

Permanent First Molar Eruption Failure in Children: clinical management of three clinical scenarios

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Abstract

Background Eruption failure in the mixed dentition presents many challenges, but eruption disorders in a child patient offer solutions that are not possible in adult patients. The opportunity to remedy the occlusal outcomes for eruption problems in the mixed dentition depends on the type of problem; we consider three major categories of eruption problems and corresponding management strategies. The distinction between a mechanical failure of eruption (MFE), ankylosis of a single tooth, or Primary Failure of Eruption (PFE) due to a genetic defect that alters dental eruption is key to the potential intervention. The therapeutic solutions proposed in the literature differ greatly for the three clinical scenarios. In MFE, orthodontic therapy can be successful if the obstacle to eruption is identified early. For cases of ankylosis, the affected tooth can be extracted, and the space closed orthodontically if timed appropriately. A diagnosis of PFE, however, carries a certain poor prognosis with a continuous arch wire; orthodontic forces will result in the intrusion of adjacent teeth.

Case report We evaluated the clinical outcomes of three patients presenting with eruption failure of the permanent first molar(s) due to: 1) ankylosis; 2) MFE; and 3) PFE. Taken together, these cases provide indications for treatment possibilities supporting the growing patient.

Conclusion Early treatment of ankylosis can yield positive results, but the possibility of failure must be considered and, therefore, monitored carefully. For MFE, the timing of intervention should align with patients in the late mixed dentition. Finally, a diagnosis of PFE carries the certainty that affected teeth cannot be moved orthodontically; the resultant dentoskeletal development may however benefit from a functional orthopaedic appliance to prevent asymmetric growth.

KEYWORDS Primary Failure of Eruption (PFE), Mechanical Failure of Eruption (MFE), Ankylosis, early treatment, orthodontics.

Introduction

Failure of eruption seen in first permanent molars is a rare event [Roulias et al., 2022], but it presents the clinician with two broad challenges. First, the correct diagnostic classification can be difficult to confirm, and second, the resultant therapeutic options are often limited and offer suboptimal results. Among the providers who may first discover an eruption disorder in a child (i.e., the general practice and paediatric dentists), neither may elect to

provide therapeutic management of this malocclusion since it often falls into the scope of work more often performed by an orthodontist. However, when this problem is observed in a child, if the provider does not arrive at a timely and correct diagnosis and management, the prognosis is poor. Distinguishing the cases into primary failure of eruption (PFE), ankylosis, and mechanical failure of eruption (MFE) is a necessary first step to creating an adequate treatment plan [Inchingolo et al., 2023]. The diagnosis is crucial because the possibilities of helping the eruption using orthodontic forces are very different in the three cases. If we consider the orthodontic management of ankylosis, the options are limited but contrasting in approach. Case reports of Pithon [2011–2016] and Rosner et al. [2010] suggest luxation before applying an orthodontic force. Luxation should be reapplied to the ankylosed tooth in case of a partial failure of the orthodontic movement. Marañón-Vásquez [2019] and Kulol [2006] reported that sometimes luxation often results in re-ankylosis and failure in orthodontically guided eruption. Alternatively, an appropriately timed extraction of an ankylosed first permanent molar shows some promising outcomes. This approach was described in a case report by Park et al. [2021], who extracted the ankylosed first molar near the developmental stage as the second molar erupted. This allowed for eruption and mesial drifting of the second molar and normal eruption of the third molar. More invasive solutions proposed by Takagi et al. [2022] apply to the adult dentition, including a corticotomy surrounding the affected tooth before orthodontic extrusion. While the corticotomy approach is rather aggressive for a single ankylosed tooth, it has been described as one possibility in the treatment of PFE-affected teeth [Frazier-Bowers et al., 2016]. The prognosis for patients with MFE has a higher probability of a favorable result, especially in the child patient. When a diagnosis of MFE is made considerably after the late mixed dentition, the severity of the clinical problem will often increase, and the management will be more challenging. Furthermore, if the mechanical obstacle, such as the delayed resorption of a second deciduous molar or the lack of space, is combined with the interposition of the tongue, orthodontic therapy can be very difficult. The traction of impacted or infraoccluded teeth when root formation is completed requires careful planning of the anchorage and careful monitoring of therapeutic progress. Two interesting examples of orthodontic management in a MFE diagnosis are described by Awad et al. [2021] and by Mubeen and Sehra [2018]. In contrast with ankylosis or MFE, PFE associated

Descriptor	Ankylosis	Tongue pressure (MFE)	PFE
Age of patient at initial records	9 years (Figure 1)	10 years (Figure 4)	7 years (Figure 7)
Bony Pathway Clear	Yes (Figure 1)	Yes (Figure 5)	Yes (Figure 7)
Therapy Used	Phase I: Anchorage device with elastic chains and buttons (Figure 2) Phase II: Fixed multibracket therapy (Figure 3)	Phase I: Myofunctional therapy (Figure 6a) Phase II: Fixed orthodontic appliance – MBT with vertical elastics (Figure 6b)	Phase I: Function Generating Bite appliance (Figure 8) Phase II: Bionator appliance (Figure 9)
Teeth Involved	Lower left first molar (36)	MFE: 16, 26, 36, 46 Infraocclusion: 55, 65, 75, 85	PFE: Lower left first molar (36) Infraocclusion: 55, 65, 75, 85
Clinical Presentation	- Dilacerated distal root of tooth 36 - No reduction in bone height or resorption - No open bite present - No crossbite present - No tongue thrust habit present	- Normal roots - No reduction in bone height or resorption - Bilateral open bite - No crossbites present - Incomplete eruption of all four permanent first molars - Infraocclusion of the deciduous molars - Tongue thrust habit present	- Normal roots - No reduction in bone height or resorption - Large open bite on the left - Anterior and lateral crossbite on the right - Incomplete eruption of left first molars - Infraocclusion of deciduous molar - Second molars completely unerupted - Tongue thrust habit present
Presence of PTH1R Mutation	Not tested	No	Yes

TABLE 1

with a variant in the PTH1R gene consistently shows the failure of orthodontic therapies (except for the rarely described incomplete penetrance) [Frazier-Bowers et al., 2010; Yamaguchi et al., 2011; Hanish et al., 2018]. The most common effects are inclination of the occlusal plane due to the intrusion of adjacent teeth, and lateral open bite [Thuair et al. 2024]. Early treatment is indicated in the most severe cases to avoid consequences for jaw growth. Thuair et al. [2024] suggest extraction of the affected teeth, followed by temporary restorations in children and teenagers under 18 years of age. The removable dentures should be changed during growth to adapt to the development of the dental arches. Treatment information for PFE, in contrast to MFE and ankylosis, primarily applies to adult patients and depends on the severity of the case. In simpler cases, it is suggested to construct build-ups on the crowns of infraoccluded teeth. In more complex cases it is suggested to intervene with combined surgical and prosthetic interventions, or with removable prostheses [Yamaguchi, 2022; Wagner et al., 2023; Thuair et al. 2024]. However, the evidence and data evaluating the short- and long-term outcomes of PFE (or lateral open bite) is sparse, and the surgical approach (i.e. corticotomy) is not an option for the growing child. There is a dearth of publications on the clinical management of PFE, especially related to early treatment. Therefore, we consider and summarise the treatment possibilities for three eruption disorder diagnoses and indicate the limits of treatment in the children. This work explores treatment options for paediatric patients with molar eruption failure when an early diagnosis is made. Over the course of ten years, our collective studies, out of necessity, have included the assessment of many clinical images that track dental development and occlusal relationships. Careful consideration of our paediatric patients' longitudinal clinical records combined with the analysis of the PTH1R gene, allows us to observe clinical outcomes in three clinical illustrative cases of the therapeutic possibilities in PFE, MFE and ankylosis, respectively.

Materials and Methods

The clinical cases we present here have the characteristic of having one or more permanent first molars with eruption problems and being children with mixed dentition. Patients have no systemic

pathologies. The study protocol was written in accordance with the Declaration of Helsinki and approved by the Ethic Committee of Catholic University of Sacred Heart of Rome (ID 565-11/2015). Clinical cases were collected from 2015 to present to increase the chance of identifying the rare clinical condition PFE. We identified three clinical scenarios representative of distinct clinical problems underlying the failure or interruption of the eruption process of the first permanent molars: ankylosis, failure due to the presence of a mechanical obstacle (MFE) and the presence of pathogenic variants in the PTH1R gene (PFE).

Case selection criteria

The selection criterion for the three clinical examples of eruption failure included:

- initial records (diagnosis) in the mixed dentition;
- clinical documentation spanning at least 2 years;
- compliant patient;
- presence of at least one affected permanent first molar;
- absence of systemic pathologic or genetic syndromes, including craniofacial and skeletal;
- inclusion of at least one patient with ankylosis; one patient with MFE, and one patient with PFE using previously described diagnostic rubric [Rhoads et al. 2013].

A summary of each eruption failure clinical scenario includes diagnosis and treatment is reported below (See Table I).

Clinical Scenario: Ankylosis

The dental eruption status of a 9-year-old patient, in early mixed dentition was characterised by an impacted lower left first molar with roots approximating the lower edge of the mandible. The distal root was hooked, the height of the bone was not reduced and the bone in the eruption path was not clear. These features directed the diagnosis of ankylosis (Fig. 1). The eruption path was not clear, and additional clinical signs including fully formed roots and the presence of a cyst surrounding the crown were present that led to the diagnosis of ankylosis. A banded appliance that included a lingual arch was used as anchorage—cemented on the right first permanent molar and the left second deciduous molar. In an abundance of caution (in case the diagnosis was PFE), the anchorage was prepared on the adjacent deciduous molar to

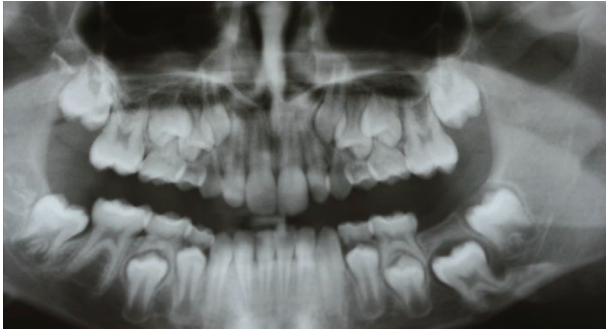


FIG. 1. Panoramic radiograph of a 9-year-old patient in early mixed dentition showing an impacted lower left first molar (tooth 36) with roots positioned near the inferior border of the mandible. The distal root is dilacerated.

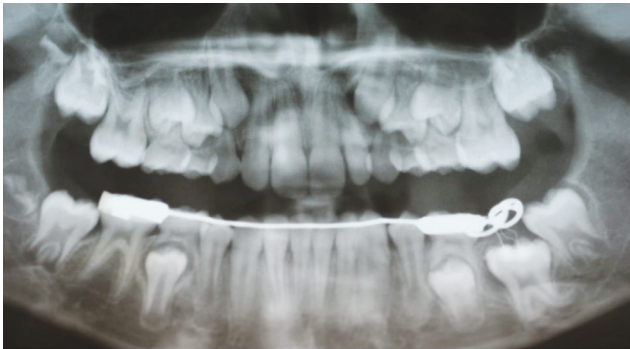


FIG. 2. Ankylosis case: Phase 1 treatment. An anchorage device was fabricated with bands on the right first permanent molar (tooth 46) and the left second deciduous molar (tooth 75), connected by a lingual arch. Using the deciduous molar as anchorage reduced the risk of iatrogenic intrusion in case of failure. A distal eyelet was welded to the device above the impacted molar. Bone along the eruption path was removed, and two buttons were bonded to the occlusal surface of tooth 36, with elastic chains attached for traction.

decrease the risk of iatrogenic intrusion. A distal eyelet was welded to the device in the area above the impacted molar. The bone present along the eruption path was removed surgically and two buttons were positioned on the occlusal surface of the impacted molar, with elastic chains attached to bind and traction the tooth (Fig. 2). The elastic chains were replaced every 15 days using a light tensile force and resulted in effective tooth movement and occlusal relationship, which rules out PFE and supports a diagnosis of ankylosis. The therapy lasted 8 months, after which the second deciduous molar exfoliated and comprehensive orthodontic treatment ensued. Following eruption of the second permanent molar, fixed orthodontic appliances were bonded in both arches to

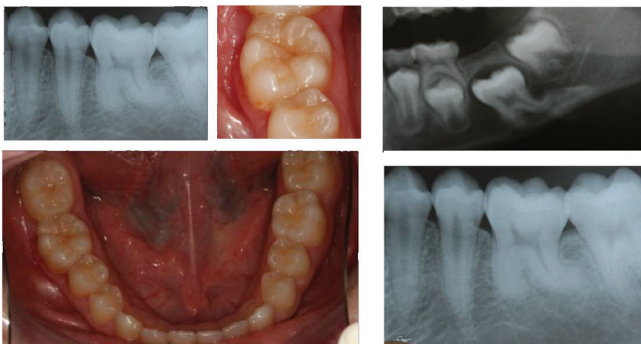


FIG. 3. Ankylosis case: final. Clinical outcome following traction of tooth 36 with elastic thread after 8 months of treatment shows alignment and inclusion in the dental arch. Fixed appliances were used to complete treatment.

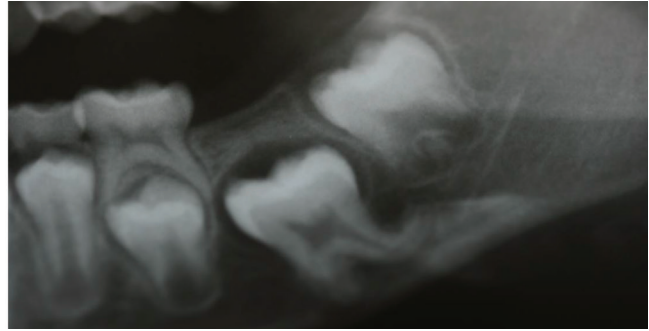


FIG. 4.

MFE 16-26-36-46 + infraocclusion 55-65-75-85. Tongue thrust. Intraoral view of a 10-year-old patient presenting with a bilateral open bite, the incomplete eruption of all four permanent first molars, and infraocclusion of the deciduous molars (more pronounced at the second molars). Clinical evaluation could not rule out a diagnosis of primary failure of eruption (PFE), but the family history and sequencing of PTH1R were negative for PFE.

showed no pathogenic PTH1R variant. The patient was treated with a pre-formed rubber myofunctional device (GC Orthodontics Inc. Alsip, IL, United States). This first therapeutic phase aimed at limiting the lateral interposition of the tongue between the arches, during the period of monitoring the tooth exchange. During this phase, an orthopantomographic radiograph was repeated after 1.5 years, where the progress of the eruption of the first molars was observed (Fig. 5). Treatment in permanent dentition started with fixed orthodontic therapy. The open bite was corrected by applying vertical (up/down elastics) in the buccal segment (premolar teeth). No undesirable effects were observed during the therapy which resulted in the successful eruption of the teeth and appropriate occlusal relationships (Fig. 6).

Clinical Scenario: PFE

The patient in mixed dentition presented for consultation and initial records at the age of 7 years. The occlusal relationships were as follows: 1) anterior and lateral crossbite on the right, and 2) significant open bite on the left (Fig. 7). The patient had completed the permutation of the lower incisors, while the upper lateral incisors were still in the process of eruption. All deciduous canines and molars were still present. On the left side, the upper and lower deciduous molars showed signs of infraocclusion, more severe in the second deciduous molars than in the first. The first permanent molars erupted and the roots were not yet fully formed. There is



FIG. 5 MFE 16-26-36-46 + infraocclusion 55-65-75-85 Tongue thrust. Orthopantomographic radiographs showing the progression of the first molar eruption before and after 1.5 years of treatment with a pre-formed rubber myofunctional device. The device prevented lateral tongue interposition between the arches during the development of the dental arches. The follow-up radiograph demonstrates notable eruption progress of the first molars compared to the initial radiograph.

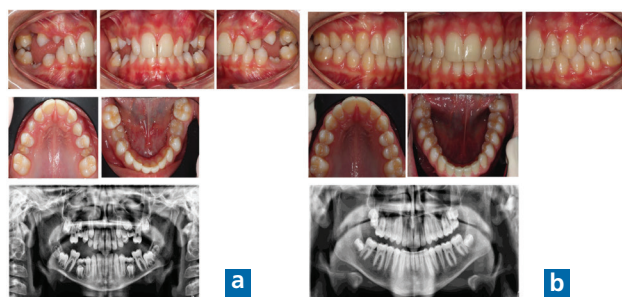


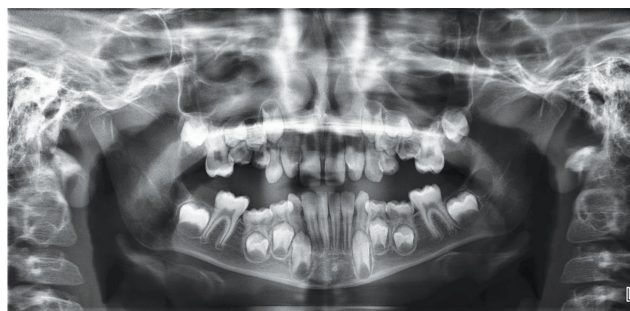
FIG. 6: MFE 16-26-36-46 + infraocclusion 55-65-75-85 Tongue thrust. Initial presentation showing bilateral molar infraocclusion (teeth 16, 26, 36, 46) and infraocclusion of deciduous molars (teeth 55, 65, 75, 85), associated with a tongue thrust habit.

FIG. 6A: After phase I (myofunctional therapy). Orthopantomogram taken after phase I treatment with a pre-formed rubber myofunctional device, showing progress in molar eruption and reduction of tongue interposition.

FIG. 6B: After phase 2 (Fixed orthodontic appliance – MBT with vertical elastics).

FIG. 6. FIG. 6A. FIG. 6B. Post-phase II treatment with fixed orthodontic appliances (MBT system) and vertical elastics, demonstrating closure of the open bite, proper molar eruption, and restoration of functional occlusal contacts.

a clear asymmetry in the eruptive movement of the permanent molars, as those on the left side have just emerged with their cusps, while those on the right have their crowns completely visible in the mouth. Observation of the panoramic radiograph revealed the agenesis of the upper right second premolar. The tongue was interposed in the space between upper and lower left dental arches, contributing to the worsening of the lateral open bite. The patient's mother had the first lower right molar in infraocclusion, supporting the suspicion of PFE (Fig. 7). A genetic test confirmed the diagnosis of PFE; both child and his mother carried the c.720 G > C;p.(Lys240Asn) variant in the PTH1R gene [Modafferi et al. 2024]. Taking into account the diagnosis of PFE, it was decided to limit management to monitor the spontaneous eruptive movements of the permanent molars, avoiding application of orthodontic forces directly on the affected teeth. Therapeutic objectives were established instead to harmonise the growth of the skeletal bases. Specifically, in the initial phase the objective was to encourage the expansion of the upper arch and correct the crossbite. The orthodontic device used was a Function Generating Bite appliance (FGB) [Piancino and Kyrkanides, 2016; Tortarolo et al., 2023] with retroincisive springs to correct the inclination of the upper incisors, palatal expansion arms and mandibular retrusion arch (Fig. 8). The patient was very compliant, wearing the FGB appliance 12 hours per day for one year. This initial phase of therapy allowed the transverse expansion of the palate and the correction of the lingual inclination of the upper incisors, obtaining the correction of the



lateral and anterior crossbite. No improvement in the left lateral open bite was observed, and the tongue continued to interpose itself between the left hemiarches. For this reason, it was decided to use a different functional appliance, which had greater control over the tongue posture. The FGB appliance also maintained the correct inclination of the occlusal planes. The final step of treatment utilised a Bionator [Balters, 1964; Abbing et al., 2024] to prevent worsening of the lateral open bite (Fig. 9).

Discussion

During the search for cases of eruption failure, several patients with eruption problems were referred to our team; most were marked by a failure of the orthodontic approaches used. The treatment result often included the undesirable effect of intruding teeth adjacent to the affected molars when employing a continuous arch wire. This finding necessitated a therapeutic phase to recover the initial occlusal relationships, which were still suboptimal. Instead, early diagnosis and appropriately timed treatment offer a greater chance of obtaining clinical results. This is in contrast with an intervention in the adult patient with eruption disorders that often require extraction of the affected teeth—and may still lead to poor occlusal relationships. Our current knowledge base of eruption failure treatment does not provide enough data points to codify

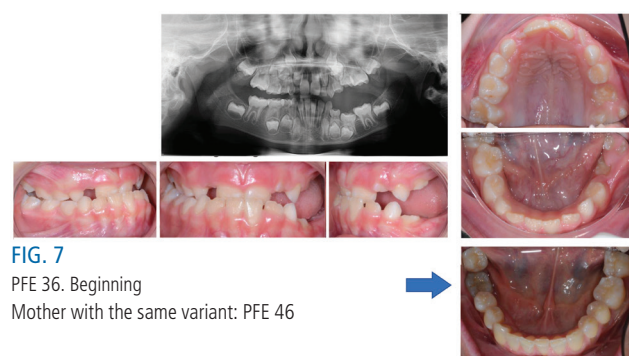


FIG. 7

PFE 36. Beginning

Mother with the same variant: PFE 46

FIG. 7. Initial clinical presentation of a 7-year-old patient with anterior and lateral crossbite on the right and a large open bite on the left. The mixed dentition showed complete eruption of the right first permanent molars, while clinical signs of primary failure of eruption (PFE) were present on the left. Both upper and lower left first molars were unerupted, with infraocclusion of the left deciduous molars, especially the second molars, which were almost fully covered by gingiva. A panoramic radiograph revealed agenesis of the upper right second premolar, and the patient exhibited a tongue thrust habit, worsening the lateral open bite. The patient's mother had the first lower right molar in infraocclusion, confirming the suspicion of PFE. Genetic testing further confirmed the diagnosis of PFE.

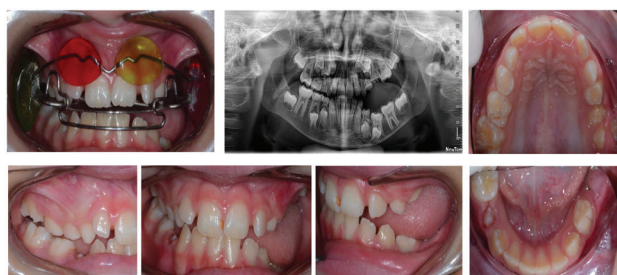


FIG. 8 PFE 36. After 18 m. of Function Generating Bite appliance. Before and after images showing the results of 18 months of treatment with a Function Generating Bite appliance. The device, equipped with retroincisive springs to correct upper incisor inclination, palatal expansion arms, and a mandibular retrusion arch, was used in the initial phase to expand the upper arch and correct the crossbite. The patient wore the appliance for 12 hours a day for one year, significantly improving occlusion and arch alignment.

the factors leading to therapeutic success, for instance, in managing ankylosis. There is a paucity of information to understand whether the ankylosis and curvature of the distal root are primary or secondary to the lack of reabsorption of the bone along the eruption path. We appreciate using primary teeth as anchorage that may limit any consequences to the permanent dentition in case of failure. This precaution has been suggested several times in mixed dentition also for the anchoring of rapid maxillary expansion devices [Primožic et al., 2021; Quinzi et al., 2021]. We therefore hypothesise that early therapy should be attempted and carefully monitored. For example, the absence of signs of ankylosis and PTH1R gene variants makes a diagnosis of MFE most plausible that correspondingly carries a more favorable prognosis. In MFE it is possible to move the teeth with comprehensive orthodontic treatment. The literature shows that infraocclusion problems of primary molars often do not require intervention [Kuroi, 2006; Tieu et al., 2013; Patano et al., 2023]. Monitoring dental development with minimal intervention is appropriate, with a careful determination of the appropriate timing to begin comprehensive orthodontic treatment is required. If tongue movement dyskinesias are observed, it may be helpful to begin myofunctional therapy early [Gelb et al., 2021; Botzer et al., 2021; Boyd et al., 2021]. It has been shown that in young patients, orthodontic therapies are favored by the greater presence of factors capable of inducing bone remodeling [Kapoor et al., 2014]. Furthermore, in many cases, missing the ideal treatment window leads to an aggravation of the malocclusion [Grippaudo et al., 2020]. Even a diagnosis of MFE requires early orthodontic intervention beginning with managing (i.e. removing) the obstacle to eruption. Finally, the case of PFE treated with orthopaedic-functional therapy represents the first attempt described at early treatment of PFE. The treatment in this case aims at avoiding the inclination of the occlusal plane and guide the correct development of the jaws. This therapy does not help the tooth eruption, therefore at the end of growth you will have to face the problem of incomplete eruption of the molar. The proposed solution has led to clear improvements, which encourage the use of this type of therapy. We encountered some difficulties in making the family understand the usefulness of focusing attention on growth rather than on the problem of the unerupted teeth. Patients with PFE expect an orthodontic solution that is not possible to practice, and for this reason it is difficult to communicate with them and obtain collaboration. Furthermore, since the problem cannot be solved at its origin, orthopaedic-functional therapies should be continued until growth stops. The length of treatment is a factor that can determine the loss of collaboration. If functional



FIG. 9 PFE 36. A Bionator appliance was used to address the prevention of tongue interposition and maintaining the correct inclination of the occlusal planes. The therapy is still ongoing, with the appliance designed to support these goals and further enhance occlusal development.

orthopaedic therapy does not show appreciable clinical results, it would be best to stop. An early diagnosis and regular follow-up until growth stops give more chance to solve clinical problems [Wagner et al., 2023]. During growth, orthodontic movement of the non-affected teeth could be possible and advisable to improve the dental occlusion and masticatory function.

Conclusion

The early observation of permanent molar failure of eruption presents itself as a problem that both the orthodontist and the family wish to remedy as soon as possible. This path is not always practicable, and if followed it can present pitfalls and the possibility of unsuccessful treatment results. Importantly, the key to success is to start with the correct diagnosis including carefully consideration of the best differential diagnosis. Finally, the benefits and risks associated with each treatment option must be vetted with evidence of success and failure, and this must be discussed with the family to ensure alignment of expectations. There are many indications anecdotally and otherwise to support future studies that examine the interrelationship between eruption problems and dentoskeletal development. In the three clinical scenarios presented here, we found that while interceptive treatment for eruption disorders is more promising for a growing patient, there is a critical need to complete larger cohort studies that examine the impact of eruption disorders on the sagittal, vertical and transverse relationships.

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