Tooth Eruption and Common Disturbances

9

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Learning Outcomes
By the end of this chapter, readers will:

- Understand the normal development and eruption pattern of permanent teeth.
- Be able to determine when non-eruption of teeth maybe pathological.
- Know which children need to be referred and when and which children can be monitored.

9.1 Introduction

The mixed dentition can be defined as the transition period from when the first permanent molars start to erupt until all the primary teeth are shed. This spans from the age of approximately 6–13 years, although there can be wide variation. Malocclusions and ectopic teeth can quickly become apparent in this age group. Although definitive orthodontic treatment is not normally completed until the child is in the permanent dentition, early invention in certain cases is essential. In this chapter, normal development and aberrations will be discussed along with management strategies.

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9.2 Dental Development and Eruption of Permanent Teeth

Dental development occurs in three distinct phases. The first is the pre-eruptive stage which spans from the initiation of mineralisation to crown completion (Tables 9.1 and 9.2). Complex epithelial–mesenchymal interactions result in secretion of extracellular organic matrix followed by mineral deposition in the form of hydroxyapatite crystals. During this stage, enamel is vulnerable to insults which can result in hypoplasia or hypocalcification. The second phase occurs once the roots start to form and the teeth emerge into the oral cavity (prefunctional phase). The main direction of the eruptive force is axial. During the intraosseous phase, the rate of eruption is slow (1–10 µm/day[2]), as it is dependent on the rate of bone resorption, under the influence of the dental follicle in the direction of eruption and bone deposition apically. Under normal circumstances, in order for the permanent teeth (excluding the molars) to erupt, primary root resorption must also occur. The permanent incisors and canines develop in a lingual position to their predecessors so initial root resorption occurs lingually; subsequent movement of the tooth germ leads to apical resorption. Primary molar roots resorb on the internal surfaces where the premolar crown lies.

Once the tooth penetrates the oral mucosa, the rate of eruption increases to up to 75 µm/day. The third stage, the functional phase, is concerned with the attainment of a functional occlusion. Eruption into the occlusal plane is accomplished by both root growth and formation of the bone in the area of the crypt. Development and eruption of teeth is largely symmetrical. It is important to remember that they continue to erupt slowly throughout life to compensate for occlusal wear. Extraction or non-eruption of an opposing tooth can result in rapid eruption; this is an important consideration in the early elective loss of first permanent molars due to caries or hypomineralisation.

Eruption of the permanent teeth usually starts between the age of 5 and 6 years (Tables 9.1 and 9.2) and continues until the age of 12–13 years. There are ethnic variations with native American and black African populations being advanced in comparison to other populations. In addition, the time of eruption of permanent teeth correlates to the time of eruption of primary teeth. Those children whose primary teeth erupt late tend to have delays in their permanent dentition.

Table 9.1 Maxillary dental development (adapted from Berkovitz, Holland and Moxham)

Tooth	Eruption (years)	Crown mineralisation period	Root complete (years)
Central incisor	7–8	3 months–5 years	10
Lateral incisor	8–9	10 months–5 years	11
Canine	11–12	4 months–7 years	13–15
First premolar	10–11	18 months–6 years	12–13
Second premolar	10–12	2–7 years	12–14
First molar	6–7	Birth–3 years	9–10
Second molar	12–13	2–8 years	14–16
Third molar	16+	7–16 years	Up to 25 years

Table 9.2 Mandibular dental development (adapted from Berkovitz, Holland and Moxham)

Tooth	Eruption (years)	Crown mineralisation period	Root complete (years)
Central incisor	6–7	3 months–5 years	9
Lateral incisor	7–8	3 months–5 years	10
Canine	9–10	4 months–7 years	12–14
First premolar	10–12	21 months–6 years	12–13
Second premolar	11–12	2–7 years	13–14
First molar	6–7	Birth–3 years	9–10
Second molar	12–13	2–8 years	14–16
Third molar	16+	7–16 years	Up to 25 years

Fig. 9.1 Flush terminal plane commonly seen in primary molars

The first permanent molars are typically the first teeth to erupt, initially into a half unit class II relationship (Fig. 9.1). This is due to the presence of a flush terminal plane in the primary dentition in up to 76% of children. Mesial shift of the lower teeth allows a development of a class I molar relationship. In the anterior segment, there may be initial crowding due the width discrepancy between the primary and permanent incisors which settles with arch growth. In addition, there may be a transient anterior open bite as the teeth erupt which risks continuing if habits such as digit sucking are prolonged. Midline diastemas are common in this stage accompanied by distal tipping of the lateral incisors (Fig. 9.2). This is known as the 'ugly duckling' or Bengston stage and frequently resolves without intervention. With the lower incisors, the permanent teeth may erupt lingually. While most migrate buccally, in cases where there is no root resorption, the lower primary incisors may require extraction.

After a quiescent phase, eruption of premolar and lower canine teeth commences around the age of 9 years and continues typically until around 13 years. The leeway space represents the difference in mesiodistal width between the primary canine and molars and the permanent canine and premolars which is approximately 2–2.5 mm. If this is insufficient to accommodate the canine and two premolar teeth, this results in the exclusion of the permanent canine as this is the last tooth in the arch to erupt. Secondary crowding can be attributed to early loss of primary molar teeth often through caries and predominantly affects the second premolar. Other factors affecting eruption of permanent teeth include pathology associated with primary teeth, primary failure of eruption and ankylosis. From a systemic point of view, endocrine disorders (hypopituitarism, hypothyroidism, hypoparathyroidism) can slow

Fig. 9.2 The 'ugly duckling' or Bengston stage

emergence. Certain genetic conditions such as Down syndrome can be associated with delayed eruption. Precocious puberty and raised body mass index have been associated with increased eruption rates.

9.3 Identifying Abnormal Development

9.3.1 Clinical Examination

In order to recognise delayed or ectopic eruption, it is important to first understand normal eruption patterns in the mixed dentition. By undertaking regular review, the general dentist is in an excellent position to refer early or undertake interceptive treatment which may simplify or eliminate orthodontic treatment need. When a child is in the primary dentition, observation is key as discrepancies may be amplified in the permanent dentition. For example, where primary teeth are already crowded, crowding in the permanent dentition is likely to be worse.

When undertaking a mixed dentition examination, special attention should be paid to any asymmetry of eruption, rotations of teeth or aberrant angulation. A large midline diastema may indicate the presence of an unerupted supernumerary tooth. If a retained primary tooth is present, mobility should be checked as a firm tooth indicates a lack of resorption by the permanent successor particularly if the contralateral tooth has been lost more than 6 months previously. Palpation may reveal a buccal or palatal swelling which may indicate an unerupted tooth, supernumerary tooth or soft tissue or bony pathology. As a rule, permanent canines undergoing normal eruptive patterns should be palpable by 10–11 years of age in the buccal sulcus. It is suggested that dentists should consider palpating for upper canines annually from the age of 8 years. Where there is a suggestion of ectopic eruption, sensibility testing of adjacent teeth should be undertaken as resorption is a risk. A thorough orthodontic assessment should be undertaken to identify any developing malocclusions, hypodontia and/or crowding.

9.3.2 Radiographic Examination

In cases of infraocclusion and ectopic eruption of first permanent molars, a periapical or sectional panoramic view may be used to visualise root morphology and establish the presence of permanent successors. Parallax is the most widely used technique to identify the position of an ectopic tooth. Parallax can be defined as the apparent displacement of an object because of the different positions of the observer. It involves two radiographs taken with a shift in the cone position between the two views; this may be horizontal or vertical. As the tube shifts between the two views, the ectopic tooth will change its position in relation to the adjacent teeth. If the ectopic tooth moves in the same direction as the tube shift, then the tooth is palatally displaced, if it moves in the opposite direction, then the tooth is buccally displaced, known as the SLOB rule. It is recognised that horizontal parallax is more reliable than vertical parallax when identifying the position of unerupted incisors and canines.

Horizontal Parallax Includes either an upper standard occlusal (midline view) and periapical (centred on the impacted tooth region) or two periapicals (one centred on the upper central incisor and the other centred on the canine region).

Vertical Parallax Includes either an upper standard occlusal (midline view with X-ray beam aimed downwards) and a panoramic radiograph or a periapical (bisected angle technique with X-ray beam aimed downwards) and a panoramic radiograph (Fig. 9.3).

Cone-beam computed tomography (CBCT) is a useful tool to identify and accurately locate the position of impacted teeth. This imaging technique also allows clinicians to detect any resorption of the roots of adjacent teeth and the amount of bone surrounding each tooth, which can aid surgical planning. The current UK and European guidance recommend small field of view (FOV) CBCT in selected cases where conventional radiographs fail to provide sufficient information on the position of ectopic teeth. As CBCT is associated with a higher effective dose of ionising radiation than conventional radiography, it should be reserved for select paediatric cases rather than used routinely.

9.4 Ectopic Eruption

9.4.1 Eruption of Maxillary Central Incisors

Unerupted maxillary central incisors usually present by the age of 9 years in the mixed dentition with a reported incidence of 0.04%. Non-eruption, however, may present earlier and can be defined as delayed under the following circumstances:

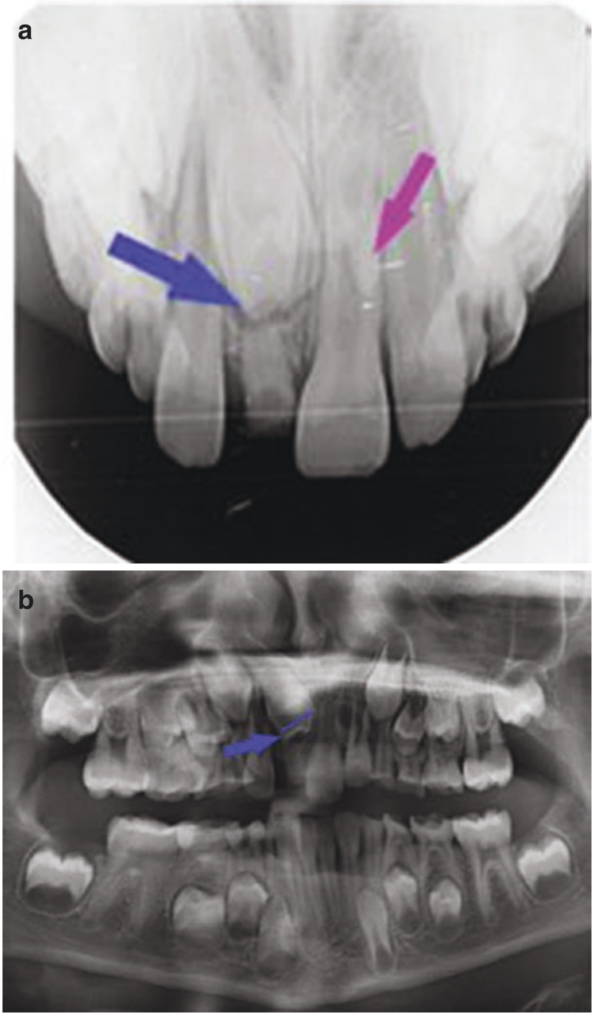

Fig. 9.3 Upper standard occlusal view (**a**) and dental panoramic tomograph (**b**) demonstrating vertical parallax. The radiographs show a tuberculate supernumerary tooth palatal to the upper right central incisor (blue arrow). As the X-ray tube moves towards the horizontal the incisal edge of the supernumerary moves in the same direction in respect to the incisor incisal edge (blue line). NB: there is a second conical supernumerary tooth that has had no effect on eruption of the left central incisor (purple arrow)

1. Eruption of contralateral incisors has occurred 6 months prior.
2. Unerupted maxillary incisors a year after eruption of mandibular incisors.
3. Abnormal eruption sequence where second incisors erupt prior to the first incisors.

By far, the most common cause for unerupted incisors is the presence of supernumerary teeth accounting for 28–60% of cases. Supernumerary teeth can be defined as additional teeth when compared to the normal series. They are more commonly found in males than females and have a prevalence of 0.3–0.8% in the primary dentition and 0.1–3.8% in the permanent dentition. Most are located in the premaxilla. Classification is most commonly based on the shape with conical being the most common (75%) followed by tuberculate (12%), supplemental (7%) and odontomes (6%). Odontomes can further be classified as compound or complex. It is the tuberculate and odontome supernumerary teeth that commonly prevent eruption; conical teeth are more likely to cause displacement (Fig. 9.4). Further details on supernumerary teeth and their management can be found in Chap. 13.

Other causes of delayed incisor eruption can be elicited from a detailed history, clinical and radiographic examination. Trauma, particularly intrusive injuries of primary teeth, can result in crown and/or root dilaceration of the permanent incisor as discussed in Chap. 6. Early loss of the primary incisor whether that be through extraction or avulsion can result in delayed eruption of its successor. More rarely, cystic lesions can cause ectopic eruption. More generalised, systemic conditions should be considered and may be revealed when taking a medical and/or family history. These include cleft lip and palate, cleidocranial dysplasia and Gardner's syndrome.

9.4.1.1 Management

When managing an unerupted incisor, the most important factors to consider are the position of the incisor, the developmental stage of the root and the amount of space available for the tooth to erupt once treatment has been undertaken. Planning should involve a multidisciplinary approach with input from an orthodontist and a paediatric dentist or oral surgeon. The management options are outlined in Table 9.3. If there is insufficient space for the incisor to erupt, an upper removable appliance with maxillary expansion can be used to create space prior to surgical intervention or alternatively elective extraction of the primary canines can be considered to redistribute the space. If an attachment such as a gold chain is placed and there is no spontaneous eruption, an upper removable appliance or sectional fixed appliance can be used to apply traction to the unerupted tooth and bring it into alignment.

Fig. 9.4 Typical clinical appearance of an unerupted upper right central incisor with the retained primary predecessor in an 8-year-old. The child's radiographs can be seen in Fig. 9.3a, b. Note that there is insufficient space for the incisor to erupt

Table 9.3 Management options for the unerupted maxillary incisor (Adapted from RCS guidelines 2016, Yaqoob et al.)

Treatment option	Description	Indications
No treatment	Radiographic and clinical observation	May be considered in cases where the incisor is malformed and/or severely displaced or where a child cannot comply with treatment or has a complex medical history. The teeth should be observed for cystic change. Aesthetic concerns may be addressed by a prosthesis
Removal of supernumerary tooth	Extraction of supernumerary tooth only	Recommended for those <9 years old as the majority will erupt spontaneously (49–91%) providing there is sufficient space. Associated with reduced risk of damage to the immature incisor The incisor should be observed for 9–12 months before considering further intervention
Removal of supernumerary tooth with exposure of the unerupted incisor	Extraction of supernumerary tooth with exposure of the incisor and attachment of a gold chain	Recommended for those >9 years. Reduces the risk of need for repeat GA Suitable for motivated patients with good oral hygiene who are willing to have either removable or fixed orthodontic treatment Closed preferred over open exposure. Closed exposure results in better aesthetics and gingival contour
Surgical removal	Removal of severely dilacerated or ankylosed incisors that cannot be brought into alignment	Recommended where the tooth has minimal potential for eruption or where the root morphology is unfavourable. Orthodontic treatment may be undertaken to create space for a prosthesis The extracted incisor may be decoronated and used as a pontic
Autotransplantation	Premolar transplanted into incisor space if incisor is to be lost	May be considered in acquired hypodontia cases. Recommended where the premolar is extracted as part of orthodontic treatment plan. Periodontium of the patient's own tooth and alveolar process are preserved. Patients should be highly motivated that orthodontic, endodontic and restorative treatment are required. External root resorption and early loss are risks

9.4.2 Assessment of Ectopic Canines

The maxillary canine is the second most common tooth, after the third molar, to become impacted with a prevalence of 1.5%. Ectopic canines are twice as common in females when compared to males, and the incidence of canine impaction in the maxilla is more than twice that in the mandible. It is well established in the literature that ectopic canines are more likely to impact palatally rather than buccally.

Impaction can be caused by several factors and is now recognised to have a polygenic component. Research has shown that 85% of palatally impacted canines had sufficient space for eruption compared to 17% of buccally impacted canines. Therefore, crowding is a predominant aetiological factor for buccally impacted canines. In palatal impactions, guidance theory postulates the role of the lateral incisor root as a physical guide and should the root of the lateral incisor be dysmorphic or absent, the canine will not erupt. Others argue there may be a genetic predisposition to palatally impacted canines and other associated dental anomalies, such as missing or microdont/peg lateral incisors. There have also been associations with other anomalies such as enamel hypoplasia, infraocclusion of primary molars and aplasia of second premolars.

9.4.2.1 Management

Clinical and radiographic indications for intervention include:

- Permanent canine not palpable in labial sulcus by 10 years old.
- Primary canine root resorption not progressing.
- Radiographs indicate ectopic position.
- Damage to adjacent teeth (Using CT, resorption of the incisor roots has been reported to be as high as 48%).
- Canine crown overlaps the second and/or first incisor root.
- Enlargement of canine follicle.

Where suspicion is raised that the permanent canine is ectopic, early referral to a paediatric or orthodontic specialist is recommended. There are several management options available for ectopic canines as listed below (Table 9.4).

9.4.3 Ectopic Eruption of First Permanent Molars

Ectopic eruption of the first permanent molars is a localised disturbance whereby the permanent molar tooth erupts at a mesial angle under the distal part of the second primary molar. It is 25 times more common in the maxilla than the mandible, can be uni- or bilateral and occurs in approximately 4% of the population. The aetiology is unknown, but they are more common in children with cleft lip and palate. Consequences are frequently mild; where there is little resorption of the upper second primary molar root and the permanent molar uprights itself erupting into a favourable position. This occurs in 50–69% of cases and is more common in those under 8 years. In very severe cases, where resorption of both the distal and mesial roots occurs, the results include early loss of the primary molar, mesial eruption of the first permanent molar and shortening of the arch length (Fig. 9.5). Various methods have been reported to disimpact and distalise the first permanent molar including brass wire or elastomeric separator, removable or fixed orthodontic appliances.

Table 9.4 Management of the unerupted canine (Adapted from RCS guidelines 2016, Husain, Burden and McSherry)

Treatment option	Description	Indications
No treatment	Radiographic and clinical observation	Considered if the patient requests no treatment, there is no evidence of root resorption or pathology associated with adjacent teeth and no active orthodontic treatment is planned. These teeth require long-term clinical follow up as dentigerous cyst formation is a risk
Interceptive treatment	Extraction of the primary canine	Reserved for cases where the permanent canine is not severely displaced and the patient is aged between 10 and 13 in the absence of crowding. Often the extraction of the primary canine improves the position of the ectopic canine. Other treatment options should be considered if there is no improvement in position 12 months following extraction
Surgical exposure and orthodontic alignment	Exposure of the impacted tooth and bonding of an orthodontic chain	Suitable for motivated patients with good oral hygiene who are willing to have lengthy fixed orthodontic treatment. Only suitable if the canine is in a favourable position to allow orthodontic alignment
Surgical removal	Surgical extraction of the ectopic canine	For patients who wish to avoid lengthy orthodontic treatment and are generally happy with the appearance of their teeth. Surgical removal of an ectopic canine should be considered with early root resorption of adjacent incisor teeth or the position of the canine is unfavourable for surgical exposure (close proximity to midline, above the apices of adjacent teeth and horizontal angulation). Extraction of buccally ectopic canines can also simplify treatment
Transplantation	Surgical extraction of the ectopic canine in an atraumatic manner, and repositioning into correct position in the dental arch	May be considered if all other options have been explored or failed. It is important that there is adequate space for the canine and sufficient alveolar bone. Depending on the stage of root development of the transplanted tooth, endodontic treatment may be required

Fig. 9.5 Ectopic eruption of upper first permanent molars in a 7-year-old. The upper right molar is severely ectopic and has caused the second primary molar to exfoliate. The upper left molar is also ectopic and has caused the distal root of the second primary molar to resorb

9.5 Common Occlusal Anomalies

9.5.1 Infraocclusion of Primary Molars

Infraocclusion results where there is a localised failure of primary molar eruption compared to the adjacent teeth; the affected tooth has the appearance of 'submerging'. It is a relatively common phenomenon with a prevalence of up to 9% of the population. The mandibular molars are ten times more likely to be affected than the maxillary ones. Treatment is based on the severity and presence of successor premolars. Infraocclusion is described as mild where the occlusal table sits above the contact point of the adjacent tooth, moderate where the infraocclusion is at the contact point or severe where the infraocclusion is below the contact point (Fig. 9.6). For mild and moderate with successor teeth, normal exfoliation would be expected and teeth can be monitored. Severe infraocclusion can result in tipping of the adjacent teeth so extraction of the infraoccluded tooth should be considered. In hypodontia cases, the decision may be taken to undertake a composite build up or extract the tooth depending on the overall orthodontic condition of the patient. Extractions can be difficult due to ankylosis and access.

9.5.2 Crossbites

Crossbites can be defined as an arch relationship discrepancy affecting one or more teeth. The aetiology can be skeletal, soft tissue, dentoalveolar or due to habits (such as digit sucking or biting on objects). Crossbites can be located anteriorly or posteriorly. It is important to check whether or not there is an associated displacement. Indications for treatment of anterior crossbites are to improve aesthetics, to prevent tooth surface loss (wear facets are a common finding) and to prevent or arrest gingival recession or loss of attachment (Fig. 9.7). Management can be undertaken using a removable or fixed appliance and there is little evidence

Fig. 9.6 Severe infraocclusion of the lower left second primary molar

Fig. 9.7 Anterior crossbite upper right central incisor

Fig. 9.8 Unilateral posterior crossbite left side affecting second primary and first permanent molars

to suggest any real difference between the two treatment modalities. Once a positive overjet has been obtained, the result will be stable unless excess mandibular growth occurs.

A posterior crossbite can be defined as a malocclusion where the buccal cusps of the upper canine and/or molar teeth occlude lingually to the buccal cusps of their lower counterparts. Posterior crossbites are a relatively common phenomenon affecting 1–16% of children in the primary dentition and can be bilateral or unilateral. Posterior crossbites are frequently attributed to narrow maxillary arches which may be the result of prolonged digit or dummy sucking or upper airway obstruction. In unilateral posterior crossbites, the discrepancy between the upper and lower arch size results in a mandibular functional shift and a midline discrepancy (Fig. 9.8). Treatment of a unilateral posterior crossbite is usually undertaken in the mixed dentition as the palatal suture has not yet fused. This is usually achieved using an upper removable appliance with a midline screw and anterior capping to disclude the teeth. Other treatment option includes a quad helix appliance or rapid maxillary expansion.

9.6 Summary

Understanding normal development is the key to spotting anomalies in eruption patterns. Dental eruption tends to be symmetrical so any situation where a contralateral tooth has been erupted for more than 6 months should be investigated. This could be as simple as checking the mobility of the overlying primary tooth. Annual palpation for permanent canine teeth in the buccal sulcus from the age of 8 years helps to determine if the tooth is ectopic. Ectopic teeth should be closely monitored as the risk of resorption of adjacent teeth can be significant and can result in loss of otherwise healthy teeth.

Further Reading

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