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Management of Unerupted Maxillary Incisors

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Introduction

Failure of eruption associated with maxillary permanent incisor teeth usually presents in the mixed dentition stage and is often noticed between the ages of 7-9 years. The maxillary incisors are vulnerable to eruption failure secondary to space loss, obstruction or trauma. The anterior maxilla is a common site for the development of supernumerary teeth or odontomes; whilst the developing permanent maxillary incisors are also susceptible to dilaceration and eruption failure following trauma affecting the primary incisor dentition. Missing and unerupted maxillary incisors can be regarded as unattractive and have a potentially negative impact on facial and dental aesthetics, which may effect self-esteem and social interaction (Shaw *et al.,* 1991). Early diagnosis and appropriate management is recommended.

This guideline has been based on current evidence and should be continually developed, as further evidence is made available. There are currently no high-quality randomized controlled trials investigating treatment interventions for the management of unerupted maxillary incisors and with the exception of one investigation, all current evidence is retrospective.

1 Diagnosis and management

1.1 Definition

Delayed eruption of the permanent maxillary incisor teeth can be considered in the following circumstances:

- eruption of the contralateral incisor occurred more than 6 months earlier;
- the maxillary incisors remain unerupted more than one year after the eruption of the mandibular incisors; and
- there is a significant deviation from the normal eruption sequence (for example, lateral incisors erupting prior to the central incisor)

1.2 Causes of delayed eruption

A number of local factors have been associated with delayed eruption of the maxillary incisor dentition. These include the early extraction or loss of primary teeth (with or without space loss); prolonged retention of primary teeth; crowding in the upper labial segment; previous trauma; and localised pathology, which can include supernumerary teeth, odontomes and more rarely, cystic formation. The most common causes are physical obstruction due to the presence of supernumerary teeth or odontomes and trauma to the primary dentition, which may contribute to dilaceration of the permanent successor/s.

Other, less frequent associations include cleft lip and palate (Paradowska-Stolarz *et al.,* 2014) and systemic conditions, which can include the development of multiple supernumerary teeth as part of their phenotypic spectrum (such as cleidocranial dysplasia) (Suri *et al.,* 2004).

2 Incidence and prevalence

It is often stated that the maxillary central incisor is the third-most commonly impacted tooth after third permanent molars and maxillary canines. Failure of eruption associated with maxillary permanent incisors is more frequently seen in the presence of other inherited dental anomalies such as enamel hypoplasia, supernumerary teeth and ectopic teeth (Bartolo *et al.,* 2010). However, by far the most frequent cause of eruption failure is the presence of a supernumerary tooth.

Variation in the reported incidence of maxillary permanent incisor impaction is evident within the literature. In an investigation of Caucasian skulls 5 impacted central incisors were identified in a sample of 1462 (0.0034%) with only 1.96% of all the identified impacted maxillary teeth being central incisors (Mead, 1930). In another sample population aged between 17-26 years, an incidence of 0.04% impacted maxillary central incisors was observed (Grover and Lorton, 1985). In a cohort of patients referred to regional hospitals in the United Kingdom and aged between 6½ to 14 years, the prevalence of supernumeraries in the premaxilla was reported as 2.6% resulting in failed eruption of 42% of the maxillary central incisor teeth (Di Biase, 1968-69).

3 Establishing the cause of eruption failure

3.1 Medical and dental history

A detailed medical and dental history should be obtained to determine any possible hereditary or environmental factors, which may be contributing to

the delay in eruption. A history of trauma to the primary dentition should be sought and documented with approximate dates of the traumatic episode(s) and a description of both the magnitude and direction of the traumatic impact.

3.2 Clinical examination

An intra-oral examination should be undertaken to identify any primary teeth retained significantly beyond their normal exfoliation dates. Clinical features such as spacing and rotations and displacement of permanent teeth should be recorded in the upper incisor region (Tay *et al.,* 1984; Nik-Hussein, 1990). Space loss due to drift of the adjacent lateral incisor into the central incisor position may suggest a disturbance in normal dental development. The presence of labial or palatal swellings, which may indicate the site of an unerupted incisor, should be noted in addition to the angulation and inclination of adjacent teeth and availability of suitable space for eruption of the incisors (approximately 9 mm for a permanent maxillary central incisor and 7 mm for a permanent maxillary lateral incisor) (Moyers *et al.,* 1976).

3.3 Radiographic examination

Failure of eruption associated with of one or more permanent maxillary incisor teeth or retention of the primary incisors beyond the normal age-range warrants further investigation. Intra-oral radiographs can assist in making a diagnosis (Thom and Isaacson, 2013; Isaacson *et al.,* 2015). Periapical views and/or an upper standard occlusal radiograph can be useful in determining the presence and position of maxillary incisor teeth and any underlying developmental anomalies or pathology. These radiographs can also facilitate the use of horizontal or vertical parallax in order to localise the bucco-lingual position of the unerupted tooth (Jacobs, 1999). A cephalometric radiograph can also be of value in the location and assessment of unerupted, malformed or misplaced incisors, particularly in relation to the height of impaction and bucco-lingual inclination of the crown and root of the tooth.

Cone beam computed tomography (CBCT) technology is now widely available for imaging the maxillo-facial region and can, in selected cases, be useful to investigate impacted and ectopic teeth, providing a clear three-dimensional view of these teeth and the associated structures. CBCT is associated with a greater overall effective dose than conventional radiography and should therefore only be prescribed when the required information cannot be adequately obtained using lower dose conventional radiography (SEDENTEXCT, 2012). If dilaceration of an incisor root is suspected, CBCT may be valuable in treatment planning as the degree of aberrant crown-root angulation can be assessed and imaging used to plan the optimal direction of traction applied, ensuring that both the crown and root are maintained in alveolar bone during alignment of the tooth.

4 General principles of management

Despite the lack of definitive treatment protocols, the general principles of managing the delayed eruption or impaction of the permanent maxillary incisor teeth, include the provision of adequate space in the dental arch and the removal of any obstruction to eruption. Consideration should also be given to further promoting eruption through surgical exposure of the incisor, with or without subsequent orthodontic traction. Definitive treatment planning will depend on patient factors such as patient medical history, age and potential compliance; whilst dental factors include the presence of retained primary teeth, the position and stage of development of the impacted incisor, the nature of any physical obstruction to eruption and the presence of unfavourable root formation (dilacerations).

The potential risks of treatment include failure of eruption, ankylosis, external root resorption and poor gingival aesthetics. These risks should be carefully explained to the patient and parent(s). However, in the majority of cases treatment is successful. A number of factors should be considered in treatment planning and these are detailed below.

4.1 Patient factors

4.1.1 Medical history

A number of medical conditions can potentially impact on orthodontic and/or surgical treatment (Patel et al., 2009) and it is important to establish a comprehensive medical history for any patient before

embarking on treatment for an impacted maxillary incisor.

4.1.2 Age

The optimal age for surgical removal of a supernumerary tooth is unknown because in most cases the age at removal will be influenced by the age when the diagnosis was made. Retrospective analysis suggests that spontaneous eruption of an unerupted permanent maxillary incisor is more likely to occur if any associated supernumerary is removed between 8-9 years of age (Munns, 1981; Leyland et al., 2006). However, patient age has also been reported as a non-significant factor in determining spontaneous eruption (Di Biase, 1971).

4.1.3 Compliance

It is important to evaluate potential future compliance for any orthodontic patient and most children are able to cope relatively easily with treatment for an impacted maxillary incisor. However, this problem can affect younger children and a judgement has to be made about their ability to undergo any necessary treatment.

4.2 Dental factors

4.2.1 Retained primary teeth

Any retained primary tooth should be extracted. Where the permanent maxillary incisor is close to eruption or when there is no other obvious causative factor, spontaneous eruption of the successor may occur.

4.2.2 Position of the impacted incisor

The vertical position of the impacted permanent maxillary incisor has been shown to influence both successful spontaneous eruption and the time taken to erupt (Chaushu *et al.,* 2015; Smailiene *et al.,* 2006). A small retrospective study demonstrated that the higher the vertical position of an unerupted maxillary incisor, the less likely it was to erupt spontaneously after an obstructing supernumerary tooth was removed. In this investigation, only 28.6% of unilaterally impacted permanent maxillary incisors erupted spontaneously when their initial position was at the level of the apical third of the root of the contralateral erupted maxillary incisor (Smailiene *et al.,* 2006).

4.2.3 Developmental stage of the impacted incisor

The stage of development of an impacted permanent maxillary central incisor may also influence eruption of this tooth. Some reports suggest that incisors with immature roots are more likely to erupt spontaneously following supernumerary removal than those with mature roots (Foley, 2004, Mason et al., 2000). However, others have found no difference in the eruption of unerupted incisors in relation to their stage of root development (Di Biase, 1971).

4.2.4 Nature of any physical obstruction to eruption

If the cause of any obstruction is a supernumerary tooth, the morphology of this tooth and the resultant degree of incisor displacement will both influence the success of spontaneous eruption of the permanent maxillary incisor following surgical removal of the supernumerary (Ashkenazi et al., 2007: Bryan et al., 2005; DiBiase 1969; Foley 2004; Patchett et al., 2001; Smailiene et al., 2006). Tuberculate supernumerary teeth and odontomes are more likely to obstruct permanent maxillary incisor eruption with greater resultant displacement than conical supernumerary teeth (Ashkenazi et al., 2007; Foster and Taylor, 1969; Leyland et al., 2006; Mason et al., 2000; Patchett et al., 2001). It has been further reported that one third of compound and one half of complex odontomes prevent eruption of teeth (Katz 1989).

4.2.5 Unfavourable root formation

Dilaceration is defined as an acute deviation of the long axis of the tooth, located to the crown or the root portion and originating from a traumatic non-axial displacement of already formed hard tissue in relation to the developing soft tissue (Andreasen, 2007). This malformation can affect the permanent maxillary incisors and is thought to be caused by environmental (trauma to primary predecessors) and developmental factors. Traumatic injuries to the primary dentition are relatively common, with a prevalence ranging from 11-30% (Andreasen and

Ravn, 1972). The potential benefits of aligning permanent maxillary incisors with root dilacerations in adolescent patients include maintenance of dental aesthetics, associated psychosocial benefits and preservation of alveolar bone for future osseous-retained restorations. Dilacerated incisors may be brought into the line of the arch following exposure and application of orthodontic traction (Nashashibi, 1986; Sandler and Reed, 1988). An adult sample has shown limited evidence of favourable long-term periodontal outcomes following the orthodontic eruption of dilacerated permanent maxillary incisors (Farronato et al., 2014). It has also been suggested that dilacerated permanent maxillary incisors will take longer to align successfully and have a poorer prognosis for successful eruption than those impacted due to simple obstruction (Chaushu et al., 2015). The use of a lateral skull radiograph or CBCT can be beneficial if dilaceration is suspected from standard radiographic views. The extent of the dilaceration, inclination of the crown and root and the quality and quantity of the alveolar bone at the site where the tooth will be moved can be assessed with greater clarity in three dimensions. Ultimately, the extent of the dilaceration and inclination of the crown will determine whether attempting orthodontic alignment is feasible.

5 Management options

5.1 Removal of a physical obstruction

The presence of a supernumerary tooth or odontome is responsible for delayed eruption or impaction of the permanent maxillary incisors in approximately 28-60% of cases (Betts and Camilleri, 1999; Bodenham, 1967; Di Biase, 1969; Foster and Taylor, 1969;Gregg and Kinirons, 1991; Howard, 1967). Indeed, 90-98% of maxillary supernumerary teeth develop within the midline and maxillary central incisor region (Tay *et al.,* 1984).

5.2 Removal of the obstruction only

Following the removal of a supernumerary tooth, retrospective evaluation suggests that between 49-91% of permanent maxillary incisors will erupt spontaneously (Foley, 2004; Leyland *et al.,* 2006; Mason *et al.,* 2000; Witsenburg and Boering, 1981). Although these figures appear to be favourable, there is a large variation in the reported time taken for the incisor to erupt, which can be up to 18 months (Leyland *et al.,* 2006). For optimal results, it would seem sensible to suggest that the supernumerary tooth is removed with minimal disturbance to the follicle of the unerupted incisor, although there is no evidence with regard to this.

5.2.1 Removal of the obstruction with creation of space

Eruption of the maxillary incisor can be further facilitated with space creation in conjunction with removal of the obstruction. Retrospective evaluation has suggested that following the removal of a supernumerary tooth, spontaneous eruption is more likely if space exists in the dental arch to accommodate the unerupted incisor (Bryan *et al.,* 2005; Di Biase, 1971; Howard, 1967; Leyland *et al.,* 2006; Mitchell and Bennett, 1992; Smailiene *et al.,* 2006; Witsenburg and Boering, 1981). However, between 30-54% of impacted incisors will still require further surgical intervention (Foley, 2004; Mason *et al.,* 2000; Patchett *et al.,* 2001; Witsenburg and Boering, 1981) and some form of orthodontic alignment (Di Biase, 1971). Prospective analysis further supports space creation in facilitating eruption, with 82% of incisors erupting spontaneously when combined with maxillary expansion (Pavoni *et al.,* 2013).

Space can be created with a simple removable appliance in selected cases or fixed appliances (sectional or full arch) with or without extraction of primary canines. Adequate space creation using fixed orthodontic appliances prior to any surgical intervention has been shown to significantly reduce overall treatment time (Di Biase 1971; Lygidakis *et al.,* 2015; Pavoni *et al.,* 2013).

5.3 Surgical intervention(s)

In addition to the surgical removal of any obstruction, surgical exposure of the maxillary incisor teeth may also be indicated. In these circumstances, early orthodontic traction can enhance this facilitated eruption (Ashkenazi *et al.,* 2007). There is a lack of scientific evidence to support the decision as to whether unerupted permanent maxillary incisors should be surgically

exposed at the time of supernumerary removal or whether spontaneous eruption should be allowed. Following the removal of a supernumerary tooth, between 30-54% of impacted permanent maxillary incisors will require further surgical intervention to facilitate their eruption (Foley, 2004; Mason et al. 2000; Patchett *et al.,* 2001; Witsenburg and Boering, 1981). It is good clinical practice to avoid the need for repeat general anaesthesia whenever possible and so it is prudent to consider surgical exposure and bonding of an orthodontic attachment at the time of supernumerary removal. This attachment can then be used later if required, to align the incisor and therefore avoid the need for a second general anaesthetic (RCS UK National Guidelines in Paediatric Dentistry, 2008). The success of surgical exposure combined with orthodontic traction has been reported to exceed 90%, with the height of the impacted incisor appearing to influence the duration of such treatment (Chaushu *et al.,* 2015). Ideally, if young patients have a good standard of oral hygiene, can tolerate and are compliant with fixed orthodontic appliances, then these represent the appliances of choice to apply light traction to the exposed incisor. As the majority of patients with unerupted maxillary incisors present in the mixed dentition stage, the first permanent molars, lateral incisors and the contralateral central incisor tooth are usually included in the fixed appliance as these are often the only permanent teeth that have erupted at this time. In this situation, a 2 x 4 fixed appliance can useful for space creation, space maintenance and the application of traction to the unerupted incisor if required (McKeown and Sandler, 2001).

Either an open exposure or closed eruption procedure can be employed to promote eruption of unerupted maxillary incisors.

5.3.1 Open exposure

The open exposure of an unerupted permanent maxillary incisor, by means of a simple elliptical incision of the overlying soft tissue, is rarely indicated but may be useful when there is a soft tissue impaction, with the tooth occupying a very superficial position just beneath the mucosa. The vertical position of the incisor and width of the attached mucosa must allow a band of attached gingiva to be retained after the exposure, so that this can form a healthy gingival attachment to the tooth over time when it is in its final position (Becker *et al.,* 2002; Vanarsdall and Corn, 2004). Where the vertical height of the unerupted incisor precludes a simple soft tissue excision over the crown of the tooth because a normal gingival attachment will not be generated, an apically repositioned flap can be used to expose the crown of the tooth, provided that it is not significantly mesially or distally displaced. This technique has been associated with increased incisor crown length and poor soft tissue aesthetics (Chaushu *et al.,* 2009; Vanarsdall and Corn, 2004; Vermette *et al.,* 1995). Whilst open exposure affords the orthodontist the advantage of bonding to the unerupted incisor under a dry field and planning the direction of traction applied, post-operative hygiene and care following an apically repositioned flap can be challenging for a young patient.

5.3.2 Closed eruption technique

In the closed eruption technique, a mucoperiosteal flap incorporating the attached gingiva is raised and an attachment bonded to the impacted incisor before the flap is replaced into its original position. The attachment should incorporate a gold chain or traction ligature to facilitate the application of orthodontic forces (Becker *et al.,* 1996; 2002; Noar and Gaukroger, 2000; Oliver and Hardy, 1986). Ideally, the attachment should be low profile and bonded to the palatal surface of the unerupted incisor to allow orthodontic traction to be applied in the most favourable direction and to reduce the risk of fenestration of the attachment through the thin overlying alveolar mucosa as the tooth is aligned. Clinical photographs taken with the flap raised and attachment bonded at the time of surgery may be helpful in planning the direction of future traction, especially if both permanent central incisors are unerupted.

5.3.3 Open versus closed eruption techniques

There are only a few studies that have specifically compared open *versus* closed eruption techniques for impacted permanent maxillary incisor teeth. Early studies demonstrated superior results for closed eruption in terms of gingival, periodontal and pulpal

status. Longitudinal assessment of closed versus open eruption has reported longer clinical crowns and decreased bone support in association with open eruption (Chaushu *et al.,* 2009).

5.4 Incisor removal

When a permanent maxillary incisor has to be removed due to significant dilaceration or ankylosis and infra-occlusion, space should be maintained for subsequent replacement, initially with a fixed or removable prosthesis. In the longer-term, an implant-retained prosthesis may be considered (Henry *et al.,* 1996; Kokich and Crabill, 2006). Prolonged absence of a tooth within the dental arch can lead to significant loss of alveolar volume in the affected region. This bone loss can result in a reduction of both height and width of the alveolus which may subsequently require augmentation, thus complicating both implant placement and long-term success. Alternative management strategies, particularly in the younger child, include accepting the unerupted tooth and leaving it *in situ* until the start of definitive orthodontic treatment to manage the malocclusion or to bring the tooth into the line of the arch, even though it may be sacrificed later. Other options aimed at preserving alveolar bone following the extraction of an unerupted central incisor include moving a reasonably sized lateral incisor tooth into the central incisor position for camouflage or to accept spontaneous space closure in the labial segment and then open up space with a fixed appliance prior to definitive restoration in the permanent dentition (Kokich and Crabill, 2006).

5.5 Ankylosed maxillary incisors

A potentially unfavourable complication of aligning unerupted permanent maxillary incisors is ankylosis. The following treatment options are available for ankylosed permanent maxillary incisors:

- Periodical follow-up with possible composite build-up for any minor infra-occlusion;
- Repositioning of the ankylosed incisor (including surgical dislodgement and repositioning; osteotomy and repositioning or distraction osteogenesis);
- Extraction of the ankylosed incisor followed by orthodontic space closure;
- Decoronation of the incisor, if growth is still active, to preserve the width and vertical height of the alveolar bone (Malmgren, 2000); and
- Extraction of the ankylosed incisor followed by replacement with conventional or implant prosthesis if the patient's growth is nearing completion.

There is currently insufficient high-level evidence for comparing the effectiveness of different treatment methods relating to the ankylosed maxillary incisor (de Souza et al., 2015).

5.6 Autotransplantation

The autotransplantation of a developing premolar to replace a missing permanent maxillary incisor has been documented to provide a physiologically sound tooth and maintenance of the alveolar process with good long-term survival rates (Czochrowska et al., 2000). The most commonly selected combination is autotransplantation of the lower second premolar to replace a maxillary central incisor. The main advantage is physiological; as the process involves placement of the patient's own vital tooth with a preserved periodontium, which is followed by morphological alteration through coronal reshaping. The main disadvantage is that the tooth can have a poor morphology and require extensive restorative work. In addition, there can be problems with the functional occlusion due to the presence of a palatal cusp. Moreover, in some cases there can be rapid external root resorption and, ultimately, premature loss of the transplanted tooth.

5.7 Monitoring of further dental development

Patients with impacted permanent maxillary central incisors are reported to have an increased risk of further disruption to normal dental development. In a retrospective study, the prevalence of maxillary canine displacement on the same side as an unerupted incisor was reported to be significantly increased compared to the contralateral side (Chaushu et al., 2003).

Recommendations

The occurrence of unerupted or impacted permanent maxillary incisors may be associated with both developmental and environmental factors. This

condition can lead to poor dental and facial aesthetics and malocclusion, including localised space loss. It is desirable for impacted maxillary incisor teeth to be accommodated in the dental arch if practicable, ideally at the earliest opportunity, to afford dental, functional, aesthetic and psychosocial benefits to the patient.

- When treatment planning for an unerupted permanent maxillary incisor, it is important that space is available for the impacted tooth in the arch and that any obstruction is removed;
- Other factors that can influence spontaneous eruption include the vertical position, displacement and root development of the impacted incisor;
- The most common reason for obstructed permanent maxillary incisor eruption is the presence of a supernumerary tooth. Retrospective data suggests that a significant proportion of these teeth can be expected to erupt following removal of the obstruction;
- In the younger patient (<9 years of age) with an immature permanent maxillary incisor, it may be reasonable to allow up to 9-12 months for spontaneous eruption of the incisor after the removal of an obstruction before considering further intervention;
- In the older individual (>9 years of age) with a mature permanent maxillary incisor, it is reasonable to consider "open" or "closed" surgical exposure with bonding of an orthodontic attachment at the time of removal of any obstruction, particularly if the unerupted incisor is high;
- It is desirable, particularly when surgical treatment has to be carried out under general anaesthesia, to avoid multiple procedures. If surgery is required to remove an obstruction, then serious consideration should be given to simultaneous closed exposure and bonding of an orthodontic attachment with a gold chain;
- Patient compliance must be assessed as some younger patients may not be able to accept fixed appliance treatment and surgical exposure with traction. Each individual case must be considered independently;
- A dilacerated permanent maxillary incisor should be aligned in the dental arch with the use of a closed surgical exposure and orthodontic traction, if at all possible; and
- Ideally, examination and treatment planning should be undertaken within a multi-disciplinary clinic. In this way, collective decisions can be made with paediatric dental and/or oral surgery colleagues regarding the timing of treatment, most appropriate choice of surgery and, if necessary, the best position of any attachment in order to optimise a favourable outcome.

References

Andreasen JO, Andreasen FM, Andersson L (Editors). *Traumatic Injuries to the Teeth.* 4th Edition. Wiley-Blackwell; 2007.

Andreasen JO, Ravn JJ, 1972. Epidemiology of traumatic dental injuries to primary and permanent teeth in a Danish population sample. *Int J Oral Surg* 2007; **1**: 235-239.

Ashkenazi M, Greenberg BP, Chodik G *et al.* Postoperative prognosis of unerupted teeth after removal of supernumerary teeth or odontomas. *Am J Orthod Dentofacial Orthop* 2007; **131**: 614-619.

Bartolo A, Camilleri A, Camilleri S. Unerupted incisors - characteristic features and associated anomalies. *Eur J Orthod* 2010; **32**: 297-301.

Becker A, Brin I, Ben-Bassat Y *et al.* Closed-eruption surgical technique for impacted maxillary incisors: a postorthodontic periodontal evaluation. *Am J Orthod Dentofacial Orthop* 2002; **122**: 9-14.

Becker A, Shpack N, Shteyer A. Attachment bonding to impacted teeth at the time of surgical exposure. *Eur J Orthod* 1996; **18**: 457-463.

Betts A, Camilleri GE. A review of 47 cases of unerupted maxillary incisors. *Int J Paediatr Dent* 1999; **9**: 285-292.

Bodenham RS. The treatment and prognosis of unerupted maxillary incisors associated with the presence of supernumerary teeth. *Br Dent J* 1967; **123**: 173-177.

Bryan RA, Cole BO, Welbury RR. Retrospective analysis of factors influencing the eruption of delayed permanent incisors after supernumerary tooth removal. *Eur J Paediatr Dent* 2005; **6**: 84-89.

Chaushu S, Becker T, Becker A. Impacted central incisors: factors affecting prognosis and treatment duration. *Am J Orthod Dentofacial Orthop* 2015; **147:** 355-362.

Chaushu S, Dykstein N, Ben-Bassat Y *et al.* Periodontal status of impacted maxillary incisors uncovered by 2

different surgical techniques. *J Oral Maxillofac Surg* 2009; **67:** 120-124.

Chaushu S, Zilberman Y, Becker A. Maxillary incisor impaction and its relationship to canine displacement. *Am J Orthod Dentofacial Orthop* 2003; **124:** 144-150; discussion 150.

Czochrowska EM, Stenvik A, Album B *et al.* Autotransplantation of premolars to replace maxillary incisors: a comparison with natural incisors. *Am J Orthod Dentofacial Orthop* 2000; **118:** 592-600.

de Souza RF, Travess H, Newton T *et al.* Interventions for treating traumatised ankylosed permanent front teeth. *Cochrane Database Syst Rev.* 2015: 12;CD007820.

Di Biase DD. Midline supernumeraries and eruption of maxillary central incisors. *Dent Pract Dent Rec* 1969; **Sep;20(1):** 35-40

Di Biase DD. Midline supernumeraries and eruption of the maxillary central incisor. *Dent Pract Dent Rec* 1969; **20:** 35-40.

Di Biase DD. The effect of variations in tooth morphology and position on eruption. *Dent Pract Dent Rec* 1971; **22:** 95-108.

Farronato G, Giannini L, Galbiati G *et al.* A 5-year longitudinal study of survival rate and periodontal parameter changes at sites of dilacerated maxillary central incisors. *Prog Orthod* 2014 Jan 6; **15:** 3.

Foley J. Surgical removal of supernumerary teeth and the fate of incisor eruption. *Eur J Paediatr Dent* 2004; **5:** 35-40.

Foster TD, Taylor GS. Characteristics of supernumerery teeth in the upper central incisor region. *Dent Pract Dent Rec* 1969; **20:** 8-12.

Gardiner JH. Supernumerary teeth. *Dent Pract Dent Rec* 1961; **12:** 63-73.

Gregg TA, Kinirons MJ.. The effect of the position and orientation of unerupted premaxillary supernumerary teeth on eruption and displacement of permanent incisors. *Int J Paediatr Dent* 1991; **1:** 3-7.

Grover PS, Lorton L. The incidence of unerupted permanent teeth and related clinical cases. *Oral Surg Oral Med Oral Pathol* 1985; **59:** 420-425.

Henry PJ, Laney WR, Jemt T *et al.* Osseointegrated implants for single-tooth replacement: a prospective 5-year multicenter study. *Int J Oral Maxillofac Implants* 1996; **11:** 450-455.

Howard RD. The unerupted incisor. A study of the postoperative eruptive history of incisors delayed in their eruption by supernumerary teeth. *Dent Pract Dent Rec* 1967; **17:** 332-341.

Isaacson KG, Thom AR, Atack NE *et al. Orthodontic Radiographs, 4th Edition.* British Orthodontic Society; 2015.

Jacobs SG. Radiographic localization of unerupted maxillary anterior teeth using the vertical tube shift technique: the history and application of the method with some case reports. *Am J Orthod Dentofacial Orthop* 1999; **116:** 415-423.

Katz RW. An analysis of compound and complex odontomas. *ASDC J Dent Child* 1989; **56:** 445-449.

Kokich VG, Crabill KE. Managing the patient with missing or malformed maxillary central incisors. *Am J Orthod Dentofacial Orthop* 2006; **129:** S55-63.

Leyland L, Batra P, Wong F *et al.* A retrospective evaluation of the eruption of impacted permanent incisors after extraction of supernumerary teeth. *J Clin Pediatr Dent* 2006; **30:** 225-231.

Lygidakis NN, Chatzidimitriou K, Theologie-Lygidakis N *et al.* Evaluation of a treatment protocol for unerupted maxillary central incisors: retrospective clinical study of 46 children. *Eur Arch Paediatr Dent* 2015; **16:** 153-164.

Malmgren B. Decoronation: how, why and when? *J Calif Dent Assoc* 2000; **28:** 846-854.

Mason C, Azam N, Holt RD *et al.* A retrospective study of unerupted maxillary incisors associated with supernumerary teeth. *Br J Oral Maxillofac Surg* 2000; **38:** 62-65.

McKeown HF, Sandler PJ. The two by four appliance: a versatile appliance. *Dent Update* 2001; **28:** 496-500.

Mead SV. Incidence of impacted teeth. *Int Orthod* 1930; **16:** 885-890.

Mitchell L, Bennett TG. Supernumerary teeth causing delayed eruption - a retrospective study. *Br J Orthod* 1990; **19:** 41-46.

Moyers RE, van der Linden PGM, Riolo ML *et al. Standards of Human Occlusal Development. Monograph 5, Craniofacial Growth Series.* Ann Arbor, Michigan, Center for Human Growth and Development, University of Michigan, 1976

Munns D. Unerupted incisors. *Br J Orthod* 1981; **8:** 39-42.

Nashashibi IA. Orthodontic movement of a palatally displaced, dilacerated, unerupted maxillary central incisor. *J Pedodont* 1986; **11:** 83-90.

Nik-Hussein NN. Supernumerary teeth in the premaxillary region: its effects on the eruption and occlusion of the permanent incisors. *Aust Orthod J* 1990; **11:** 247-250.

Noar JH, Gaukroger MJ. Customized metal coping for elastic traction of an ectopic maxillary central incisor. *J Clin Orthod* 2000; **34:** 585-589.

Oliver RG, Hardy P. Practical and theoretical aspects of a method of orthodontic traction to unerupted teeth illustrated by three cases. *Br J Orthod* 1986; **13:** 229-236.

Paradowska-Stolarz A, Dubowik M, Szelag J *et al.* Dental anomalies in the incisor-canine region in patients with cleft lip and palate - literature review. *Dev Period Med* 2014; **18:** 66-69.

Patchett CL, Crawford PJ, Cameron AC *et al.* The management of supernumerary teeth in childhood–a retrospective study of practice in Bristol Dental Hospital, England and Westmead Dental Hospital, Sydney, Australia. *Int J Paediatr Dent* 2001; **11:** 259-265.

Patel A, Burden DJ, Sandler J. Medical disorders and orthodontics. *J Orthod* 2009; **36:** 1-21.

Pavoni C, Franchi L, Lagana G *et al.* Management of impacted incisors following surgery to remove obstacles to eruption: a prospective clinical trial. *Pediatr Dent* 2013; **35:** 364-368.

Davies C, Harrison M, Roberts G. *Guideline for the Use of General Anaesthesia (GA) in Paediatric Dentistry* 2008. Faculty of Dental Sugery, Royal College of Surgeons of England. https://www.rcseng.ac.uk/dental-faculties/fds/publications-guidelines/clinical-guidelines/

Sandler PJ, Reed RT. Treatment of a dilacerated incisor. *J Clin Orthod* 1988; **22:** 374-376.

SEDENTEXCT. *Radiation Protection No 172: Cone Beam CT for Dental and Maxillofacial Radiology. Evidence-based guidelines.* 2012. http://www.sedentexct.eu/content/guidelines-cbct-dental-and-maxillofacial-radiology

Shaw WC, O'Brien KD, Richmond S *et al.*1991. Quality control in orthodontics: risk/benefit considerations. *Br Dent J* 1991; **170:** 33-37.

Smailiene D, Sidlauskas A, Bucinskiene J. Impaction of the central maxillary incisor associated with supernumerary teeth: initial position and spontaneous eruption timing. *Stomatologija* 2006; **8:** 103-107.

Suri L, Gagari E, Vastardis H. Delayed tooth eruption: pathogenesis, diagnosis, and treatment. A literature review. *Am J Orthod Dentofacial Orthop* 2004; **126:** 432-445.

Tay F, Pang A, Yuen S. Unerupted maxillary anterior supernumerary teeth: report of 204 cases. *ASDC J Dent Child* 1984; **51:** 289-294.

Thom A., Isaacson K. *Radiographs in the Management of the Developing Dentition. Selection Criteria for Dental Radiography.* Faculty of General Dental Practice (UK); 2013. pp41-50.

Vanarsdall RL, Corn H. Soft-tissue management of labially positioned unerupted teeth. July 1977. *Am J Orthod Dentofacial Orthop* 2004; **125:** 284-293.

Vermette ME, Kokich VG, Kennedy DB. Uncovering labially impacted teeth: apically positioned flap and closed-eruption techniques. *Angle Orthod* 1995; **65(1):** 23-32; discussion 33.

Witsenburg B, Boering G. Eruption of impacted permanent upper incisors after removal of supernumerary teeth. *Int J Oral Surg* 1981; **10:** 423-431.