth

Introduction

The relative rarity of teeth as specimens submitted to a general histopathology laboratory means that submission of teeth can lead to confusion as to how they should be processed and assessed. In this review we aim to give a brief outline of the pathology of teeth with a practical focus on how teeth should be assessed and a brief discussion of the more common abnormalities which may be present in teeth submitted to a general pathology laboratory (dental caries excepted). Admittedly, the equipment and expertise required for some of the techniques described is disappearing, even from oral and maxillofacial pathology services, and the identification of appropriate onward specialist centres for particular specimens is important.

In many cases, the uncertainty starts with the request form itself. A particular source of confusion is tooth notation, which takes various forms. The FDI notation system (ISO-3950)[1] should be utilized (Figure 1) as, other than a full longhand description (e.g. upper left second premolar), there is potential for confusion. The FDI notation system provides consistency and clarity and removes the ambiguity which is often present in other more 'individual' forms of notation shorthand. The Universal Numbering System which is commonly used in the USA also gives teeth individual, but different, numbers, and clarification may be useful if the submitting practitioner is not known to the pathologist.

Keith D Hunter *BSc BDS FDSRCSEd PhD FRCPath is a Clinical Senior Lecturer in Oral Pathology at the Glasgow Dental School, Faculty of Medicine, University of Glasgow, Glasgow, UK.*

Geoff Craig *BDS PhD FDSRCS (Eng & Ed) FRCPath is an Emeritus Professor of Oral Pathology & Forensic Odontology, The University of Sheffield, School of Clinical Dentistry, Sheffield, UK.*

FDI Two-Digit Notation

Permanent Teeth

upper right								upper left							
18	17	16	15	14	13	12	11	21	22	23	24	25	26	27	28
48	47	46	45	44	43	42	41	31	32	33	34	35	36	37	38
lower right								**lower left**							

Deciduous teeth (baby teeth)

upper right								upper left							
			55	54	53	52	51	61	62	63	64	65			
			85	84	83	82	81	71	72	73	74	75			
lower right								**lower left**							

Figure 1 FDI tooth notation (from http://www.fdiworldental.org/resources/5_0notation.html).

Important elements in the assessment of tooth pathology

Clinical

Much relevant information is gained from an accurate clinical history. This includes a clear description of the clinical appearance of the abnormalities, and a clinical photograph is often very useful. The extent of the abnormality, that is single tooth, multiple teeth, a whole quadrant or all teeth affected, may also be useful in the determination of chronological or other effects. As inherited factors underlie the development of many conditions, a family history should also be provided whenever possible.

In addition to clinical photographs, radiographs are very useful in the assessment of a number of morphological features. Preferably these should be intra-oral radiographs but a good quality panoramic radiograph is also useful. These allow for assessment of the relative radiodensity of the dental hard tissues and the morphology of the crown, pulp chamber and roots of the submitted tooth, in addition to other abnormalities or dental disease.

Examination of the tooth

The identity of submitted teeth should be confirmed by morphology where possible and this correlated with the identification on the request form (and other ancillary material). A full description of the tooth should be recorded and, if appropriate, a gross photograph should be taken (Figure 2). Salient features to note include the morphology of the crown and roots, the number of roots and any gross abnormality of enamel, dentine or cementum. The presence of other dental disease, such as dental caries or other non-carious tooth surface loss, should also be recorded.

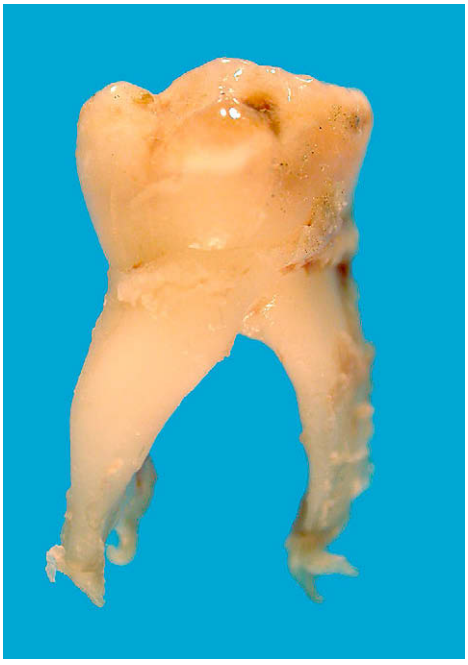


Figure 2 Gross photograph of an upper molar tooth with abnormal enamel affecting the whole crown.

Specimen processing

It is unlikely that many general pathology laboratories will have access to facilities which allow the production of ground sections of teeth, yet as will become apparent in the discussion below, ground sections are required for the assessment of a number of dental abnormalities. Teeth submitted with clinical suspicion of a defect of enamel, regardless of whether this is considered to be environmental in origin or inherited, require a ground section to examine the structure of enamel. This is particularly important as the enamel matrix of erupted teeth has a very low organic content, thus after decalcification little significant matrix is retained for examination. On occasion, a ground section may also be useful in the detailed assessment of dentine and cementum. Usually only one half of a tooth is used for ground sections and the other half should be decalcified. Ground sections are mounted using Pertex or Harleco synthetic resin (HSR), as these have a similar refractive index to enamel. When referring teeth to a laboratory with the facility to produce ground sections, it is important to ensure that the additional information outlined above is transmitted to the pathologist.

Teeth may be decalcified in formic acid (5–10%, for approximately 5–8 days). EDTA (10%, in various formulations) may also be used; however this process is much slower. Where microwave decalcification is available, this can be used to speed up the decalcification process, reducing decalcification time by up to 50%, with no adverse effect on morphology.[2] Radiographs may be useful to allow assessment of completeness of the decalcification process, prior to an attempt to cut the tooth. In circumstances where examination of the coronal pulp is required, it may be advisable to section the tooth with a fine saw across the root(s) to allow the pulp to fix properly before decalcification.

Histological examination of teeth

Examination of teeth may require the use of polarized light and, on occasion, a source of fluorescent or ultraviolet light.

Localized conditions which only affect the teeth

Developmental disturbances in tooth form

There are many variations in the form of teeth which are common and relatively unimportant. These include variation in the form of the occlusal surface and shape of the crown, the number, size and shape of roots and, more rarely, fused or incompletely divided teeth.

Odontomes are relatively common and, whilst some are catalogued with odontogenic tumours,[3] they are developmental abnormalities (essentially hamartomatous in nature) which contain dental hard tissues. Three main types are described; invaginated, complex and compound. Histopathological examination can be conducted solely on decalcified sections, although there are occasions where a ground section may be useful.

Invaginated odontome results from invagination of part of the enamel organ into the crown of the developing tooth. The teeth most commonly affected are the maxillary lateral incisors and the abnormality may be bilateral. The clinical appearance and presentation is variable, but often pulpitis or its sequelae develop, due to the easy ingress of microorganisms into the invagination and thus to the dental pulp via patent dentinal tubules that may not be lined fully by the invaginated enamel. The teeth may be grossly distorted or swollen, with a radiographic appearance of a tooth inside a tooth ('dens in dente', Figure 3a). Histologically, there is invagination of enamel and dentine into the crown and/or root of the tooth (Figure 3b). The invagination opens onto and is in continuity with the enamel of the occlusal surface.

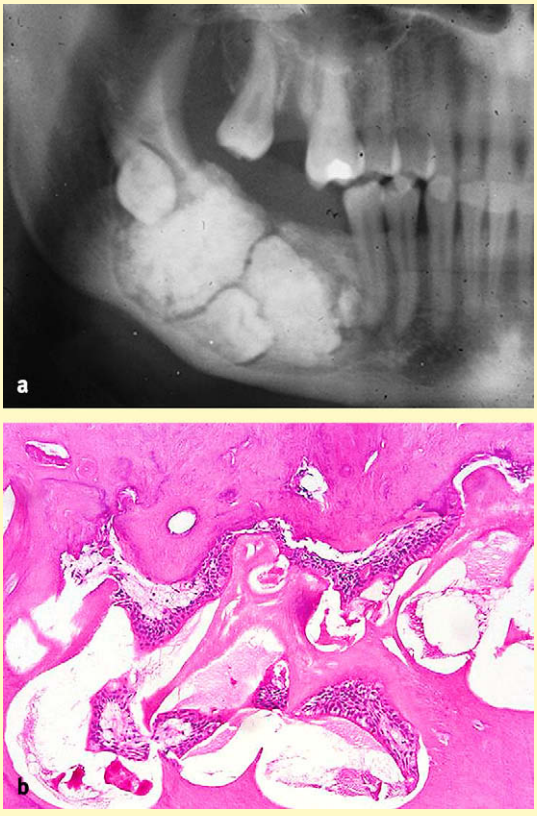
Complex odontomes are classically described as comprising haphazardly arranged dental hard tissues, whilst the **compound variant** comprises a number of well formed tooth-like structures.

Figure 3 Sectioned upper lateral incisor with an invagination evident within the crown of the tooth.

Intermediate forms do occur and the predominant form determines the final diagnosis.

Complex odontomes occur largely in the second decade and may be found as an incidental finding on a radiograph taken for orthodontic reasons or for investigation of unerupted teeth. They are most commonly found in the mandibular premolar/molar region, but can occur anywhere in the jaws. Complex odontomes are often associated with unerupted teeth and may attempt to erupt into the oral cavity, when symptoms may rapidly develop. Radiographically, a radiopaque mass, often with a 'radiating' structure and a pronounced radiolucent rim, is present (Figure 4a). Histologically, the complex odontome contains irregularly arranged enamel, dentine, cementum and dental pulp, with dentine often predominating but with the tissues maintaining their normal morphogenetic relationships one to another (Figure 4b). Enamel can be recognized by residual enamel matrix after decalcification.

Compound odontomes most often develop in the anterior maxilla (Figure 5a). The small tooth-like structures within the lesion have a normal relationship of enamel, dentine and cementum (Figure 5b), but do not resemble individual teeth from the normal dentition.



a Section from a panoramic radiograph showing a complex odontome associated with unerupted and displaced teeth in the lower right quadrant. **b** Photomicrograph from a decalcified section of a complex odontome. Present in this field are dentine, odontoblasts and a small amount of enamel matrix.

Figure 4

Developmental disturbances in tooth structure

There are numerous causes of alteration in the structure of the dental hard tissues, which may be related to local factors (infection, trauma), generalized environmental factors (systemic infection and other disease: the so-called chronological hypoplasias, see below) and inherited factors.

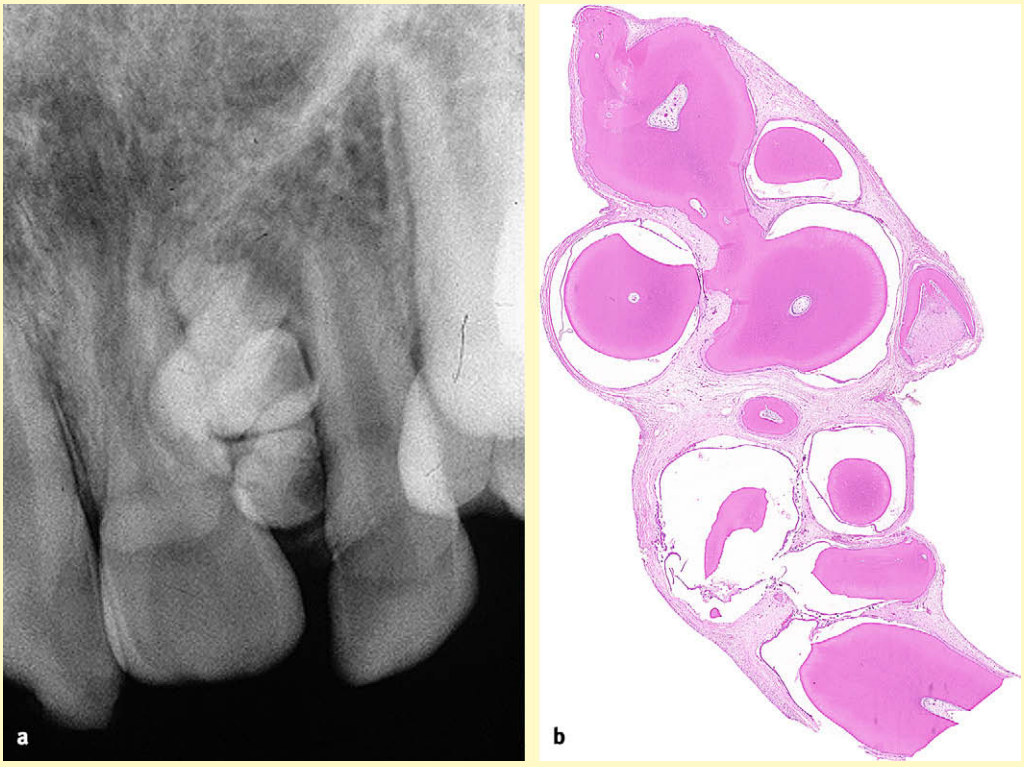
Molar–incisor-hypomineralization (MIH) may be suggested as part of the differential diagnosis for widespread enamel hypoplasia affecting one to four first permanent molar teeth and usually some of the permanent incisors. The reported prevalence varies between 2.8% and 25%. The pattern of affected teeth indicates a systemic cause at or around birth, but despite many suggested aetiologies, the cause remains unclear.[4]

Amelogenesis imperfecta (AI): in some populations the commonest inherited condition in which only teeth are affected is AI.[5] However, AI is rare and is largely seen in paediatric dentistry departments, but these teeth may also be submitted to other centres where there are centralized paediatric medical and surgical services. Assessment of these teeth requires access to ground sections for examination of the enamel.

AI is a family of related genetic-based conditions with varying inheritance patterns and variable clinical appearance (e.g. Figure 6a). The defects in the enamel have been grouped into three main categories of hypoplasia, hypocalcification and hypomaturation types (related to the main stages of enamel development), with numerous overlapping clinical phenotypes in each category. Attempts to categorize the condition using standard medical genetic methods have been hampered by a lack of detailed knowledge of the molecular basis of most forms of the condition.[6] Histologically, the hypoplastic forms tend to have an abnormal enamel prism structure in addition to a reduction in the amount of enamel formed (Figure 6b). The hypomineralized or hypomature forms can be more difficult to demonstrate in ground sections, but relative differences in mineralization can be exaggerated by lowering the condenser. In these cases, the addition of a decalcified section may be useful as the demonstration of a significant amount of retained enamel matrix may indicate a mineralization defect.

Dentinogenesis imperfecta (DI) is an inherited disorder of dentine development with a prevalence of 1:6000–1:8000 live births.[7] It may be seen in association with osteogenesis imperfecta (type 1, mutations in collagen 1A) or solely as a disorder of teeth (type 2, mutations in dentin sialophosphoprotein (DSPP)).[8] Other rarer forms also exist. The condition is inherited in an autosomal dominant manner, and affects both the primary and secondary dentitions. The classical clinical description is of teeth which erupt with normal crown morphology, but these have an opalescent, amber-coloured appearance. The enamel is poorly adherent and is often rapidly lost, exposing the abnormal softer dentine (Figure 7a) which wears away rapidly. Radiographs show teeth with short roots and variable obliteration of the pulp chamber.

Decalcified H&E-stained sections are most useful in the assessment of these teeth as ground sections may be difficult to generate. Features include dentine with a reduced number of tubules, often with an irregular arrangement, and cellular inclusions form the pulp. This abnormal dentine fills the pulp chamber



a Periapical radiograph of a compound odontome in the upper incisor region. **b** Low power photomicrograph of a compound odontome, demonstrating the multiple discrete denticles.

Figure 5

and root canals (Figure 7b). The junction with the enamel is flat rather than scalloped, which contributes to the rapid loss of the enamel.

Other rare defects in dentine formation: there are many, very rare conditions which may result in abnormalities in the formation of dentine. One which may be encountered is *dentine dysplasia (DD)*. Two main types have been described: type 1 ('rootless teeth') has normal crown morphology but markedly shortened roots which are composed of abnormal dentine (Figure 8). This dentine fills the pulp chamber in a manner resembling water streaming round boulders, which is best seen in a ground section. In type 2 (coronal DD) the primary teeth look clinically very like DI teeth, but show complete obliteration of the pulp chamber. Secondary teeth often look normal, but have altered pulp chamber morphology and multiple pulp stones.

Defects in cementum formation: cementum can be viewed in both ground and decalcified sections. The normal arrangement is of a complete covering layer of acellular (primary) cementum in contact with the root dentine, and this is covered to a variable extent by a layer of cellular (secondary) cementum. *Hypercementosis* is a common feature seen in a number of clinical situations, including mobile teeth, unerupted teeth, periapical inflammation and Pagets disease of bone (Figure 9). *Hypocementosis* without other systemic disease is rare, but may be seen in conditions such as cleidocranial dysplasia, where there is a lack of cellular cementum deposition.[9]

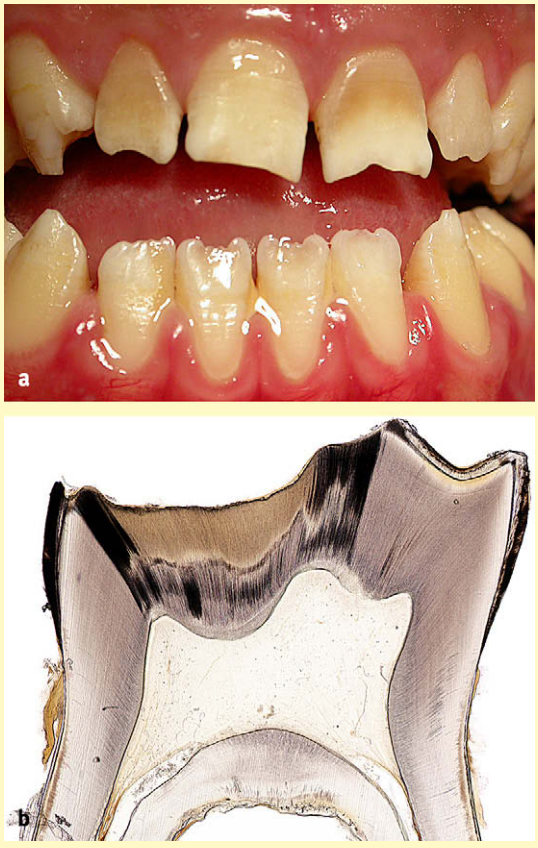
Defects affecting more than one dental hard tissue: *regional odontodysplasia* is a developmental abnormality which affects every part of the developing tooth. The aetiology is unknown and the abnormality classically affects more than one tooth in a particular jaw segment.[10] Both primary and secondary dentitions may be affected and the extent of the abnormality is variable. Clinically, the teeth in the affected area may be unerupted. If these teeth erupt, they often have unusual crown morphology with gross defects in the enamel. Radiographically, the teeth show markedly thinned enamel and dentine, with little or no radiodensity distinction. These teeth have been described as 'ghost teeth' (Figure 10a). They are most commonly examined in decalcified sections. Histologically the enamel is hypoplastic and may be very irregular in form. Small 'enameloid' deposits may be seen in the adjacent soft tissue of the dental follicle. The dentine is thin with a prominent interglobular mineralization pattern (Figure 10b).

There are other, much rarer, conditions which affect more than one tissue in the developing tooth. These include *odontogenesis imperfecta*. Readers are directed to a relevant dental pathology text for more detail.[11]

Tooth abnormalities in systemic diseases

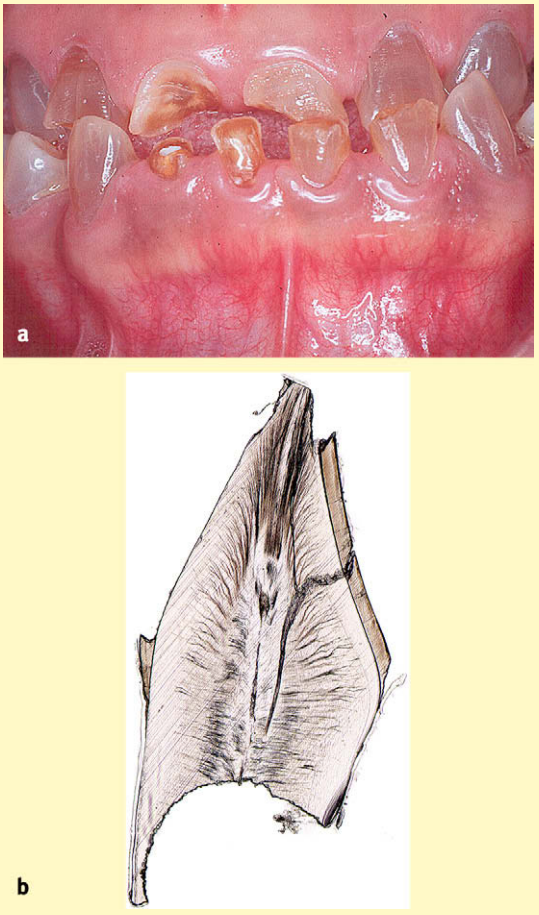
Syndromes with tooth abnormalities

Numerous syndromes which affect the head and neck have dental manifestations.[12] These are too numerous to catalogue here, but a summary of the dental abnormalities found in some of the



a Clinical appearance of amelogenesis imperfecta is very variable. In this clinical picture the enamel is very thin and smooth and has been rapidly worn to expose the dentine. **b** Photomicrograph of a ground section, demonstrating hypoplastic amelogenesis imperfecta of a molar tooth. Much of the occlusal enamel has been lost and there is dental caries affecting the exposed dentine. The remaining enamel is very thin.

Figure 6



a Clinical photograph of a patient with severe dentinogenesis imperfecta. The teeth have an opalescent, amber-coloured appearance and have been very rapidly worn down. **b** Low power photomicrograph of an incisor tooth from a patient with dentinogenesis imperfecta, demonstrating obliteration of the pulp chamber and a grossly abnormal tubular pattern in the dentine.

Figure 7

more common syndromes is given in Table 1. These effects are often complex and a specialist opinion may be useful in these cases.

Developmental disturbances in tooth structure

As mentioned above, particular subtypes of patients with osteogenesis imperfecta may also have dentinogenesis imperfecta. Enamel defects have also been described in a number of inherited and acquired chronic diseases, including epidemolysis bullosa[19] and coeliac disease.[20] Abnormalities in tooth structure may also be seen in inherited and acquired disorders of metabolism affecting bone and other mineralized tissues such as rickets, X-linked hypophosphataemia and hypophosphatasia.

In rickets the width of the layer of dentine matrix which is not calcified (the predentine) is increased. As dentine is laid down, a band of incompletely calcified (or interglobular) dentine is formed in a pattern related to the chronology of the disease. Similar, but more extensive, features are also seen in X-linked hypophosphataemia (Figure 11). In this condition, also known as vitamin D

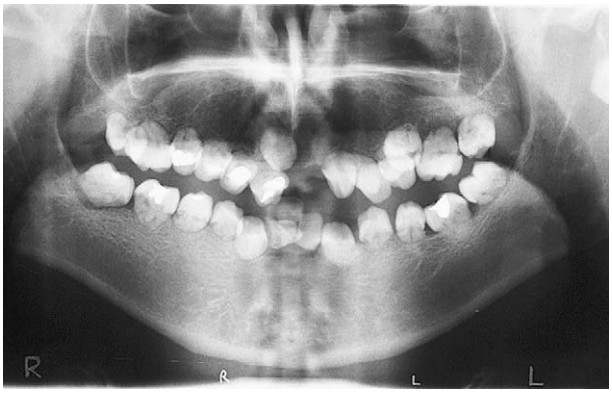


Figure 8 Panoramic radiograph demonstrating the characteristic rootless appearance of dentine dysplasia type 1.

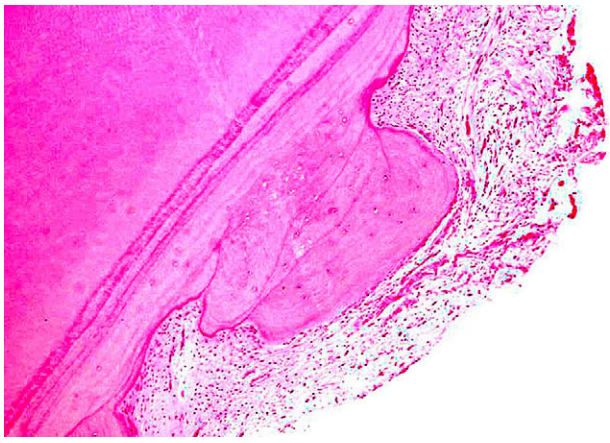
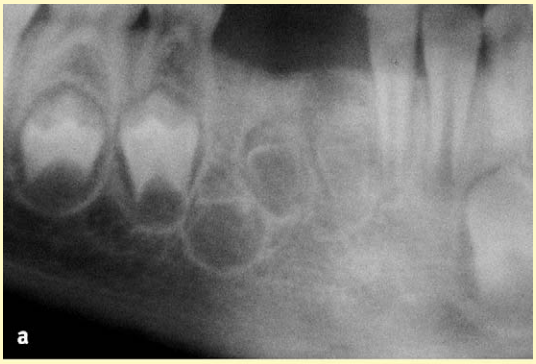
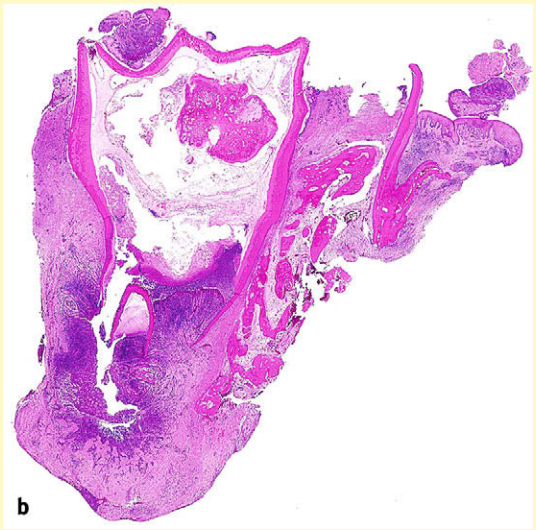


Figure 9 Photomicrograph of a decalcified section of a tooth with prominent hypercementosis. In this case the tooth was mobile due to severe periodontal disease.





a Section from a panoramic radiograph demonstrating several 'ghost teeth' in a region of the lower right quadrant.
b Photomicrograph of a decalcified section of a partially erupted 'tooth' from a different patient with regional odontodysplasia. The dentine is very thin with a very large pulp chamber and enamel is almost absent.

Figure 10

Selected syndromes in which tooth abnormalities have been reported

Syndrome	Dental features	Other features
Ectodermal dysplasia[13,14]	Anodontia/ hypodontia	Abnormal skin, hair, nails and apocrine glands
Down syndrome[15]	Microdontia, hypodontia, hypoplasia and hypomineralization	Cardiovascular, haemopoeitic and musculoskeletal abnormalities
Ehlers–Danlos syndrome[16]	Hypoplasia, dentine abnormalities, pulp calcification, hypodontia	Skin hyperextensibility, joint hypermobility and generalized connective tissue fragility: varies by subtype
Syndromic craniosynostoses: e.g. Apert,[17] Crouzon	Delayed eruption, abnormal crown shape, hyperdontia	Multiple craniofacial abnormalities
Tricho-dento-oseous syndrome[18]	Enamel hypoplasia and taurodontism	Course curly hair, abnormal skull and mastoid bone

Table 1

resistant rickets, a mutation in the *PHEX* gene alters phosphate metabolism in the proximal tubule of the kidney.[21] Other rarer forms also exist.[22] In addition to the prominent interglobular dentine pattern, the affected teeth have large pulp chambers which may extend to the enamel–dentine junction. This renders these teeth more susceptible to bacterial entry to the pulp and thus to pulp death. It is useful to examine these teeth in both ground and decalcified sections; however the pattern of interglobular dentine and the pulp chamber morphology on decalcified sections is often sufficient for the diagnosis to be confirmed.

Hypophosphatasia is an inherited defect/absence of tissue non-specific alkaline phosphatase (TNSALP). Widespread

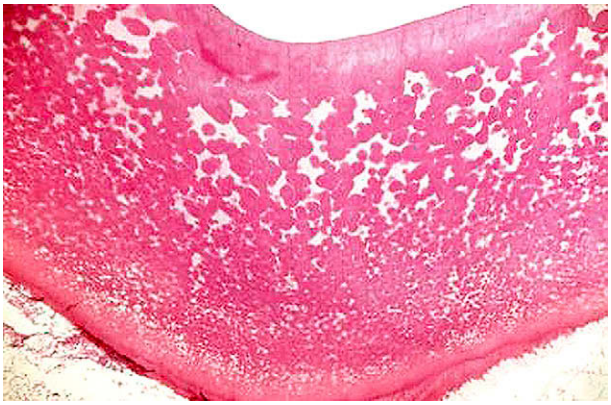


Figure 11 Photomicrograph of a decalcified section of a tooth from a patient with hypophosphataemia, demonstrating prominent interglobular dentine pattern throughout the dentine.

hypomineralization results in hypocementosis (in addition to the skeletal manifestations) and thus to the formation of a defective periodontal ligament attachment which may result in premature tooth loss.[23] Histologically, these teeth may completely lack both cellular and acellular cementum, which can be detected in both ground and decalcified sections.

Discolouration of teeth

Discolouration of teeth may indicate underlying systemic disease or other systemic effects. However, given the relative frequency of discolouration of teeth, it is important to differentiate extrinsic (common and generally not a significant indicator of underlying disease) from intrinsic sources. The commonest causes of intrinsic discolouration of teeth are not related to tooth development or systemic disease, but are the consequence of pulp death and the diffusion of elements of the necrotic pulp into the dentine. However, many of the disorders outlined above may result in discolouration of the teeth due to changes in the structure or thickness of one or more of the dental hard tissues.

Systemic causes of intrinsic discolouration are rare. In *neonatal jaundice*[24] and *congenital porphyria*[25] (Figure 12) bile pigments or porphyrins may be deposited in the developing teeth. These will be concentrated at particular incremental points relating to the timing of the systemic upset (at or around birth in neonatal jaundice, and periodically in porphyria). In porphyria, the pigments in the teeth will emit a red fluorescence under ultraviolet light. Other rare metabolic abnormalities, such as *alkaptonuria*, may discolour teeth (in this case the discolouration is blue).

Abnormalities related to medication: systemic administration of certain *tetracycline*-type antibiotics during tooth development (at any point from 29 weeks' gestation to approximately 18 years) results in deposition of tetracycline in the tooth along an incremental line, coincident with the period of administration.[26] Clinically this results in a yellow–grey discolouration (Figure 13a), which will emit a bright yellow fluorescence under ultraviolet light (Figure 13b). On ground section, this linear deposition of tetracycline is most marked in the dentine.

Dental abnormalities have also been described in children who have undergone *cytotoxic chemotherapy* for childhood malignancy. Features described include enamel hypoplasia, pitting and discolouration, and root abnormalities.[27,28] In most cases these teeth should be submitted with the appropriate clinical history.

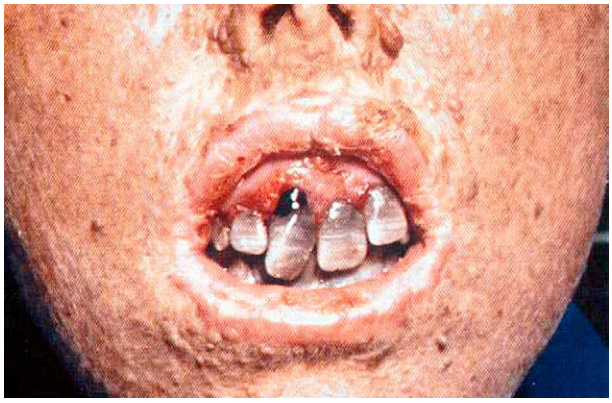
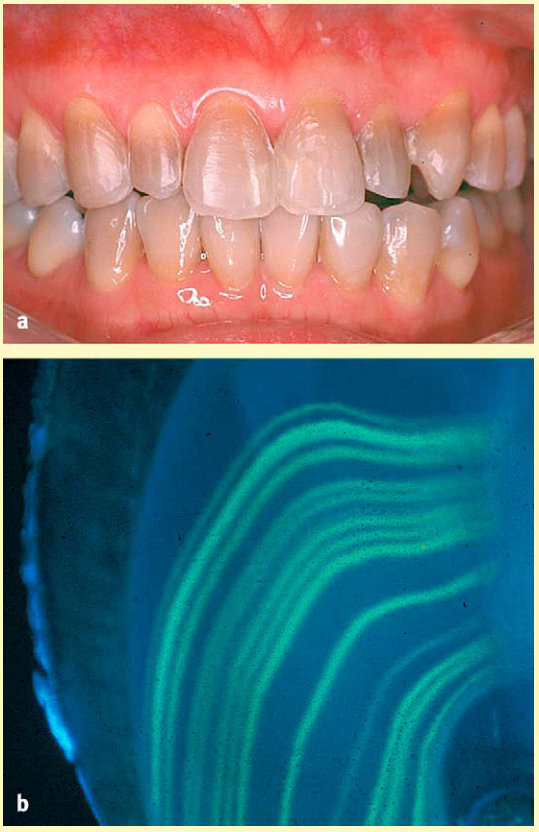


Figure 12 Erythodontia in congenital porphyria.

Forensic odontology

Forensic odontology finds its main use in identification, sometime of the living but more often of the deceased.[29] Teeth and the infinitely variable patterns of their presence, absence and the restorations (fillings, crowns, root treatments, bridges) they may contain have been the mainstay of routine dental identification for many years. To be feasible, the dental route to identification requires the existence of antemortem dental records for the unidentified person(s). Given that in a developed society only 50–60% of adults will attend regularly for dental treatment, it is clear that for between 40% and 50% of the adult population no antemortem dental record will exist. There is also increasingly a concern among forensic odontologists that the dramatic improvements in oral health in developed countries over the past three to four decades is reflected in childhood and young adult populations that are virtually free from fillings.

Can other attributes associated with teeth, including the existence of tooth pathology, serve as possible indicators of identification? The answer is of course, yes! Though not an exclusive indicator of identity, age estimation is often a key determinant in refining potential identities, especially in mass disasters.[30]



Effects of the administration of tetracycline during tooth development: **a** clinical and **b** ground section from a permanent molar tooth examined by incident ultraviolet light and showing brilliantly fluorescing bands attributable to tetracycline; each band represents a separate course of the antibiotic.

Figure 13

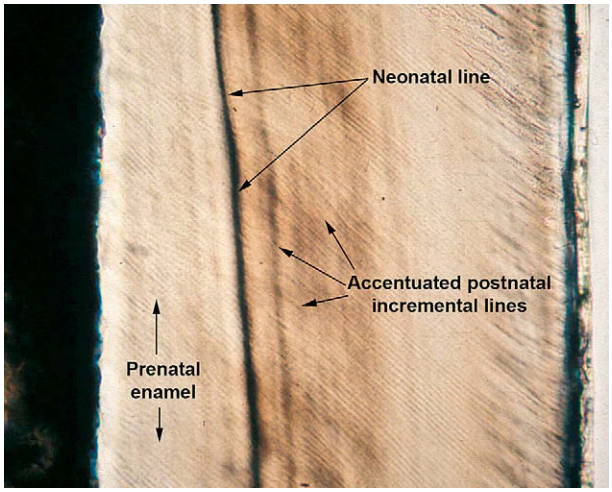
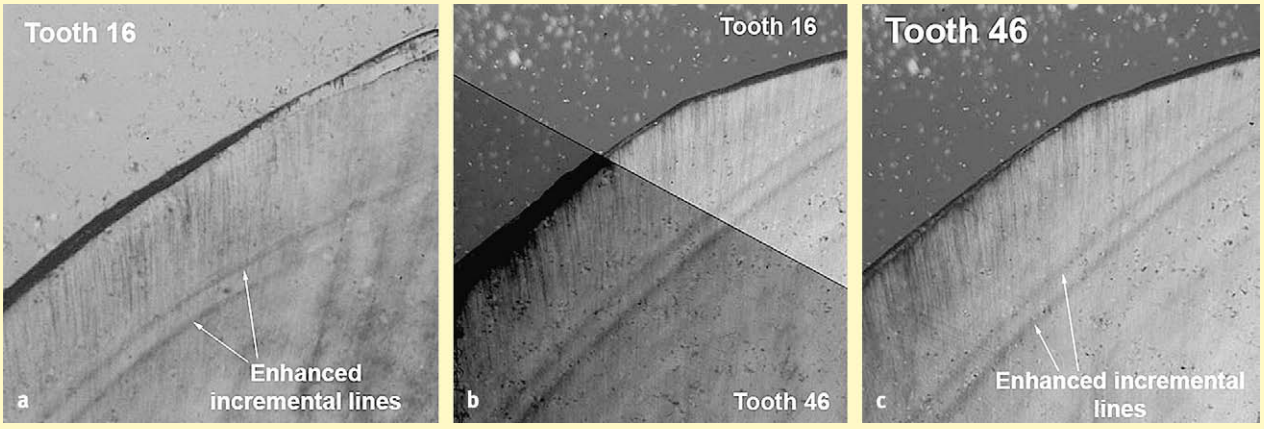


Figure 14 Neonatal line and incremental lines: ground section from a permanent incisor showing a strip of dentine (black) to the left and a prominent neonatal line separating the prenatal and postnatal enamel; the latter shows further accentuated incremental lines.

Teeth can provide valuable estimates of chronological age in both the living and the deceased; such estimates achieve their greatest accuracy and reliability in the developing fetus and the immediate postnatal periods; the regular, daily incremental manner in which enamel and dentine are deposited throughout tooth development, considered in conjunction with the well-documented onset times for tooth formation, may enable an age estimation that is accurate to within a few days (±). The transition and relative trauma associated with the birth process affects teeth developing at that time (essentially the deciduous or primary dentition) and is thought to result in a temporary arrest of enamel and dentine formation that lasts for some 7–10 days; when hard tissue formation resumes, the arrest is reflected in the enamel of the relevant teeth by the presence of an enhanced incremental line, the so-called neonatal line (Figure 14); forensically speaking, the demonstration of a neonatal line indicates that the infant survived for at least the first 7–10 days after birth.

Continuing enamel formation in the postnatal period may also be subject to both local (e.g. physical trauma and infections) and systemic disturbances (e.g. childhood fevers, excessive fluoride ingestion), and at their most severe these may result in frank defects in the enamel such as hypoplasia (pits and grooves) and hypocalcification (altered colour). All teeth with enamel forming contemporaneously will show evidence of a defect with a systemic background, though at different positions on the tooth according to when a particular tooth started developing; at a more subtle level, milder systemic upsets that are common throughout childhood (e.g. pyrexias of unknown origin) can also be recorded indelibly and immutably in developing enamel as enhancements of incremental line structure akin to the neonatal line (see Figure 14). In a forensic context, these accentuated incremental lines can be used to reconstruct disaggregated and dispersed teeth from a single dentition; ground sections are cut and attempts are made to match the incremental line patterns from different teeth found at different locations but suspected to belong to one individual. The process is analogous to the unique rifling pattern in a gun barrel that is transferred to the shell case when successive bullets are fired from the same gun; indeed, a ballistic comparator microscope can be used to compare the enamel for different teeth. Figure 15 is a montage from a case in which teeth and other human remains were recovered from a garden at a house in West Yorkshire and from the defendant's place of work some miles away. The remains were suspected to be those of girl of about 13–14 years of age; ground sections from both first permanent molar and lateral incisor teeth found at different sites showed the unequivocal presence of matching incremental lines, thus linking the teeth to one victim.

From birth to approximately 20 years of age (when the third molar or wisdom teeth complete root development) the deciduous (primary) and permanent (secondary) dentitions are developing in the jaws and erupting into the mouth. The so-called landmark stages of tooth development (initial calcification of



a ground section of the enamel on tooth 16 (recovered from the defendant's garden) showing a pair of enhanced incremental lines. **c** Ground section of the enamel on tooth 46 (recovered from the defendant's place of work) also showing a pair of enhanced incremental lines in a similar position, chronologically, to those in tooth 16. **b** superimposition of the images for tooth 16 and tooth 46 shows that the enhanced incremental lines coincide.

Figure 15

the crown; crown completion; eruption and root completion) have been documented from many radiographic studies over the years and are widely published in the peer-reviewed literature. Thus, with access to postmortem dental X-rays and published charts of tooth development, the investigator can readily derive an estimate of chronological age that has to be expressed as a mean and standard deviation with confidence intervals; absolute estimates of age are of course not possible.

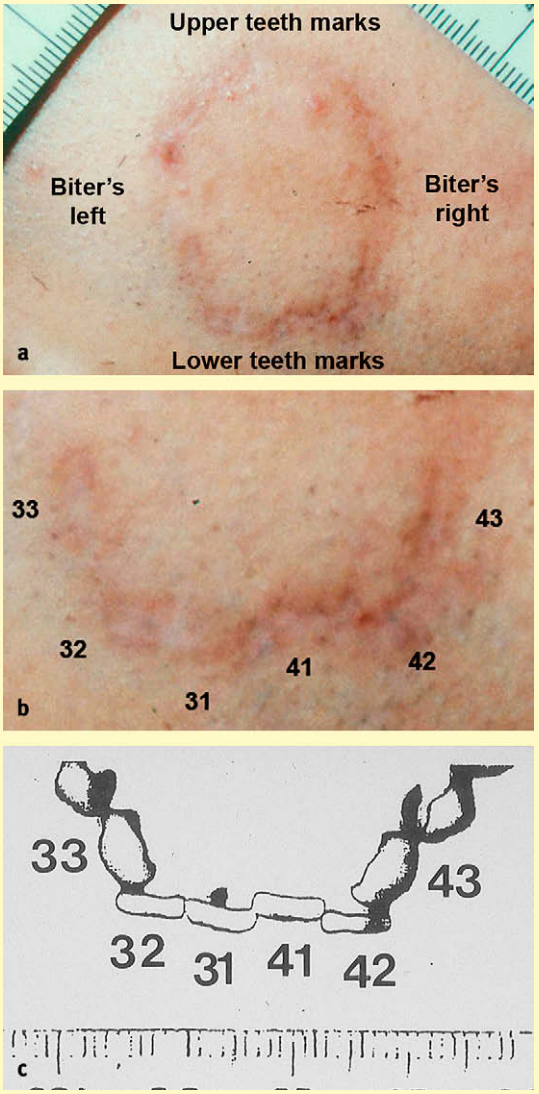
After the third molar has completed its root formation at about 20 years of age, dental methods of age estimation rely largely on destructive techniques that require the examination of ground sections, preferably from single-rooted teeth and scoring a number of histological features that are considered to reflect the ageing process. Clearly some of the parameters recommended for assessment can also be influenced by coincidental tooth pathology, though by examining a number of teeth it is argued these influences can be minimized. The resulting age estimates are just that, estimates with standard deviations amounting to ± 10% of the mean estimated age, thus the older the deceased the less accurate the estimate.

Just as bone can take up circulating substances (e.g. certain drugs and pigments) when it is forming, so can developing teeth. Unlike bone, however, which turns over throughout life, teeth can provide a permanent record of past interactions with such agents. As outlined above, the most well-known in this context is the ability of the tetracycline antibiotics to bind to mineralizing enamel and dentine (see Figure 13); each florescent band reflects a course of the antibiotic and from their position within the dentine it is possible to reconstruct the chronology of prescribing. One of the authors (GTC) has a case of dental identification in which the 35-year-old victim's identity was ultimately established by way of an age estimation involving examining ground sections of the victim's teeth, which brought to light significant tetracycline staining; the latter enabled a potential childhood medical and prescribing chronology to be reconstructed and this matched that available for the presumed deceased person.

Bite mark analysis

Bite mark analysis is a difficult and controversial part of forensic odontology and should only be undertaken by those with relevant experience; contrary to popular media belief, it lacks the exclusivity of fingerprints or DNA as evidence of identification. As such it is more often used to exclude rather than implicate potential suspects in both criminal and civil investigations. However, there are occasions when a highly distinctive arrangement in the biter's upper and/or lower front teeth is transferred to the bitten material and in these situations the biter may be identified beyond reasonable doubt. In a criminal context, bites have been made in a range of materials left at crime scenes, including a variety of foodstuffs (e.g. fruit, cheese, pastries), inanimate vegetable products and even cannabis resin! However, it is bite marks on human skin and their prosecution that have rightly attracted most attention given that the victims are often very young, as in cases of child abuse and non-accidental injury, or adult victims of violent sexual and physical assault. In ideal circumstances it is possible to distinguish bite marks made by humans from those of animals, older rather than more recent injuries and adult from child bites, though the latter is a complex area and not for the uninitiated.

By way of example Figure 16a shows a healed and scarred bite mark on the right face of a young male; the injury can be resolved into marks made by upper and lower front teeth, with the latter being highly distinctive in arrangement (Figure 16b). Of six male suspects who consented to provide dental impressions, one stood out beyond reasonable doubt as the perpetrator of the injury (Figure 16c). This degree of certainty is rarely achievable in bite mark analysis.



a Healed and scarred bite mark on right cheek; injuries attributable to the biter's upper and lower front teeth can be resolved; the biter's lower front teeth exhibit a highly distinctive arrangement. **b** Injuries caused by the biters lower front teeth with individual marks attributed to individual teeth; 33 = lower left canine; 32 = lower left lateral incisor; 31 = lower left central incisor; 41 = lower right central incisor; 42 = lower right lateral incisor and 43 = lower right canine. **c** Transparent overlay showing the biting edge profiles of the biter's lower front teeth prepared by digitally scanning the lower front teeth on a stone dental model; tooth notation as in (b).

Figure 16

Conclusion

Teeth provide a fascinating snapshot of many developmental and environmental abnormalities, a significant number of which may affect the patient as a whole and point towards an unsuspected underlying systemic condition. Such effects may also be useful in the context of forensic investigations. Rather than a source of confusion, the processing of most teeth can be conducted in a general pathology laboratory, except for assessment of enamel which requires specialist equipment for the production of ground sections. In all cases, particularly if there is uncertainty, the local oral and maxillofacial pathologist will be able to provide advice and expertise if required. ◆

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Practice points

- A good clinical history is essential in the assessment of tooth pathology with clinical photographs and radiographs also very helpful
- The notation method used by the referring practitioner should be clarified
- Assessment of defects in enamel requires assessment of ground sections: if this is not available, the tooth should be sent to a centre with such facilities
- Get to know your local oral and maxillofacial pathologist!