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General Principles Related to the Diagnosis and Treatment of Impacted Teeth

Adrian Becker

Orthodontic Treatment of Impacted Teeth, Fourth Edition. Adrian Becker.

Companion website: www.wiley.com/go/becker/orthodontic_treatment_impacted_teeth

In order for us to understand what an impacted tooth is and whether and when it should be treated, we must first define our perception of normal development of the dentition as a whole and the time-frame within which it operates.

The development of a child has many components. In assessing the developmental age of a child, it is necessary to consider and correlate these components and there is a hypothetical mean for each, though the overall development rate rarely falls exactly on this mean. A child's growth and development rate may also be different for each of the developmental components.

- *Somatic age*: A child may be tall for his or her age, so that his or her somatic age may be considered to be advanced.
- *Skeletal age*: By studying radiographs of the progress of ossification of the epiphyseal cartilages of the bones in the hands of a young patient (the carpal index) and comparing this with average data values for children of his or her age, we are in a position to assess the child's skeletal age.
- *Sexual maturation age*: The sexual age of a child is related to the appearance of primary and secondary sexual features.
- *Mental age*: This is assessed by intelligence quotient (IQ) tests.
- *Behavioural age*: This is an assessment of a child's behaviour and his or her self-concept.

These are among the indices complementing the *chronological age*, which is calculated directly from the date registered on the child's birth certificate. All these parameters are essential in the comprehensive assessment of a child's developmental progress.

Dental age

Dental age is another of these parameters and is a particularly relevant and important assessment used in advising as to the timing of proper orthodontic treatment. The tables and diagrammatic charts presented by Schour and Massler [1], Moorrees et al. [2, 3], Nolla [4], Demirjian et al. [5], Koyoumdjisky-Kaye et al. [6], Willems et al. [7] and Liversidge et al. [8] demonstrate the stages of development of the teeth, from initiation of the calcification process through to the completion of the root apex and the average chronological ages at which each stage occurs. Normal and healthy tooth buds develop from initial calcification to root apex closure at a given rate for each of the teeth groupings. That is to say that incisors, canines, premolars, first, second and third molars, in the mandible and in the maxilla, differentiated between males and females, all have their individual specific time at which they reach the various developmental stages. These stages are empirically defined in the above classic works. Schour and Massler [1] produced an atlas from *intra utero* to adulthood, consisting of 21 consecutive drawings, which feature annual development schemes up to age 12 as well as 3 more schemes up to age 35 years. Nolla [4], on the other hand, used a radiographic assessment of tooth development at 10 different developmental stages, starting from the presence of the crypt through to root apex closure (apexification).

Estimating the stage of development based on the eruption time of teeth is an unreliable method of assessing dental age. Although eruption of each of the various groups of teeth normally occurs at a particular time (when there is half to two-thirds of the final root length), nevertheless this may be influenced by local factors, which may cause premature or delayed eruption with a wide time-span discrepancy. This may be true even when root development may be proceeding unhindered.

In contrast, examination of periapical or panoramic X-rays is a far more accurate tool for dental age assessment. With few exceptions, mainly related to frank pathology, root development proceeds in a fairly constant manner and usually regardless of tooth eruption or the fate of the deciduous predecessor.

Let us take the case of a child of 11–12 years of age who has four erupted first permanent molars and only the permanent incisors, with deciduous canines and molars completing the erupted dentition. If practitioners were to refer only to the eruption chart, they would note that at this age *all* the permanent canines and premolars should have erupted. They may then conclude that the 12 deciduous teeth had been retained beyond their due time. The treatment that would appear to be the logical sequel to this observation would be the elective extraction of all the deciduous teeth!

This, however, is an overly simplistic diagnosis, since indeed there are two possible conclusions to the practitioner's observations. It is of paramount importance to carefully study the radiographs in order to distinguish between these two possibilities and thereby avoid unnecessary harm being inflicted on the child and the parents.

The initial conclusion to which the practitioner came would indeed be correct if the radiographs were to show that the unerupted permanent canines and premolars had completed most of their expected root length, showing that the child's dental age corresponded with his chronological age. In the present case (Figure 1.1), the deciduous teeth had not shed naturally, presumably due to insufficient resorption of their roots constituting an impediment to the normal eruption of the permanent teeth. Their permanent successors must then strictly be defined as having delayed eruption. The logical line of treatment would be to extract the deciduous teeth on the grounds that their continued presence defines them as over-retained.

However, there is a second possibility, where the radiographs reveal relatively little root development, more closely corresponding on the tooth development chart

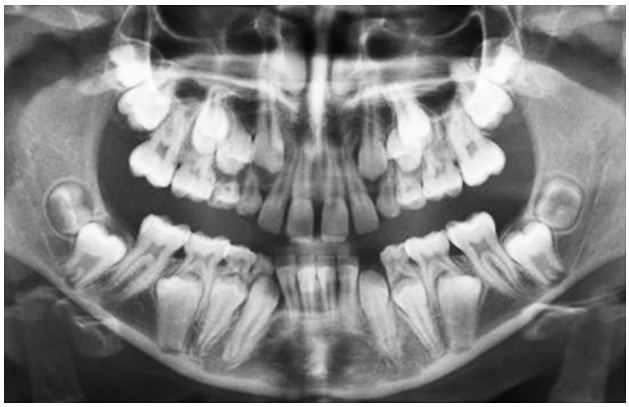

Fig. 1.1 The advanced root development of the canines and premolars indicates a dental age of 12–13 years, despite the presence of 11 deciduous teeth in this 10-year-old child. This defines the deciduous teeth as over-retained and extraction is their appropriate treatment. A note should be made and follow-up is needed regarding the relatively slow eruptive progress of the second permanent molars.

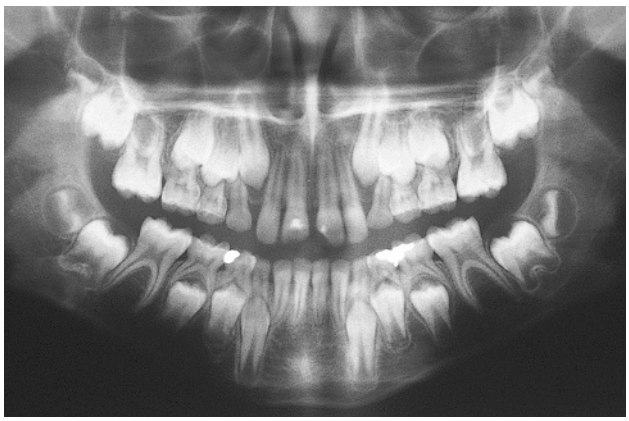

Fig. 1.2 A 12-year-old patient with root development indicating the late dental age of 9 years. Extraction of deciduous teeth is contraindicated

(Figure 1.2) to the picture of a 9-year-old child. The child's birth certificate has indicated the age of 12 years and this may well be corroborated by body size and development and even by intelligence level. Nevertheless, her dentition is that of a child three years younger, thus determining *dental age* as 9 years. Extraction of deciduous teeth in these circumstances would be the wrong line of treatment, since it is to be expected that these teeth will shed normally at the appropriate *dental* age. Early extraction may lead to the undesired characteristic consequences of early extraction, performed for a completely different reason.

An additional parameter of teeth development must also be considered. Although on average, central incisors, canines and first and second molars in the maxilla show identical rates of development of one side of the mouth compared to the other, this may not be true for certain specific teeth. There may be a marked variation between right and left sides in the development rate of maxillary lateral incisors and mandibular second premolars and, less commonly, of maxillary second premolars.

In the same way that we may determine the patient's overall dental age, these identical principles also serve to enable us to diagnose the dental age of the patient's individual unerupted permanent teeth. However, because developmental variation is found within these different groups of teeth, the developmental stage of a single tooth cannot be used as an indicator for overall dental development and dental age must be evaluated employing a comprehensive, all-round assessment. Only then can a definitive determination be offered.

Accurate assessment of dental age is critical in deciding when to treat a patient in general and in regard to the treatment of impacted teeth in particular.

We are now in a position to define the terms that we shall use throughout this text, as follows:

- *Retained deciduous tooth*: This term has a positive connotation and refers to a tooth that remains in place beyond its normal, chronological shedding time due to the absence, or retarded development, of the permanent successor. A radiograph of the permanent successor is required in order to determine the presence and developmental status of the unerupted permanent tooth.
- *Over-retained deciduous tooth*: In contrast, this term has a negative connotation and refers to a tooth whose unerupted permanent successor exhibits root development in excess of two-thirds of its expected final length (Figure 1.3). Here too, a radiograph of the permanent successor is required in order to determine the status of the deciduous tooth and its implied treatment.

Fig. 1.3 The mandibular left second deciduous molar is retained (extraction contraindicated), since the root development of its successor is inadequate for normal eruption. The right maxillary deciduous canine, in contrast, is over-retained (extraction advised), since the long root of its successor illustrates delayed eruption.

- *Permanent tooth with delayed eruption*: This term refers to an unerupted tooth whose root is developed in excess of two-thirds of its expected final length and whose spontaneous eruption may nevertheless be expected within a reasonable time.
- *Impacted tooth*: This refers to a tooth whose root is developed in excess of two-thirds of its expected final length, but which is not expected to erupt in a reasonable time.

When assessing the dental age of the patient, it is important to emphasize that one should not include the maxillary lateral incisors, the mandibular second premolars and the third molars in this calculation. The development timetable of these teeth is not always in line with that of the patient's other, ontologically more stable teeth [9, 10]. These are the same teeth that are most frequently congenitally missing in cases of partial anodontia (hypodontia) or oligodontia. Indeed, reduced size, poorly contoured crown form and late development of these teeth are all considered microforms of congenital absence [9–12]. The variation in their timing is, however, always expressed as *lateness* and they are never seen in a chronologically more *advanced* state of development than the other teeth. If the individual dental age of any of these variable groups of teeth is advanced, then so too is the dental age of the entire dentition in which they are to be found.

In summary, therefore, we may assert as follows:

- All orthodontists must have at their fingertips the ages at which the permanent teeth normally erupt.
- Permanent teeth normally erupt when approximately two-thirds of their final root length has developed.
- The remainder of the root reaches apexification approximately 2½–3 years after eruption.
- Determining the closed apex of the tooth on a radiograph is usually an easy and accurate parameter to establish.
- Determining the completed proportion of the root of a tooth, whose final completed length is unknown, is not an assessment that can be performed accurately. It rather falls into the realm of informed guesswork.

Having now set out the principles upon which dental age may be assessed, we must turn to the practical side of translating these principles into clinical terms in a logical, systematic and didactic manner. The simplistic way of adopting the above principles would be to take the panoramic radiograph or full-mouth periapical survey and then work around each dental arch from one tooth to the next, individually and from left to right, upper to lower, evaluating each tooth in turn. This would then require coordinating all the individual results and computing a final figure that is the dental age of the patient. The resulting conclusion would have to be compared against the values seen on an idealized chart of the norms for a given population [1, 4, 13]. Although this method delivers accuracy, it requires a considerable time and it is likely to take an hour or so to reach the final conclusion. It is an arduous and tedious endeavour, which does not lend itself to the conditions that are present in a busy clinical orthodontic practice.

What is recommended is a simple, logical but systematic approach that can be employed chairside to reach a similar conclusion in just a few minutes, even at the initial orthodontic consultation visit. This method will rely on the same criteria of establishing the development of crown and root, but must do so in a step-by-step manner, starting from a different point of departure. The 'starting point' of this systematic approach has, for reasons that will be explained in the following paragraphs, been set at the cut-off dental age of 9 years.

Assessing dental age in the clinical setting – the Jerusalem method

There are several criteria that are appropriate to the appraisal of tooth development when using full-mouth periapical radiographs or a panoramic film. The information that is available regarding the ages at which the various stages of dental development occur is based on the classic random studies that have been carried out over many decades of the local populations of the researchers involved. The figures for the mean ages at which these stages occur, in the hypothetical child, are as follows:

1 The first signs of the presence of a tooth are discernible radiographically with the initiation of calcification of incisal edges and cusp tips. Thereafter, one may observe the formation of the completed crown as well as progressive degrees of root formation (usually expressed in fractions), and thence the fully closed root apex. Since orthodontic treatment is largely performed on a relatively older section of the child population, the stages of actual formation of the root become the only relevant factors.
2 The accuracy with which one may assess fractions of an incomplete, immeasurable and merely 'expected' final root length is not reliable and is very much a matter of individual observer variation.
3 The stage of tooth development that is easiest to define with confidence and with accuracy is that which relates to the closure of the root apex. So long as the dental papilla at the root end remains discernible, the apex is open and Hertwig's root-forming, epithelial sheath is in an active stage of increasing root length. However, once fully closed, the papilla disappears and a continuous lamina dura will be seen on a periapical radiograph, closely following the root outline. These are the specific diagnostic signs of that landmark event. Apexification is therefore the most important single factor upon which a

system of assessment may be faithfully and easily made of the dental age of a given patient in the clinical environment.

4 From population studies, we learn that the first permanent tooth to erupt in the mouth is the mandibular central incisor, closely followed by the first permanent molars, and this occurs at the age of 6 years.

5 Root development of the permanent teeth is completed approximately 2.5–3 years after their normal eruption [4]. This allows us to conclude that, at the age of 8.5–9 years, the child's mandibular incisors will be the first teeth to exhibit closed apices and will usually be closely followed by the four first permanent molars. This being the case, it is clear that the age of 9 years must be the basic starting point from which to commence the evaluation of the child's dental age. If mandibular incisors or molars demonstrate root closure, then the tentative diagnosis would be that the patient has a dental age of *at least* 9 years. If the apices are still open, then the conclusion would be that the child has a lower dental age.

It should be emphasized, however, that the exercise is aimed at ranking a specific child's dental development vis-à-vis the above hypothetical mean. Whether or not the evaluated tooth has actually erupted is entirely irrelevant to this equation.

Let us examine the progressive diagnostic path in its correct order (see also Table 1.1):

1 If the mandibular central incisor roots are complete, we may presume that the patient is at least 9 years old (dental age), i.e. this figure is derived from 6 years (the normal age of eruption as determined by two-thirds root length development), with the addition of 2.5–3 years to apexification.

2 We may then proceed and check for closed apices of the first molars (9–9.5 years).

3 At 9.5 years, the mandibular lateral incisors roots will have completely developed.

4 The next teeth in the expected eruption series are the maxillary central incisors, whose closed apices would indicate a dental age of 10 years.

5 Because their rate of development is variable, it would be wise to bypass the assessment of the maxillary lateral incisors at this point in the diagnostic process and move on to examine the later teeth.

6 Apexification of the mandibular canines and first premolars (12–13 years).

7 Thereafter, the maxillary first premolars (13–14 years).

8 In common with the maxillary lateral incisors, the mandibular second premolars are also developmentally variable teeth and their assessment should also be bypassed for the present calculation.

9 Next there are the maxillary canines (14–15 years).

10 The final stage of development relates to the four second molars (15 years).

Table 1.1 Apexification age of individual tooth types.

9 years	Mandibular central incisors
9–9.5 years	First molars and mandibular lateral incisors
10 years	Maxillary central incisors
11 years	Maxillary lateral incisors
12–13 years	Mandibular canines
13–14 years	Maxillary first premolars
14–15 years	Second premolars and maxillary canines
15 years	Second molars

This stage-by-stage apexification determination will lead us to the last tooth in this sequence with a closed apex (Figure 1.4), which indicates the dental age of the patient. Once the determination is completed, it is valuable to return to the maxillary lateral incisor and the mandibular second premolar. If these are developing normally, then their age of eruption would be 8 years and 11 years, respectively, with an apexification date of 11 and 14 years, respectively. Retarded development of these individual teeth may be age assessed according to the above criteria for calcification. An illustration of this situation would be where the overall dental age assessment is diagnosed as 12 years, yet the right maxillary lateral incisor might match a 9-year-old child and the left mandibular second premolar might even be characteristic of someone 8 years of age.

In contrast to the above process of examination and assessment and in the case of a dental age less than 9 years, none of the permanent teeth will have completed their root development. Here clinicians will have no choice but to rely on their own estimation of the degree of root development, of the degree of crown completion and, in the very young, of the stage of initiation of crown calcification (Figure 1.5). This is most conveniently carried out by working backwards from the expected development at age 9 years and, with this as a base, comparing the dental development

Fig. 1.4 Root apices are closed in all first molars, all mandibular and three of the maxillary incisors, excluding the left lateral incisor. Canine and premolar apices are open.

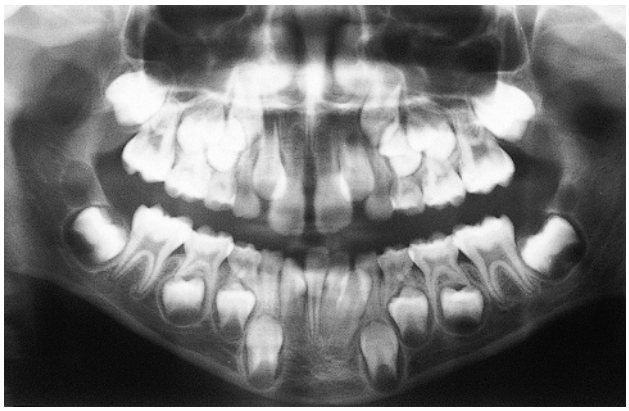

Fig. 1.5 No closed apices. Dental age assessment 7–7.5 years.

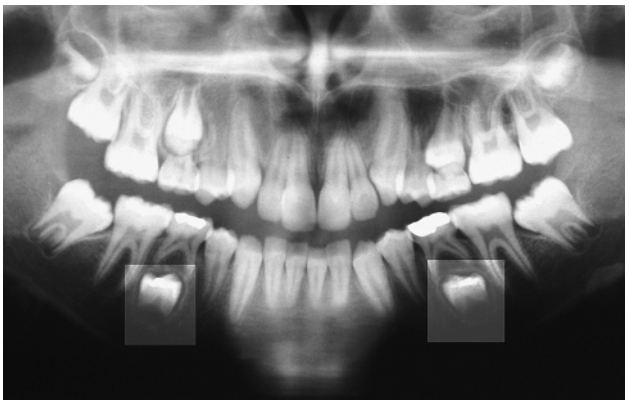

Fig. 1.6 Late-developing second mandibular premolars with retained (*not* over-retained) deciduous second molars in a child with a dental age of 11–12 years. The contrast and brightness of this poorly contrasted picture have been adjusted in the relevant areas to clearly show the stage of development of these tooth buds.

status of the patient, beginning with the mandibular central incisors and the first permanent molars.

By way of illustration, at a dental age of 6 years the length of the roots of the mandibular central incisors and the first permanent molars will be seen to be one-half to two-thirds developed. Confirmation of this will come from a comparison, which may be made with the development stage reached by the other teeth, where one would anticipate that unerupted maxillary central incisors will have reached one-half root length, mandibular canines one-third root length, first premolars one-quarter root length, and so on.

As already noted, however, variations do occur, particularly with maxillary lateral incisors, mandibular second premolars or third molars. This may lead to certain apparent contradictions. It is therefore recommended to exclude consideration of these teeth when making the relevant assessments and thereby not only simplifying the process, but also contributing to the accuracy of the resulting assessment.

In addition, as stated above, *early* development of these teeth in relation to the development of the remainder of the dentition does not appear to occur. Indeed, individual variability is expressed only in terms of degrees of *lateness*. Accordingly, the developmental status of these teeth is available as corroborative evidence for the determination of dental age, but only if their own developmental stage is shown to be in line with the remainder of the dentition.

In a similar way, one should not incorporate abnormal features in the calculation process of the assessment of dental age. Unusually small teeth, coniform premolars, mandibular incisors and peg-shaped lateral incisors are all wont to develop very much later than normally shaped and sized teeth of the same series; indeed, sometimes as much as three or four years later. Thus, in diagnosing dental age for a patient with an abnormality of this nature, a general determination of the dentition should point out that this abnormal tooth may display a much lower dental age. A 14-year-old patient who has a complete permanent dentition, including the second molars, may yet exhibit a mandibular second deciduous molar. The radiographs (Figure 1.6) show the apices of the first molars, central and lateral incisors, mandibular canines and premolars to be closed, while the maxillary canines and the second molars are almost closed. However, the unerupted mandibular second premolar has an open root apex and presents a development stage equivalent to about a quarter of its expected eventual length, or even less. Correspondingly, although we may assess the dental age of the dentition as a whole to be 11-12 years, we would have to point out that the dental age of the unerupted second premolar is approximately 7 years. The conclusion here, in the context of this terminology, is clearly that the second premolar, *individually*, does not exhibit delayed eruption and the deciduous second molar is not over-retained. Thus, it would not be appropriate to extract the deciduous tooth at this point, but rather to wait for at least a few years, during which time the tooth may be expected to shed normally.

In summary, there are four different parameters that can explain the existence of certain deciduous teeth that are inconsistent with the chronological age of the patient. Each of these parameters has clinical repercussions and labelling a patient as one particular grouping will in fact dictate the nature of the treatment required:

1 *A late-developing dentition*: In this condition the dental age of the patient has developed slower than his chronological age. This is evident radiographically by a lesser root formation in the entire dentition than that which is expected at the chronological age. Typically, this is accompanied clinically by the continued and symmetrical presence of all the deciduous molars and canines on both sides of the jaw. Here, the extraction of deciduous teeth is contraindicated, since the teeth are expected to exfoliate normally when the appropriate *dental* age is reached.

2 *A normally developing dentition with over-retained deciduous teeth*: In this condition and despite the fact that the dental age of the patient correlates with her chronological age, the radiograph demonstrates one or more permanent teeth, which show well-developed roots but have remained unerupted, i.e. beyond their due eruption time. In most examples of this condition, the anomaly tends to be localized in a single section of the dentition. This may be due to an ectopic siting of the permanent tooth bud, which has stimulated the resorption of only a portion of the root of its deciduous predecessor. Shedding has not occurred due to the continued presence of the remaining part of the root or of another unresorbed root. Indeed, sometimes the condition may be found symmetrically in a single dental arch or even in both arches. In this condition the recommended treatment is extraction of the over-retained tooth or teeth.
3 *A normally developing dentition with single or multiple late-developing permanent teeth*: This condition is commonly found in relation to the maxillary lateral incisor and the mandibular second premolar teeth. Normal shedding of the tooth is expected to occur when the root of the permanent tooth reaches two-thirds to three-quarters of its expected length. Accordingly, extraction of the deciduous predecessor is to be avoided.
4 *A combination of the above*: Sometimes one may see features of all of these three alternatives in a single dentition. In such a case the recommended treatment would need to be multiple and selective, each condition treated in its appropriate way.

The importance of a careful diagnosis and differentiation of the above conditions cannot be over-emphasized. All the aspects of planning and timing of treatment of the patient with impacted teeth depend entirely on a correct diagnosis.

When is a tooth considered to be impacted?

Based on the principles set out by Grøn [13], it has been widely accepted that, under normal circumstances, a tooth erupts with a developing root and with approximately three-quarters of its final root length. Typically, when they erupt the mandibular central incisors and first molars will have marginally less root development, whereas the mandibular canines and second molars will demonstrate slightly more root development. This is now generally accepted as a diagnostic baseline from which to evaluate the eruption of teeth in general.

Thus, where an erupted tooth shows less root development (Figure 1.7), it would be appropriate to label it as prematurely erupted. (This will usually be the consequence of the early loss of a deciduous tooth, particularly where extraction was dictated by the presence of periapical pathology, typically due to untreated caries.)

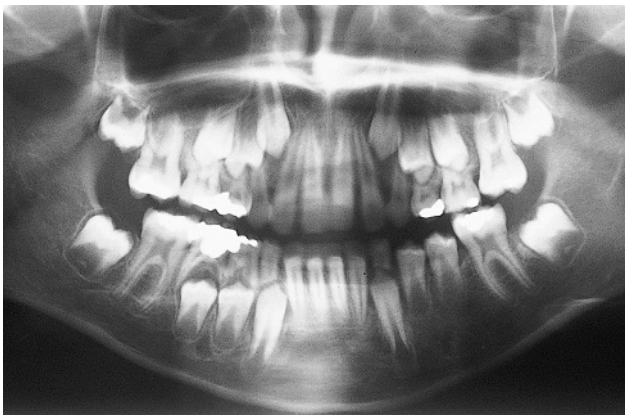

Fig. 1.7 The left mandibular premolars are prematurely erupted, with insufficient root development, due to premature extraction in a caries-prone dentition.

Conversely, where an unerupted tooth exhibits a more completely developed root, then the eruption process of this tooth must be presumed to have been impeded. (This may have been caused by any one of several aetiological possibilities, such as a failure of resorption of the roots of a deciduous tooth, or an abnormal eruptive path, the presence of a supernumerary tooth, or dental crowding, perhaps a much-enlarged dental follicle/dentigerous cyst, or indeed any other forms of soft tissue pathology or disturbance in the eruption mechanism of the tooth.) One should not overlook the possibility that the cause of the non-eruption may also be a thickened post-extraction or post-trauma repair of the mucosa.

It is to be noted that if there is a history of very early extraction of one or two deciduous molars, we may find that there will be a substantial delay in the eruption of the premolars, indeed, even complete non-eruption, caused by a thickened mucosa overlying the teeth. It is usually possible, for a period of a year or more, to palpate these teeth by virtue of their distinct outline being clearly visible and causing a bulging of the gum. However, eruption may not occur at all.

Impacted teeth and local space loss

Let us now look at the consequences of the inevitable time lapse between the performance of a surgical procedure to remove the cause of an impaction and the full eruption of the impacted tooth into the vacated space in the dental arch. The extent of this time-span is linked to several factors, specifically the initial distance between the tooth and the occlusal plane, the stage of development of the particular tooth, the age of the patient and the manner in which hard and soft tissue may be laid down in the healing wound. There are consequences to this time period, which need to

be addressed. Local changes in the erupted dentition, such as space loss and tipping of the adjacent erupted teeth, may occur as a result of the break in integrity of the dental arch caused by the surgical procedure. The surgical intervention is no less likely to elicit the drifting of neighbouring teeth than is any other factor that may be caused by loss of dental tissue and interproximal contacts.

If an odontome or supernumerary tooth creates an obstacle to an unerupted permanent tooth, the result may be substantial vertical (and sometimes mesial, distal, buccal or lingual) displacement of the permanent tooth. In such a case, the ideal treatment would be to remove the obstructing body in order to leave the deciduous teeth intact, since the deciduous teeth would function to maintain arch integrity during the time lapse needed for the permanent tooth to erupt normally. However, in order to gain access to perform the necessary surgery, it is usually necessary to extract one or more deciduous teeth. This brings to the forefront the importance of interim space maintenance, particularly in the posterior area, during the lengthy time needed to allow for the long distance that a displaced permanent tooth may have to travel before it erupts into the mouth. Advance orthodontic planning is called for, preferably before or immediately subsequent to the surgical procedure. The interim space-holding device should be retained until full eruption of the permanent tooth has occurred.

The impaction of teeth is often associated with the lack of available space in the immediate area. This is frequently due to the drifting of adjacent teeth, as well as to crowding of the dentition in general. In these circumstances, the spontaneous eruption of an impacted tooth is unlikely to occur unless adequate or, preferably, excess space is available. It would be better to delay the excision of the associated pathological entity and permit this corrective treatment to be attempted, until the root development of the unerupted tooth is adequate to bring about the desired eruption. However, the surgeon may not give consideration to the orthodontic aspect and will probably insist on removing most forms of pathology as soon as a tentative diagnosis is reached, in order to obtain examinable biopsy material for the establishment of a definitive diagnosis. Nevertheless, the entirely benign nature of odontomes and supernumerary teeth causes these obstructions to be considered exceptions to this rule and the timing of their removal may be considered in a more leisurely fashion.

Whose problem?

Patients do not go to their dentist complaining of an impacted tooth. Indeed, they are frequently totally unaware that this abnormality exists. There is no pain, no discomfort and no swelling. The layperson would not see that there is a missing tooth, since the deciduous predecessor may not have shed naturally and no gap would be visible to the untrained eye. The vast majority of impacted teeth are discovered quite by chance, often in routine dental examination, and are not the result of a patient's direct complaint. As a general rule, it is the paediatric dentist or the general dental practitioner who, during a routine dental examination, may discover and record the existence of an over-retained deciduous tooth. A periapical radiograph will then confirm the diagnosis.

In the present context, there are two situations where abnormality in appearance can motivate a patient to seek professional advice.

The first typically occurs when the patient is 8–10 years old. A single maxillary central incisor has erupted a year or so previously and the discerning parent notices that the erupting lateral incisor on the opposite side has not left enough space for the anticipated eruption of the second central incisor (Figure 1.8). The deciduous central incisor may be present over-retained or it may have exfoliated. Although the parent has recognized the abnormality, he or she will not generally have the technical understanding to think of the possibility of impaction of the unerupted central incisor.

The second situation will occur with a 14–15-year-old patient who has become worried by an unsightly carious lesion in an over-retained maxillary deciduous canine. The patient will usually be unaware that this is not a permanent tooth. Appropriate professional advice will need to be given, explaining that the appropriate line of treatment is probably not restoration, but rather extraction and resolution of the impaction of the permanent canine.

In either of these two situations, because of symptoms related to relatively rare complications of impacted teeth, some patients in this category will have initially been seen by their general dental practitioner. The symptoms that may lead to this path are, *inter alia*, mobility or migration of adjacent teeth (due to extensive root resorption), painless bony expansion (dentigerous or radicular cyst) or perhaps pain and/or discharge caused by a non-vital over-retained deciduous tooth or an infected cyst, with communication to the oral cavity [14].

Fig. 1.8 Space loss in a 10-year-old child, due to an impacted maxillary right central incisor.

Initially, it will be necessary to ascertain whether there is a good chance that resolution will be spontaneous once the aetiological factor has been removed or whether active appliance therapy may be indicated. In order to do this, it is important to accurately and visually assess the exact position, long-axis angulation and rotational status of the tooth and make an assessment of space in the arch. Having done so, the paediatric dentist or general dental practitioner will now have to decide who should treat the problem.

Many dentists, believing that surgery will be required, will prefer not to accept responsibility for this type of situation and will refer the patient to an oral and maxillofacial surgeon. The surgeon may opine that the problem is essentially surgical in nature and will proceed to remove the over-retained deciduous teeth, clear away other possible aetiological factors, such as supernumerary teeth, odontomes, cysts and tumours, and also expose the impacted permanent tooth. If the impacted tooth is buccally located, the surgical flap may be apically repositioned to prevent primary closure and to maintain subsequent visual contact with the impacted tooth after healing has taken place. In many cases, this will have the effect of encouraging eruption. For the few weeks following, until healing (by 'secondary intention') has occurred, the wound will usually be packed with a proprietary zinc oxide/eugenol-based periodontal pack (e.g. CoePack®) or a gauze strip impregnated with Whitehead's varnish. The surgeon uses careful placement and wedging of the pack between an impacted tooth and its neighbour in order to help free the tooth and allow it to erupt naturally when the pack is removed.

In the more difficult impactions, wider surgical exposure may be undertaken, which would involve fairly radical bone resection, both around the crown and down to the cemento-enamel junction, with complete removal of the dental follicle. The principal aims of this procedure are to clear away all possible impediments to eruption and to ensure that subsequent healing of the soft tissues does not cover the tooth again.

Thereafter, for a period of several months or even years (for some of the more awkwardly positioned teeth), the surgeon, family dentist or children's dentist will usually follow up the spontaneous eruption of the impacted tooth until it reaches the occlusal level. Only then, if alignment is poor or the tooth still has not erupted, will the patient probably be referred to the orthodontist.

What is quite clear is that the patient should have been referred to the orthodontist directly in the first place. Although the orthodontist cannot directly influence the position of the impacted tooth until after the appropriate access has been provided surgically and until an attachment has been placed on the tooth, nevertheless, with proper planning and management, including referral for surgical exposure at the appropriate stage in the treatment, a much higher qualitative level of care would be provided and in a very much shorter time-frame.

This will be discussed in the ensuing chapters of this book.

The timing of the surgical intervention

From this discussion, it is clear that the timing and nature of the surgical procedure are determined at the time of the initial diagnosis, by the degree of development of the teeth concerned.

The first scenario occurs at an early stage, when a radiographic survey of a very young child may reveal pathology, such as a supernumerary tooth, an odontome, a cyst or a benign tumour, which appears likely to prevent the normal and spontaneous eruption of a neighbouring tooth. In such a case, it would be inappropriate to expose the crown of an immature tooth. One would not want to encourage the tooth to erupt before an adequate (half to two-thirds) root length has been produced. Secondly, at that early stage of its development, the tooth cannot yet be considered to be impacted. Given time and freedom to manoeuvre, the tooth will probably erupt by itself.

Early exposure risks the possibility of damage to the crown and to the subsequent root development of the tooth. On the other hand, however, it would not be wise to ignore the situation after the discovery of the pathological condition (Figure 1.9). The potential for impaction has been revealed and leaving the condition untreated may worsen the prognosis. Accordingly, the appropriate treatment at this stage might be the removal of the pathological entity, without disturbing the adjacent permanent teeth or their follicular crypts. It may then reasonably be expected that normal development and eruption will occur in due course. However, while this is clearly the desirable course of action, access to the targeted area may be impeded by the proximity of adjacent developing structures, so that delay may still be advisable. A competent oral and maxillofacial surgeon should be consulted.

The second scenario occurs when the discovery of the pathological condition is only made when the patient is much older. In this case (Figure 1.10), the superiorly displaced central incisor has a two-thirds root and is ready for eruption. The appropriate treatment here is to extract the deciduous and supernumerary teeth and hope that this will encourage eruption of the permanent incisor. In many scenarios, spontaneous eruption may be expected even with a closed apex, provided there is adequate space in the dental arch and little or no displacement of the impacted tooth [15, 16].

As we shall see in subsequent chapters, there are several situations and tooth types where spontaneous eruption may not occur, or may not occur in a reasonable time-frame. This will be so in the case of severe displacement of the affected tooth. In these instances, it may be necessary to supplement the natural eruptive potential of the tooth and divert it mechanically, with the use of an orthodontic appliance.

(a) (b)

Fig. 1.9 (a) Chance finding of mesiodens in a 4-year-old child. (b) Chance finding of odontoma in a 1-year-old infant.

Fig. 1.10 An 8-year-old child exhibits an unerupted maxillary left central incisor with two supernumerary teeth superimposed, pointing in opposite directions. The permanent incisor is developed adequately for eruption (retarded eruption) and the deciduous incisor is over-retained.

Patient motivation and the orthodontic option

Angle's class II malocclusion is to be found in 20–25% of the child population in most countries of the Western world [17, 18]. However, this is not reflected in an orthodontic practitioner's office, where one finds that up to 75% of patients are being treated for this malocclusion. The reason for this incongruity in seeking treatment is entirely facial appearance, since the visible manifestation of the condition causes the patient's appearance to be adversely affected to a much greater extent than by most other conditions. In other words, appearance plays an extremely large part in the initiative and motivation of the parent to seek treatment for the child and for the child to be ready to be treated.

Most of the other patients on the orthodontist's roster are being treated for additional (though arguably less unsightly) conditions (such as crowding, single ectopic teeth, open bites or class III relationships). It follows that relatively few patients with acceptable appearance have been referred for strictly health reasons, which may not normally be apparent to the patient. This small number of patients will have agreed to orthodontic treatment only after being motivated by the careful and persuasive explanations of a general or paediatric dentist, orthodontist, periodontist, prosthodontist or oral surgeon, who will have warned them of the ills that are otherwise likely to befall them and their dentition.

Aside from maxillary central incisors, most impactions are symptomless and do not usually present an obviously abnormal appearance. The natural result is that motivation for treatment in symptom-less cases is minimal and much time has to be spent in explanations to patients before they accept that treatment is appropriate and before they are prepared to accept the constraints entailed in its execution.

However, the story does not end there, since most patients require periodic 'pep talks' to maintain their cooperation and their resolve to complete the treatment. Many patients may not maintain the required standard of oral

hygiene, thus rendering the continuation of treatment difficult if not impossible. On the other hand, it is just as difficult to remove appliances from a patient in the middle of treatment, when impacted teeth have partially erupted and large spaces are already present in the dental arch. For these reasons, although ambitious and innovative treatment plans are in order, it is essential to take into account the aspect of motivation before advising lengthy and complicated treatment, since the risk of the treatment being prematurely aborted may be high.

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